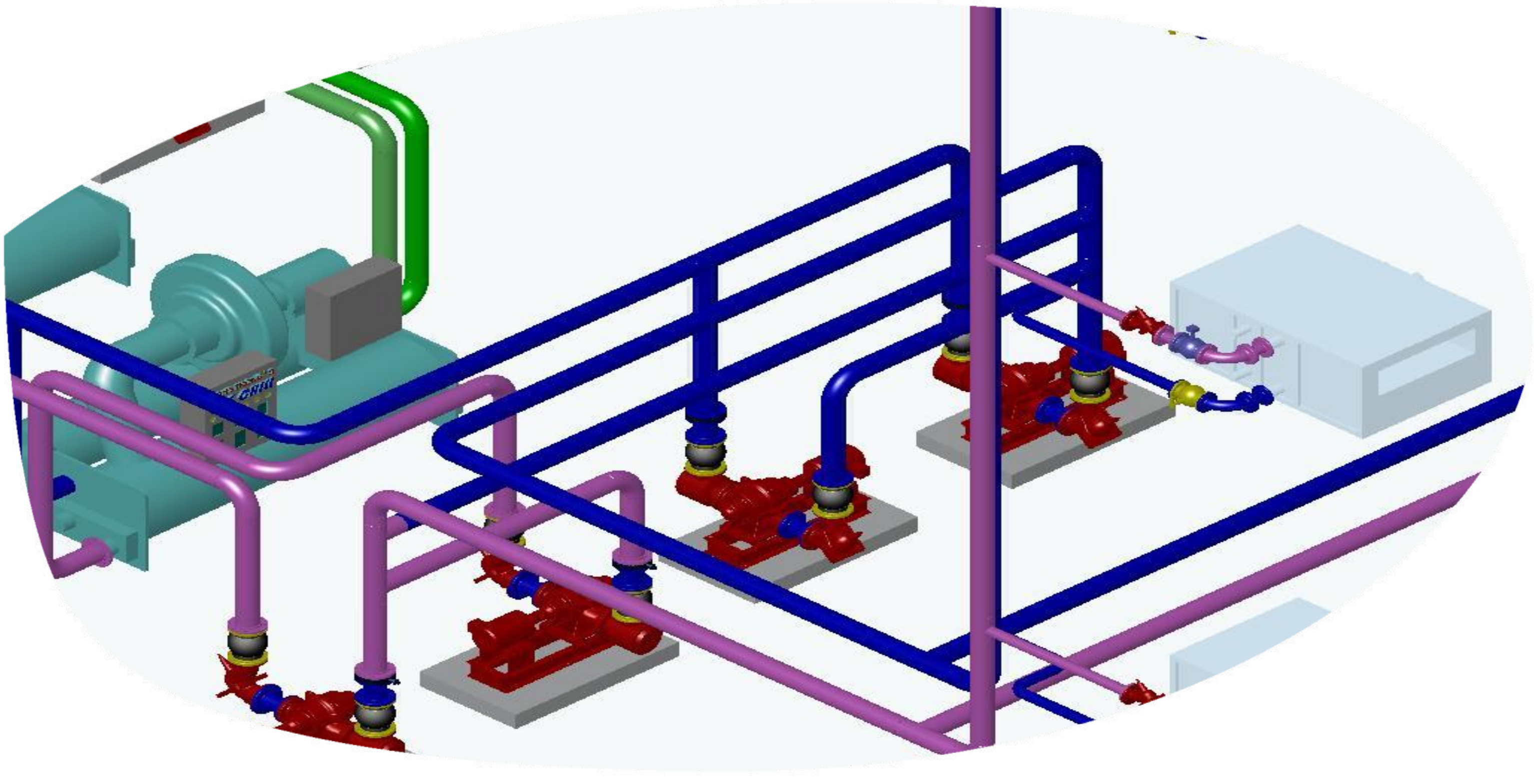
Designing a Chiller Plant Room to be the Most Efficient



Session 2 of 3 of the Series:

Optimizing Your Chiller Plant Room

Moderated by Laxmi Rao

Presented by Roy Hubbard and Bill Stewart

Johnson Controls

Welcome

- **Webinar Duration:** 1 hour 30 minutes

- **Panelists:** Please silence /shut cell phones.

- **Questions to Presenters:** Please type in **Questions** in the **Q&A box** at the lower right hand corner of screen. **Questions will be answered after the end of the presentation.**

- **Moderator** will hand **Questions to presenters.** *Responses to unanswered questions will be provided by Jill Woltkamp after the webinar.*

- If you are just dialed in with audio, also send questions to jill.h.woltkamp@jci.com

- **Webinar (function) questions :** Please chat with Cheryl. Use the Chat box in the middle right hand section of the screen and choose - **"Chat privately to Cheryl".**

- **Survey:** Please complete the survey following the webinar

- **Webinar Download:** Recording and Presentation slides will be available at **www.districtenergy.org**

- **Note:** Session 2 will be more meaningful after viewing Session 1. "Using variable Speed drives in Central Plants with Multiple Chillers"

SELECT, DESIGN, OPTIMIZE

Optimizing Your Chiller Plant Room Webinar Program:

#1 Using Variable Speed Drives in Central Plants with Multiple Chillers

August 16, 2012

#2 Designing a Chiller Plant to be the Most Efficient

October 11, 2012

#3 Defining and Implementing Chiller Plant Optimization

Thursday
December
6th

Johnson Controls

Agenda

- Review the 5 VSD Myths
- Myth # 6 – Water Flow Tracks Load
- Myth # 7 – Pump Speed Tracks Flow
- Myth # 8 – Pumps/Towers Use More Energy Than Chillers Can Save
- Summary
- Q&A

Review

The 5 Variable Speed Drive Myths are:

BUSTED

Johnson Controls

Review

#1

In a central plant: Run the fewest number of constant speed chillers, as heavily loaded as possible

Review

#1

In a central plant: Run the fewest number of constant speed chillers, as heavily loaded as possible

BUSTED

The most efficient place to run your chiller today is at PART LOAD

Review

#2

Chillers cannot run on cold tower water

Review

#2

Chillers cannot run on cold tower water

BUSTED

Variable Orifice Technology allows the ability to use cold tower water

Johnson Controls

#3

Do not use VSDs on Fully Loaded Chillers in a Central Plant

Review

#3

Do not use VSDs on Fully Loaded Chillers in a Central Plant

VSD technology saves an additional 17% energy on a fully loaded chiller with 55°F ECWT

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Review

#4

Variable Speed Drives Only Save Energy on a Single Chiller

Review

#4

Variable Speed Drives Only Save Energy on a Single Chiller

BUSTED

Run All Chillers at Part Load with Variable Speed Drives to Save Energy

Review

#5

0.50 kW/ton, average, is Best-in-Class Efficiency for Chillers in a Central Plant

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Review

#5

0.50 kW/ton, average, is Best-in-Class Efficiency for Chillers in a Central Plant

0.40 and lower, average, is achievable with Part Load, Variable Speed Drive Chillers

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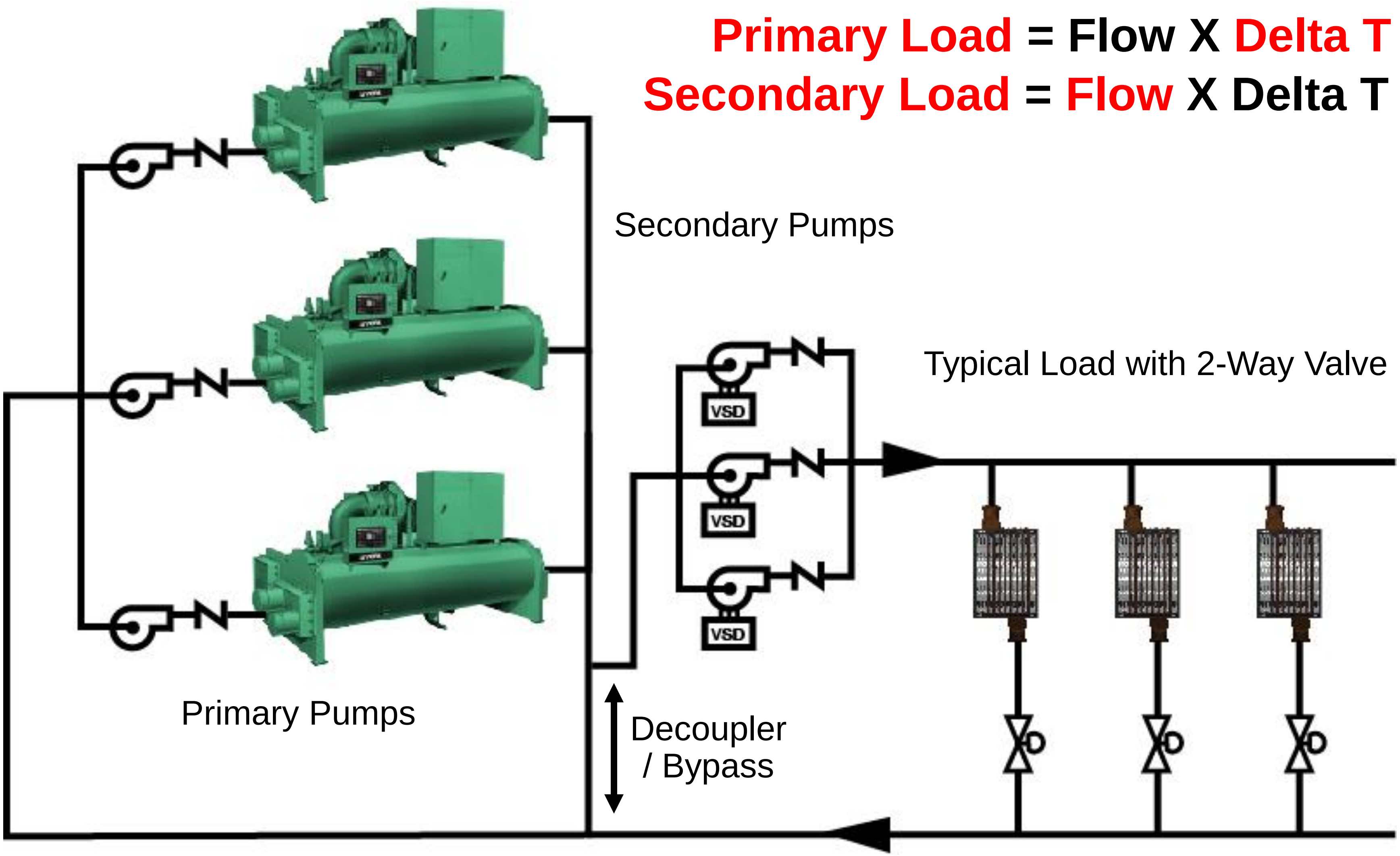
Completed..

Up Next....

Review the 5 Variable Speed Drive Myths

Present the basics of a Primary / Secondary System

Primary (Constant) / Secondary (Variable)



