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The Little Red Schoolhouse

Large Chilled Water System Design Seminar

Courtesy of Oslin Nation Company

Chiller Piping Strategies

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Chillers in Parallel using Primary-Secondary

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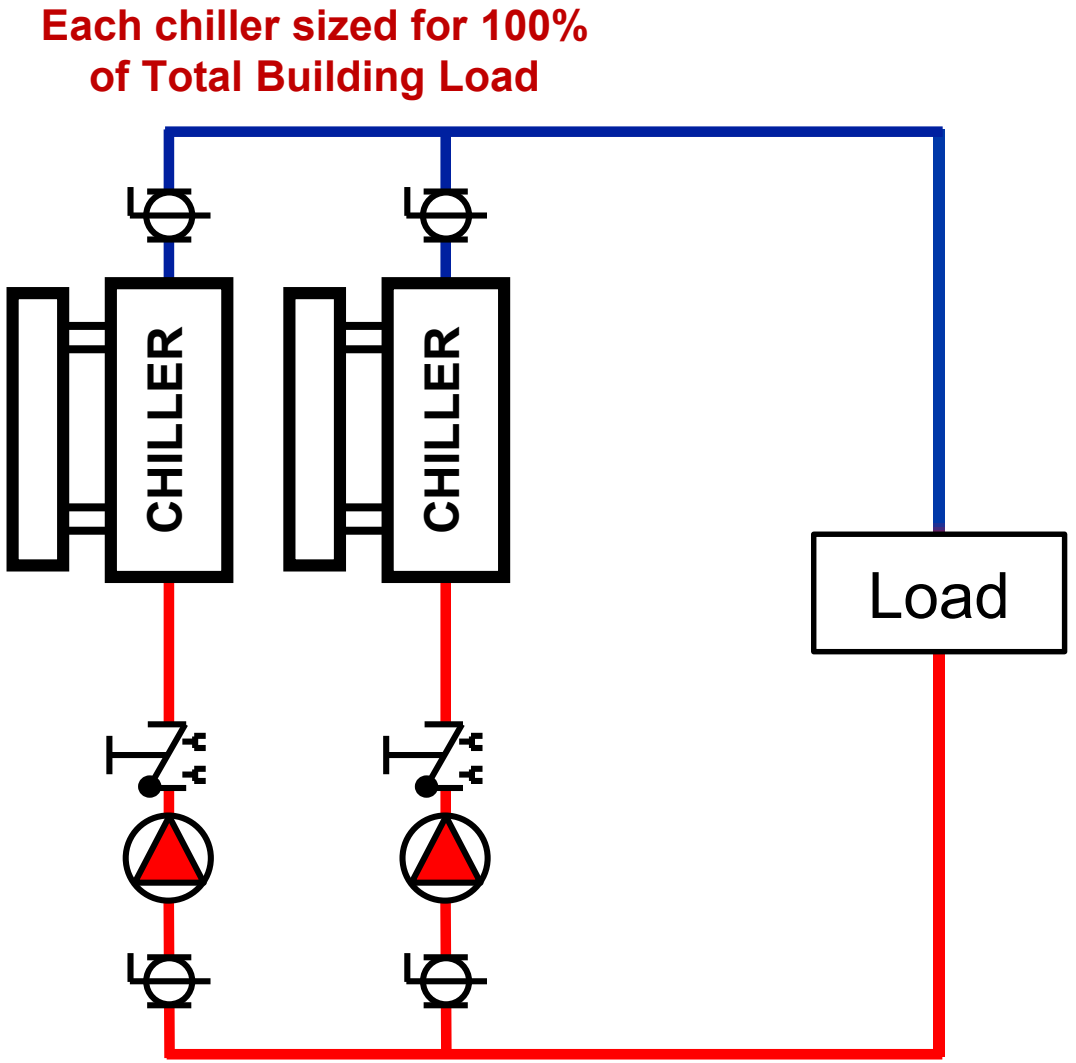
Constant Primary: Constant Speed Pumps & Chillers

- Simple design to install and control
- System *(Evaporator)* flow remains constant
- Option to reset chilled water supply temperature limited
- 3-Way valves on HVAC Coils



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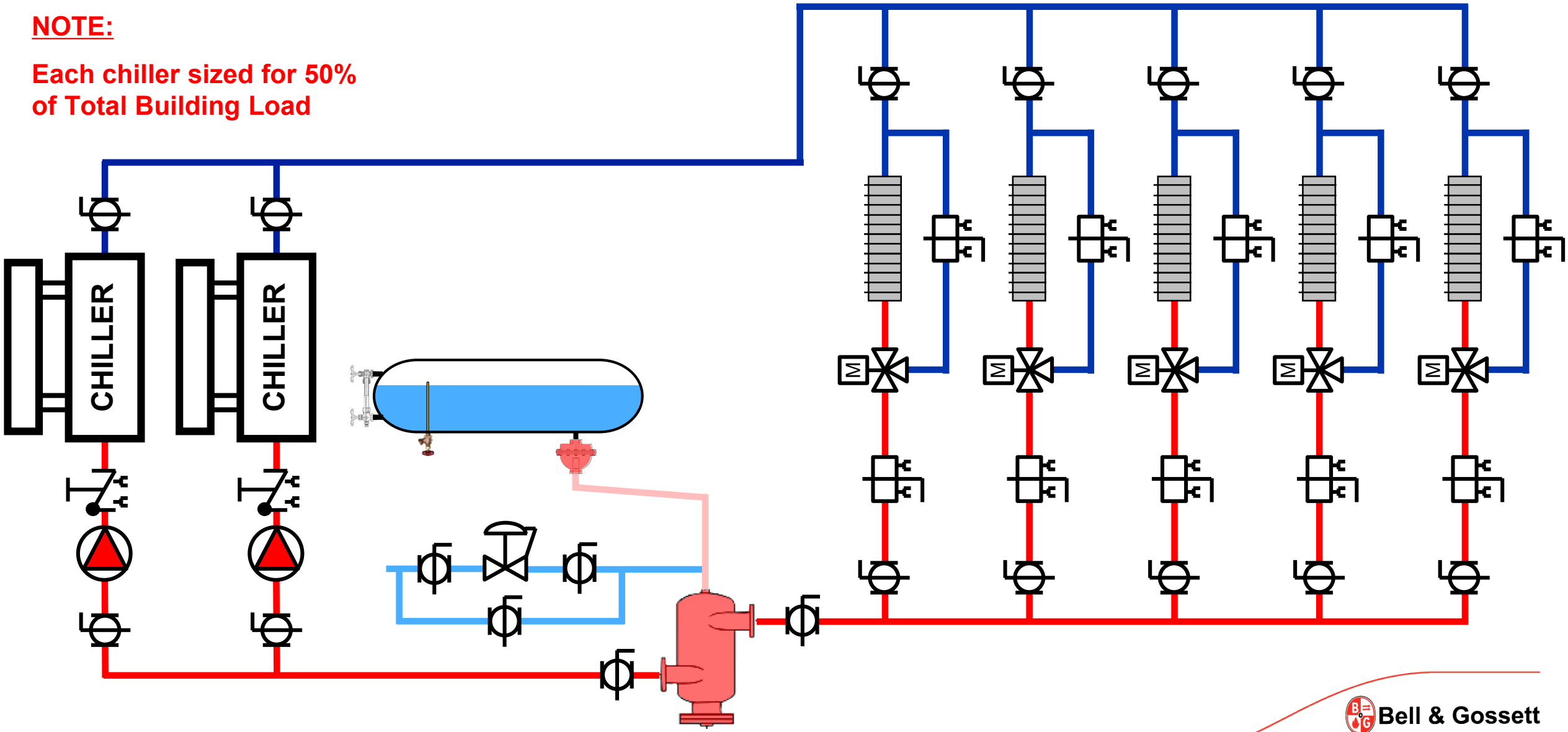
Constant Primary – Direct Return, 3-Way Valves, CBV

NOTE:

Each chiller sized for 50% of Total Building Load



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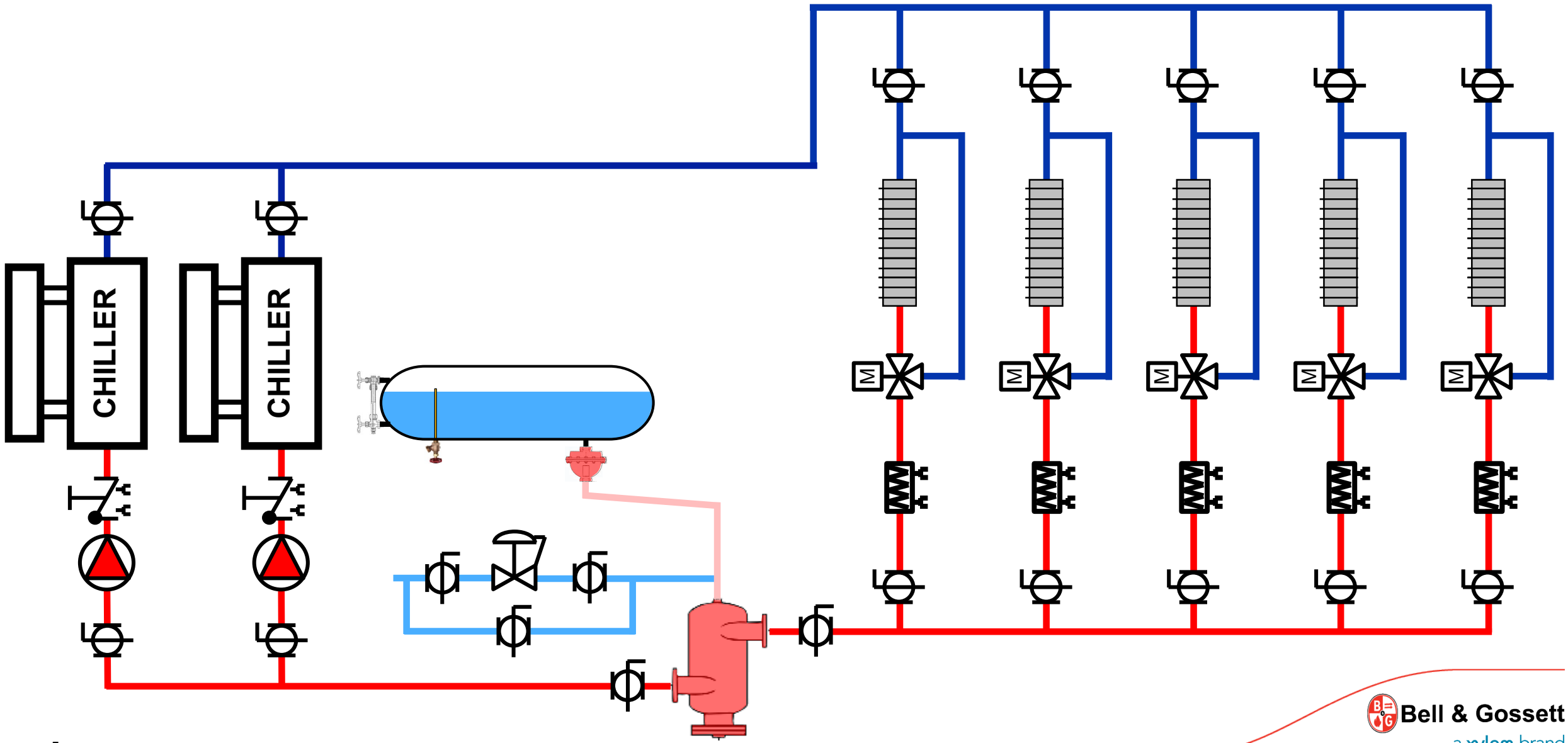
Constant Primary – Direct Return, 3-Way Valves, AFV



