

# Variable Volume Chilled Water Pumping System Controls

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# Outline

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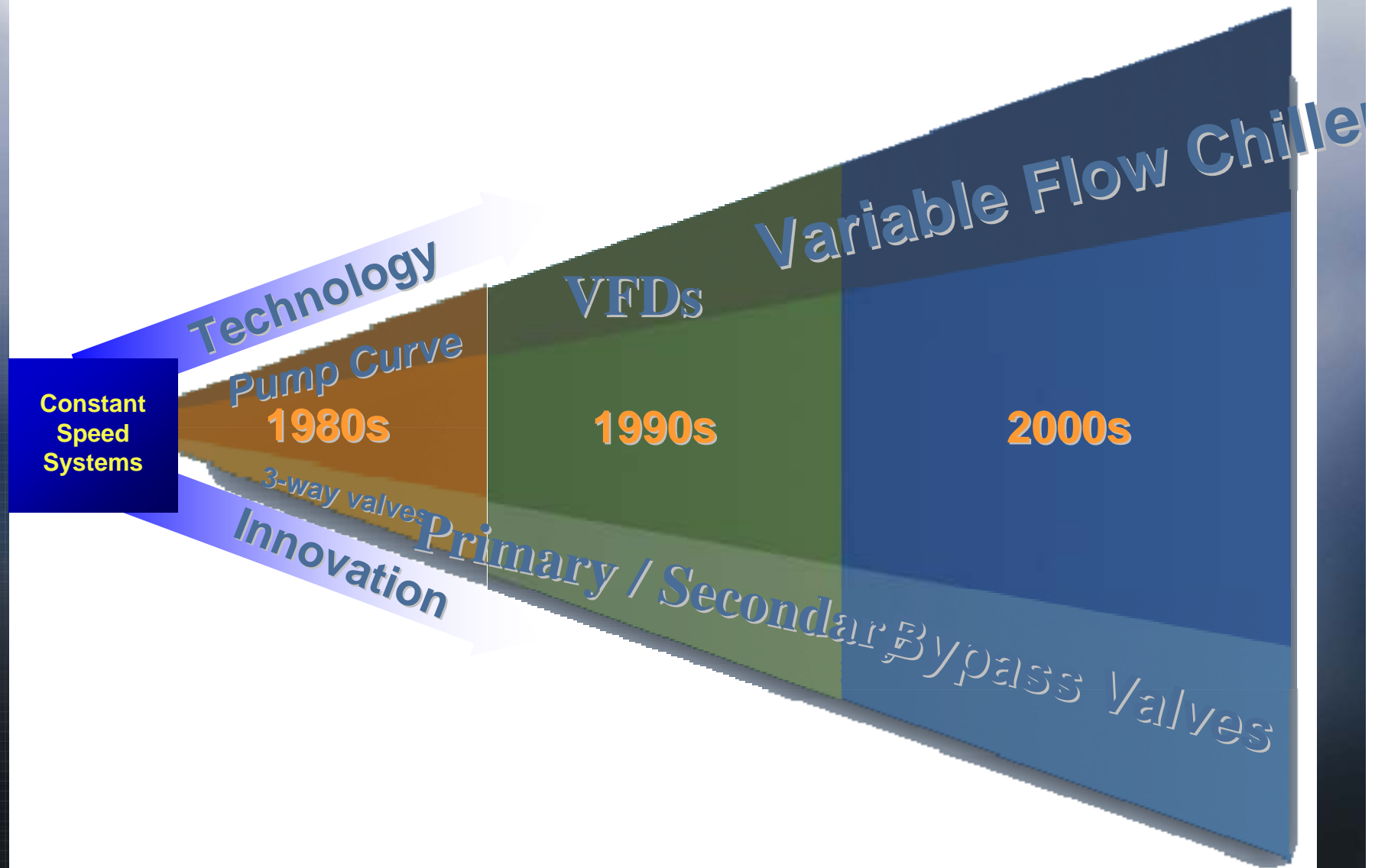
- Introduction
- Chilled Water Pumping Systems Configurations / Control Strategies
  - Primary – Secondary Pumping
  - Variable Primary Pumping
- Demonstration / Live Web Graphics
- Discussion and Questions

# Local Service and Support

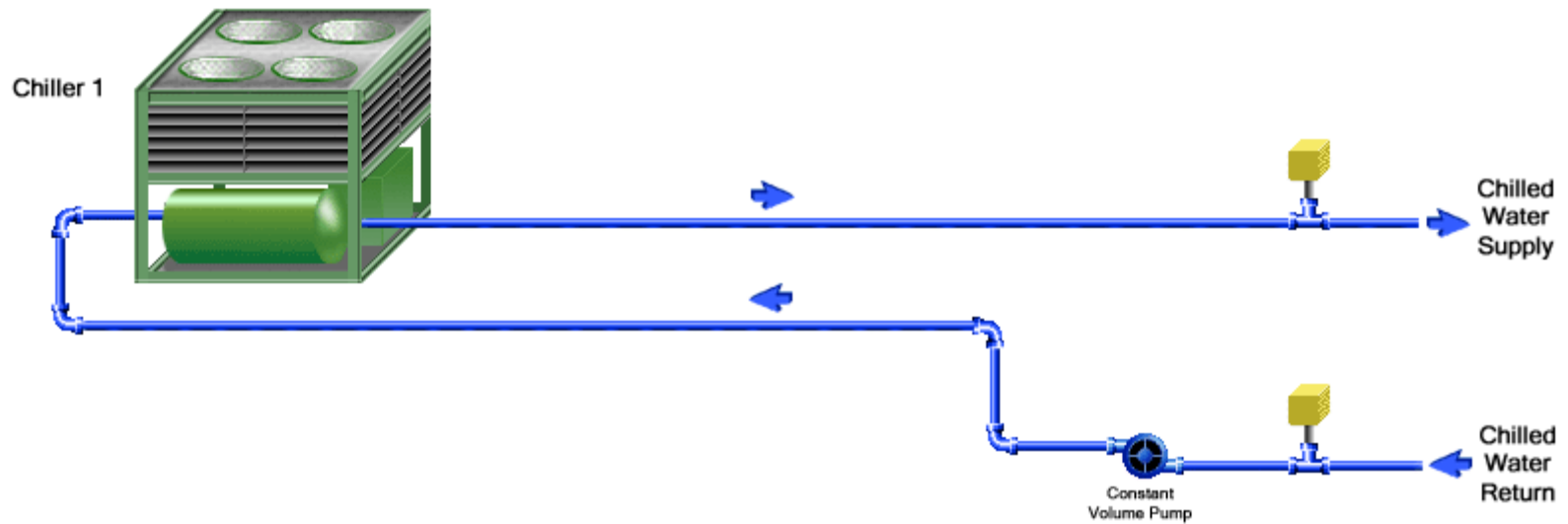
## *Innovative Energy Solutions*

- 45 year record of successful project installations
  - Hundreds of local DDC installations
- On-staff engineers, technicians
  - Factory-trained
- 24 hour 7 day on-call service for Temperature Controls and Full HVAC Mechanical Service
- Service agreements
- Comprehensive local parts stock
- Local training
- Over 250 years HVAC / Controls experience on staff