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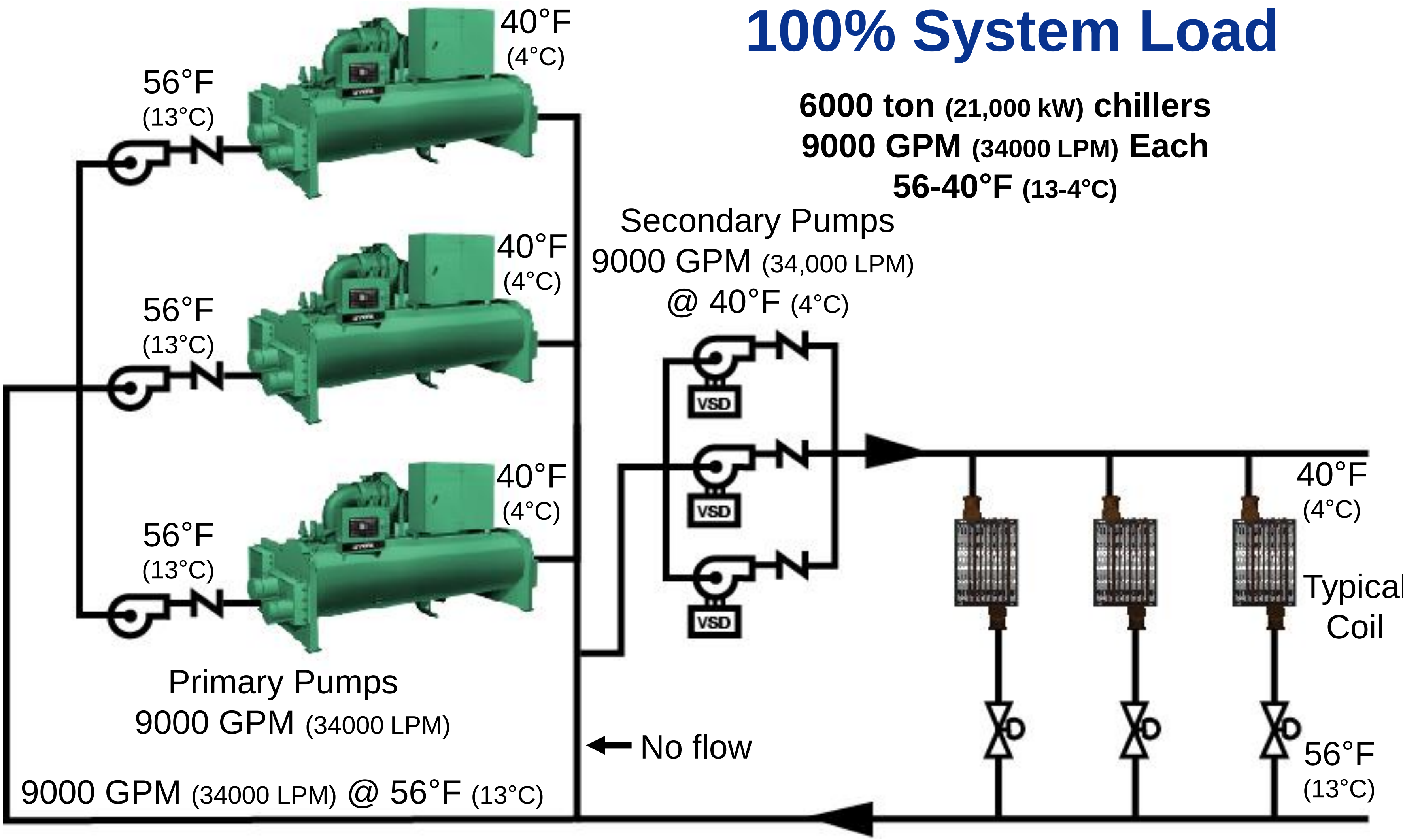
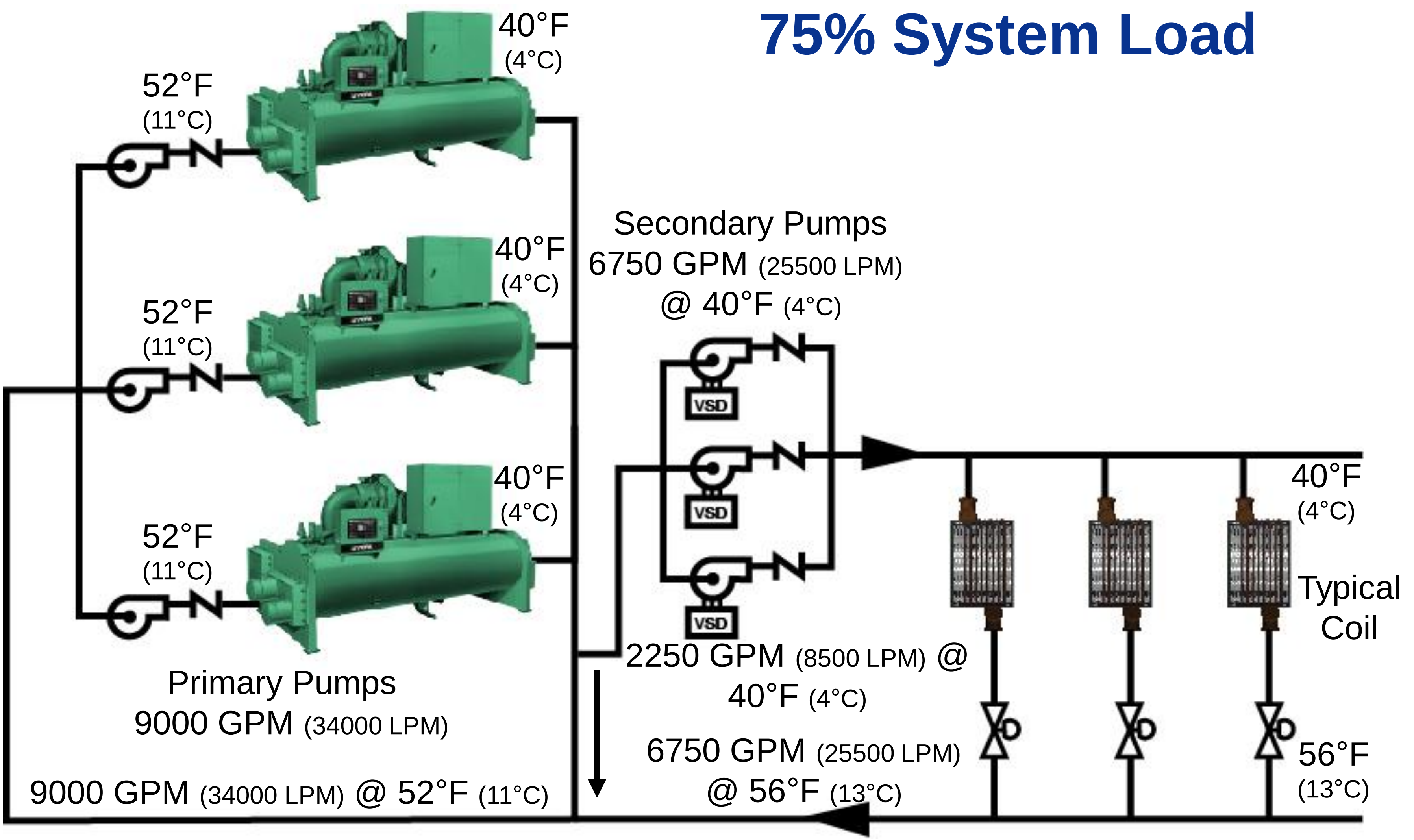
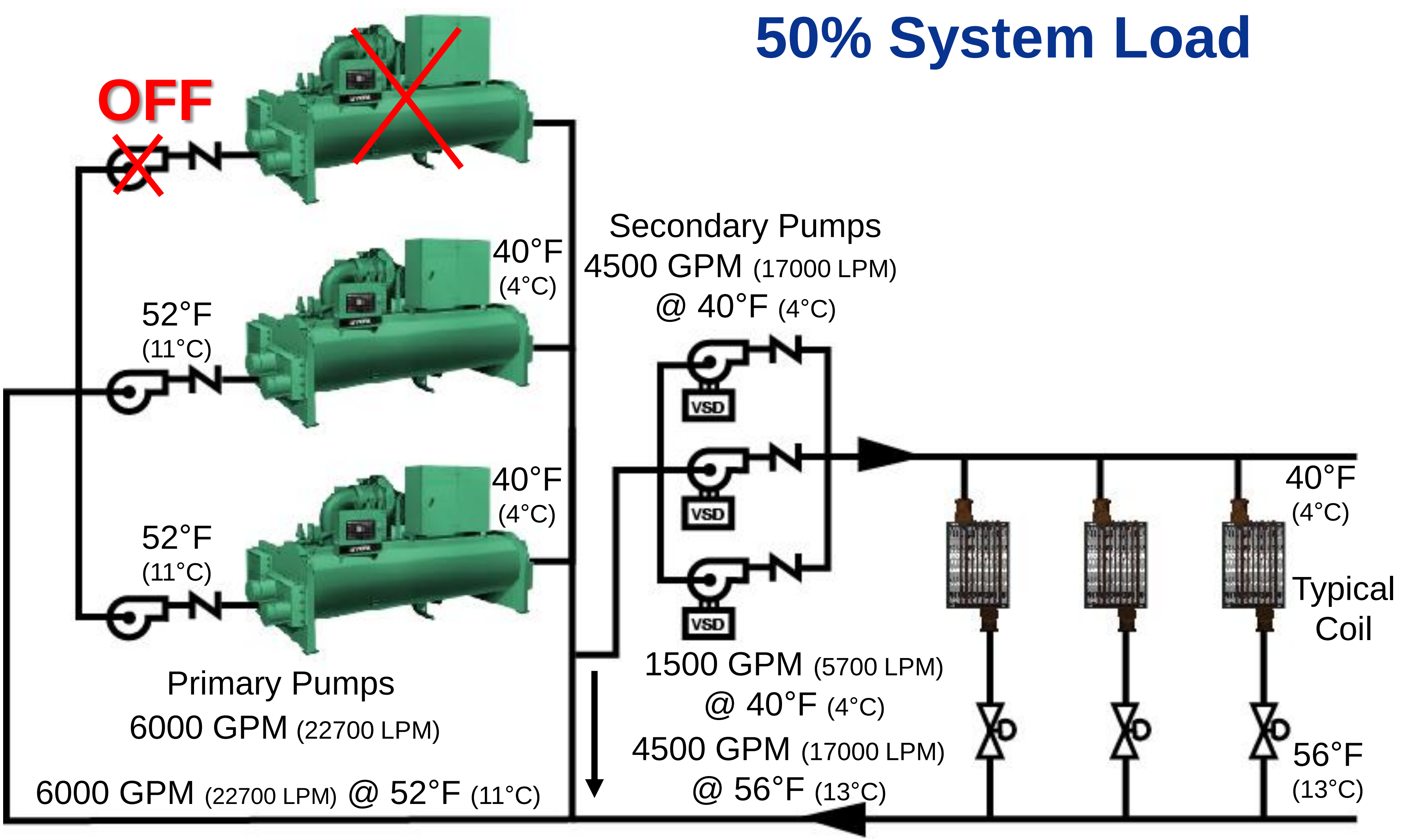
Primary / Secondary System at Design



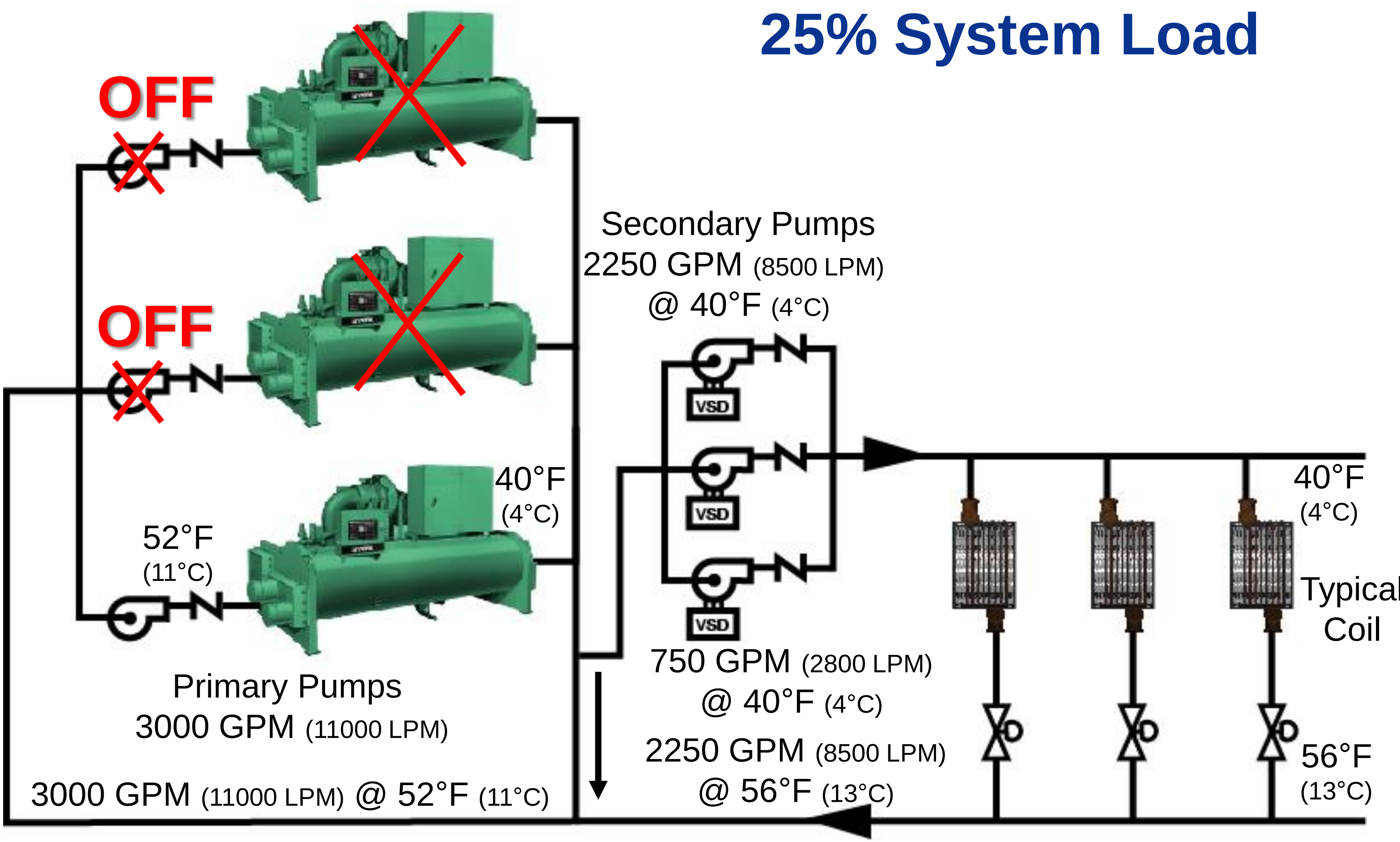
Primary / Secondary System at Part Load



Primary / Secondary System



Primary / Secondary System



Completed..

Up Next....