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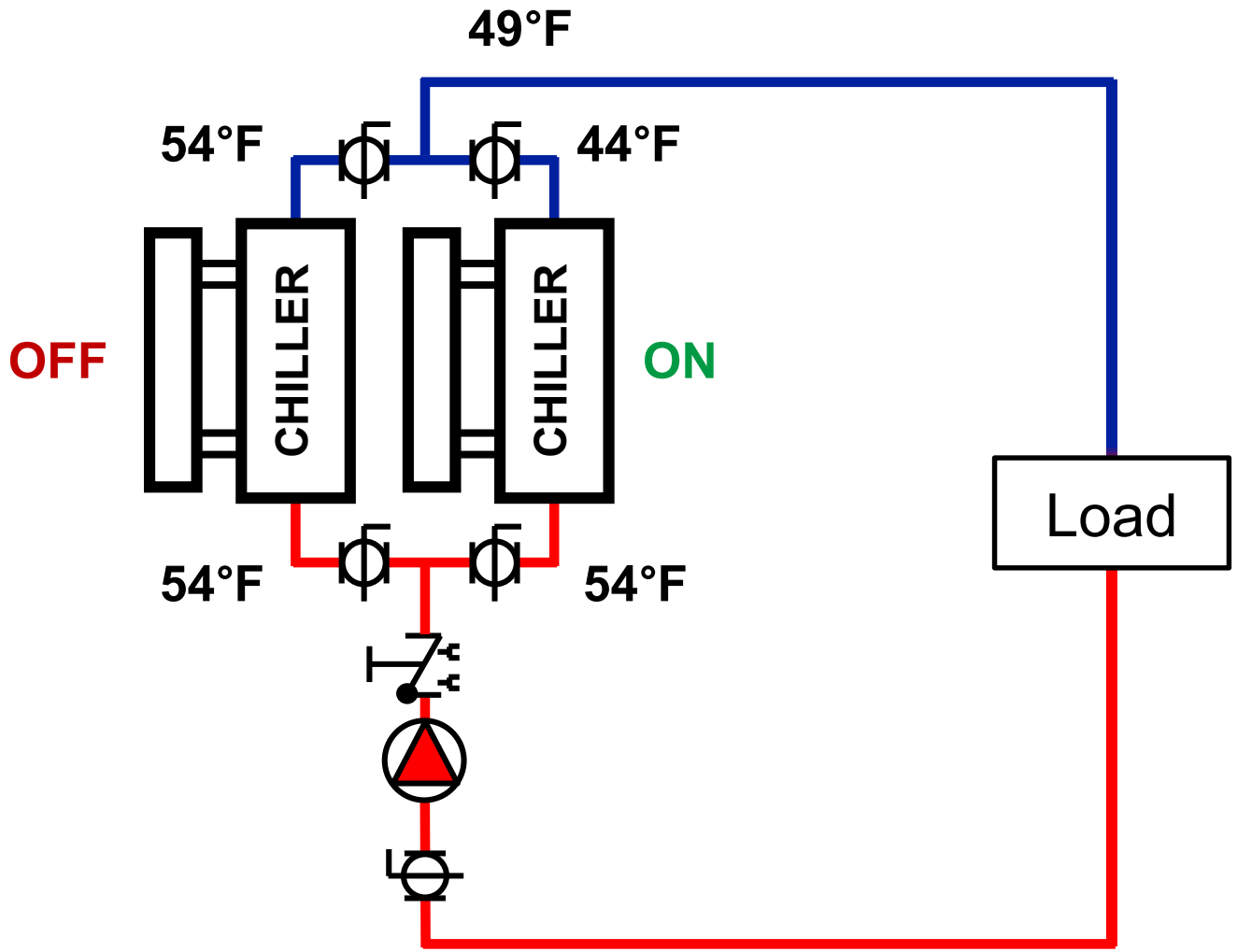
Constant Primary: Constant Speed Pump & (2) Chillers

Each chiller sized for 50% of Total Building Load

- Constant flow through both chillers regardless if On or Off
- Blended supply water temperature when only single chiller operational
- May result in poor dehumidification control or maintenance of specific loads
- Adjusting operating chiller setpoint downward increases energy usage



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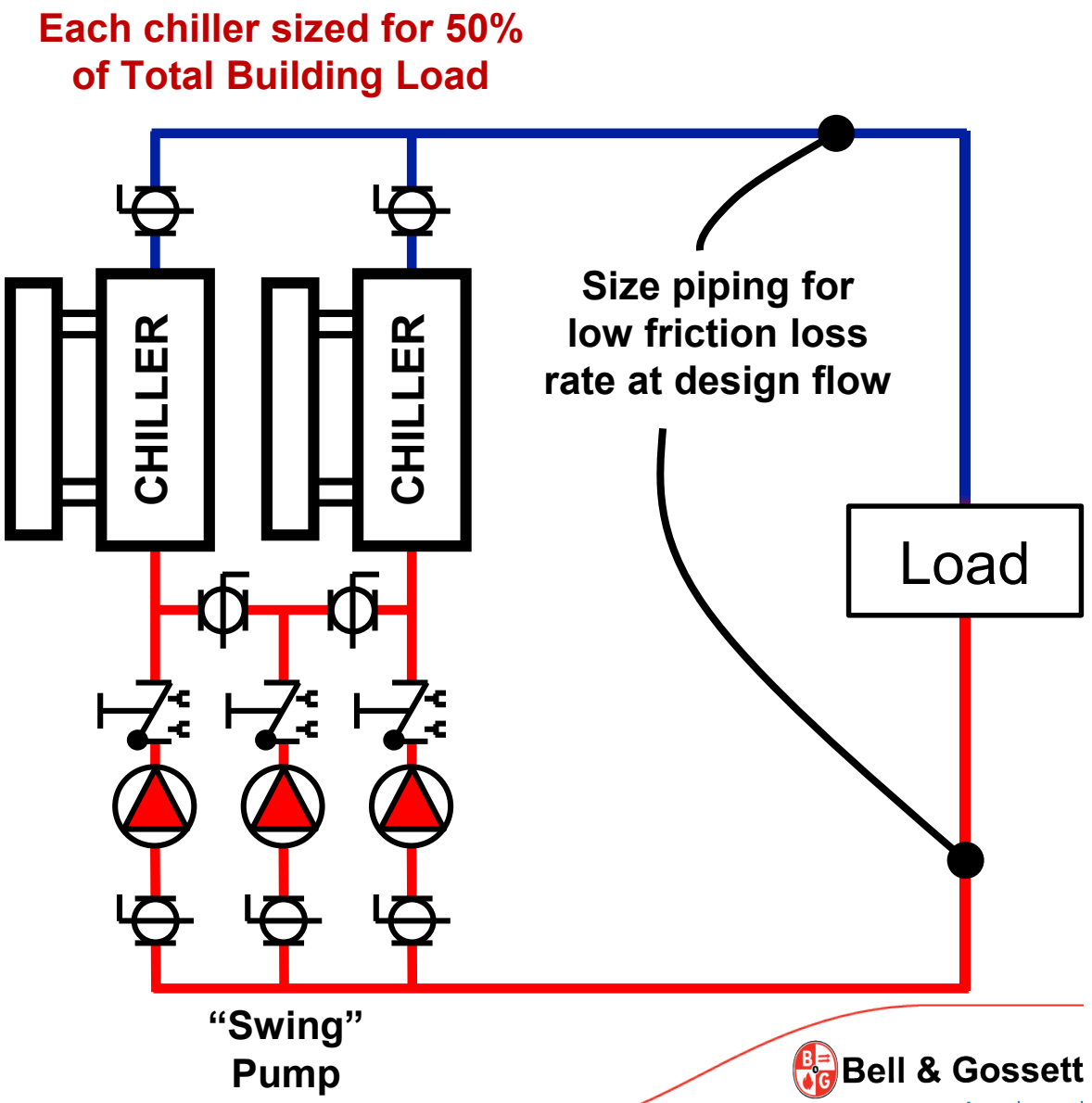
Constant Primary: Constant Speed Pumps & Chillers

- Chillers and Pumps now operating in parallel, with dedicated pump per chiller
- Consider adding a “Swing” pump for backup
- Must apply principles of parallel pumping when calculating required pump heads
  (Doubled flow increases system pressure drop by 4 times)

