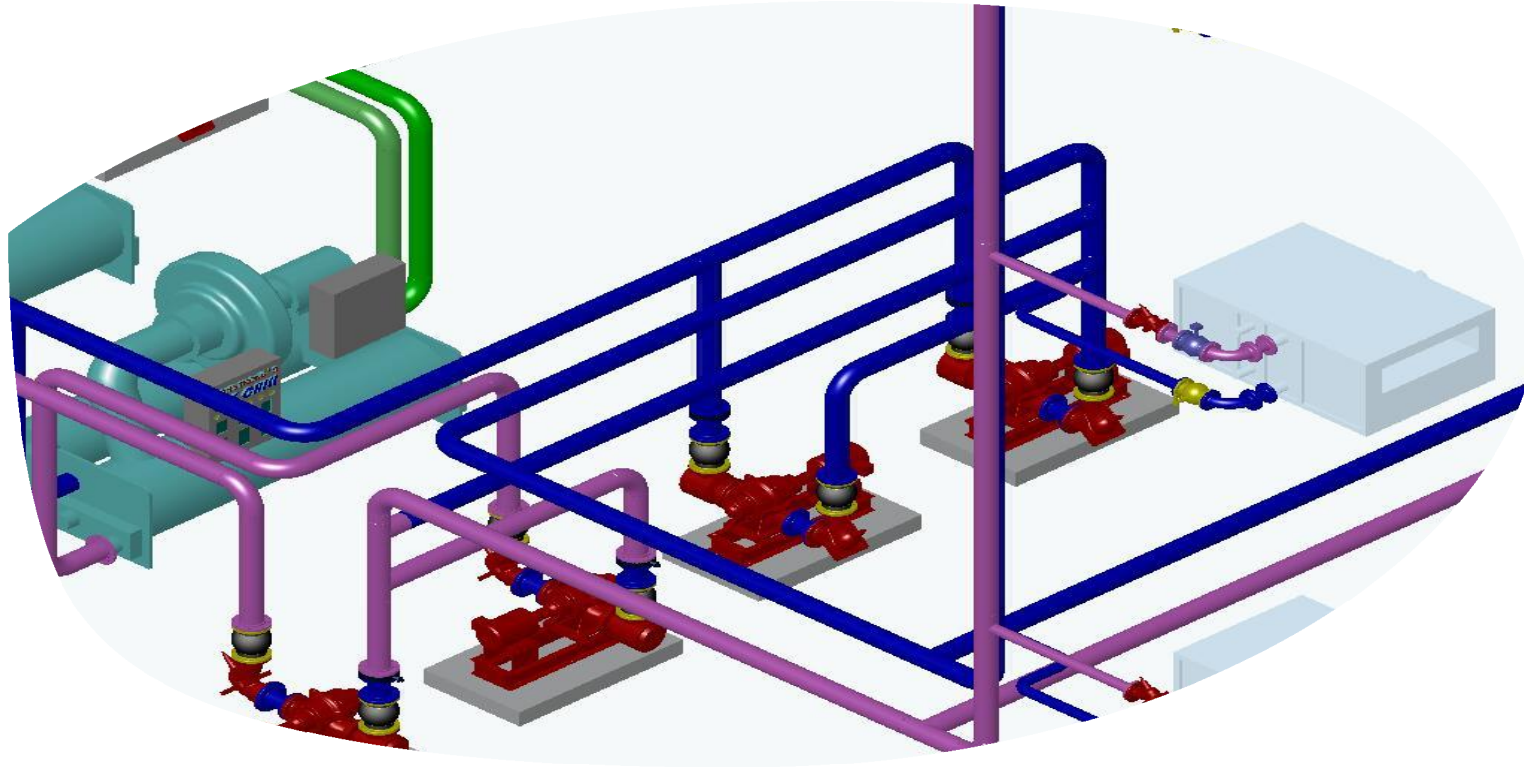


# Variable Primary Systems



Richard Roberts – Systems Sales Engineer  
January 03, 2012



# Variable Primary Flow Only (VPF) Advantages

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- **Lower Capital Cost Installed (vs Primary/Secondary)**

- No secondary pumps/piping/valves/electrical to buy and install
- Fewer piping and electrical connections – less field labor
- No large common pipe, but smaller bypass pipe/valve/flow meter/controls



- **Lower CHW Pumping Energy**



- **Potential Savings, may reduce pump horsepower and initial cost.**

- Reference ARTI (Air Conditioning & Refrigeration Technology Institute)
  - Estimated energy savings of 3 to 8 percent
  - Estimating initial cost saving of 4 to 8 percent
  - Estimating life cycling saving cost 3 to 5 percent
-

# Variable Primary Flow Only (VPF) Advantages

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- **Smaller Footprint (vs Primary/Secondary)**

- More space available for better access to the other equipment



- **Higher Reliability**

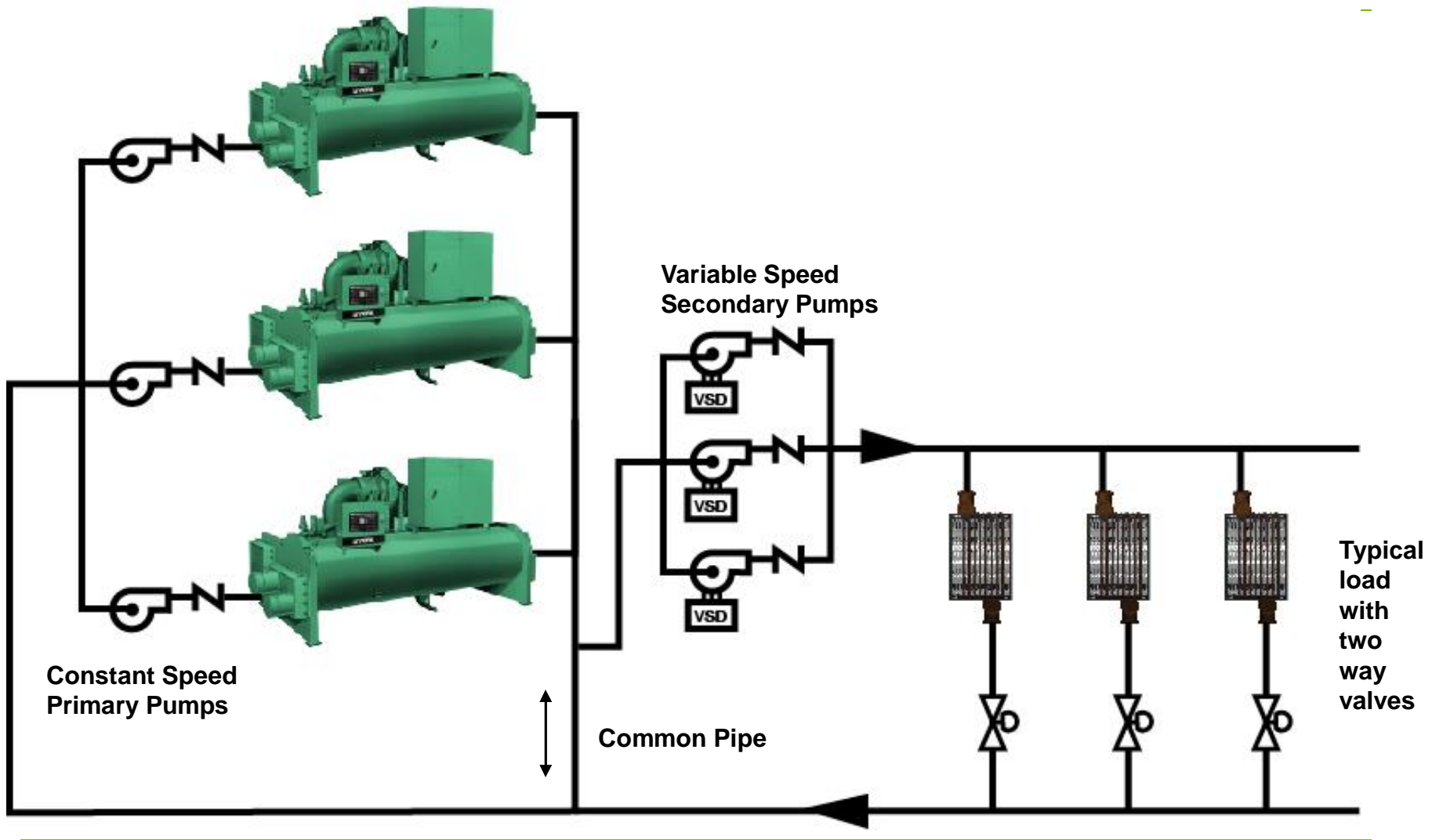
- Fewer mechanical components
  - Any pump can serve any chiller
-

## Variable Primary Flow Only (VPF) Disadvantages

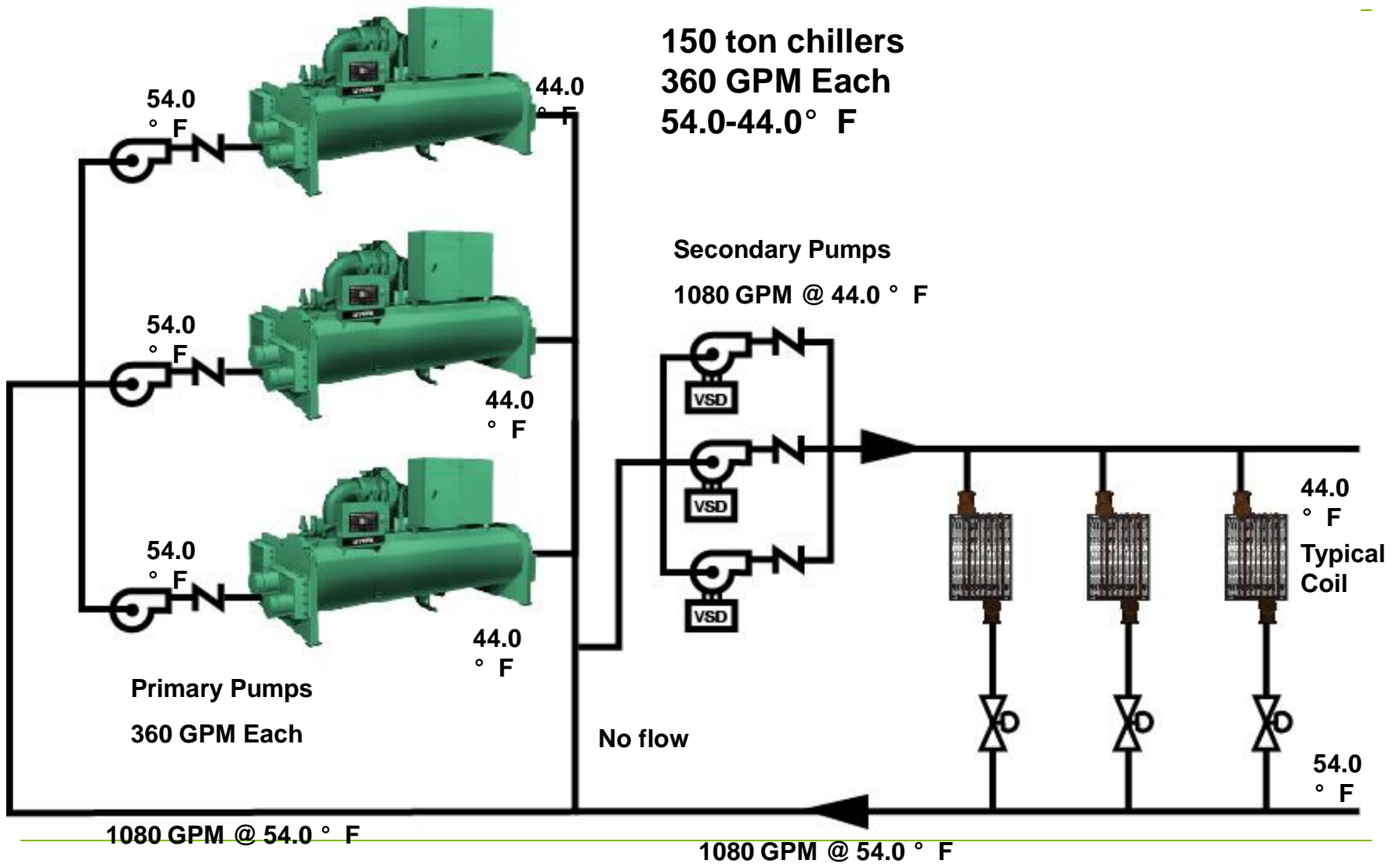
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- Potentially higher PSID rated 2-Way valves in system
  - Requires more robust (complex and calibrated) control system
  - Requires coordinated control of chillers, isolation valves, and pumps in sequencing
  - Potentially longer commissioning time and start-up (ref ASHRAE Taylor article)
  - **Requires greater operator sophistication**
  - Sudden flow variation through the chiller
    - More of an issue when additional machines are staged on
  - More complexity with bypass control
-

