DEPPMANN ACADEMY 2025

Cleveland Detroit Grand Rapids



HOUSEKEEPING



PRESENTERS

Name	Accreditation	Position	Years (RLD / Ind.)
Kyle Wefing	HI PSAP	VP, Sales	8 / 19
Brad Notter		Education Leader	29 / 29
Ryan Groves		Sales Engineer, Grand Rapids	2 / 7
Mike Kennedy		Sales Engineer, Detroit	20 / 20
Jason Winslow		Sales Engineer, Detroit	3 / 6
Nick Tabar	PE, CPD, MBA	Sales Engineer, Cleveland	4 / 9
Mark Fine	LEED AP	Sales Engineer, Detroit	24 / 38
Nick Tafelski		Sales Engineer, Detroit	2 / 2
Andrew Ward	WQA CWR*	WSG Division Manager	1 / 10
Chip Bidigare	WQA CWR*	WSG Outside Sales Rep	24 / 34
Gary Rutman	WQA CWR*	WSG Outside Sales Rep	23 / 23

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AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break & Trivia	
9:45-10:45 –	Domestic Hot Water Recirculation Systems –	Ryan Groves
10:45-11:00 –	Break & Trivia	
11:00-12:00 –	Exploring Heat Exchangers –	Mike Kennedy & Jason Winslow
12:00-1:00 –	Lunch & Dad Jokes	
1:00-2:00 –	From 0 to 60Hz: The Basics of VFDs –	Nick Tabar
2:00-2:15 –	Break & Trivia	
2:15-3:15 –	F & T Steam Basics –	Mark Fine & Nick Tafelski
3:15-3:30 –	Break & Dad Jokes	
3:30-4:30 –	Practical Water Quality Testing –	Andrew Ward

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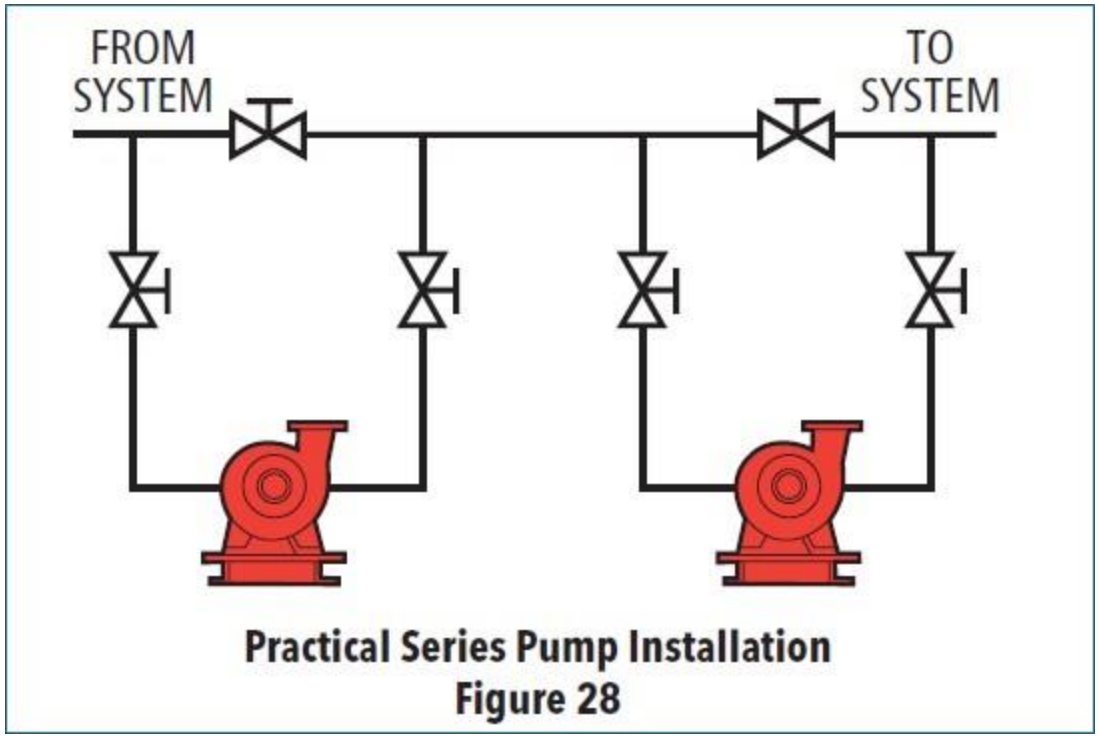
THE LOST ART OF PARALLEL PUMPING: SMART, EFFICIENT, AND COST-EFFECTIVE HYDRONIC DESIGN

Brad Notter – R L Deppmann Education Leader
Kyle Wefing – Vice President, Sales



PUMPING SYSTEMS REVIEW

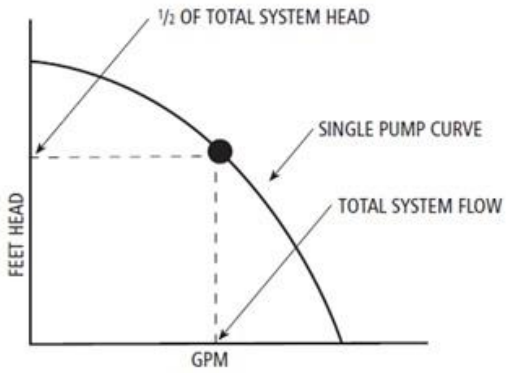
Series Pumping: Sums the head together



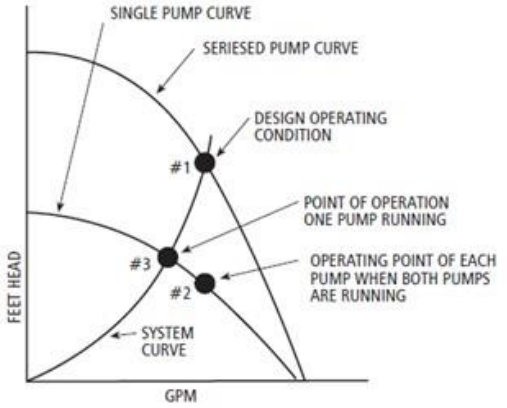
Practical Series Pump Installation
Figure 28

PUMPING SYSTEMS REVIEW

Series Pumping:



Basic Series Pump Operation
Figure 29



Single Pump Operation - Seriesed Installation
Figure 32

In series pumping, we have one pump pumping into another. The flow rate is the same in all the series pumps. The head may be different but is normally the same is each pump. The results are a design condition of the GPM at the sum of the head of all the operating pumps.

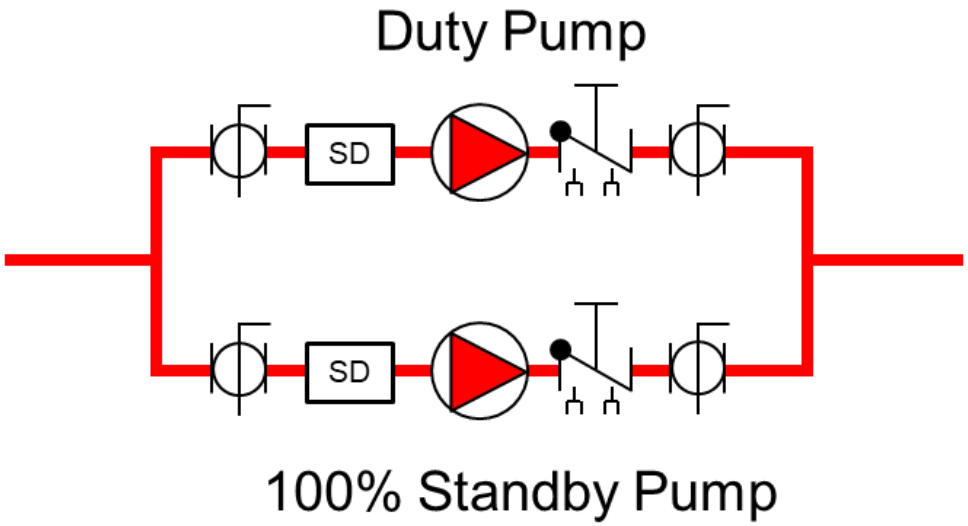
The figure shown has two pumps in parallel. Each at the same flow rate but ½ of the head.

The series curve is the sum of the pump heads of each pump at given flow rates.

When one pump is staged off, the remaining operating pump operates at the intersection of the system curve and the pump curve.

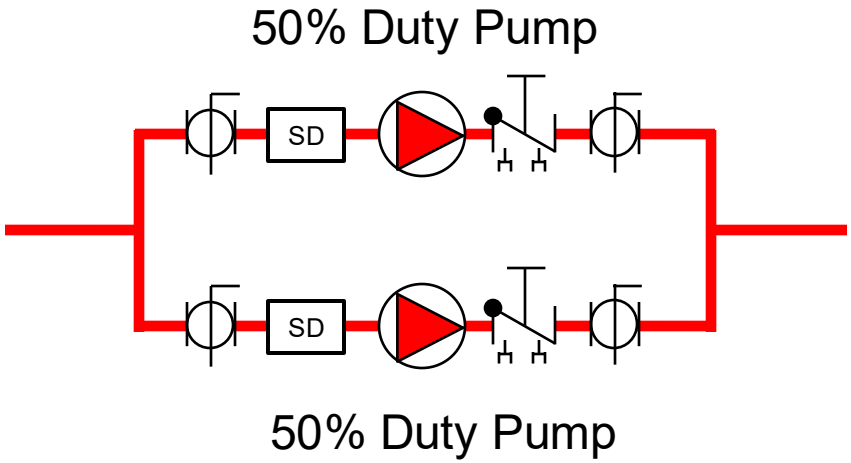
PUMPING SYSTEMS REVIEW

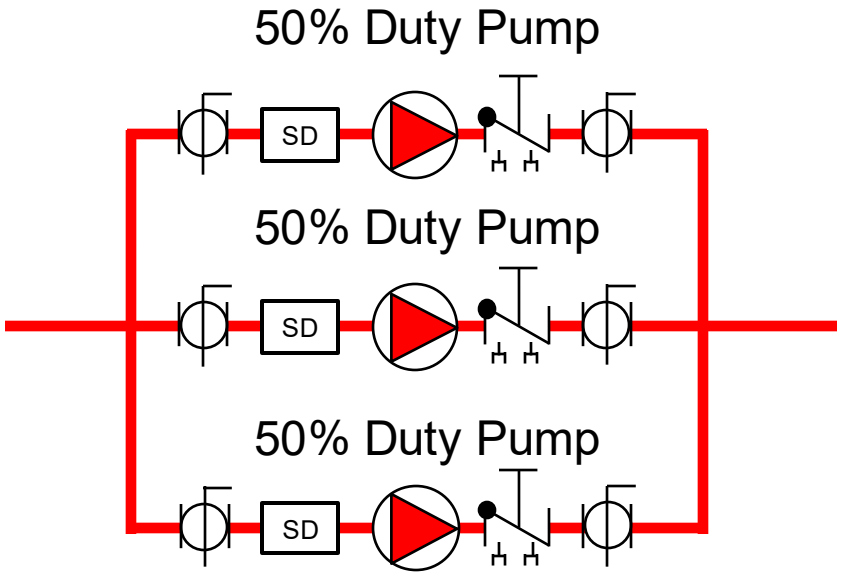
Standard Design -One Duty Pump & One Standby Pump



PUMPING SYSTEMS REVIEW

Common Parallel Designs





Also known as N+1

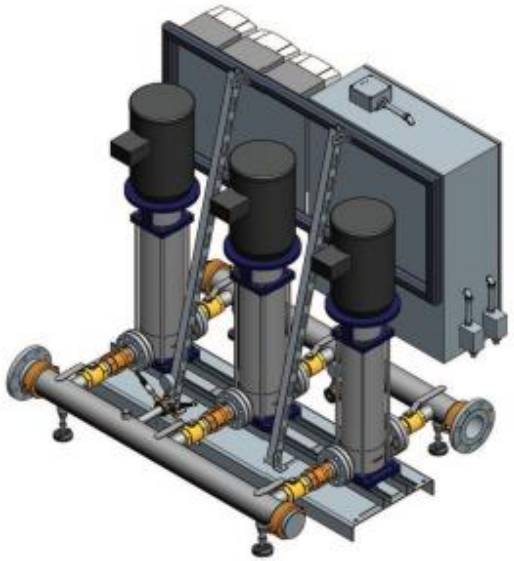
PUMPING SYSTEMS REVIEW

Series & Series-Parallel



Multi-Stage Pump
Figure 41

Multistage pumps can be thought of as “factory built multiple pumps in series.”



Parallel, Multistage Domestic Water System Pump Package
Figure 42

Domestic water pressure booster systems in modern tall buildings, often benefit from combination series-parallel variable-speed pumping

WHEN TO USE PARALLEL PUMPING

- High Flowing Systems
- Large Varying Flowrates
- Load Match to Building Profile
- Higher Turndown
- System Diversification
- Future Additions

WHEN TO USE PARALLEL PUMPING

Golden Rule of Hydronics:

50% of flow rate equals 70-90% of Heat Transfer

Do you need 100% Standby Capacity in a Heating or Cooling System?

# of Parallel Operating Pumps	% of Flow Standby
2	65% -75%
3	85% - 95%

More on this shortly!

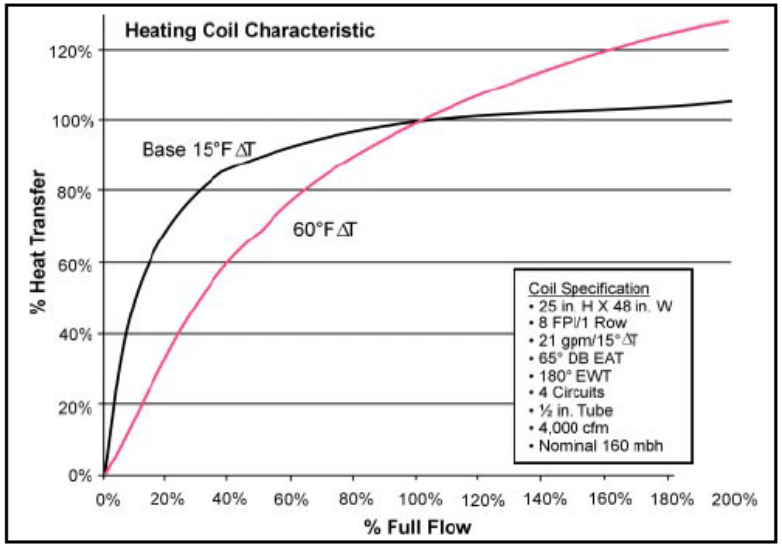


Figure 2a: Typical heating coil characteristic. This characteristic curve is similar to that shown in the *ASHRAE Handbook—Applications,* Chapter 36, Page 8, Figure 3. It was developed using a manufacturer's coil-sizing program and a spreadsheet for plotting.

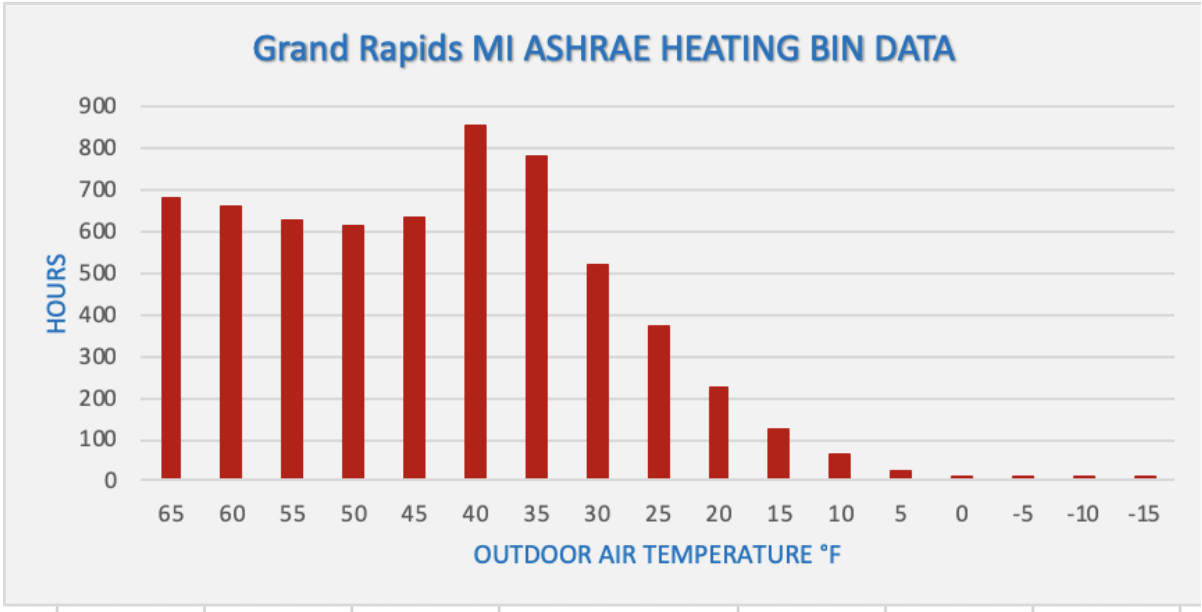
From ASHRAE Journal article by Mark Hegberg November 2000

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LOAD MATCHING YOUR BUILDING

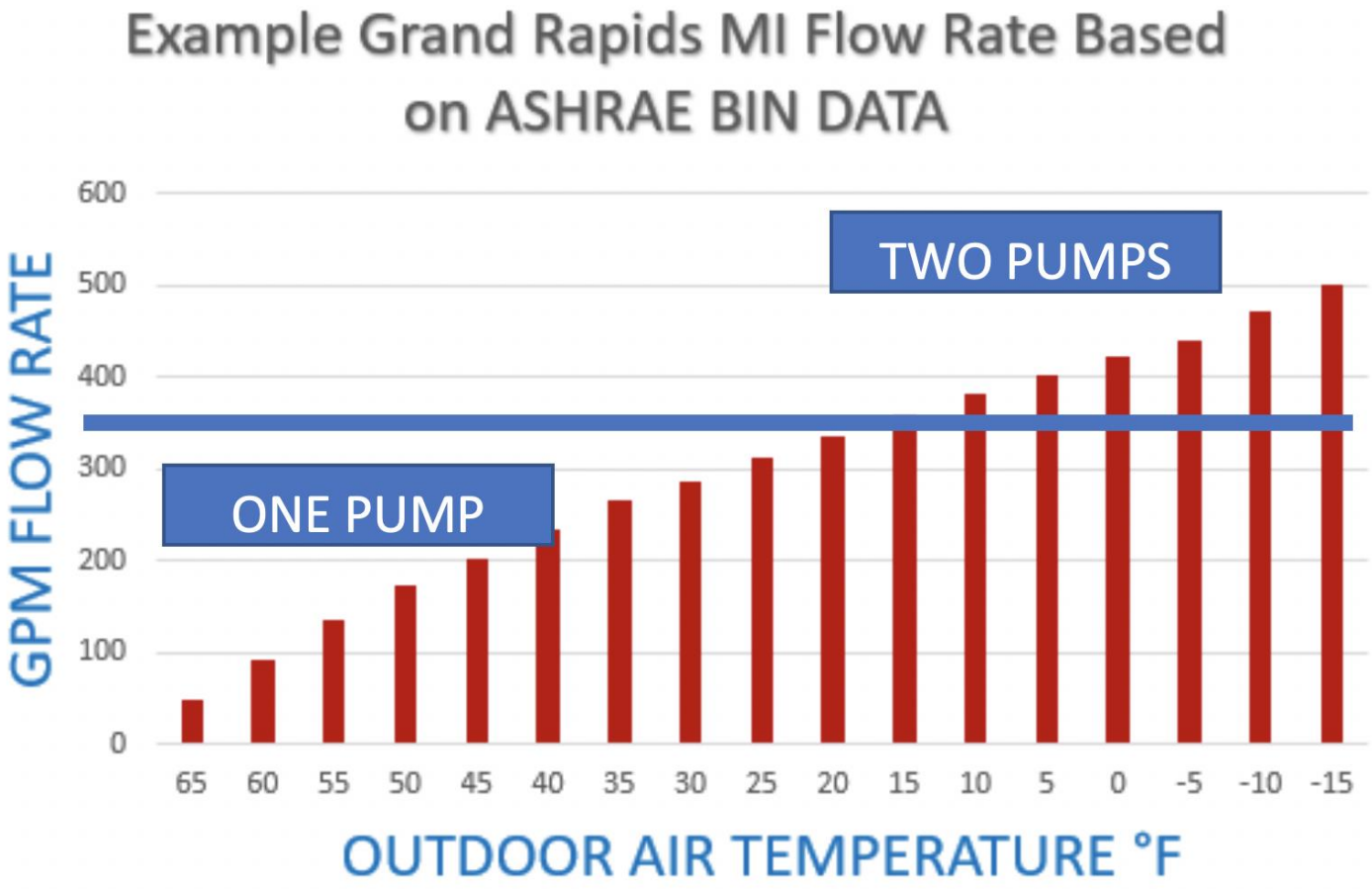
Do you need 100% Standby Capacity in a Heating or Cooling System?

Let's Look at Bin Data for Grand Rapids MI



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LOAD MATCHING YOUR BUILDING



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QUICK REVIEW - AFFINITY LAWS

1. Capacity (flow) varies as the rotating speed :

$$FLOW_2 = FLOW\ (SPEED_2 / SPEED_1)$$

2. Head (pressure) varies as the square of the rotating speed :

$$HEAD_2 = HEAD_1\ (SPEED_2 / SPEED_1)^2$$

3. Brake horsepower (BHP) varies as the cube of the rotating speed :

$$BHP_2 = BHP_1\ (SPEED_2 / SPEED_1)^3$$

SYSTEM CURVE

The *system curve* is a plot of the system head loss for any flow through the system.

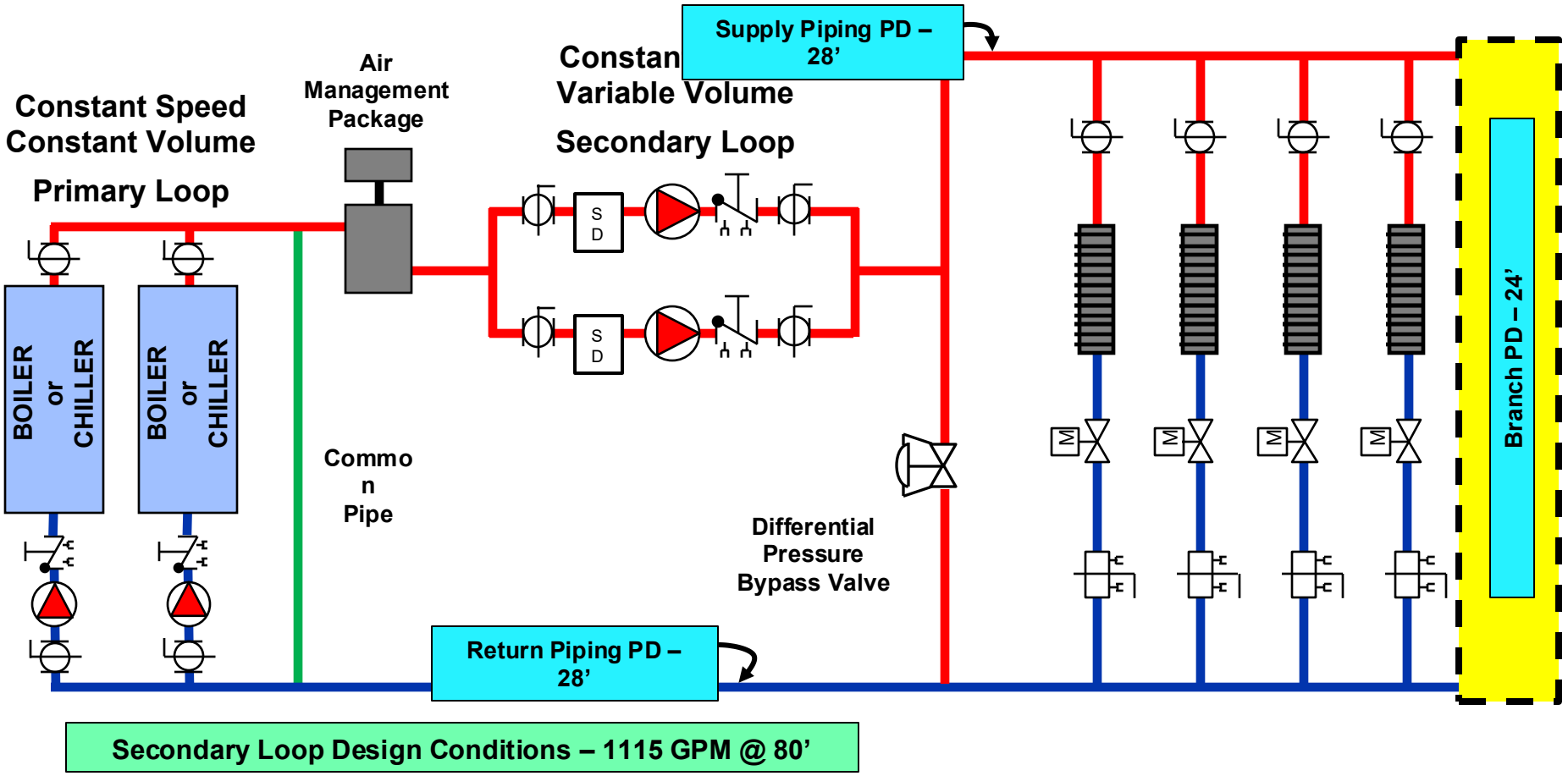
The system curve can be plotted if the head loss (h_1) is known for any flow (GPM_1) through the system.

$$h_2 = \left(\frac{h_1}{GPM_1^2} \right) \times GPM_2^2$$

Using this, what would be the pressure drop required at a third of the flow rate? A third squared is a ninth. If we use this formula for various percentages of flow, we get the following.

FLOW RATE	100	90	80	70	60	50	40	30	20	10	0
PRESSURE DROP	100	81	64	49	36	25	16	9	4	1	0

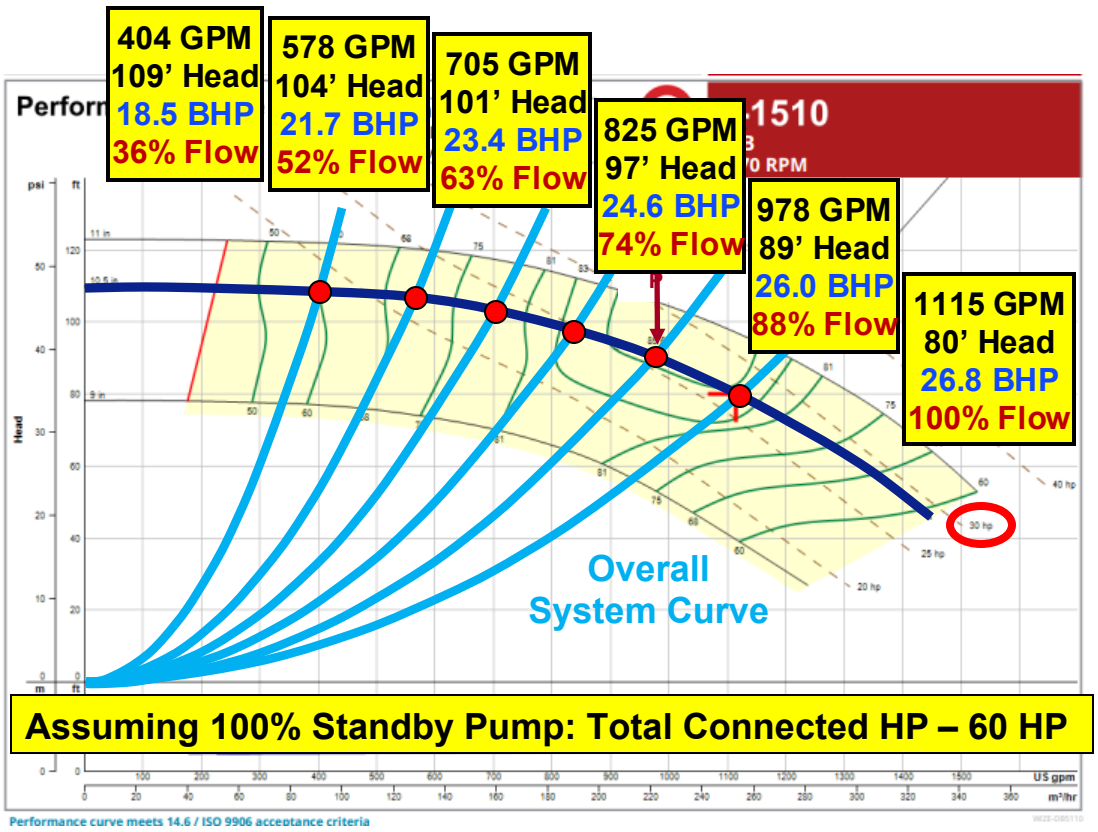
A LOOK BACK IN TIME – CONSTANT SPEED VARIABLE VOLUME SYSTEMS

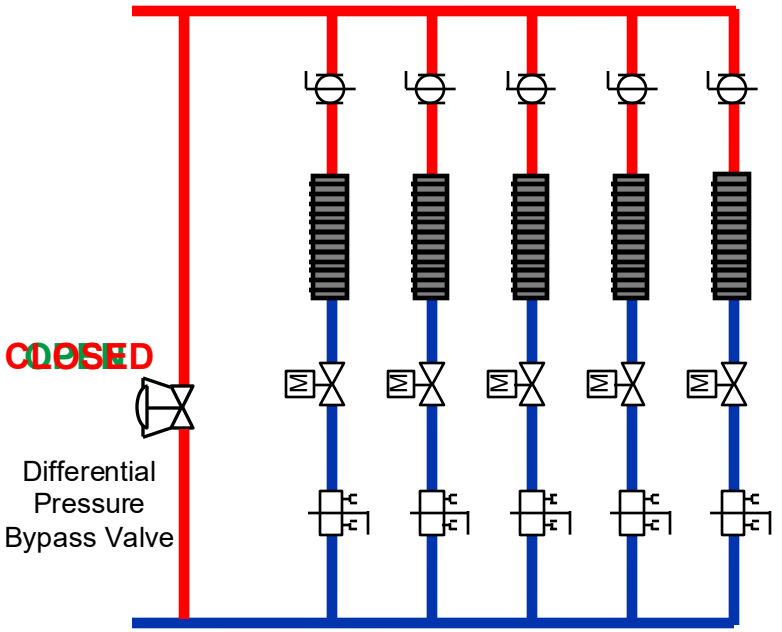


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WHAT INFLUENCE WILL A CONTROL VALVE HAVE ON THE SYSTEM CURVE?