Present the basics of a Primary / Secondary System

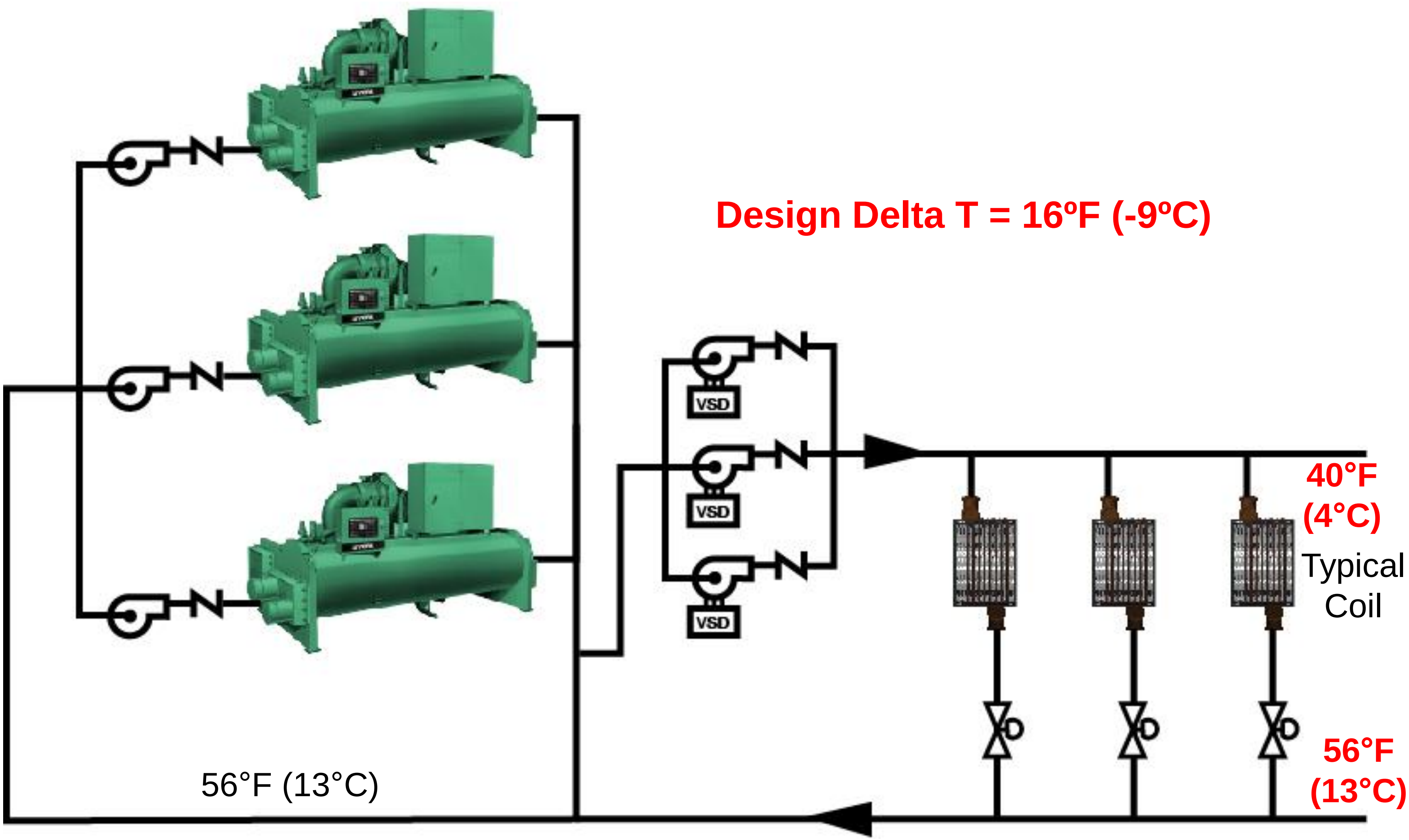
Review Myth #6

Johnson Controls

#6

Chilled Water Flow Tracks Campus Cooling Load

Low Delta T Syndrome

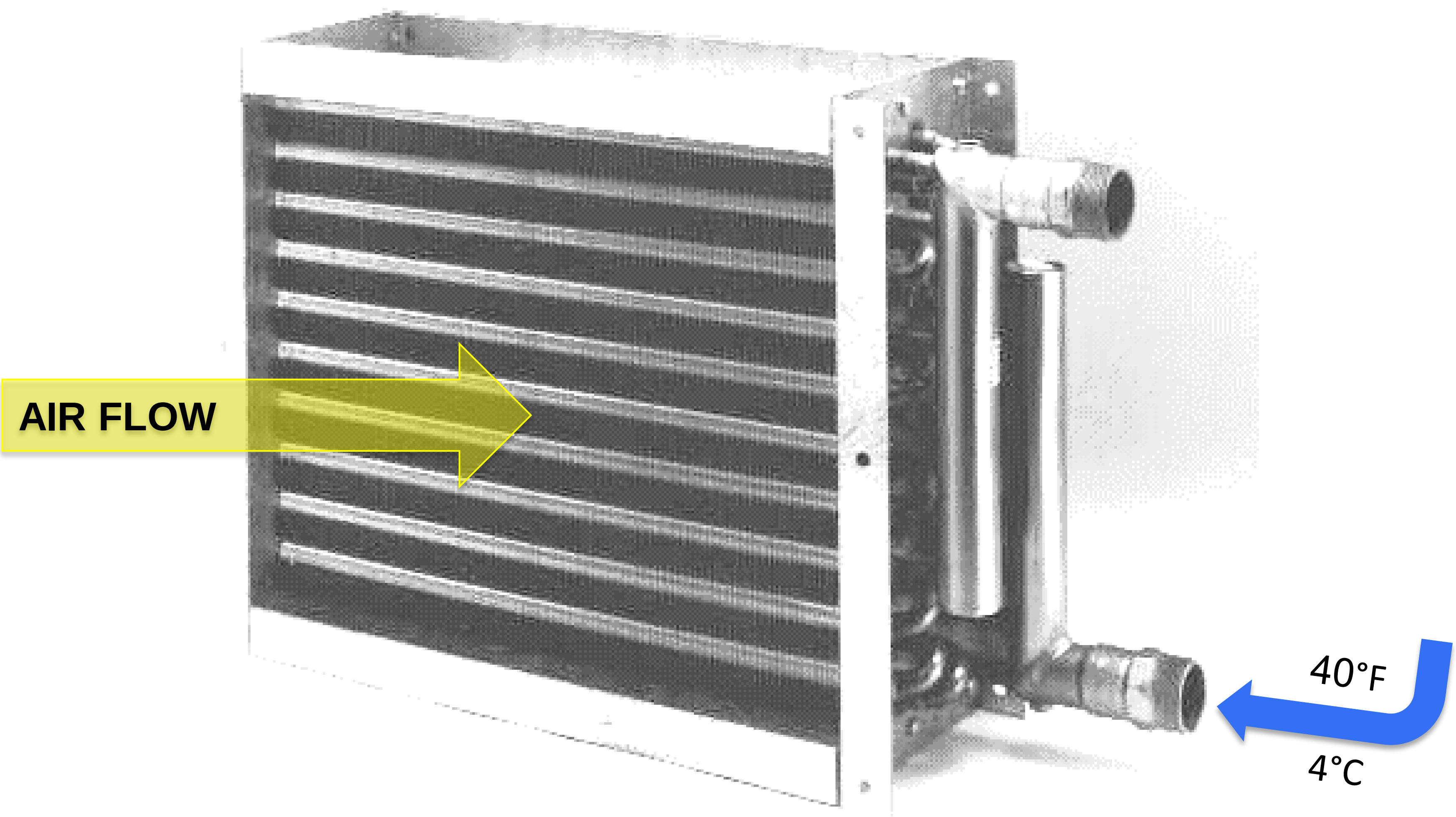


Johnson Controls

Major Causes of Low Delta T

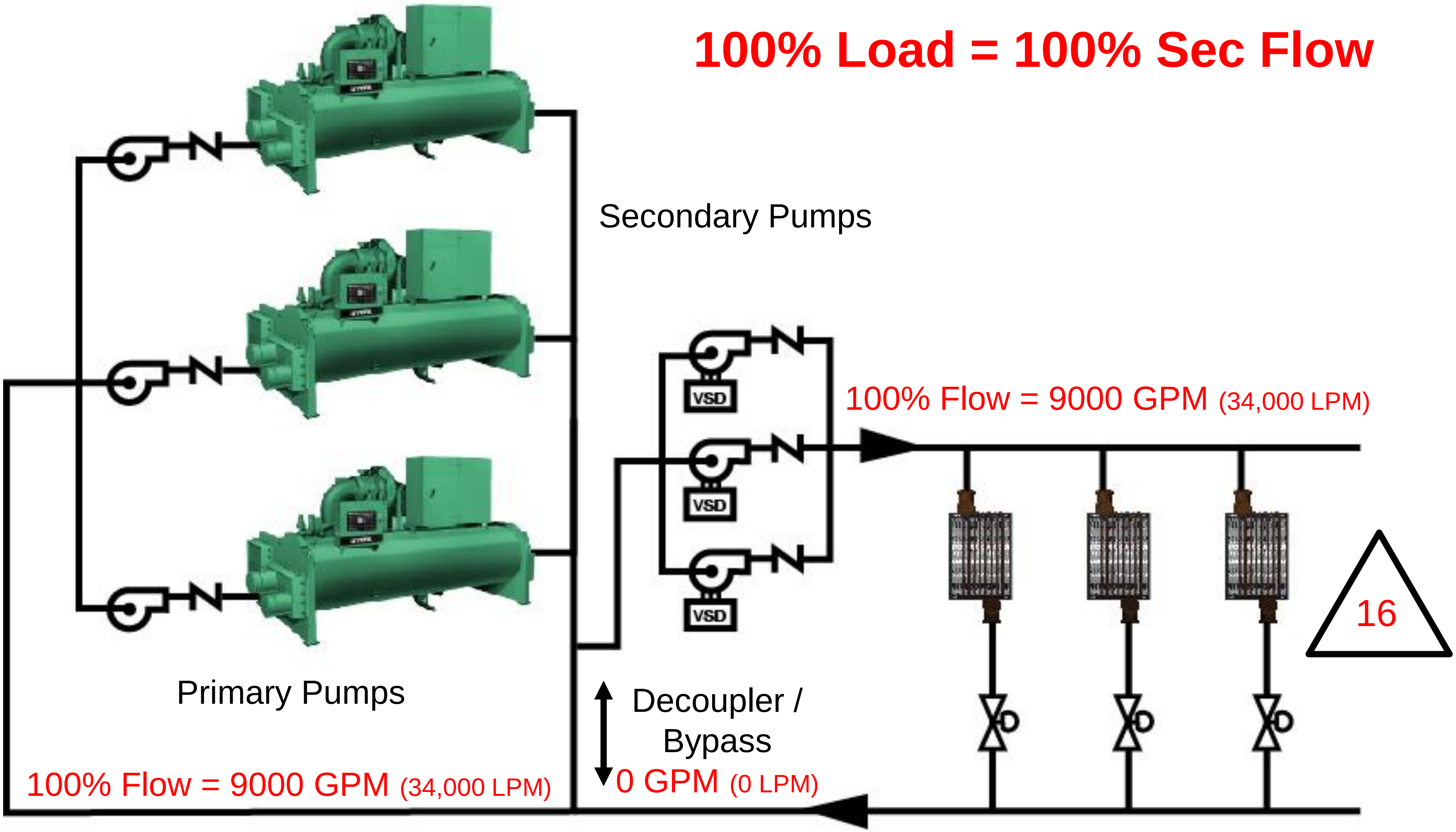
- Dirty Coils
- Controls Calibration
- Leaky 2-Way Valves
- Coils Piped-Up Backwards
- Mixing 2-Way with 3-Way Valves
- Etc., Etc.

Chilled Water Coil



Primary (Constant) / Secondary (Variable)

Ideal Operation



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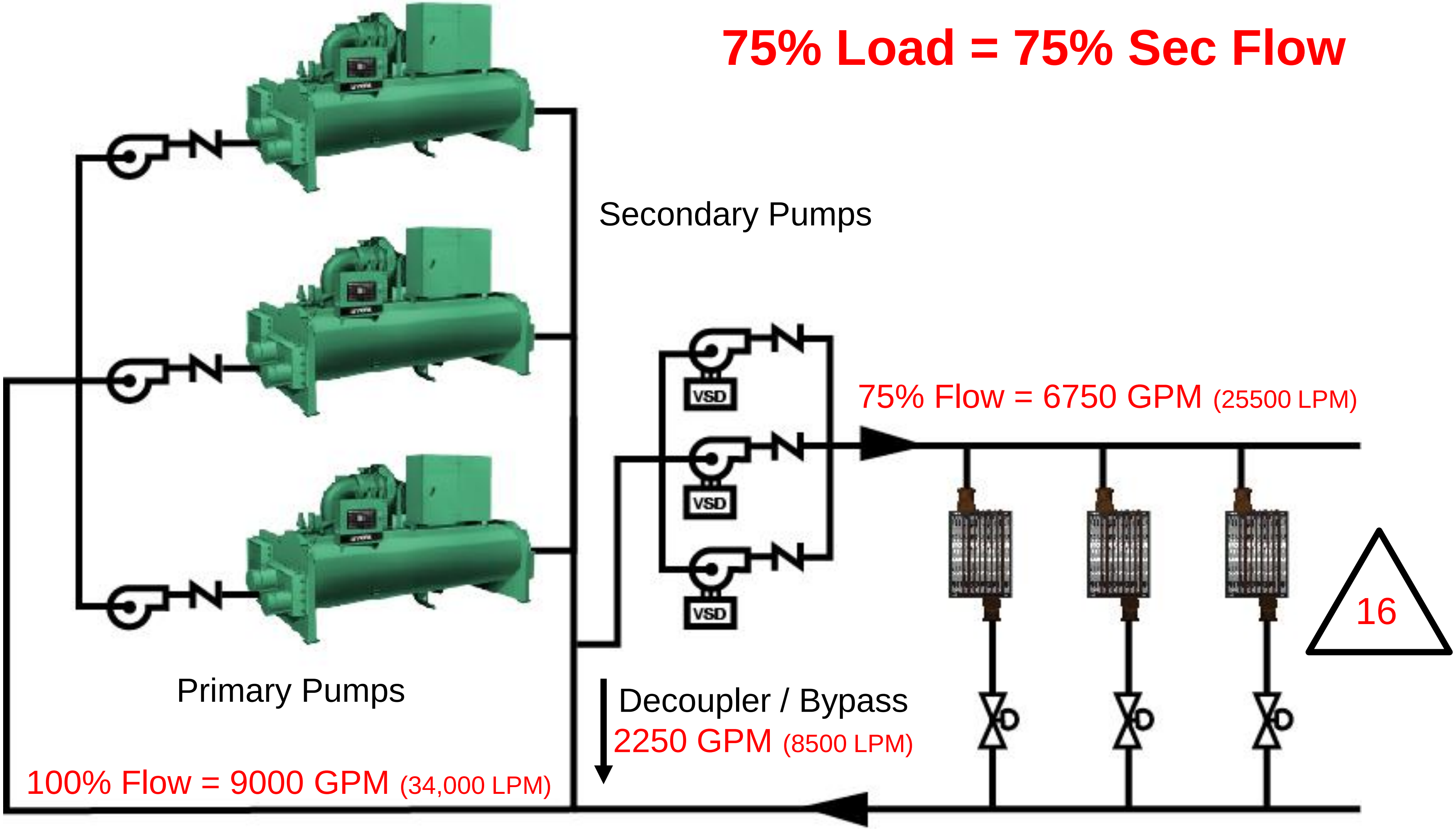
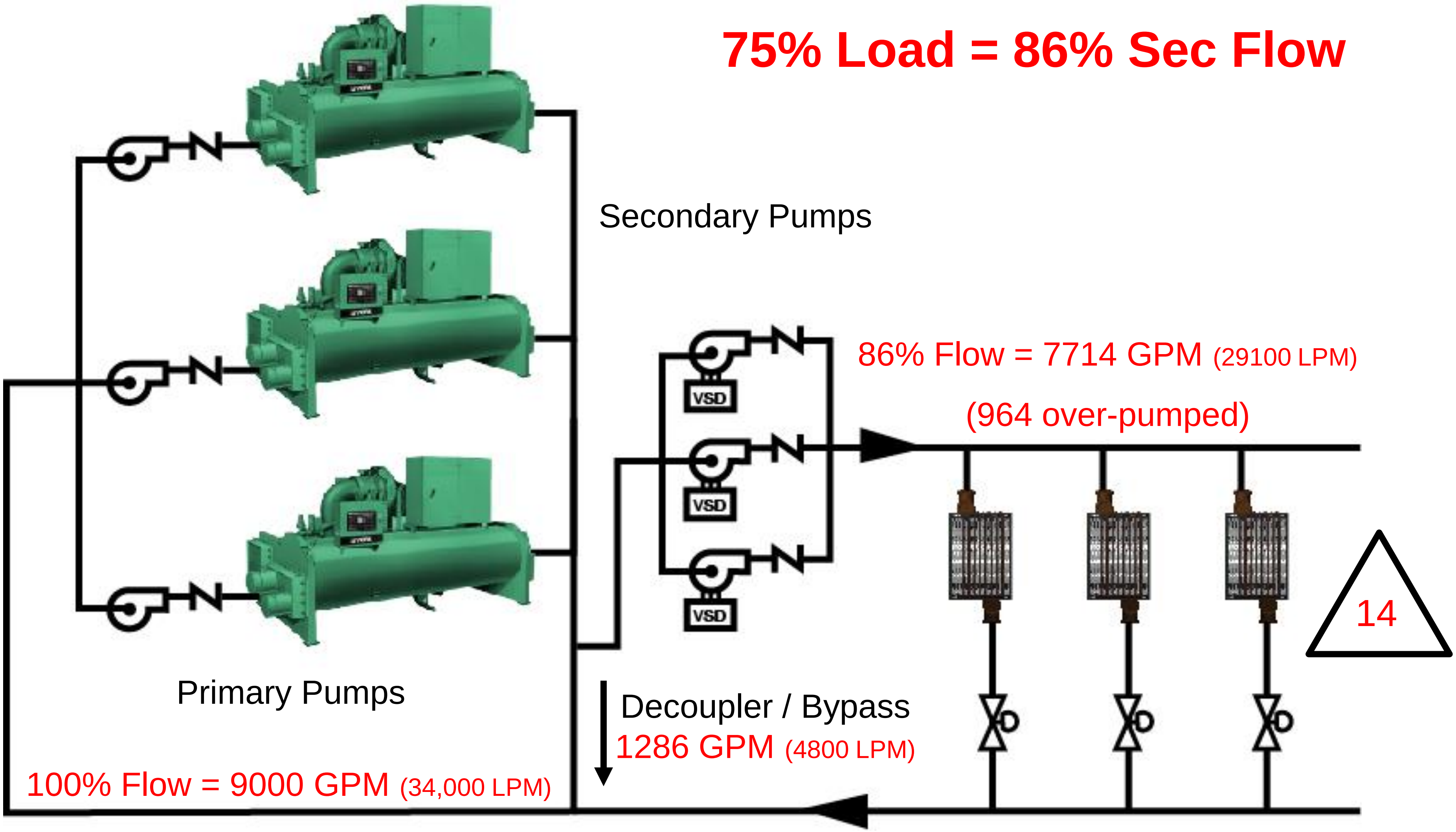
Ideal Operation