$$h_2 = \left[\frac{Q_2}{Q_1}\right]^2 \times h_1$$



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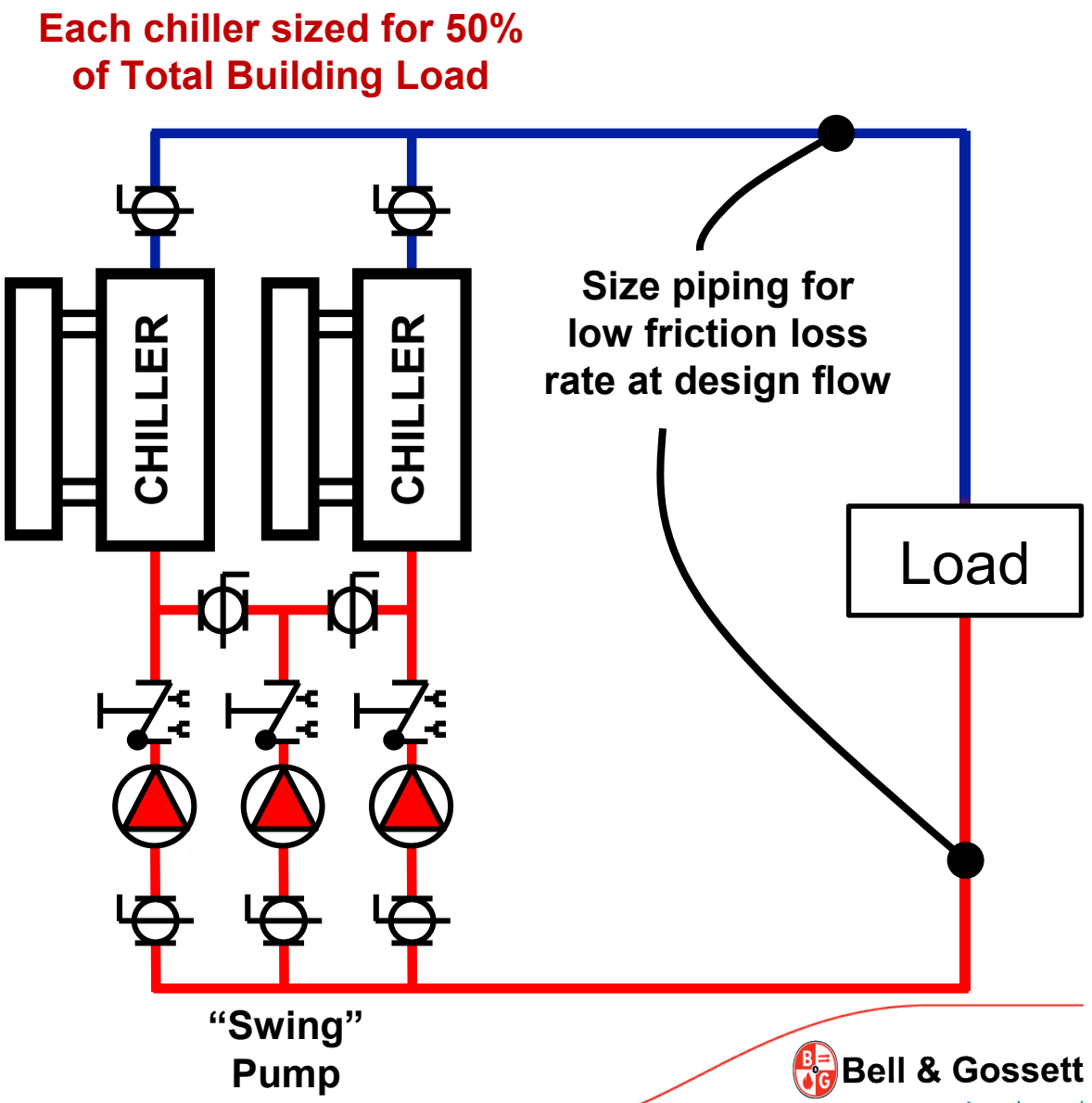
- A mixture of 2-Way and 3-Way valves on HVAC Coils may be possible.
  (Must maintain minimum flows in operating chillers)
- All chillers have same LWT setpoints



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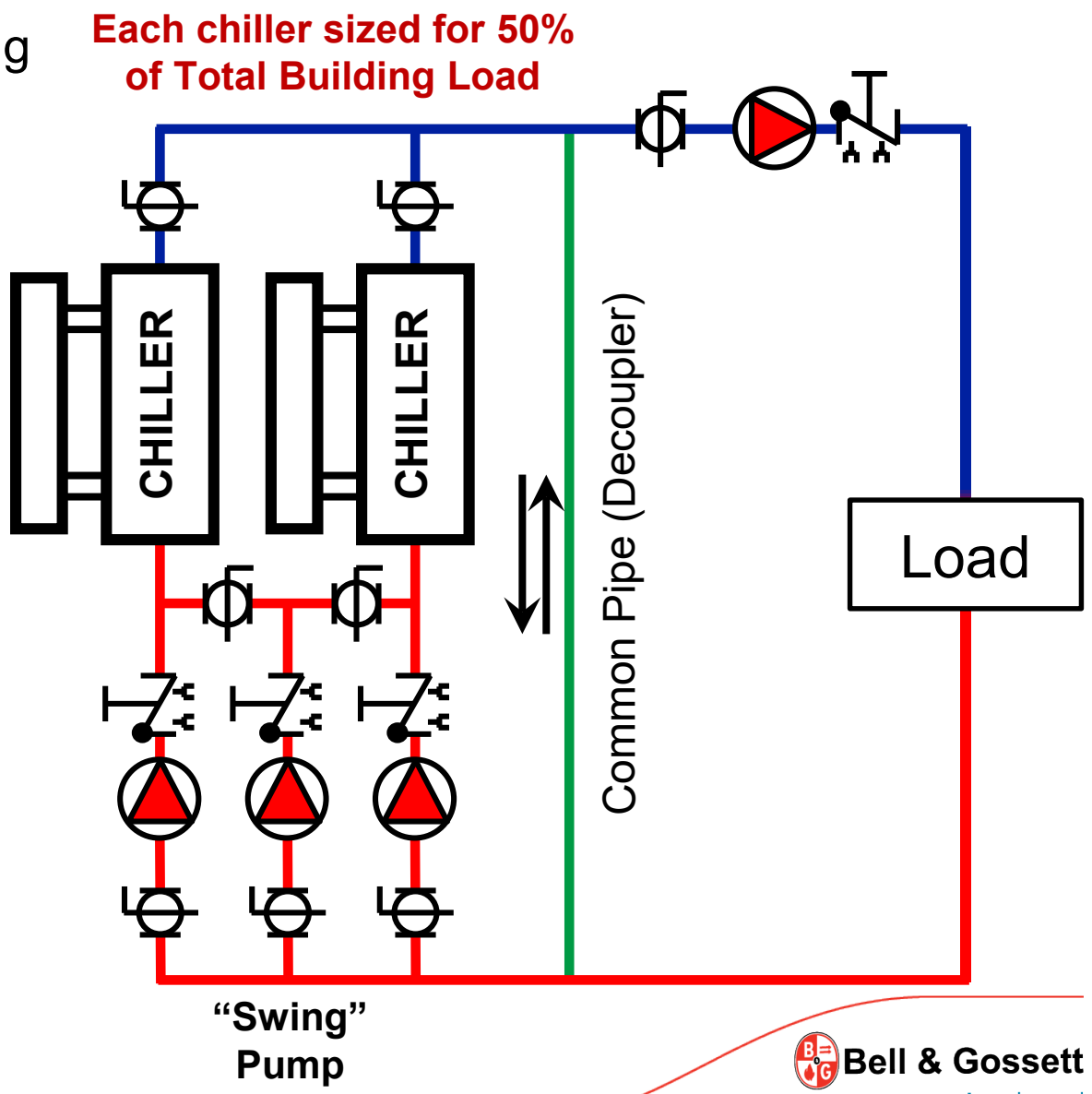
Constant Speed Pumps & Chillers: Primary-Secondary Piping

- Minimizes extra piping friction losses by decoupling chillers (Primary) from Load (Secondary)
- Each circuit shares:
  - Common Pipe
  - Cold Static Fill Pressure *(Static Column)*
  - System Fluid
- Chiller control and staging can be simplified
- Dedicated pumps become smaller
- Each circuit temperature control now independent



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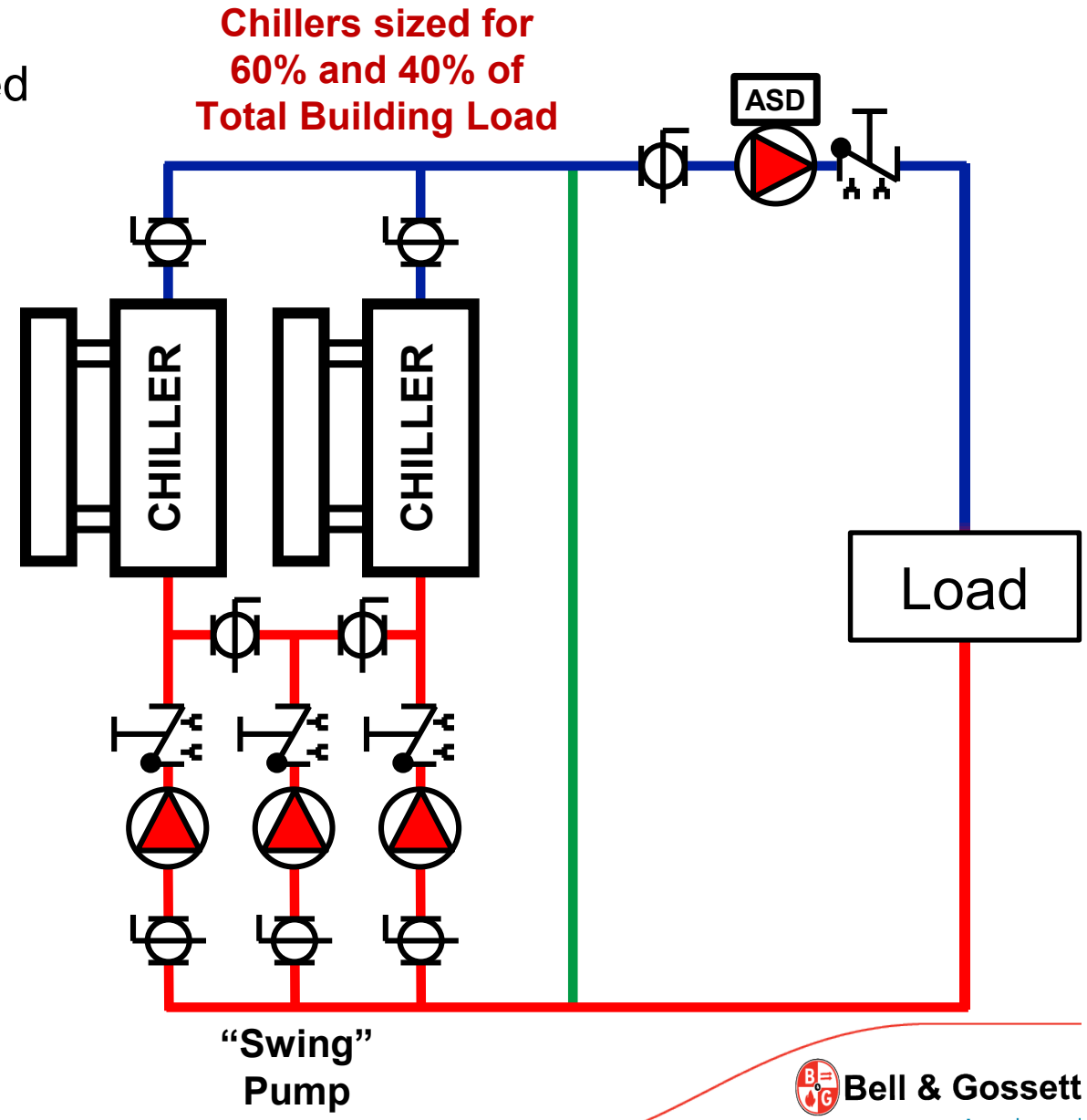
Constant Speed Pumps & Chillers: Primary-Secondary Piping