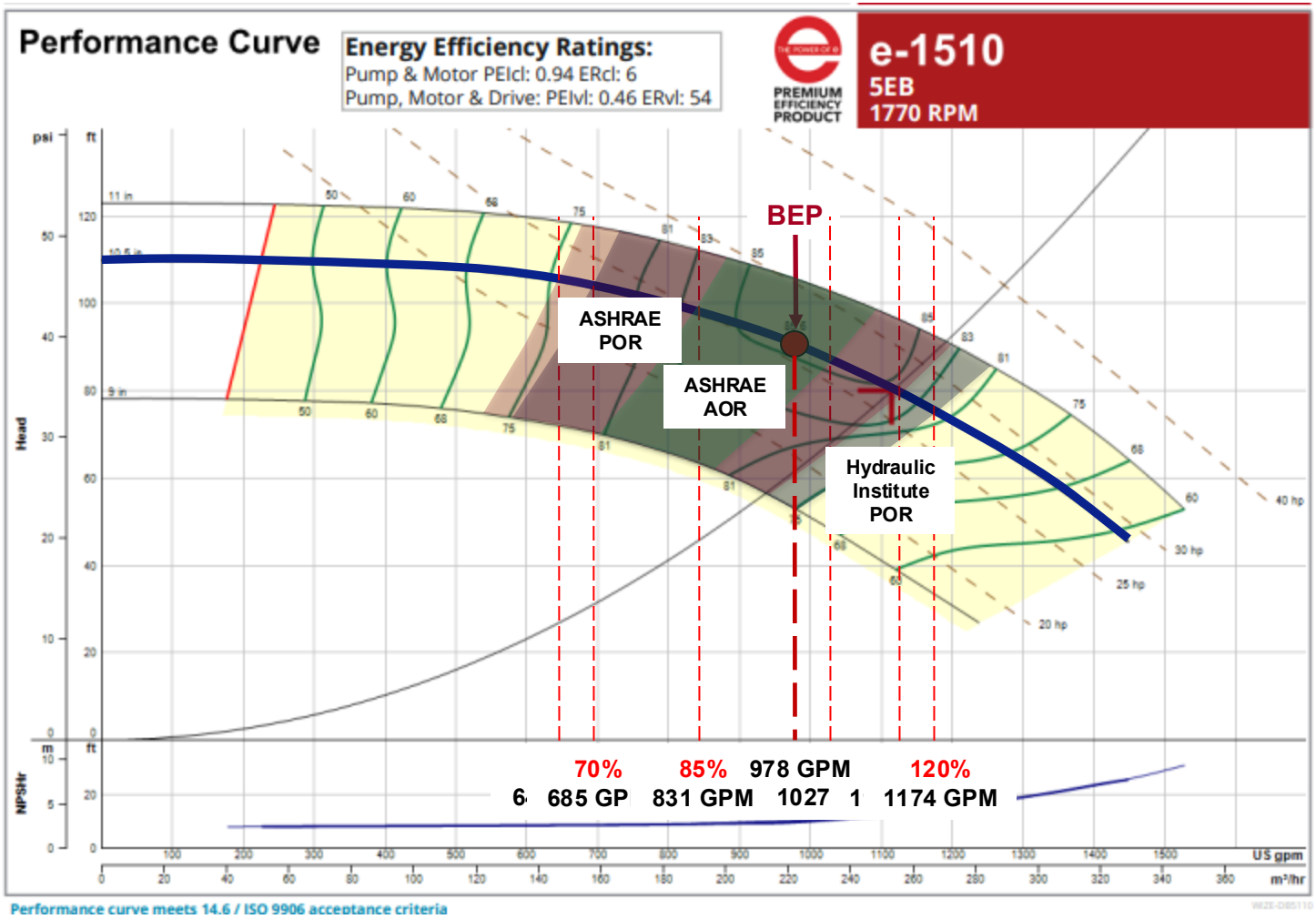
Single Pump at Constant Speed, Variable Volume Operation





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DEFINING THE *PREFERRED* AND *ACCEPTABLE* OPERATING REGIONS

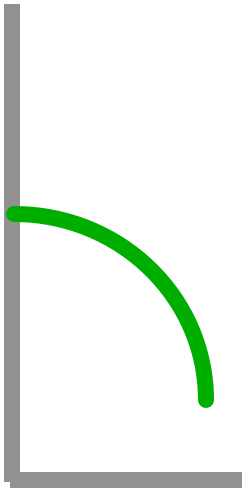


- **ASHRAE 90.1** defines the Preferred Operating Region (POR) for a pump as **85%-105%** of the flowrate at BEP on the performance curve of installed impeller.
- **ASHRAE 90.1** defines the Acceptable Operating Region (AOR) for a pump as **66%-115%** of the flowrate at BEP on the performance curve of installed impeller.
- **Hydraulic Institute** defines the Preferred Operating Region (POR) for a pump as **70%-120%** of the flowrate at BEP on the performance curve of installed impeller.

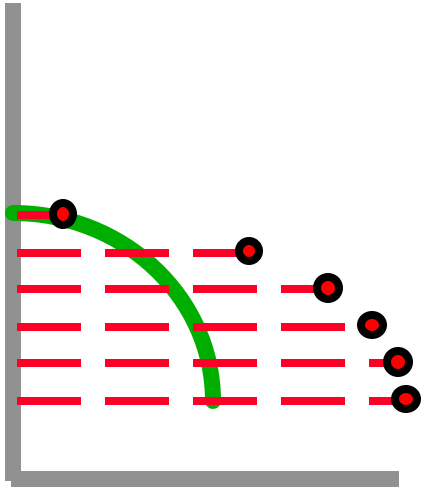
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CONSTRUCTING A PARALLEL PUMP CURVE

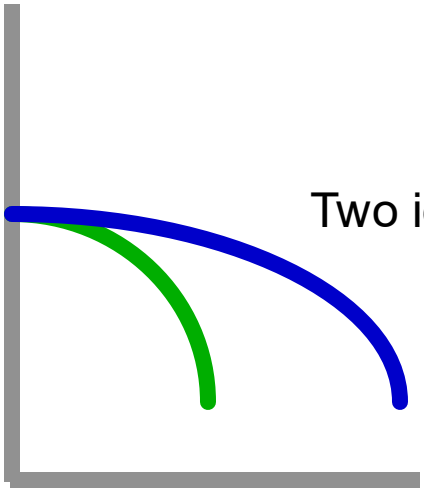
WHEN PUMPS ARE SAME SIZE AND MODEL (PREFERRED!)



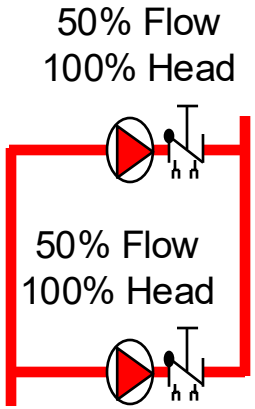
Single Pump Curve



Double the Flow at Several Values of Head



Connect the Points to Make the Parallel Curve

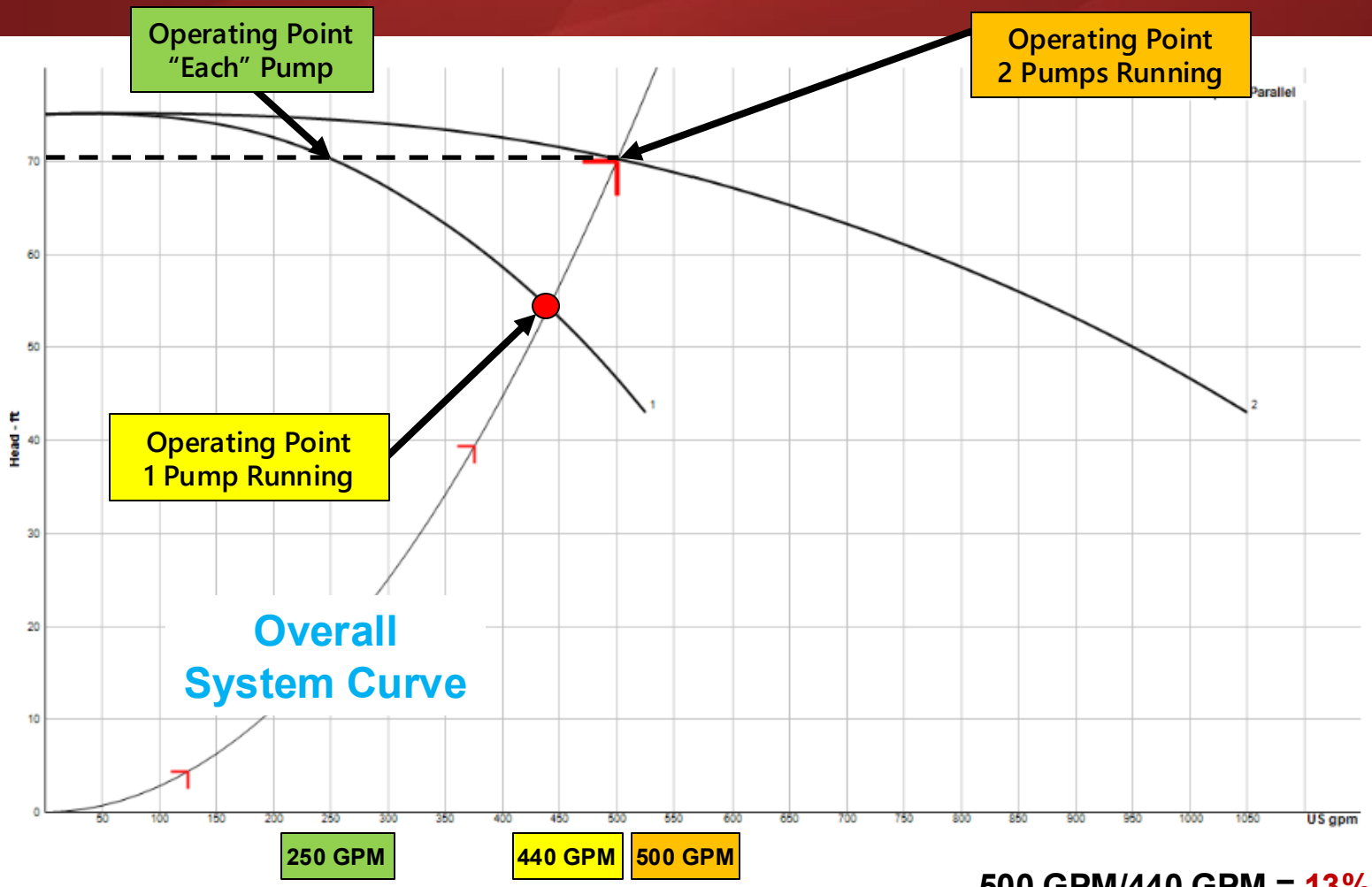


Two identical pumps in parallel

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EXAMPLE – PARALLEL PUMPING – HOW DOES THE FLOW CHANGE

TWO PUMPS FOR A TOTAL LOAD OF 500GPM AT 70' HEAD – 1510 3EB 10HP 9.0" IMPELLER



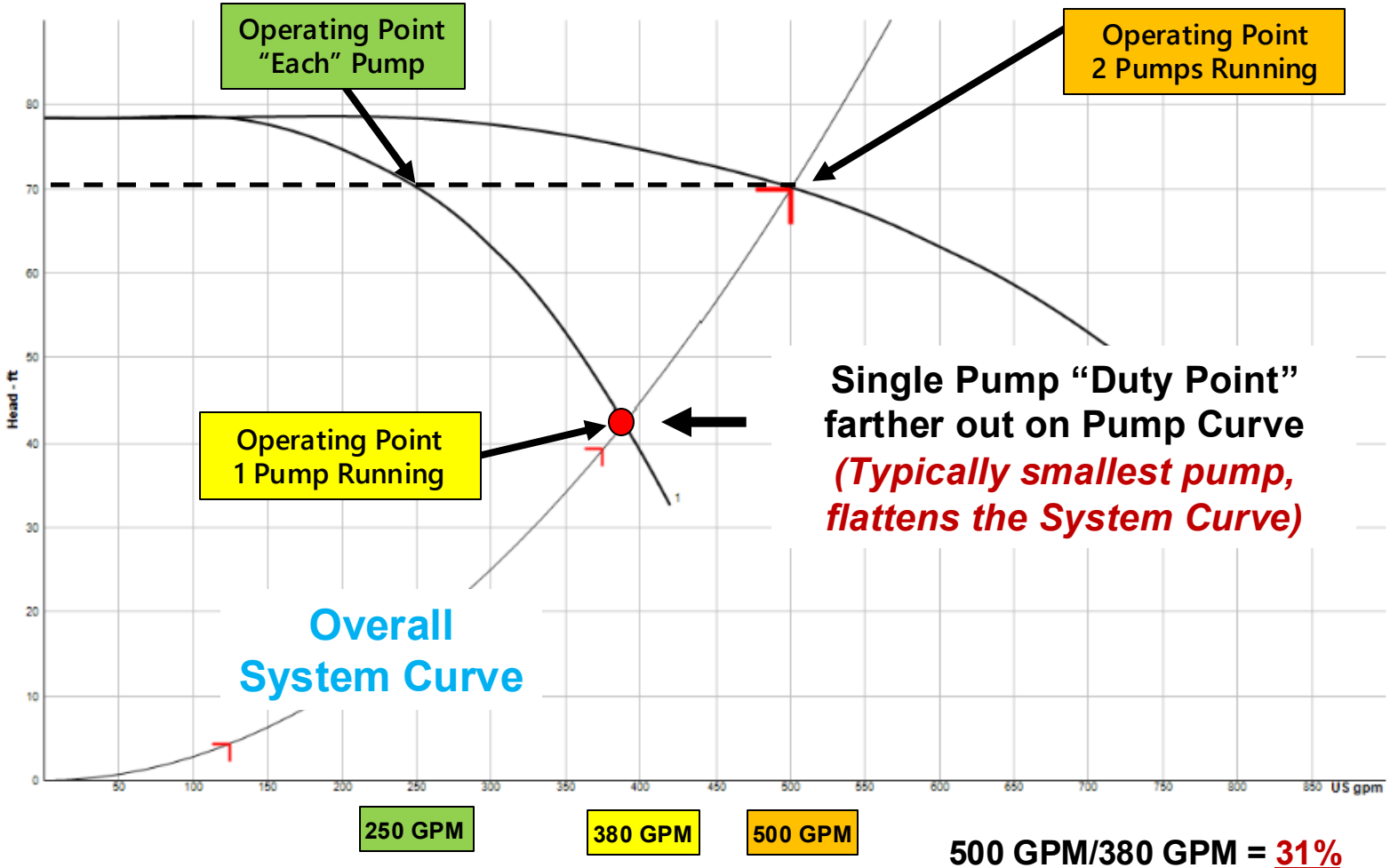
What happens when 2nd pump is turned "On"?

500 GPM/440 GPM = 13% Increase in System Flow

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EXAMPLE – PARALLEL PUMPING – HOW DOES THE FLOW CHANGE

TWO PUMPS FOR A TOTAL LOAD OF 500GPM AT 70' HEAD – 1510 2.5BB 7.5HP 8.75" IMPELLER



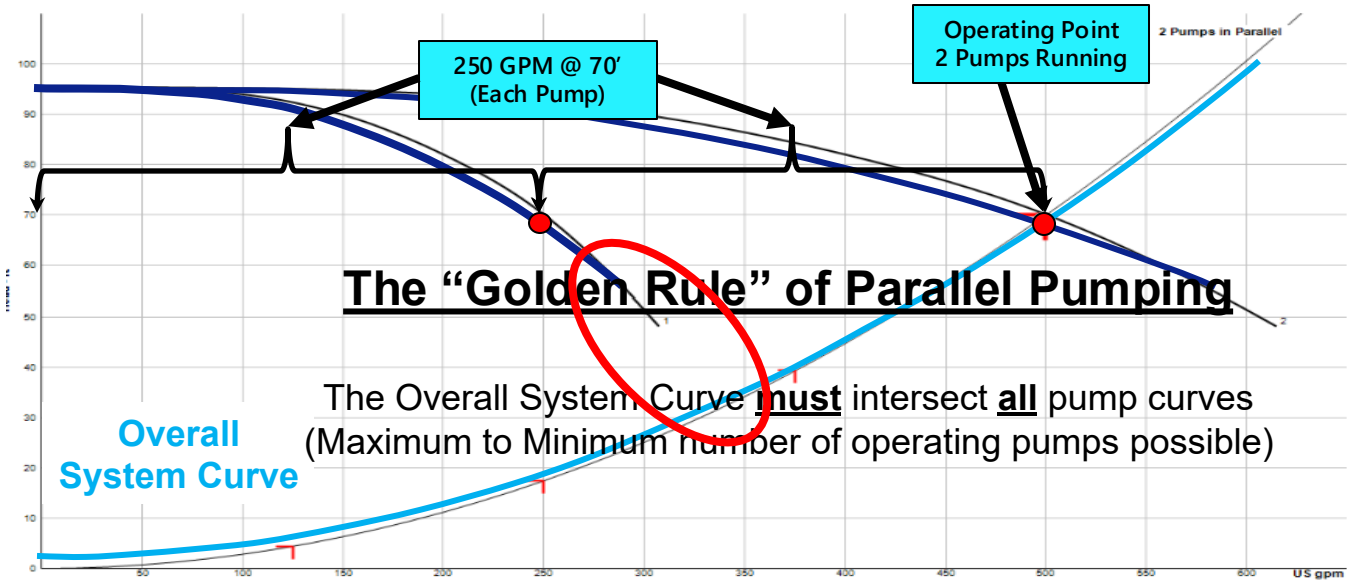
What happens when 2nd pump is turned "On"?

500 GPM/380 GPM = 31%
Increase in System Flow

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EXAMPLE – PARALLEL PUMPING – HOW DOES THE FLOW CHANGE

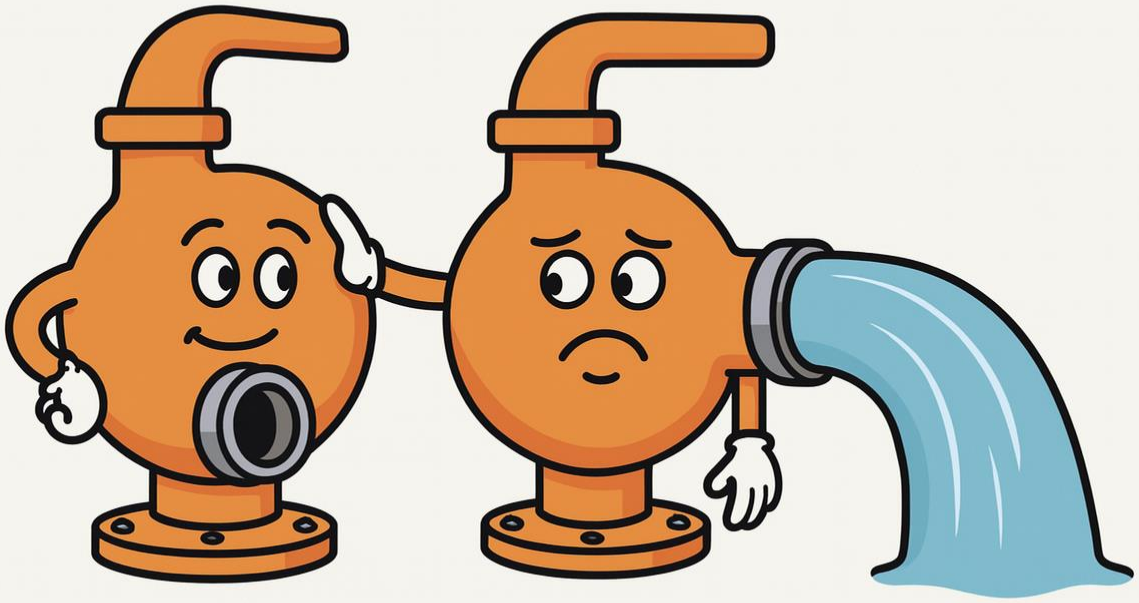
TWO PUMPS FOR A TOTAL LOAD OF 500GPM AT 70' HEAD – 1510 2BD 7.5HP 9.5" IMPELLER



What happens when 1 pump is turned **"Off"** ?

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Why did the two pumps work in parallel?



Because they just couldn't handle the flow alone!

SOURCE: ASHRAE, HVAC SYSTEMS 2024

Section 44.12: If the building does not require critical HVAC pumping service, **then a duty-standby arrangement may not be required and designing for multiple pumps in parallel may be more cost effective.** The appropriate level of redundancy should be discussed with the owner. For example, a flow capacity split of 50:50 results in each pump being sized for 50% of the peak design flow; if one of the pumps were unavailable, **the remaining pump could provide approximately 70% of the peak design flow rate** (depending on the pump and system curves):

Table 2 Flow Redundancy

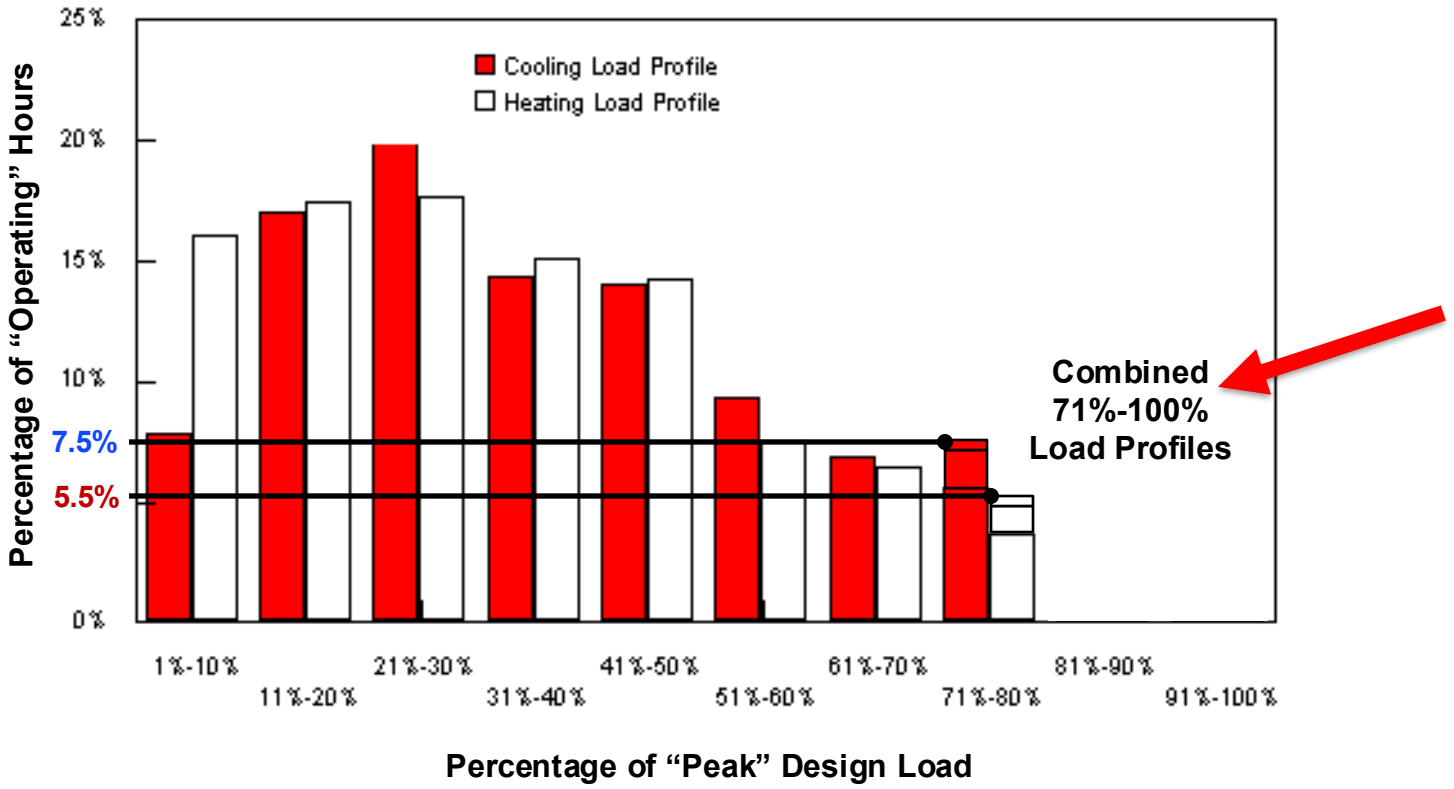
Application	Proposed Flow Redundancy	Flow Capacity Split (for Two-Pump System)
Generic duty	70%	50:50
High comfort sensitivity	85%	70:70
Mission critical	100%	100:100

SOURCE: ASHRAE, HVAC SYSTEMS 2024

Section 13.7: The system curve crosses the single-pump curve considerably to the right of its operating point when both pumps are running. This leads to two important concerns: (1) the pumps must be powered to prevent overloading during single-pump operation, and (2) **a single pump can provide standby service of up to 80% of design flow**; the actual amount depends on the specific pump curve and system curve.

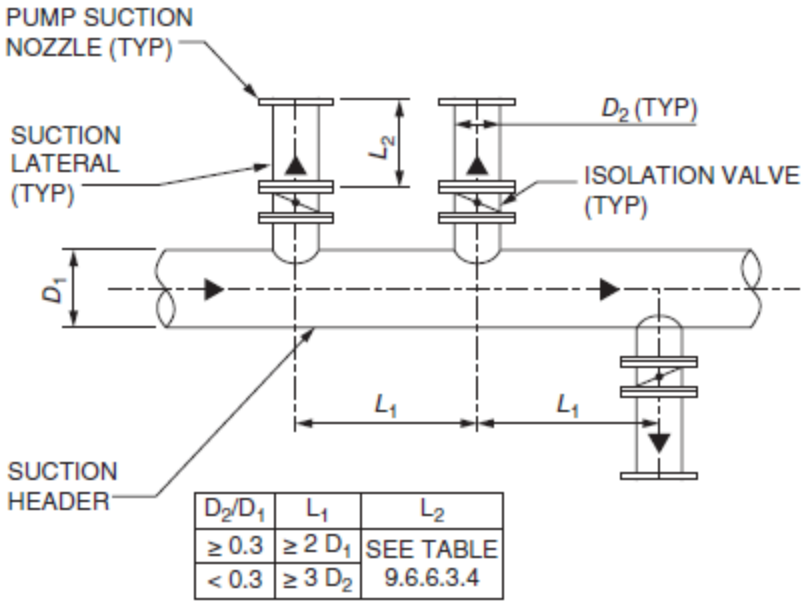
SOURCE: ASHRAE, HVAC SYSTEMS 2024

Average Comfort Heating & Cooling Load Profiles for Commercial Buildings in North America



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9.6.6.5.3.2 There shall be minimum interaction between the suction flow of one pump with another. Figure 9.6.6.5.3a illustrates the minimum recommended spacing and length of pump suction pipe, based on the ratio of the suction lateral diameter to header diameter.



D_2/D_1	L_1	L_2
≥ 0.3	≥ 2 D_1	SEE TABLE 9.6.6.3.4
< 0.3	≥ 3 D_2	

Figure 9.6.6.5.3a — Minimum required suction pipe length and spacing for parallel pumps

HYDRAULIC INSTITUTE

SOURCE: ROTODYNAMIC PUMPS / ANSI/HI 9.6.6-2022

Table 9.6.6.3.4 — Minimum required straight pipe length (L_2) before pump suction nozzle
(refer to Figures 9.6.6.3.4a – k)

Fitting	Number of pipe diameters[a,b]		Comments
	Long radius	Short radius	
90° elbow	4	5	For double suction pumps, add one pipe diameter if the elbow and pump shaft are in the same plane. Area reduction (%) = $(A_{in}-A_{out})/A_{in}$
Reducing elbow with < 30% area reduction	3	4	
Reducing elbow with 30% to ≤ 50% area reduction	2	3	
Reducing elbow with > 50% area reduction	0	1	
Reducers	Concentric	Eccentric	
1 pipe size reduction	0 (<10°)[c]	0 (<20°)[c]	
2 pipe size reductions	0 (<20°)	0 (<30°)	
3 pipe size reductions	0 (<20°)	1 (<30°)	
4 pipe size reductions	2 (<20°)	3 (<40°)	
5 pipe size reductions	3 (<30°)	4 (<40°)	
≤ 45° lateral	4		
Tee, branch flow, > 45°	5		
Continuous-bore valve (100% open)	0		(Continuous-bore ball and gate valves)
Eccentric plug valve - rectangular 80% port	4		
Eccentric plug valve - rectangular 100% port	3		
Butterfly valve[d]	2		

Notes:

1) If an allowed fitting is connected directly to the pump, the next fitting upstream shall have a length L_2 between it and the pump at least equal to the number of straight pipe diameters referenced in this table. The length of the allowed fitting is not to be included as a part of this distance. If several fittings are adjacent, longest L_2 governs. See Figure 9.6.6.3.4g. Allowed fittings include a concentric reducer of 1 - 3 pipe size reduction, an eccentric reducer of 1 - 2 pipe size reduction, a continuous bore valve or a fitting approved by the pump manufacturer.
2) Butterfly valves installed on the suction side of pumps with double suction impellers shall be oriented such that the valve operating shaft is in a parallel plane to the pump shaft.
3) Globe valves and diaphragm valves shall not be used on the suction side of the pumps.
4) For vertical in-line pumps, elbows may be installed on the suction side with an orientation parallel to the pump shaft a distance L_2 a minimum of two pipe diameters for long radius elbows and three pipe diameters for short radius elbows.
5) Length of straight pipe between fitting and pump may be reduced from that presented in the above table with approval of the pump manufacturer.
6) Alternative values may be used if substantiated by a physical model study. See Section 9.6.6.3.5
7) The data in this table are based on commercially available fittings.
8) Flow-straightening devices do not serve as a substitute for the L_2 requirements in this table unless validated by a physical model study. Refer to Appendix E.2 for information on flow straightening devices, and section 9.6.6.3.5 for information on physical model studies.
9) Refer to the information provided in subsection 9.6.6.3.4 for further guidance

1. Varying suction or discharge pressures along a common header can impact the performance of pumps operating in parallel. It is important to carefully analyze the pressure drop along each header segment and through each suction and discharge lateral to achieve a low pressure variation (between laterals) relative to the total head produced by each pump. Minimizing the pressure variation between laterals will promote balanced NPSHA and flow through each pump. The pressure on the suction side of the pumps should be nearly equal; likewise the pressure on the discharge side of the pumps should be nearly equal (see Figure 9.6.6.5.3b).

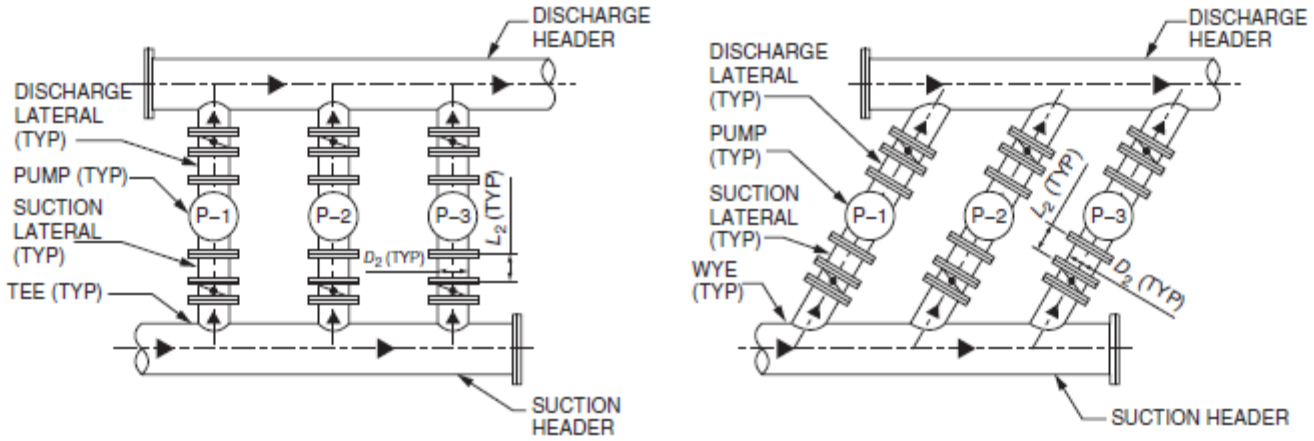


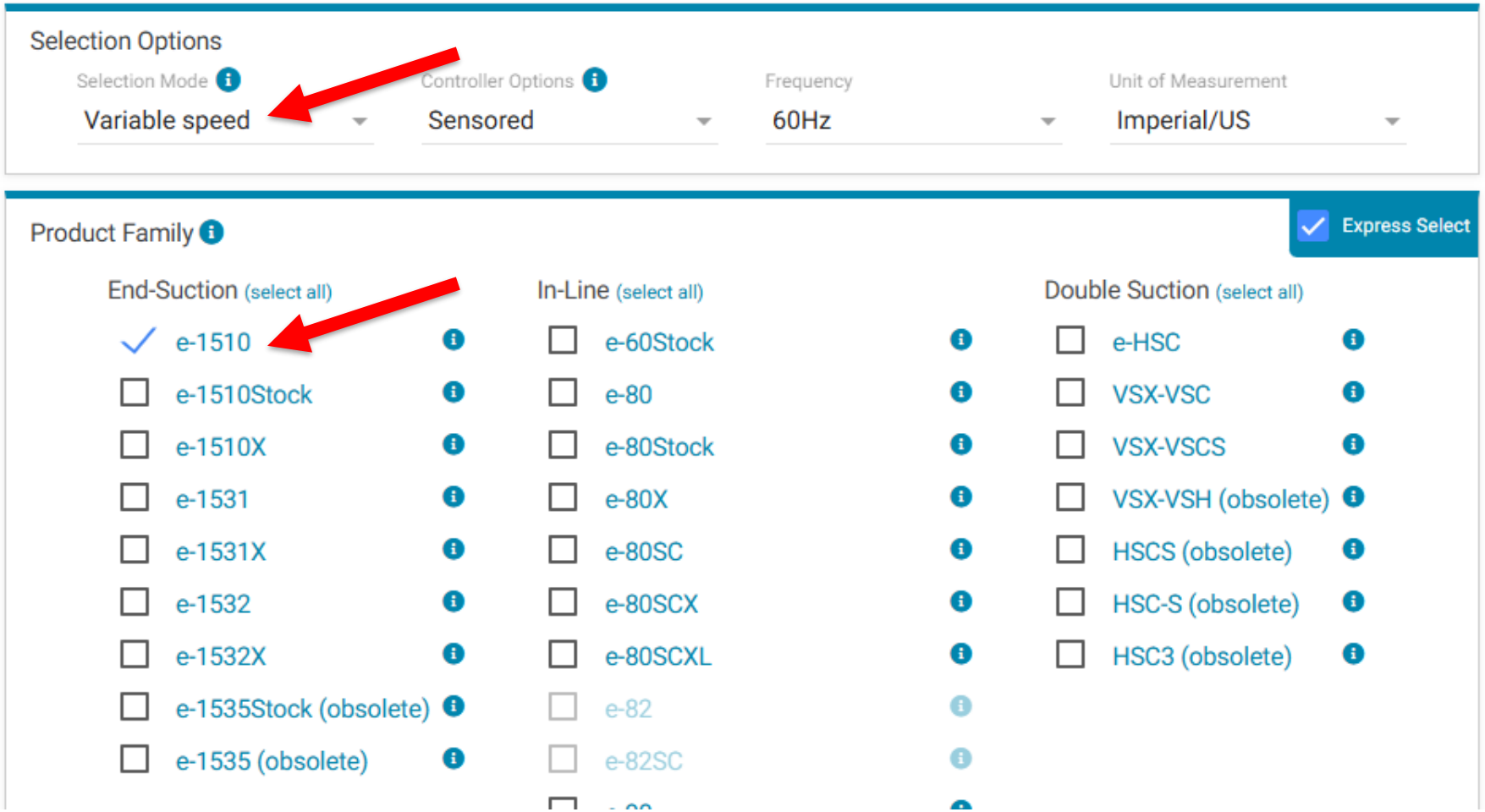
Figure 9.6.6.5.3b — Parallel pump installation L_2