# Primary/Secondary System

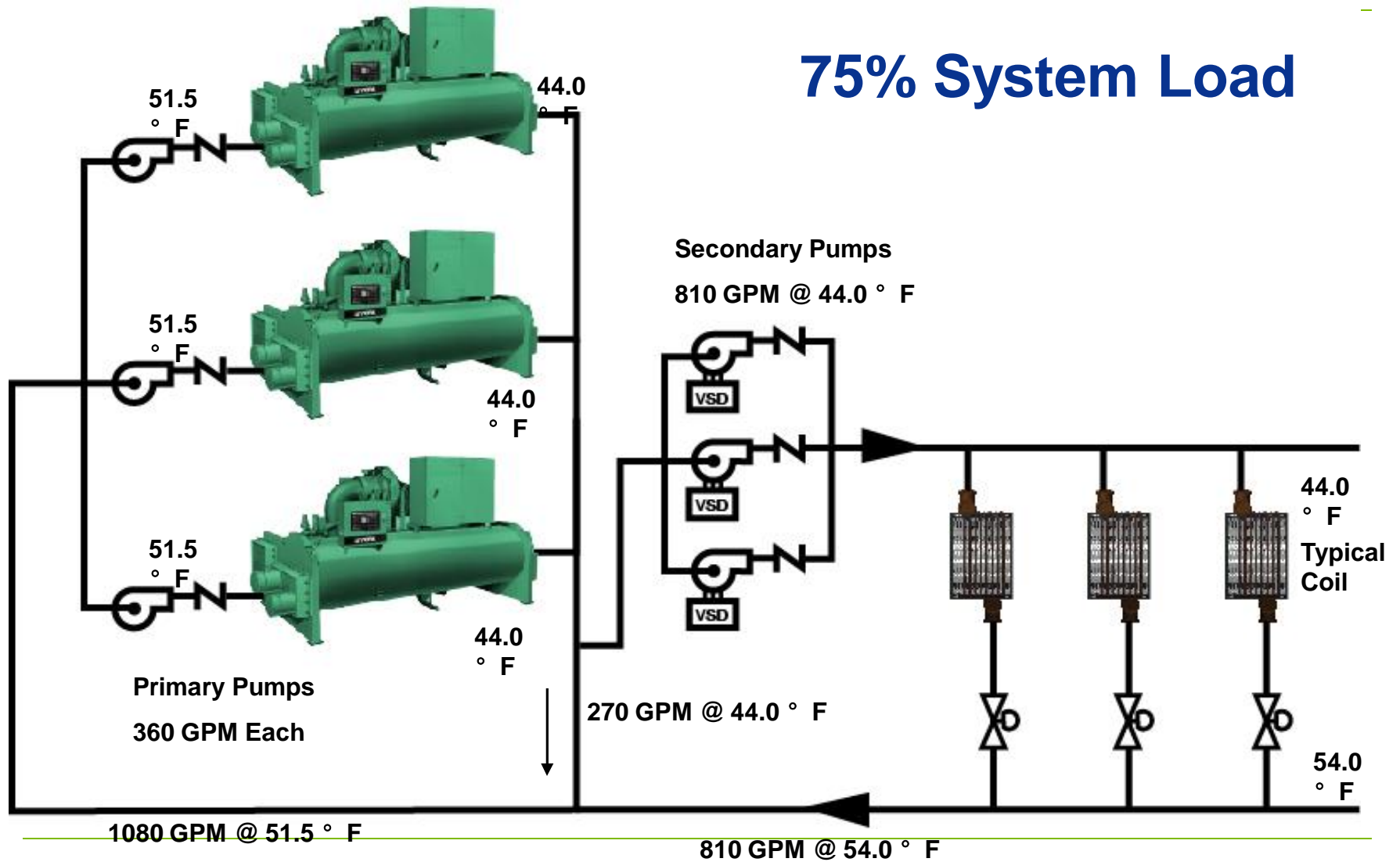


# Primary/Secondary System at Design



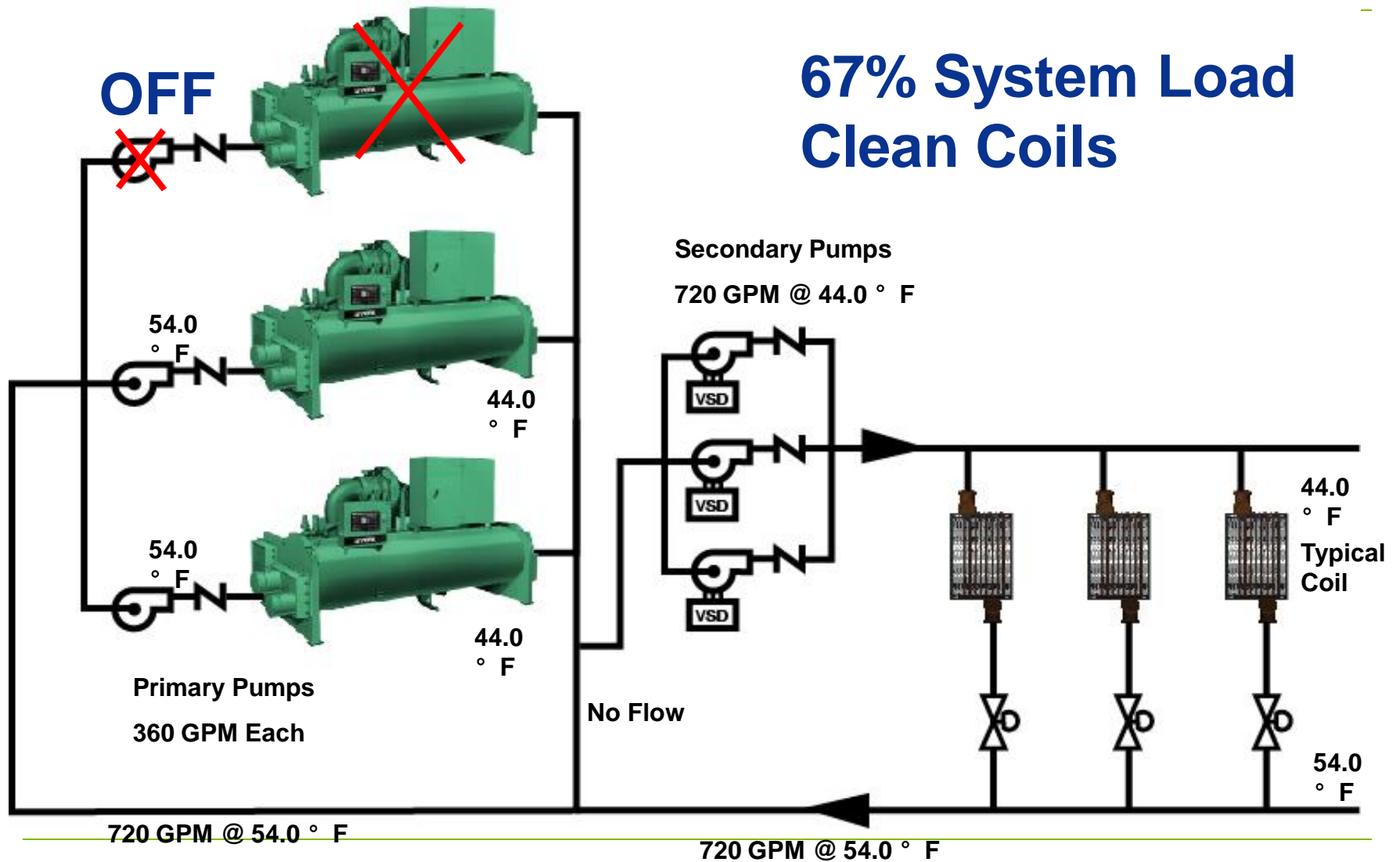
# Primary/Secondary System at Part Load

## 75% System Load



# Primary/Secondary System

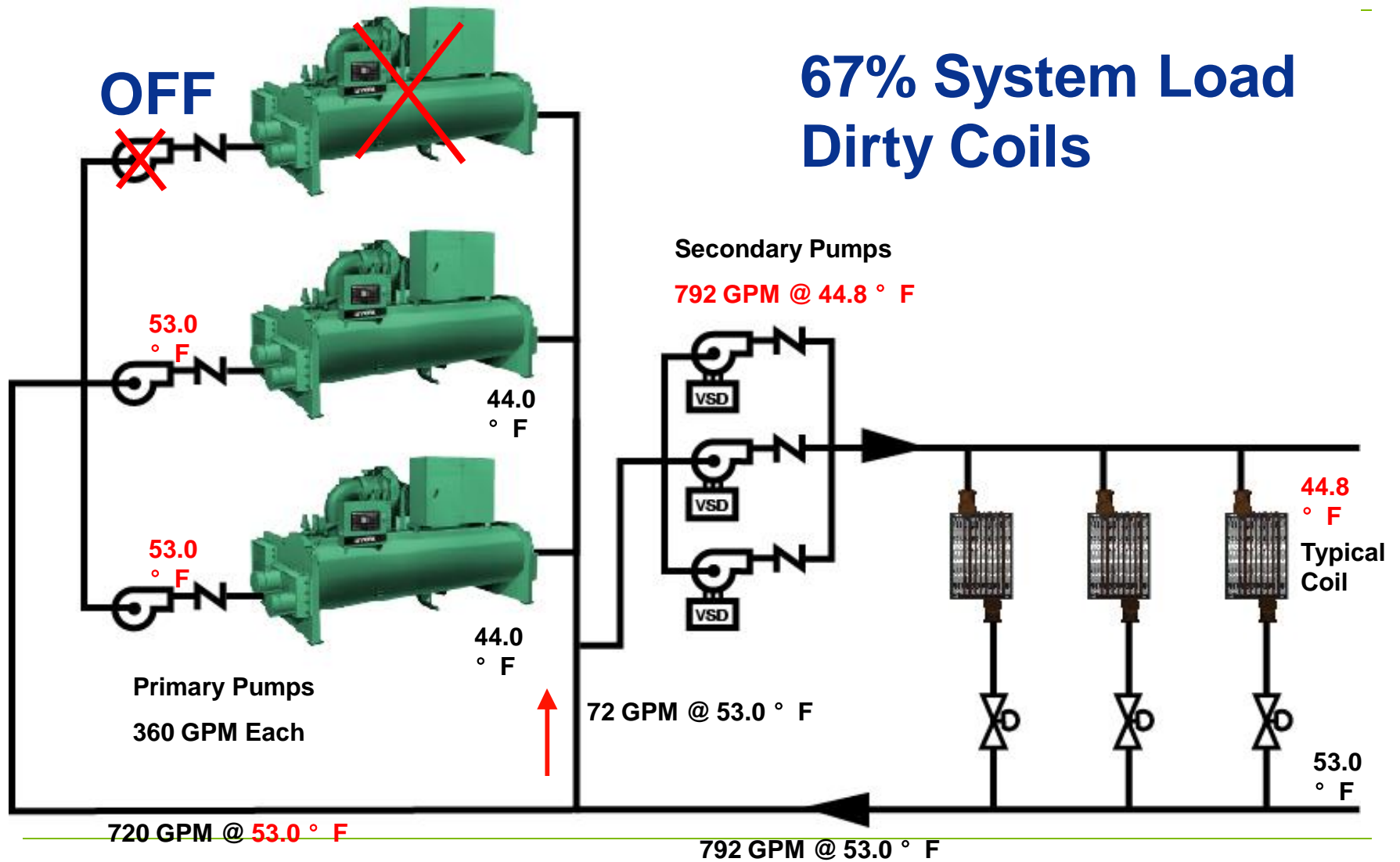
## 67% System Load Clean Coils





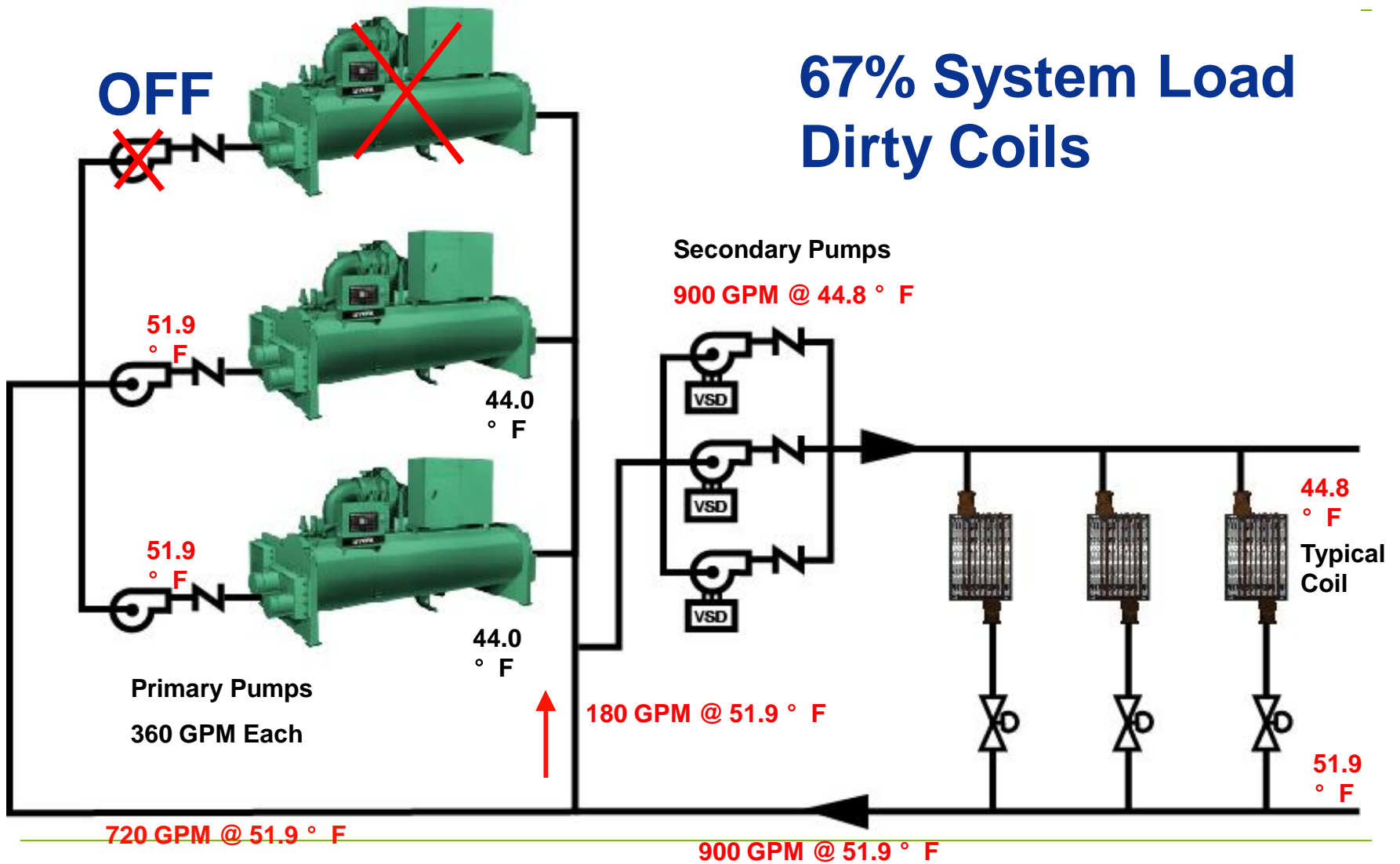
# Primary/Secondary System

## 67% System Load Dirty Coils

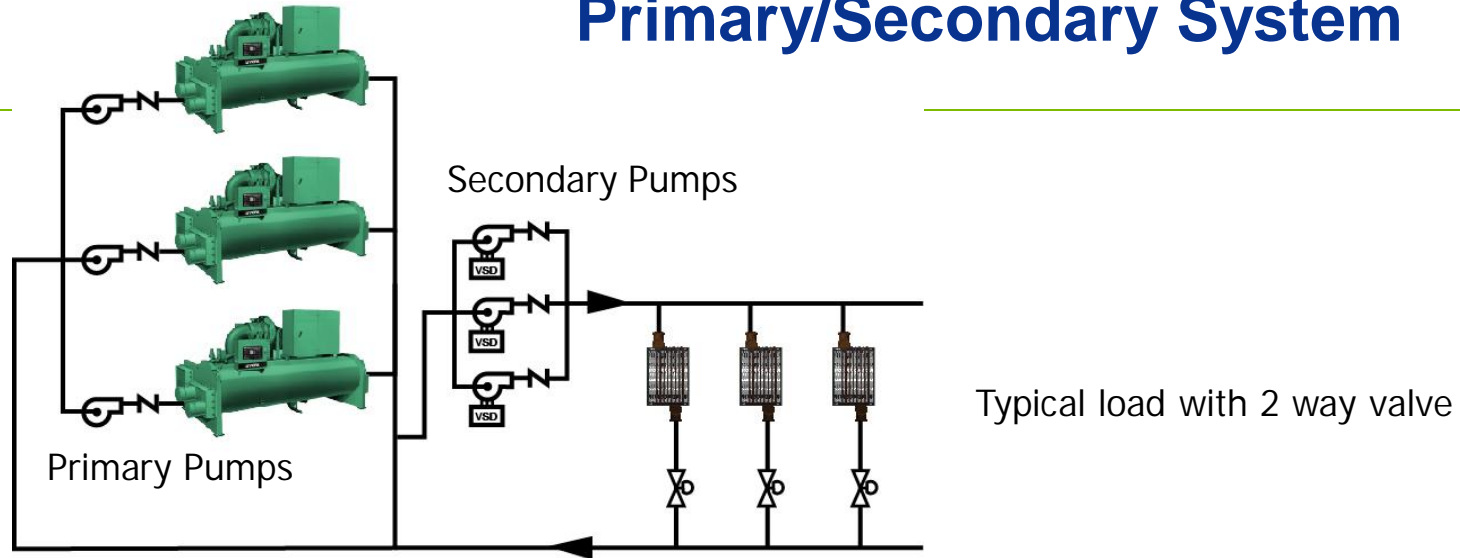


# Primary/Secondary System

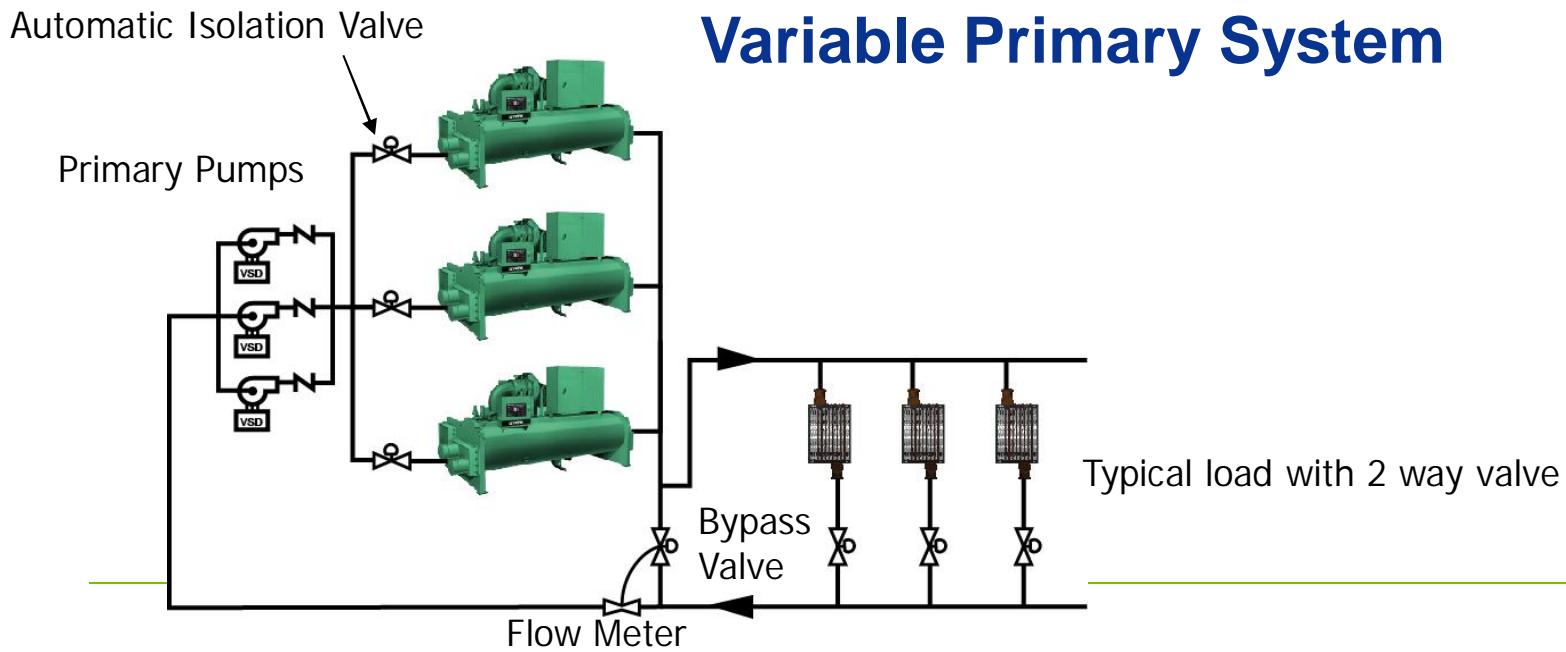
## 67% System Load Dirty Coils



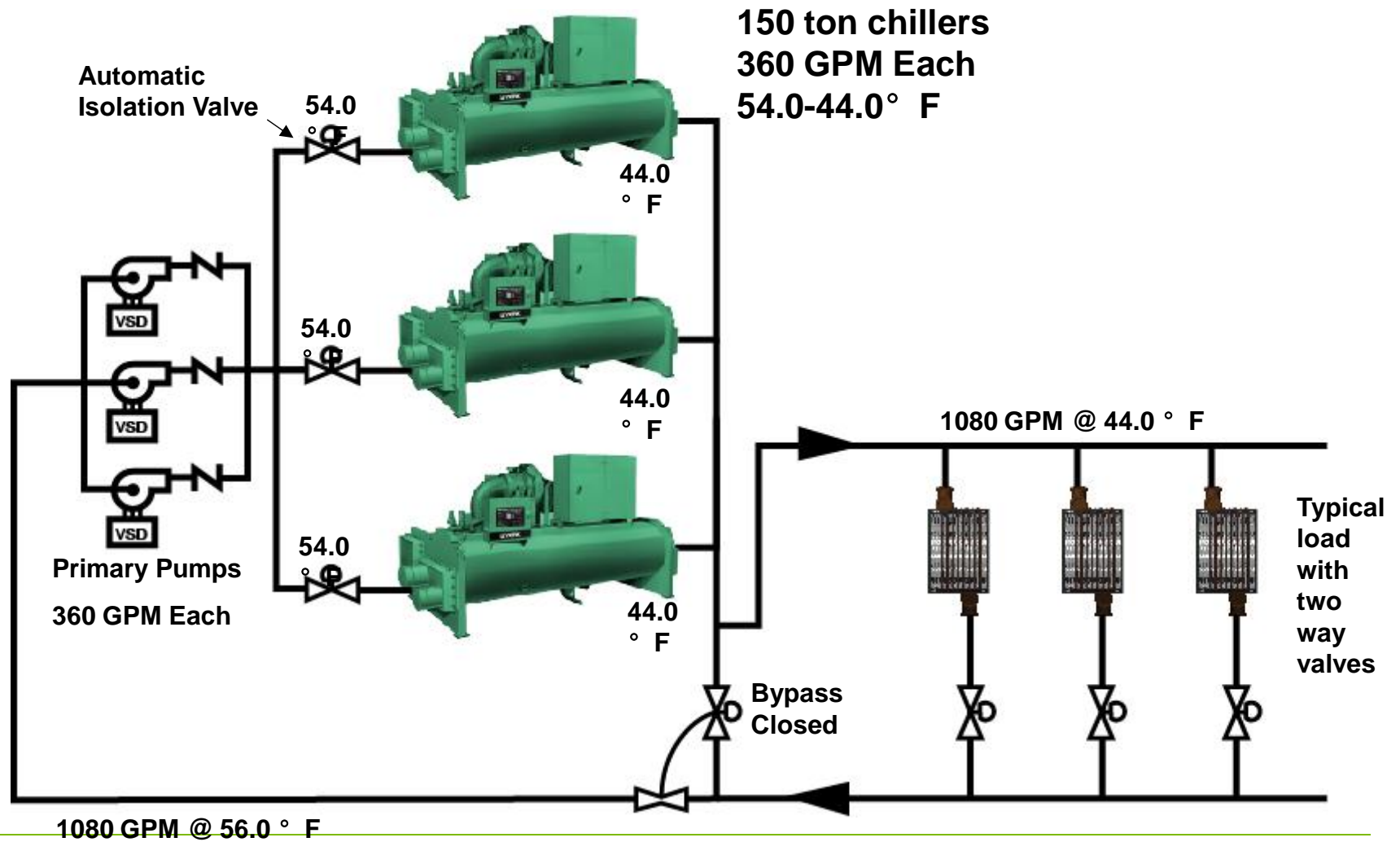