Primary (Constant) / Secondary (Variable)

Low Delta T Operation



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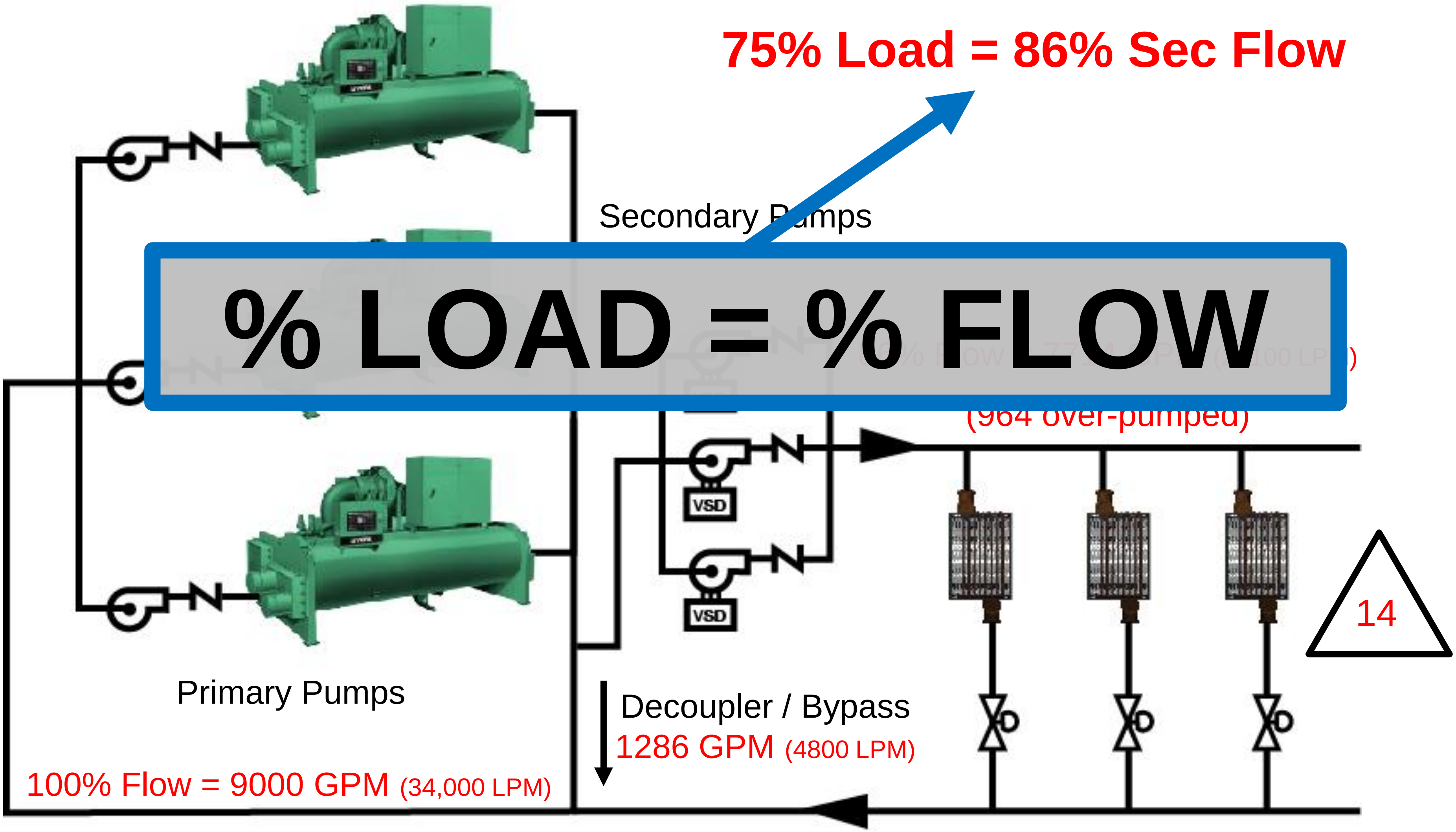
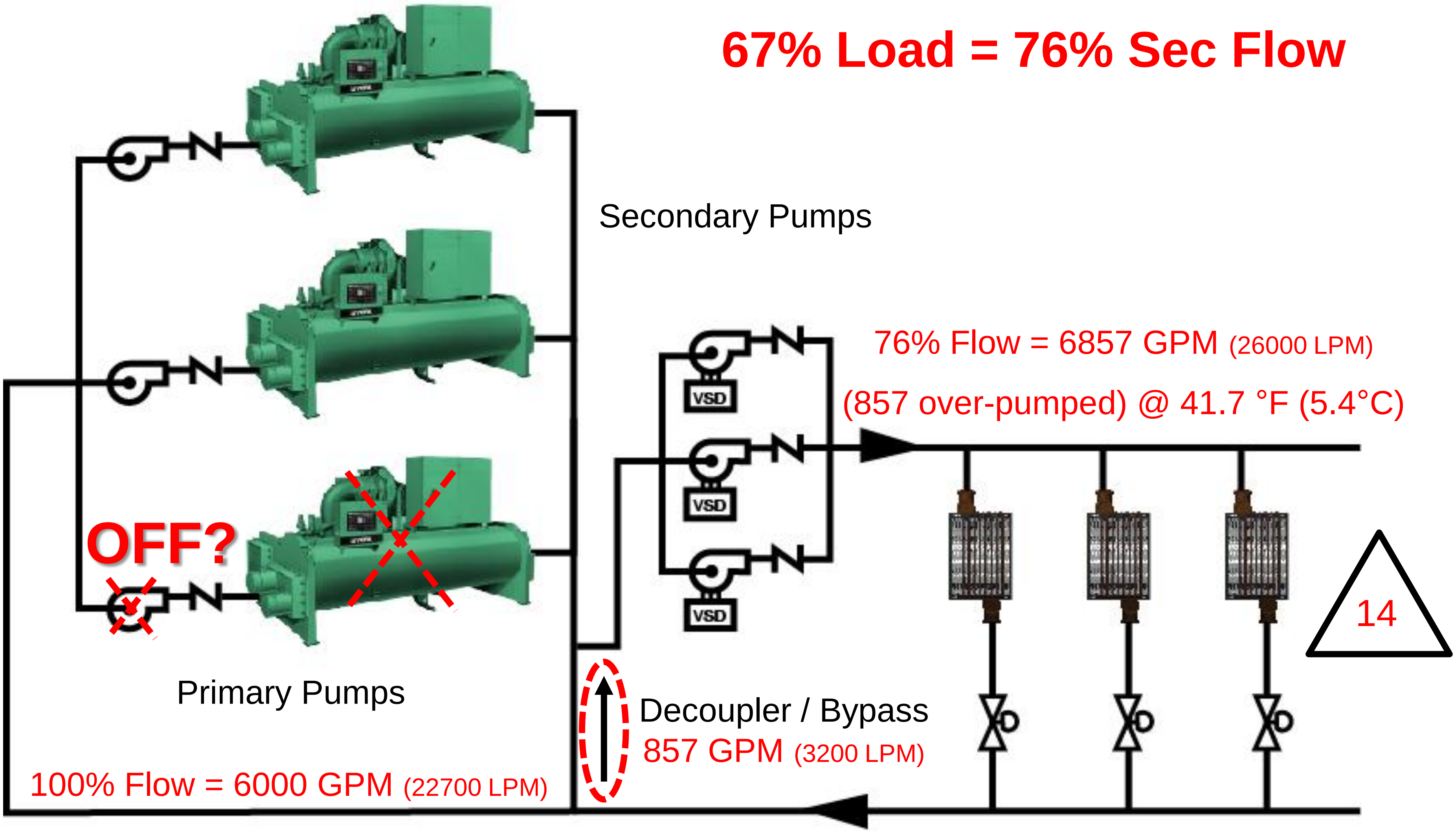


Primary (Constant) / Secondary (Variable)

Low Delta T Operation

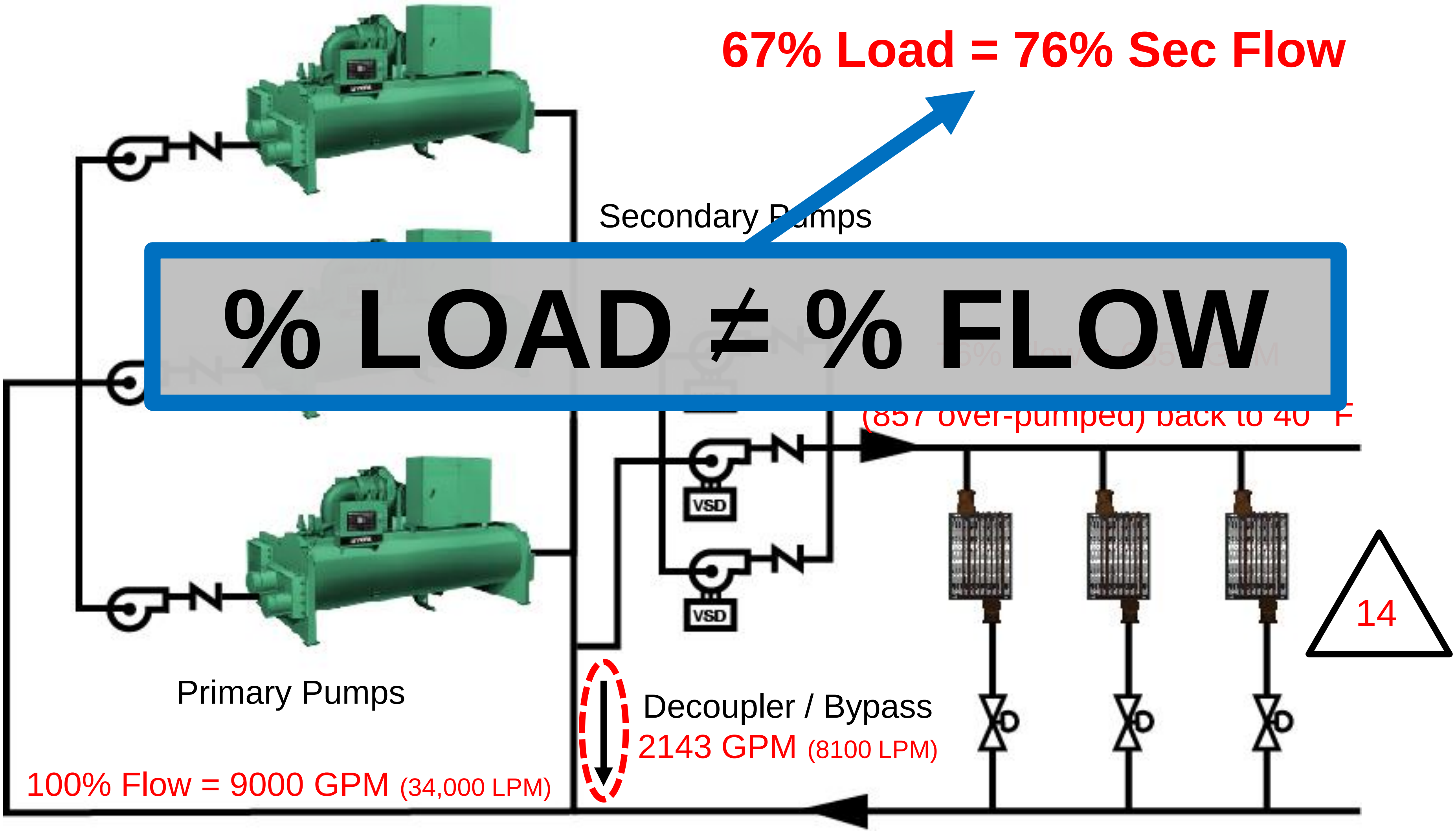


Primary / Secondary Rule of Flow

Primary Flow Must Always be <u>EQUAL TO</u> or <u>GREATER THAN</u> Secondary Flow

Primary (Constant) / Secondary (Variable)

Low Delta T Operation



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#6

Chilled Water Flow Tracks Campus Cooling Load

BUSTED

Real world operating systems will always develop low delta T; requiring more flow than needed for load.

Impact of Low Delta T

- Increased Flow for a Given Load – Pumps have to run faster and use more energy
- Can't load-up chillers greater than the low delta T ratio (actual delta T / design delta T)
- Increased Plant Energy – Must run more chiller systems than needed

Solve at Load, Mitigate at Plant

Mitigation of Low Delta T in Plant

- **Load (chillers capacity) = Flow x Delta T**
- **Increase Delta T across chillers with CHW Re-set (down)**
- Use VPF Headered Pumping Systems (mitigates energy waste in plant)

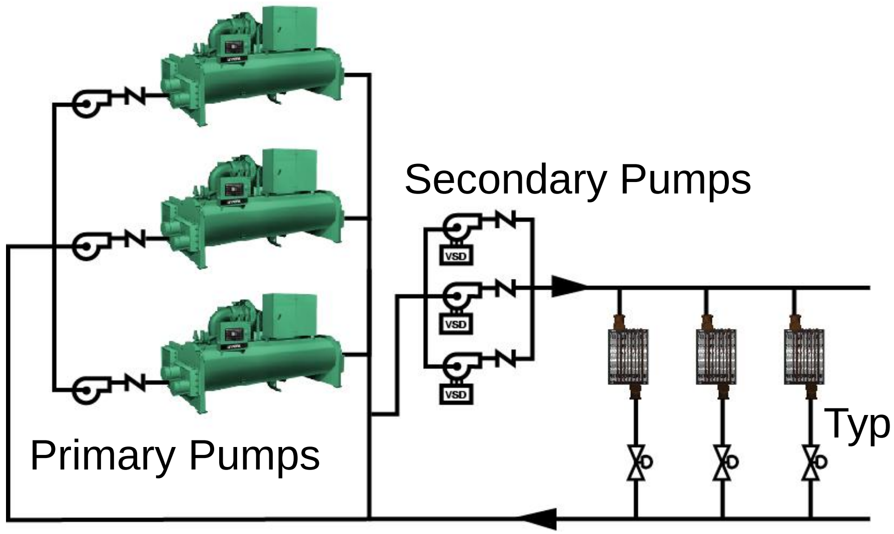
Completed..

Up Next....