SELECTION COMPARISON

	Duty + Standby (2 Pumps)	Parallel Pump (2 Pumps)	Parallel Pump (3 Pumps)

Example	
Building Type:	K-12 School
Building Load:	5,000MBH
Delta T:	20°F
Design Day Flow Rate:	**500GPM**
Pressure Drop:	**70'**

SELECTION COMPARISON



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SELECTION COMPARISON

Selection Options

Selection Mode: Variable speed

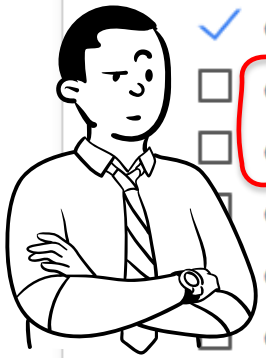
Controller Options: Sensored

Frequency: 60Hz

Unit of Measurement: Imperial/US

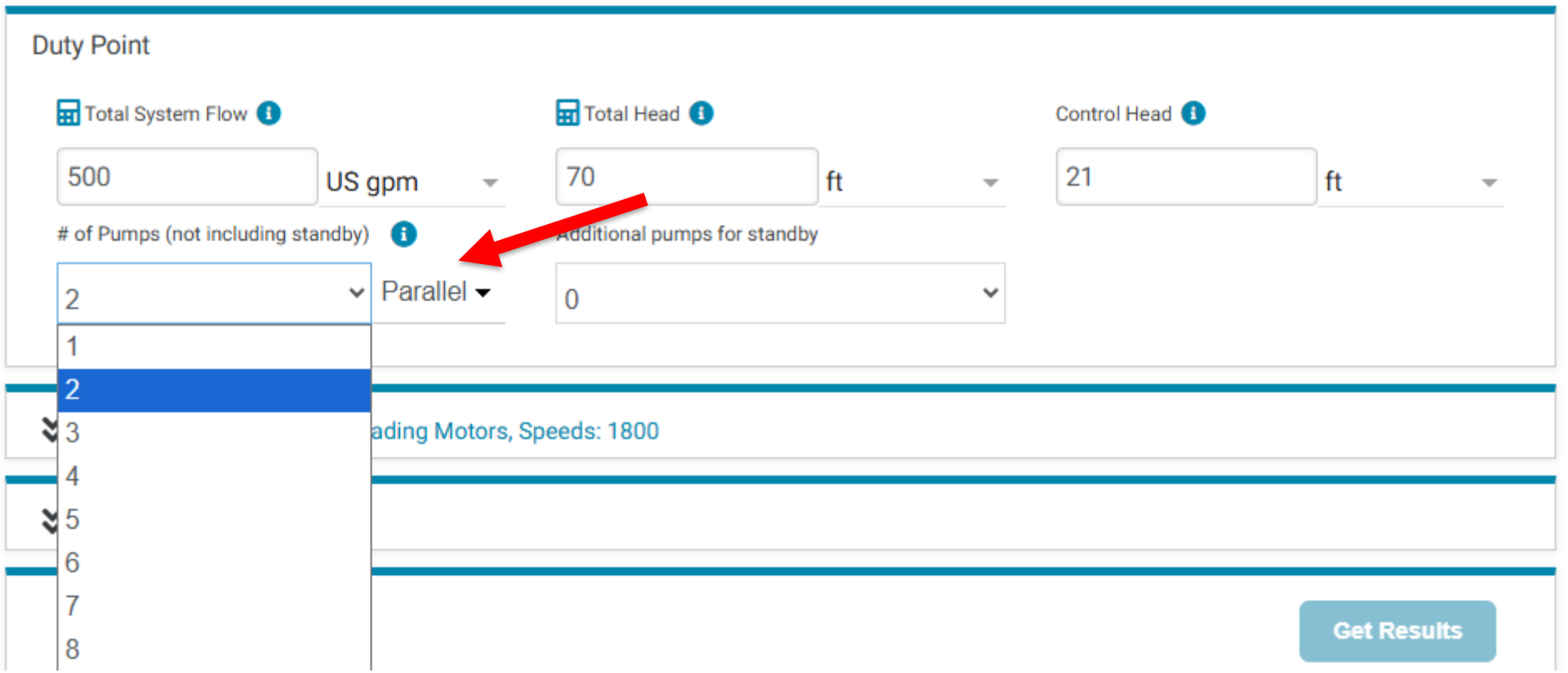
Product Family

Express Select



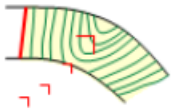
End-Suction (select all)	In-Line (select all)	Double Suction (select all)
☑ e-1510	☐ e-60Stock	☐ e-HSC
☐ e-1510Stock	☐ e-80	☐ VSX-VSC
☐ e-1510X	☐ e-80Stock	☐ VSX-VSCS
☐ e-1531	☐ e-80X	☐ VSX-VSH (obsolete)
☐ e-1531X	☐ e-80SC	☐ HSCS (obsolete)
☐ e-1532	☐ e-80SCX	☐ HSC-S (obsolete)
☐ e-1532X	☐ e-80SCXL	☐ HSC3 (obsolete)
☐ e-1535Stock (obsolete)	☐ e-82	
☐ e-1535 (obsolete)	☐ e-82SC	

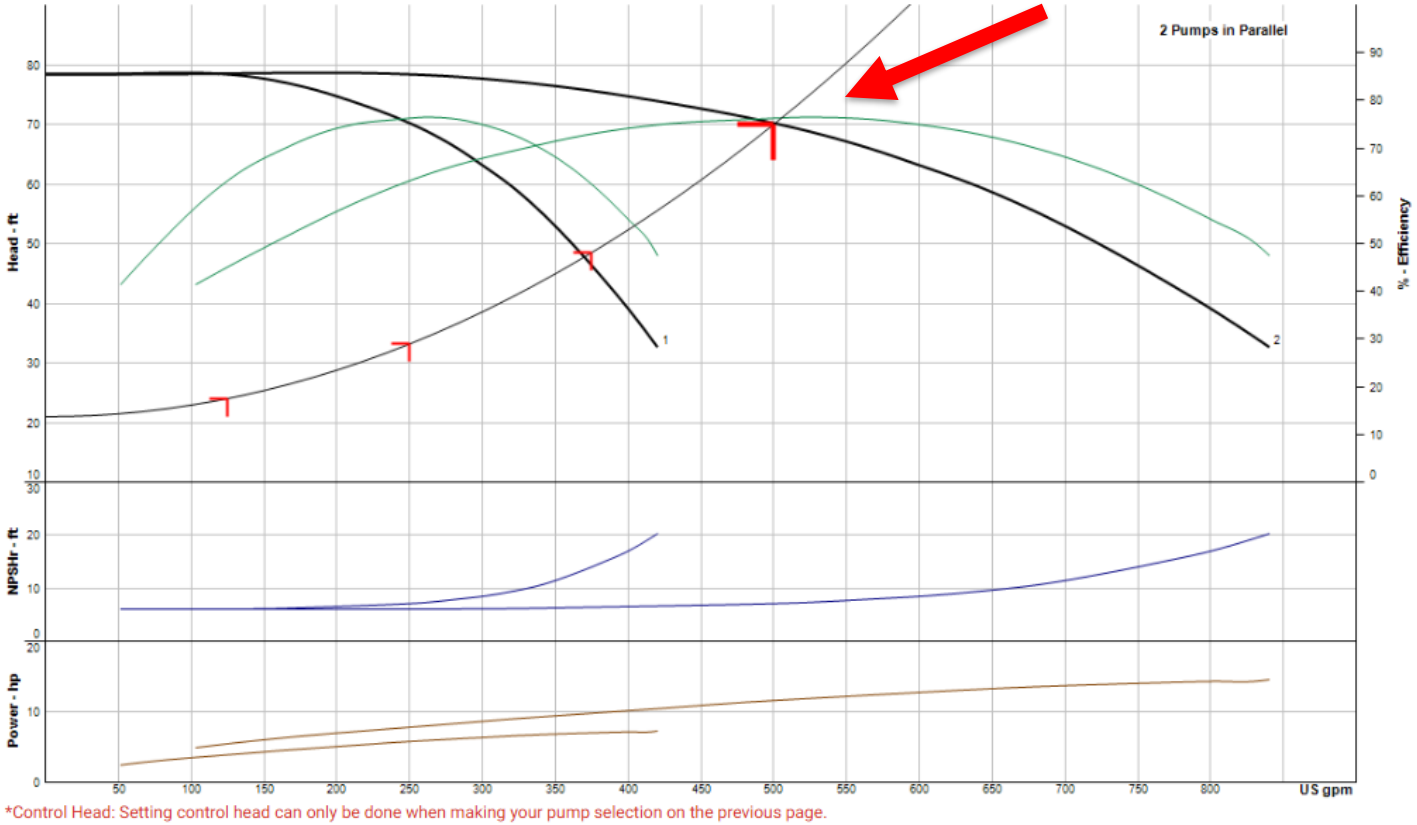
SELECTION COMPARISON



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SELECTION COMPARISON

	Curve	% End Of Curve	Pump Series	Pump Size	Pump PLEVv (%)	Pump Duty Point EFF (%)	Pump Speed (RPM)	Impeller	NPSHr (ft)	Motor (HP)	Actions
☐ Compare		59.6	e-1510	2.5BB	See Best Eff Staging	76.2	1749	8.75 in	7.15	7.5	Add to Schedule Documents Operating Cost Best Eff Staging



*Control Head: Setting control head can only be done when making your pump selection on the previous page.

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COST COMPARISON

	Duty + Standby (2 Pumps)	Parallel Pump (2 Pumps)	Parallel Pump (3 Pumps)

Example	
Building Type:	K-12 School
Building Load:	5,000MBH
Delta T:	20°F
Design Day Flow Rate:	**500GPM**
Pressure Drop:	**70'**

COST COMPARISON

	Duty + Standby (2 Pumps)	Parallel Pump (2 Pumps)	Parallel Pump (3 Pumps)
Pump	B&G 4EB, 15HP	B&G 2.5BB, 7.5HP	B&G 2.5BB, 7.5HP
Suction Diffuser	GF, 6"x5"	ED, 4"x3"	ED, 4"x3"
Triple Duty	3DS-5B, 5"	3DS-4B, 4"	3DS-4B, 4"
VFD	15HP, 480V	7.5HP, 480V	7.5HP, 480V
PP Controller	---	B&G PPS	B&G PPS
Pipe Drop Size	6"	4"	4"
Redundancy	100%	70%	100%+
Equipment Price			
Equipment Savings			

MOST EXPENSIVE?

COST COMPARISON

	Duty + Standby (2 Pumps)	Parallel Pump (2 Pumps)	Parallel Pump (3 Pumps)
Pump	B&G 4EB, 15HP	B&G 2.5BB, 7.5HP	B&G 2.5BB, 7.5HP
Suction Diffuser	GF, 6"x5"	ED, 4"x3"	ED, 4"x3"
Triple Duty	3DS-5B, 5"	3DS-4B, 4"	3DS-4B, 4"
VFD	15HP, 480V	7.5HP, 480V	7.5HP, 480V
PP Controller	---	B&G PPS	B&G PPS
Pipe Drop Size	**6"**	4"	4"
Redundancy	100%	70%	100%+
Equipment Price	$24,460	$16,825	$23,290
Equipment Savings		**$7,635**	**$1,170**

COST COMPARISON

100% Duty + Standby Operation:
(1+1) B&G 4EB Pump

Design Point

Total Flow
500 US gpm

Total Head
70 ft

Shutoff Head
91.4 ft

Operating Assumptions

Days Per Year Operation: 180

Electricity Cost Per kWh (cents): 0.1109 Michigan

Hours Per Day 100%	Hours Per Day 75%	Hours Per Day 50%	Hours Per Day 25%
0.24	10.08	10.8	2.88

Total hours per day: 24

Savings Summary

Control Stragey	Annual Operating Cost	Savings vs. constant speed	ASHRAE 90.1 2010/2013 compliant
Constant Speed	$3,342	---	NO
Sensorless or pump DP Control	$1,977	40.8%	NO
Remote Sensor w/ fixed DP	$1,789	46.5%	YES
Remote Sensor w/ DP reset	$1,308	60.9%	YES

Parallel Pumps Operation:
(2) B&G 2.5BB Pumps

Operating Assumptions

Days Per Year Operation: 180

Electricity Cost Per kWh (cents): 0.1109 Michigan

Hours Per Day 100%	Hours Per Day 75%	Hours Per Day 50%	Hours Per Day 25%
0.24	10.08	10.8	2.88

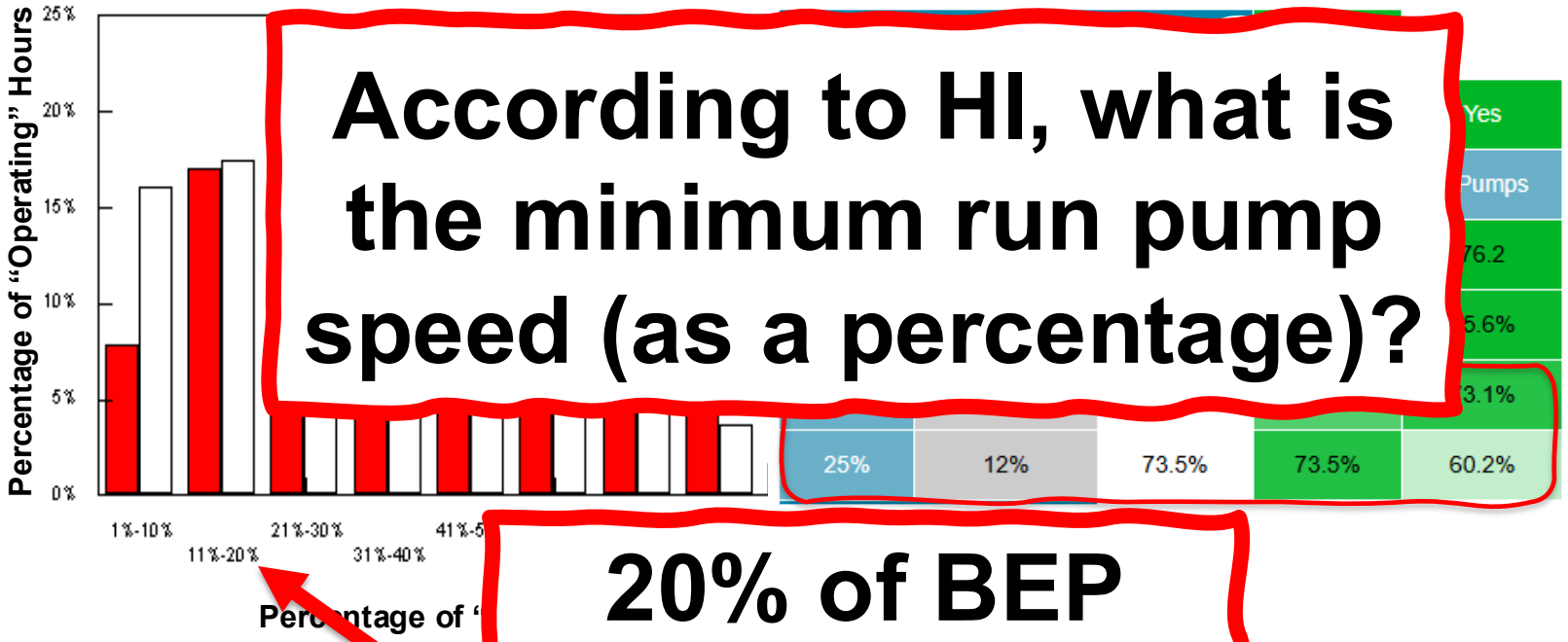
Total hours per day: 24

Savings Summary

Control Stragey	Annual Operating Cost	Savings vs. constant speed	ASHRAE 90.1 2010/2013 compliant
Constant Speed	$2,890	---	NO
Sensorless or pump DP Control	$1,941	32.9%	NO
Remote Sensor w/ fixed DP	$1,767	38.9%	YES
Remote Sensor w/ DP reset	$1,305	54.9%	YES

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Parallel Pumps Operation:
(2) B&G 2.5BB Pumps



According to HI, what is the minimum run pump speed (as a percentage)?

20% of BEP

Or 5:1 turndown

SCHEDULING PARALLEL PUMPS

AVOIDING PITFALLS

TAG	Model	GPM	Head	HP	RPM	Service	Note
P-1	e1510 2.5BB	250	70	7.5	1800	HHW	Stg
P-2	e1510 2.5BB	250	70	7.5	1800	HHW	Stg
P-3	e1510 2.5BB	250	70	7.5	1800	HHW	Stdby

- All pump schedules should indicate the operating pumps vs. the standby pumps.
  1. Example 1 Note: P1 & P2 operate in staged parallel mode **using a total flow rate of 500GPM.**
  2. Example 2 Note: P1, P2, and P3 operate in staged parallel mode with one standby.
  3. Example 3 Note: Pumps P1,P2, and P3 are 50%-50%-50% parallel pumps.
  4. Example 4 Note: Pumps shall be Bell & Gossett

Note if using 33%-33%-33% or similar and the single pump curve does not cross system curve, you will need to operate two pumps all the time.

You should let the controls people know when this happens so they can stage pumps appropriately!

Built-in Pump Options w/ Smart Pumps

End Suction: e-1510x, e-1531x, e-1532x
Inline: e-80X, e-80SCX
Circulator: ecocirc XL



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Controller for Conventional Pump & VFD

B&G PPS Parallel Pump Controller



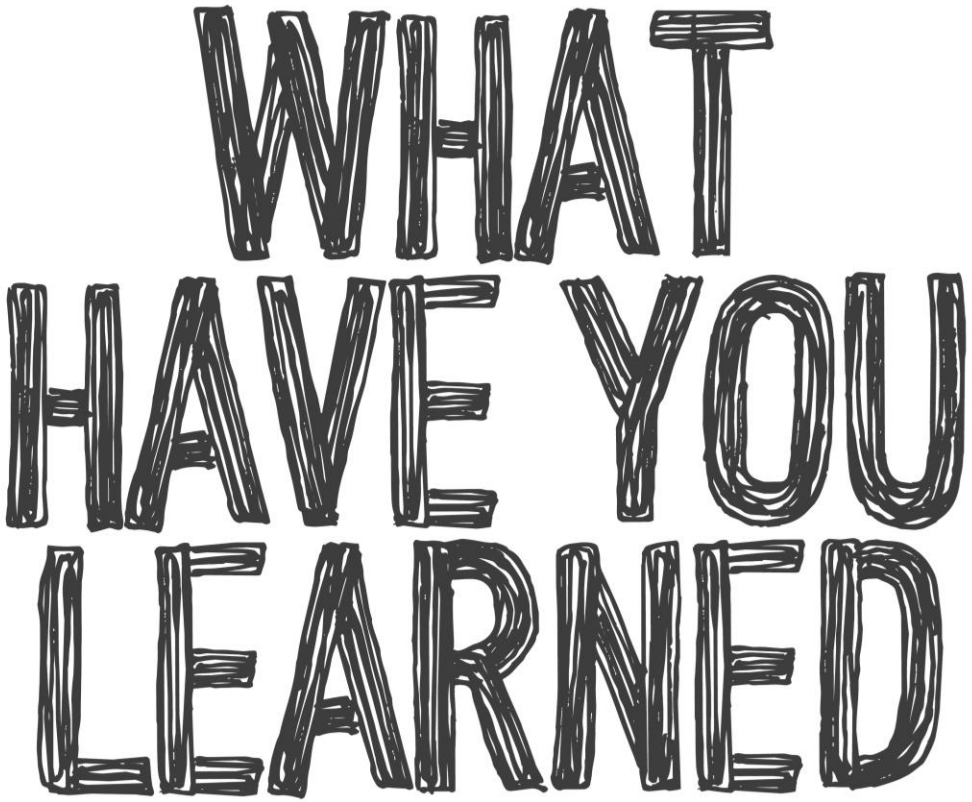
TECHNOLOGY OPTIONS



Controller for Conventional Pump & VFD

Building Management System

SUMMARY





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SUMMARY

1. What is the Golden Rule of Hydronics?
2. According to ASHRAE, what application type is best suited for a duty plus standby pump configuration?
3. In a general duty application with a parallel pump configuration, what percentage of peak flow can a single pump provide?
4. What percentage of operating hours for a heating application are above 70% of "Peak" Design Load?
5. TRUE or FALSE: The operational costs of the parallel pump example shown today are significantly higher than a 100% duty + standby configuration.



RL Deppmann Monday Morning Minutes

HVAC Hydronic System: Parallel Pumping Specifications: https://www.deppmann.com/blog/monday-morning-minutes/hvac-hydronic-system-parallel-pumping-specifications/

Parallel Pumping in Condenser Applications (Part 1): https://www.deppmann.com/blog/monday-morning-minutes/parallel-pumping-condenser-applications/

Parallel Pumping in Condenser Applications: Limiting the Flow Rate (Part 2): https://www.deppmann.com/blog/monday-morning-minutes/parallel-pumping-condenser-applications-limiting-flow-rate-part-2/

Parallel Pumping in Condenser Applications: Automatic Differential Pressure Control (Part 3): https://www.deppmann.com/blog/monday-morning-minutes/parallel-pumping-condenser-applications-automatic-differential-pressure-control-part-3/

Centrifugal Pumps – Parallel Pumping: https://www.deppmann.com/blog/monday-morning-minutes/centrifugal-pumps-parallel-pumping/

Centrifugal Pumps – When and How to Use Parallel Pumping: https://www.deppmann.com/blog/monday-morning-minutes/centrifugal-pumps-when-and-how-to-use-parallel-pumping/

More articles available at: https://www.deppmann.com/?s=parallel

Bell & Gossett

Bell & Gossett PPS Parallel Pump Controller: https://www.xylem.com/en-us/products--services/pumps-packaged-pump-systems/monitoring-control-equipment/control/speed-control/pps-parallel-pump-controller/

Bell & Gossett esp-Systemwize: https://www.esp-systemwize.com/

Bell & Gossett TEH Manual: https://www.xylem.com/siteassets/brand/bell-amp-gossett/resources/technical-brochure/teh-1109a-parallel-and-series-pump-application.pdf

Brad Notter – Education Leader

Kyle Wefing – Vice President, Sales



AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break	
9:45-10:45 –	**Domestic Hot Water Recirculation Systems –**	**Ryan Groves**
10:45-11:00 –	Break	
11:00-12:00 –	Exploring Heat Exchangers –	Mike Kennedy & Jason Winslow
12:00-1:00 –	Lunch	
1:00-2:00 –	From 0 to 60Hz: The Basics of VFDs –	Nick Tabar
2:00-2:15 –	Break	
2:15-3:15 –	F & T Steam Basics –	Mark Fine & Nick Tafelski
3:15-3:30 –	Break	
3:30-4:30 –	Practical Water Quality Testing –	Andrew Ward

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BREAK & TRIVIA



RETURN AT 9:45AM

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DOMESTIC HOT WATER RETURN SYSTEMS

Presented by: Ryan Groves

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AGENDA

- Purpose of hot water recirculation systems
- Balancing methods
- Sizing example
- High rise applications
- Hot water recirculation creep
- Wrap up

HOT WATER RECIRCULATION

Energy losses from hot-water distribution systems usually amount to at least 10 to 20% of total hot-water system energy use in most potable water-heating systems and are often as high as 50%; losses of over 90% have been found in some installations.

-2023 ASHRAE HVAC Applications Handbook

HOT WATER RECIRCULATION

Water Waste for Residence without HWR					
Pipe Type	**Supply Pipe Length** (ft)	**Pipe Volume** (US gal)	**Draws / Day**	**Wasted Water / Day** (US gal)	**Wasted Water / Year** (US gal)
3/4″ Copper Type L	100′	2.5	10	25	9,125
3/4″ Copper Type L	135′	3.38	10	33.8	12,337
3/4″ Pex	135′	2.45	10	24.5	8,943
3/4″ Copper Type L	180′	4.5	10	45	16,425

HOT WATER RECIRCULATION

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Study Information

- Study conducted by Berkely National Laboratory in 2011
- Goal of study was to evaluate waste of water and energy associated with hot water distribution systems
- 3 households evaluated over 1 week timeframe
- All with natural gas storage type water heaters

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HOT WATER RECIRCULATION



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HOT WATER RECIRCULATION

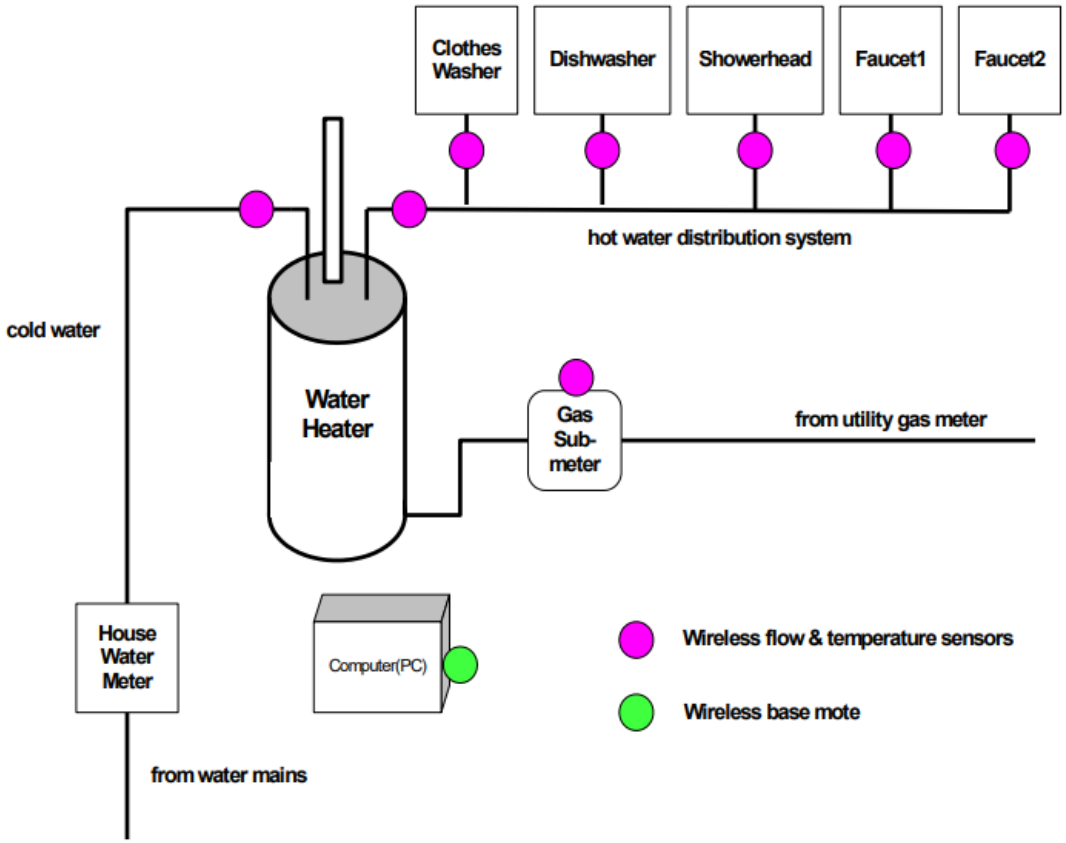


Figure 2. Points at which water flow and temperature were measured during pilot project.

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HOT WATER RECIRCULATION

Table 1. Durations of five shower events

Date	Total Duration of Water Flow (minutes)	Duration of Shower (minutes)	Time Wasted (minutes)	% of Time Wasted
1/7/2009	4:59	4:06	0:53	21.5%
2/27/2009	5:46	4:22	1:24	32.1%
3/20/2009	6:19	4:16	2:03	48.0%
3/21/2009	5:48	4:34	1:14	27.0%
3/22/2009	8:02	5:40	2:22	41.8%
average	6:11	4:36	1:35	34.5%

HOT WATER RECIRCULATION

Table 2. Water used and wasted during five shower events

Date	Total Water Flow	Water Used for Shower	Water Wasted	% of Water Wasted
1/7/2009	12.5 gal (47.2 L)	10.4 gal (39.4 L)	2.1 gal (7.8 L)	19.9%
2/27/2009	10.5 gal (39.7 L)	8.0 gal (30.2 L)	2.5 gal (9.4 L)	31.2%
3/20/2009	11.6 gal (44.0 L)	8.4 gal (31.7 L)	3.3 gal (12.3 L)	39.0%
3/21/2009	11.6 gal (43.8 L)	9.2 gal (34.7 L)	2.4 gal (9.0 L)	26.0%
3/22/2009	15.5 gal (58.9 L)	11.5 gal (43.4 L)	4.1 gal (15.5 L)	35.7%
average	12.3 gal (46.7 L)	9.5 gal (35.9 L)	2.9 gal (10.8 L)	30.2%

HOT WATER RECIRCULATION

Table 3. Energy used and wasted during five shower events

Date	Total Energy From Water Heater	Energy Used at Shower	Energy Wasted	% of Energy Wasted
1/7/2009	5169 BTU (5.454 MJ)	4114 BTU (4.340 MJ)	1055 BTU (1.113 MJ)	25.7%
2/27/2009	4335 BTU (4.573 MJ)	2554 BTU (2.695 MJ)	1780 BTU (1.878 MJ)	69.7%
3/20/2009	4151 BTU (4.379 MJ)	2847 BTU (3.004 MJ)	1304 BTU (1.375 MJ)	45.8%
3/21/2009	4192 BTU (4.423 MJ)	3122 BTU (3.294 MJ)	1070 BTU (1.128 MJ)	34.3%
3/22/2009	5499 BTU (5.801 MJ)	3902 BTU (4.117 MJ)	1596 BTU (1.684 MJ)	40.9%
average	4669 BTU (4.926 MJ)	3308 BTU (3.490 MJ)	1361 BTU (1.436 MJ)	41.1%

HOT WATER RECIRCULATION

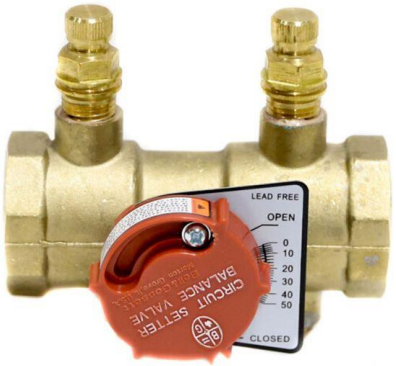
607.2 Hot or Tempered Water Supply to Fixtures

The *developed length* of *hot* or *tempered water* piping, from the source of hot water to the fixtures that require *hot* or *tempered water*, shall not exceed 50 feet (15 240 mm). Recirculating system piping and heat-traced piping shall be considered to be sources of *hot* or *tempered water*.

