Primary/Secondary Variable Chilled Water System

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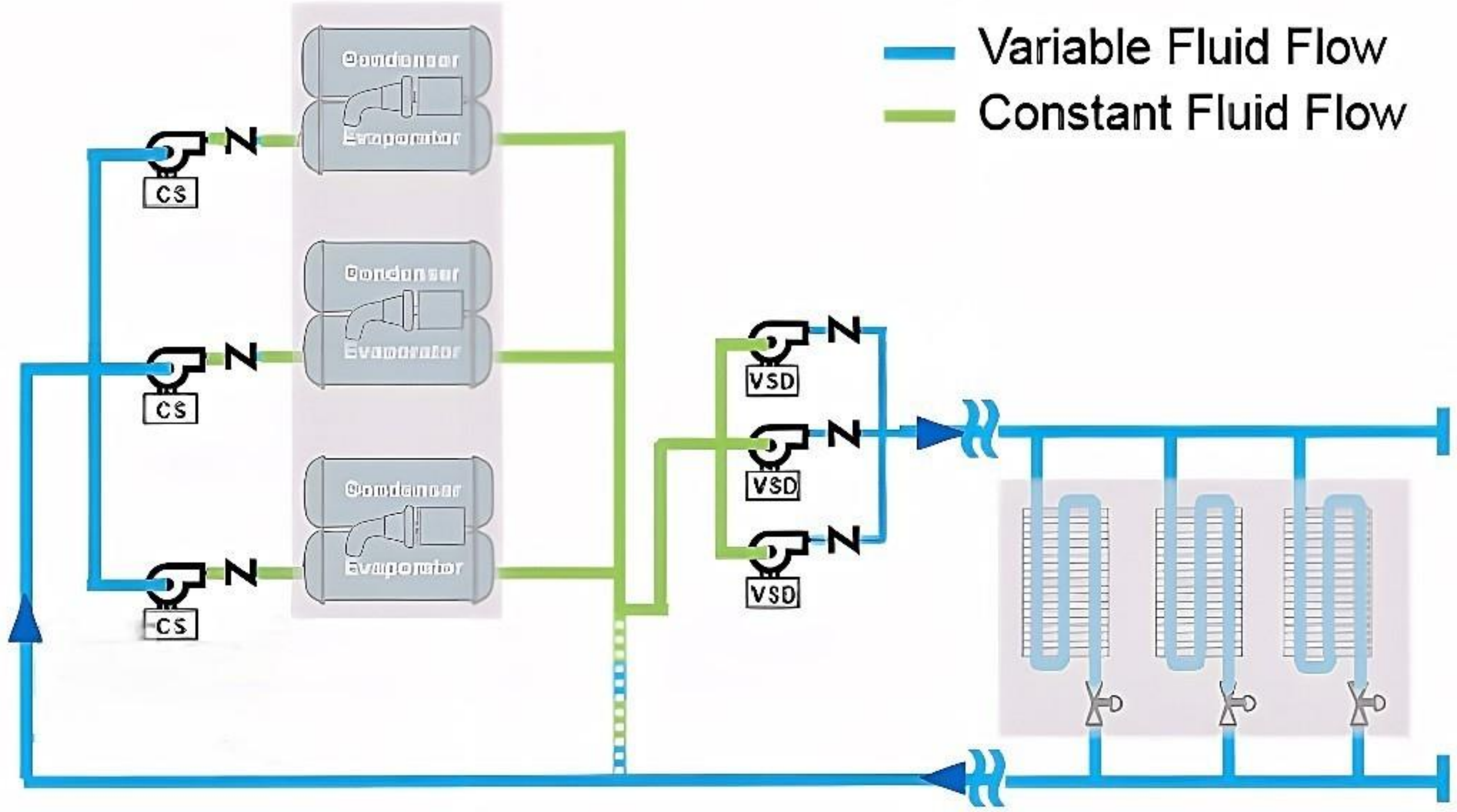
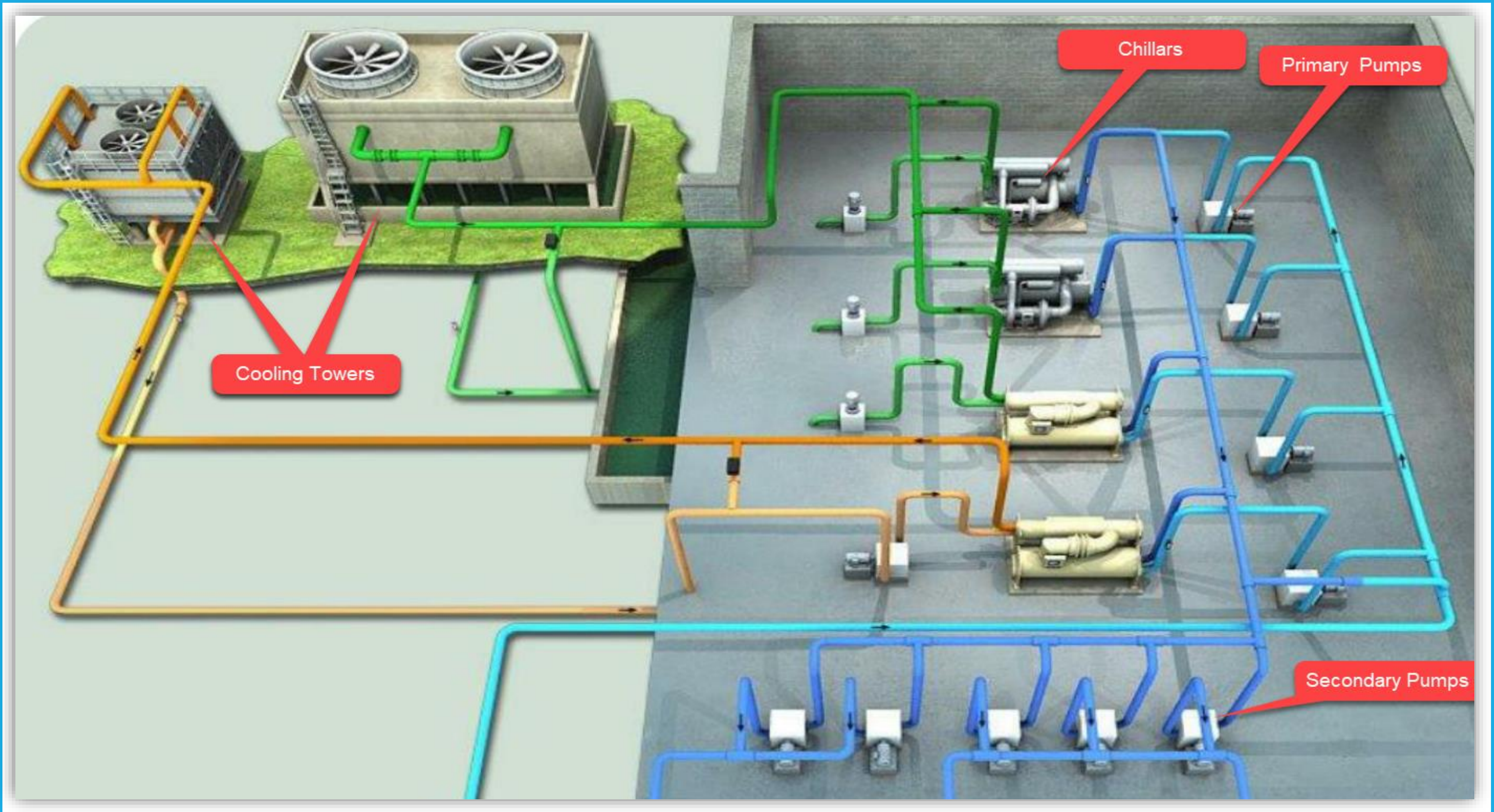
Constant Primary / Variable Secondary Flow:



Types of Chilled Water System

- Constant Volume Primary Chilled Water Systems
- **Primary/Secondary Chilled Water Systems**
- Primary/Secondary/Tertiary pumps Chilled Water Systems
- Variable Primary Flow Chilled Water Systems

Primary/Secondary Chilled Water System


Chillars
Primary Pumps
Cooling Towers
Secondary Pumps

System Contains

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- Chillers
- Primary Pump (Without VFD)
- Secondary Pump With VFD
- AHU With Cooling Coils
- Manifolds with 2 Way Modulating Valve/PICV
- Cooling Tower and its Cycle
- Decoupler Line/Common Header/ Low Loss Header

CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

In a primary-secondary HVAC pumping system, 2 hydraulically separate chilled water circuits are present.

The primary circuit has low head primary pumps which typically maintain a constant flow rate through chillers. The secondary circuit has high head secondary pumps which maintain flow through loads (AHUs, FCUs, etc). Secondary pumps are usually fitted with VFDs so that they may vary flow through the secondary circuit as per load conditions. This results in better control and hence better overall system efficiency.

CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

In primary/secondary systems, water flows through the chiller primary loop at a constant rate, and water flows through the secondary loop, which serves air handlers or fan coils, at a variable rate. The constant speed pumps in secondary circuit are replaced with "variable speed" pumps. The speed of the secondary pumps is determined by a controller measuring differential pressure (DP) across the supply-return mains or across the selected critical zones. The decoupled section isolates the two systems hydraulically.

Also the system uses two-way valves in the air handlers that modulate secondary loop flow rate with load requirements. During light load condition, the 2-way control valves will close (partially or fully) in response to load conditions, resulting in pressure rise in the secondary chilled water loop. A differential pressure sensor measures the pressure rise in the secondary loop and signals variable frequency drive of secondary pumps to alter the speed (flow).