# Evolution of Pumping Systems



# Basic Chilled Water Pumping System

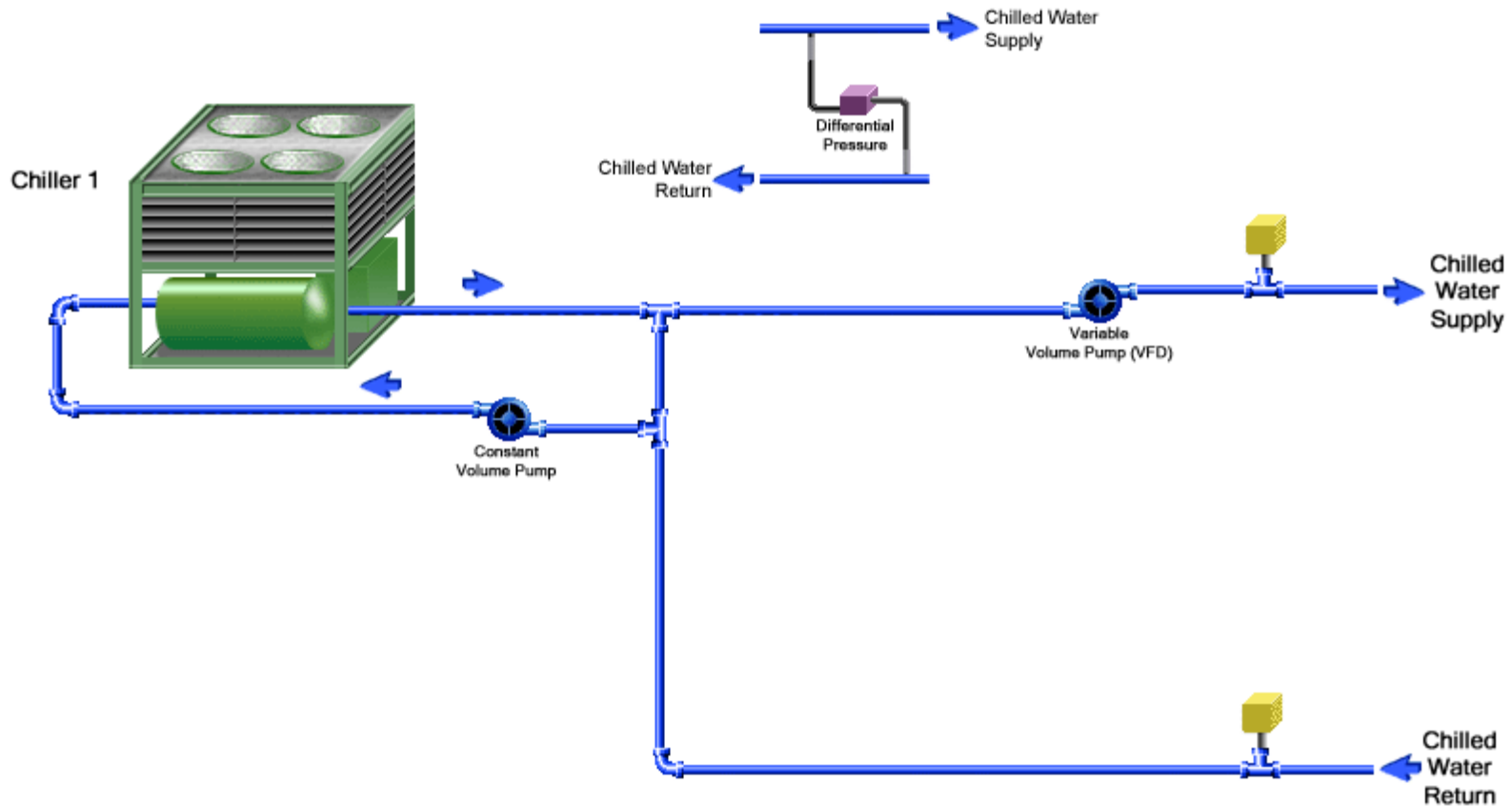


Setpoints	
Outside Air Enable Temp Setpoint .....	

# Basic Chilled Water Pumping System

- Single Chiller, Single Constant Speed Pump
- 3-way valves for all Chilled Water Coils (or even more basic – no valves – full flow) maintains constant flow.
- Control strategy: Enable chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.