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BALANCING

STANDARD



BELL & GOSSETT CIRCUIT SETTER

- Manual balance valve
- Can be used as an isolation valve
- Memory stop

PREMIUM



GRISWOLD K VALVE

- Automatic flow limiting valve
- No balancing required
- Additional isolation valve required

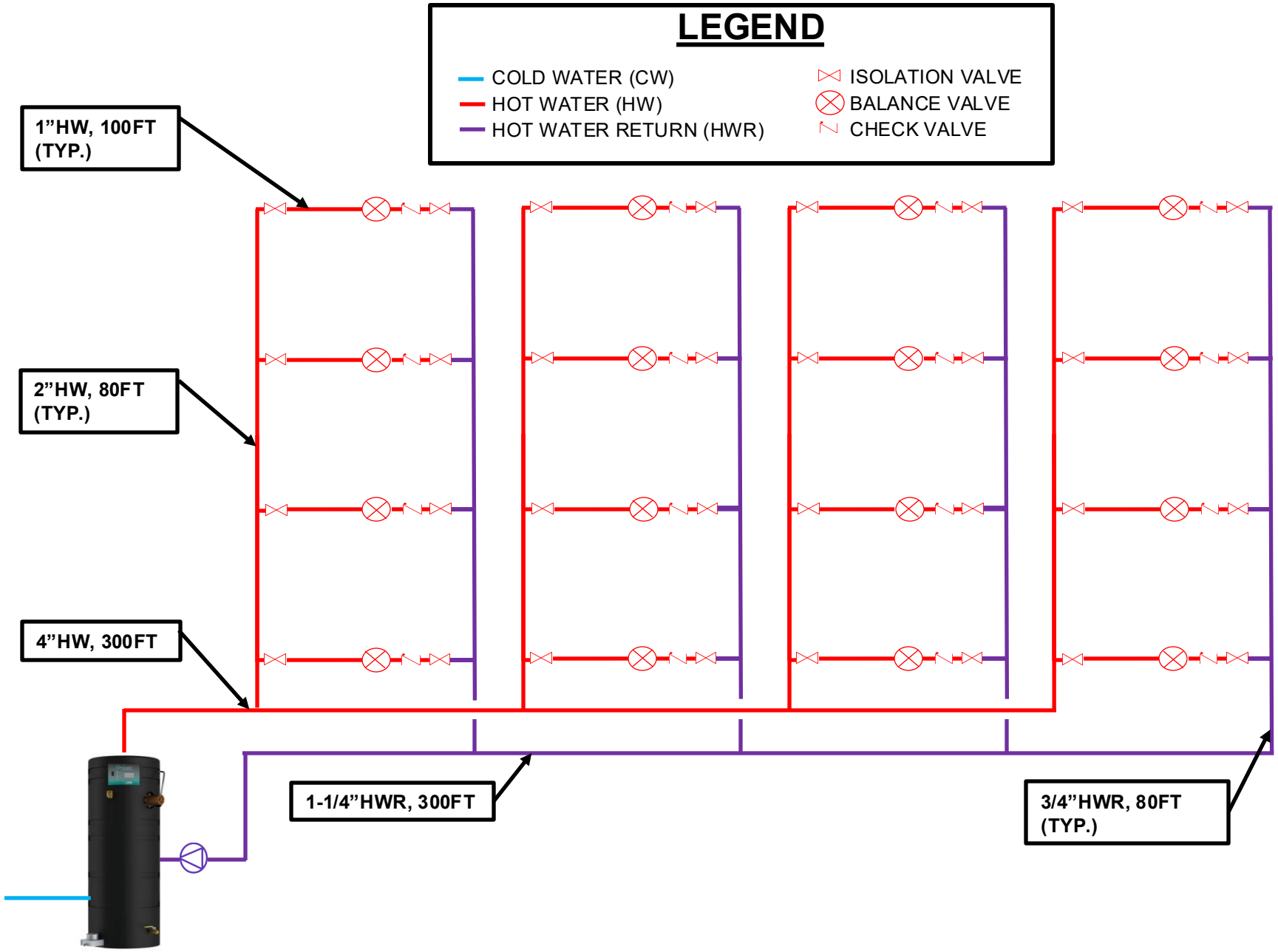
ELITE



BELL & GOSSETT TEMP SETTER

- Thermostatic balance valve
- Available with manual / auto bypass
- No balancing required

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LEGEND
COLD WATER (CW)
HOT WATER (HW)
HOT WATER RETURN (HWR)
ISOLATION VALVE
BALANCE VALVE
CHECK VALVE
1”HW, 100FT (TYP.)
2”HW, 80FT (TYP.)
4”HW, 300FT
1-1/4”HWR, 300FT
3/4”HWR, 80FT (TYP.)

HOT WATER RECIRCULATION

1. **Determine rate of heat loss**
2. Determine acceptable temperature drop
3. Determine flow rate
4. Determine required pump head
5. Determine control method

HEAT LOSS

Table 14.5 Approximate Insulated Piping Heat Loss and Surface Temperature

Nominal Pipe Size (in.)	Insulation Thickness (in.)	Heat Loss (Btu/h/ linear ft)	Surface Temperature (°F)
½	1	8	68
¾	1	10	69
1	1	10	69
1¼	1	13	70
1½	1	13	69
2 or less	½[a]	24 or less	74
2	1	16	70
2½	1½	12	67
3	1½	16	68
4	1½	19	69
6	1½	27	69
8	1½	32	69
10	1½	38	69

Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

[a]Uncirculating hot water runout branches only.

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

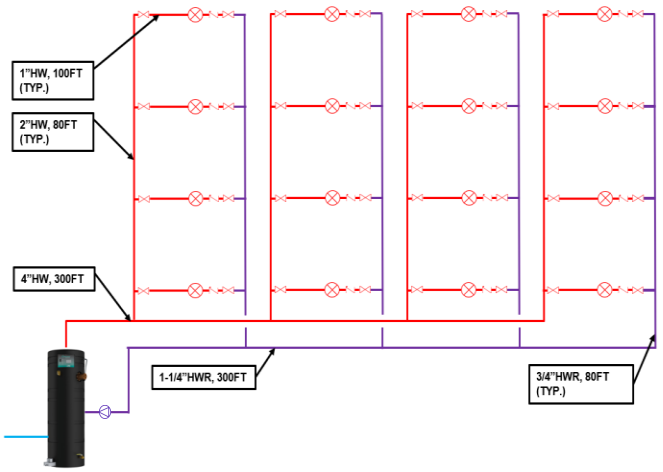
$$4"PIPE = 300FT \times 19\,Btu/FT = 5{,}700\,Btu$$

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Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

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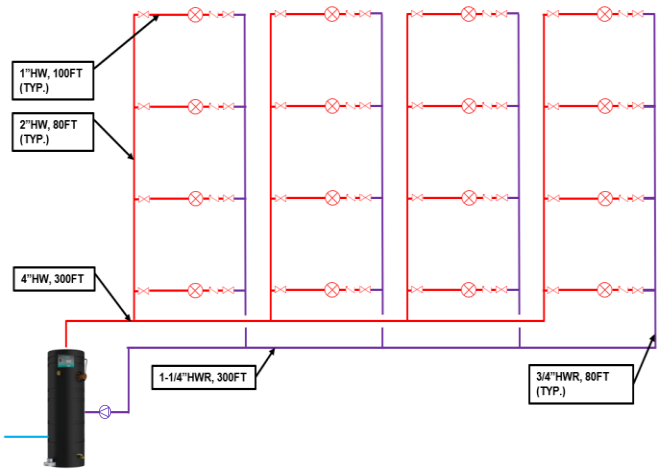
$$2"PIPE = 320FT \times 16\,Btu/FT = 5{,}120\,Btu$$

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Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

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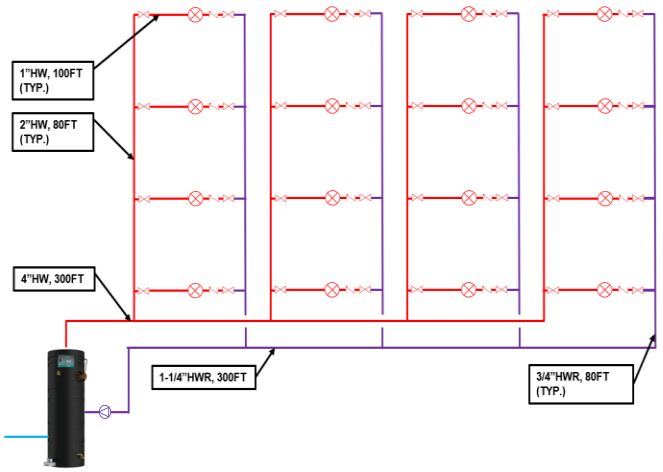
$$1"PIPE = 1600FT \times 10\ Btu/FT = 16{,}000\ Btu$$

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Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

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RETURN PIPING HEAT LOSS

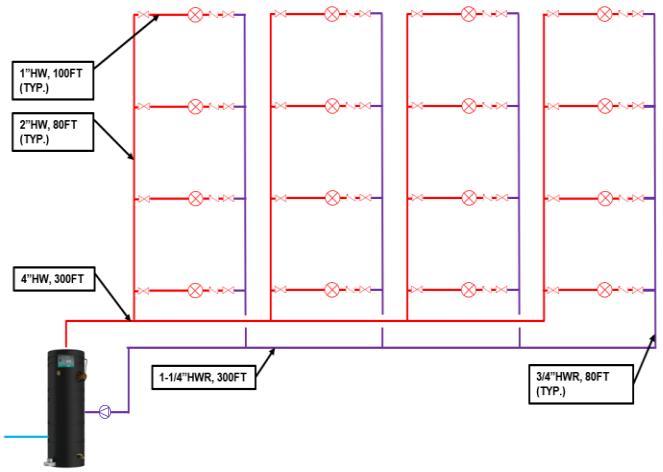
$$1\text{-}1/4"PIPE = 300FT \times 13\ Btu/FT = 3{,}900\ Btu$$

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HWR

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

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$$1"PIPE = 1600FT \times 10\ Btu/FT = 16{,}000\ Btu$$

RETURN PIPING HEAT LOSS

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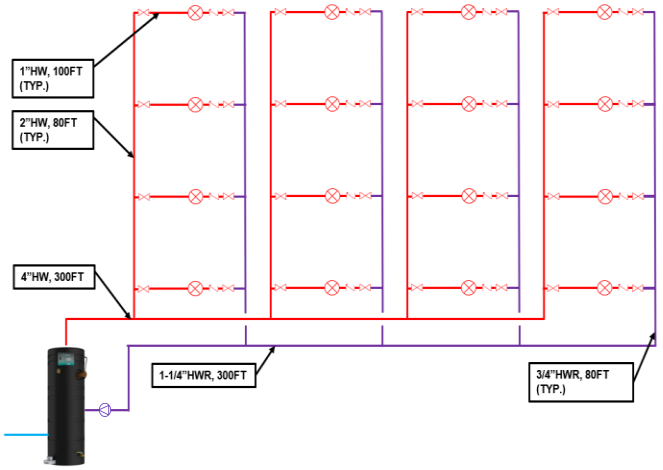
$$3/4"PIPE = 320FT \times 10\ Btu/FT = 3{,}200\ Btu$$

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HWR

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HEAT LOSS

SUPPLY PIPING HEAT LOSS

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$$2"PIPE = 320FT \times 16\ Btu/FT = 5{,}120\ Btu$$

$$1"PIPE = 1600FT \times 10\ Btu/FT = 16{,}000\ Btu$$

$$26{,}820\ Btu$$

RETURN PIPING HEAT LOSS

$$1\text{-}1/4"PIPE = 300FT \times 13\ Btu/FT = 3{,}900\ Btu$$

$$3/4"PIPE = 320FT \times 10\ Btu/FT = 3{,}200\ Btu$$

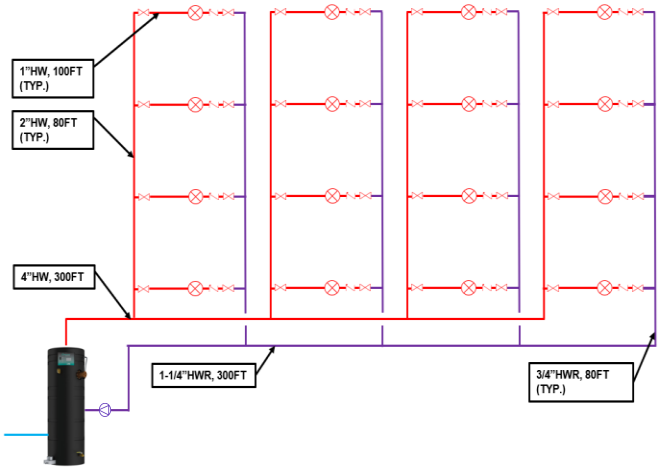
$$7{,}100\ Btu$$

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Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

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HEAT LOSS

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$$3/4"PIPE = 320FT \times 10\ Btu/FT = 3{,}200\ Btu$$

$$7{,}100\ Btu$$

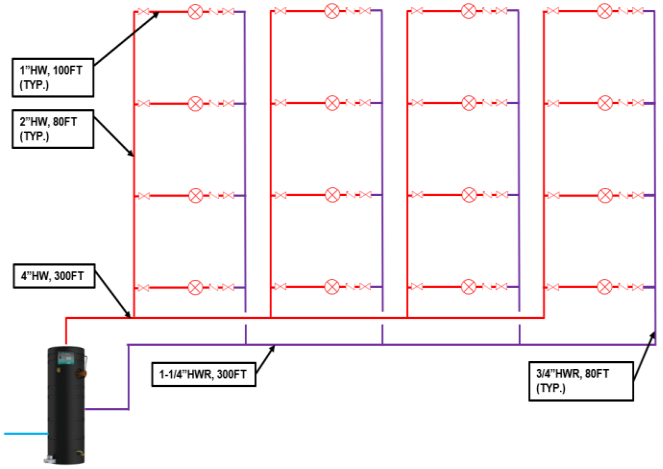
$$7{,}100\ Btu + 26{,}820\ Btu = 33{,}920\ Btu$$

Table 14.5 Approximate Insulated Piping Heat Loss and Surface Temperature

Nominal Pipe Size (in.)	Insulation Thickness (in.)	Heat Loss (Btu/h/ linear ft)	Surface Temperature (°F)
½	1	8	68
¾	1	10	69
1	1	10	69
1¼	1	13	70
1½	1	13	69
2 or less	½[a]	24 or less	74
2	1	16	70
2½	1½	12	67
3	1½	16	68
4	1½	19	69
6	1½	27	69
8	1½	32	69
10	1½	38	69

Note: Figures based on average ambient temperature of 65°F and annual average wind speed of 7.5 mph.

[a]Uncirculating hot water runout branches only.



HWR

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HOT WATER RECIRCULATION

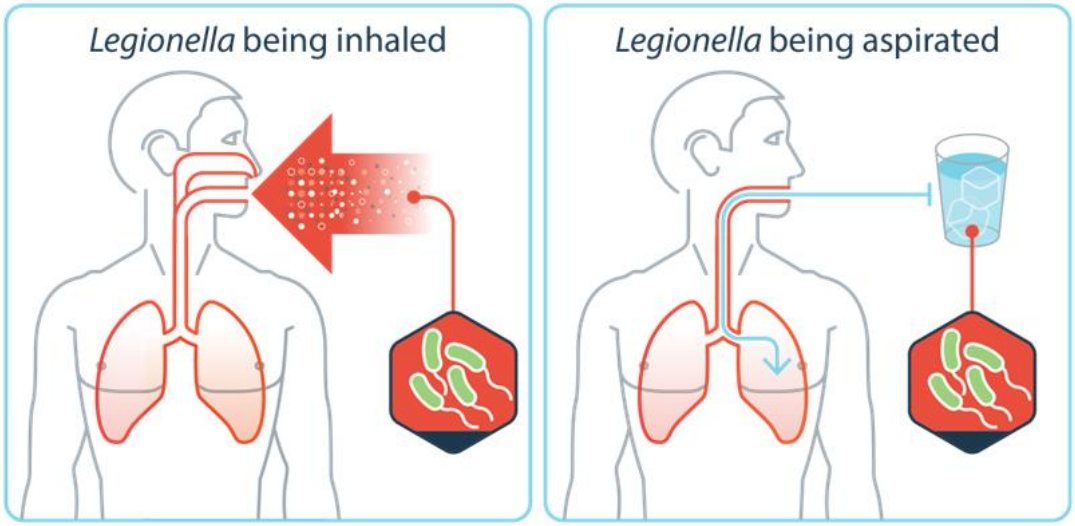
1. ~~Determine rate of heat loss~~
2. **Determine acceptable temperature drop**
3. Determine flow rate
4. Determine required pump head
5. Determine control method

LEGIONELLA

Legionnaires' Disease

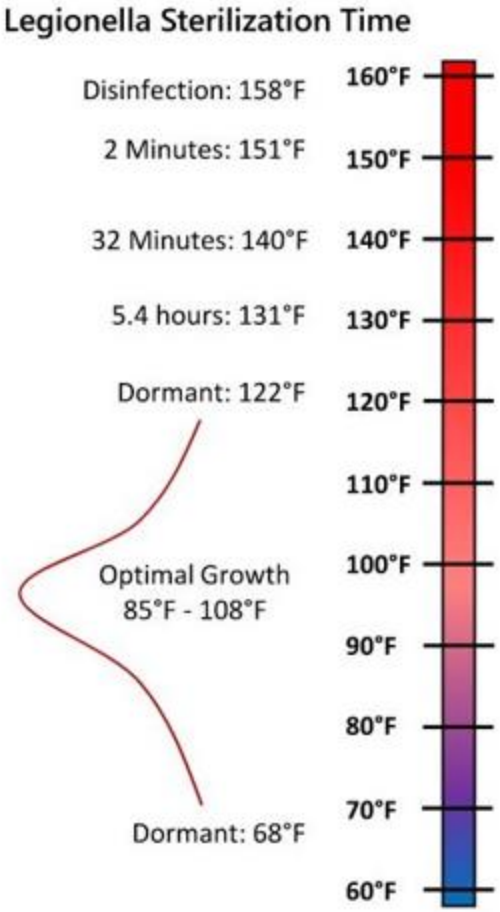
Legionnaires' disease is a serious type of pneumonia you get when Legionella bacteria infect your lungs. Symptoms include high fever, cough, diarrhea and confusion. You can get Legionnaires' disease from water or cooling systems in large buildings, like hospitals or hotels. Legionnaires' disease can be life-threatening.





DEPPMANN

STORAGE & SUPPLY TEMPERATURE

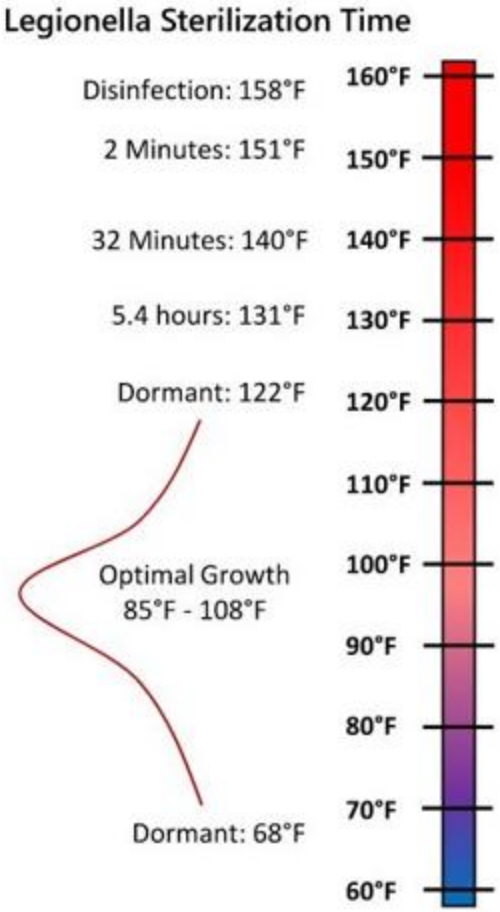


Sources: Sanden, Fields, and Barbaree, et. al., "Viability of Legionella pneumophila in chlorine free water at elevated temperatures." Abstracts of the Annual Meeting of the American Society for Microbiology 1986: 287

Moritz and Henriques, "Study of Thermal Injury: II." American Journal of Pathology 1947; 23: 695-720
Technical Bulletin 34, US Government Memorandum, C.P.S.C.

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STORAGE & SUPPLY TEMPERATURE



The recommended hot water system temperature drop should be of the magnitude of 5°F. This means that if the hot water supply starts out from the water heater at a temperature between 135 and 140°F, the lowest hot water supply temperature provided by the hot water supply system could be between 130 and 135°F.

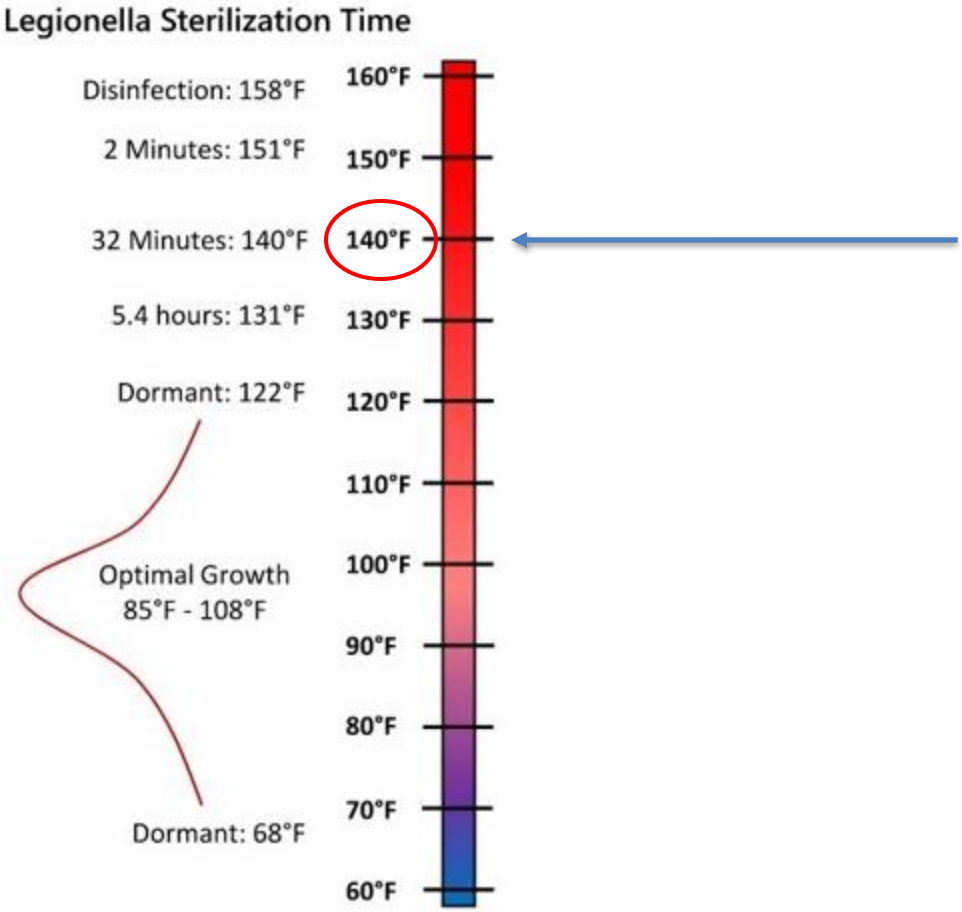
-ASPE Domestic Water Heating Design Manual

Sources: Sanden, Fields, and Barbaree, et. al., "Viability of Legionella pneumophila in chlorine free water at elevated temperatures." Abstracts of the Annual Meeting of the American Society for Microbiology 1986: 287

Moritz and Henriques, "Study of Thermal Injury: II." American Journal of Pathology 1947; 23: 695-720
Technical Bulletin 34, US Government Memorandum, C.P.S.C.

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STORAGE & SUPPLY TEMPERATURE



A supply temperature of 140°F is strongly recommended to mitigate legionella concerns.

Table 1.3 Time/Water Temperature Combinations Producing Skin Damage

Water Temperature		
°F	°C	Time (sec)
Over 140	Over 60	Less than 1
140	60	2.6
135	58	5.5
130	54	15
125	52	50
120	49	290

Source: Tom Byrley. 1979. 130 degrees F or 140 degrees F. *Contractor Magazine*. (September). First published in *American Journal of Pathology*.

Note: The above data indicate conditions producing the first evidence of skin damage in adult males.

Sources: Sanden, Fields, and Barbaree, et. al., "Viability of Legionella pneumophila in chlorine free water at elevated temperatures." Abstracts of the Annual Meeting of the American Society for Microbiology 1986: 287

Moritz and Henriques, "Study of Thermal Injury: II." American Journal of Pathology 1947; 23: 695-720
Technical Bulletin 34, US Government Memorandum, C.P.S.C.

DEPPMANN

HOT WATER RECIRCULATION

1. ~~Determine rate of heat loss~~
2. ~~Determine acceptable temperature drop~~
3. **Determine flow rate**
4. Determine required pump head
5. Determine control method

FLOW RATE

$$Q = rwc\Delta T$$

Q = *Time rate of heat transfer (BTUH)*

r = *Flow rate (GPH)*

w = *Weight of heated water (LB)*

c = *Specific heat of water (BTU / LB°F)*

ΔT = *Change in heated water temperature(°F)*

RL DEPPMANN

FLOW RATE

$$Q = rwc\Delta T$$

$$\text{GPM} = \frac{System\ Heat\ Loss}{500\ \times \Delta°F}$$

Q = *Time rate of heat transfer (BTUH)*

r = *Flow rate (GPH)*

w = *Weight of heated water (LB)*

c = *Specific heat of water (BTU / LB°F)*

ΔT = *Change in heated water temperature(°F)*

RL DEPPMANN

FLOW RATE

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$$\text{GPM} = \frac{System\ Heat\ Loss}{500\ \times \Delta°F}$$

$$\text{GPM} = \frac{33{,}920\ Btu}{500\ \times 5}$$

DEPPMANN

FLOW RATE

$$Q = rwc\Delta T$$

Q = *Time rate of heat transfer (BTUH)*

r = *Flow rate (GPH)*

w = *Weight of heated water (LB)*

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ΔT = *Change in heated water temperature(°F)*

$$\text{GPM} = \frac{System\ Heat\ Loss}{500\ \times \Delta°F}$$

$$\text{GPM} = \frac{33{,}920\ Btu}{500\ \times 5}$$

$$\text{GPM} = 13.56$$

DEPPMANN

FLOW RATE

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c = *Specific heat of water (BTU / LB°F)*

ΔT = *Change in heated water temperature(°F)*

$$\text{GPM} = \frac{System\ Heat\ Loss}{500\ \times \Delta°F}$$

$$\text{GPM} = \frac{33{,}920\ Btu}{500\ \times 5}$$

$$\text{GPM} = 13.56$$

It is recommended to have a minimum of .5 GPM across each balance valve to ensure the system can be balanced correctly.

$$\frac{13.56}{16} = .8475$$

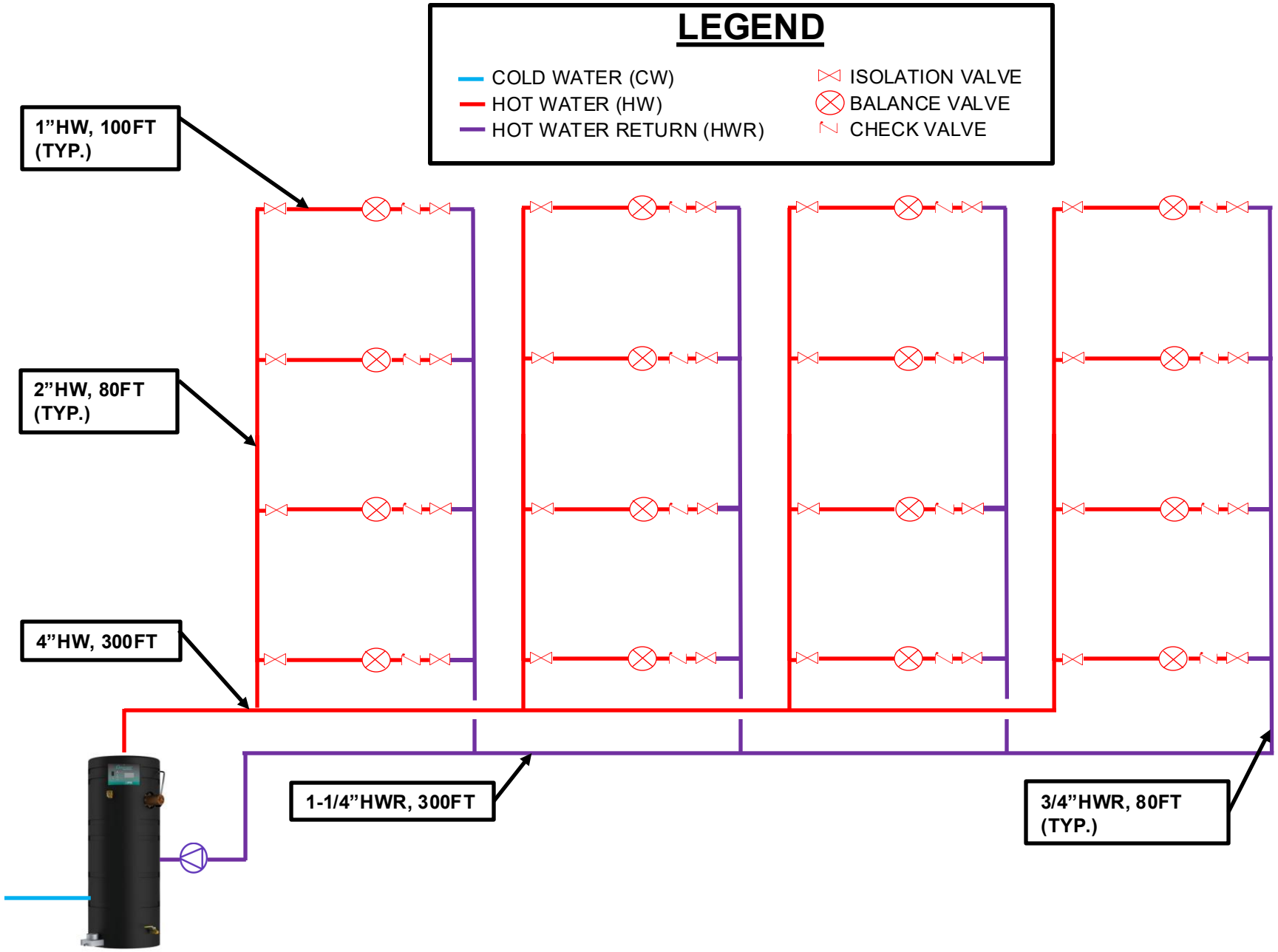


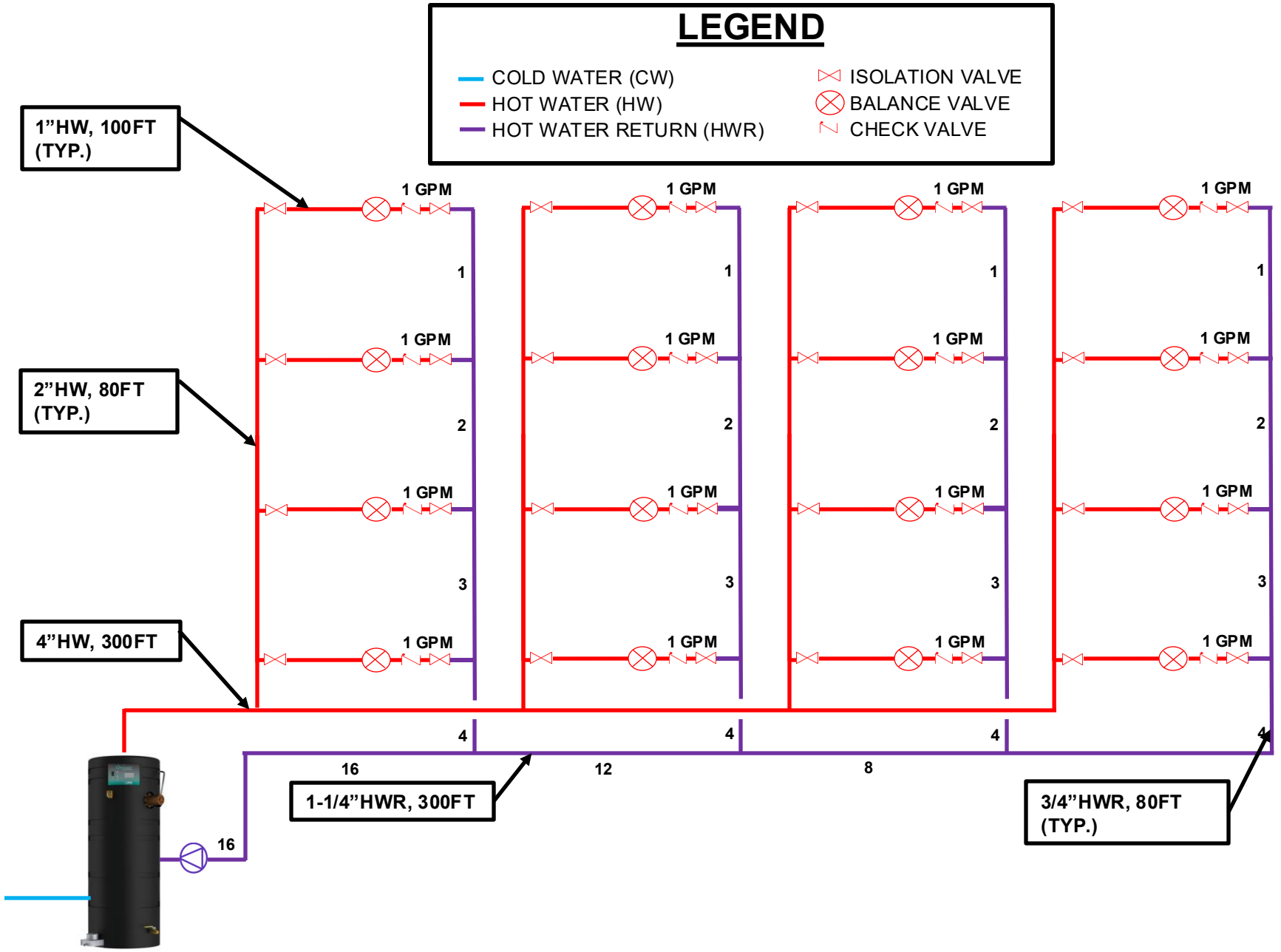
DEPPMANN

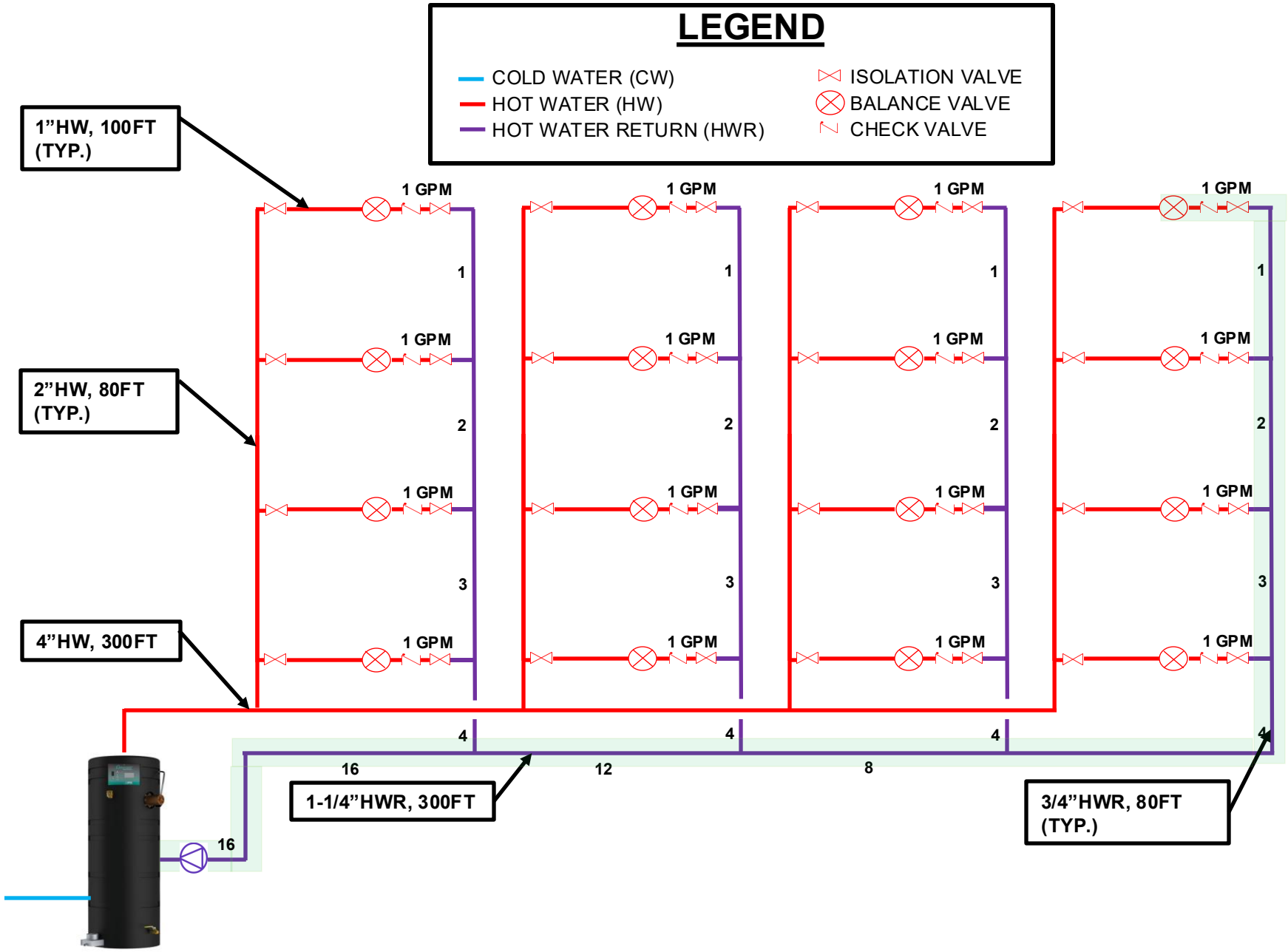
HOT WATER RECIRCULATION

1. ~~Determine rate of heat loss~~
2. ~~Determine acceptable temperature drop~~
3. ~~Determine flow rate~~
4. **Determine required pump head**
5. Determine control method

DEPPMANN


LEGEND
COLD WATER (CW)
HOT WATER (HW)
HOT WATER RETURN (HWR)
ISOLATION VALVE
BALANCE VALVE
CHECK VALVE
1”HW, 100FT (TYP.)
2”HW, 80FT (TYP.)
4”HW, 300FT
1-1/4”HWR, 300FT
3/4”HWR, 80FT (TYP.)