Primary-secondary variable-flow systems are more energy efficient than constant-flow systems, because they allow the secondary variable-speed pump to use only as much energy as necessary to meet the system demand. Refer to the schematic below.

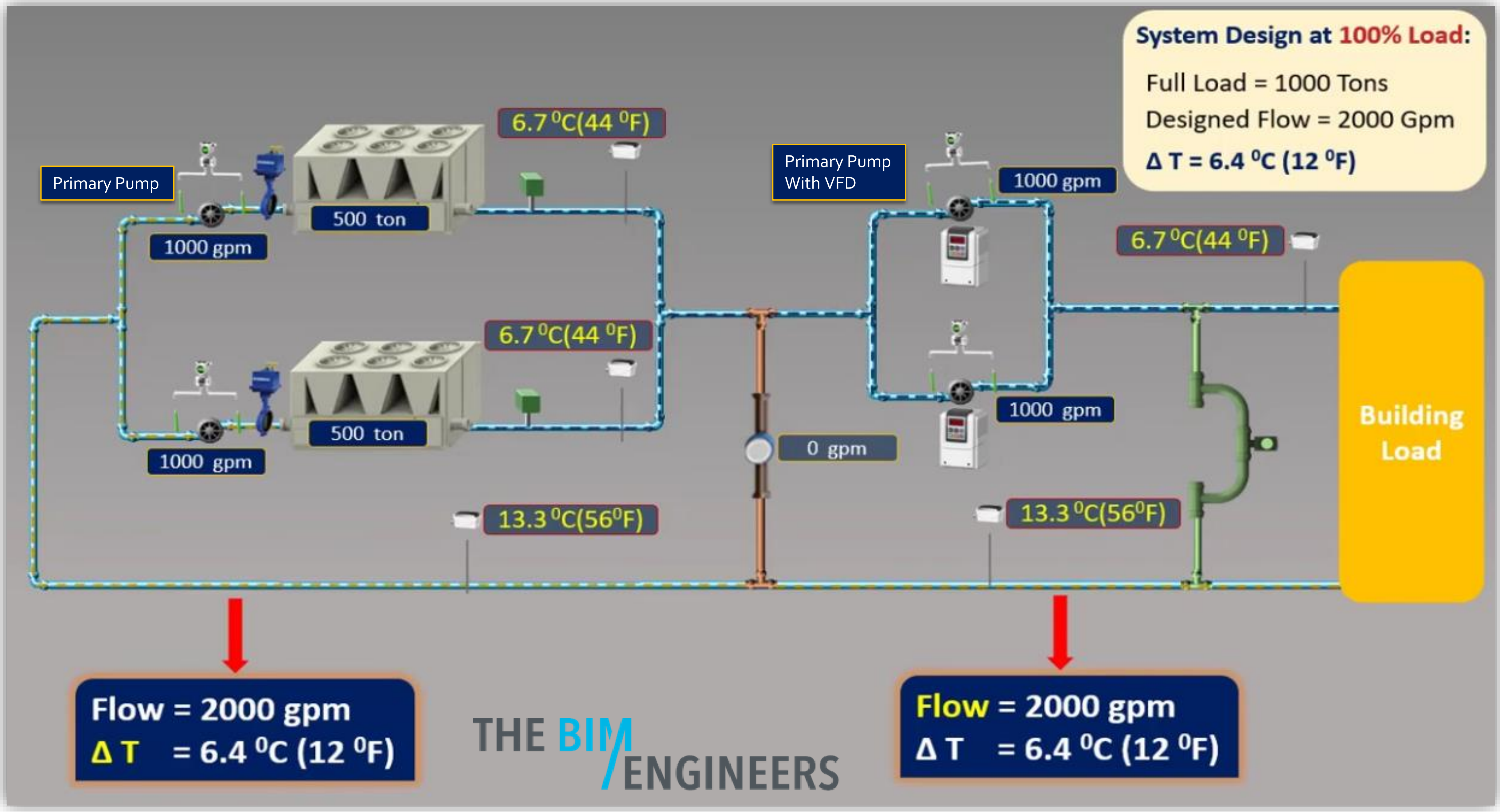
CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

Consider example A:

Chiller Data:

- GPM= 2000
- TR= 1000
- ΔT= 12⁰F
- Building Load = 2000 GPM
- Chiller Inlet Temperature = 56⁰F
- Chiller Outlet Temperature = 44⁰F

In 100% Full Load Condition, the Primary Flow is equal to secondary flow.



System Design at 100% Load:
Full Load = 1000 Tons
Designed Flow = 2000 Gpm
Δ T = 6.4 ⁰C (12 ⁰F)
Primary Pump
1000 gpm
500 ton
6.7 ⁰C(44 ⁰F)
500 ton
1000 gpm
6.7 ⁰C(44 ⁰F)
13.3 ⁰C(56⁰F)
Primary Pump
With VFD
1000 gpm
1000 gpm
0 gpm
6.7 ⁰C(44 ⁰F)
13.3 ⁰C(56⁰F)
Building
Load
Flow = 2000 gpm
Δ T = 6.4 ⁰C (12 ⁰F)
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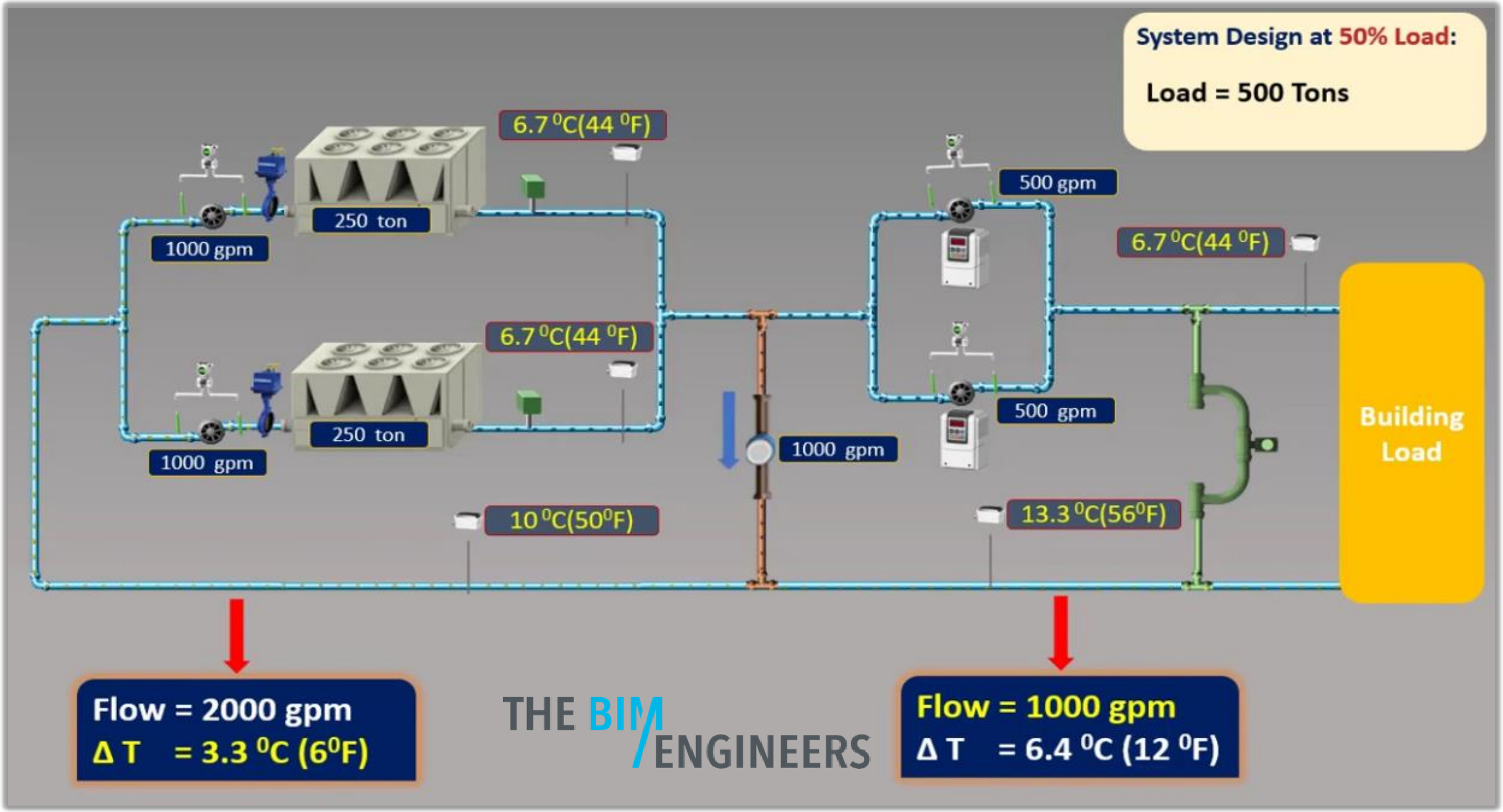
Flow = 2000 gpm
Δ T = 6.4 ⁰C (12 ⁰F)

CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

- In 50% Partial Load Condition, the Primary Flow is Greater than Secondary Flow.
- When required temperature is achieved in 50% load then 2 way modulating valve start throttling upto 50%.
- Then difference in pressure is appear and get sense by differential pressure sensor(DPT).
- DPT sends signal to VFD and VFD reduces flow of water upto 50%.
- 50% water is passed through all AHU's coils and remaining 50% water is passed through decoupler line and the value of ΔT is decreases, see diagram.....