# Primary/Secondary System



# Variable Primary System

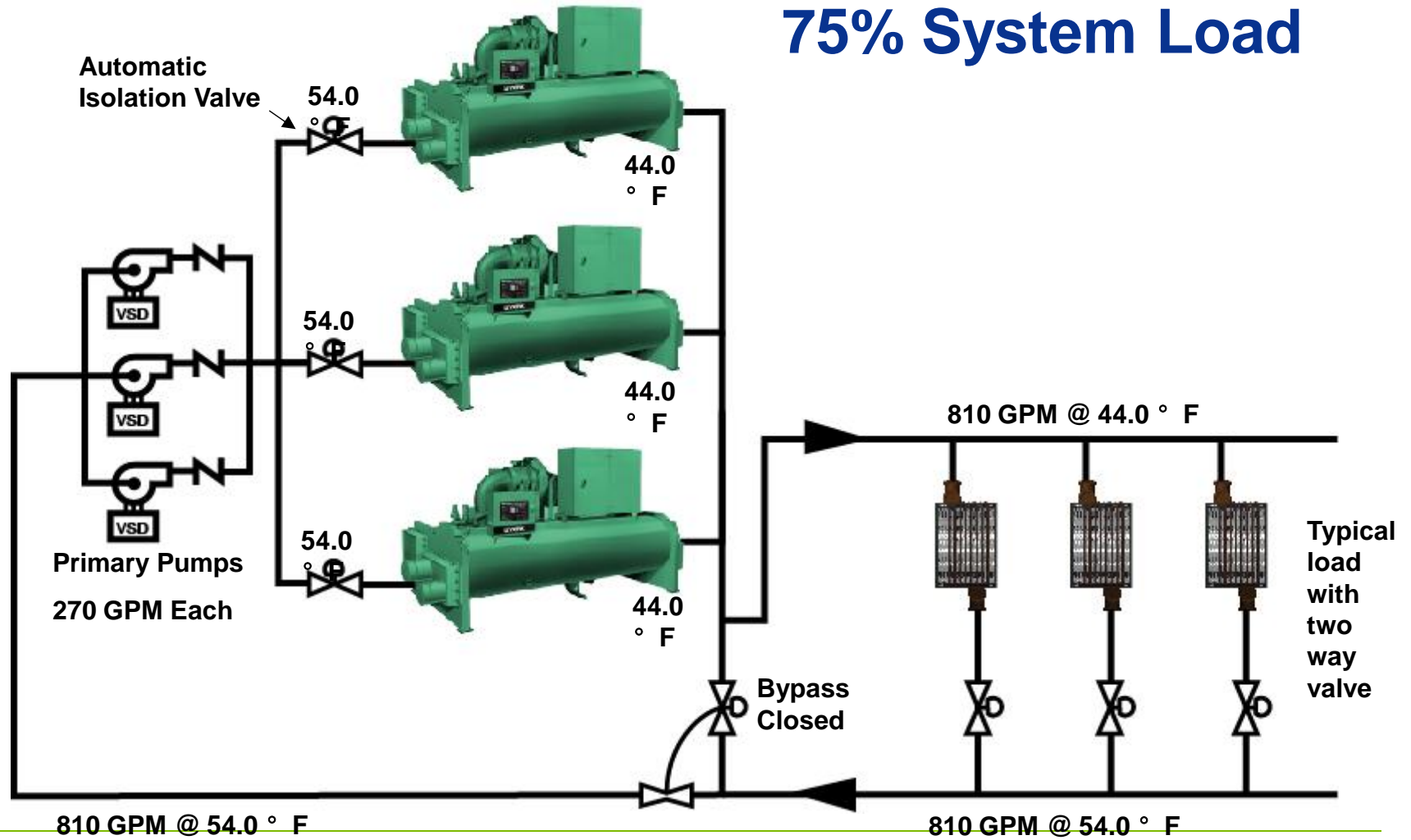


# Variable Primary System at Design



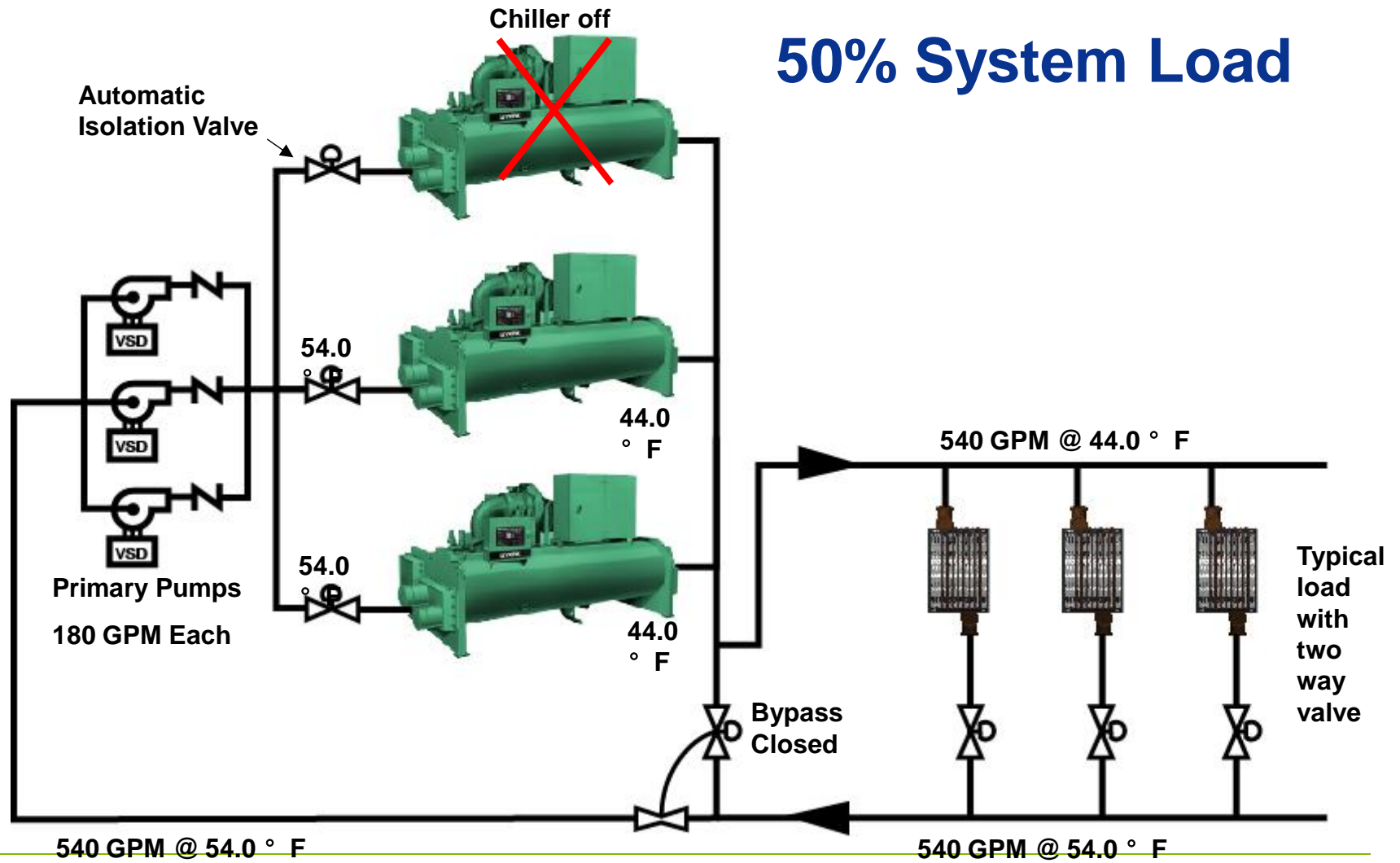
# Variable Primary System – Part Load

## 75% System Load



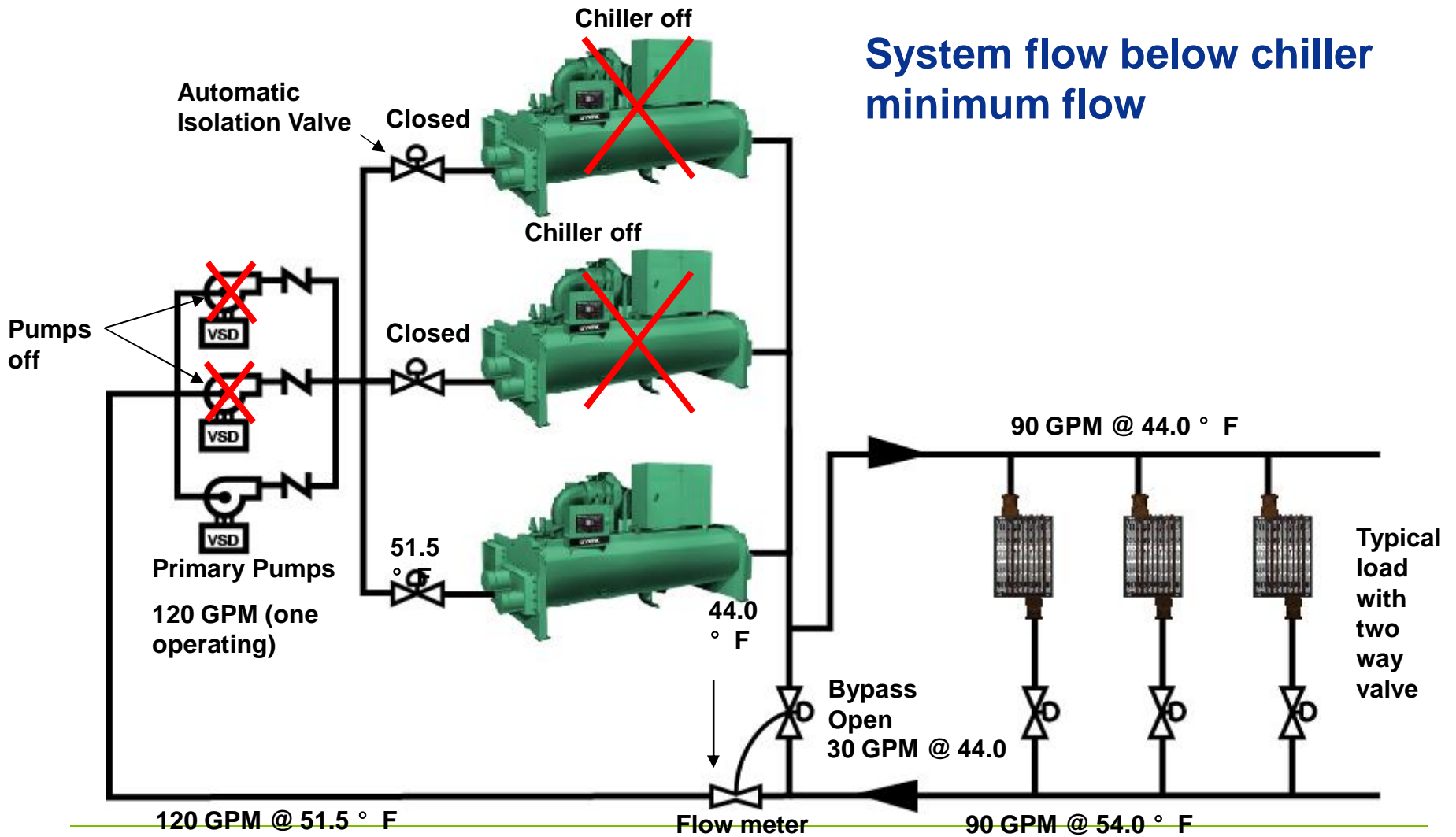
# Variable Primary System – Part Load

## 50% System Load

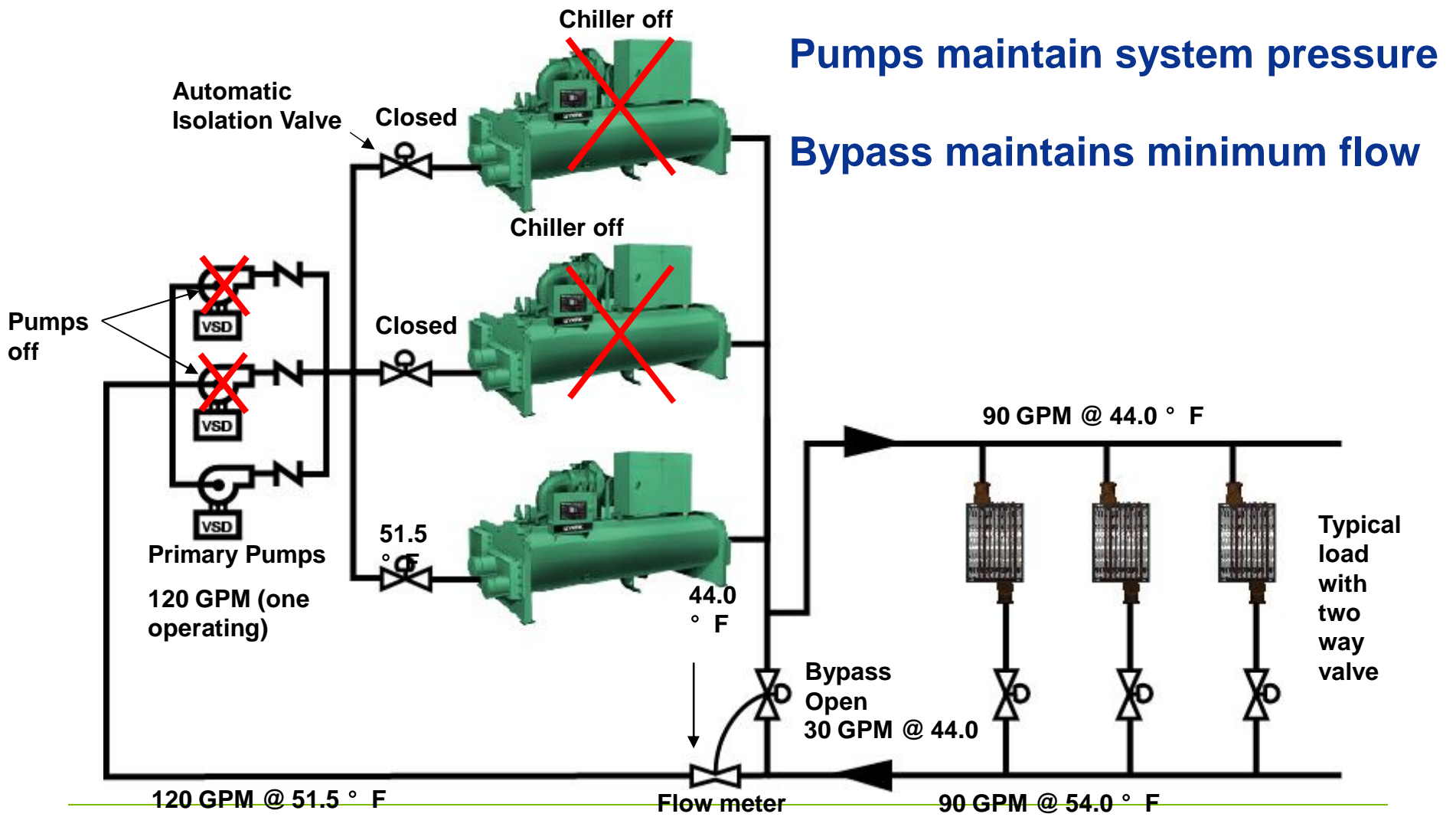


# Variable Primary System – Min Flow (120 gpm each)

**System flow below chiller minimum flow**



# Variable Primary System – Min Flow (120 gpm each)





## Designing a VPF Bypass

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- Size for minimum flow through one chiller