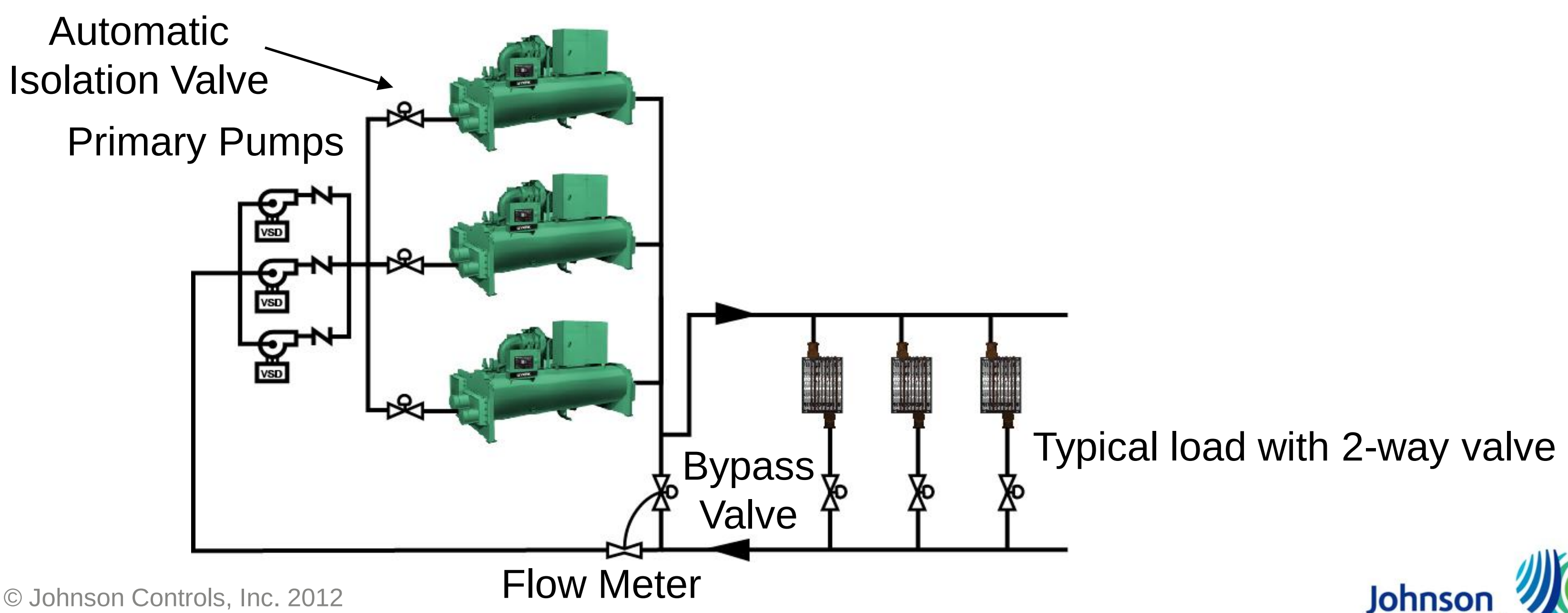
Understand Low Delta T and Bust Myth #6

Present the Basics of Variable Primary Flow

Primary / Secondary System



Variable Primary System



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Primary Only (Variable Flow)

Energy Use Advantages over Primary / Secondary System

- Better CHW Pump Energy Consumption
  - Higher Pump Efficiency
  - Lower Pump Design Head

$$BHP = \frac{GPM \times Head}{3960 \times Pump_{Eff}}$$

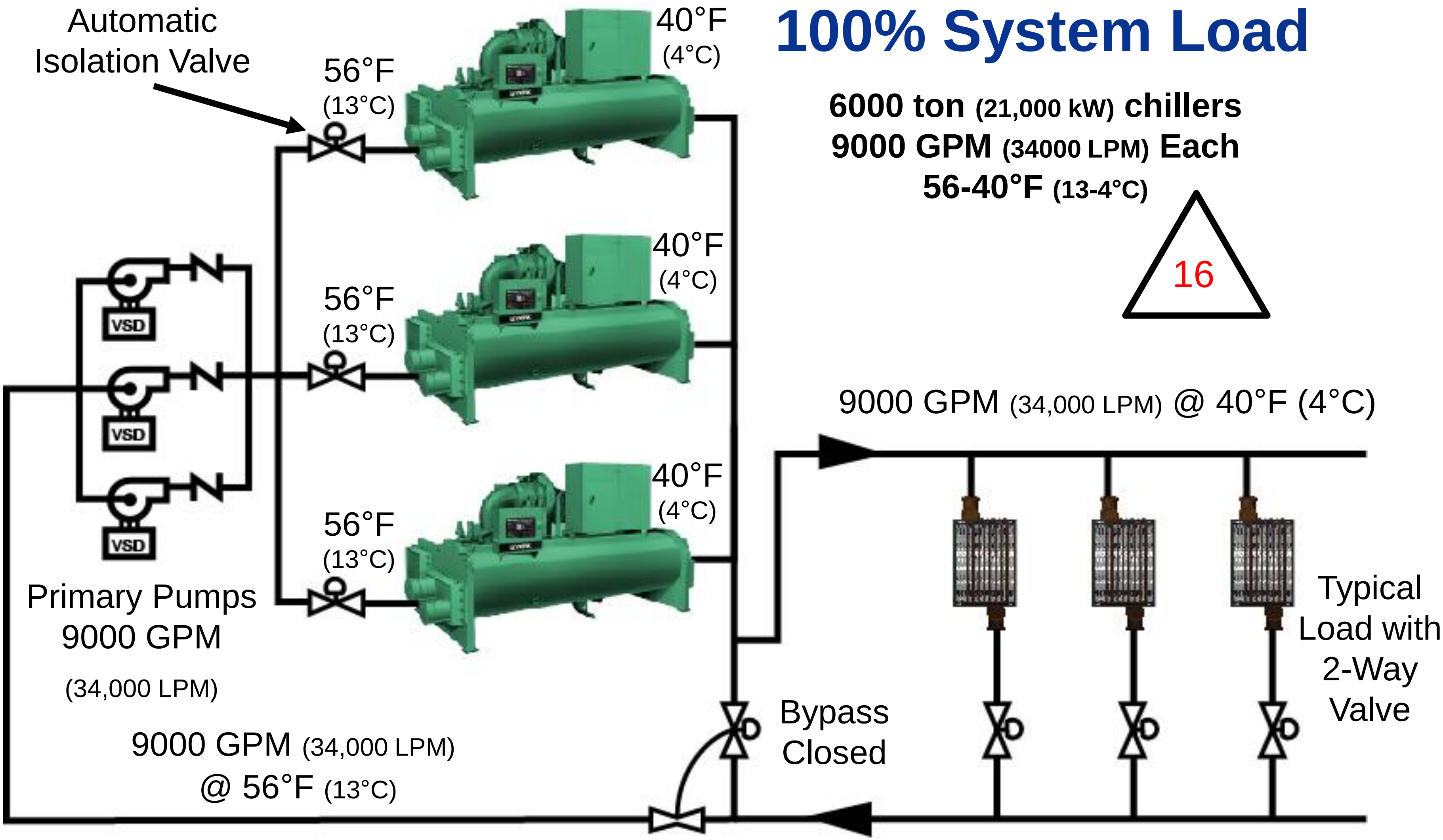
Johnson Controls

Primary Only (Variable Flow)

Energy Use Advantages over Primary / Secondary System

- Better CHW Pump Energy Consumption
  - Higher Pump Efficiency
  - Lower Pump Design Head
  - Total head is variable speed
- Less impact from Low Delta T (Headered Pumping)

Variable Primary System at Design



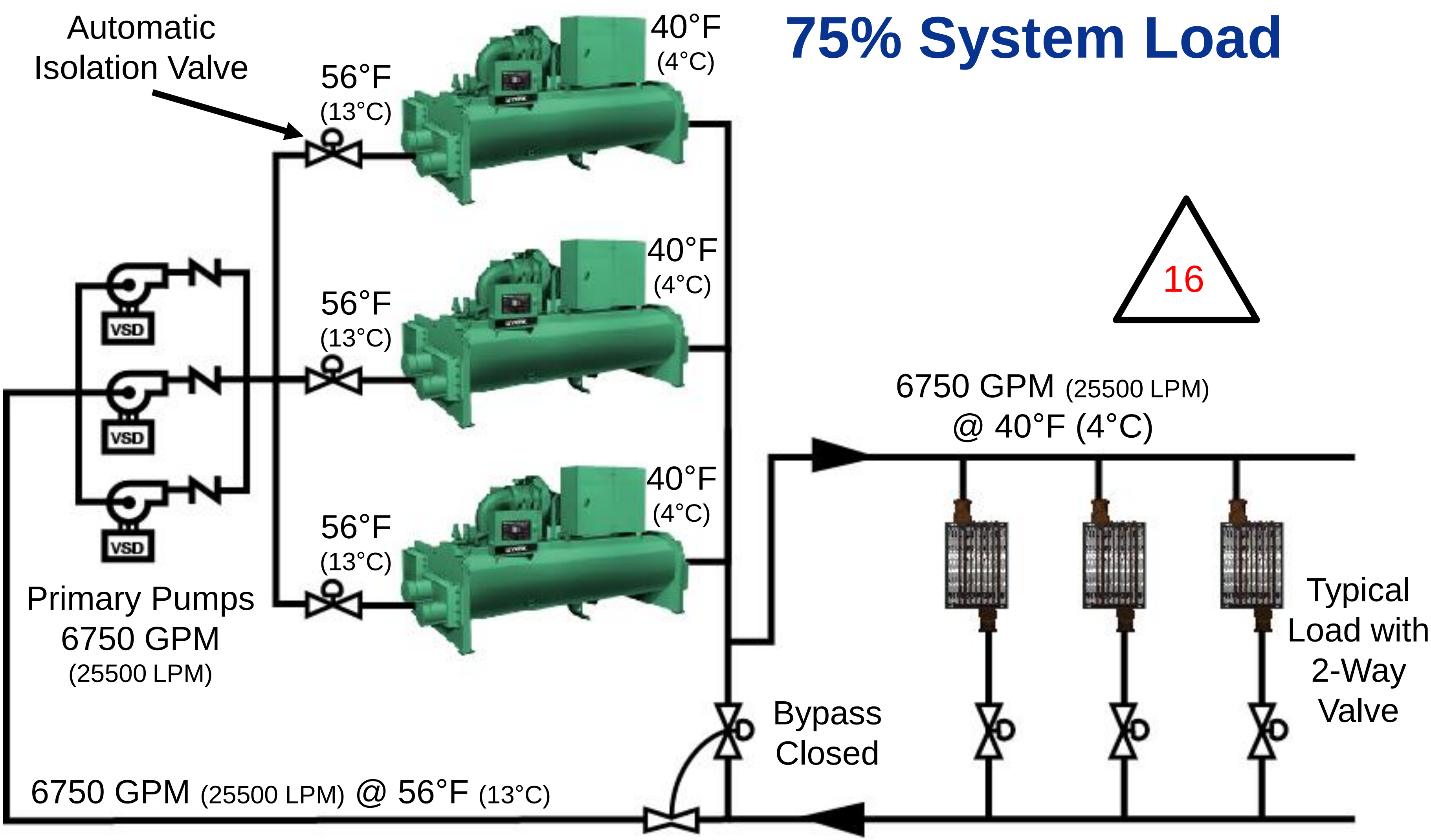
100% System Load

6000 ton (21,000 kW) chillers
9000 GPM (34000 LPM) Each
56-40°F (13-4°C)