System Design at 50% Load:
Load = 500 Tons
6.7 °C(44 °F)
250 ton
1000 gpm
6.7 °C(44 °F)
250 ton
1000 gpm
10 °C(50°F)
1000 gpm
500 gpm
500 gpm
6.7 °C(44 °F)
13.3 °C(56°F)
Building Load
Flow = 2000 gpm
Δ T = 3.3 °C (6°F)
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Flow = 1000 gpm
Δ T = 6.4 °C (12 °F)

CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

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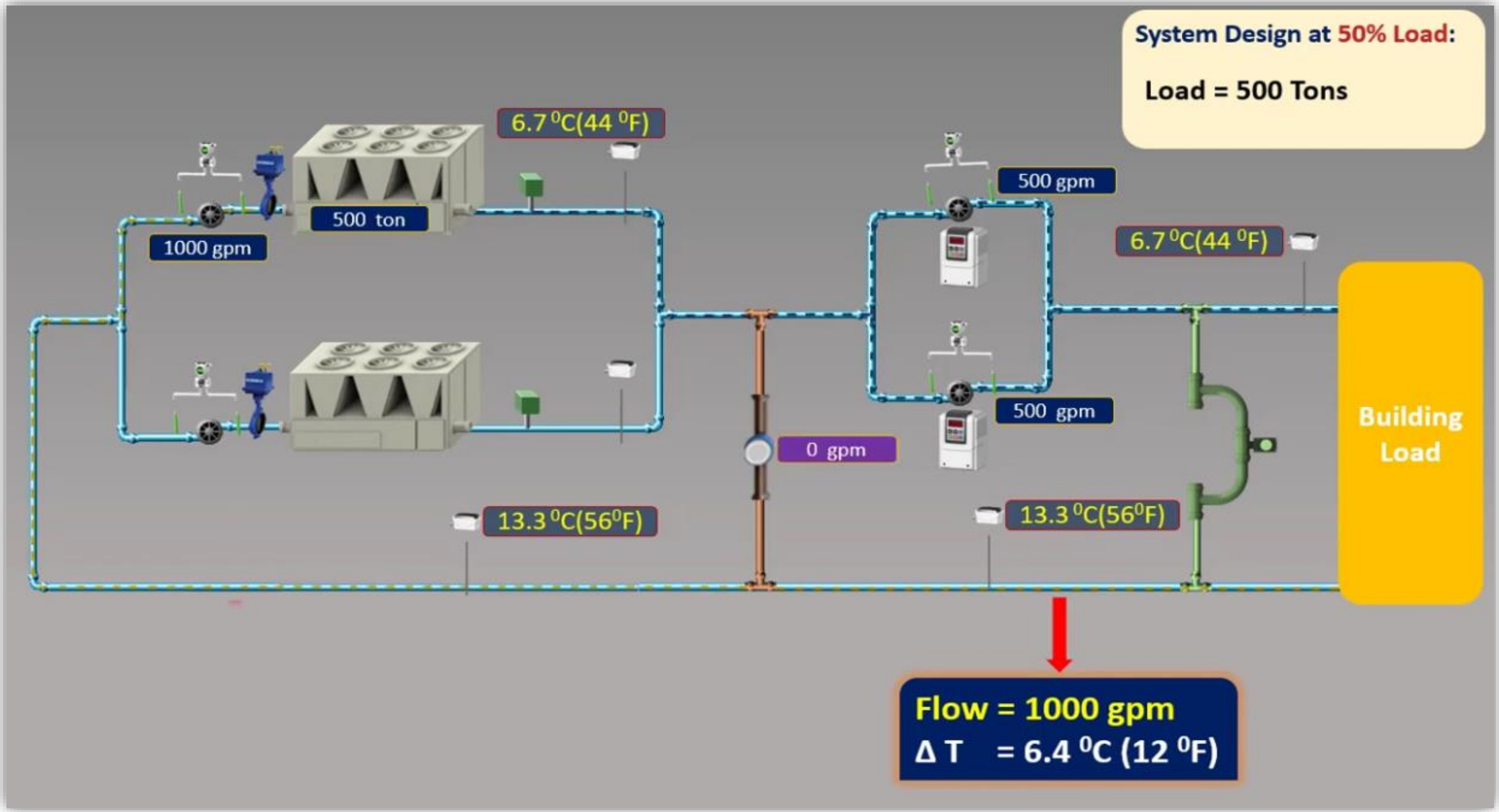
- In Decoupler line bidirectional flow meter is present and it get sense
- After 10 minutes of delay time one pump and one chiller is off/close through BMS System
- Now there is no flow in decoupler line
- Primary flow is 1000 GPM and secondary flow is also 1000 GPM, both are equal, see diagram…….


System Design at 50% Load:
Load = 500 Tons
6.7 ⁰C(44 ⁰F)
500 ton
1000 gpm
500 gpm
6.7 ⁰C(44 ⁰F)
Building Load
500 gpm
0 gpm
13.3 ⁰C(56⁰F)
13.3 ⁰C(56⁰F)
Flow = 1000 gpm
Δ T = 6.4 ⁰C (12 ⁰F)

CONSTANT PRIMARY/ VARIABLE SECONDARY SYSTEM

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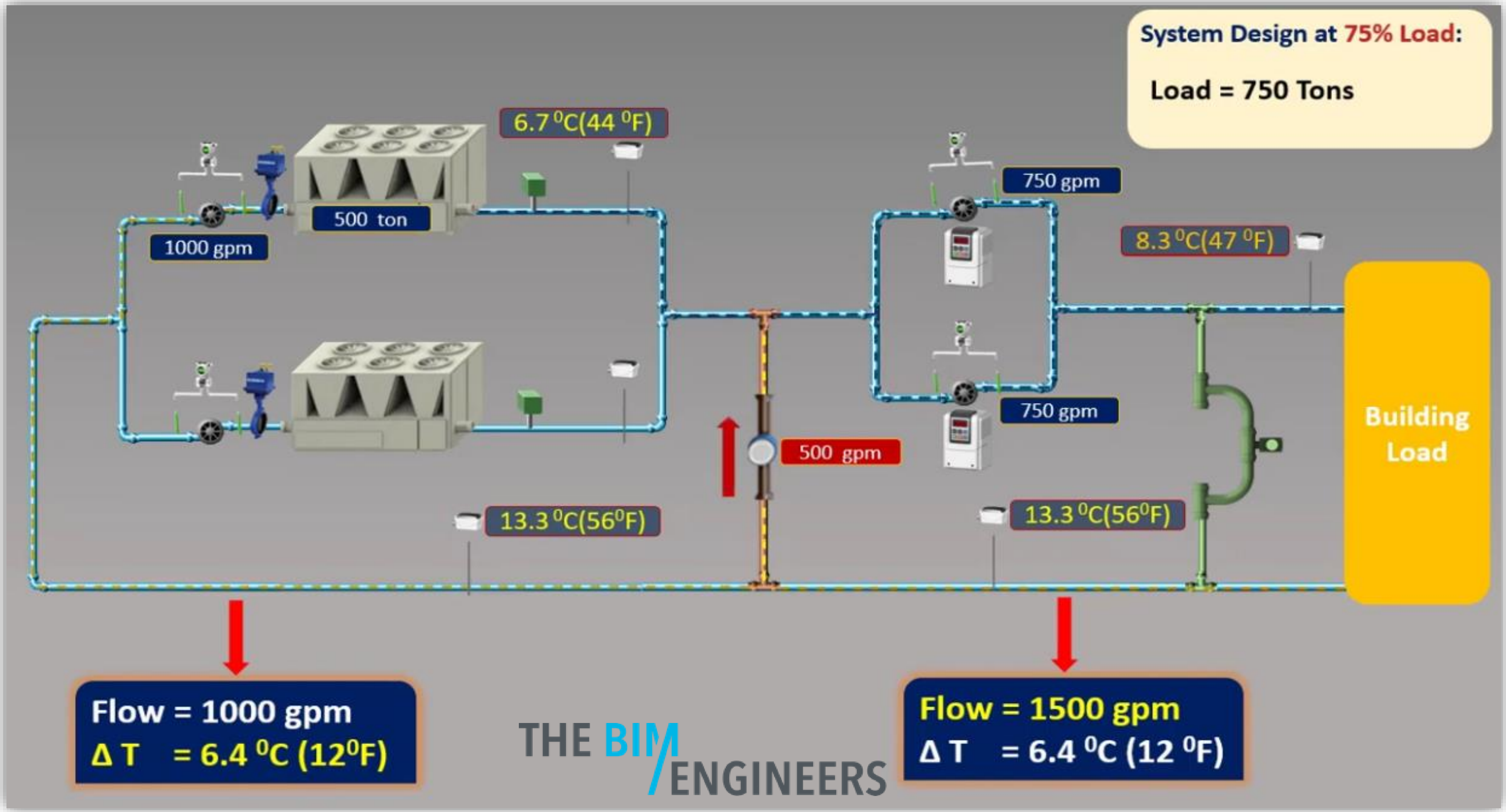
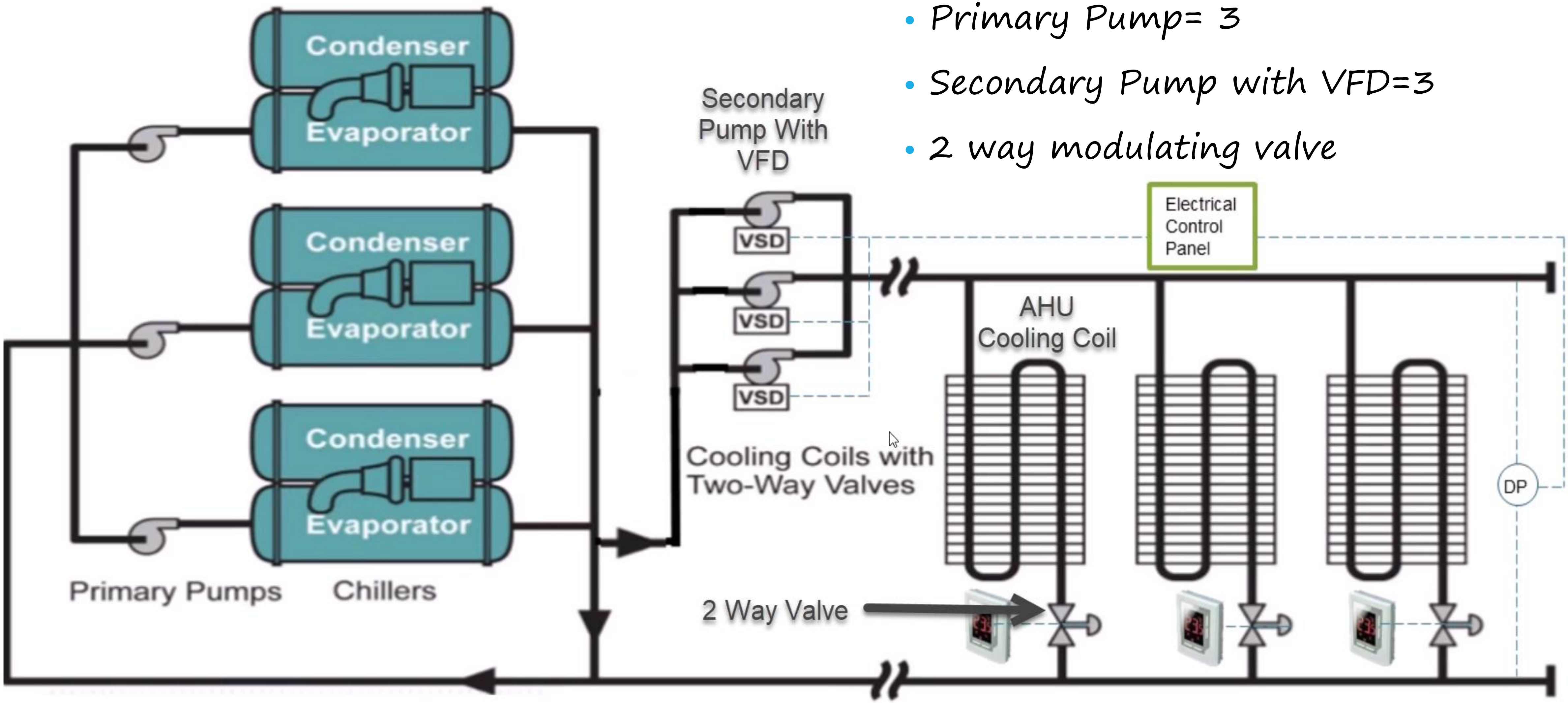
- Now Load going to increase upto 75% (1500 GPM) and system is running on in only chillar only i.e. 1000 GPM
- Then 500 GPM require for secondary pump.
- 500 GPM is passed through decoupler line in reverse flow. See diagram.....