- Different sized chiller capacities can be considered to manage peak and off-peak load differences
- Size “Swing” pump for largest chiller
- Primary & Secondary flowrates can be unequal
- Secondary Pump can operate variable speed
  (Recommend 2-Way valves on majority of HVAC coils)



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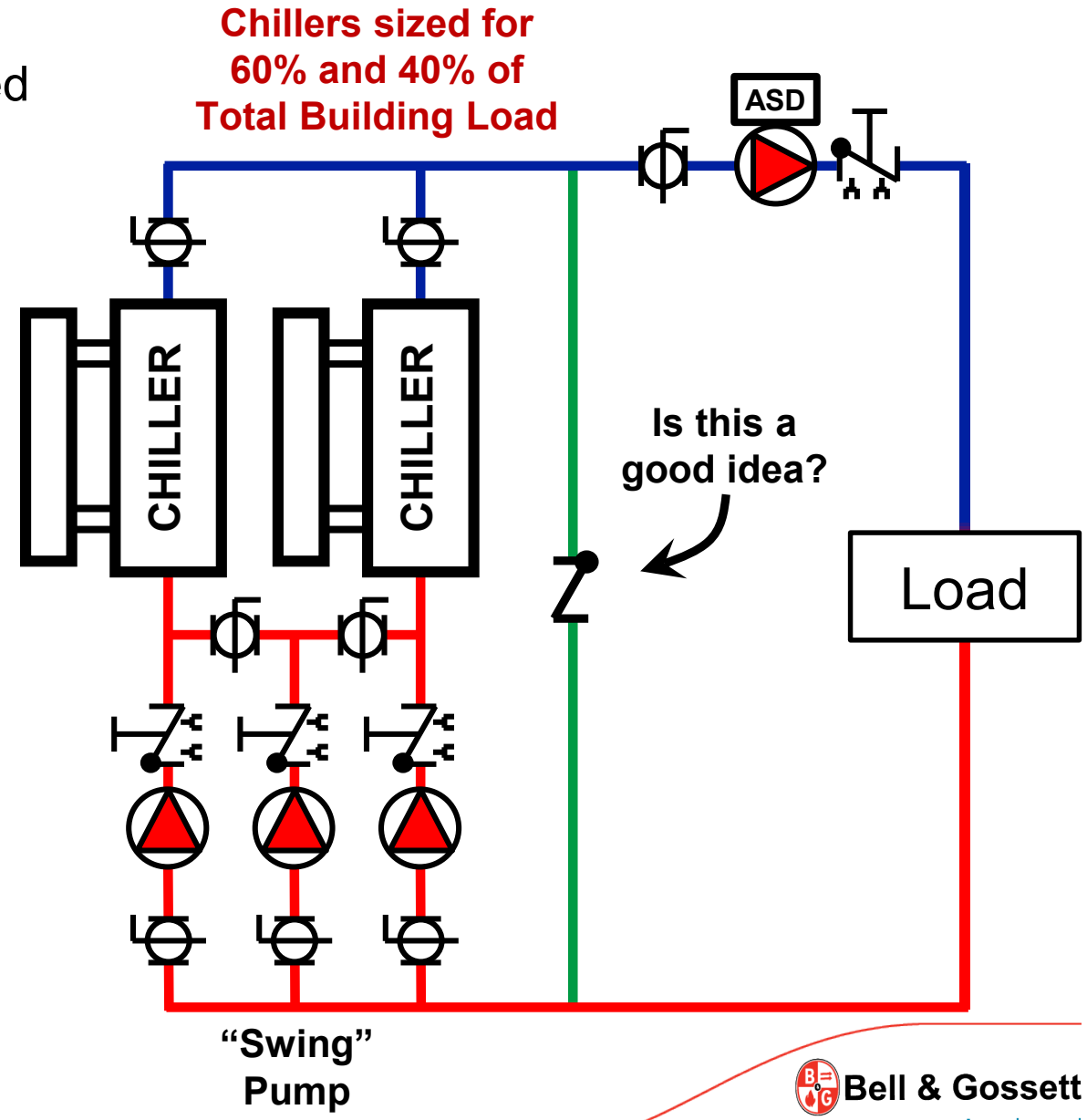

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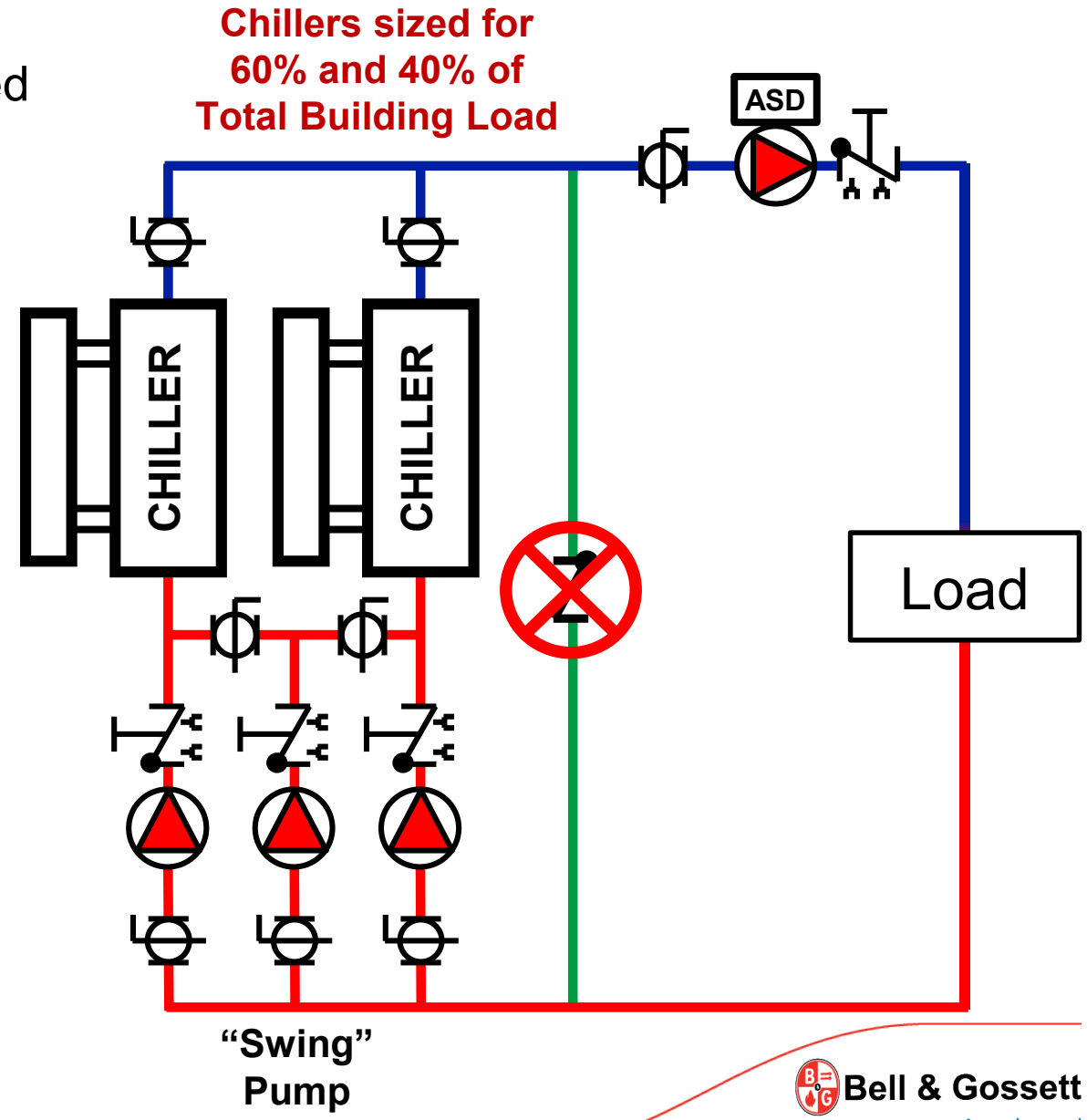
  (Recommend 2-Way valves on majority of HVAC coils)
- Do not recommend check valve in Common Pipe
  - Primary & Secondary pumps will be in Series when Secondary Flow greater than Primary
  - Chiller staging control will be erratic



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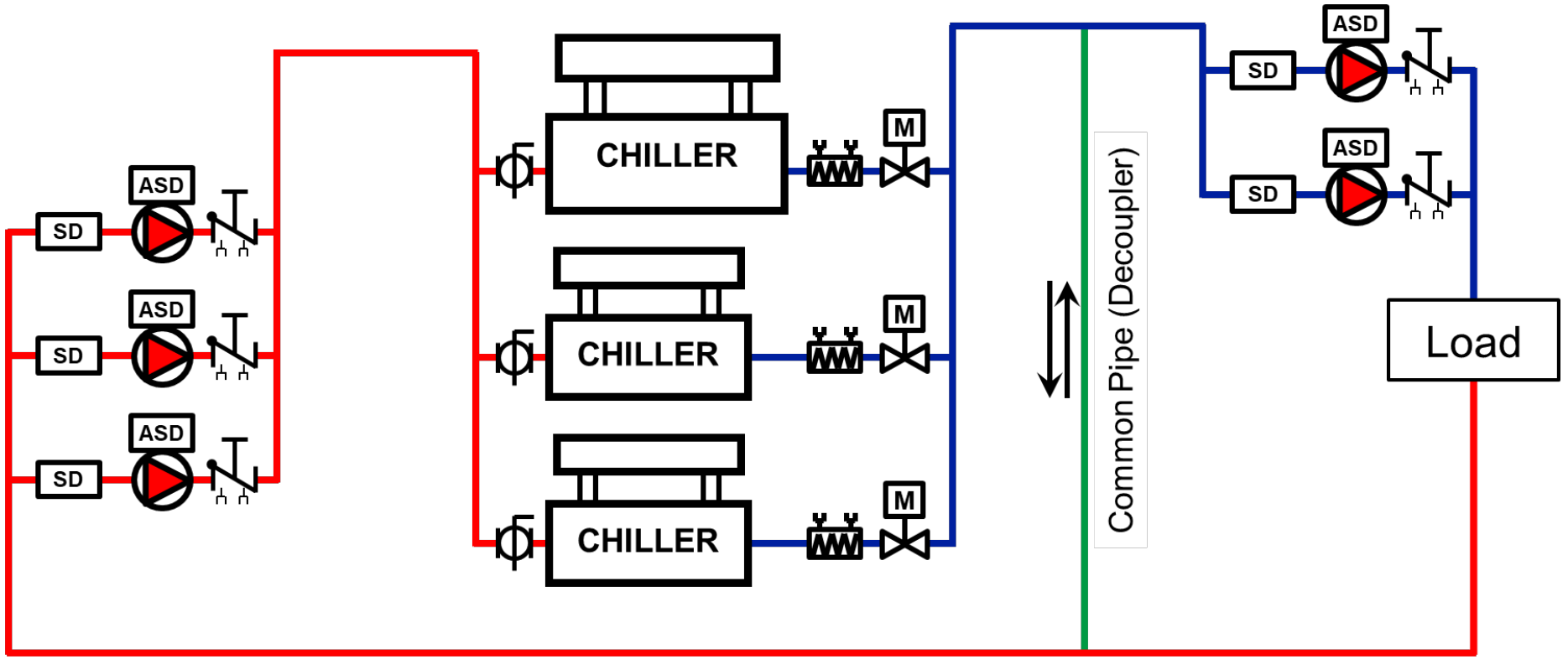
Variable Speed Primary & Secondary, Parallel Pumping