  - Valve head ratings must be higher than pump dead head
  - Linear characteristic - valve position % equals flow %
  - Fast actuator
  - Valve control range 100:1
  - Flow meter controls bypass to maintain chiller minimum flow
-

## Selecting a VPF Flow Meter for Small Tonnage Systems

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- Best accuracy job can afford
  - Minimum +/- 5% at evaporator minimum flow
  - Set bypass to open when flow equals minimum plus 2 times flow meter accuracy rating
    - Example: 120 gpm minimum, flow meter +/- 5%, set minimum flow at  $120 + 120 * 10\% = 132$  gpm
  - Calibrate flow meter at least as often as manufacturer recommends
  - Buy the best
-

## Selecting VPF AHU Control Valves

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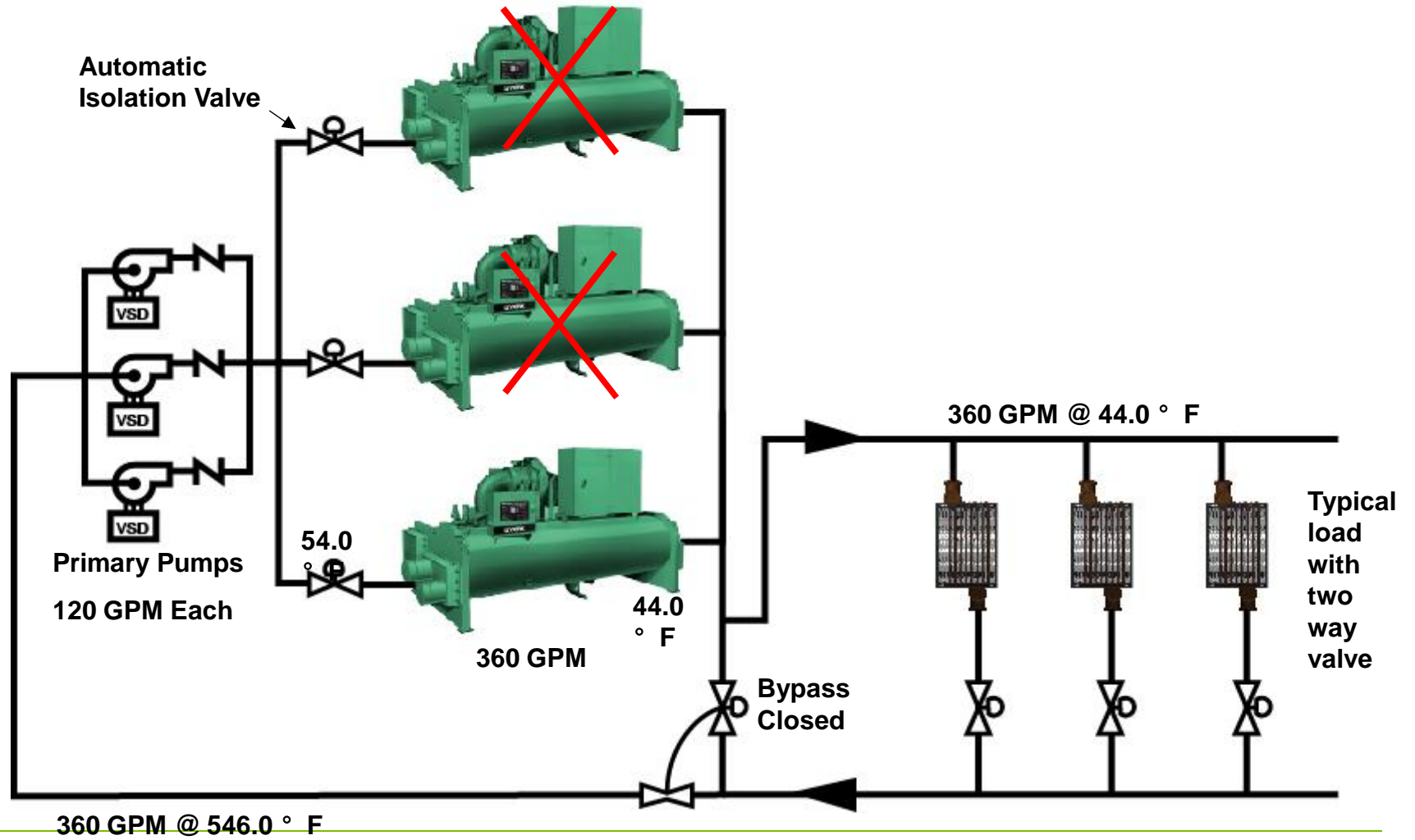
- All valve pressure ratings greater than pump dead head
  - Sized by pressure
  - % valve position equals % coil capacity
  - Control range 200:1
-

## Selecting VPF Chiller Isolation Valves

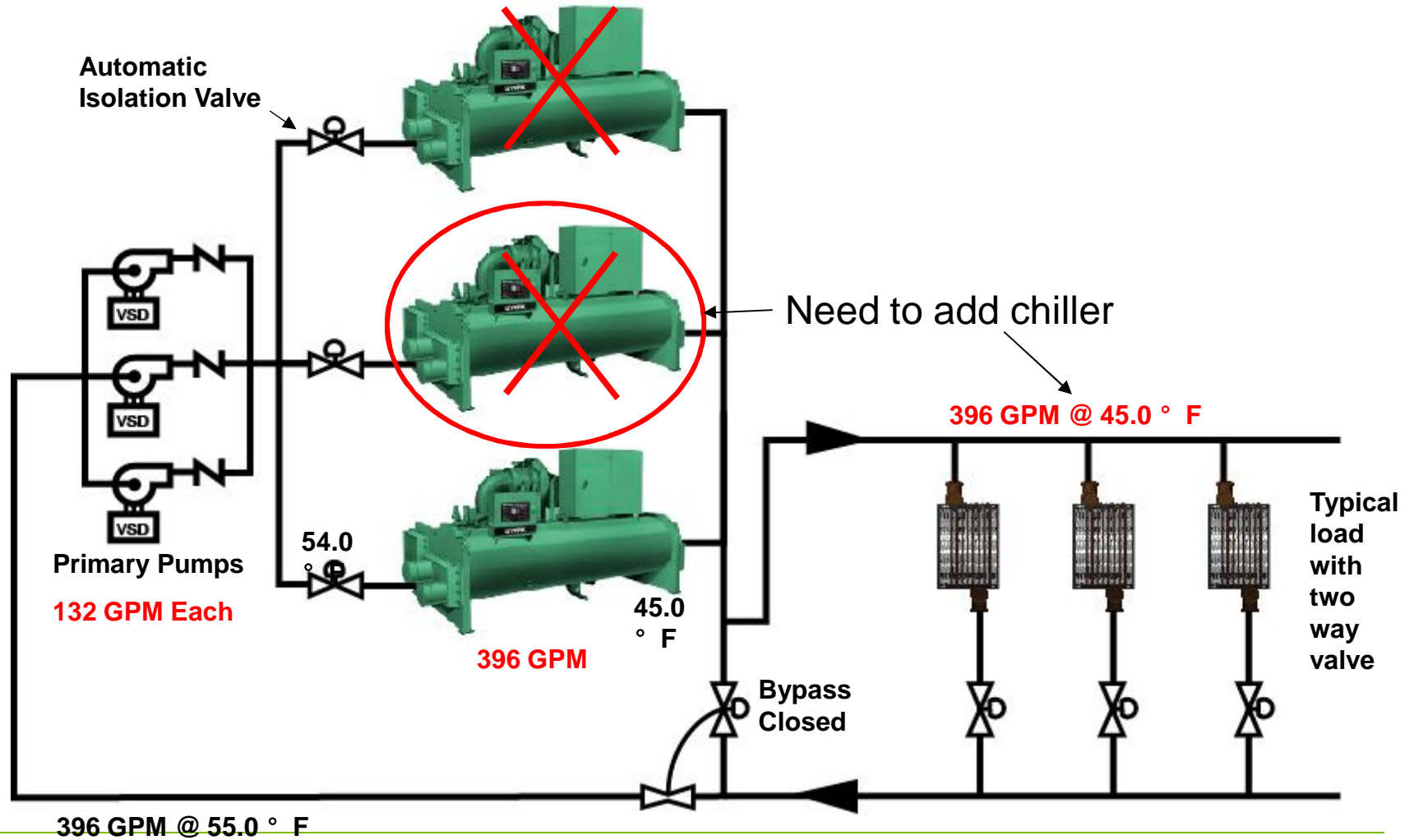
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- All valve pressure ratings greater than pump dead head
  - Linear characteristic - valve position % equals flow %
  - Modulating valve with slow actuator
-