LEGEND
COLD WATER (CW)
HOT WATER (HW)
HOT WATER RETURN (HWR)
ISOLATION VALVE
BALANCE VALVE
CHECK VALVE
1"HW, 100FT (TYP.)
2"HW, 80FT (TYP.)
4"HW, 300FT
1 GPM
1
2
3
4
16
12
8
16
1-1/4"HWR, 300FT
3/4"HWR, 80FT (TYP.)


LEGEND
COLD WATER (CW)
HOT WATER (HW)
HOT WATER RETURN (HWR)
ISOLATION VALVE
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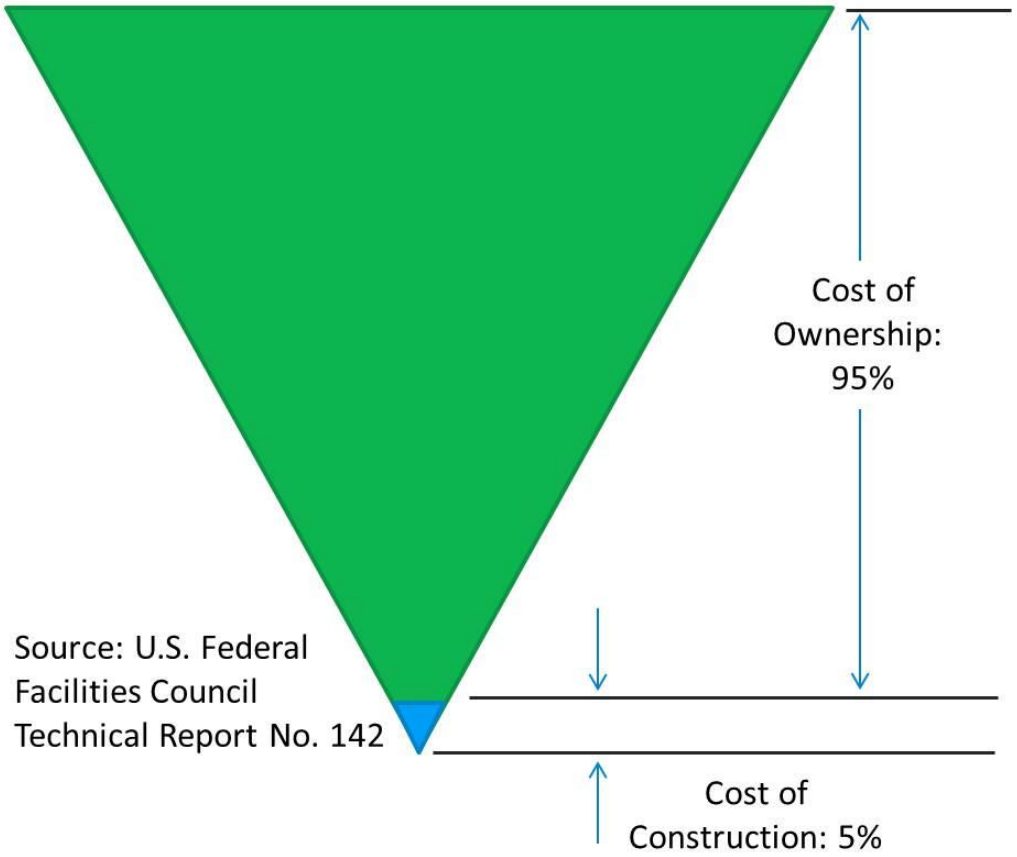
PUMP HEAD

RETURN PIPING FRICTION LOSSES				
Pipe Size	Length (FT)	Flow (GPM)	Pressure Drop/100FT (FT)	Total Pressure Drop (FT)
3/4"	20	1	0.4	0.1
3/4"	20	2	1.2	0.2
3/4"	20	3	2.5	0.5
3/4"	20	4	4.2	0.8
1-1/4"	75	4	0.3	0.3
1-1/4"	75	8	1.2	0.9
1-1/4"	75	12	2.5	1.8
1-1/4"	75	16	4.2	3.1
Automatic Balance Valve				7.4
Check Valve				1
Isolation Valve				1
Fitting Loss(25%)				5
TOTAL				**22.2**

HOT WATER RECIRCULATION

1. ~~Determine rate of heat loss~~
2. ~~Determine acceptable temperature drop~~
3. ~~Determine flow rate~~
4. ~~Determine required pump head~~
5. Determine control method

CONTROL METHODS



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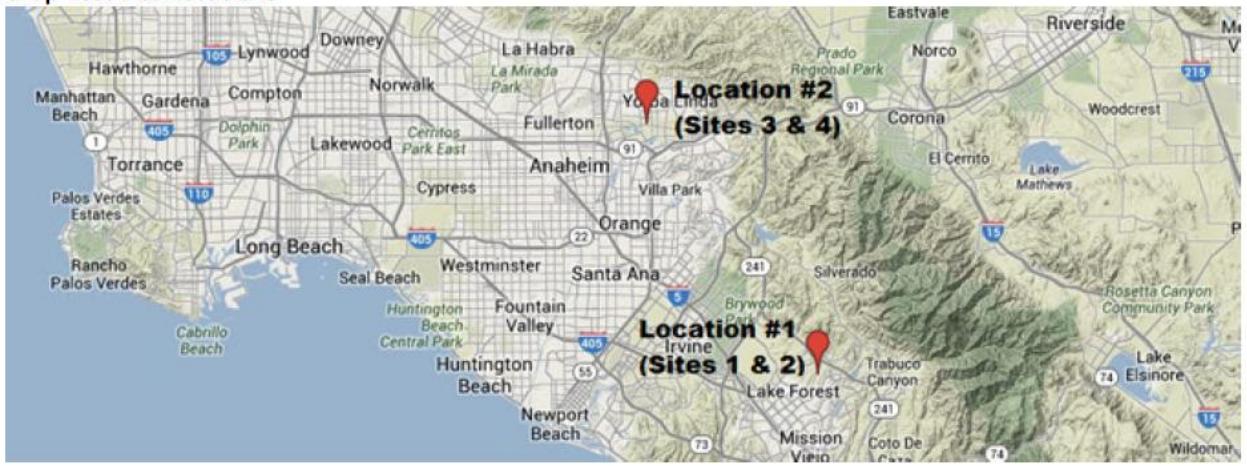
CONTROL METHODS

Study Information

- Conducted to evaluate energy savings of variable speed pumping compared to constant speed HWR systems.
- Data acquisition system was used to monitor gas and energy usage during a 5-week period for each system
- 4 test sites were evaluated
- All four sites were 48-unit multifamily housing buildings

SoCalGas
A Sempra Energy utility®

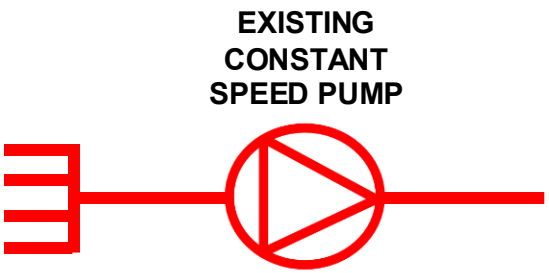
Figure 1 VFD Pump Test Site Locations



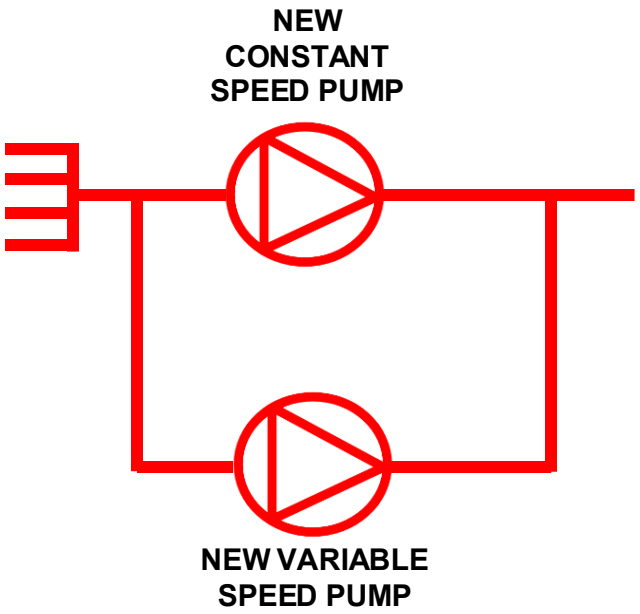
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CONTROL METHODS

EXISTING CONDITIONS AT EACH SITE



TESTING CONDITIONS AT EACH SITE



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CONTROL METHODS

Table 1 Gas and Hot Water Consumption Summary[1]

Gas Consumption (Therms)								
	Site 1		Site 2		Site 3		Site 4	
Week	CS	VFD	CS	VFD	CS	VFD	CS	VFD
1	198	206	211	189	160	138	147	112
2	209	191	220	190	146	125	140	105
3	215	199	211	185	145	121	129	103
4	200	168	207	177	146	120	141	100
5	185	154	189	158	139	112	127	90
6	140	147	N/A	N/A	N/A	N/A	N/A	N/A
Total	1,147	1,065	1,039	899	736	616	683	510
Savings	**82**		**140**		**120**		**173**	
% Savings	**7.2%**		**13.5%**		**16.3%**		**25.3%**	

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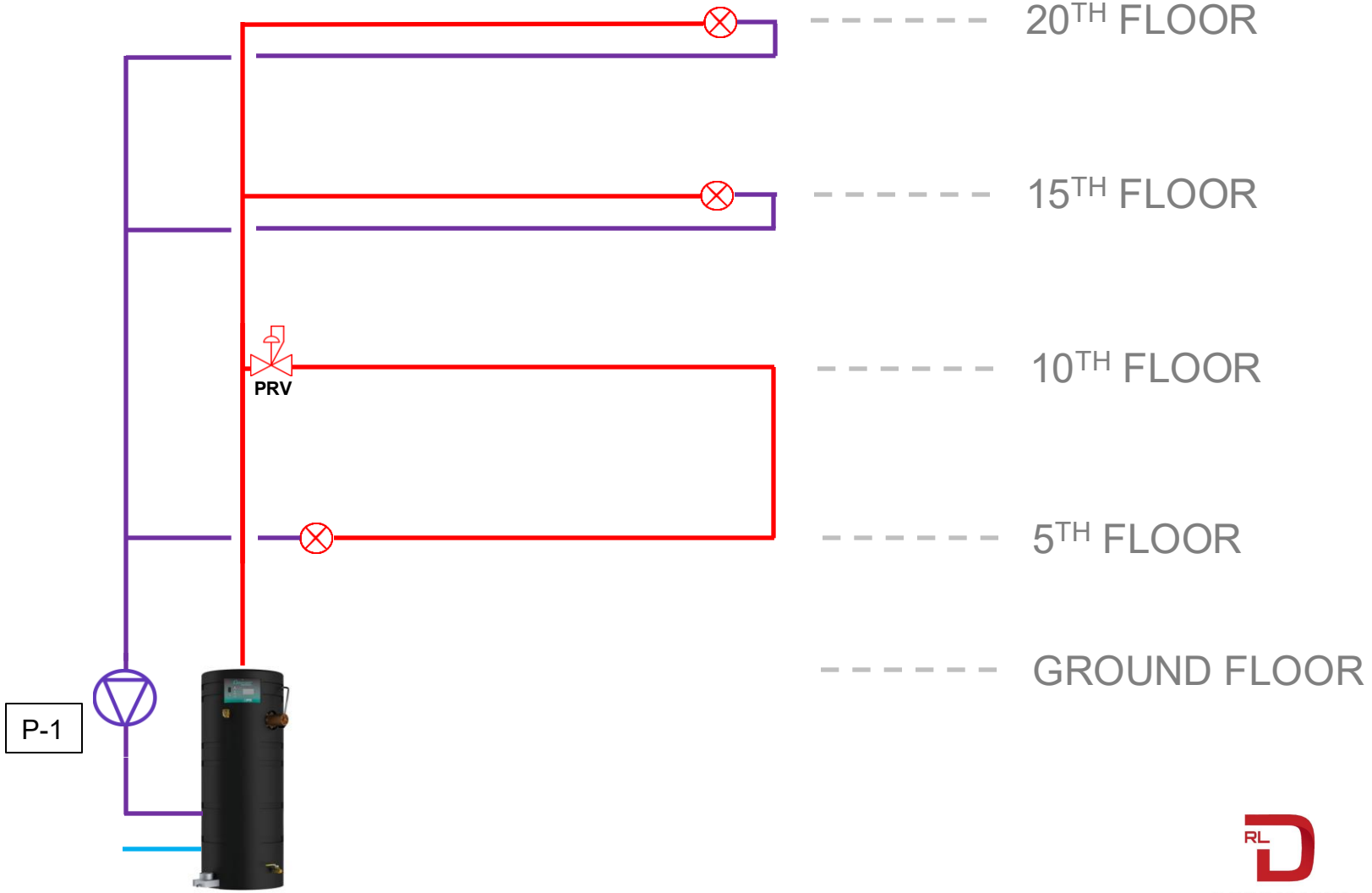
CONTROL METHODS

Table 2 Simple Payback

Location	Annual Therm Savings	Annual $ Saved ($1.042/ therm)	$ Retrofit Cost w/o rebate	Simple Payback (yrs)
Site #1	711	$ 741	$ 2,600	3.5
Site #2	1456	$ 1,517	$ 2,600	1.7
Site #3	1248	$ 1,300	$ 2,600	2.0
Site #4	1799	$ 1,875	$ 2,600	1.4
Average	**1303**	**$ 1,358**	**$ 2,600**	**2.2**

HIGH RISE EXAMPLE 1

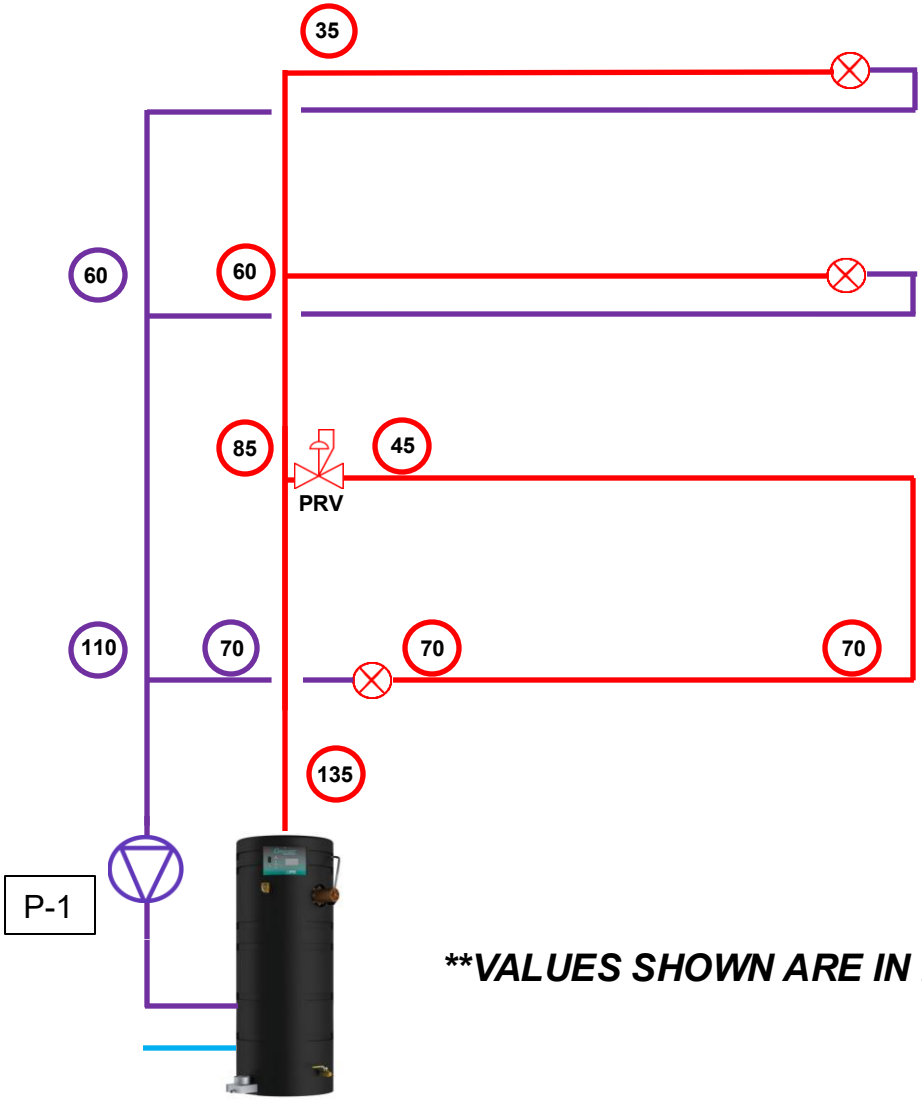
System analysis confirms that we have 35FT of head loss from system piping/accessories and this system requires 20 GPM of circulation.



DEPPMANN

HIGH RISE EXAMPLE 1

System analysis confirms that we have 35FT of head loss from system piping/accessories and this system requires 20 GPM of circulation.



20TH FLOOR

15TH FLOOR

10TH FLOOR

5TH FLOOR

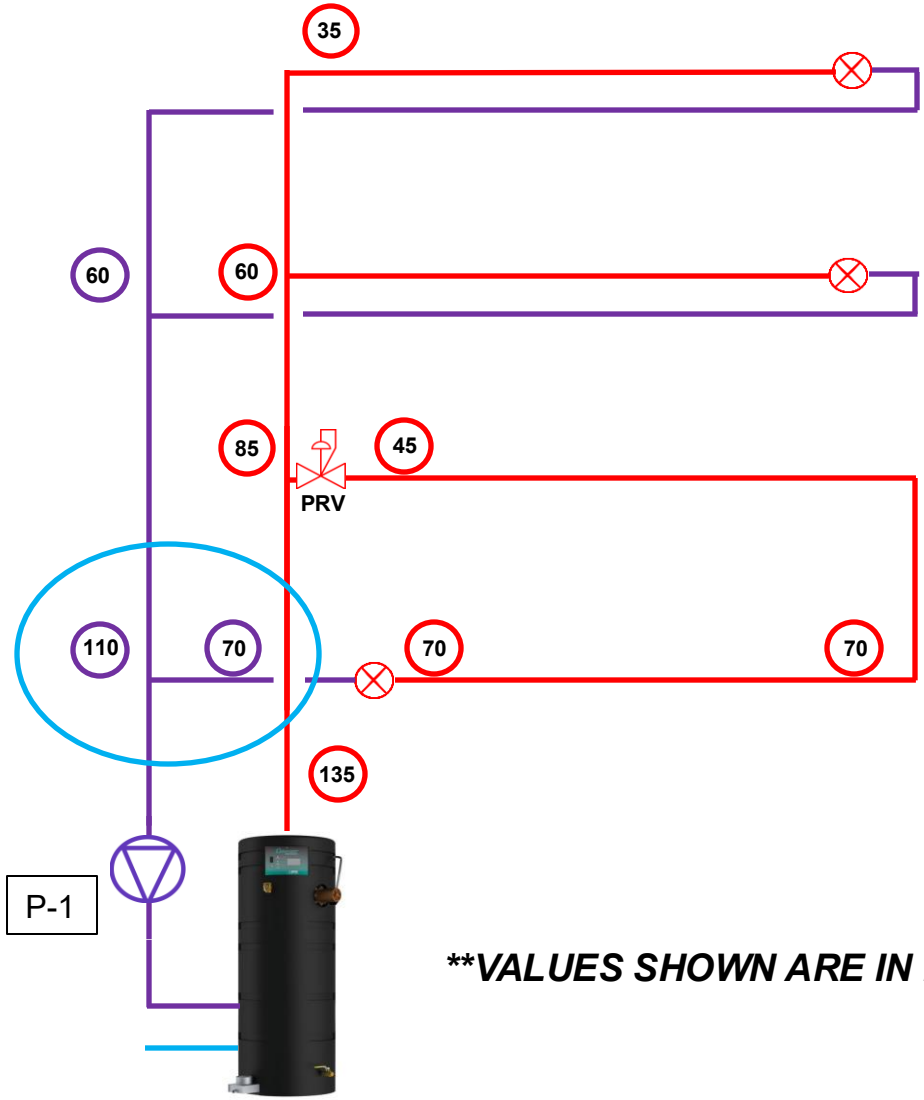
GROUND FLOOR

VALUES SHOWN ARE IN PSI

DEPPMANN

HIGH RISE EXAMPLE 1

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15TH FLOOR

10TH FLOOR

5TH FLOOR

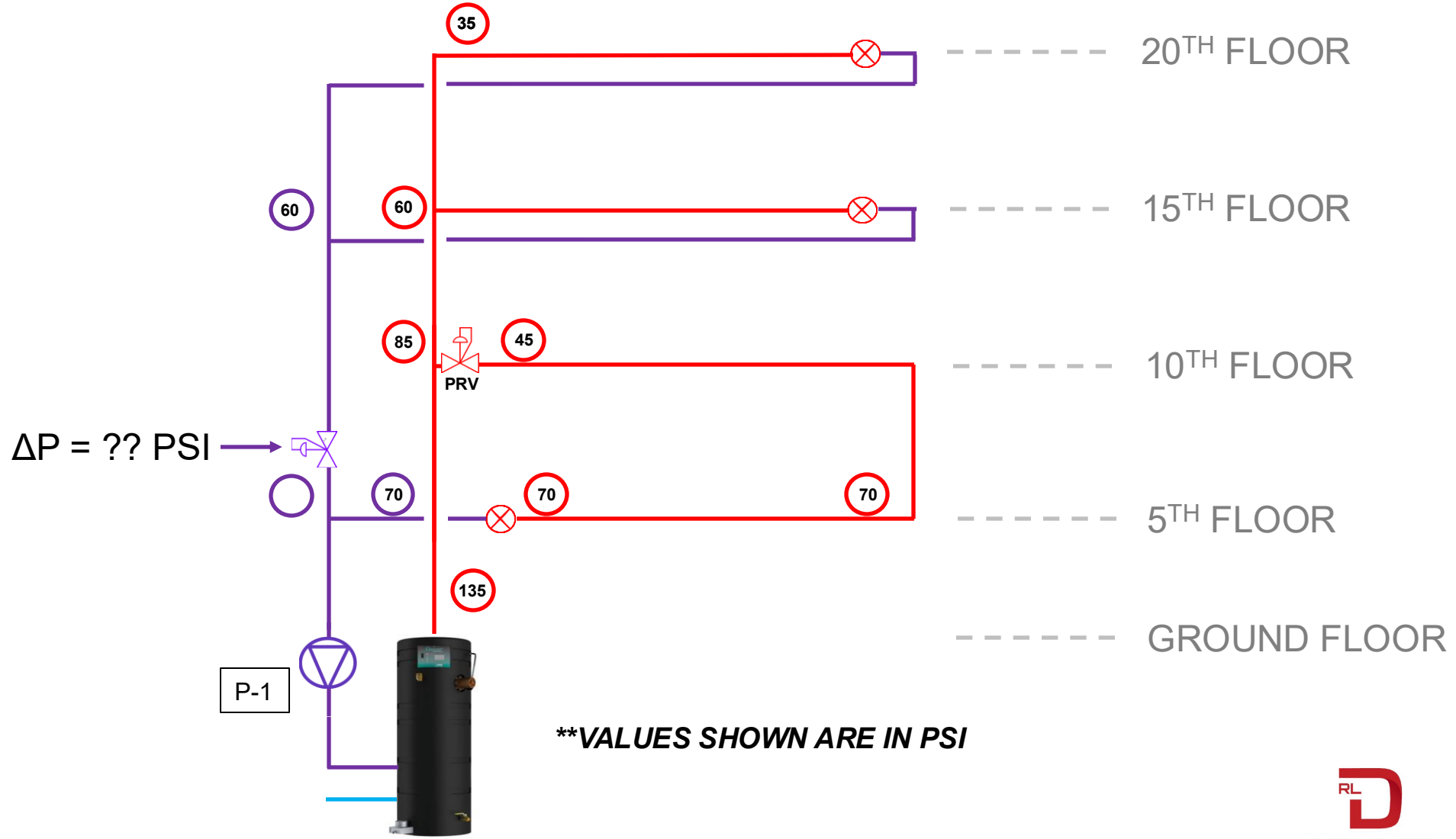
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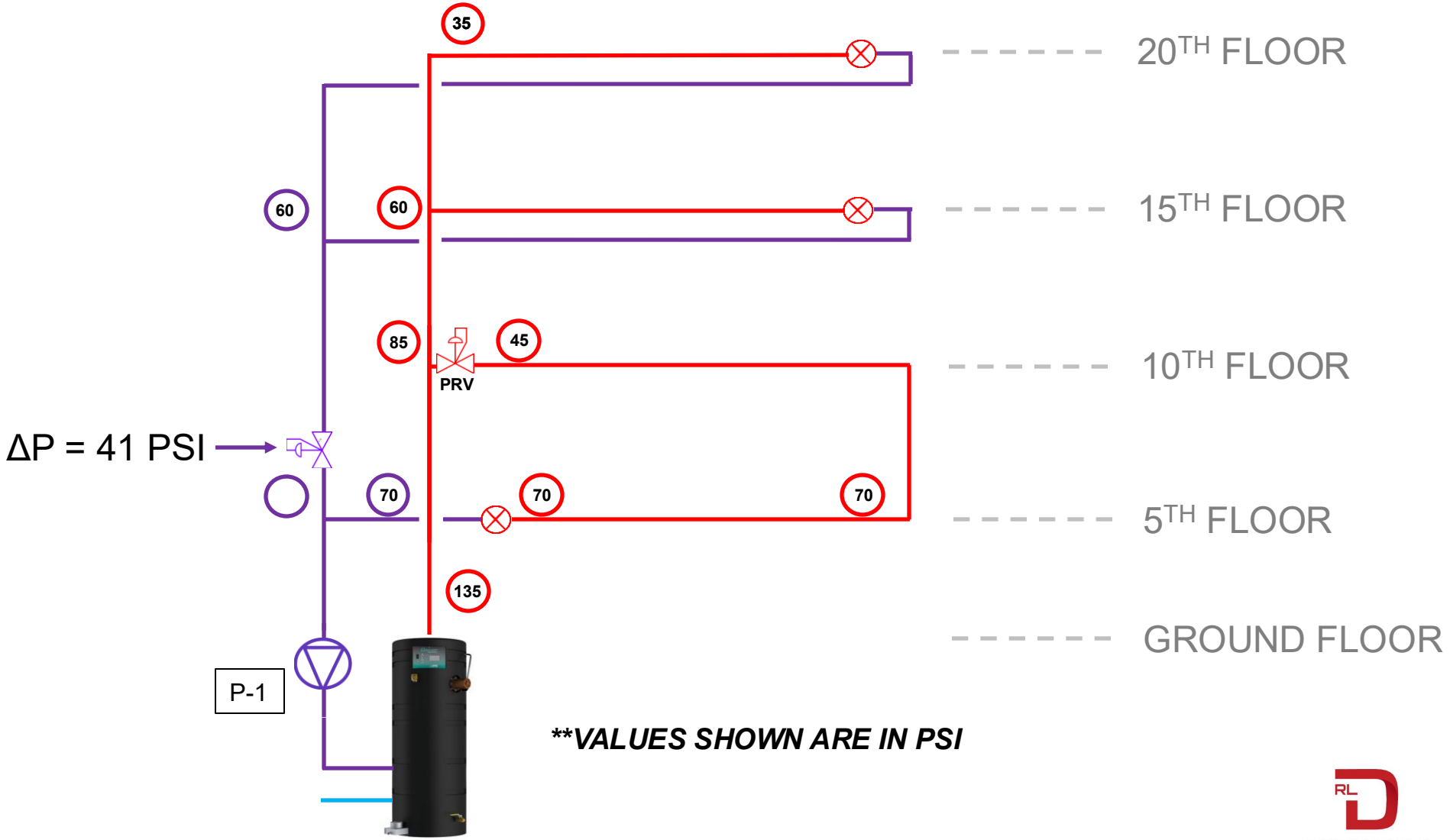