# Basic Primary / Secondary Chilled Water Pumping System with a 3-way valve



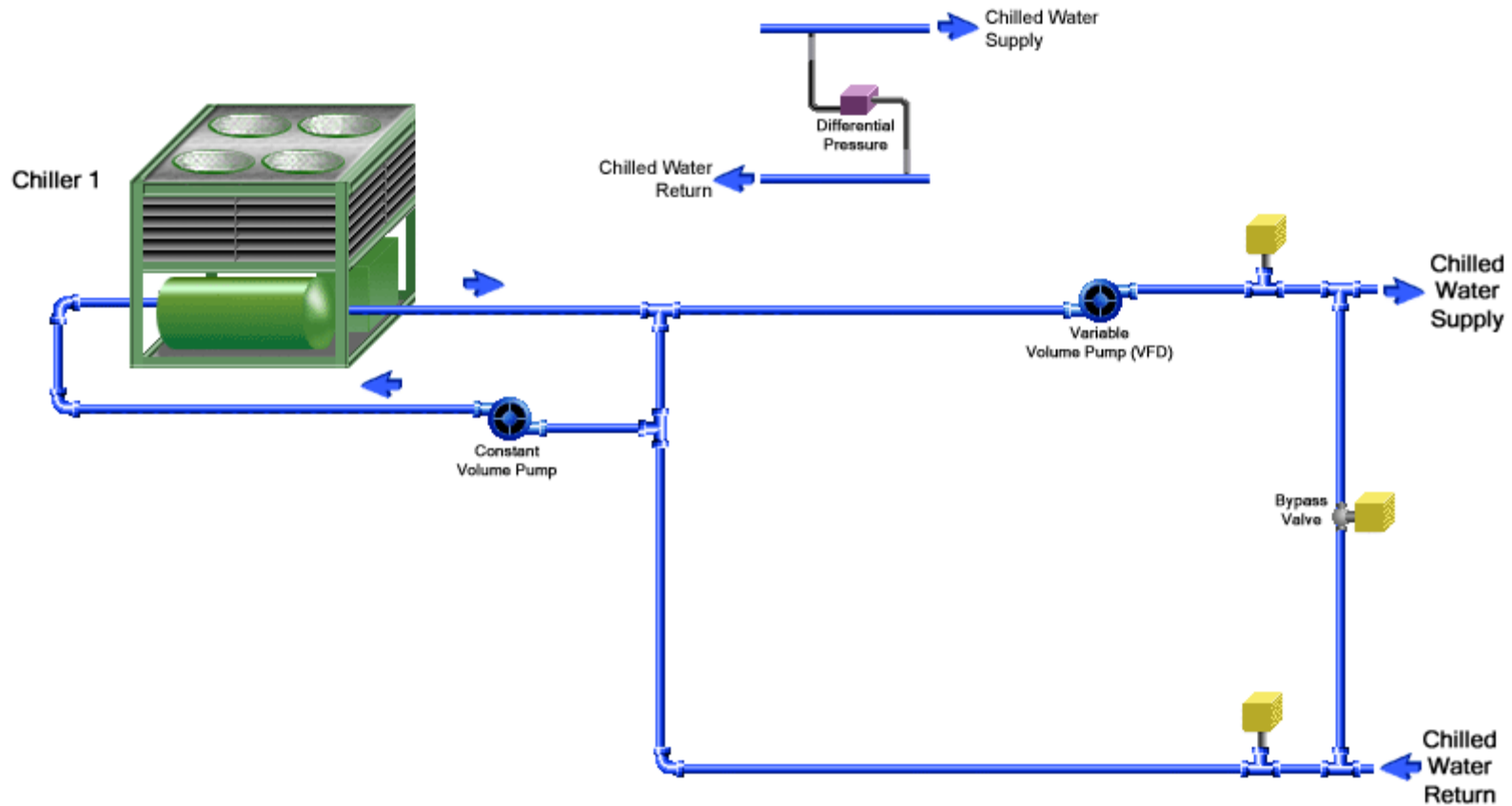
Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....
Chilled Water Supply Temp Setpoint .....	

# Basic Primary / Secondary Chilled Water Pumping System

- Single Chiller, Single Constant Speed Primary Pump, bypass loop with no valve, Variable Speed Secondary Pump.
- The primary pump pumps water through the chiller. The secondary pump pulls water from the primary system and pumps it to the coils.
- Add a Water Differential Pressure Transmitter near the end of the piping run (in an accessible location).
- VFDs and pumps have minimum recommended operating speeds, typically about 20%. Use 3-way valves for 1 or more coils to ensure that there is always this amount of water flowing in the secondary loop. My recommendation is to use 3-way valves at units that are expected to have full occupancy for the most hours and not at Gymnasium or other units that serve areas where significant operating time is at less than full occupancy (partial / low load areas).
- Control strategy: Enable both primary and secondary chilled water pumps when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the secondary pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.



# Primary / Secondary Chilled Water Pumping System with Bypass Valve

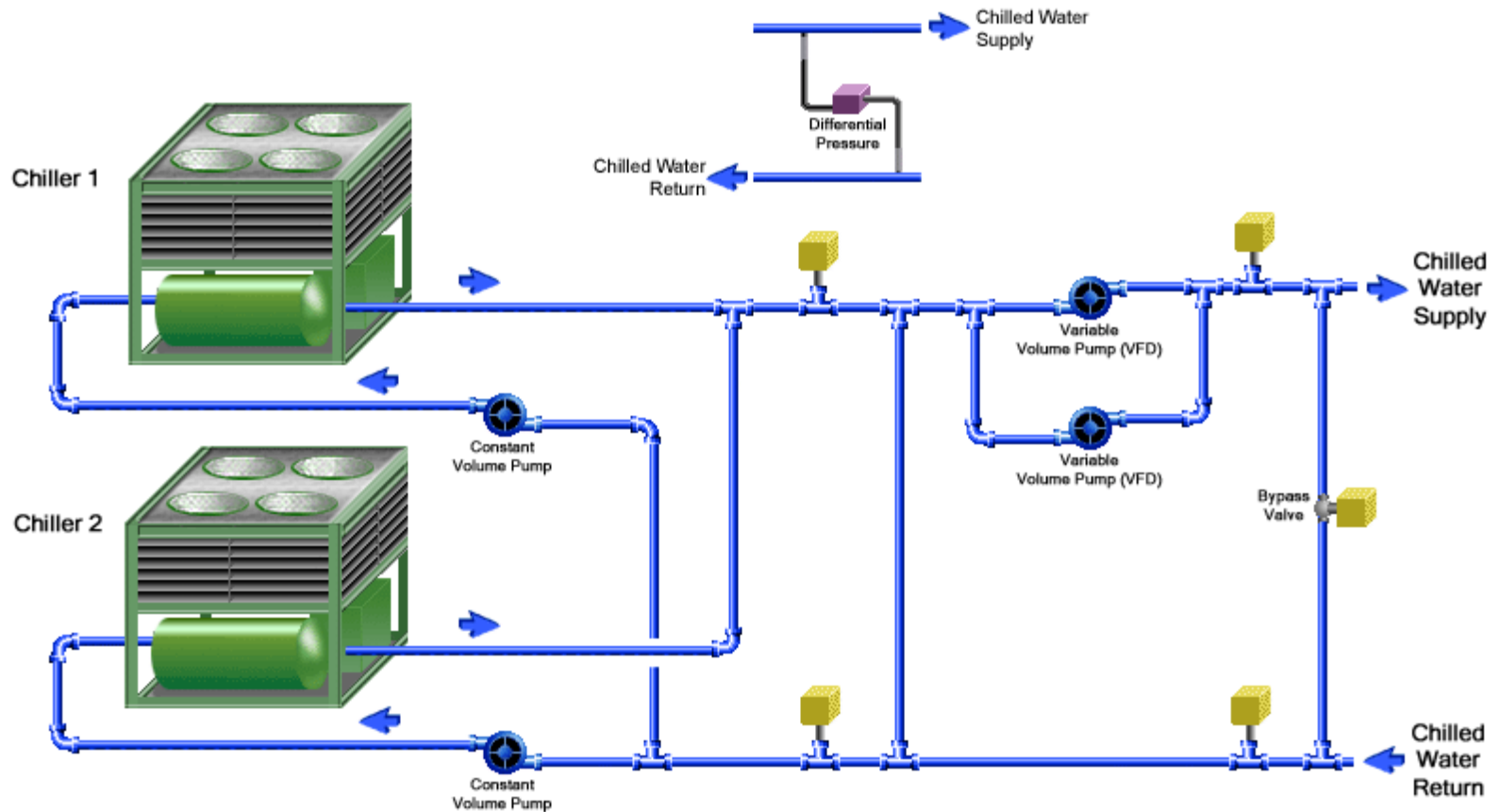


Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....
Chilled Water Supply Temp Setpoint .....	