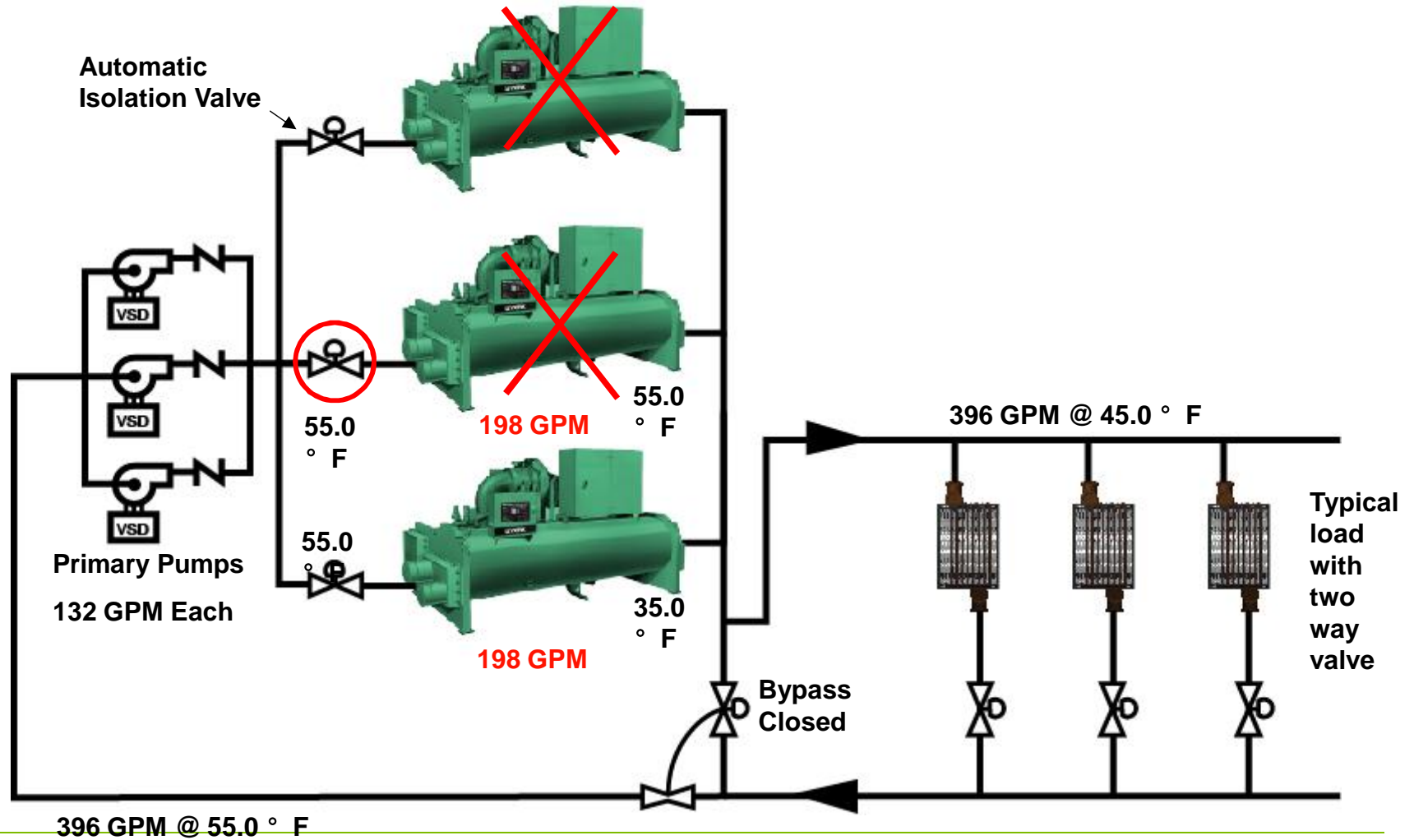
# Variable Primary System (1 chiller running)



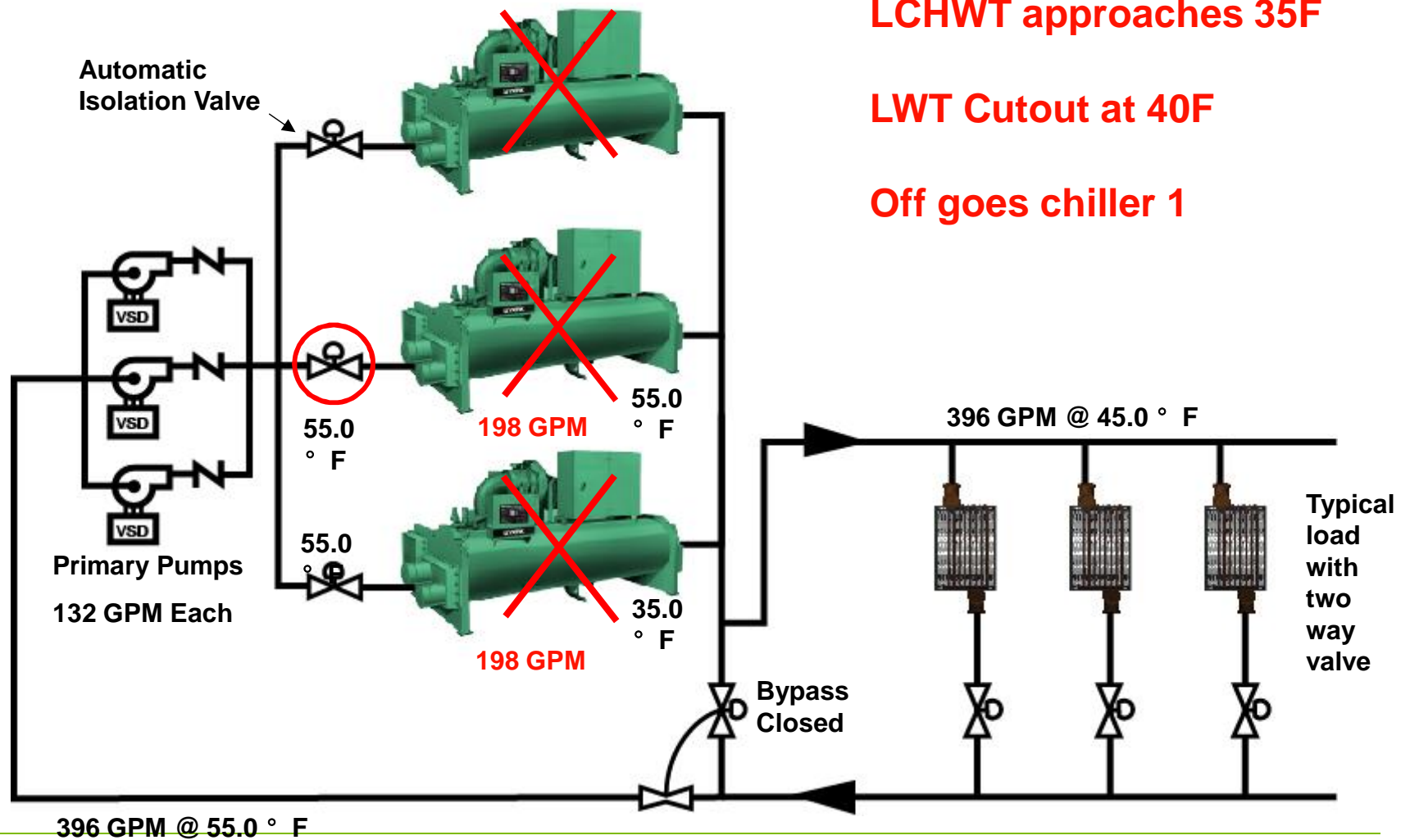
# Variable Primary System (Staging on second chiller)