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DEPPMANN

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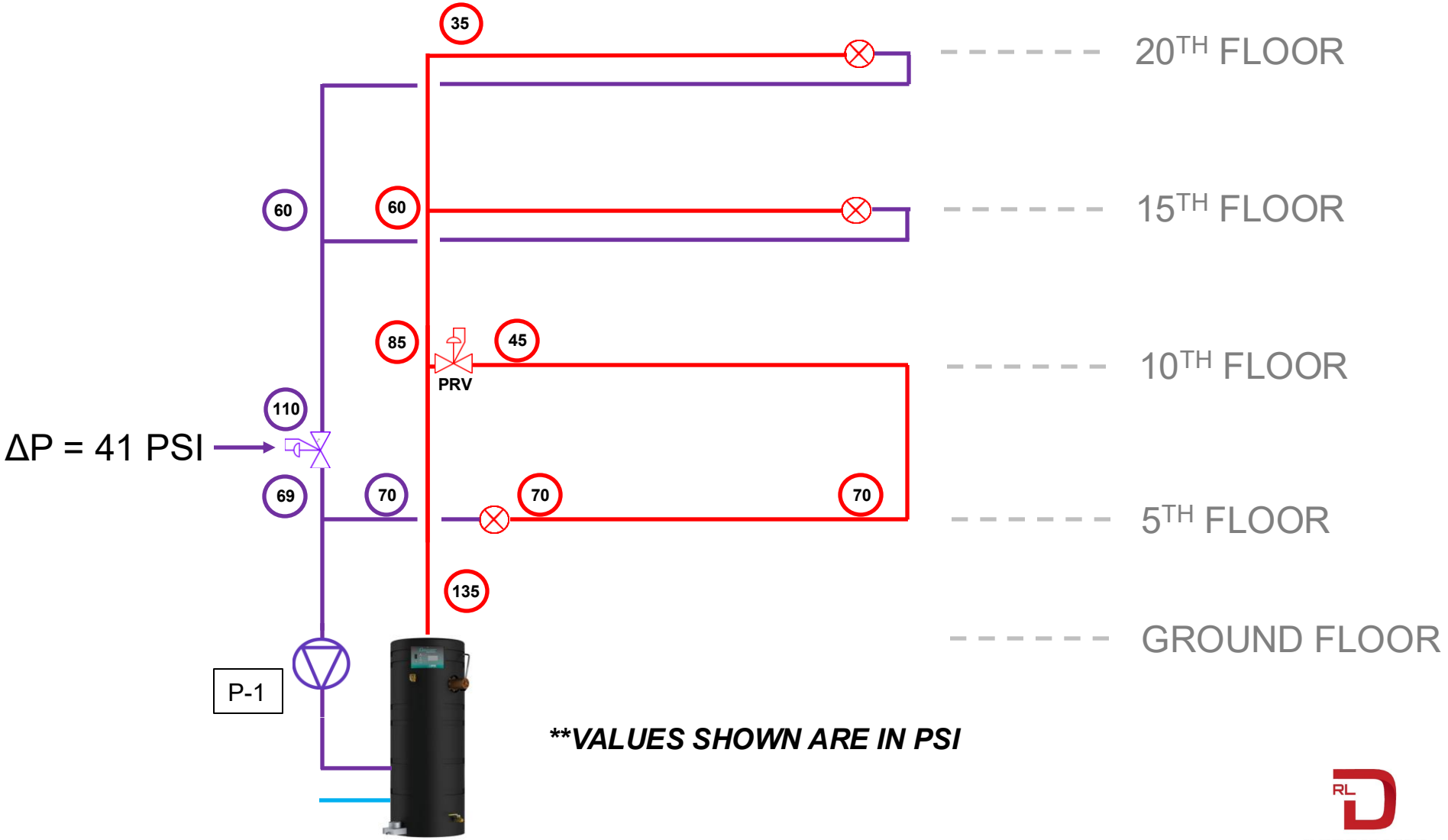


VALUES SHOWN ARE IN PSI

DEPPMANN

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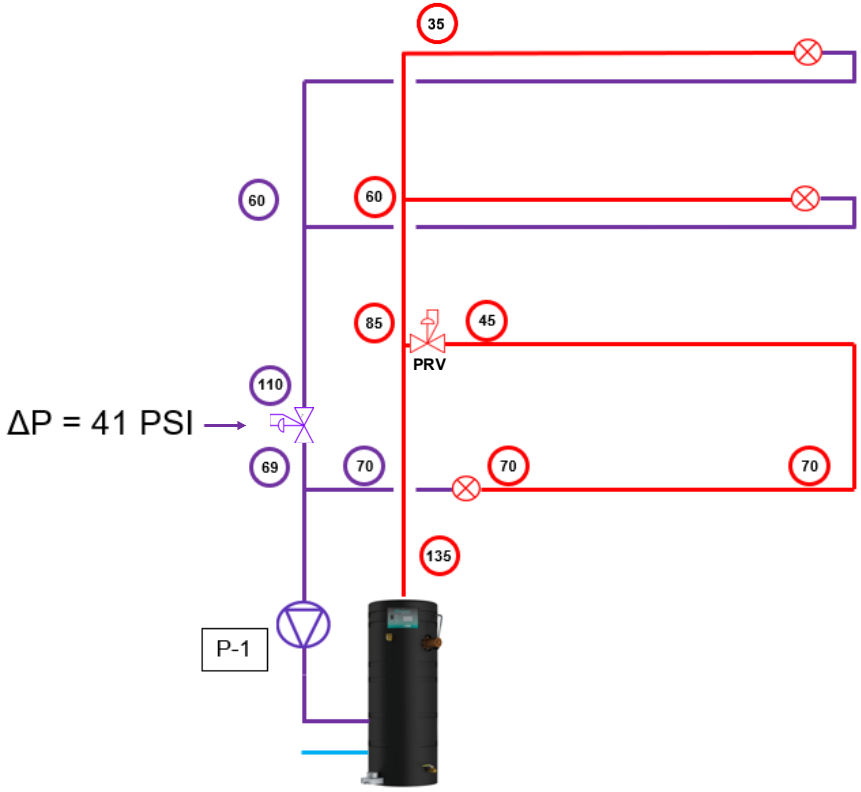
VALUES SHOWN ARE IN PSI

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HIGH RISE EXAMPLE 1

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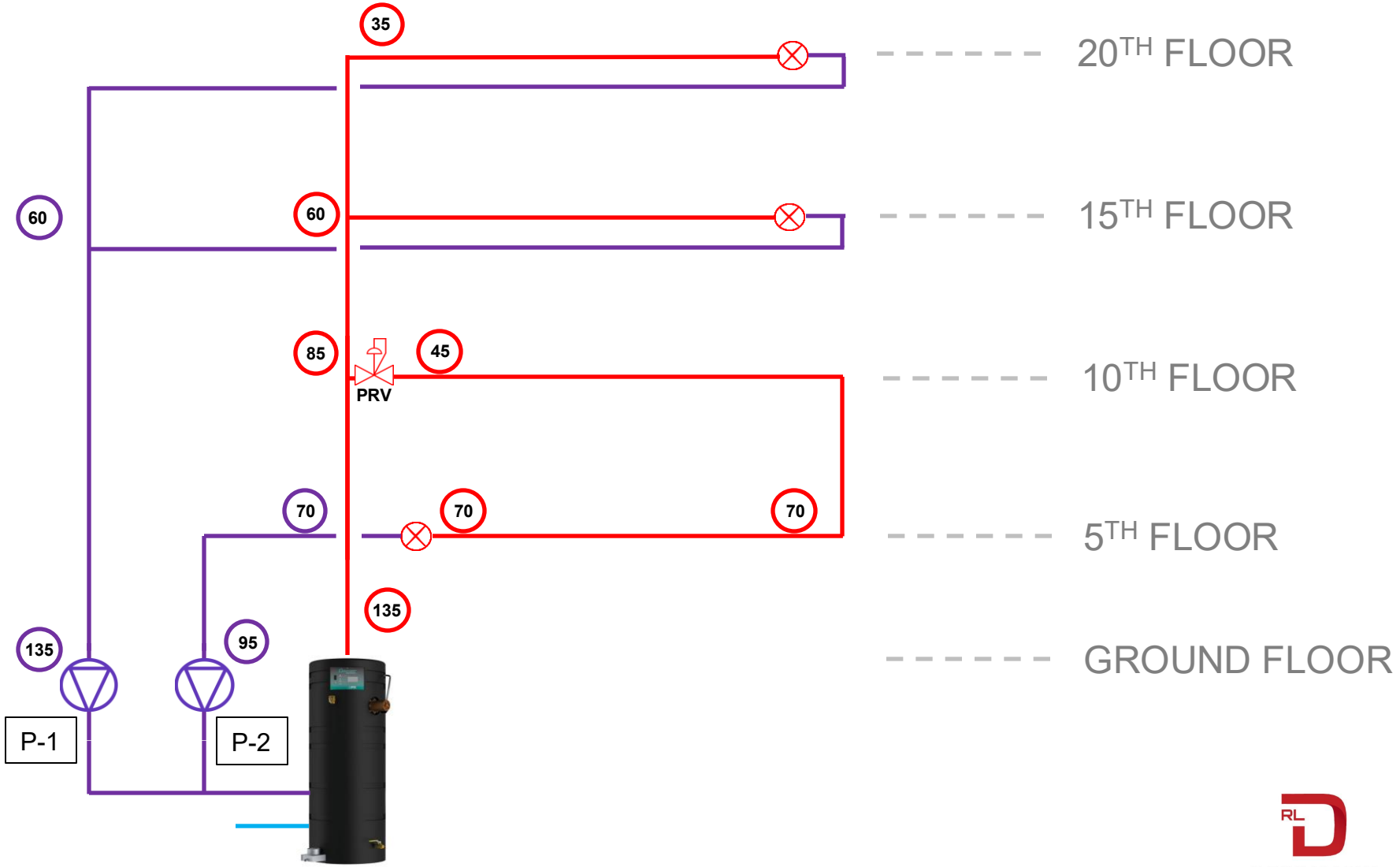
Pump P-1
20 GPM @ 130 FT Head



This method would add almost 100FT of head to our hot water return pump to balance the system.

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HIGH RISE EXAMPLE 2

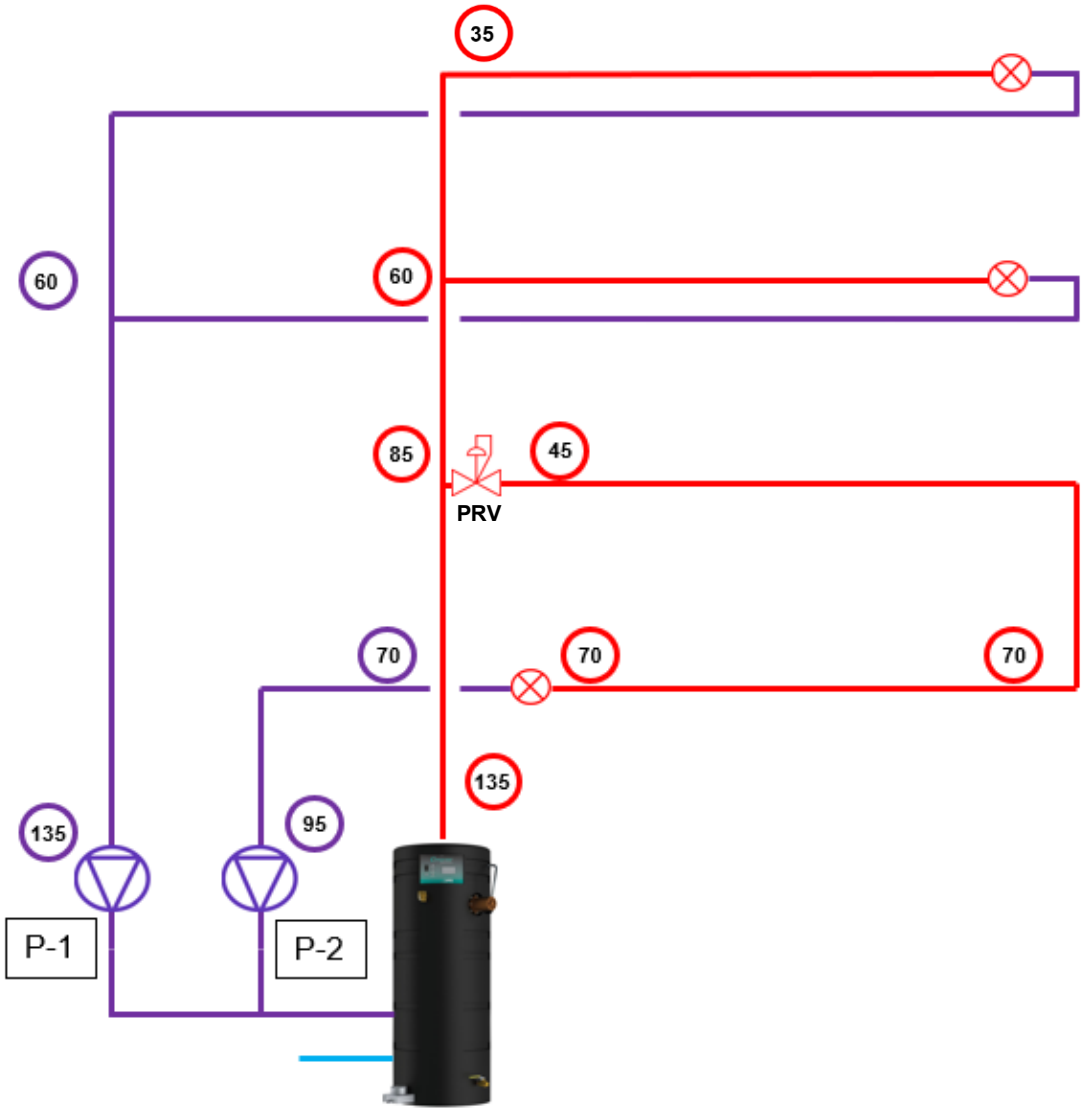


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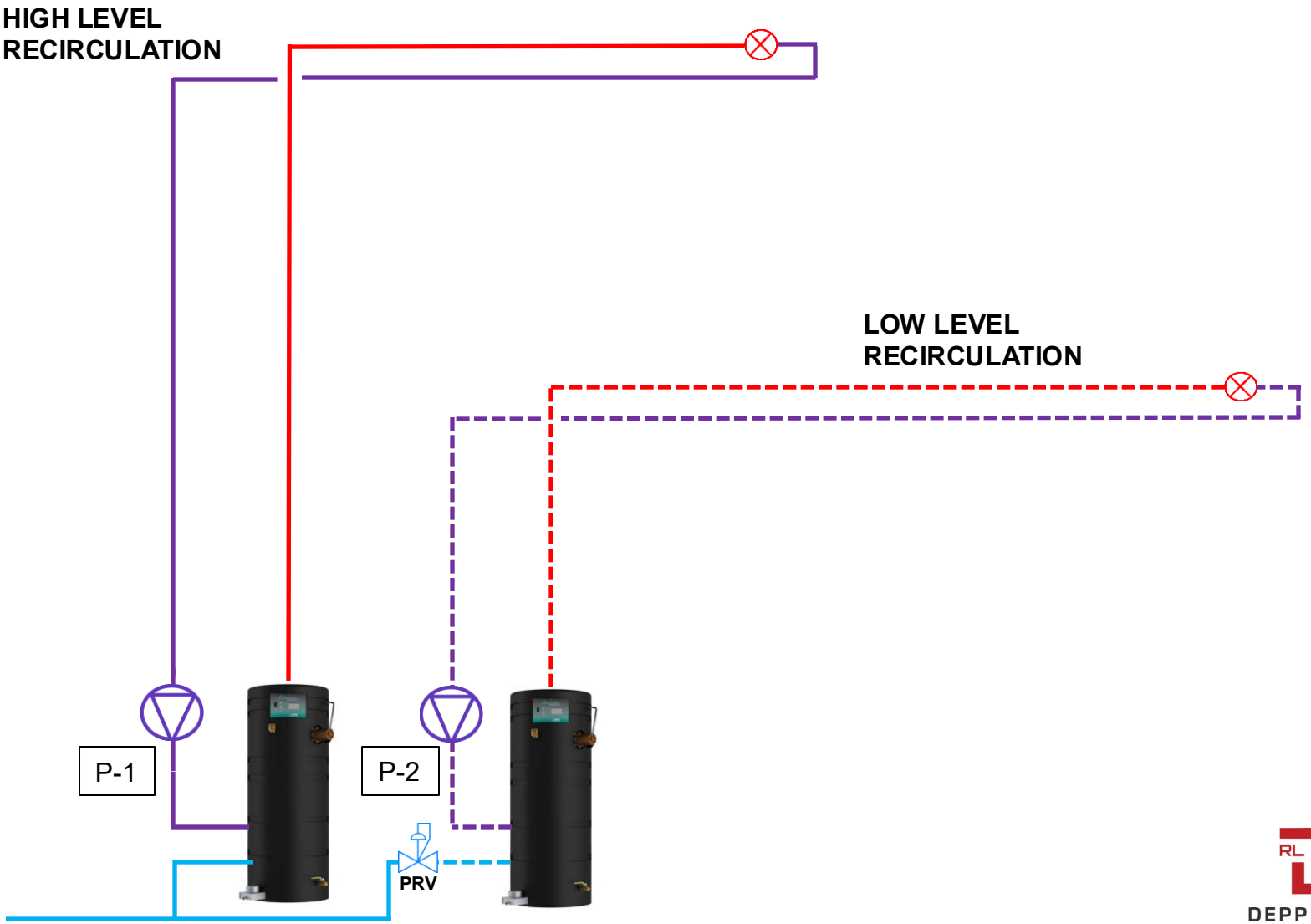
HIGH RISE EXAMPLE 2

Pump P-1
15 GPM @ 35 FT Head

Pump P-2
5 GPM @ 110 FT Head

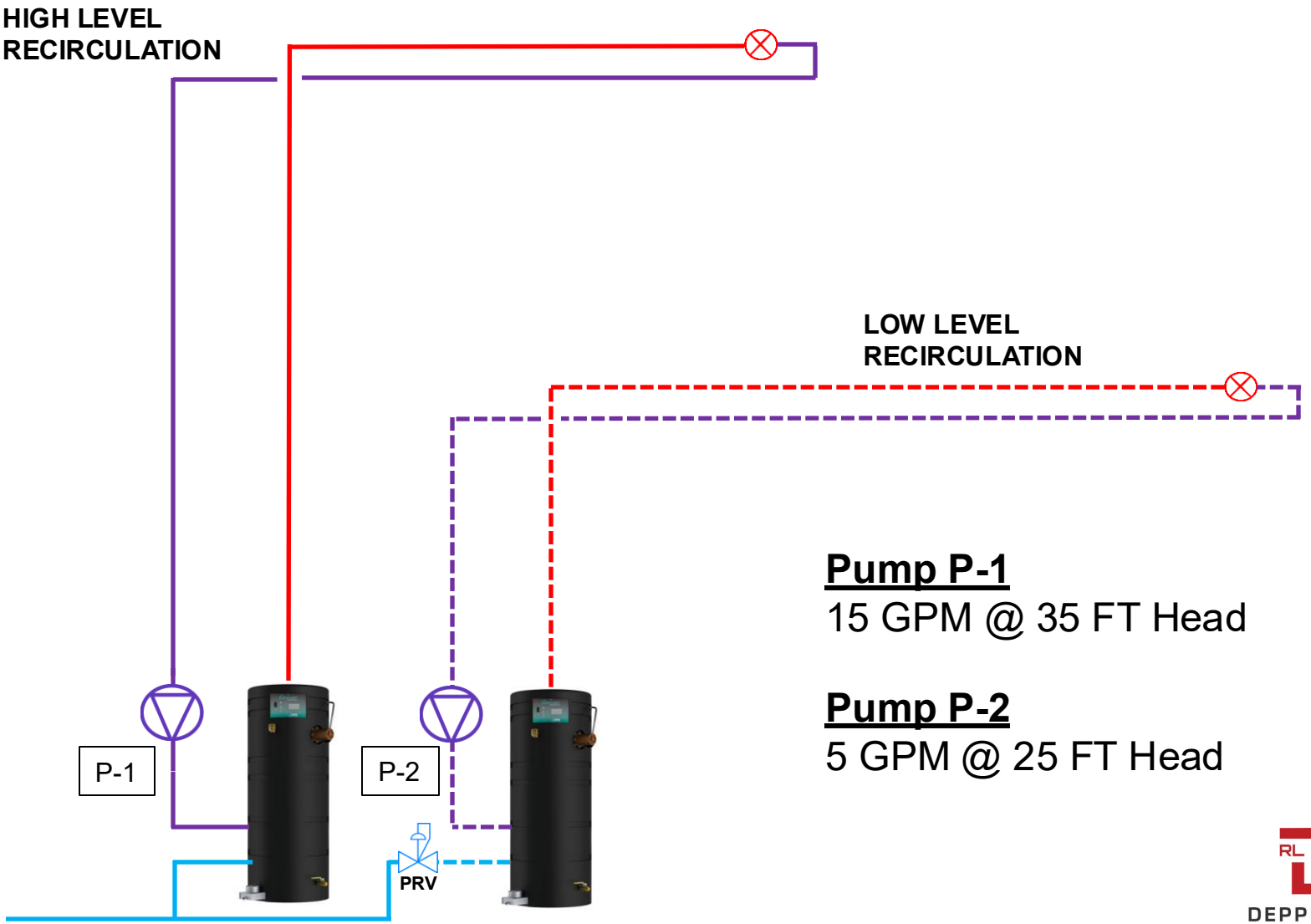


HIGH RISE EXAMPLE 3



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HIGH RISE EXAMPLE 3

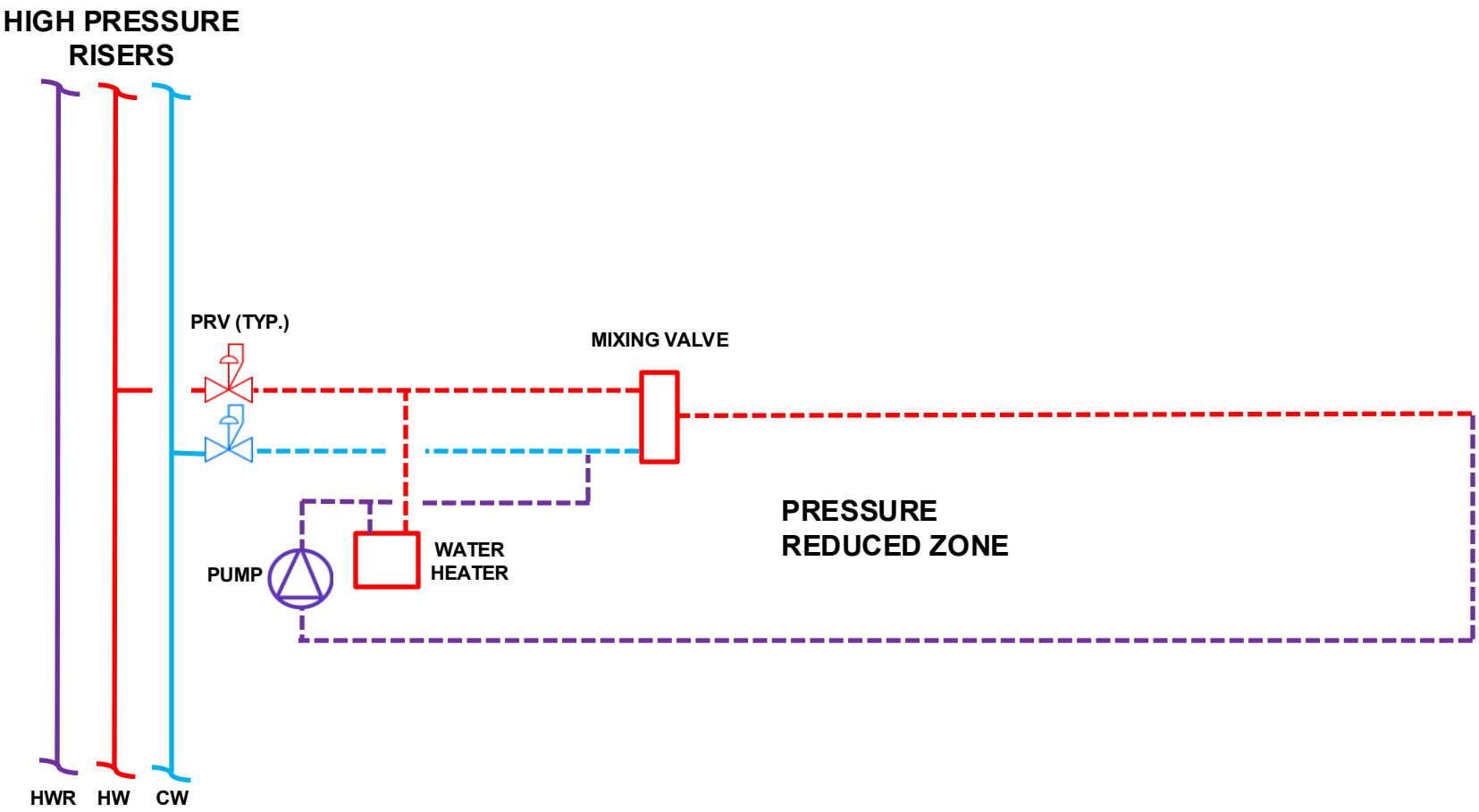


Pump P-1
15 GPM @ 35 FT Head

Pump P-2
5 GPM @ 25 FT Head

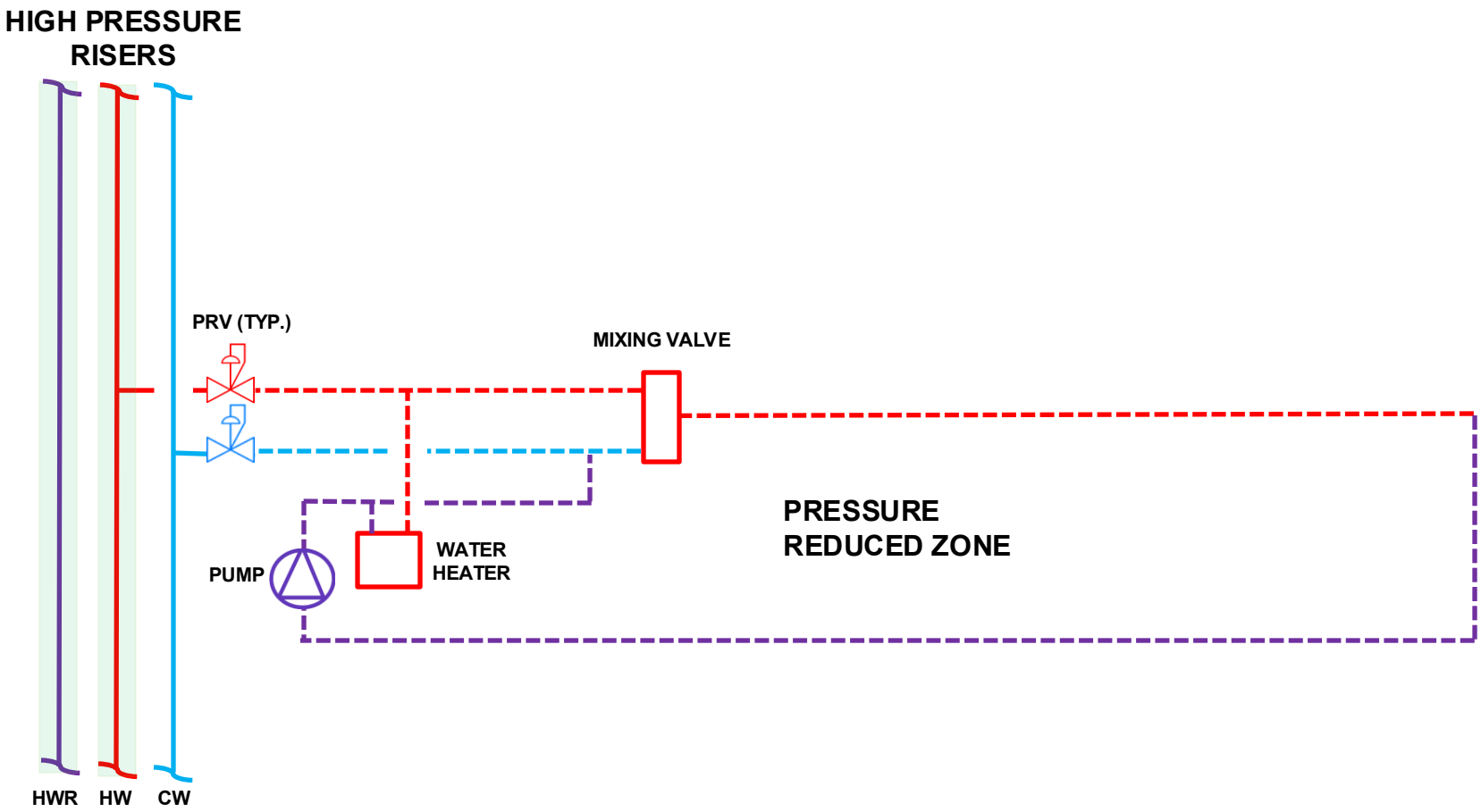
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HIGH RISE EXAMPLE 4



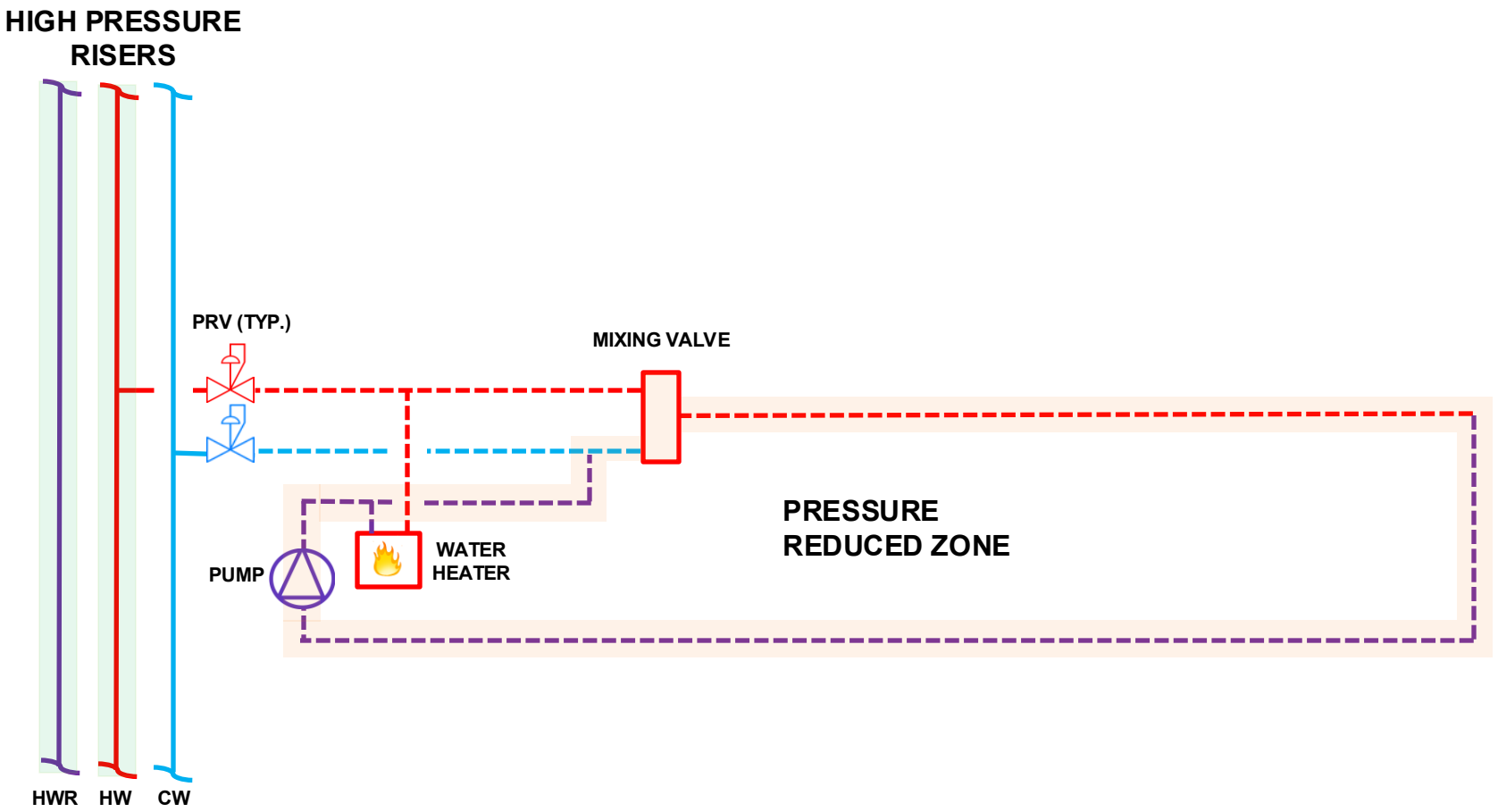
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HIGH RISE EXAMPLE 4