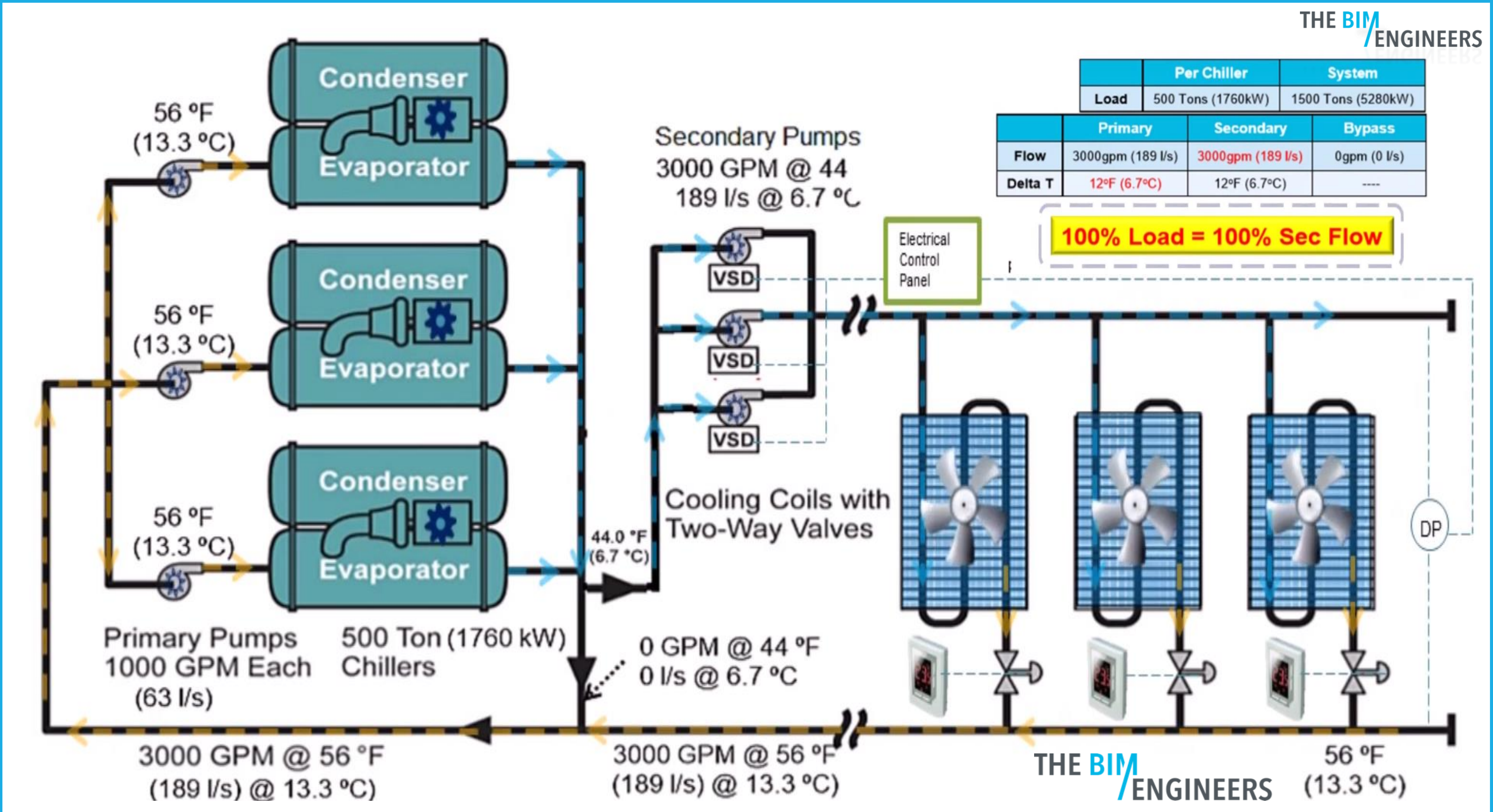


System Design at 75% Load:
Load = 750 Tons
6.7 °C(44 °F)
500 ton
1000 gpm
750 gpm
8.3 °C(47 °F)
750 gpm
500 gpm
Building Load
13.3 °C(56°F)
13.3 °C(56°F)
Flow = 1000 gpm
Δ T = 6.4 °C (12°F)
Flow = 1500 gpm
Δ T = 6.4 °C (12 °F)

Another Example

- No of Chillar=3
- AHU =3
- Primary Pump= 3
- Secondary Pump with VFD=3
- 2 way modulating valve





	Per Chiller	System
Load	500 Tons (1760kW)	1500 Tons (5280kW)

	Primary	Secondary	Bypass
Flow	3000gpm (189 l/s)	3000gpm (189 l/s)	0gpm (0 l/s)
Delta T	12ºF (6.7ºC)	12ºF (6.7ºC)	----