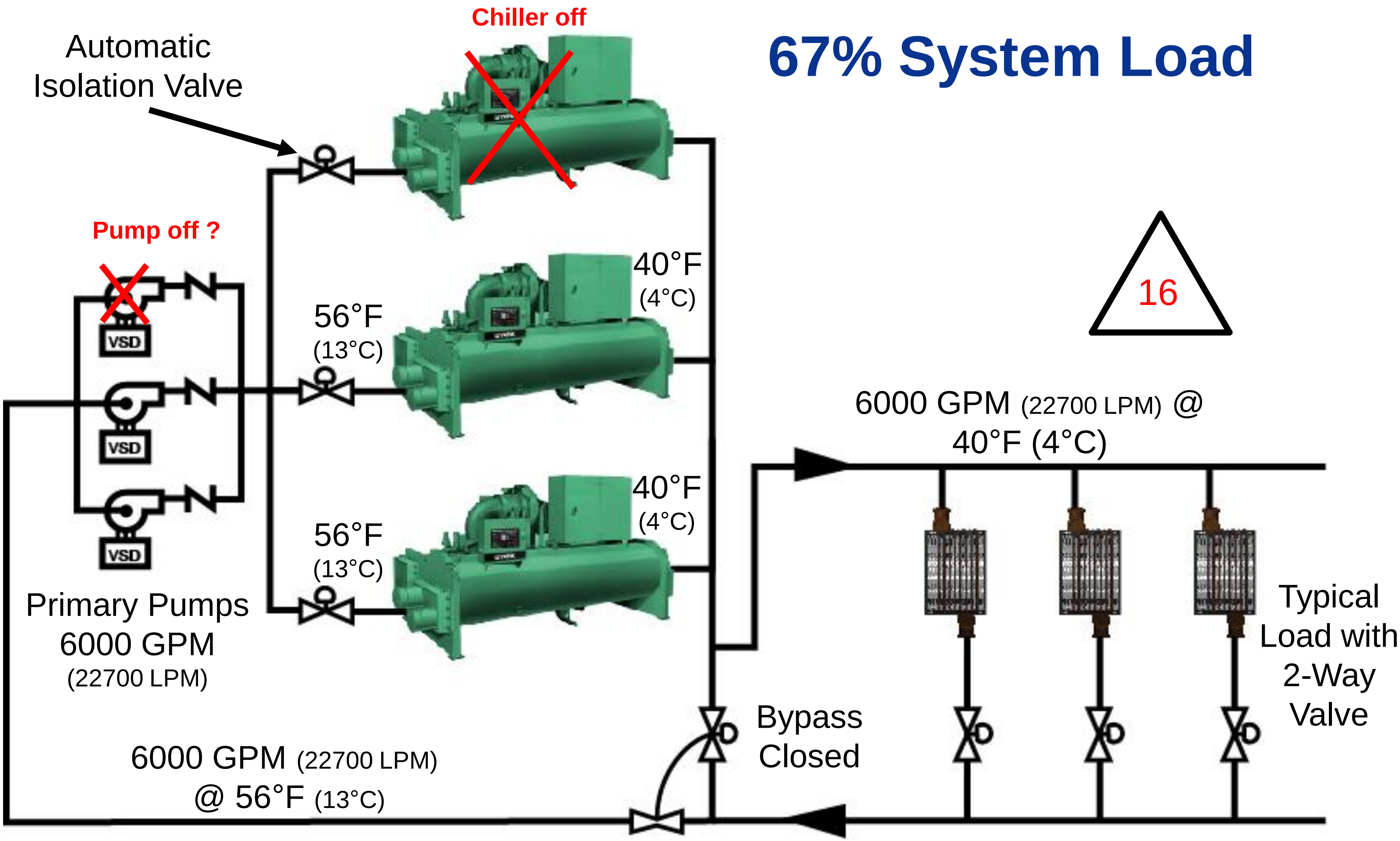
16

Johnson Controls

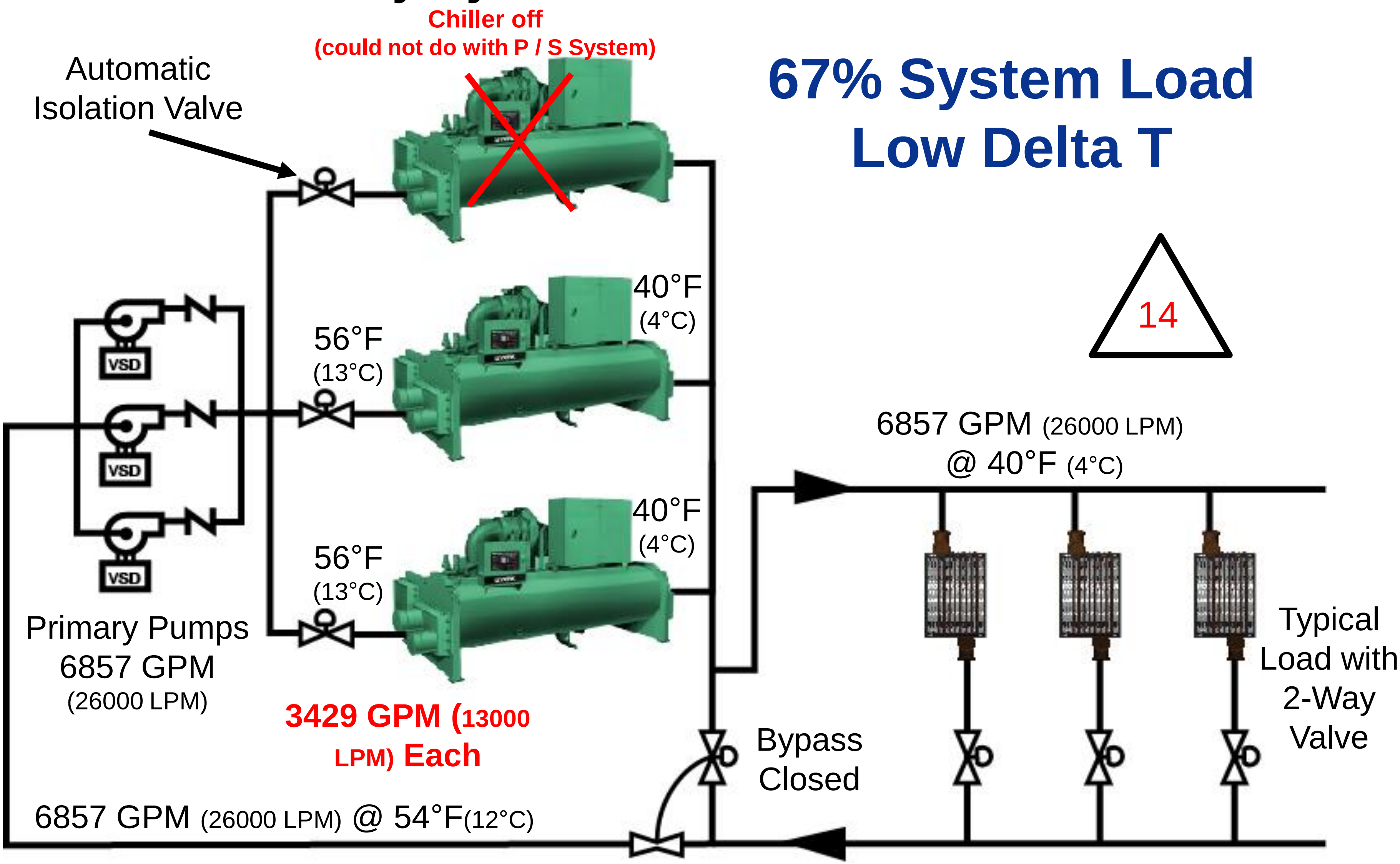
Variable Primary System at Part Load



Variable Primary System at Part Load



Variable Primary System at Part Load



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#6

Chilled Water Flow Tracks Campus Cooling Load

BUSTED

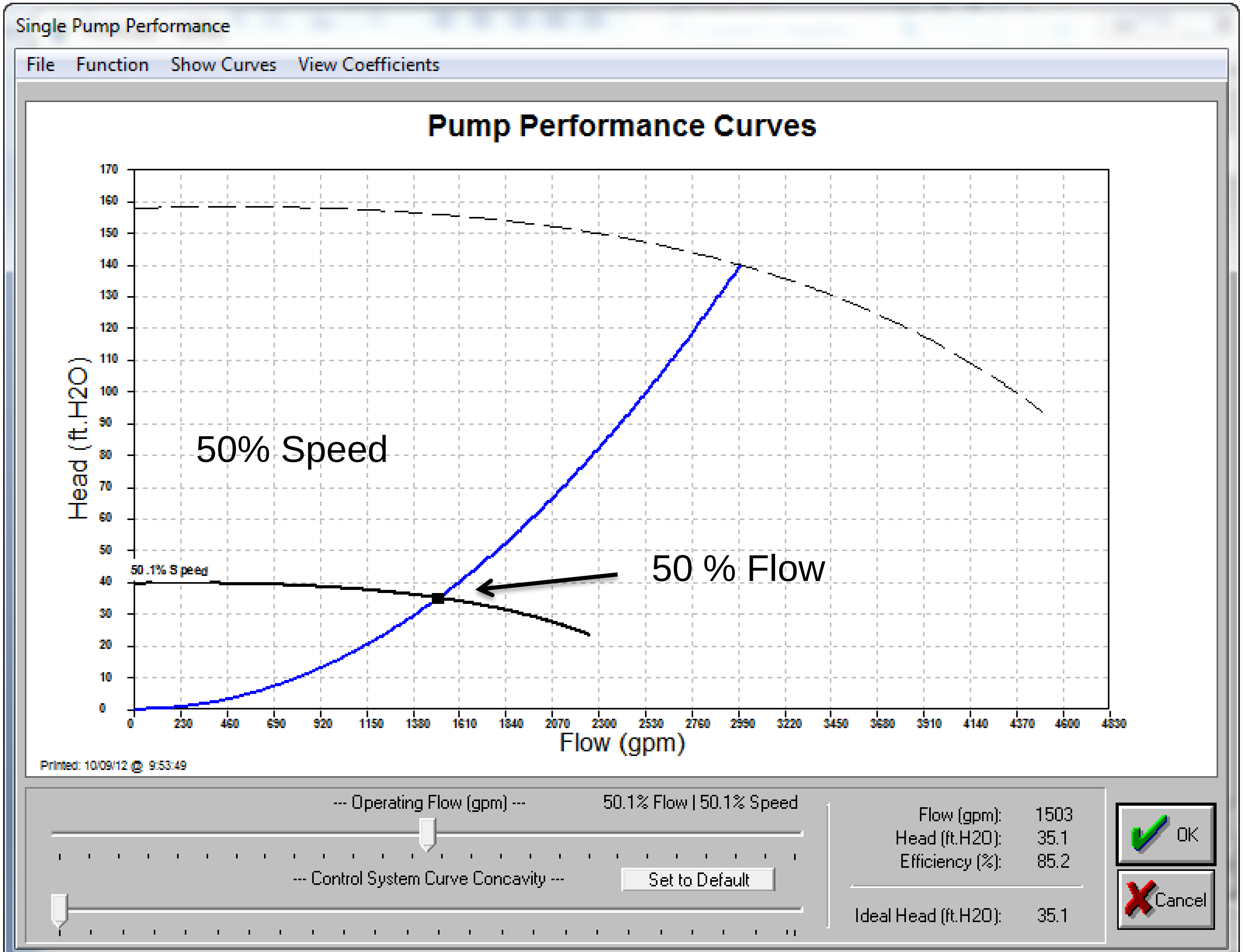
VPF Systems mitigate at the plant the negative impact of low system delta T

Johnson Controls

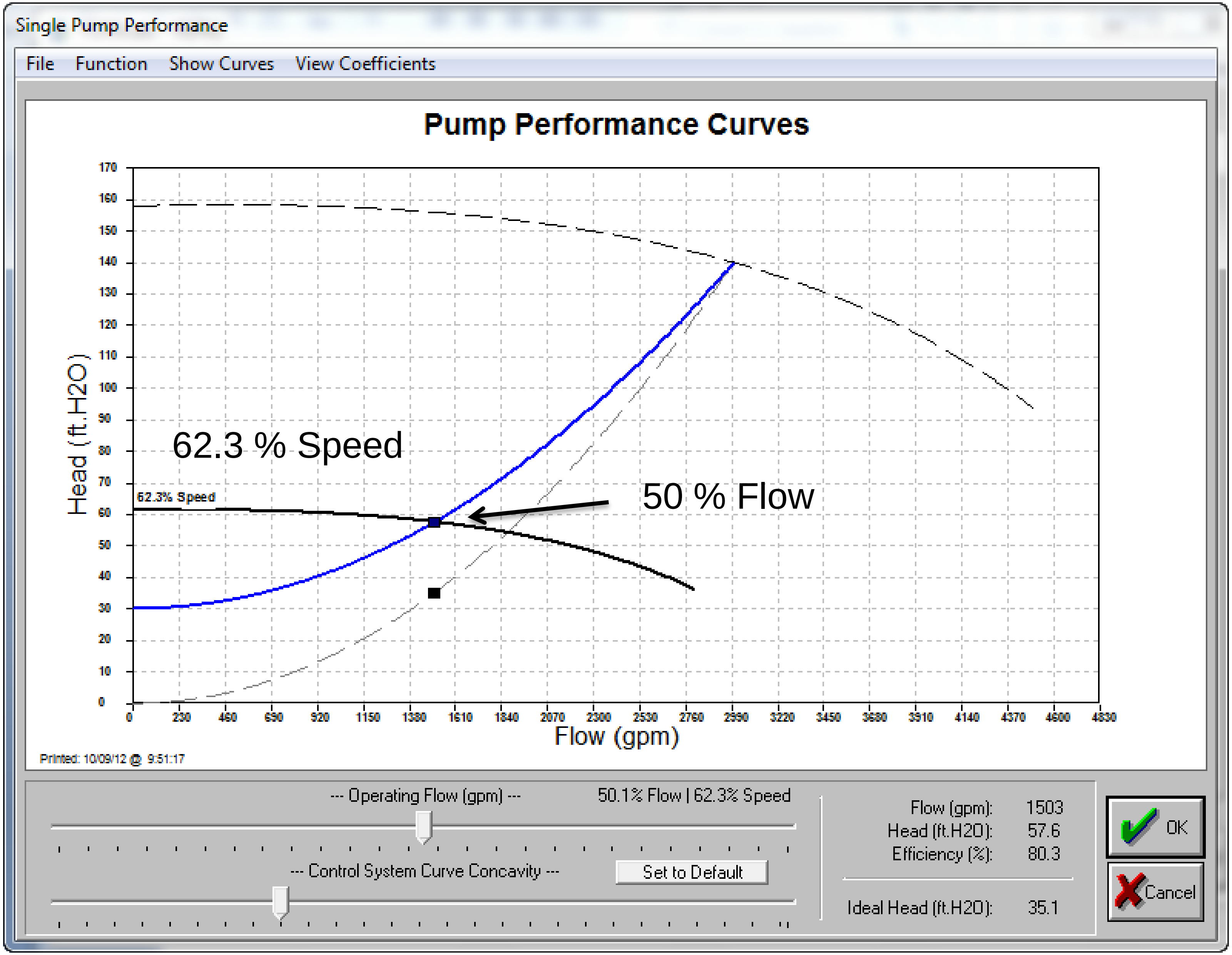
#7

Chilled Water Pump Speed Tracks Flow

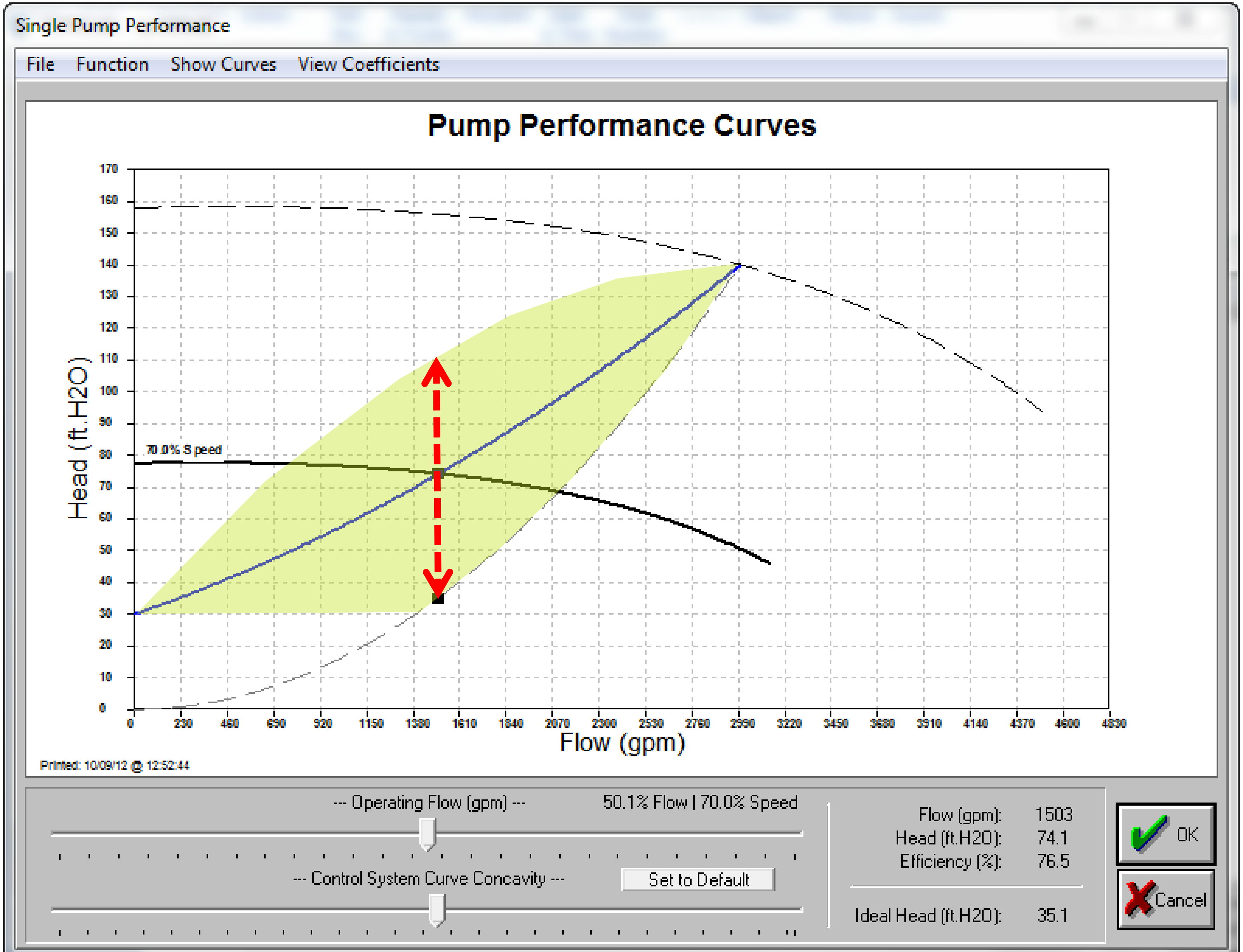
Chilled Water Pump Speed Tracks Flow



Chilled Water Pump Speed Tracks Flow



Chilled Water Pump Speed Tracks Flow



#7

Chilled Water Pump Speed Tracks Flow

BUSTED

There is always some kind of control or static head in variable speed systems. Use flow meters to track flow.