# Variable Primary System (Open isolation valve)

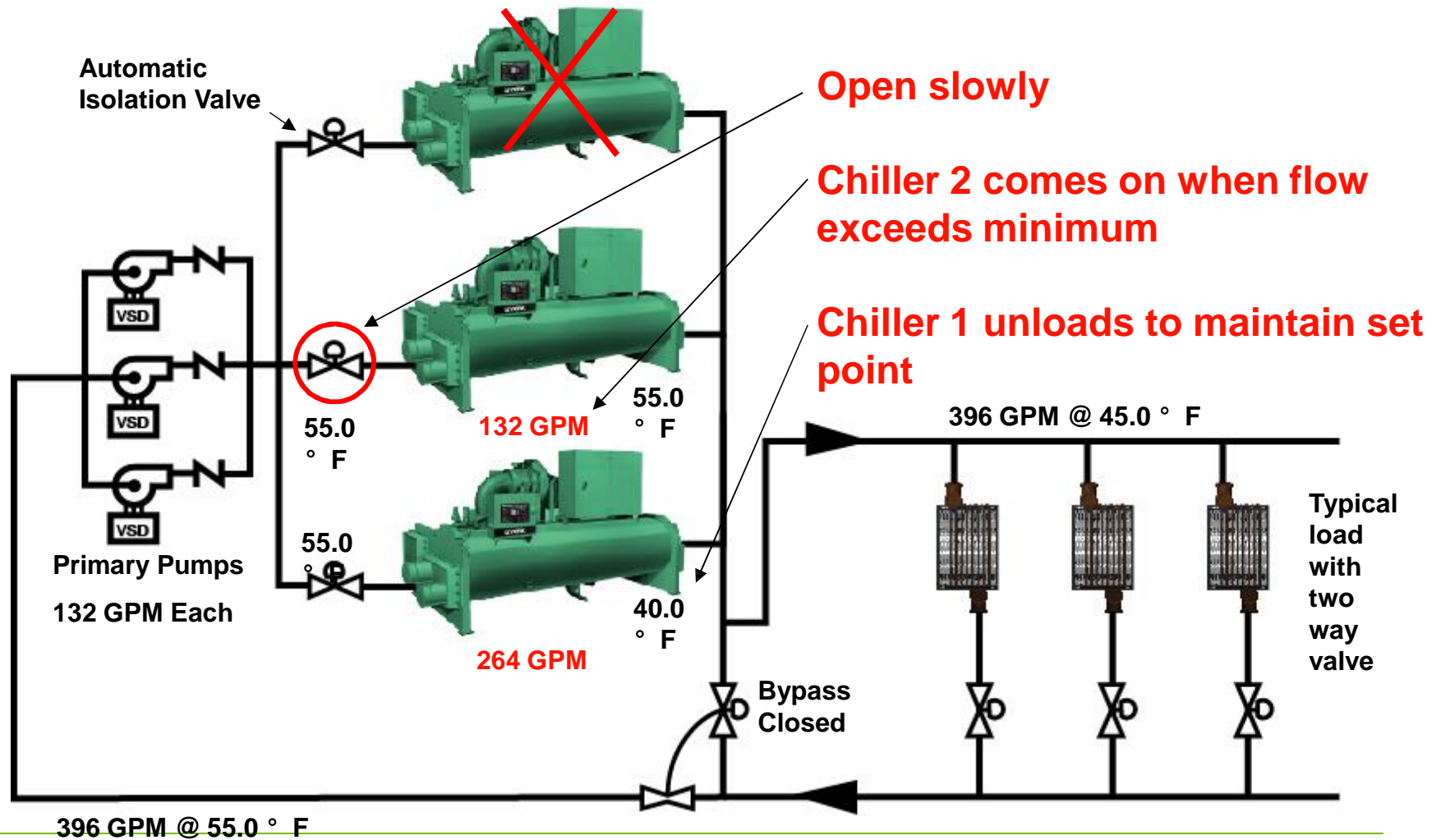


# Variable Primary System (Open isolation valve)

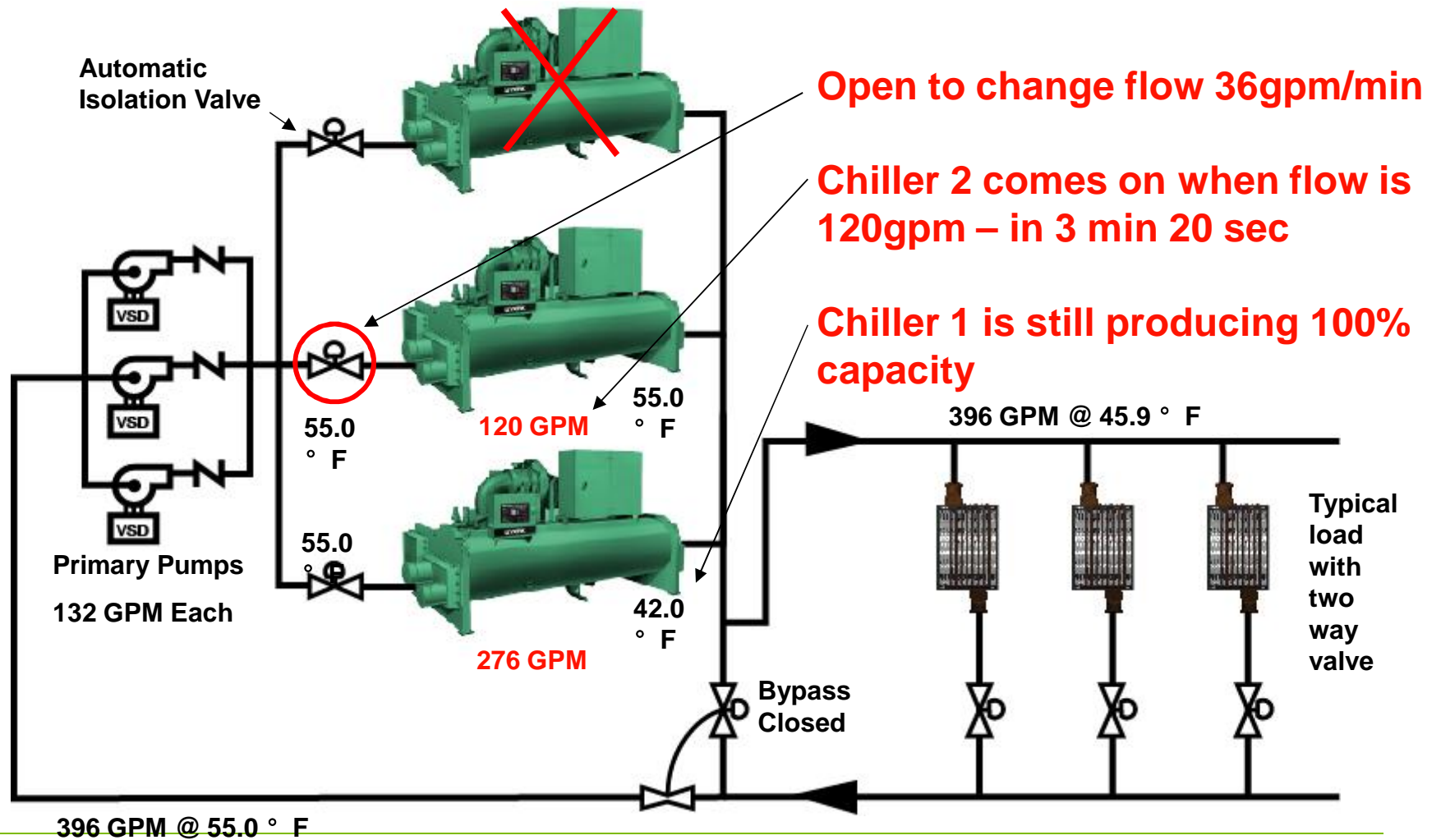




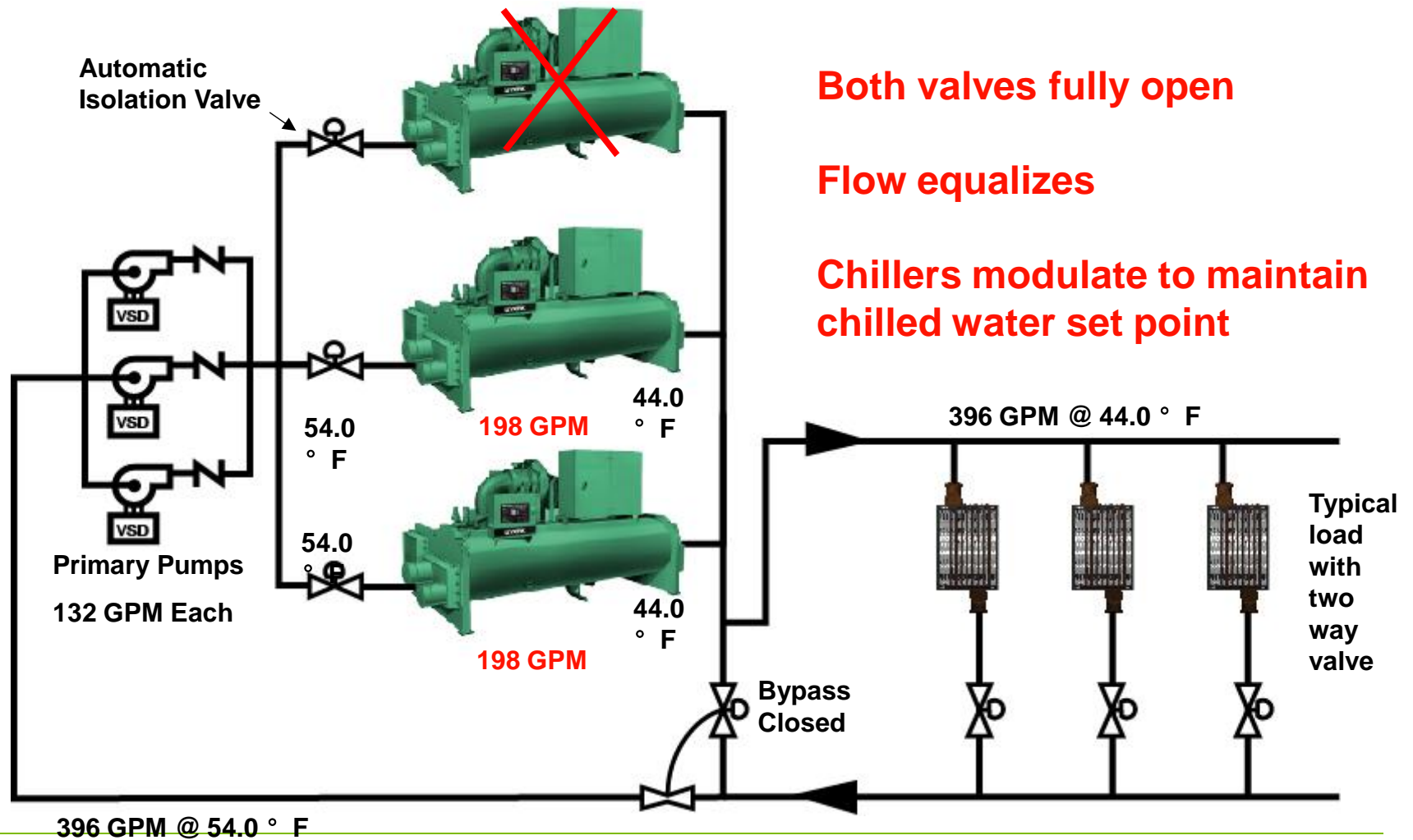
# Variable Primary System (Open isolation valve)



# Variable Primary System (Open isolation valve)



## Variable Primary System (Open isolation valve)



## Staging on Chiller 2 in VPF Systems

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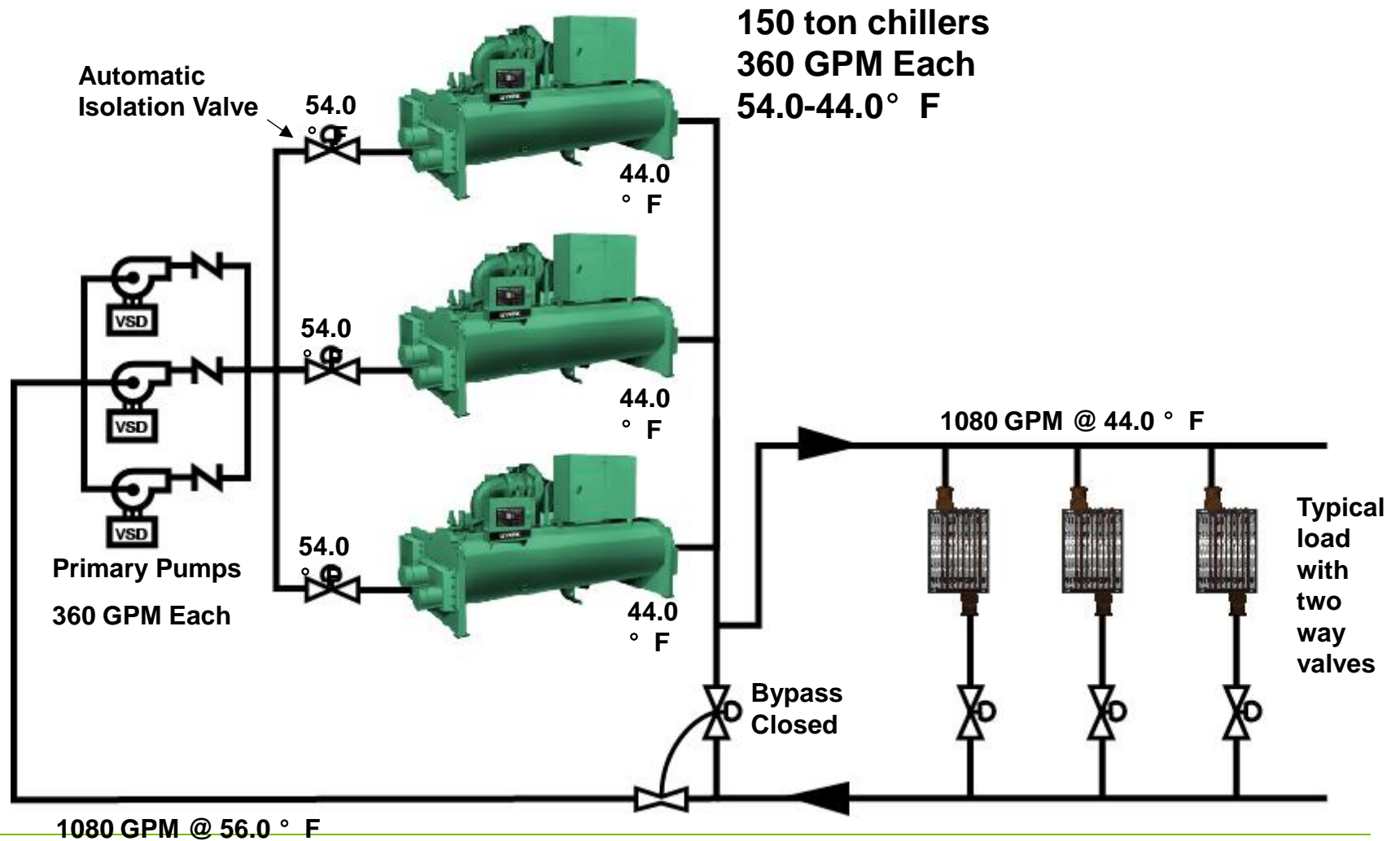
- Maintain minimum flow through the operating chiller
  - Avoid sudden changes in flow anywhere in the system
  - Prefer schemes that work when bringing on any chiller
-