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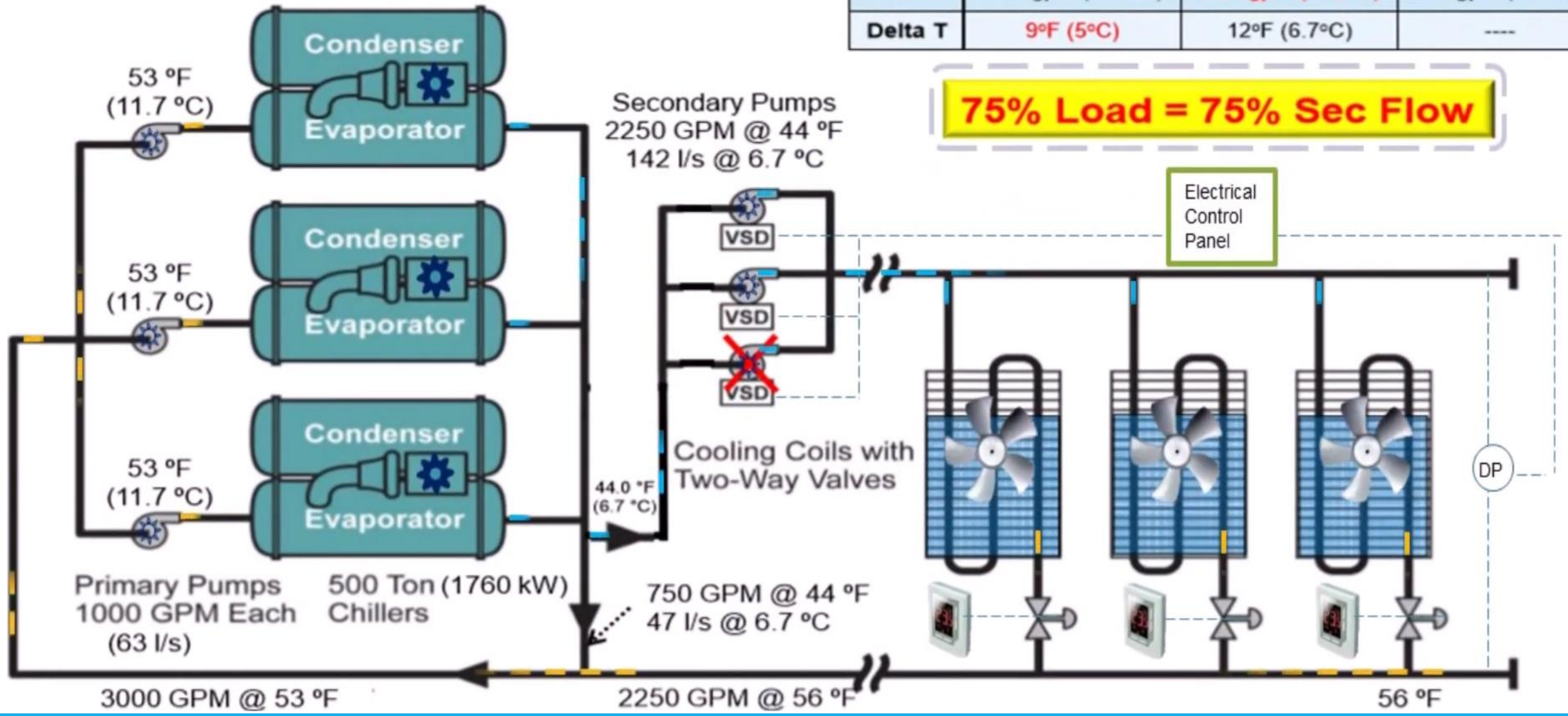
	Per Chiller	System
Load	375 Tons (1320kW)	1125 Tons (3960kW)

	Primary	Secondary	Bypass
Flow	3000gpm (189 l/s)	2250gpm (142 l/s)	750gpm (47 l/s)
Delta T	9ºF (5ºC)	12ºF (6.7ºC)	----

75% Load = 75% Sec Flow



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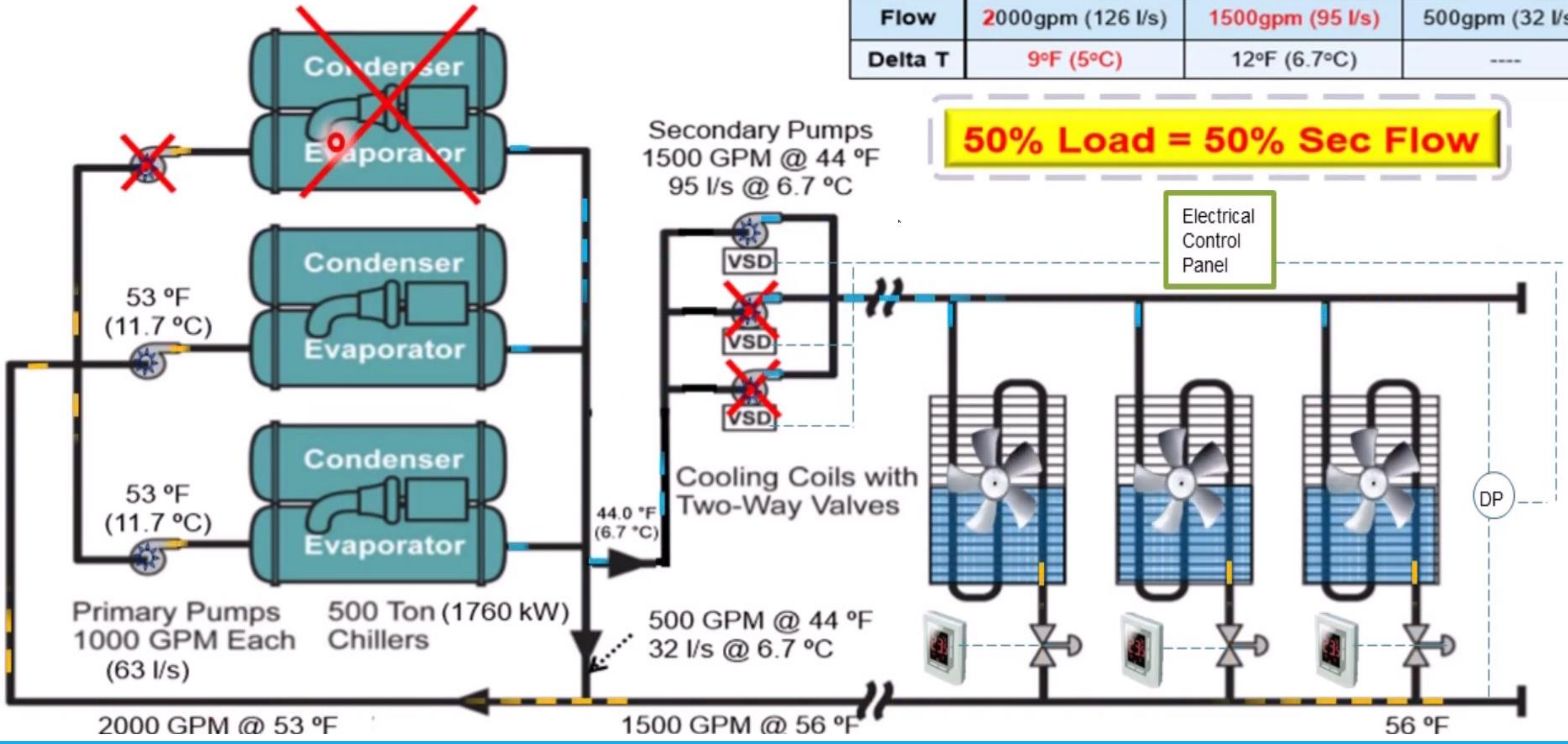
	Per Chiller	System
Load	375 Tons (1320kW)	750 Tons (2640kW)

	Primary	Secondary	Bypass
Flow	2000gpm (126 l/s)	1500gpm (95 l/s)	500gpm (32 l/s)
Delta T	9°F (5°C)	12°F (6.7°C)	----