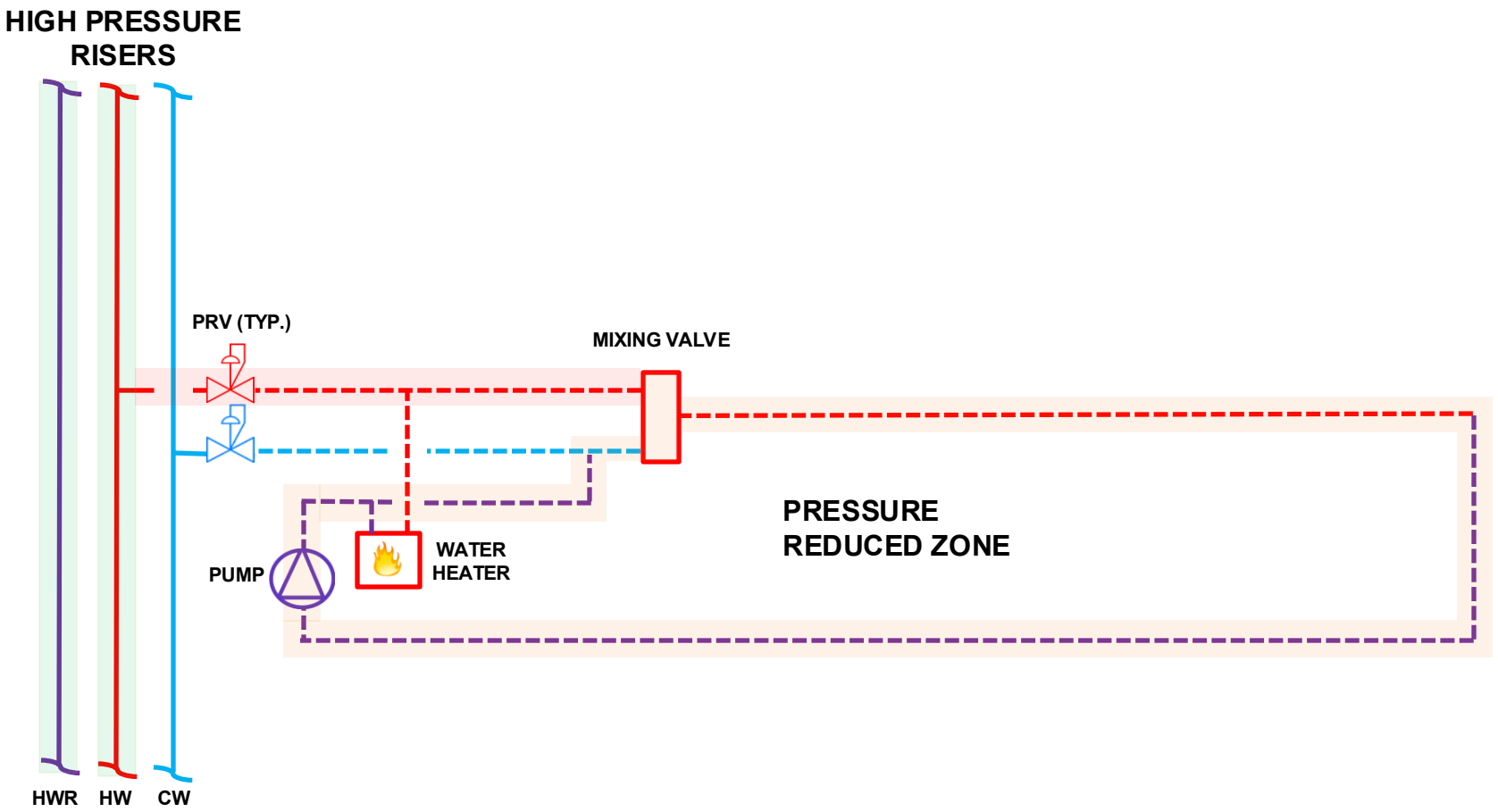
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HIGH RISE EXAMPLE 4



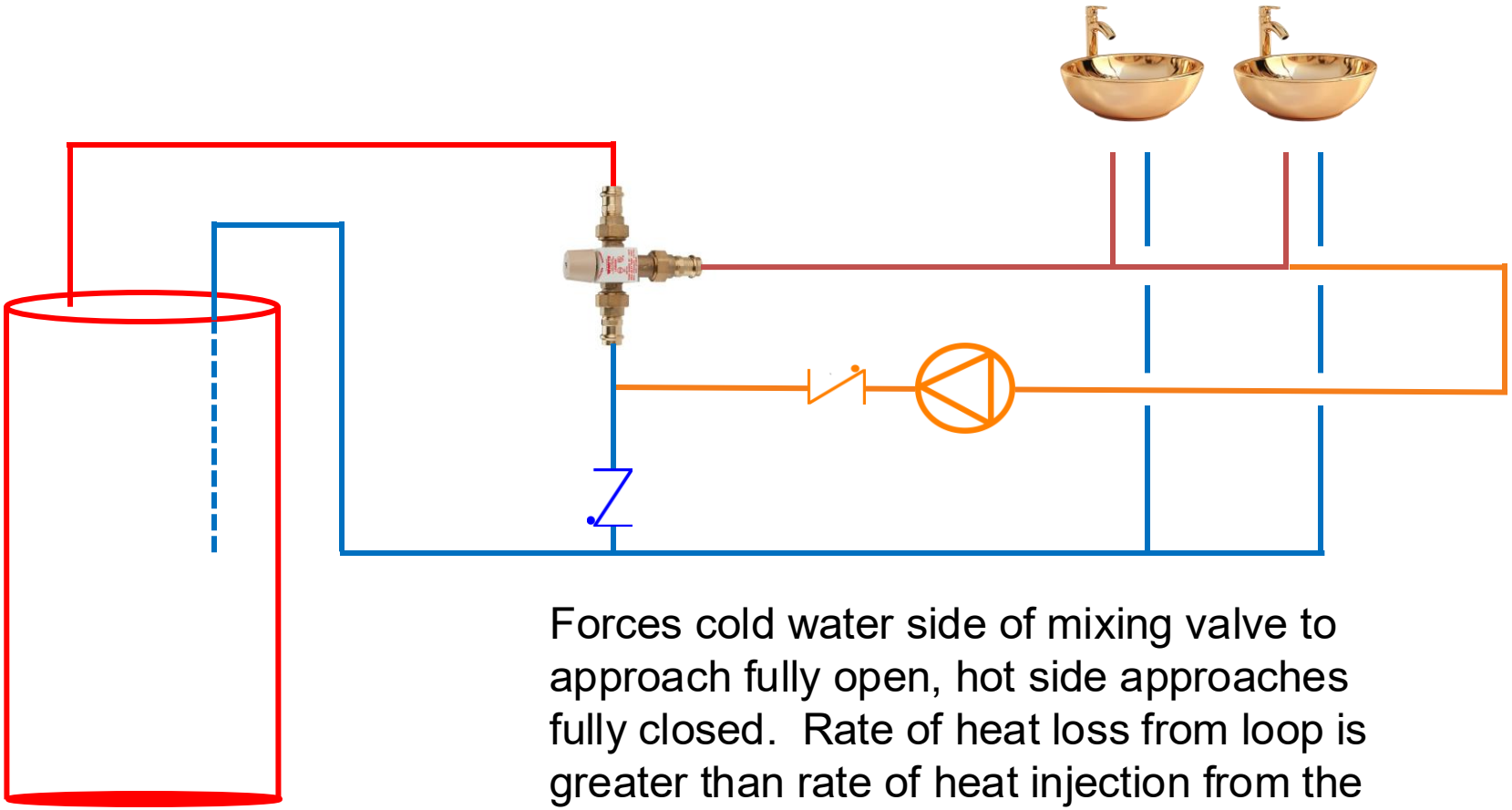
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HIGH RISE EXAMPLE 4



DEPPMANN

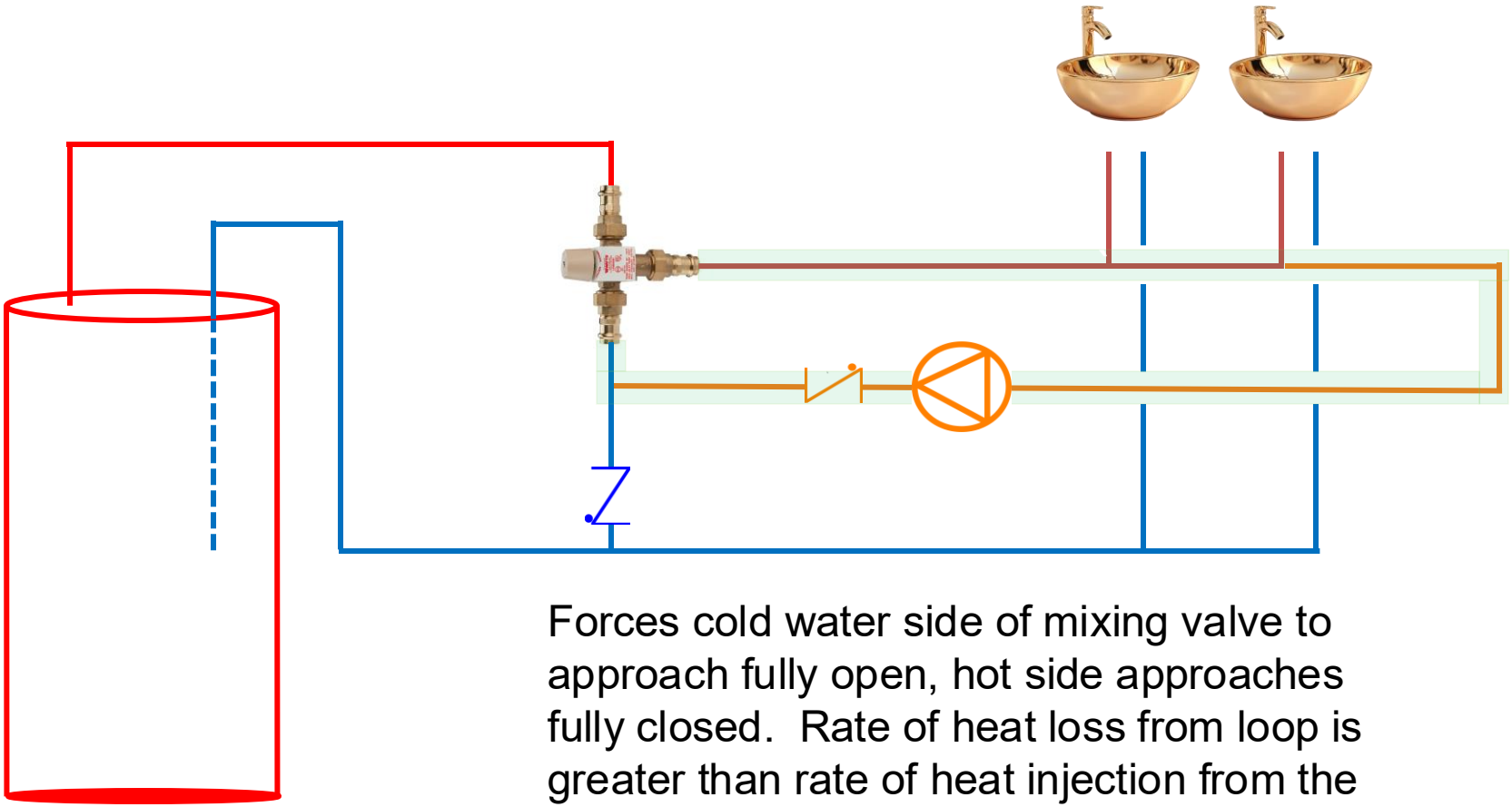
HOT WATER RECIRC CREEP



Forces cold water side of mixing valve to approach fully open, hot side approaches fully closed. Rate of heat loss from loop is greater than rate of heat injection from the tank.

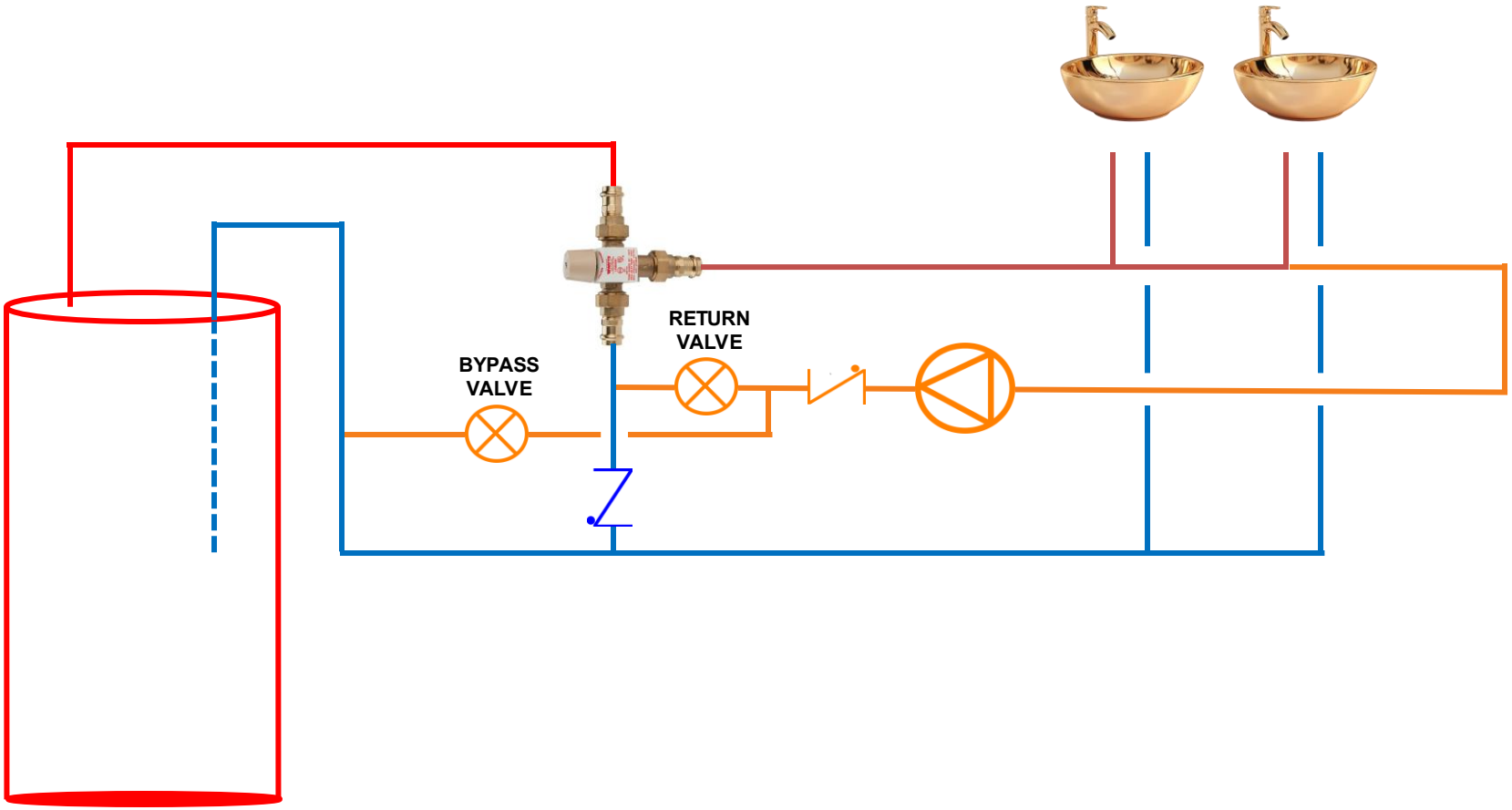
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HOT WATER RECIRC CREEP



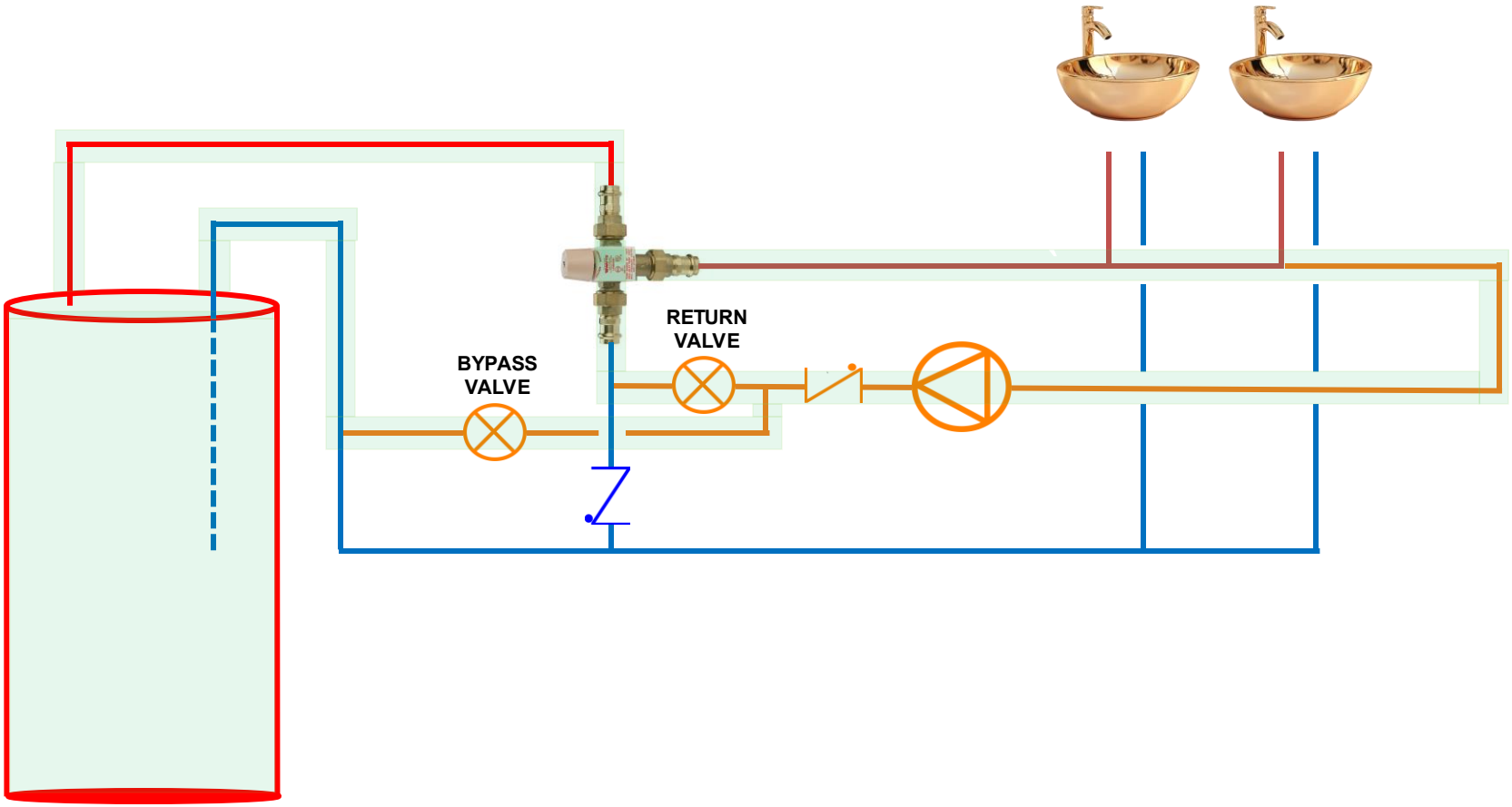
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HOT WATER RECIRC CREEP



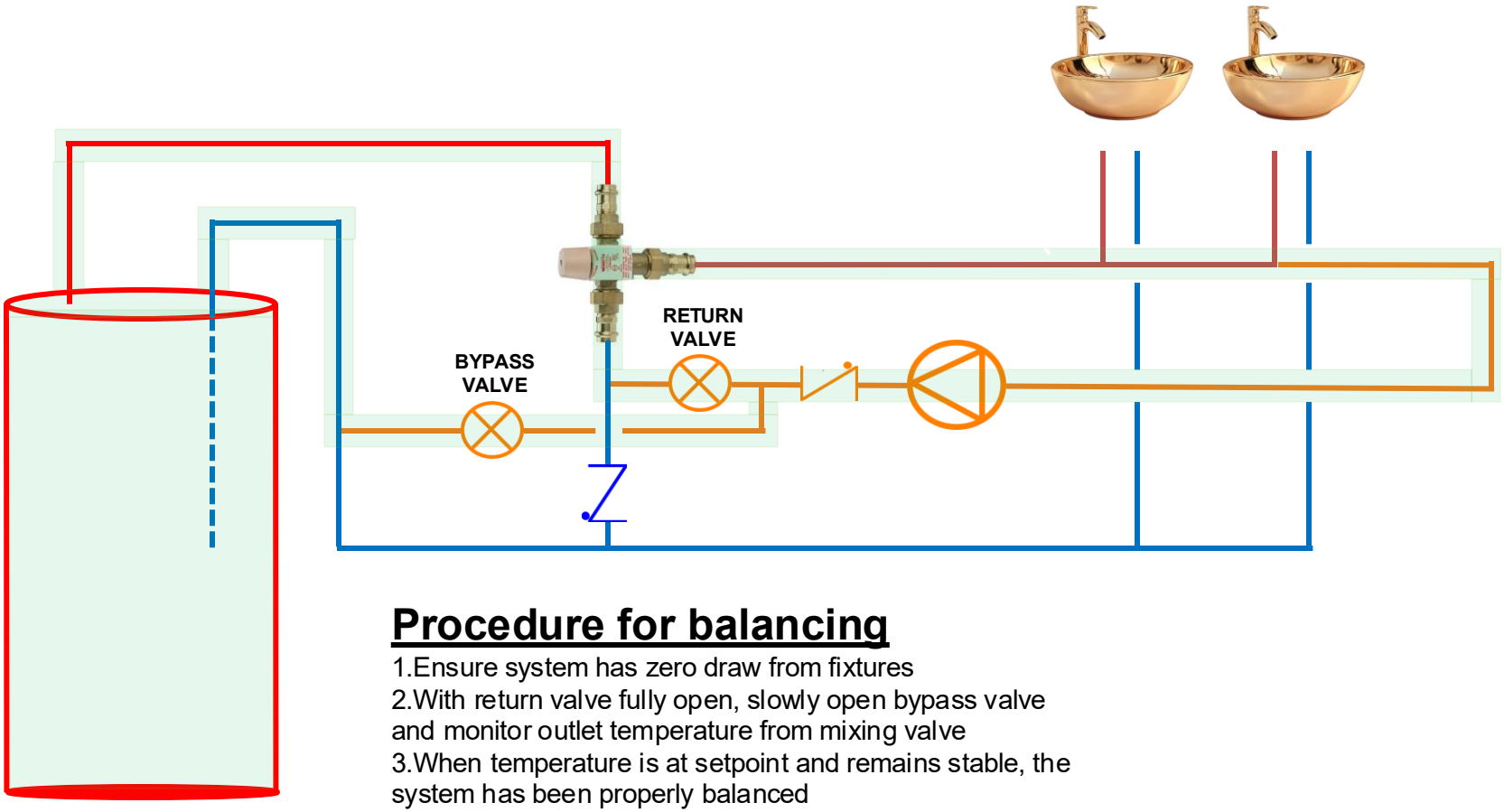
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HOT WATER RECIRC CREEP



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HOT WATER RECIRC CREEP

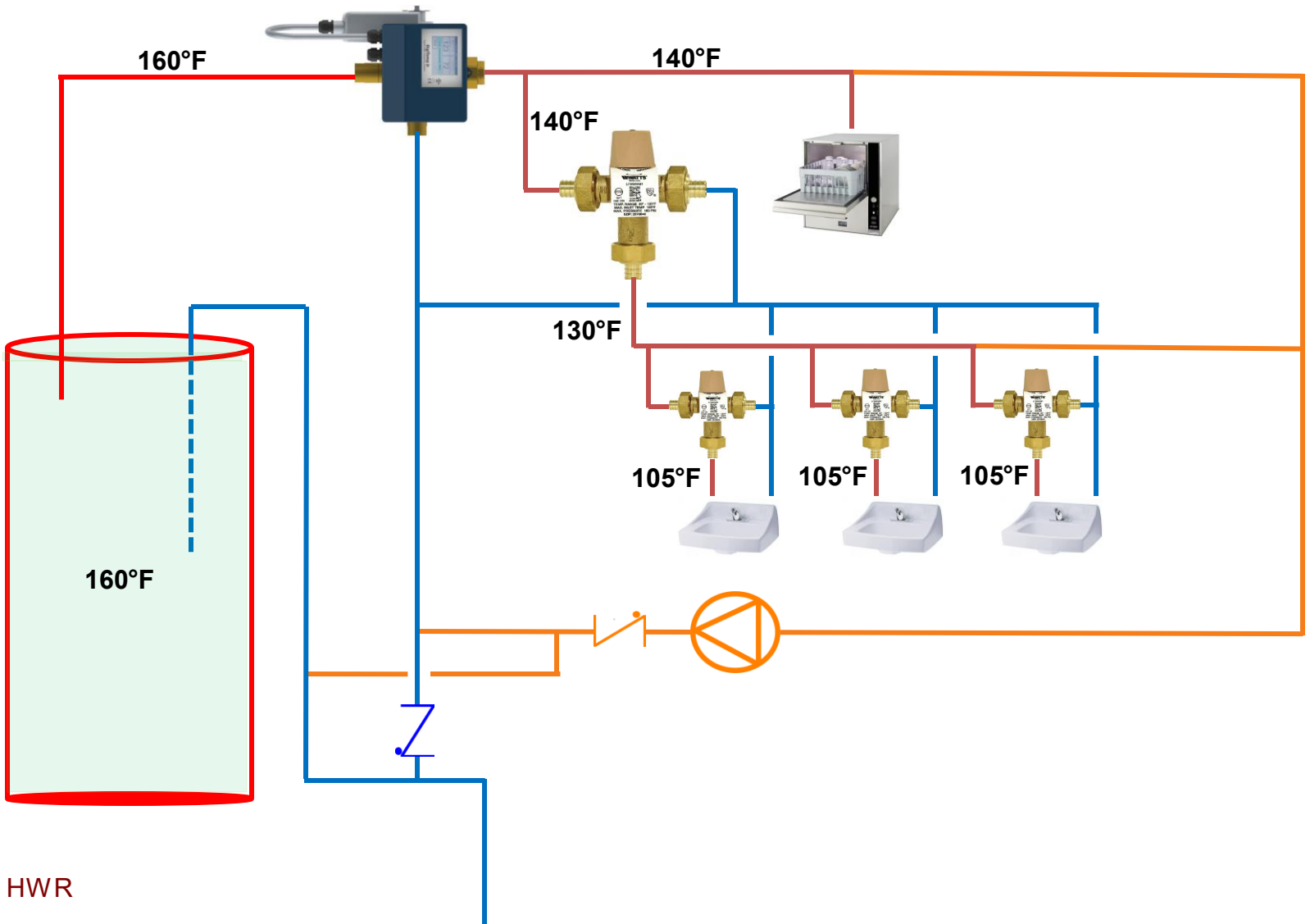


Procedure for balancing

1.Ensure system has zero draw from fixtures
2.With return valve fully open, slowly open bypass valve and monitor outlet temperature from mixing valve
3.When temperature is at setpoint and remains stable, the system has been properly balanced

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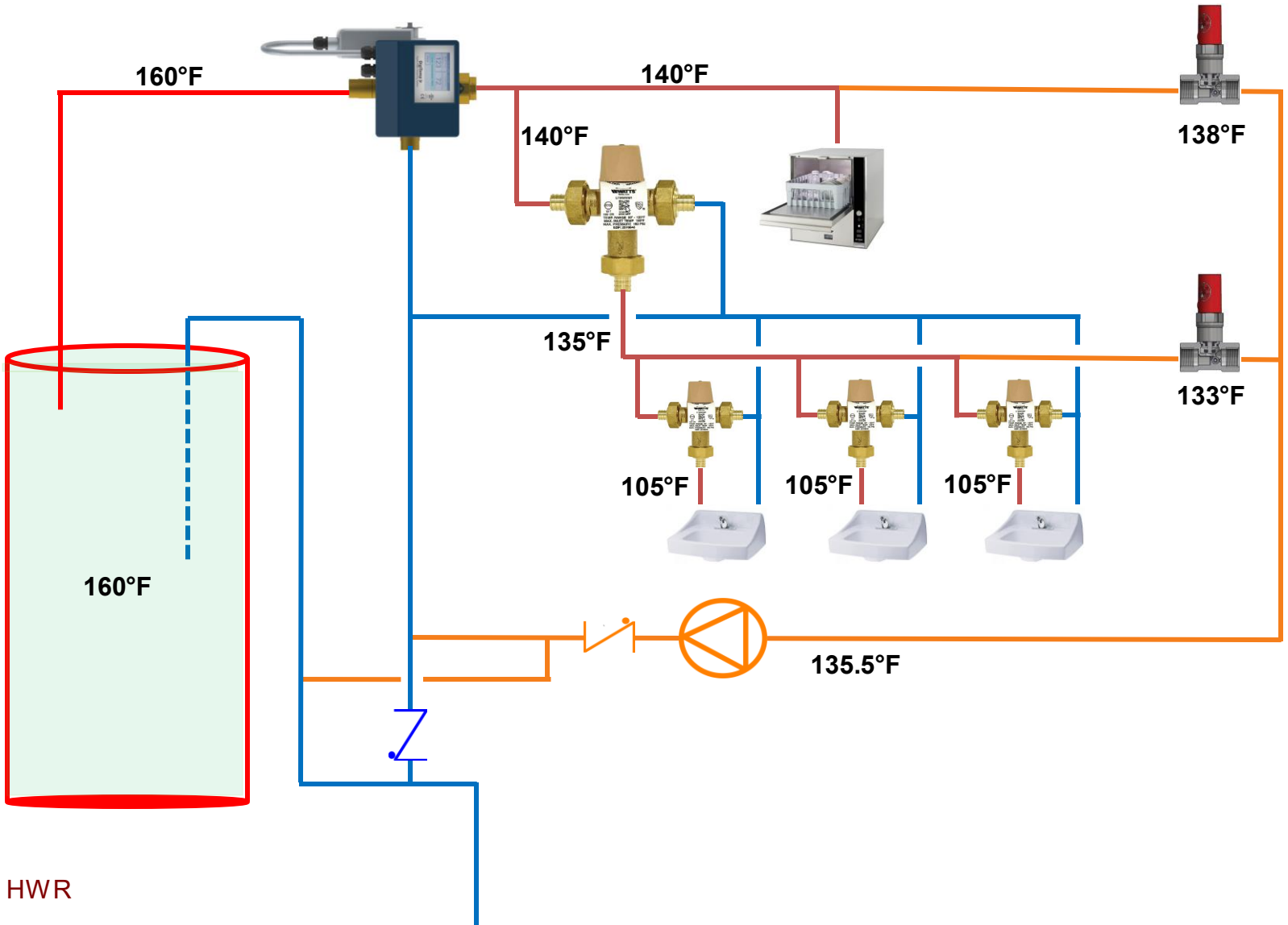
MULTIPLE TEMPERATURES



HWR

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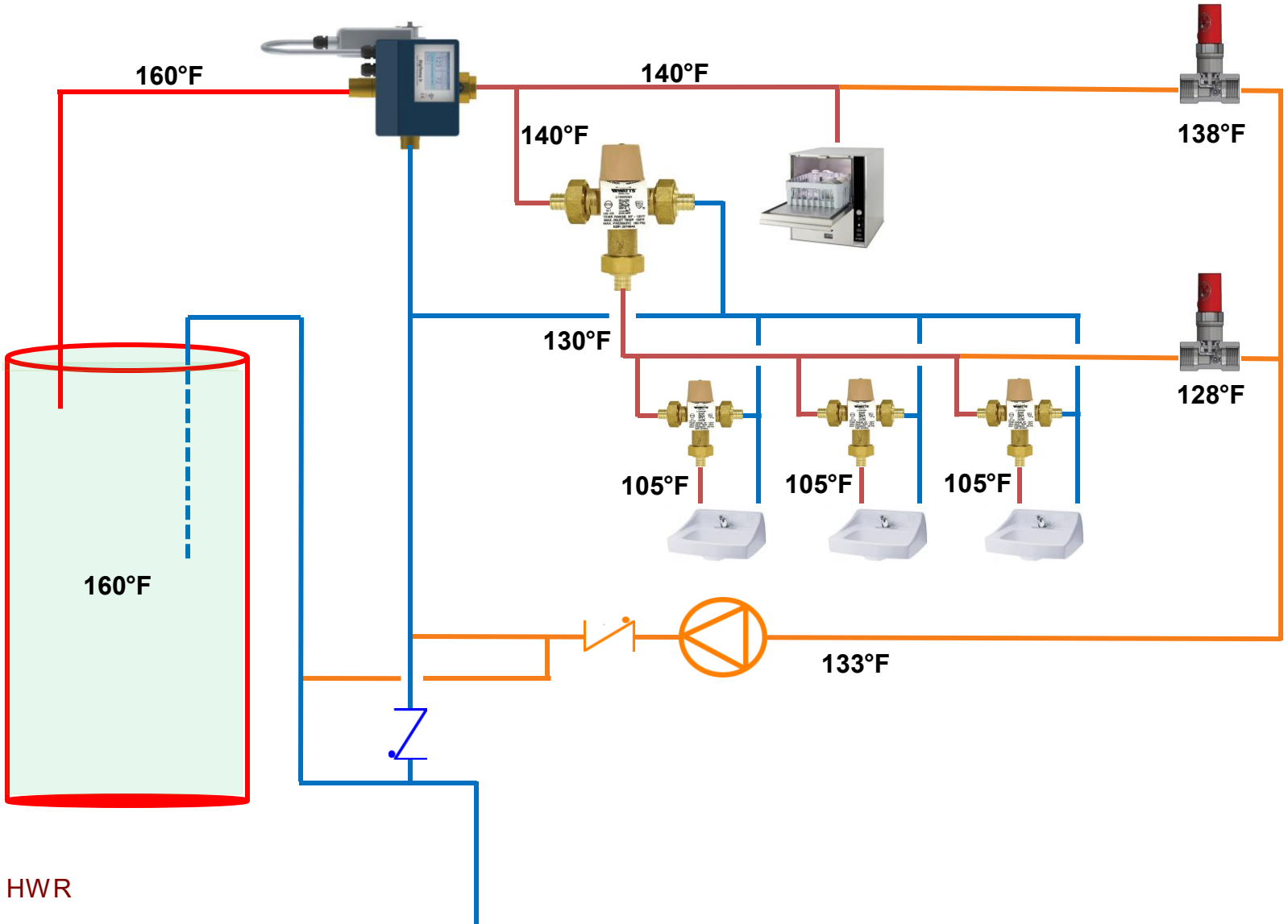
MULTIPLE TEMPERATURES



HWR

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MULTIPLE TEMPERATURES



HWR

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QUESTIONS?