## Setting Flow Rate of Change

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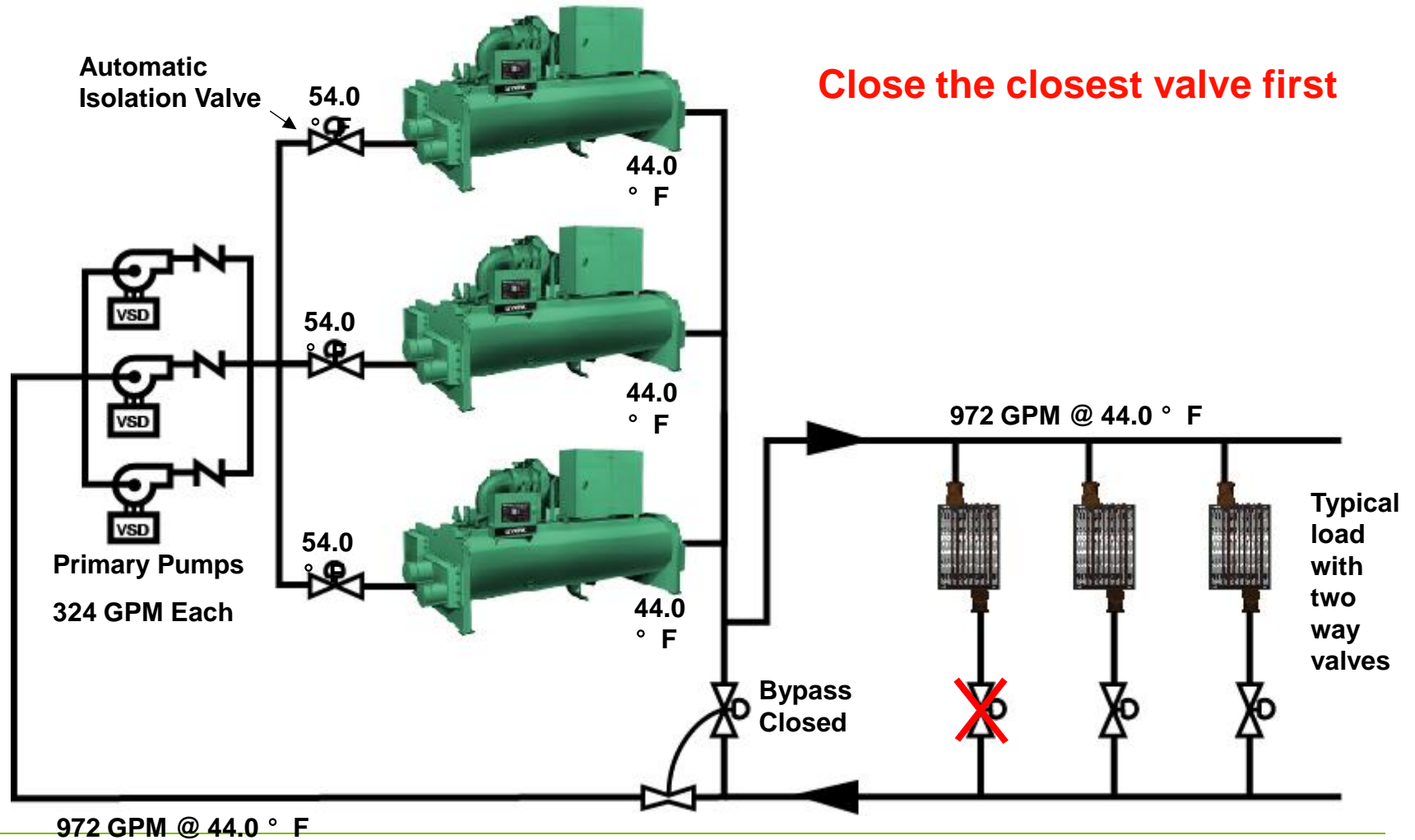
- Start with 10% of design flow per minute
  - Most small tonnage chillers can handle faster changes
  - If the project requires rapid flow changes, contact application engineering
  - If problems occur during operation, adjust the rate
-

## Variable Primary System – Handling Rapidly Decreasing Loads



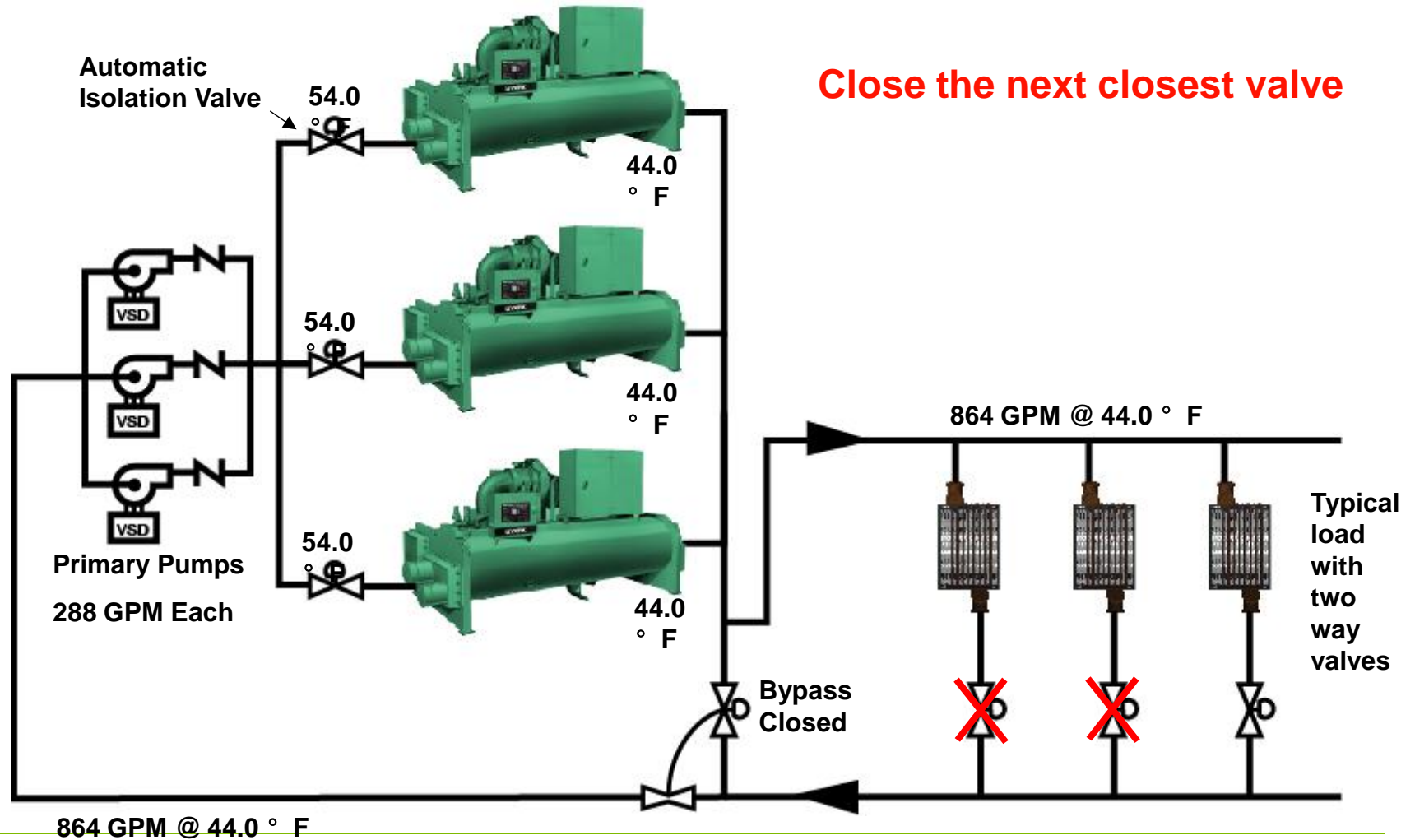


## Variable Primary System – Handling Rapidly Decreasing Loads

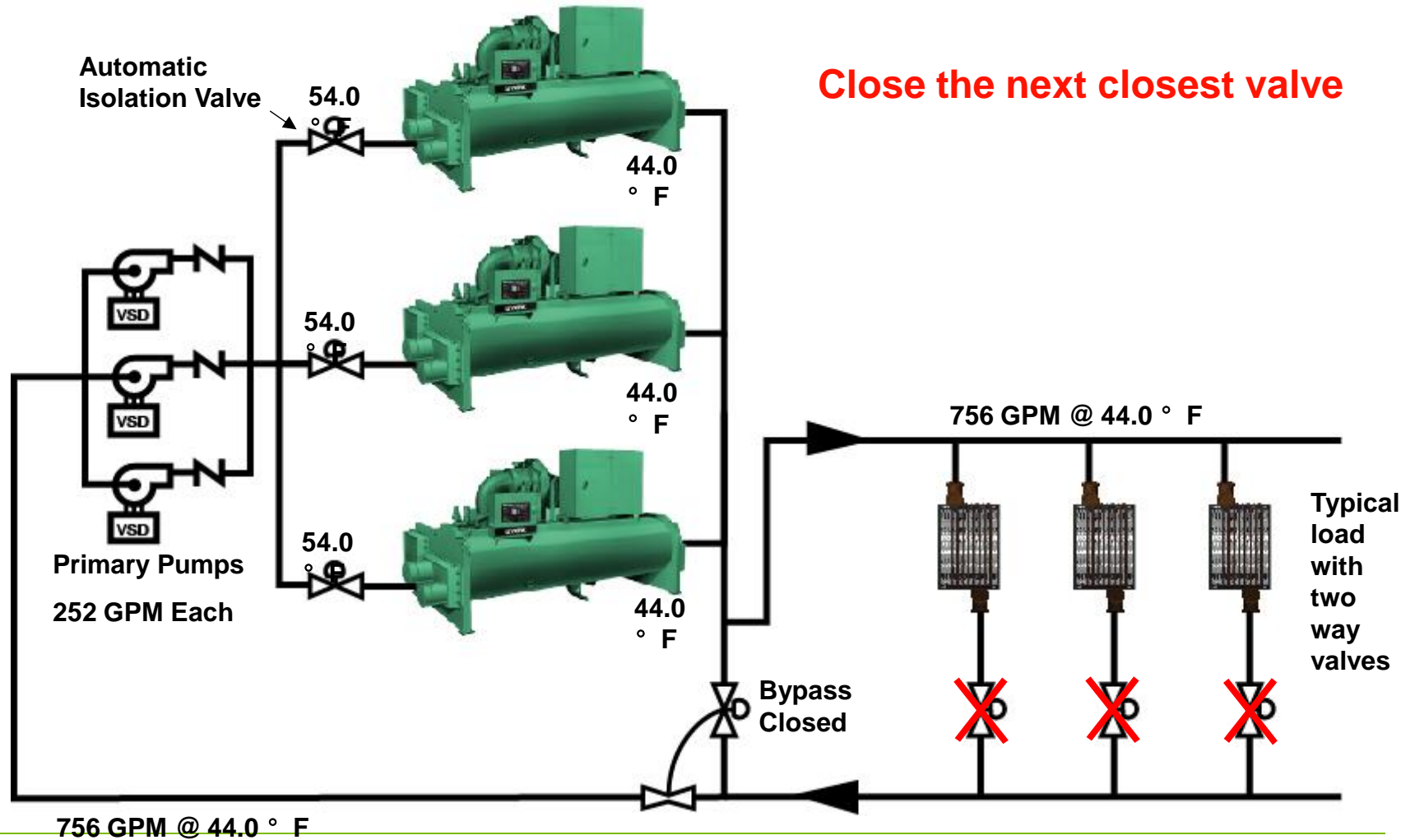




## Variable Primary System – Handling Rapidly Decreasing Loads



## Variable Primary System – Handling Rapidly Decreasing Loads



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# Questions?