50% Load = 50% Sec Flow



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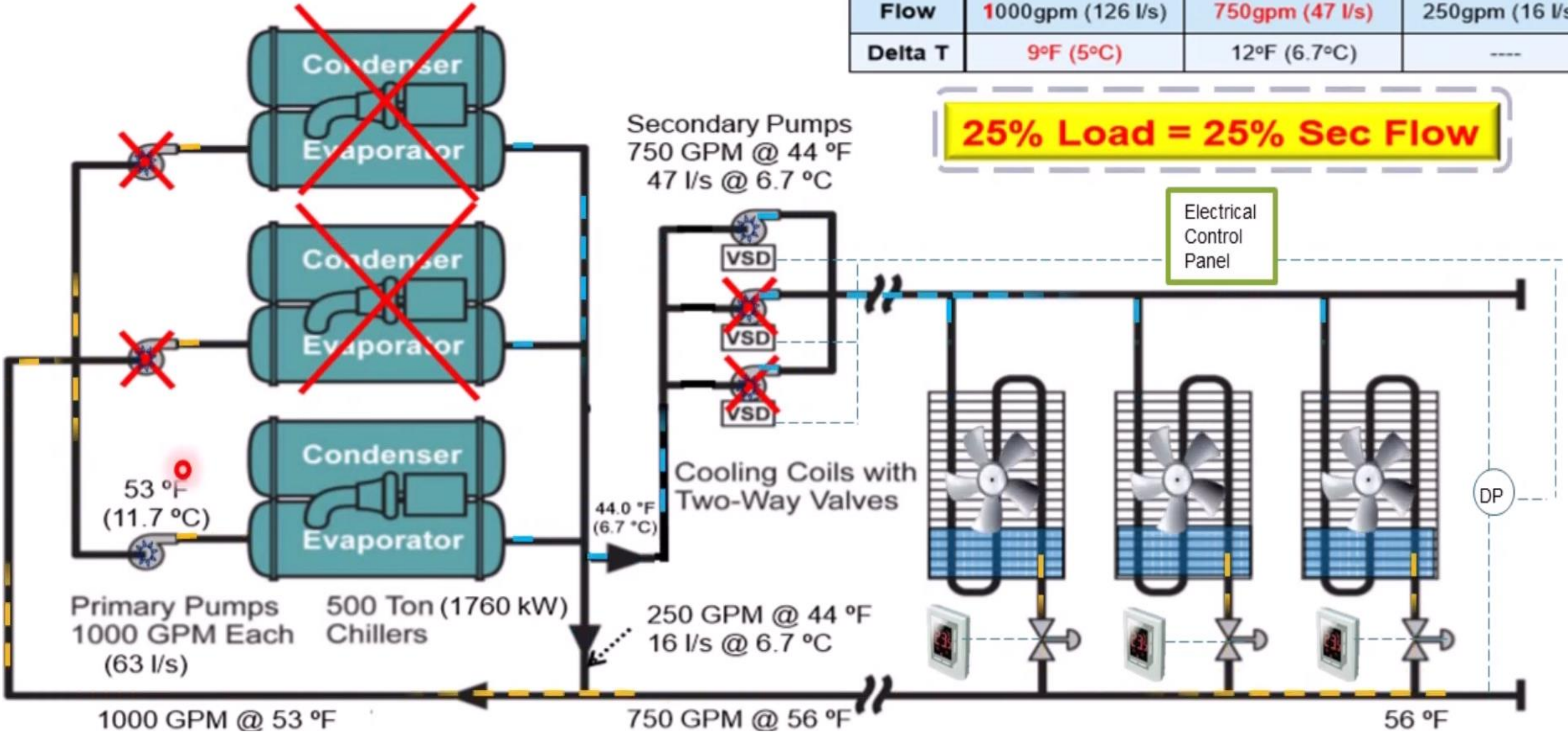
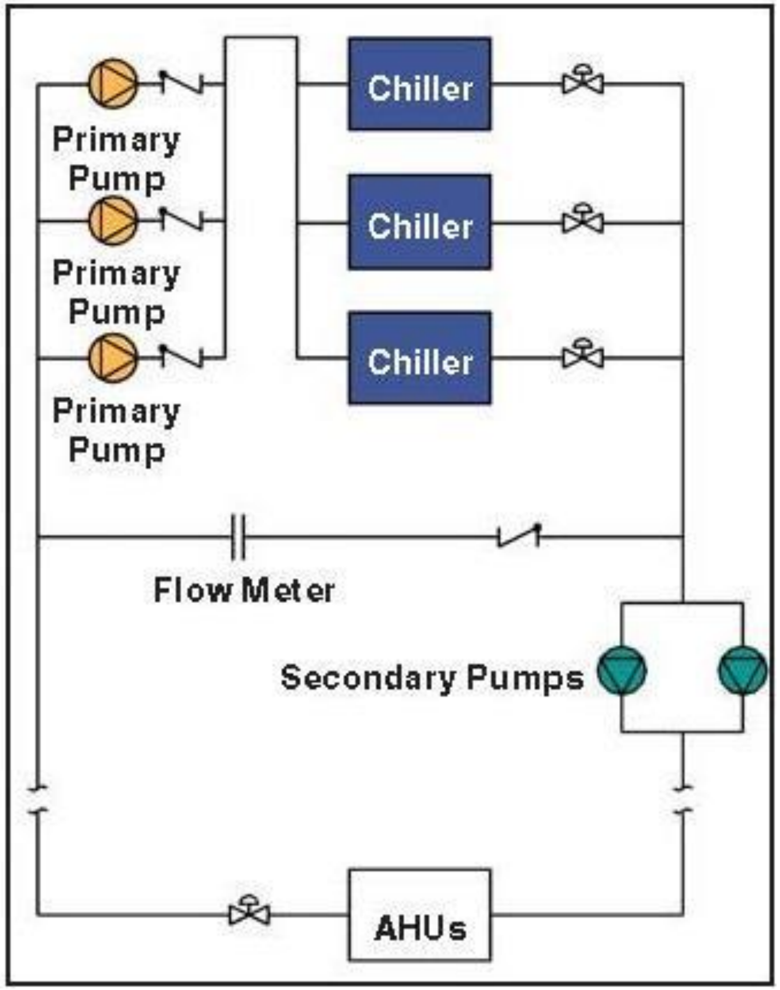
	Per Chiller	System
Load	375 Tons (1320kW)	375 Tons (1320kW)

	Primary	Secondary	Bypass
Flow	1000gpm (126 l/s)	750gpm (47 l/s)	250gpm (16 l/s)
Delta T	9°F (5°C)	12°F (6.7°C)	----

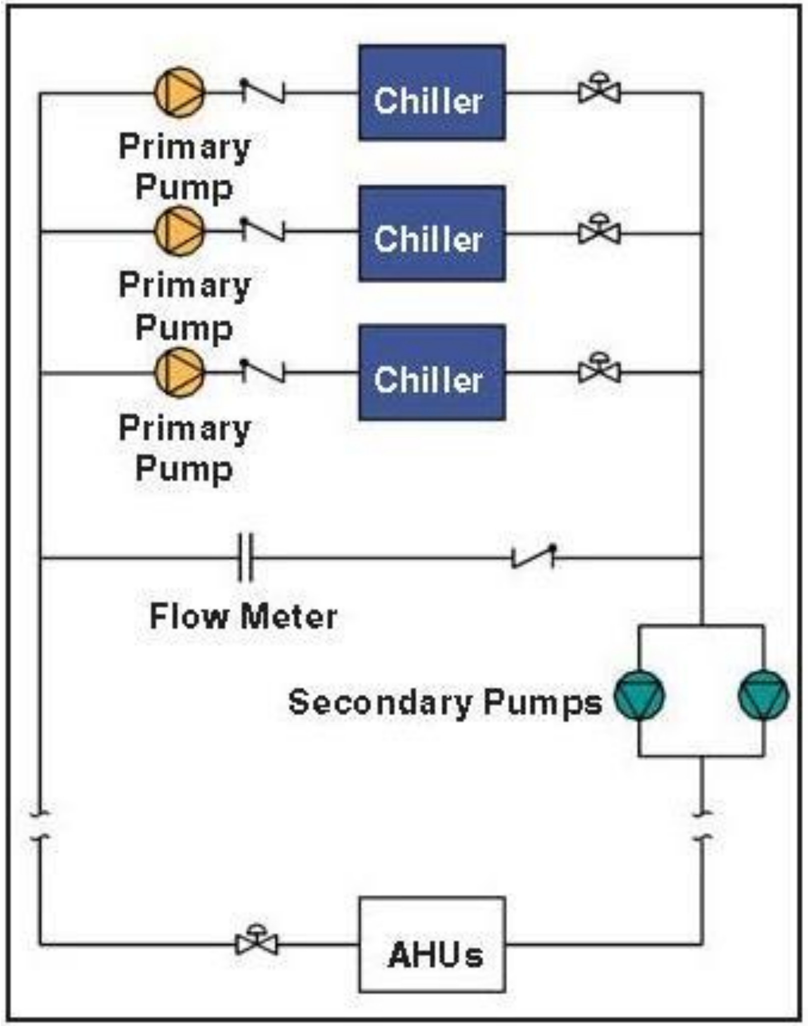
25% Load = 25% Sec Flow



Primary Pumps: Manifold or Dedicated?



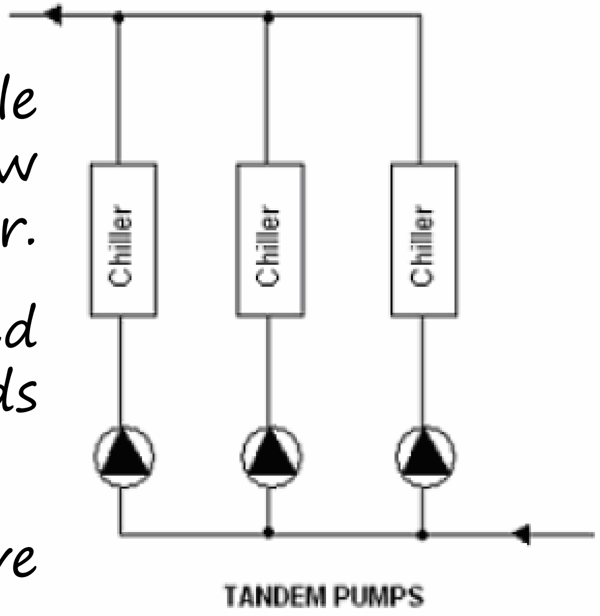
Manifold/Headered Pump



Dedicated/Tandem Pump

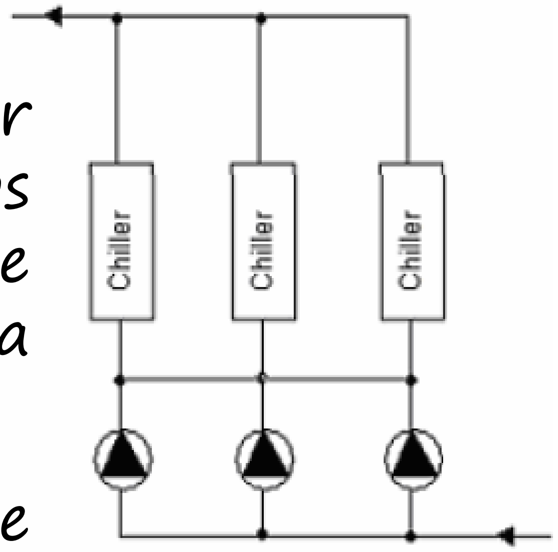
Dedicated/Tandem Pump

- Here each pump is dedicated to its respective chiller i.e. pump 1 is piped directly to chiller 1 and whenever this chiller is operating its dedicated pump should be operating. Building operators find this simplicity beneficial.
- Another benefit of dedicated pumps is that they can handle unequally sized chillers without using control valves and flow measurement devices to balance the correct flow to each chiller.
- The downside is that a standby pump cannot be started automatically by the building control system, but instead needs manual intervention.
- This can present a problem with chiller plants that do not have standby capacity.
- The constant flow systems are recommended in distributed arrangement.