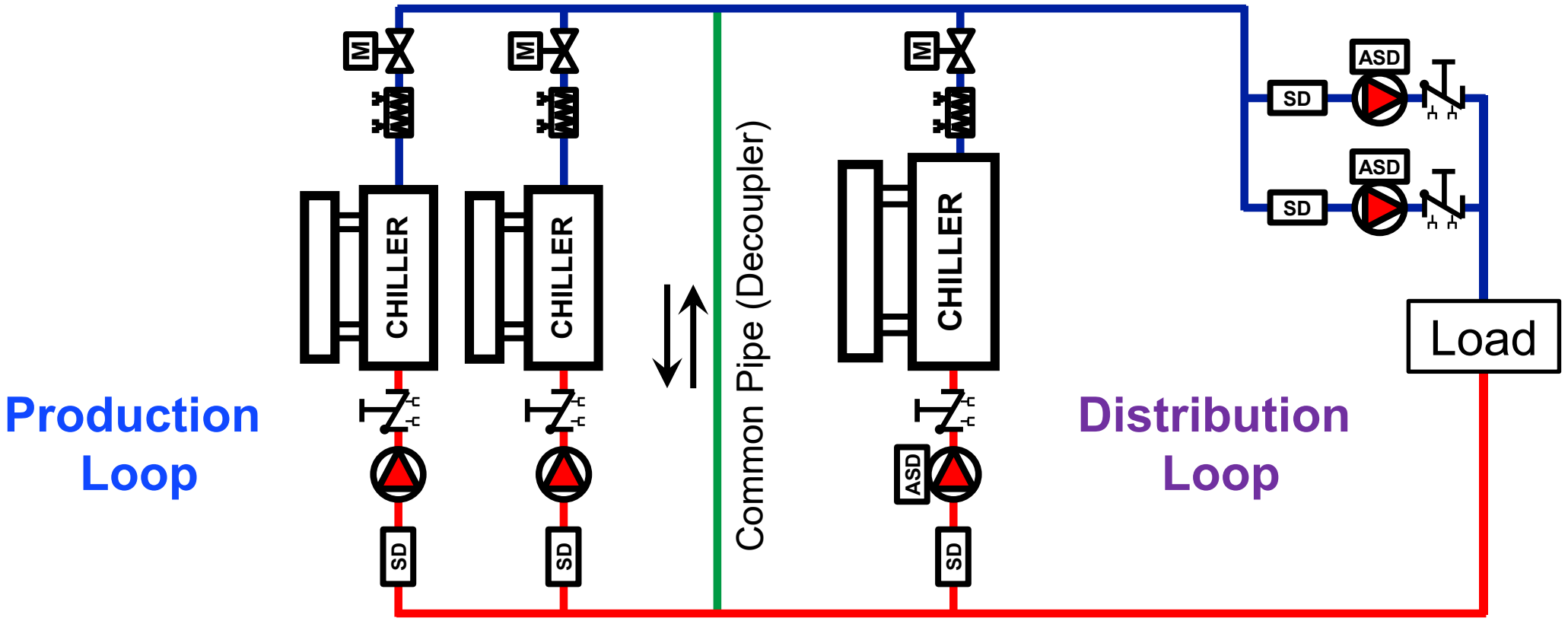
Any pump can supply any Chiller, Different size chillers possible



NOTE: If all chillers make same supply temperature, then all operating chillers are loaded to equal percentage

Parallel Chillers: Preferential Loading Configuration

Adding new High Efficiency Chiller to existing system?

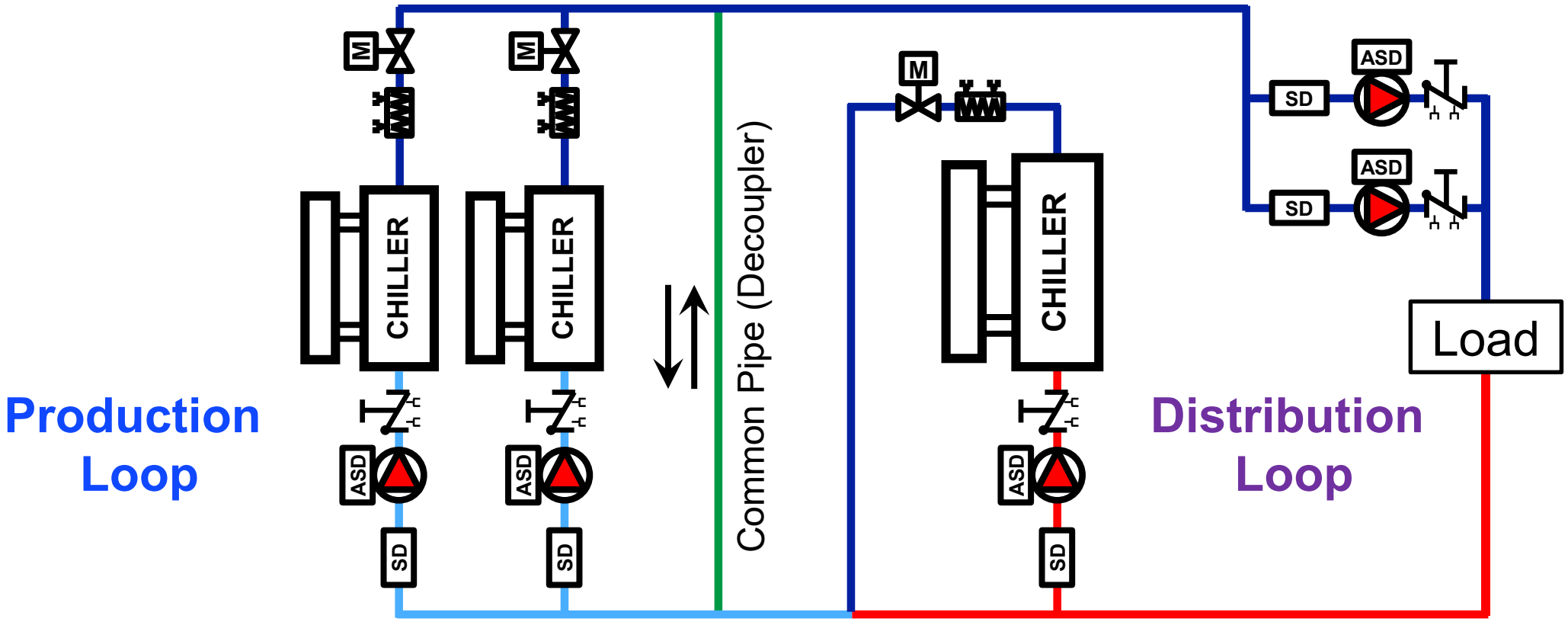


NOTE:

- **Chiller in Distribution Loop gets warmest system fluid and must be capable of making desired system fluid supply temperature**

Parallel Chillers: Preferential Loading "**Side-Car**" Configuration

Using Fluid Economizer "Free Cooling" or Heat Recovery Type Chillers



NOTE:

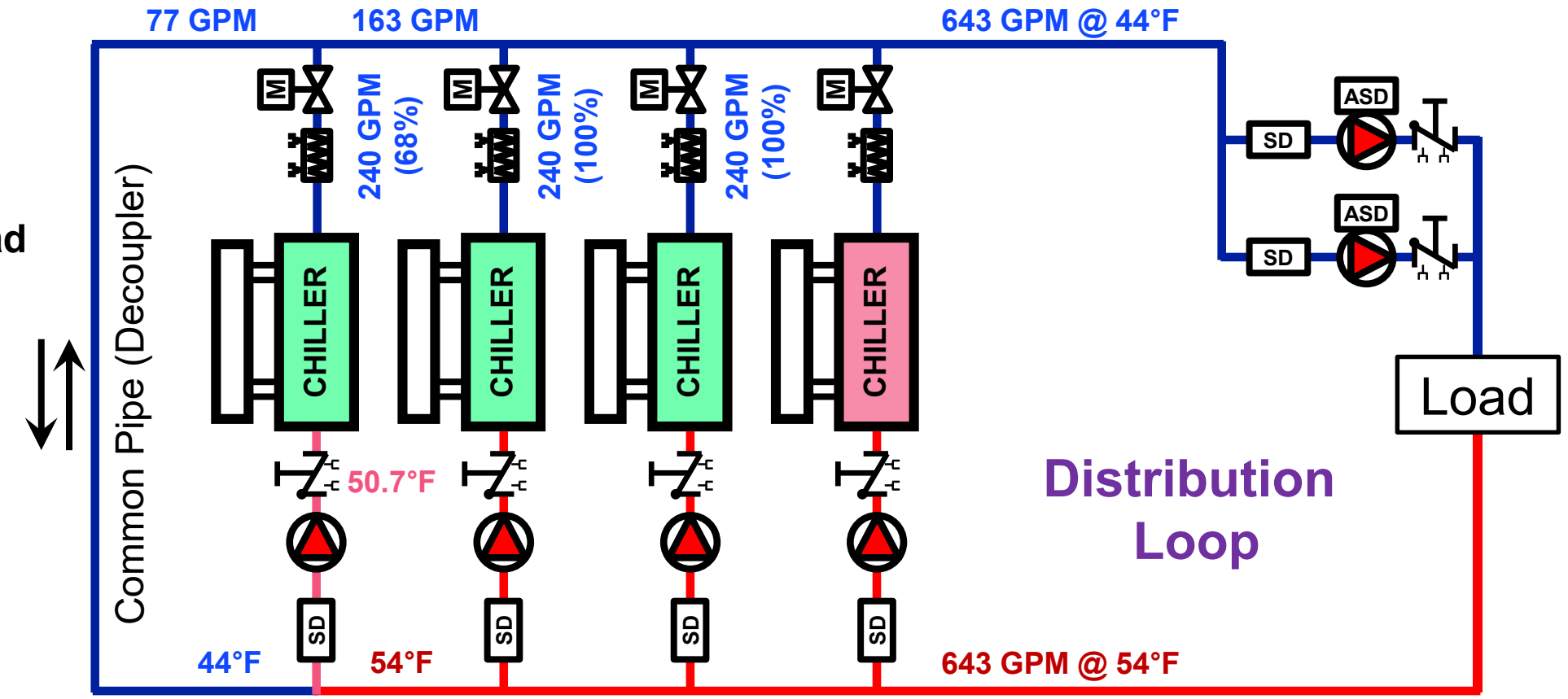
- **Pre-Cooling return water to Production Loop chillers can reduce "Lift", lowering operating Kw/Ton.**