# Primary / Secondary Chilled Water Pumping System with Bypass Valve

- Single Chiller, Single Constant Speed Primary Pump, bypass loop, Variable Speed Secondary Pump. 2-way valves at all chilled water coils and secondary bypass loop with 2-way valve.
- The primary pump pumps water through the chiller. The secondary pump pulls water from the primary system and pumps it to the coils.
- Water Differential Pressure Transmitter near the end of the piping run.
- VFDs and pumps have minimum recommended operating speeds, typically about 20%. Use a bypass valve in the secondary loop. My recommendation is to locate the valve in the chiller mechanical room.
- Control strategy: Enable both primary and secondary chilled water pumps when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the secondary pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- When secondary pump speed is at minimum setting, bypass valve modulates to maintain secondary loop differential pressure. After pressure drops below setpoint and bypass valve is closed, pump speed will vary (increase initially) to maintain differential pressure.
- OR – modulate bypass valve inversely to coil valves (be careful).

# Primary / Secondary Chilled Water Pumping System with Lead / Lag

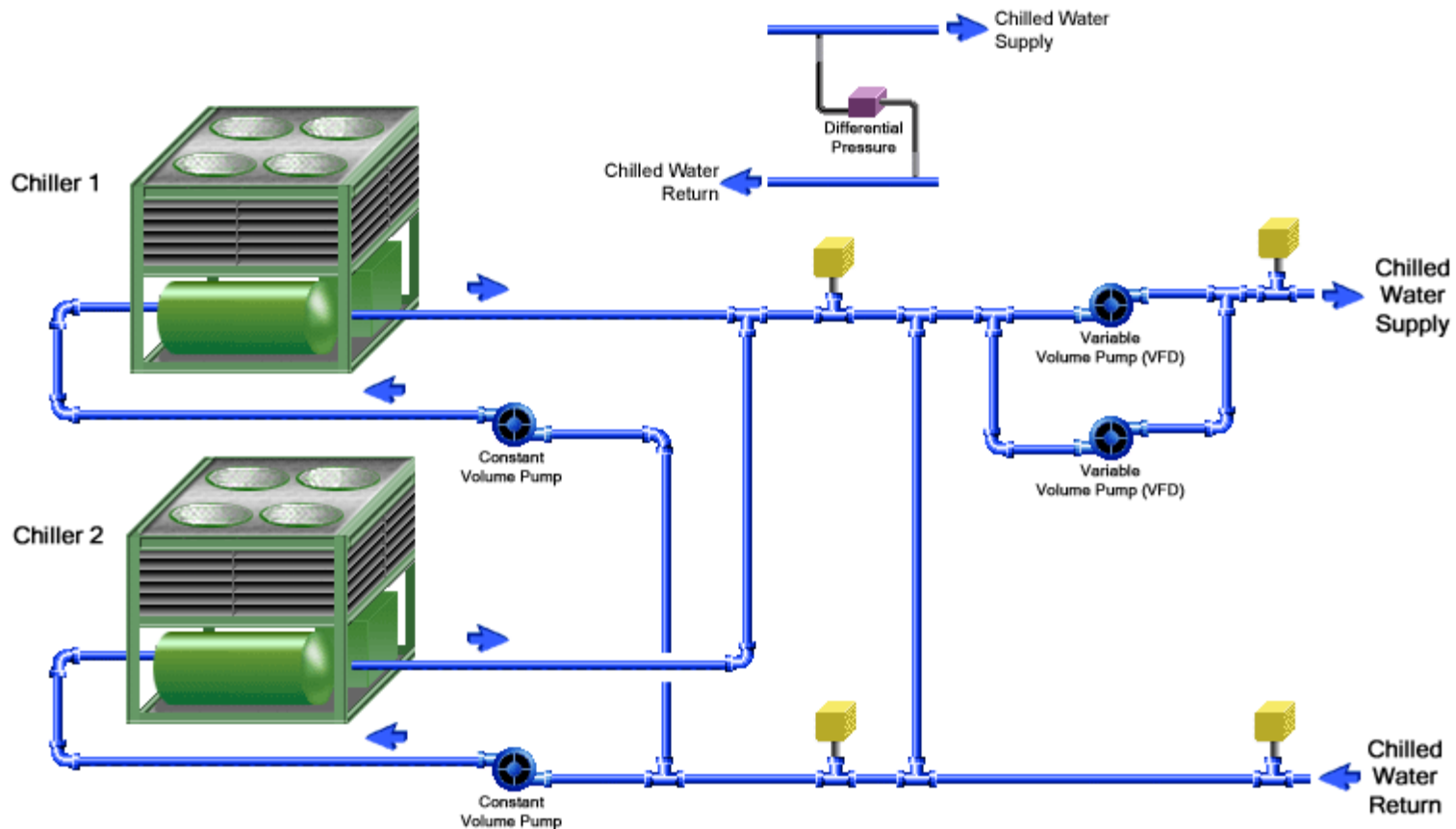


Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....
Chilled Water Supply Temp Setpoint .....	