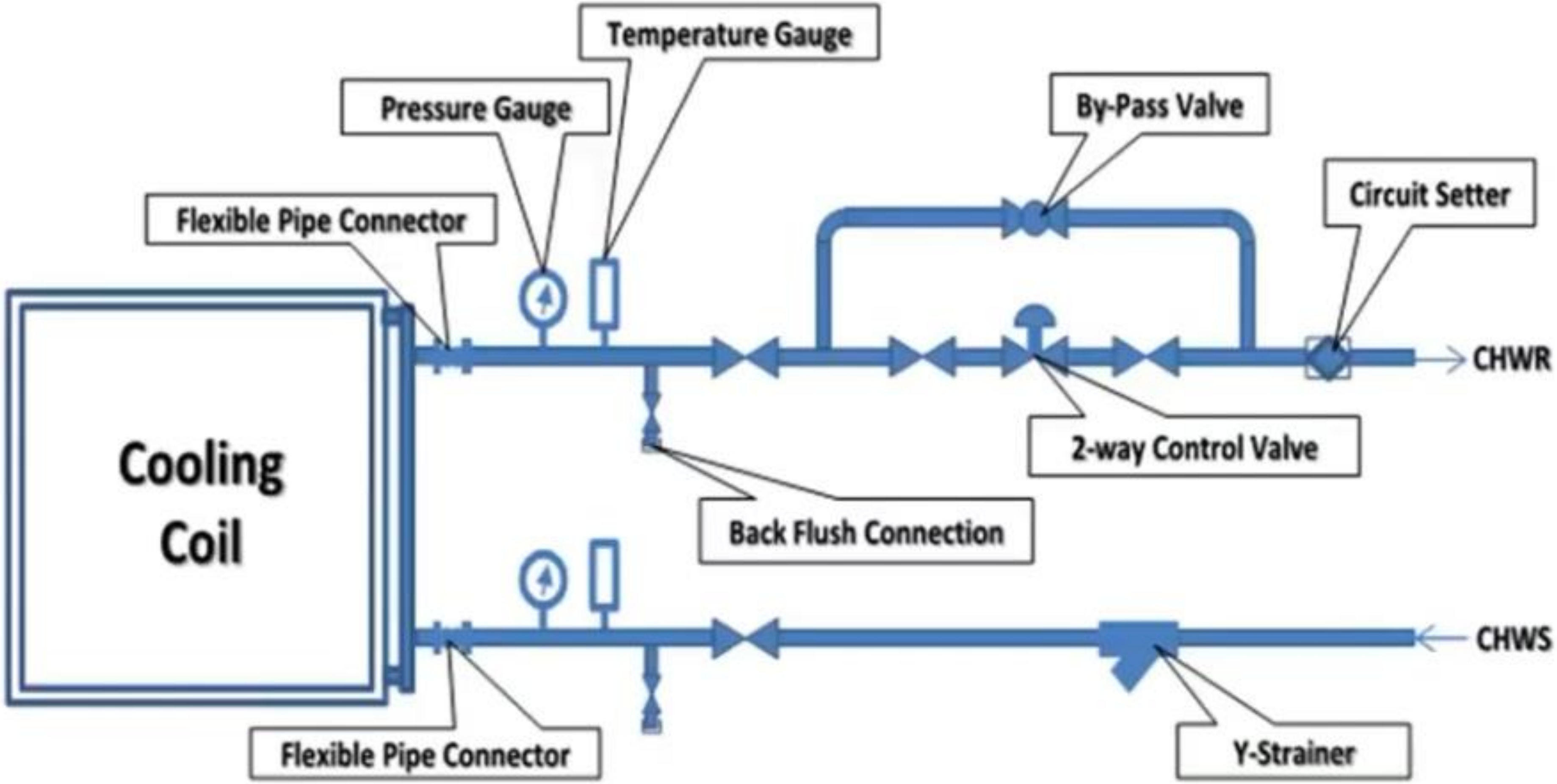
Manifold/Headered Pump

- Here the discharge of multiple pumps is connected to a common manifold before entering the chiller. This arrangement is desirable for a few reasons:
- First, they give users the ability to operate any chiller with any primary chilled water pump. This helps whenever a single pump is down for maintenance because a pump outage does not correspond to a particular chiller.
- Also, headered pumps give users the ability to operate more than one pump for a single chiller.
- This can help solve a low ΔT problem by increasing primary flow and forcing a chiller to a greater load when the return temperature is less than design.