Parallel Chillers: “Back Loading” Configuration

Combination of Constant and VFD Chillers

Example Shown:

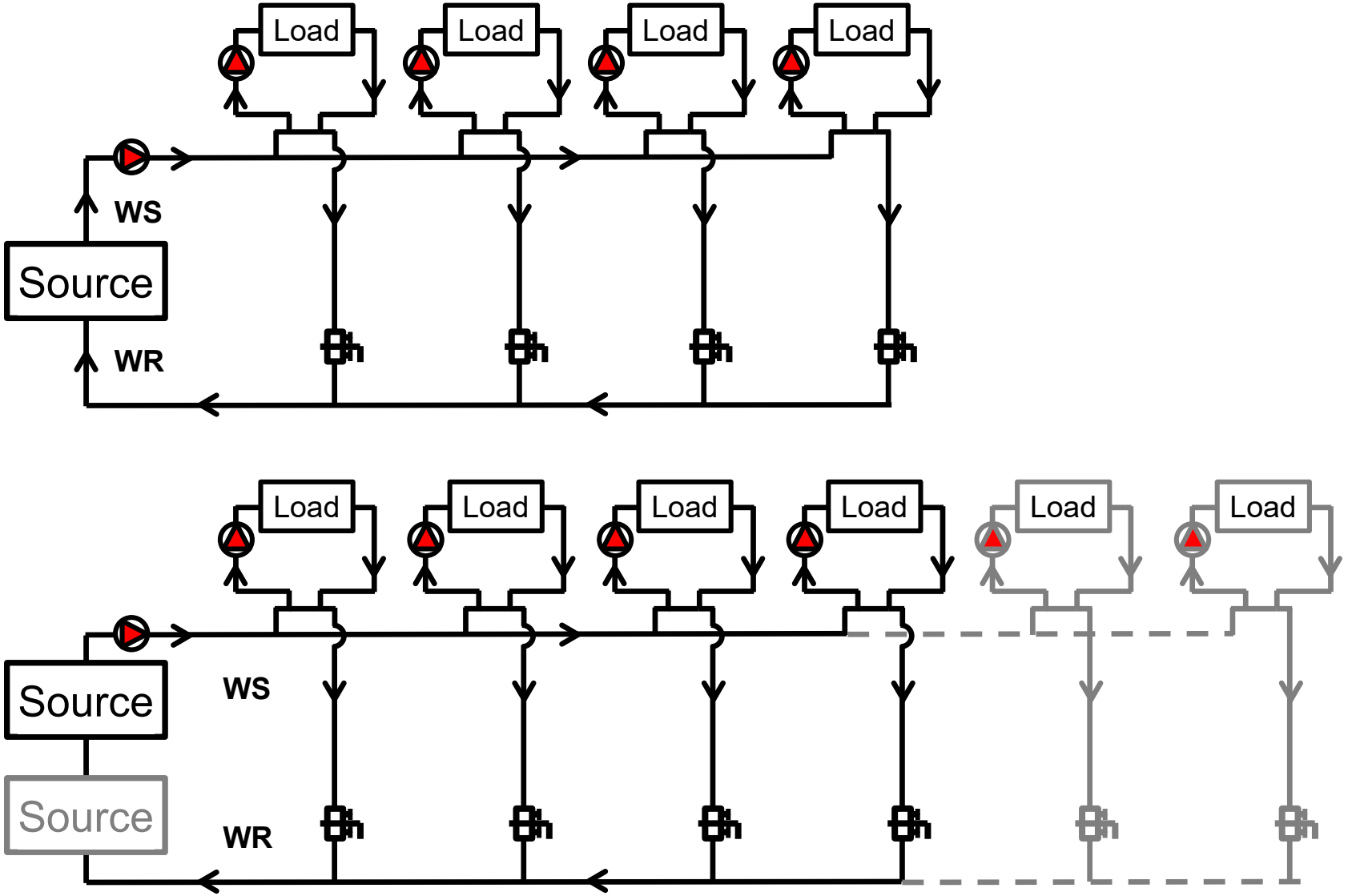
- (4) 100 Ton Chillers
- 10°F ΔT, 2.4 GPM/Ton
- 268 Tons Cooling Load



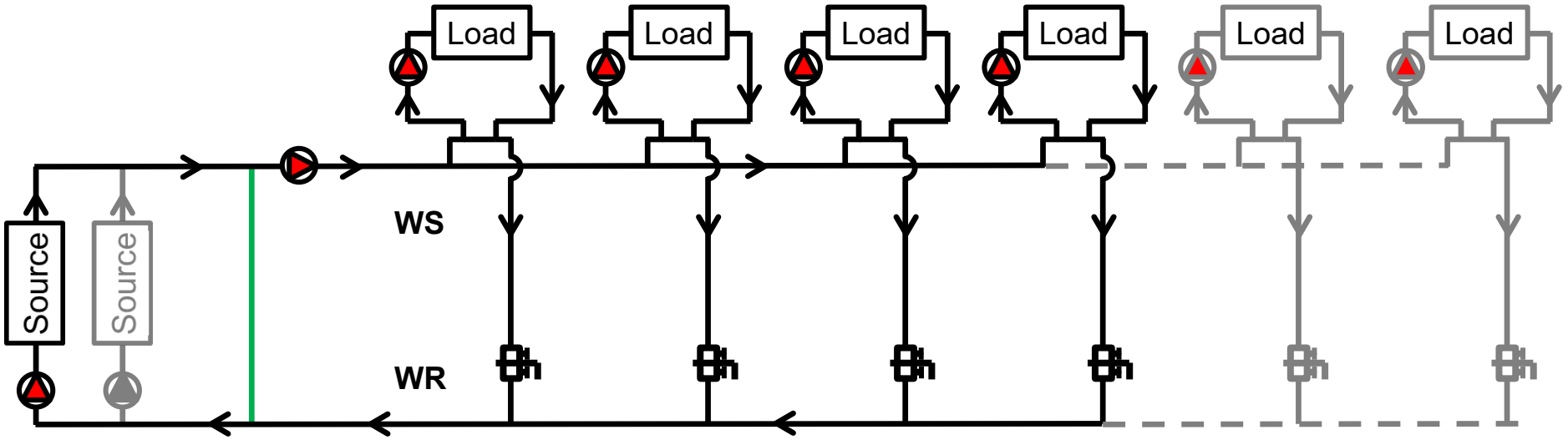
NOTE:

- Chiller(s) with better Part Load Efficiency closest to Decoupler and Chiller(s) with better Full Load Efficiency farthest away.

System Expansion with Primary-Secondary



System Expansion with Primary-Secondary-Tertiary



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Variable Primary Distribution

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Variable Primary Application Considerations

Suggested when:

- System flow can be reduced by a minimum of 30% of peak design
- System can tolerate a small variation in supply water temperature
- Existing or new chiller(s) have controls that allow for flow to be varied
- Operators will be thoroughly trained and encouraged to run as designed

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Discouraged when:

- Terminal units have all 3-Way valves (Constant Volume)
- System supply water temperature critical
- Existing or new chiller(s) require constant flow at design conditions
- Operators most likely to change everything over on day 366!!

Variable Primary Design Guidelines

- Keep evaporator flow between the minimum and maximum flow (velocity) limits
- Select all chillers to have similar pressure drops at design flow, regardless of capacity
- Suggested percentage of change in flowrate through evaporator:
  - 30% change per minute (Comfort Cooling)
  - 10% change per minute (Process Control)

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- **Bypass Valve selection:**
  - Sized to deliver highest minimum flow of any single chiller when 100% open
  - Valve differential pressure equal to system differential setpoint at installation location
  - Recommend a “Linear” Inherent Characteristic Performance Curve
  - Should not be fast-acting to prevent unstable flow changes during chiller staging