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Completed..

Up Next....

Busting Myth #7

Chiller Plant VPF Design Considerations

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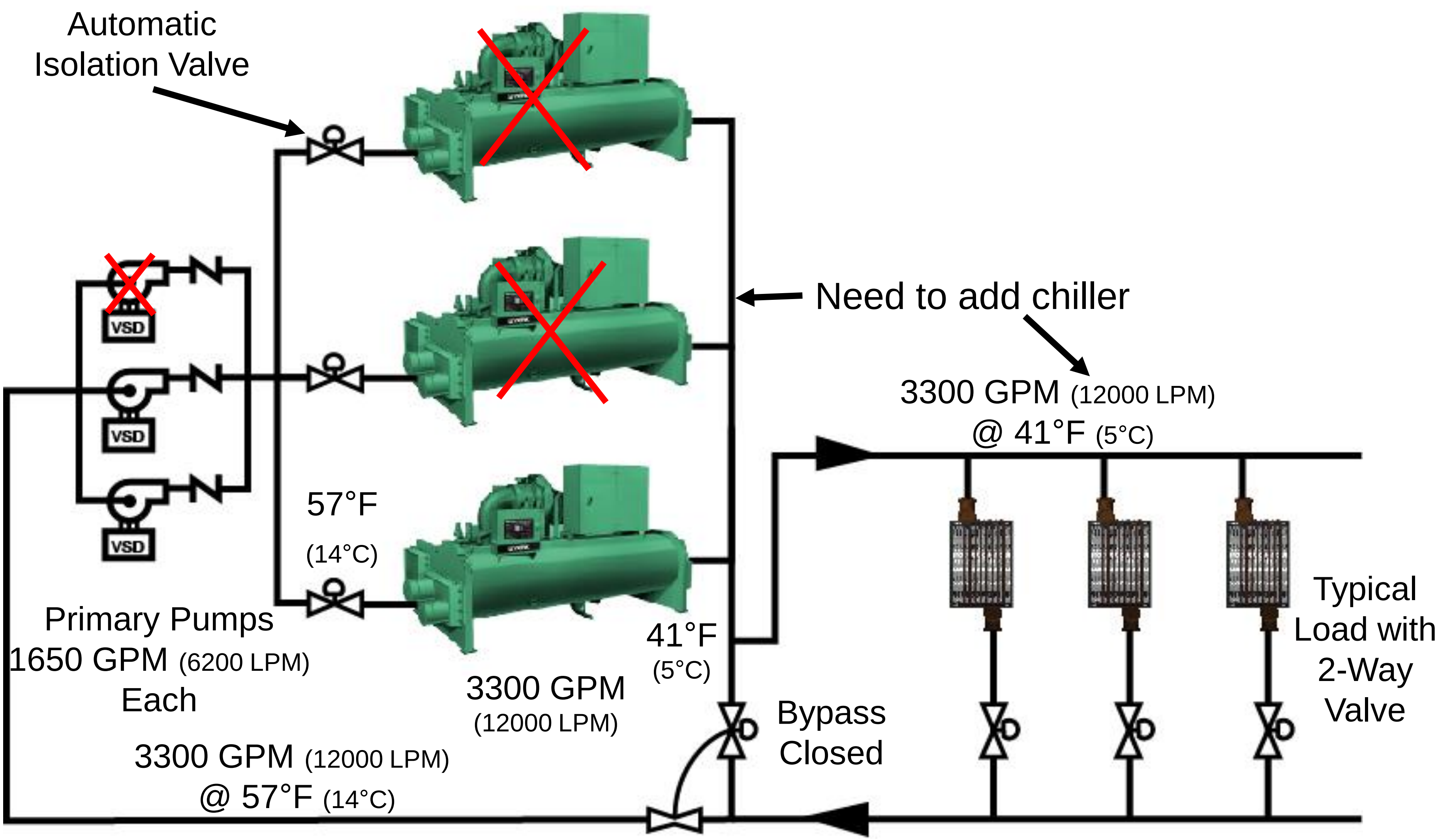
VPF Systems Design/Control Considerations Summary

- Chillers
  - Equal sized chillers preferred, but not required
  - Keep from operating below minimum flow rates with Bypass control (1.5 fps)
  - Keep from operating above Max flow rates (11.0 to 12.0 fps) (or 45/67 ft PD)
  - Modulating Isolation Valves (or 2-position stroke-able) set to open in 1.5 to 2 min (Linear Proportional)

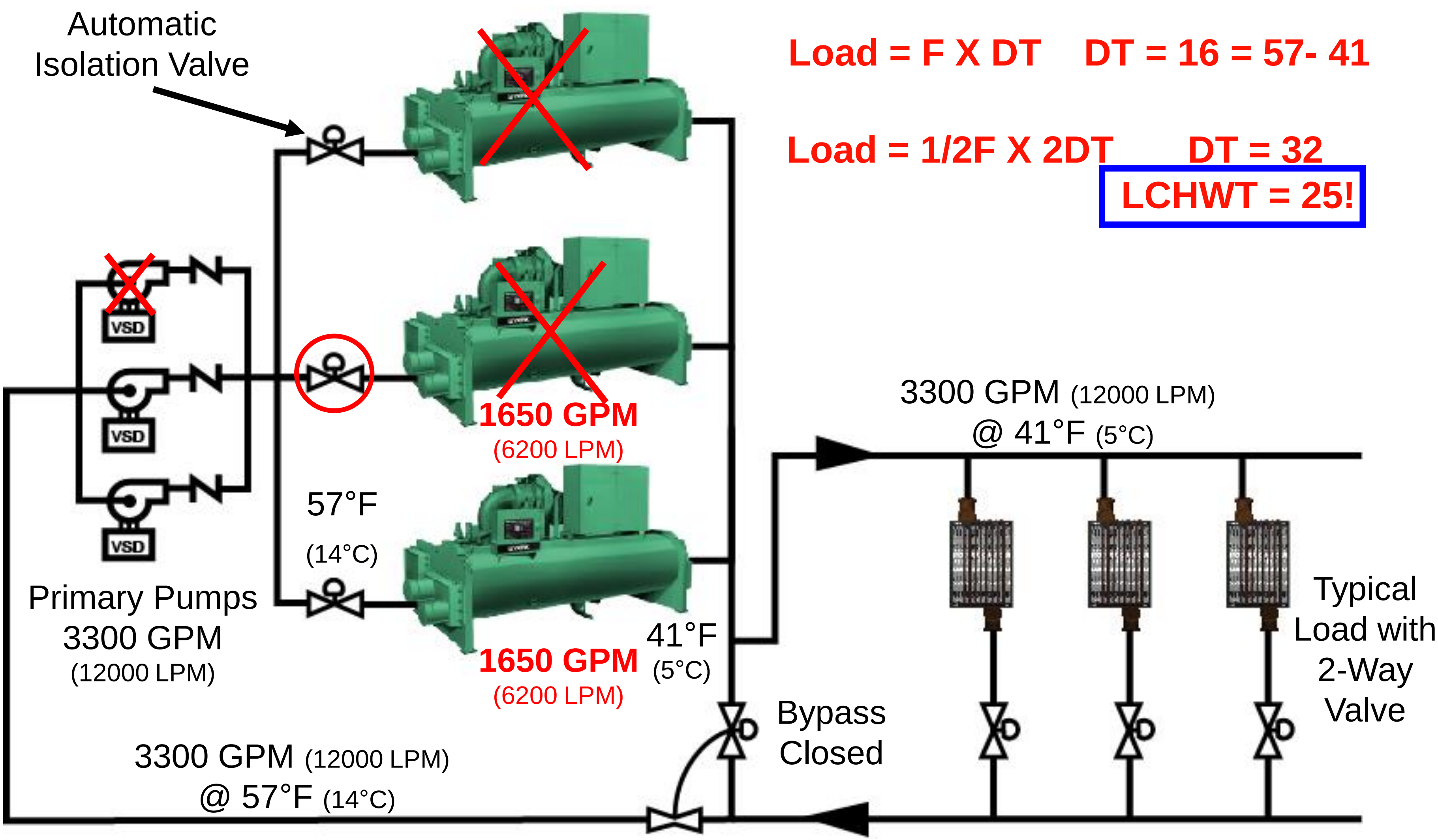
VPF Systems Design/Control Considerations Summary

- Chillers
  - Don’t vary flow too quickly through chillers (VSD pump Ramp rate – typical setting of 10%/min)
    - Chiller Type (flooded evap, DX evap, centrifugal, absorption, etc.)
    - System Water Volume (more water, more thermal capacitance, faster variance allowed) 6-10 Gal/TR
    - Chiller Load (min load - no variance, full load - max variance)
    - Active Loads (near or far from plant)
    - Sequence AHUs On/Off in 10 to 15 min intervals
    - Staging Chillers On

Variable Primary System (Staging on Second Chiller)



Variable Primary System (Open Isolation Valve)



VPF Systems Design/Control Considerations Summary

- Use Energy Based Sequencing.

With High Head, Run Chillers at High Load.

With Low Head, Run Chillers at Low Load.

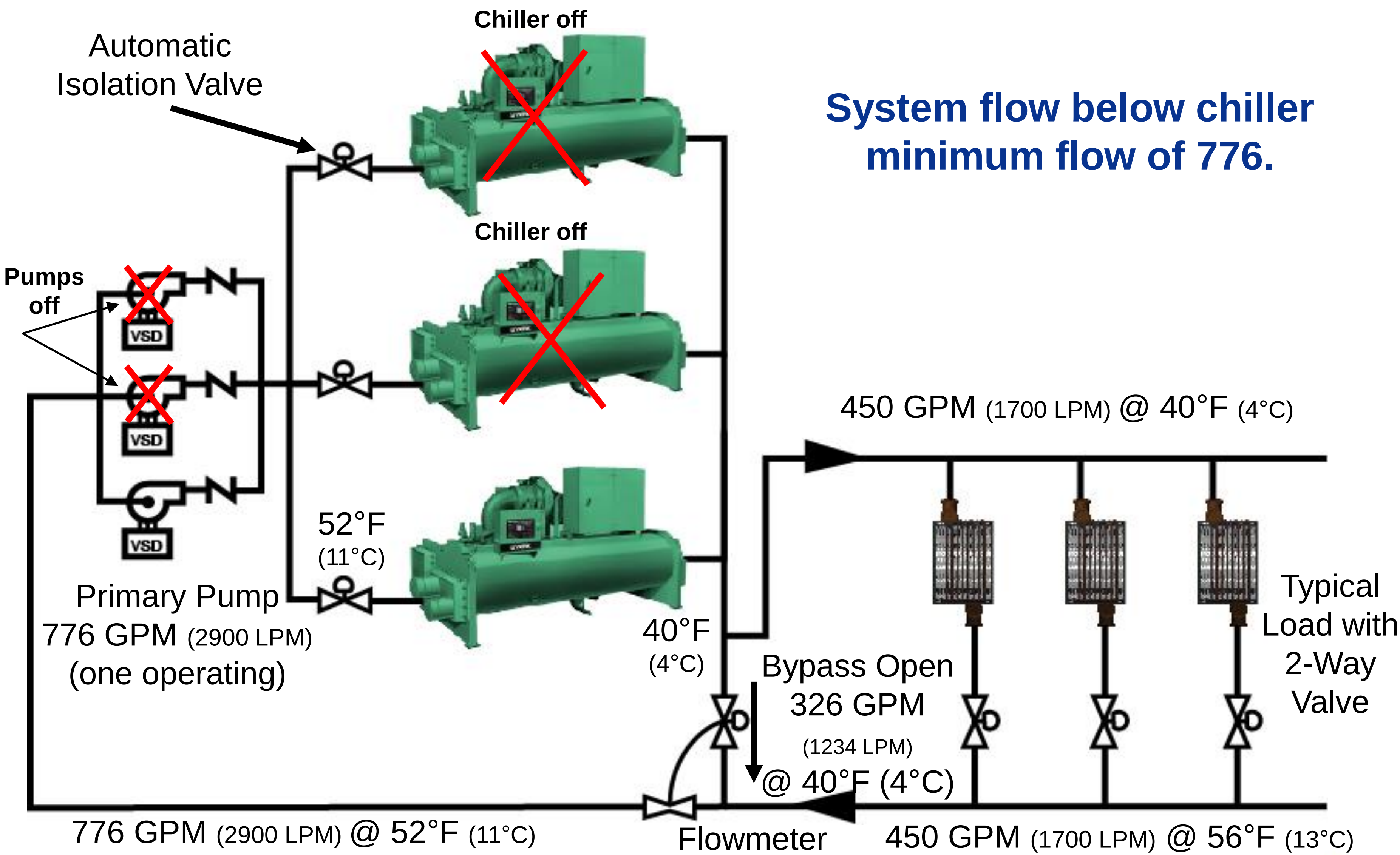
VPF Systems Design/Control Considerations Summary

- Pumps
  - Headered arrangement
  - Sequence
    - Energy Based Sequencing (CPO)
    - Stay within pump/motor limits (25% to 100% speed)
  - Speed controlled by pressure sensors at **end** of index circuit (fast response important)
    - Direct wired or Piggyback–reset pressure sensor
    - Optimized valve position of coils (Vary Speed by Valve Position)

VPF Systems Design/Control Considerations Summary

- Bypass Piping and Valve
  - Size pipe and valve for minimum flow of largest chiller
    - Needs pressure drop –recommend equal to overriding set-point in the system when valve is fully open.
    - This is not sized like a common pipe for a Primary/Secondary System (8-10 pipe diameters long with zero pressure drop)
  - Maintain a minimum chilled water flow rate through the operating chillers
    - Differential pressure measurement across each chiller evaporator
    - Flow meter required if savings are to be achieved.

Variable Primary System – Min Flow (776 GPM Each)



System flow below chiller minimum flow of 776.

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VPF Systems Design/Control Considerations Summary

- Bypass Valve
  - Pipe and valve sized for Min flow of operating chillers
  - High Range-ability (100:1 or better preferred)
  - PSID Ratings for Static, Dynamic, And Close Off = Shut Off Head of Pumps + fill pressure
  - Linear Proportion (Flow to Valve Position) Characteristic preferred (Linear with time is good)
  - Fast Acting Actuator
  - Locate in Plant around chillers/pumps (preferred)
    - Energy saved if located in plant
    - Avoid Network traffic (response time is critical to protect chillers from potential freeze-up)

Completed..

Up Next....