# Primary / Secondary Chilled Water Pumping System with Lead / Lag

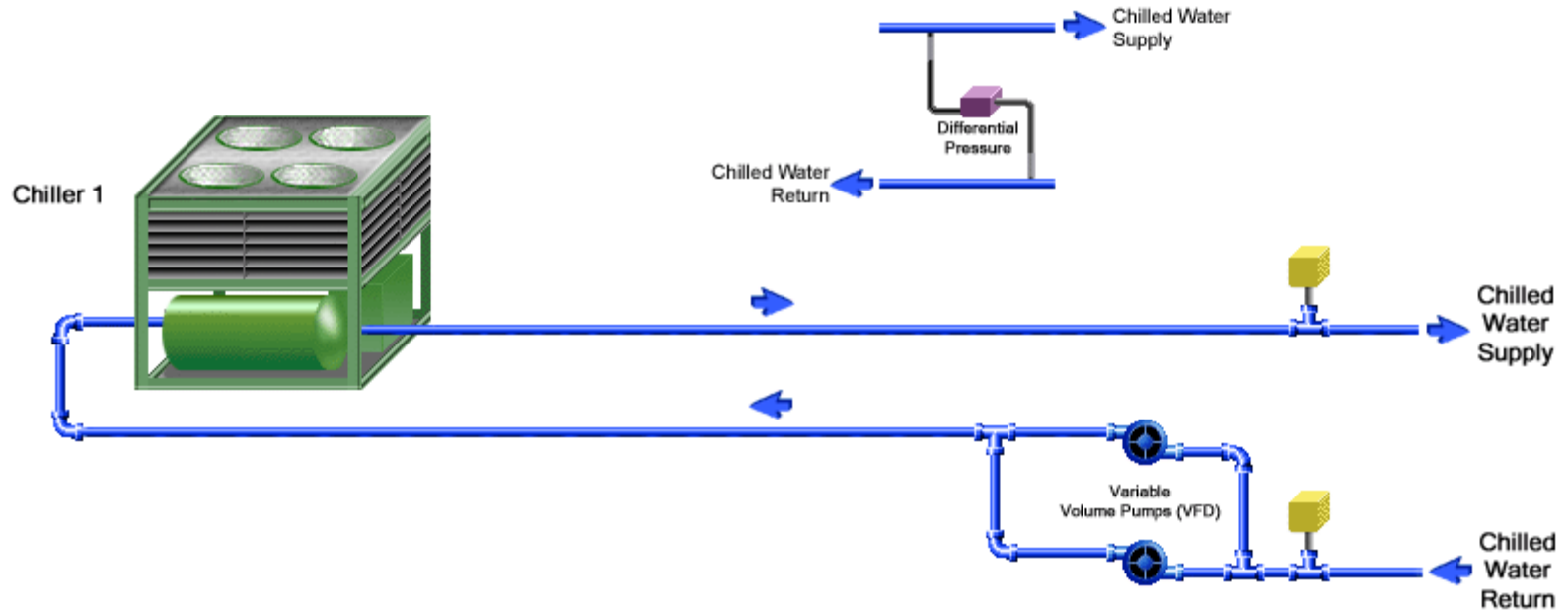
- Multiple Chillers, Multiple Constant Speed Primary Pumps, bypass loop, Multiple Variable Speed Secondary Pumps. 2-way valves at all chilled water coils and secondary bypass loop with 2-way valve.
- Each primary pump pumps water through a chiller. These can be piped so either pump can work with either chiller if isolation valves are used at each chiller or with dedicated primary pumps for each chiller. The secondary pumps pull water from the primary system and pump it to the coils.
- Control strategy: Open 1 chillers isolation valve, enable one primary and one secondary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the secondary pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- When lead secondary pump speed is at minimum setting, bypass valve modulates to maintain secondary loop differential pressure. After pressure drops below setpoint and bypass valve is closed, pump speed will vary (increase initially) to maintain differential pressure. When pump speed is above 50%, enable the lag secondary chilled water pump, vary both until their speed drops below 20%, then stop the lag pump. Bypass valve should be closed whenever 2 secondary pumps are operating.
- Only enable the lag primary pump after the lag chiller's isolation valve is open, and the lead chiller is not able to maintain the leaving water temperature setpoint. Generally, it is best to max out 1 chiller rather than to run 2 partially loaded chillers.

# Primary / Secondary Chilled Water Pumping System with Lead / Lag with enough 3-way valves and no bypass



Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....
Chilled Water Supply Temp Setpoint .....	

# Variable Primary Chilled Water Pumping System with some 3-way valves

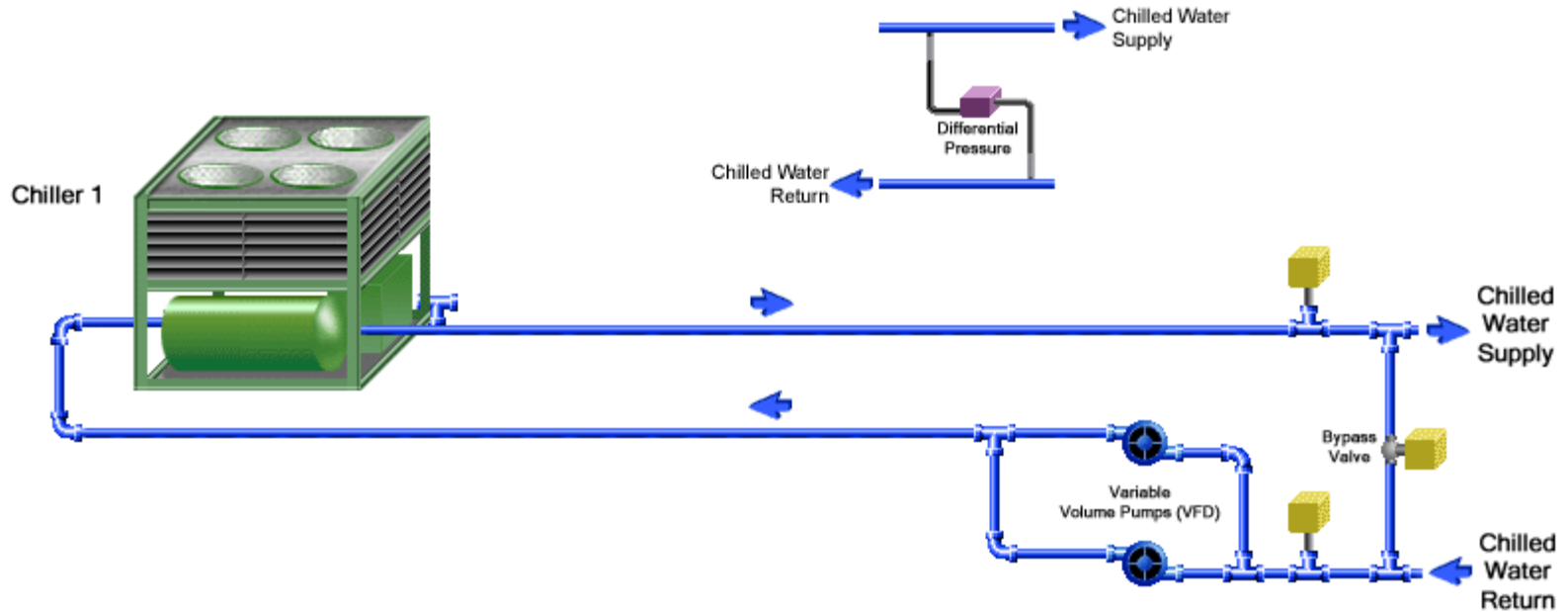


Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....