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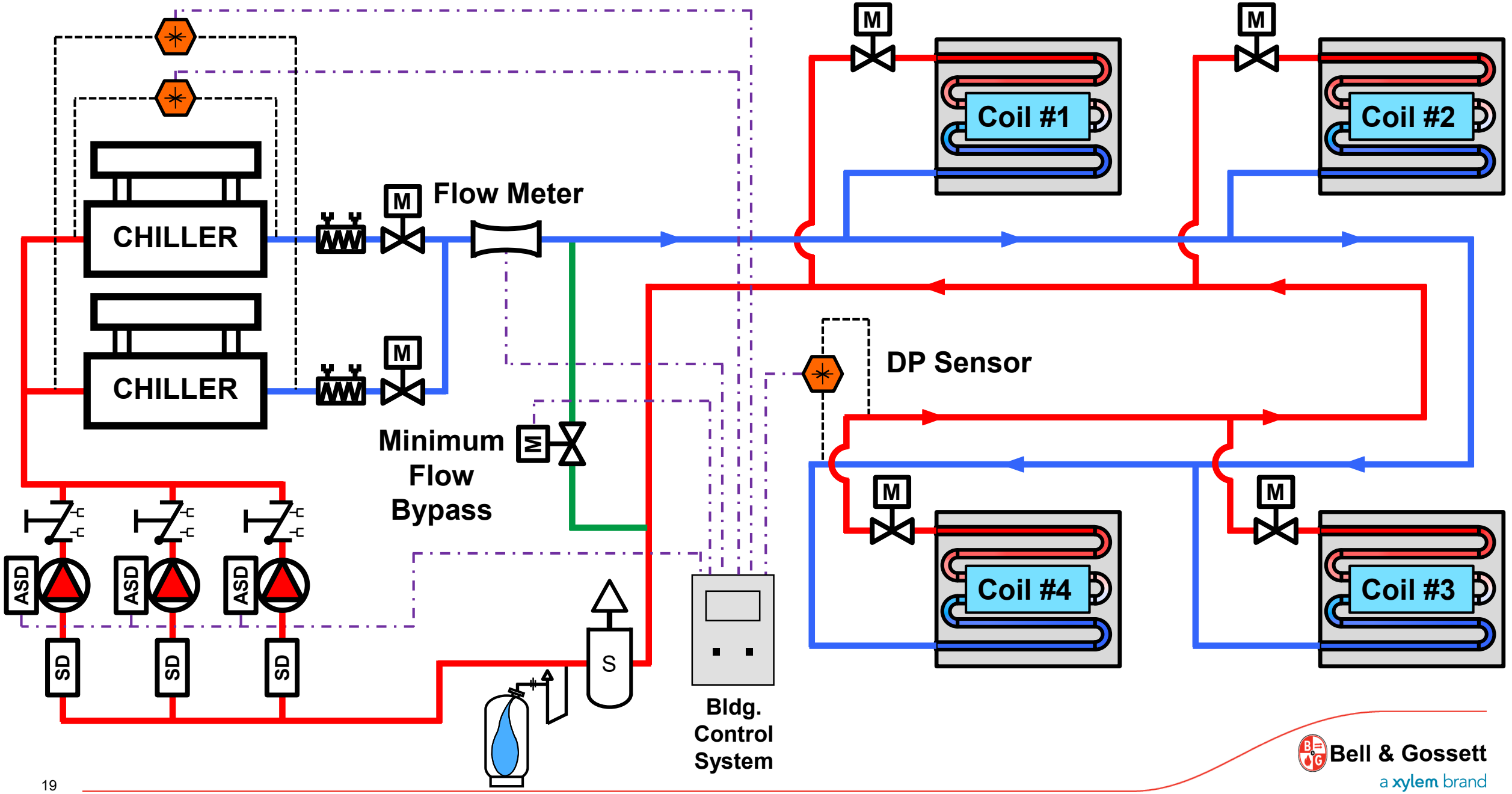
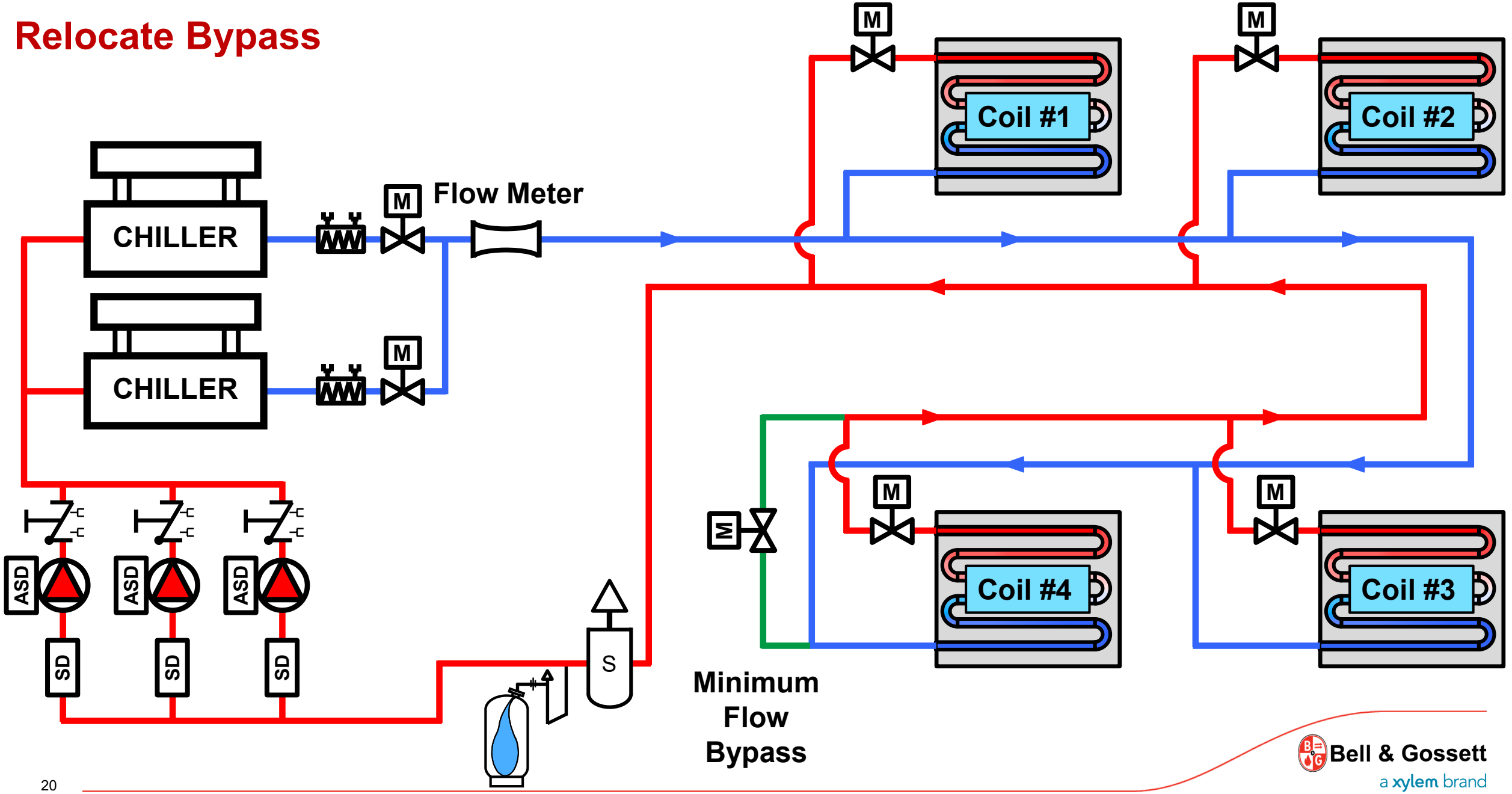
  - Should not be fast-acting to prevent unstable flow changes during chiller staging
- **Bypass Pipe sizing:**
  - Typically sized for highest minimum flow of any single chiller *(4’/100’ Friction Loss Rate)*
  - May need to consider combined minimum flow of 2 chillers operating at Part Load just before sequencing off 1 chiller

Variable-Primary – Direct Return, 2-Way Valves



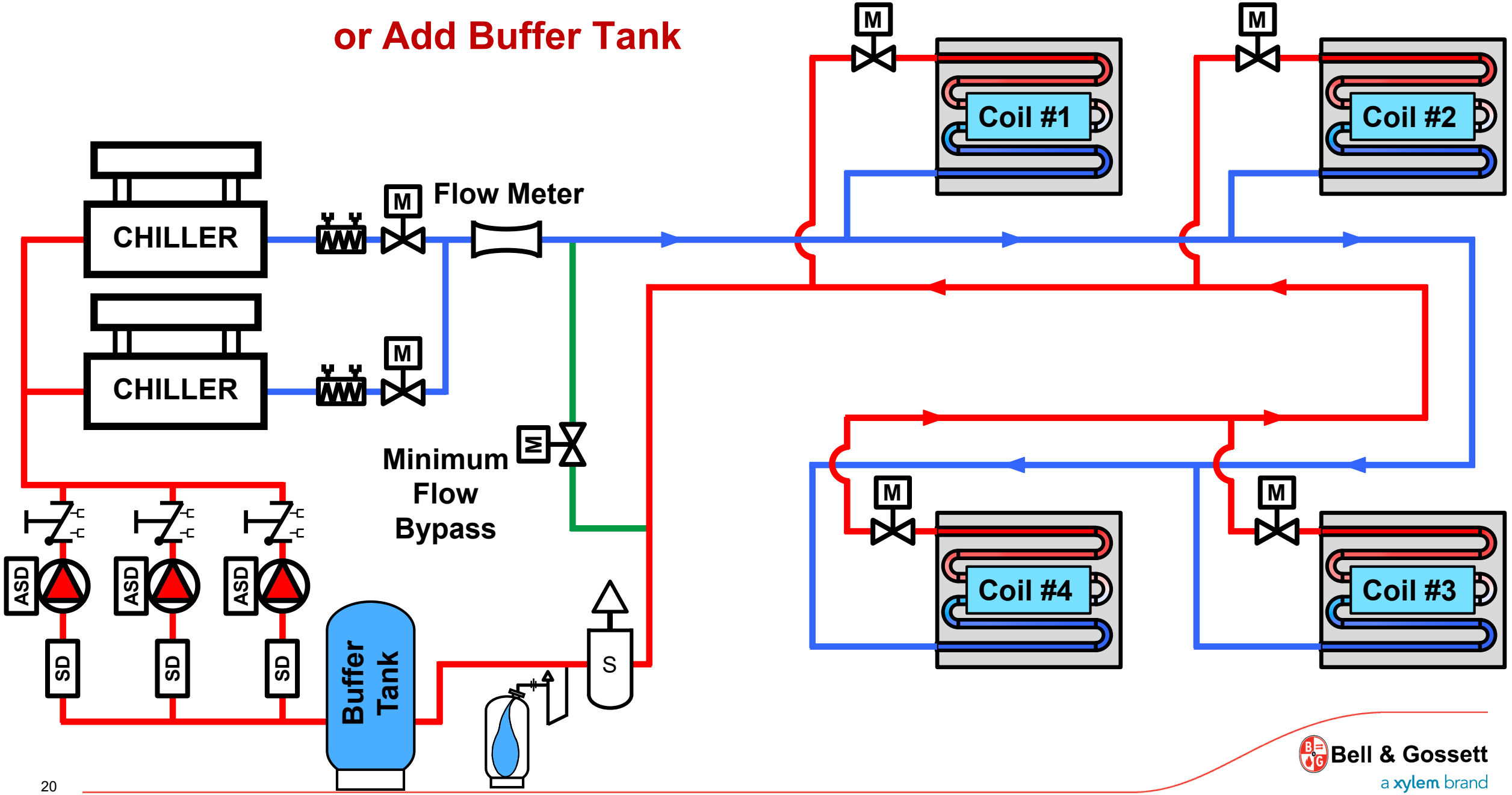
Chilled Water Loop Minimum Flow & Volume Management