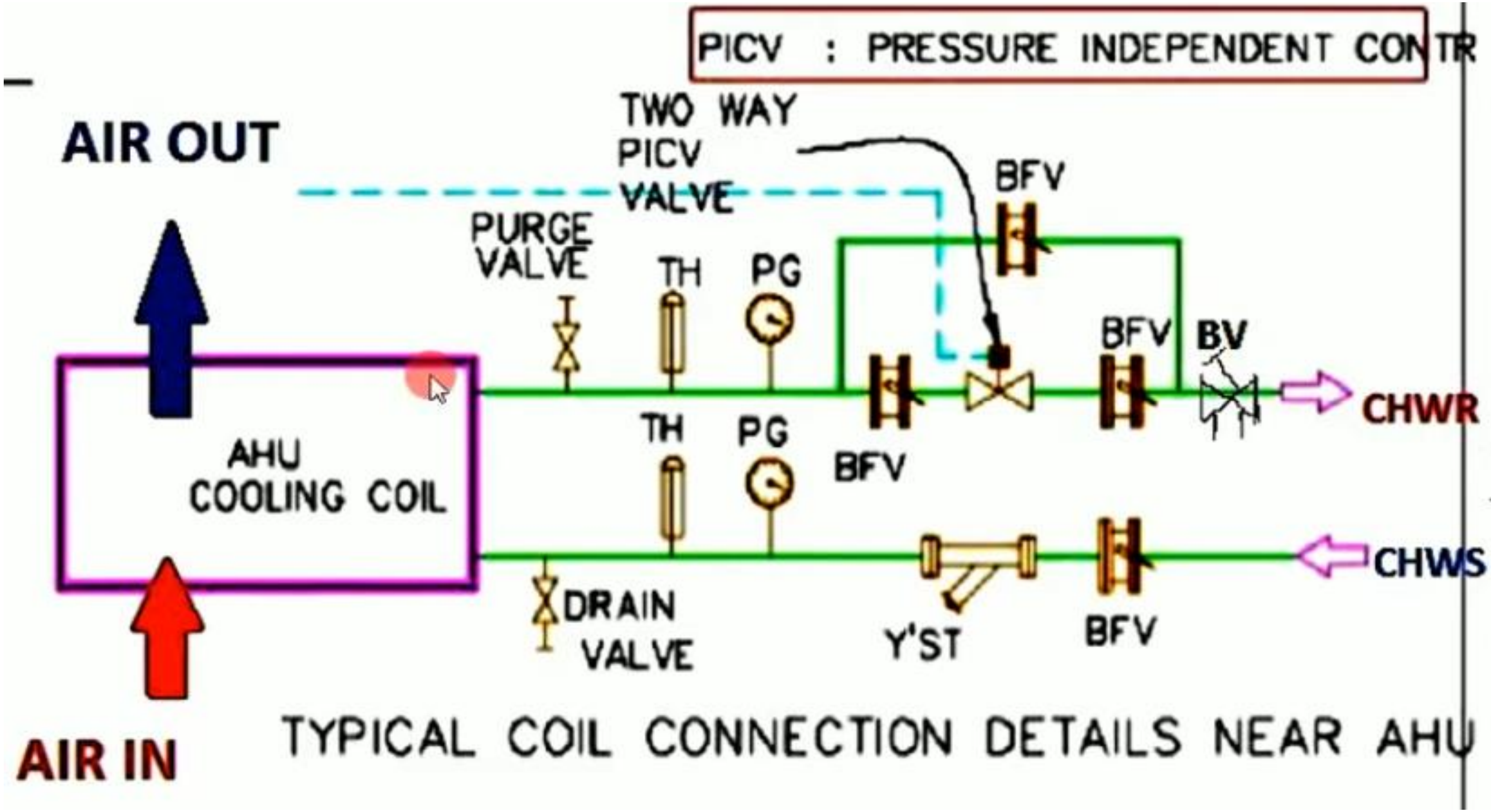


HEADERED PUMPS

Two-way Control Valve Typical Arrangement



TYPICAL PIPE CONNECTION OF AHU



AHU- Actual/Real Manifold

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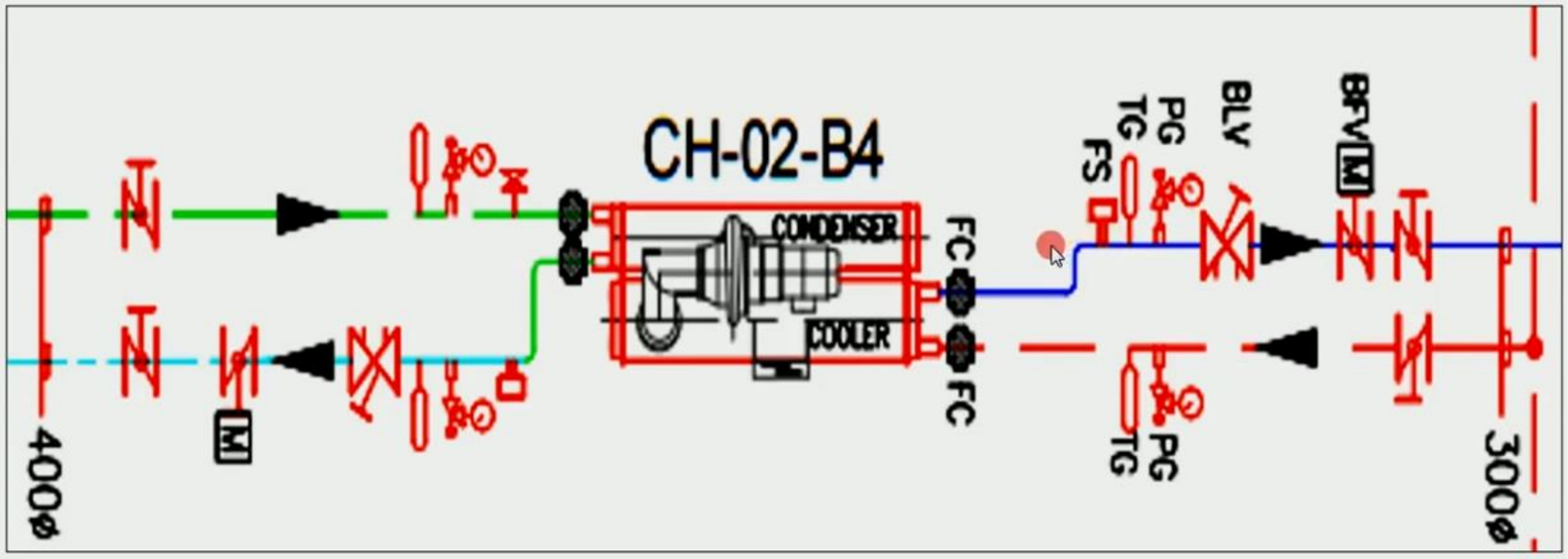
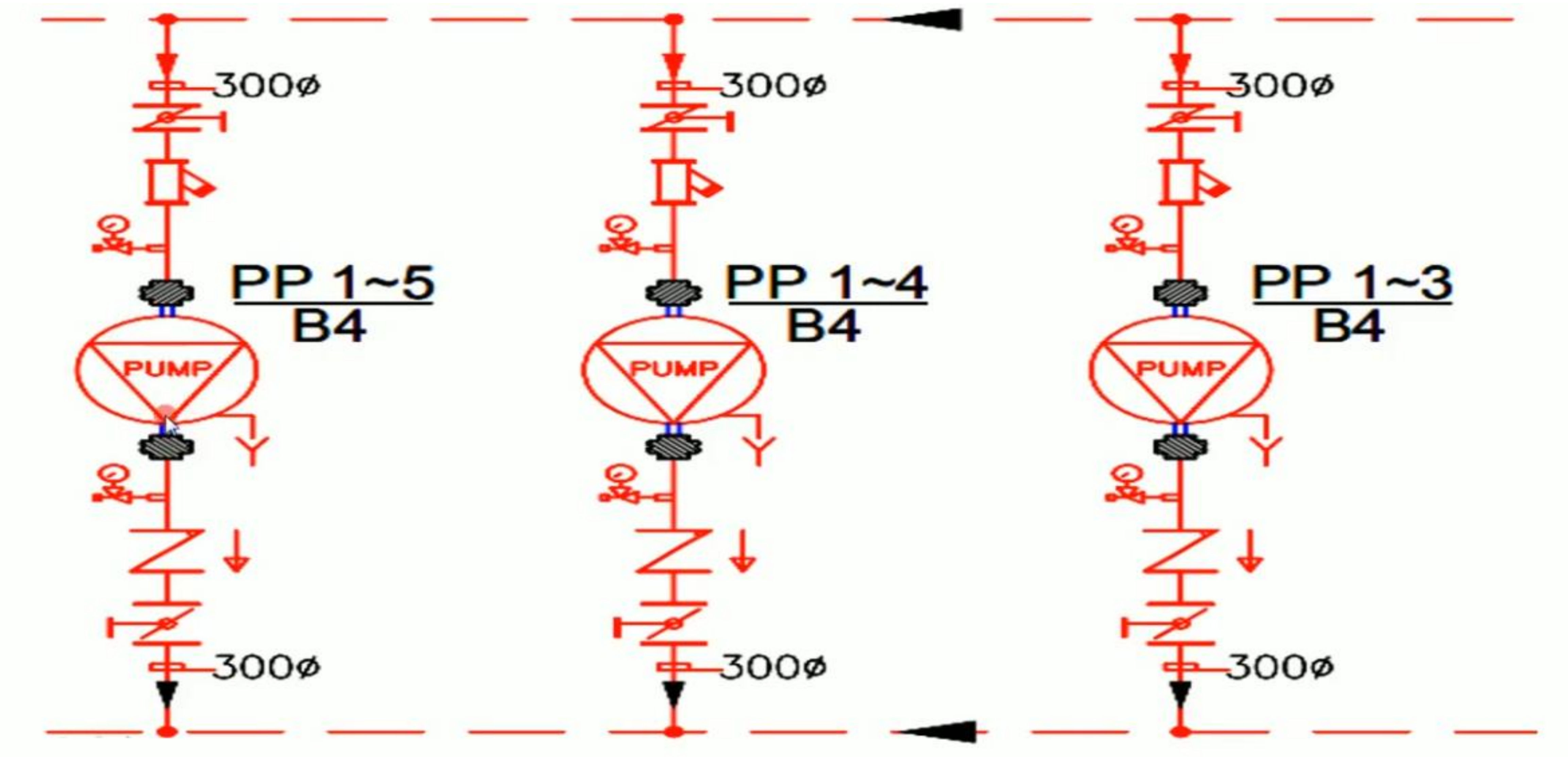
CHILLER PIPE CONNECTION DETAILS



HVAC Pump Connection Details



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AHU PIPE FITTIGS

BUTTER FLY VALVE

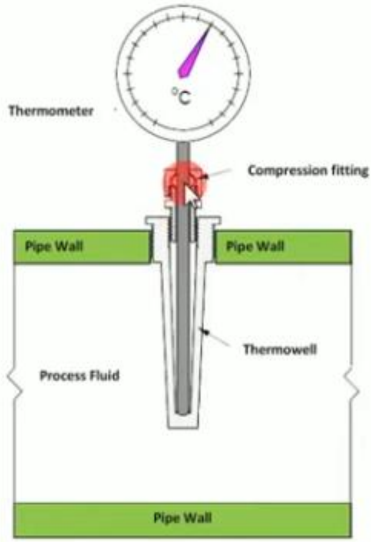
PRESSURE GUAGE WITH SYPHON

Y-STRAINER

AHU Pipe Fittings

TEMPERATURE GUAGE

THERMO WELL



AUTO-AIRVENT

TWO-WAY VALVE

BALANCING VALVE

Sizing of Decoupler/bypass Pipe

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- Size shall be equal to the diameter of largest chiller pipe.

- Its length shall be 8-10 times of the diameter.

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Advantages Of Systems

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- Constant Flow through Evaporator: The primary-secondary system maintains a constant flow through the evaporator of the chiller even though secondary flow varies.
- This eliminates the concern for chiller performance and inadvertent shutdowns. Thus, there's no possibility of freezing the chiller's evaporator in an upset condition or allowing evaporator CHW flow to slip into the laminar flow region at low loads. As long as plant primary flow exceeds system flow, chiller pumps and system pumps behave as if they're decoupled.
- Simplified Controls: Controls within a primary-secondary system are relatively simple and well established. Typical chiller controls packages do not have difficulty with the staging sequence for the chillers and responding to varying loads.
- Past Experience: The primary-secondary system is a well established operational philosophy and plant personnel are familiar with its operation. In addition, this pumping scheme has been proven reliable if operated properly.
- Divided Hydraulic Head: By dividing the total dynamic head between two hydraulically independent loops, the required motor size for each pump type (primary and secondary) will be smaller when compared to a direct-primary system.
- This also reduces the risk that the system discharge pressure will exceed the design of equipment, piping, and valves in the buildings.

Disadvantages of Systems

- Does not resolve Low ΔT Syndrome: The primary-secondary system does not allow an increase in flow through the evaporator above design and; therefore, does not adjust to chilled water return temperatures that are lower than design. In addition, this pumping scheme can further exacerbate the problem during off-peak conditions. As the cooling load decreases, the secondary pump VFDs will ramp down to a lower speed, thus allowing these pumps to produce less flow. The constant volume circulation pumps will then over pump the primary loop causing supply water to flow through the neutral bridge and mix with return water. This mixing lowers the return water temperature and deteriorates the system ΔT as described previously.

- Capital Investment: The greater quantity of pumps and the longer piping runs associated with this pumping scheme can yield a higher capital investment when compared to the direct-primary system.

- Higher Operating and Energy Costs: The primary-secondary system uses both constant speed and variable speed pumps to circulate chilled water through the plant as well as the distribution system. Because the primary loop will always have a constant flow, energy is wasted within this loop at off-peak loads. In addition, this pumping scheme does not allow adjustable flow through the chillers and is subject to the part load operational inefficiency described above. These features and the need for two sets of pumps will generally yield higher energy and operating costs per annum when compared to the direct-primary system.

- Requires More Plant Space: Two sets of pumps are needed to circulate chilled water through the chiller evaporator and the chilled water distribution system. This requires more floor space, more spare parts, and results in higher capital costs and pump maintenance costs when compared to the direct-primary system.

thank
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