# Variable Primary Chilled Water Pumping System with some 3-way valves

- Single Chiller, Single Variable Speed Pump
- 3-way valves for some Chilled Water Coils to maintain minimum flow required for chiller. Chillers have minimum flows that are typically higher than their associated VFDs and pumps.
- The single primary pump pumps water through the chiller and to the coils.
- Water Differential Pressure Transmitter near the end of the piping run varies the speed of the VFD.
- Control strategy: Enable the primary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.

# Variable Primary Chilled Water Pumping System with Bypass Valve



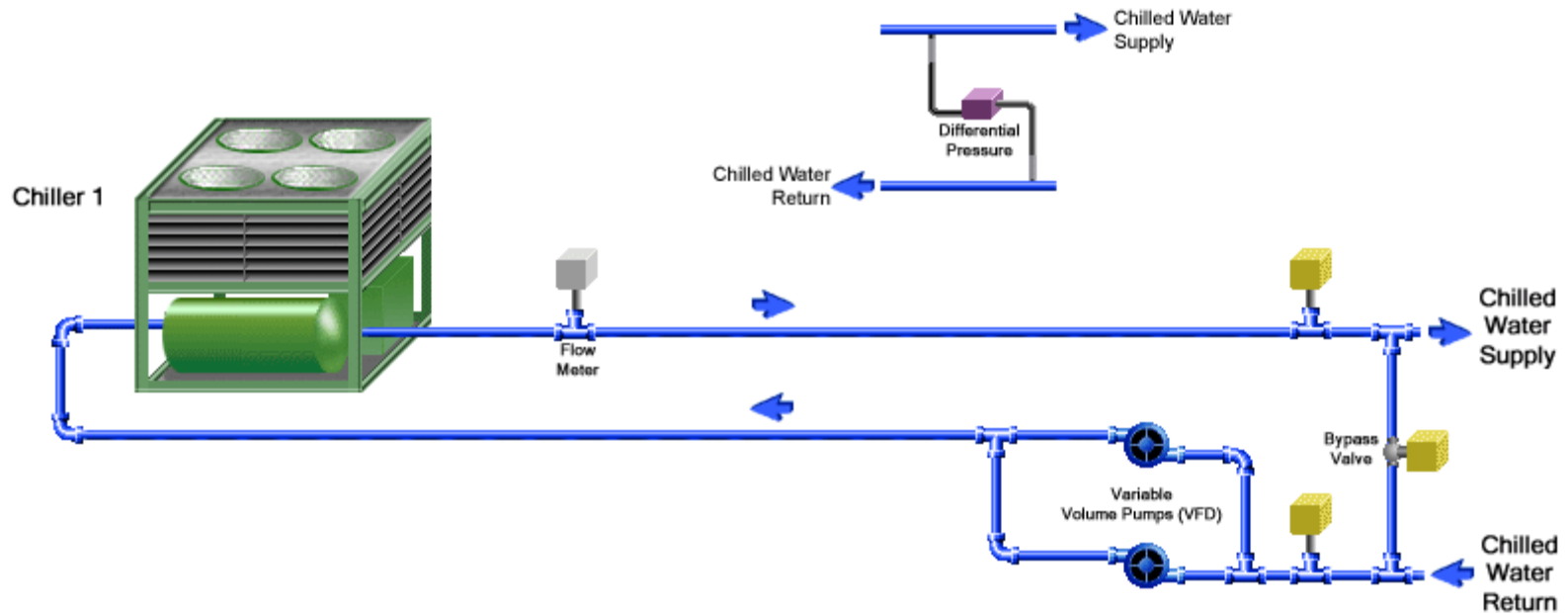
Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....



# Variable Primary Chilled Water Pumping System with Bypass Valve

- Single Chiller, Single Variable Speed Pump. 2-way valves at all chilled water coils and bypass loop with 2-way valve
- The single primary pump pumps water through the chiller and to the coils.
- Water Differential Pressure Transmitter near the end of the piping run varies the speed of the VFD and modulates bypass valve.
- Modulate bypass valve when pump reaches minimum speed.
- Control strategy: Enable primary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- When pump speed is at chiller required minimum setting, bypass valve modulates to maintain secondary loop differential pressure. After pressure drops below setpoint and bypass valve is closed, pump speed will vary (increase initially) to maintain differential pressure.