Relocate Bypass



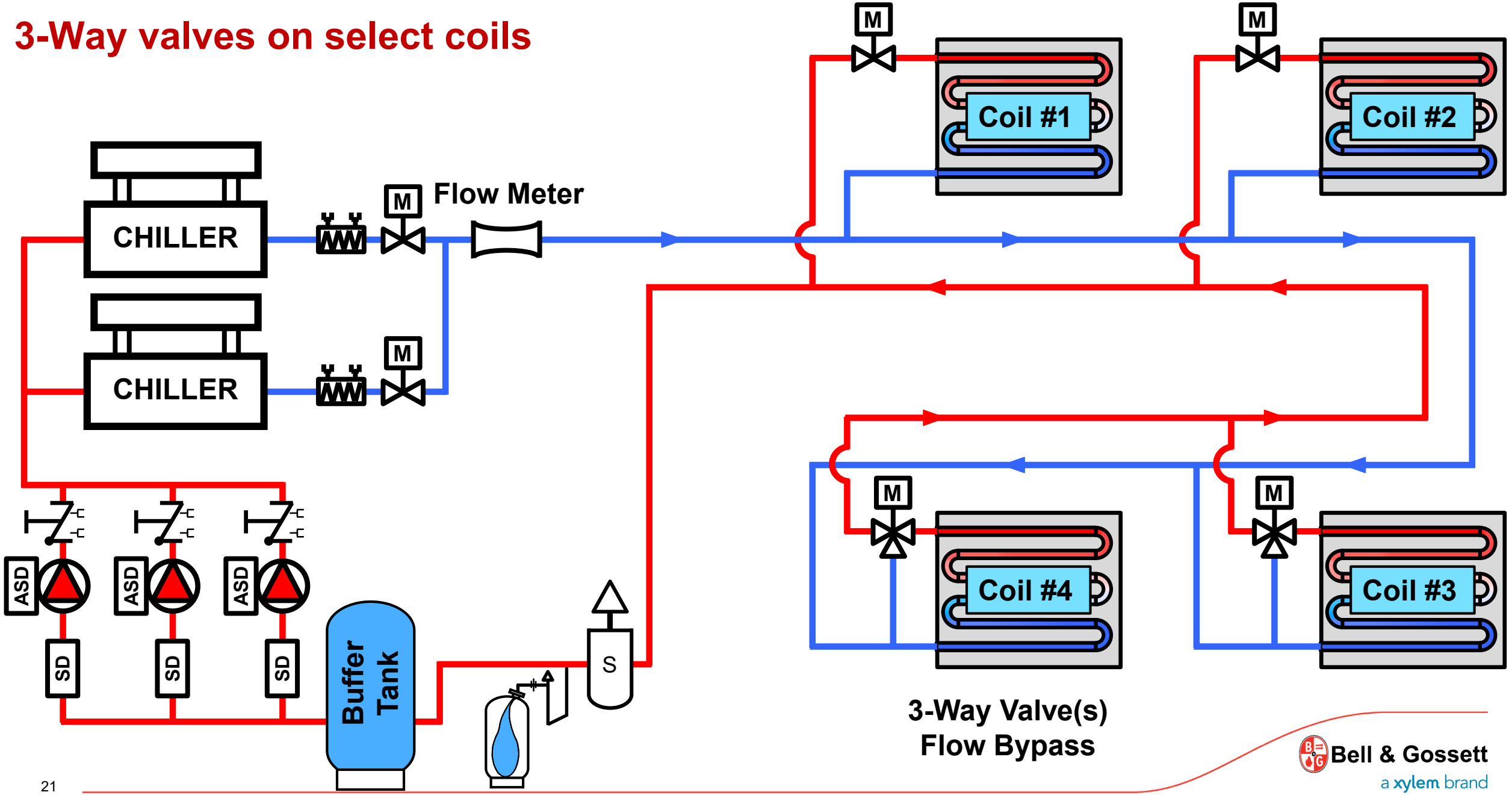
Chilled Water Loop Minimum Flow & Volume Management

or Add Buffer Tank



Chilled Water Loop Minimum Flow & Volume Management

3-Way valves on select coils



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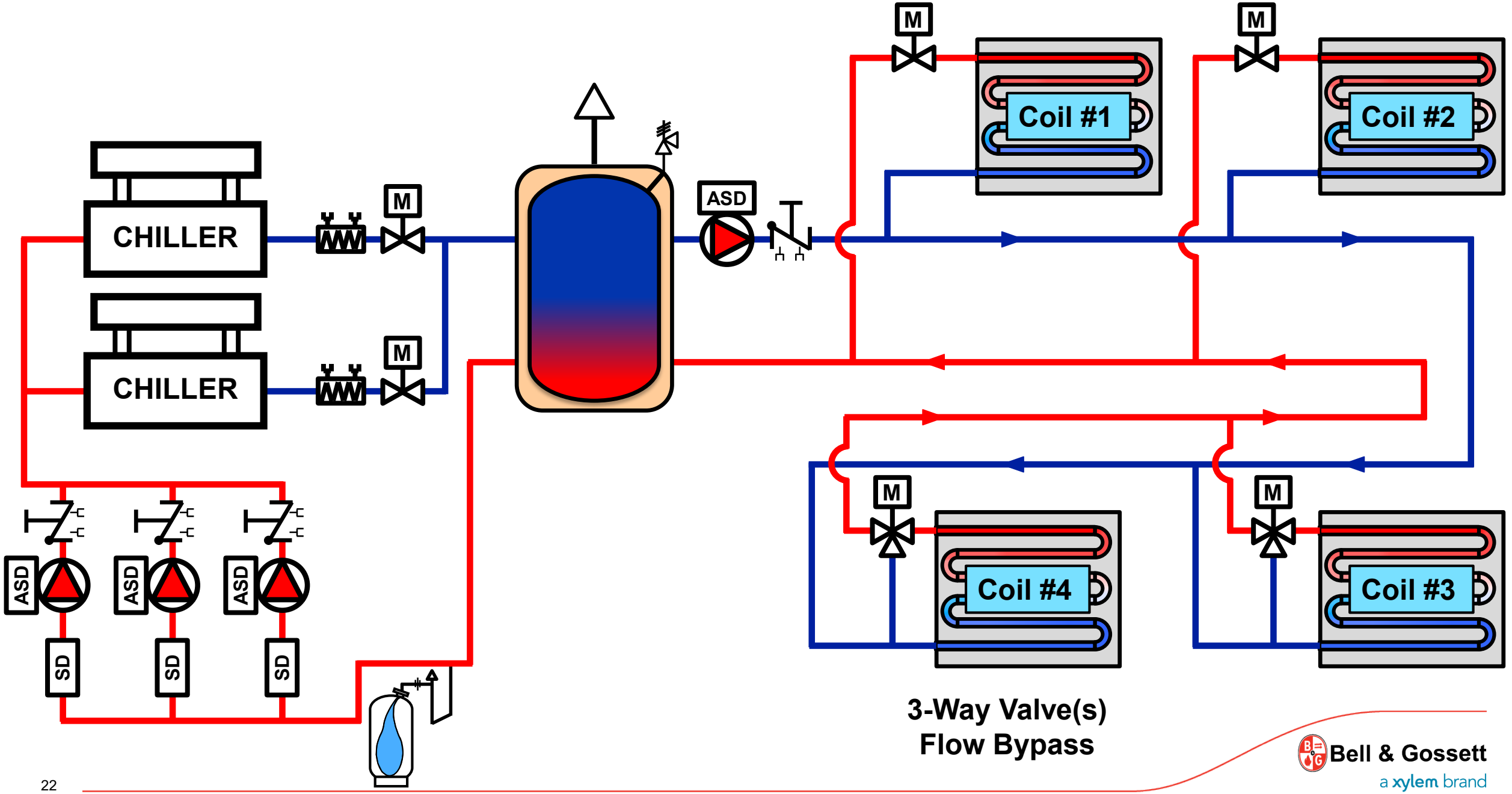
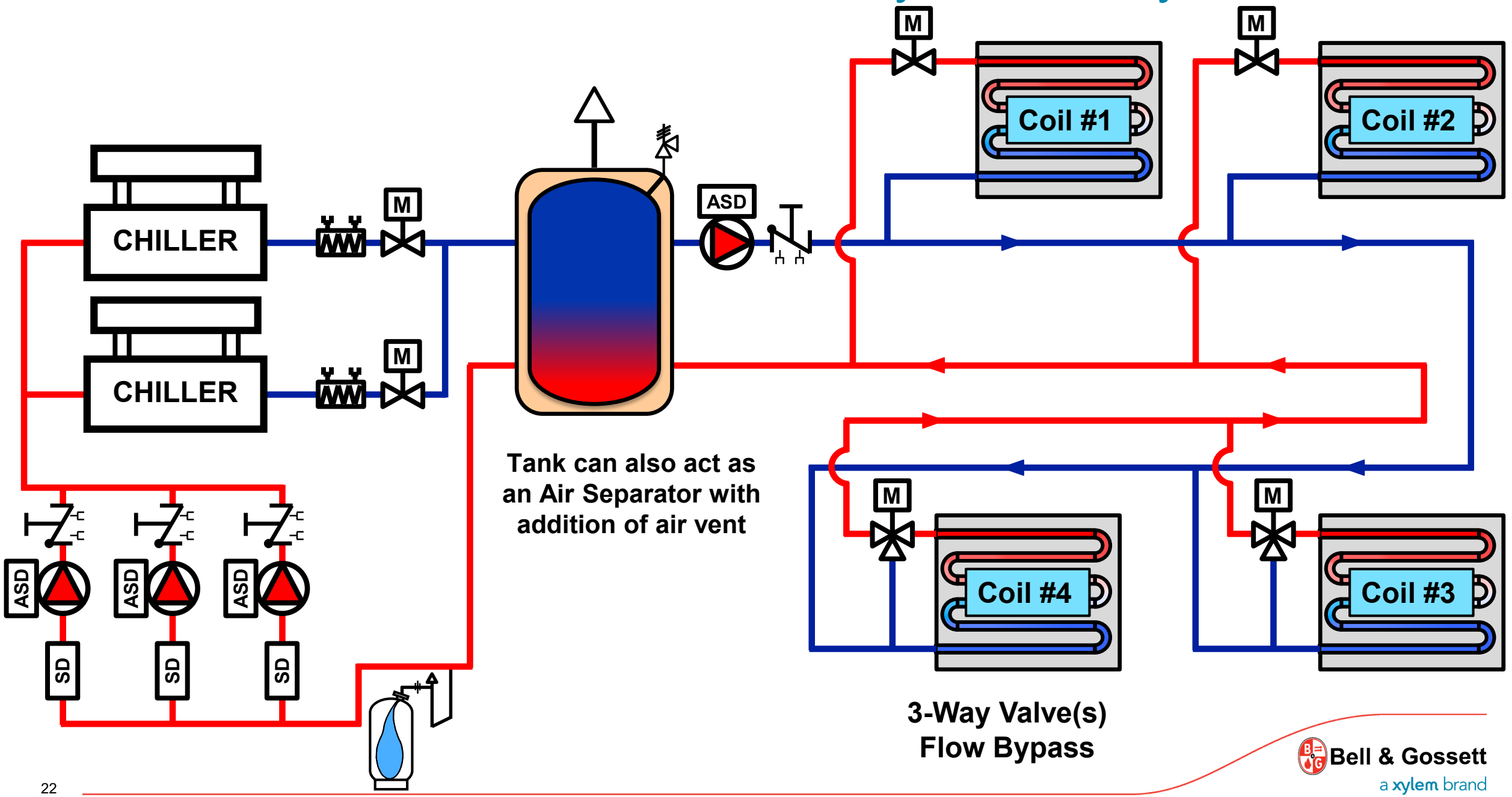
Chilled Water Buffer Tank as the Primary-Secondary Header



Chilled Water Buffer Tank as the Primary-Secondary Header



Questions?

Comments?

Observations?