Chiller Plant VPF Design Considerations

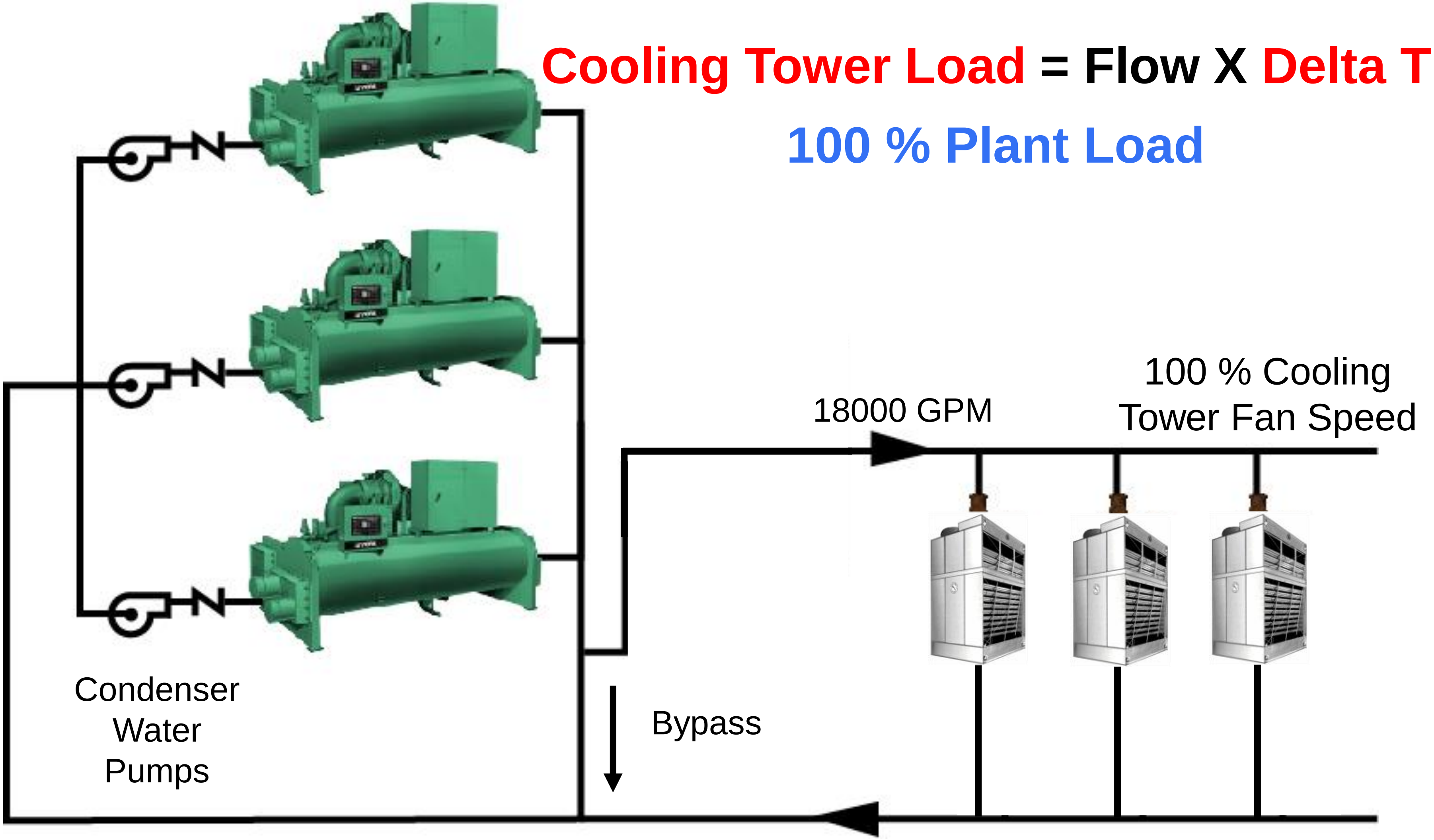
Review Myth #8

Johnson Controls

#8

Pumps/Towers use more energy than chillers can save

Condenser Water Constant Speed – Dedicated Pumps – Typical for Primary Secondary



Slow Down Condenser Pump and Tower Fan

Plant Energy –
Higher or Lower?

Plant Energy Usage Comparison (kWH) Assumptions

- 6000 Hours of Annual Operation
- Load Based Sequencing for P/S Plant (Avg Component Load 72%)
- Energy Based Sequencing used for VPF alts (Avg Component Load 58%)
- Reducing Condenser Flow Increases Fouling Rate
- Condenser Water Flow & CT Air Flow Minimum 80%
- All Chillers have VSD's
- P/S equipped VSD' s on SCHWP's and on Tower Fans
- VPF Plants Equipped with VSD's on Pumps and Towers
- Low Delta T Energy Impact not considered (P/S Plant Energy could be higher)

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Plant Energy Usage Comparison (kWH)

	P/ S - LOAD BASED SEQ
Chilled Water Pumps	1,374,000
Condenser Water Pumps	1,424,000
Cooling Tower Fans	1,100,000
Chillers	12,855,000
Total	16,754,000

P/S Plant arrangement same as previously depicted

Johnson Controls

Plant Energy Usage Comparison (kWH)

	P/ S - LOAD BASED SEQ	VPF - ENERGY BASED SEQ
Chilled Water Pumps	1,374,000	629,000
Condenser Water Pumps	1,424,000	1,464,000
Cooling Tower Fans	1,100,000	1,100,000
Chillers	12,855,000	8,577,000
Total	16,754,000	11,770,000

P/S & VPF Plant arrangements same as previously depicted

Johnson Controls

Plant Energy Usage Comparison (kWH)

	P/ S - LOAD BASED SEQ	VPF - ENERGY BASED SEQ	VPF + CWP & CT AIR FLOW OPT*
Chilled Water Pumps	1,374,000	629,000	628,000
Condenser Water Pumps	1,424,000	1,464,000	843,000
Cooling Tower Fans	1,100,000	1,100,000	569,000
Chillers	12,855,000	8,577,000	9,307,000
Total	16,754,000	11,770,000	11,349,000

P/S & VPF Plant arrangements same as previously depicted
*Condenser Water Flow & CT Air Flow at 80% of Design

#8

BUSTED

Pumps/Towers use more energy than chillers can save

Reducing Condenser Water Flow and CT Air Flow saves more energy than increase on chiller down to about 80% typical.

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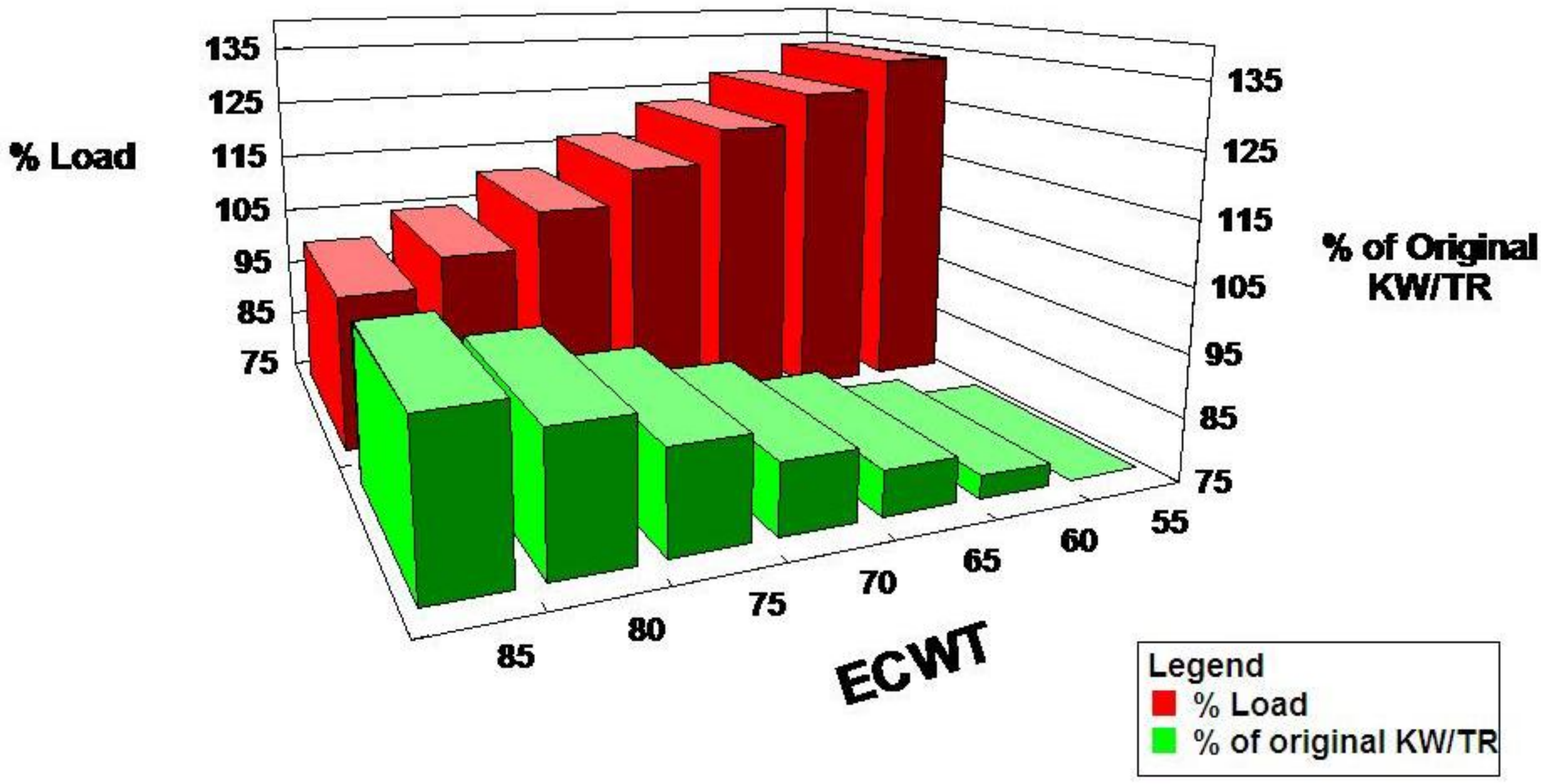
Design Considerations

- **Chillers**
  - Ensure chillers can provide full or greater capacity at 50-55 °F Entering Condenser Water Temps
  - At reduced entering condenser water temperature centrifugal chillers can produce more than design load.

VPF Systems Design/Control Considerations Summary



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Design Considerations

- **Chillers**
  - Ensure chillers can provide full or greater capacity at 50-55 °F Entering Condenser Water Temps
  - Condenser Flow
    - Recommend staying at roughly .8 or 80 % minimum flow
    - Must stay above 3.3 fps or tube fouling becomes asymptotic
    - Don’t vary flow too fast – recommend 10% per minute
    - Don’t exceed 12 fps or 45 ft pressure drop for 2 pass (67 for 3 pass)

Design Considerations

- **Cooling Tower**
  - Manufacturers do not like flow varying more than +/- 15 % from Design.
  - Varying water flow too low
    - Creates dry spots in fill resulting in large approach increases . (Chiller energy increases with increased approach)
    - Varying too low increases CT maintenance
    - Increases freezing damage risk
- **Condenser Water Pumps**
  - Headered arrangement
  - Energy Based Sequencing (CPO)
- **Balancing Valve** – minimize use. At least one fully open

Summary

The 3 Central Plant Myths are:

BUSTED

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Summary

#6

Chilled Water Flow Tracks Campus Cooling Load

#6

Chilled Water Flow Tracks Campus Cooling Load

VPF Systems mitigate at the plant the negative impact of low system delta T

Summary

#7

Chilled Water Pump Speed Tracks Flow

Summary

#7

BUSTED

Chilled Water Pump Speed Tracks Flow

There is always some kind of control or static head in variable speed systems. Use flow meters to track flow.

Summary

#8

Pumps/Towers use more energy than chillers can save

Summary

#8

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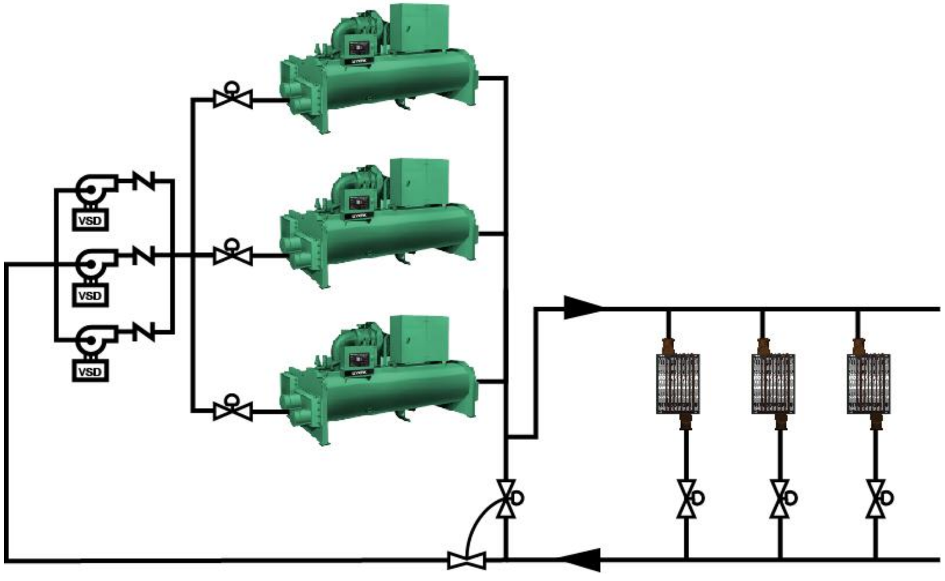
Summary



- Speed does not track flow, and flow does not track load

- Reducing condenser flow and tower air flow saves net plant energy even though chiller energy increases as long as those reductions aren't too low (80% min typical)

- Headered VPF Plant mitigates low delta T impact.

Next

CPO is an “off the shelf” control system

BUSTED???

SELECT, DESIGN, OPTIMIZE

Optimizing Your Chiller Plant Room Webinar Program:

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August 16, 2012

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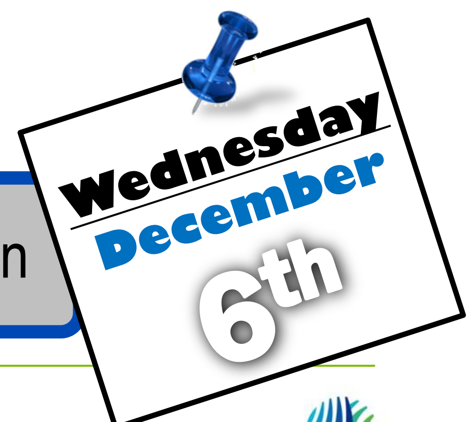

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Conclusion

- Please type in Q&A box lower right hand corner.

- Moderator will handle questions to presenter.

- Please complete the survey following the webinar

- Webinar will be recorded and available via download or streaming. Presentation slides will be available in pdf format at www.districtenergy.org

- If you are listening to the webinar recording and have questions, send them to jill.h.woltkamp@jci.com

- Registration information for the next webinar will be distributed towards the end of November