# Variable Primary Chilled Water Pumping System with Bypass Valve & Flow Meter

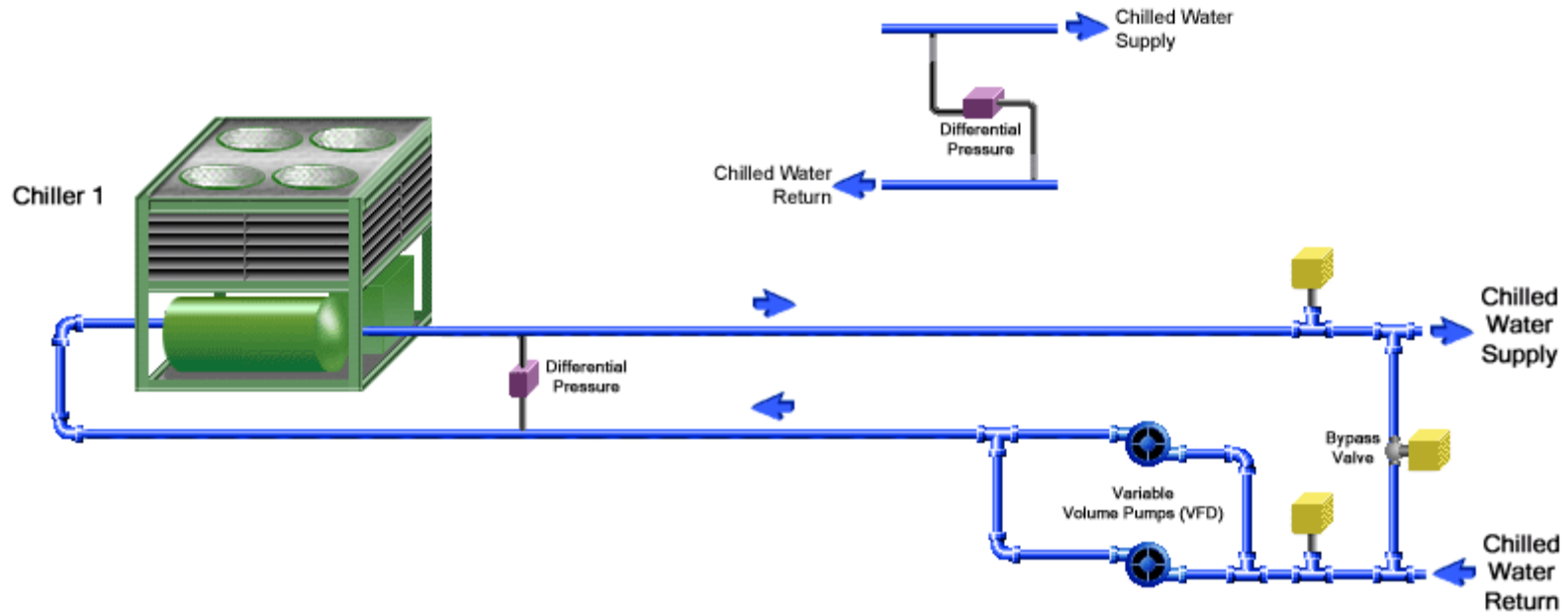


Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....

# Variable Primary Chilled Water Pumping System with Bypass Valve & Flow Meter

- Single Chiller, Single Variable Speed Pump. 2-way valves at all chilled water coils and bypass loop with 2-way valve
- The single primary pump pumps water through the chiller and to the coils.
- Water Differential Pressure Transmitter near the end of the piping run varies the speed of the VFD. The flow meter is used to modulate the bypass valve to maintain minimum chiller flow requirement.
- Modulate bypass valve when flow meter reaches minimum flow setting.
- Control strategy: Enable primary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- Modulate bypass valve to maintain chilled water flow. Pump speed will continue to vary to maintain differential pressure.

# Variable Primary Chilled Water Pumping System with Bypass Valve & chiller DPT

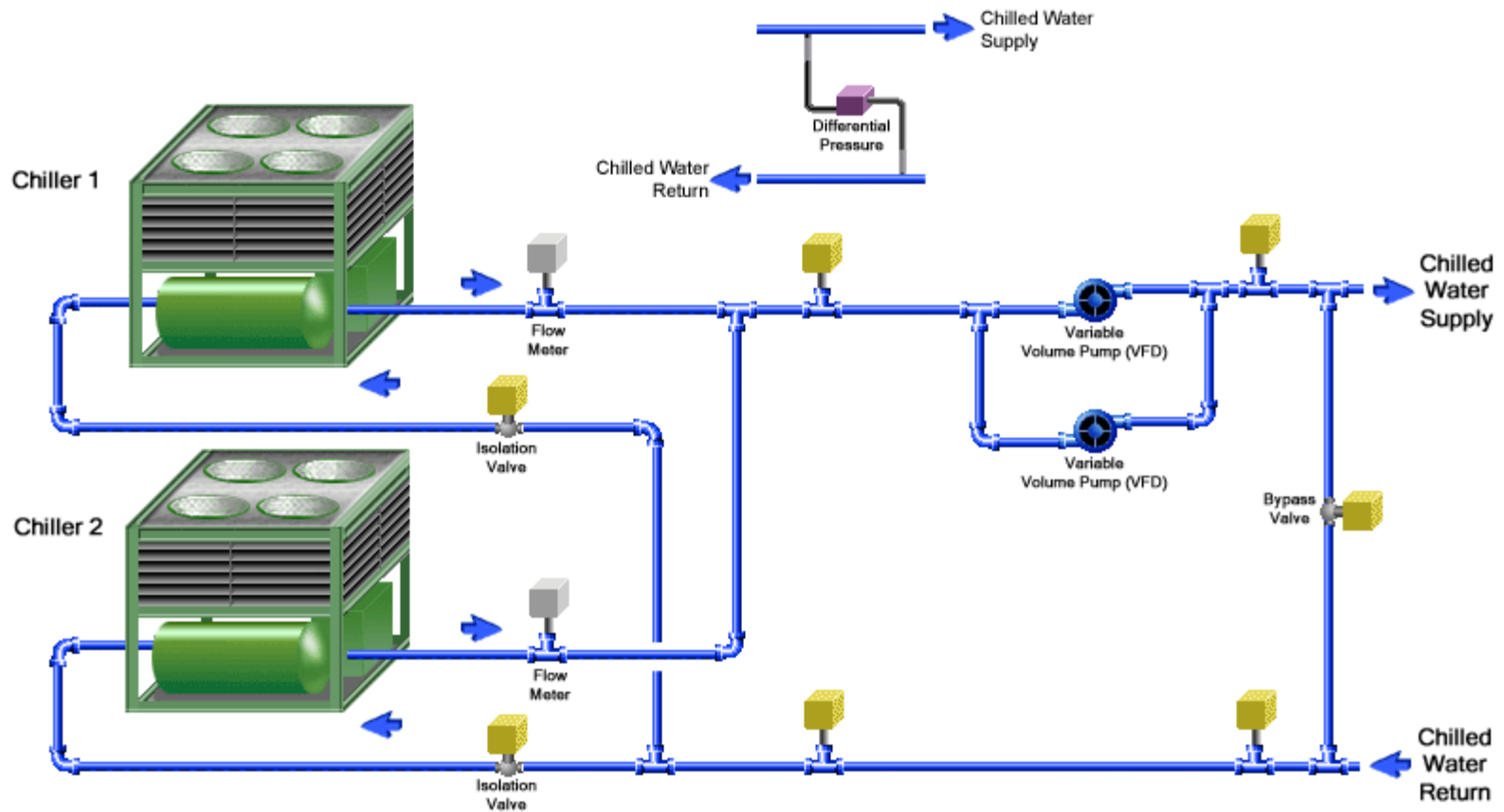


Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....

# Variable Primary Chilled Water Pumping System with Bypass Valve & chiller DPT

- Single Chiller, Single Variable Speed Pump. 2-way valves at all chilled water coils and bypass loop with 2-way valve
- The single primary pump pumps water through the chiller and to the coils.
- Water Differential Pressure Transmitter near the end of the piping run varies the speed of the VFD. The Water Differential Pressure Transmitter near the chiller is used to modulate the bypass valve to maintain minimum chiller flow requirement based on differential pressure setpoint.
- Modulate bypass valve when chiller evaporator barrel differential pressure reaches minimum flow setting.
- Control strategy: Enable primary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- Modulate bypass valve to maintain chiller evaporator barrel differential pressure. After pressure rises above setpoint and bypass valve is closed, pump speed will continue to vary to maintain differential pressure.

# Variable Primary Chilled Water Pumping System with Lead / Lag



Setpoints	
Outside Air Enable Temp Setpoint .....	Differential Pressure Setpoint .....
Chilled Water Supply Temp Setpoint .....	

# Variable Primary Chilled Water Pumping System with Lead / Lag

- Multiple Chillers, Multiple Variable Speed Primary Pumps, 2-way valves at all chilled water coils and a bypass loop with a 2-way valve.
- Each primary pump pumps water through a chiller and to the coils. These can be piped so either pump can work with either chiller if isolation valves are used at each chiller or with dedicated primary pumps for each chiller.
- Control strategy: Open 1 chiller's isolation valve, enable one primary chilled water pump when outside air temperature is above setpoint and at least 1 chilled water coil control valve is open to coil. Modulate (vary) the speed of the pump VFD to maintain a constant differential pressure. Enable chiller after flow is proven. Chiller operates to maintain leaving chilled water temperature at setpoint. Coil valves modulate to maintain comfortable space conditions.
- Bypass valve modulates to maintain minimum chiller flow through each operating chiller.
- When lead pump speed is above 50%, enable the lag chilled water pump, vary both until their speed drops below 20%, then stop the lag pump.
- When the 2nd chiller is needed – which can be determined by adding a matched pair of temperature sensors for each chiller to the associated flow meter to calculate the BTUs (or Tons), lock both variable speed pumps at 70% (Adj), wait 30 Sec, open the bypass valve to 30% (Adj), then after another 30 Sec delay, allow the isolation valve on the lag chiller open and start the lag chiller. Hold the pumps at a minimum of 70% and the bypass valve at a minimum position of 30% Open for 15 Min (Adj) to allow 2nd chiller to get loaded up. Once the 15 minutes have expired, return system to normal control.

# Flow Meter Selection and Installation Guidelines

- Turbine Meters vs. Paddle Wheel.
- See Accuracy Statement.
- See Installation Guide.
- Recommend minimum 25 pipe diameters of straight pipe. 80% upstream and 20% downstream.
- There are slightly more expensive dual turbine flow meters available if there is less than 25 pipe diameters of straight pipe.



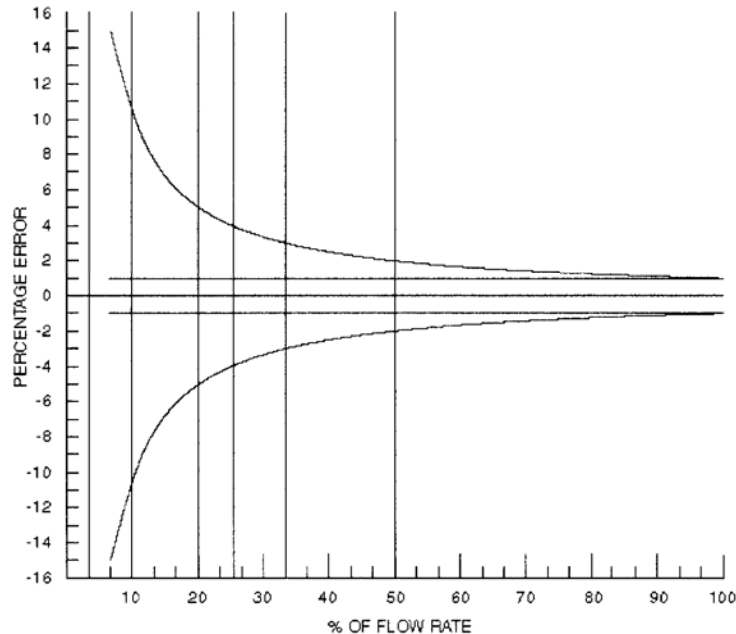
# Flow Meter Selection and Installation Guidelines

- Turbine Meters vs. Paddle Wheel.

Feature	<u>Insertion Turbine (O)</u>	<u>Paddle Wheel (K)</u>
• Reliability	Excellent – No Fault Warranty	Fair to Poor – Standard Warranty
• Accuracy	Excellent – 1% of RATE !	1% of FULL SCALE
• NIST Traceable Volume Calibration	Yes	No
• Turndown	Excellent	Fair to Poor
• Bearing Life	Excellent	Fair to Poor
• Install & Remove Under Pressure	Yes	No

COMPARISON OF COMMONLY USED ACCURACY STATEMENTS

- Paddle Wheel
- Turbine Meter.
- Turbine Meter.
- Paddle Wheel.



# Water Differential Pressure Sensor and Installation Guidelines

- Dual Pressure Sensor type.
- Improved Overpressure Tolerance.
- Basic shutoff valves instead of 3-valve bypass.
- LCD display.

# Demonstrations and Questions?



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# Questions from Presentation & Answers

Q: What is the price difference between a flow meter and a Differential Pressure Transmitter?

A: Cost of instrumentation is about \$500 more for flow meter.

Q: What type of bypass valves are recommended?

A: Ball valves for flows less than 100 GPM (2" and smaller bypass lines) and Balanced Plug Globe valves for flows over 100 GPM. Actuators can be the same as those used for AHU valves. Fast acting actuators can lead to excessive hunting. Use time delays to keep from turning on equipment before actuator has a chance to stroke valve. Use spring return, normally open, full port / line size valves for bypass applications.

Q: What is the preferred location of load side DPT – near discharge of pump or downstream – 2/3rds?

A: Either is fine – they are a reference point. If at pump, setpoint will need to be higher than if remote.

Q: Is there more Maintenance of DPT versus Flow Meters.

A: Turbine style Flow Meters have excellent long term reliability and use full port ball valve for easy installation and removal and need very little maintenance. Visit Onicon website ([www.onicon.com](http://www.onicon.com)) for more information on recommended flow meter. These have a low mass non-metallic turbines with sapphire jewel bearings and tungsten carbide shafts provide a mechanical system that virtually does not wear. HOT-TAP design is recommended for all insertion meters which allows installation and removal without system shutdown. These meters can be removed and reinserted by hand without special tools.

Q: When a 2nd chiller is needed, how do you keep the 1st chiller on-line? (How do you keep the chiller from tripping out on low temp from the flow dropping dramatically).

A: An example was given for a system that was started up and commissioned 5-6yrs ago. When the 2nd chiller is needed, lock both variable speed pumps at 70% (Adj), wait 30 Sec, open the bypass valve to 30% (Adj), then after another 30 Sec delay, allow the isolation valve on the chiller open and start the chiller. Hold the pumps at a minimum of 70% and the bypass valve at a min position of 30% Open for 15 Min (Adj) to allow 2nd chiller to get loaded up. Once the 15 minutes have expired, return system to normal control.