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THANK YOU

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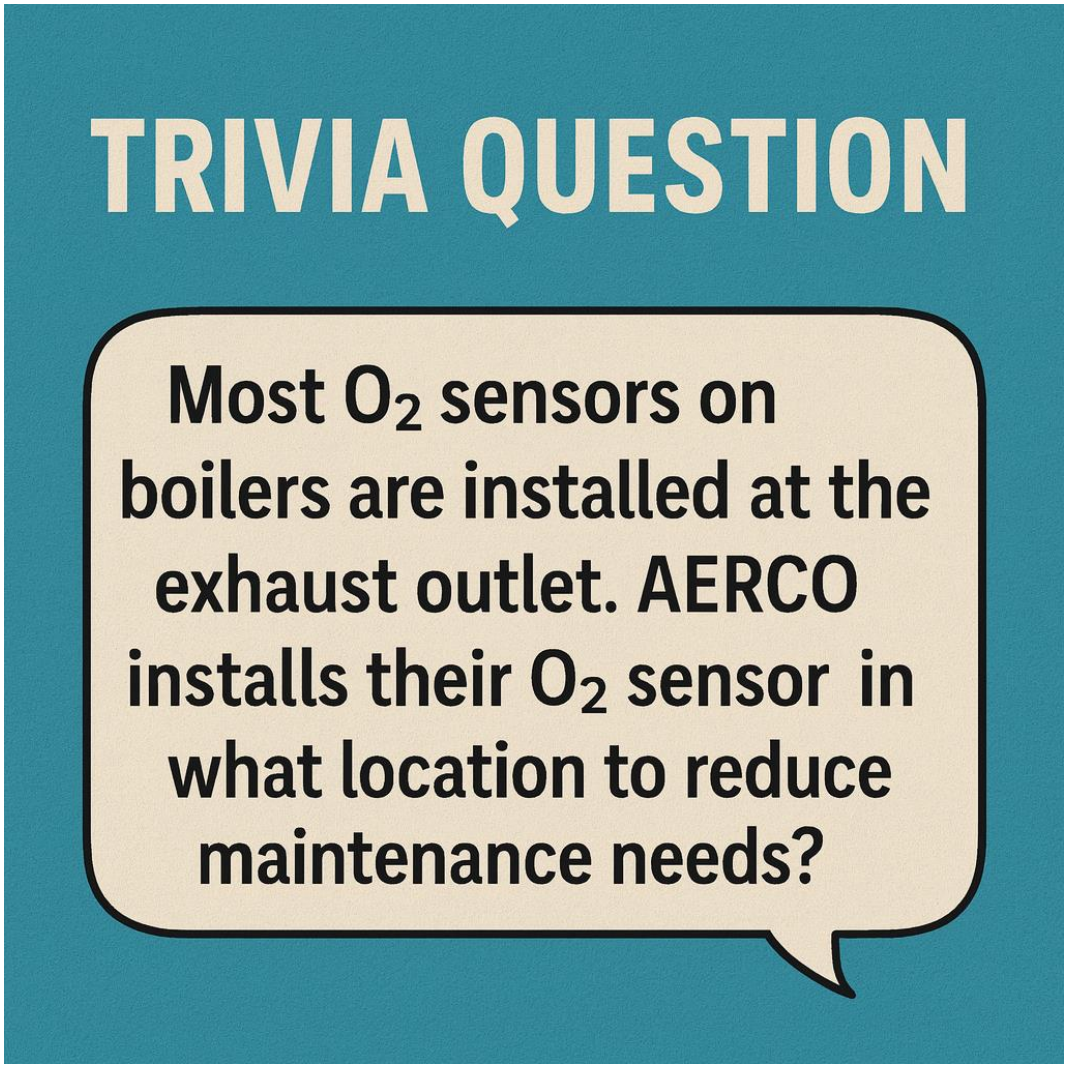


AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break	
9:45-10:45 –	Domestic Hot Water Recirculation Systems –	Ryan Groves
10:45-11:00 –	Break	
11:00-12:00 –	**Exploring Heat Exchangers –**	**Mike Kennedy & Jason Winslow**
12:00-1:00 –	Lunch	
1:00-2:00 –	From 0 to 60Hz: The Basics of VFDs –	Nick Tabar
2:00-2:15 –	Break	
2:15-3:15 –	F & T Steam Basics –	Mark Fine & Nick Tafelski
3:15-3:30 –	Break	
3:30-4:30 –	Practical Water Quality Testing –	Andrew Ward

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BREAK & TRIVIA



RETURN AT 11:00AM

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EXPLORING HEAT EXCHANGERS: TECHNOLOGIES, TYPES, AND APPLICATIONS

Mike Kennedy & Jason Winslow



AGENDA

- Fundamentals
- Types
  - Shell & Tube
  - Plate & Frame
  - Brazed Plate
- Applications
  - Steam
  - Snowmelt
  - HW/CW Systems
  - Pool

FUNDAMENTALS – KEY TERMS

BTU (British Thermal Unit)
A unit of heat; it's the amount of energy needed to raise 1 pound of water by 1°F.

Approach
The temperature difference between the outlet water and the outlet refrigerant (or process fluid) in a heat exchanger.

LMTD (Log Mean Temperature Difference)
A calculated average temperature difference between hot and cold fluids in a heat exchanger, used for sizing and performance.

Specific Heat
The amount of heat required to raise the temperature of 1 unit mass of a substance by 1 degree.

Specific Gravity
The ratio of a substance's density to the density of water; used to compare heaviness.

Sensible / Latent Heat

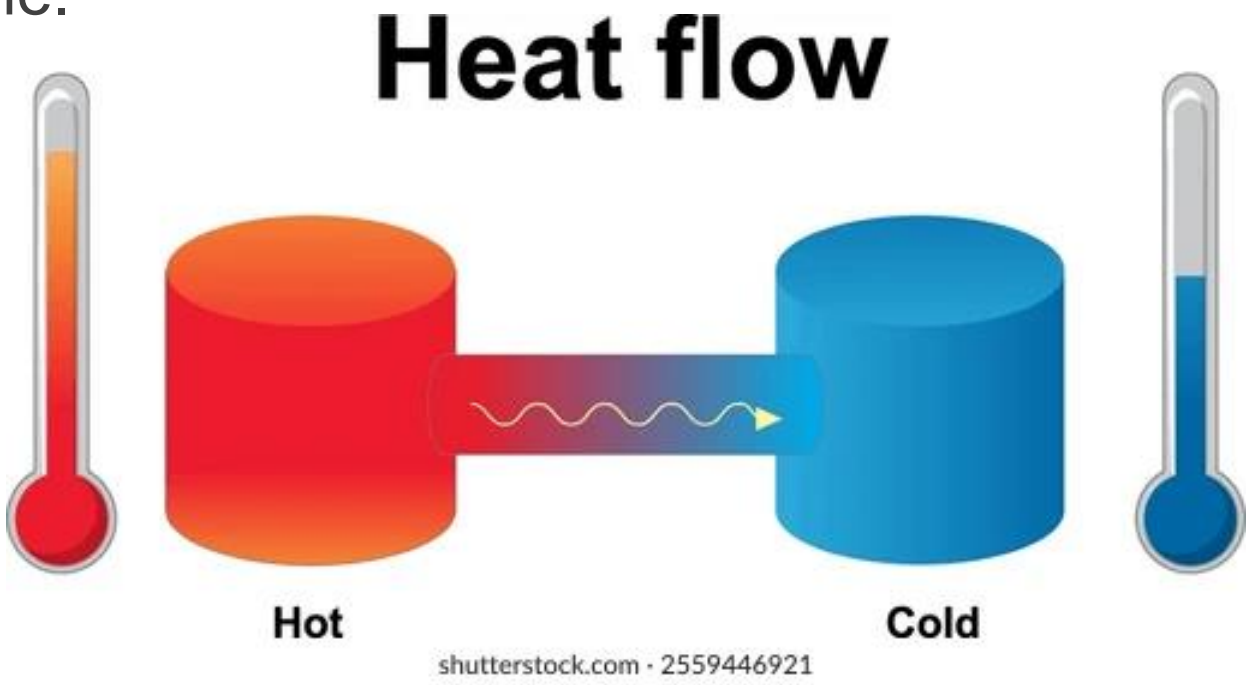
Sensible Heat: Heat that changes temperature but not phase.

Latent Heat: Heat that changes phase (like melting or boiling) without changing temperature.

Fouling Factor
A measure of resistance caused by deposits on heat exchanger surfaces, reducing efficiency.

FUNDAMENTALS

Heat transfer is the movement of thermal energy from a warmer object to a cooler one.



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FUNDAMENTALS

Why Heat Exchangers:

- **Fluid Types – separate water from non-water fluids**
- **Pressure – separate a high pressure and low-pressure system (high rise building)**
- **Safety – protect domestic water from the heating source (chemically treated boiler water or steam)**







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FUNDAMENTALS

BTU/H = GPM * ΔT * 500

- Btu/h = British Thermal Unit / Hour
- GPM = Gallons Per Minute
- ΔT = Temperature Difference
- 500 = Weight of Water (8.33 lbs) x 60 Minutes x Specific Gravity (1.0) x Specific Heat (1.0)

Q = U * A * LMTD

- Q = Heat Transfer Rate (Btu/h)
- U = Overall heat transer coefficient – Btu/(hr*ft²*°F)
- A = Heat Tranfer Surface Area (ft²)
- LMTD = Logarithmic Mean Temperature Difference (°F)

TEMPERATURE CROSS

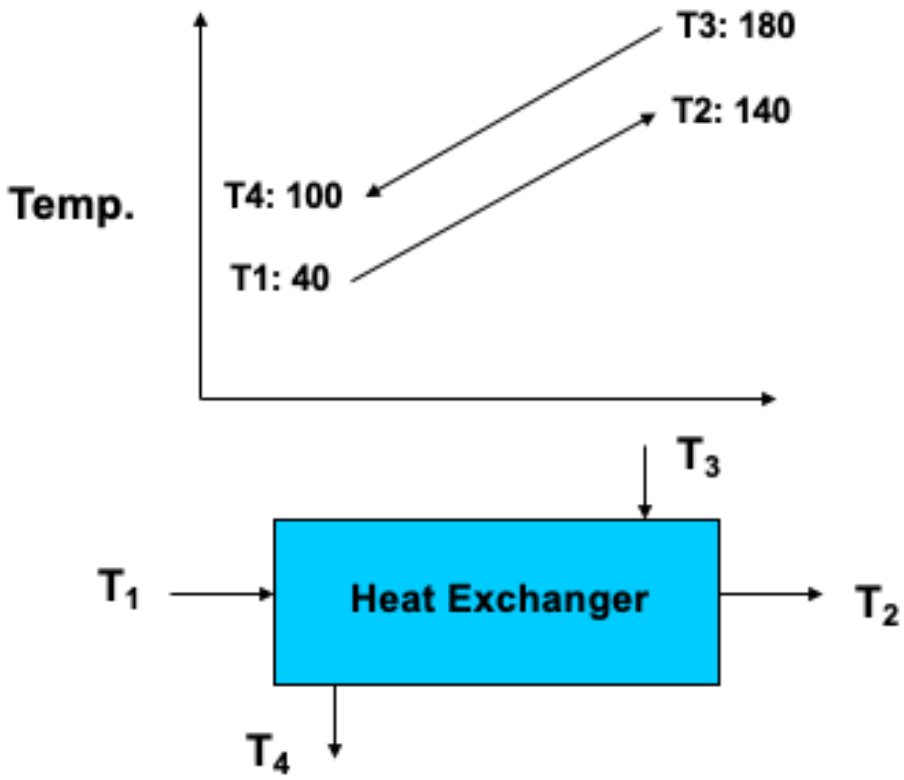


FIGURE 2

$T_1 = 40^{\circ}F$ $T_3 = 180^{\circ}F$

$T_2 = 140^{\circ}F$ $T_4 = 100^{\circ}F$

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FUNDAMENTALS – HEAT TRANSFER &GLYCOL

Fluid	Weight (lb/Gal)	Specific Heat (Btu/lb. °F)	Specific Gravity (lb/	Time (Min)	Forumual Value
Water	8.33	1	1	60	500
40% P. Glycol	8.82	.872	1.03	60	475.3
40% E. Glycol	8.90	.816	1.06	60	461.8

$$Btu/h = GPM \times \Delta T \times \frac{500}{}$$

Glycol ➔ Affect Heat Transfer (Btu/h) or Needed Flowrate (GPM)

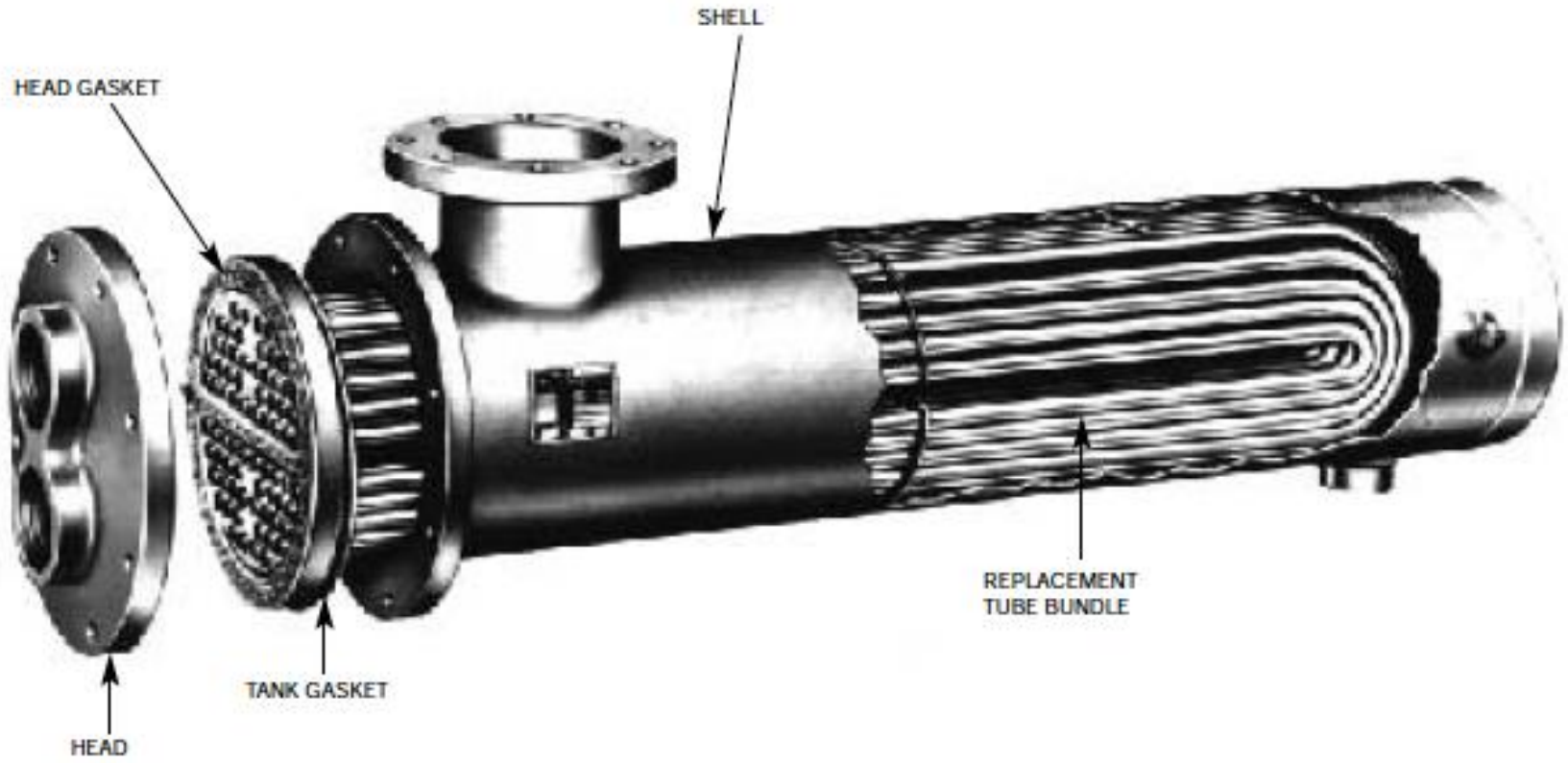




SHELL & TUBE HEAT EXCHANGER (WU/SU)

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CONSTRUCTION

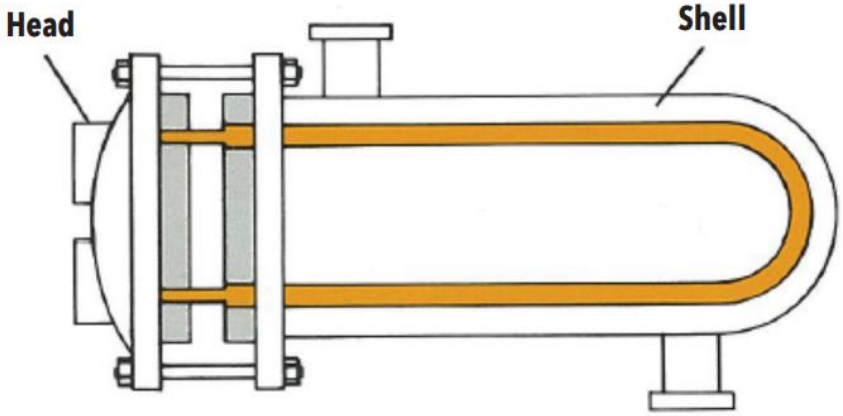


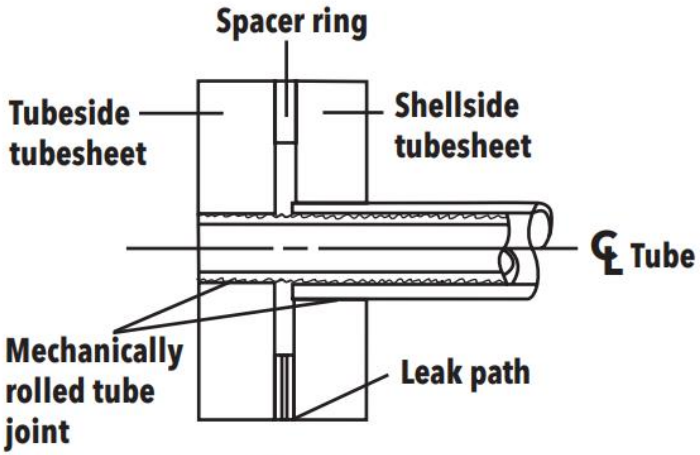
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CONSTRUCTION

Item:	Std. Material	Optional Material
Head	Fabricated Carbon Steel	Stainless Steel
Tube Sheet	Fabricated Carbon Steel	Stainless Steel, 90/10 CuNi, Brass
Tubes	Copper	Single Wall: SS, 90/10 CuNi Double Wall: Copper
Tube Size	3/4” OD	3/8” OD

SHELL & TUBE - DOUBLE WALL





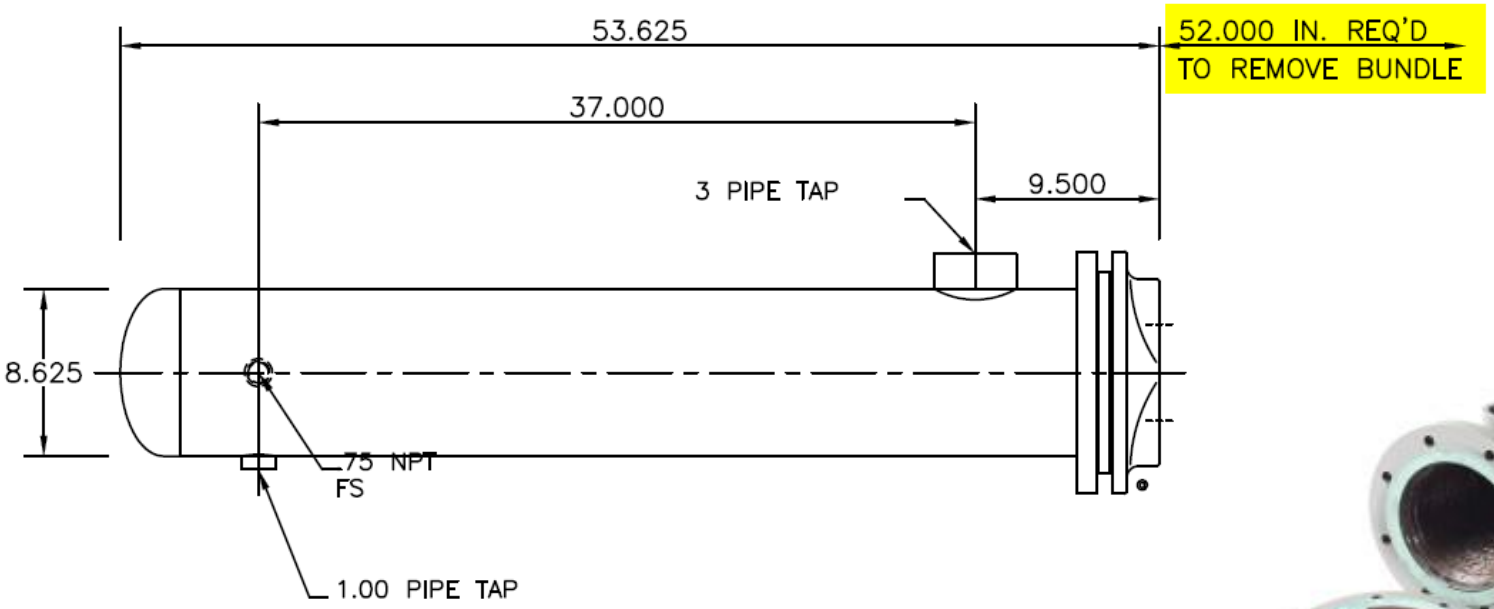
Double-wall Tube Joint



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MAINTENANCE

Tube Removal





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ACCESSORIES

Common Accessories:

- ASME Relief Valve
- Support Feet





Steam to Water HX Add…

- Vacuum Breaker
- Steam Traps





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EXTRA APPLICATIONS

Tank Heaters:

- Steam or Hot Water
- Mounted in storage tank



Straight Tube:

- Industrial Applications



"OC" (Straight Tube) Heat Exchanger

High Temperature Hot Water (HTWU)

- Up to 400°F Water / High Pressure

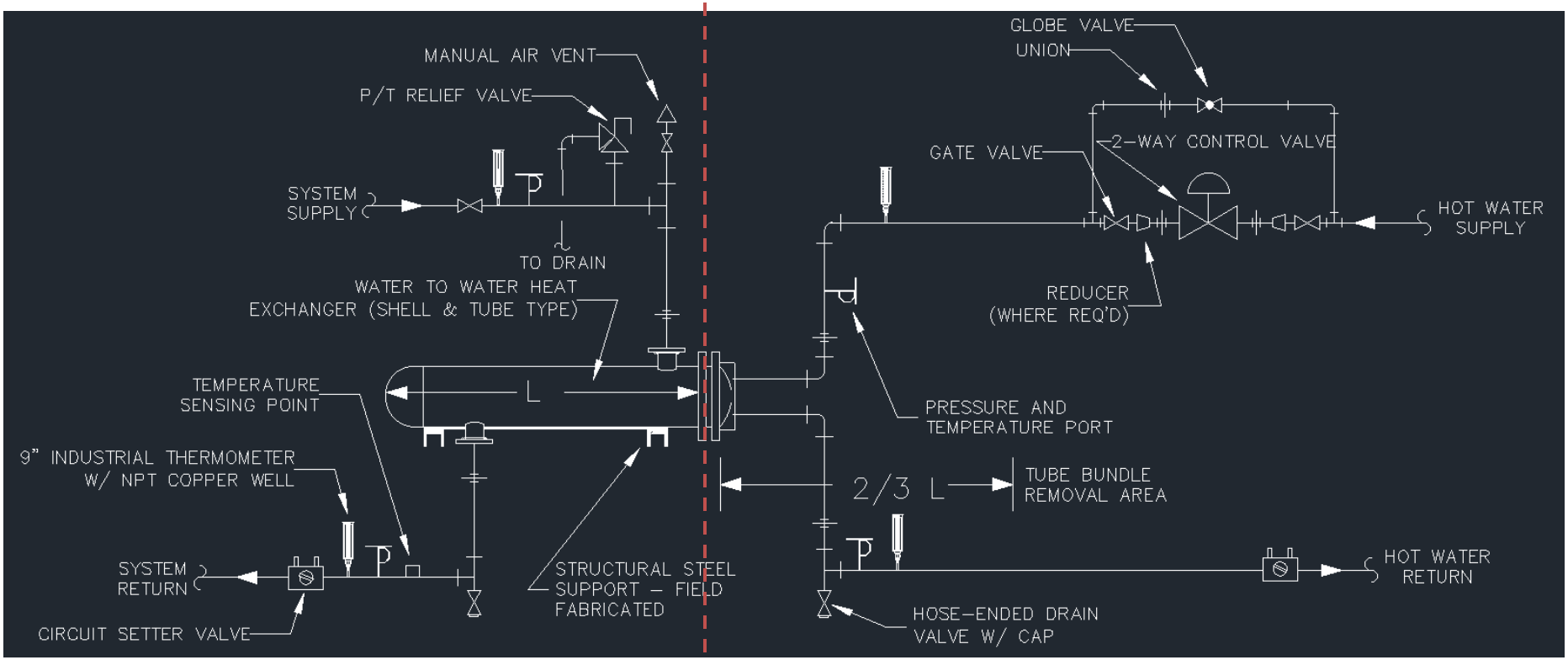
INSTALLATION





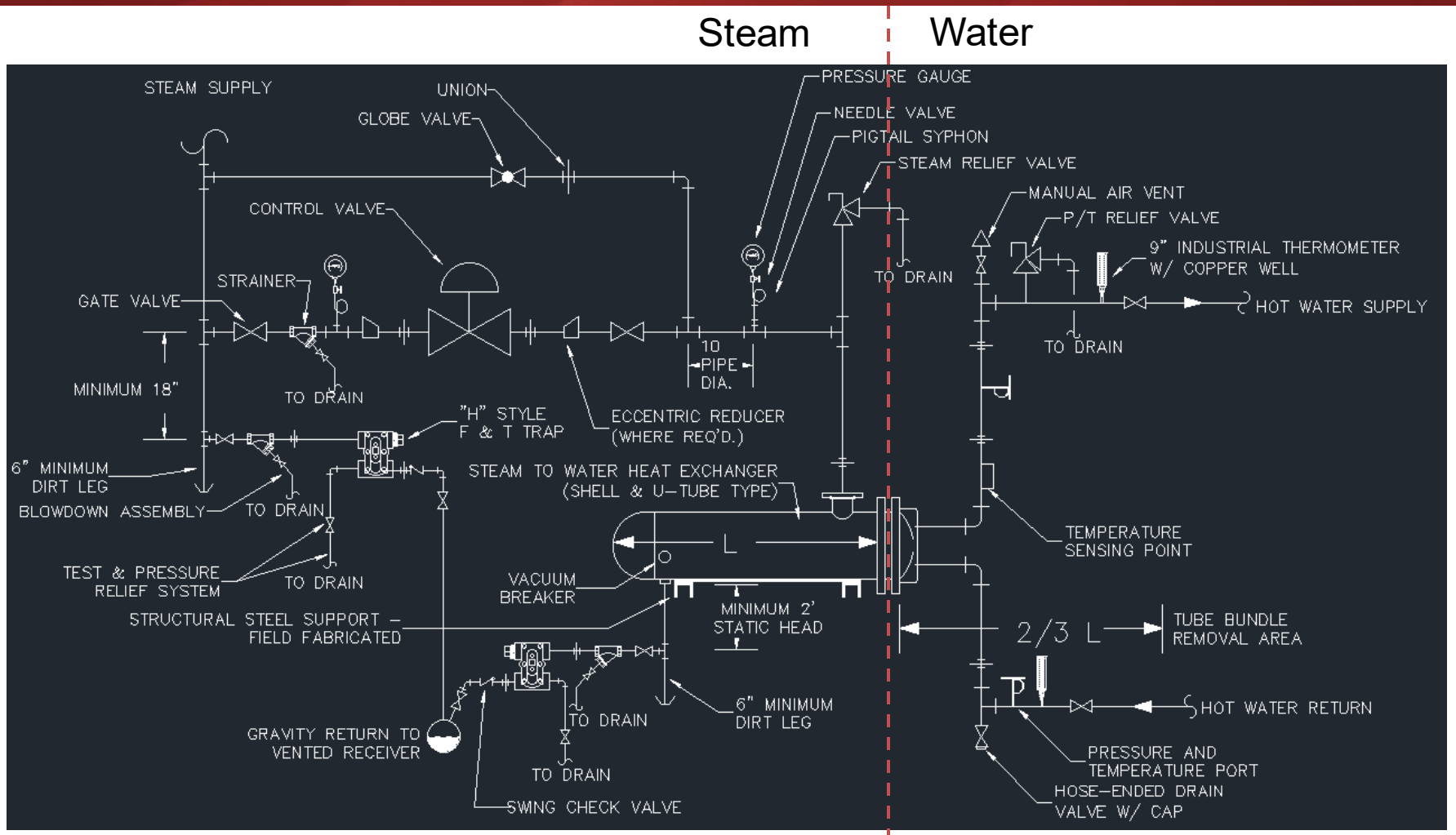
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PIPING LAYOUT : WATER TO WATER (WU)



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PIPING LAYOUT : STEAM TO WATER (SU)



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PLATE & FRAME HEAT EXCHANGER (GPX)

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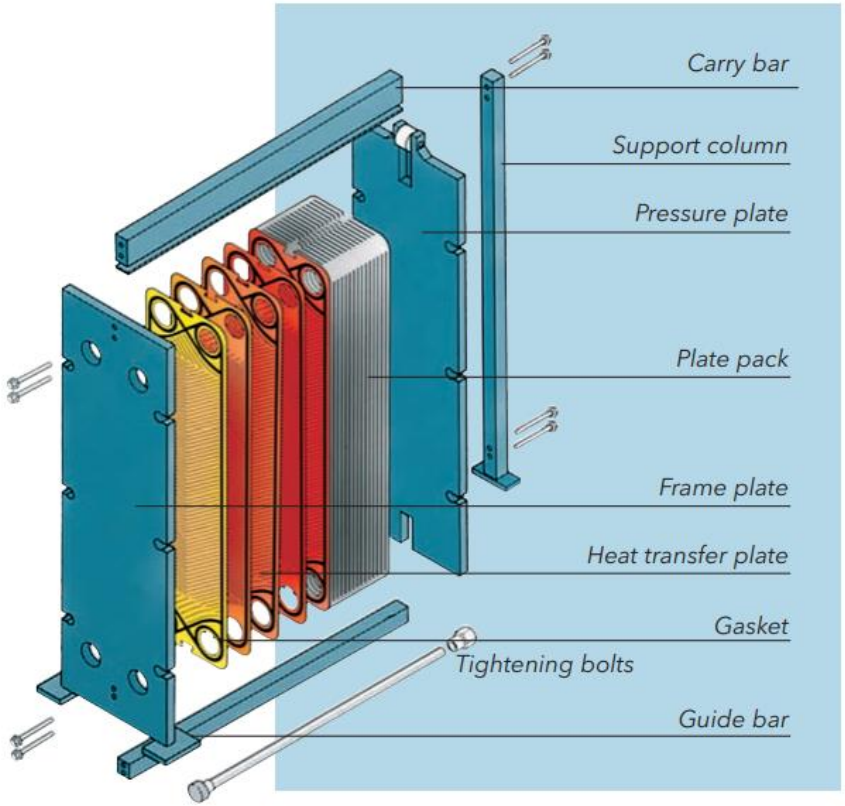
CONSTRUCTION

Carry Bar Length

- Future Capacity

Connection Types

- Standard threaded connection
- Flanged connection
- Standard studded connection
- Threaded connection with alloy nozzle
- Studded connection with alloy lining



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PLATE OPTIONS

Material

- 304 stainless steel
- 316 stainless steel
- Titanium
- Hastelloy TM, Other Higher Alloys

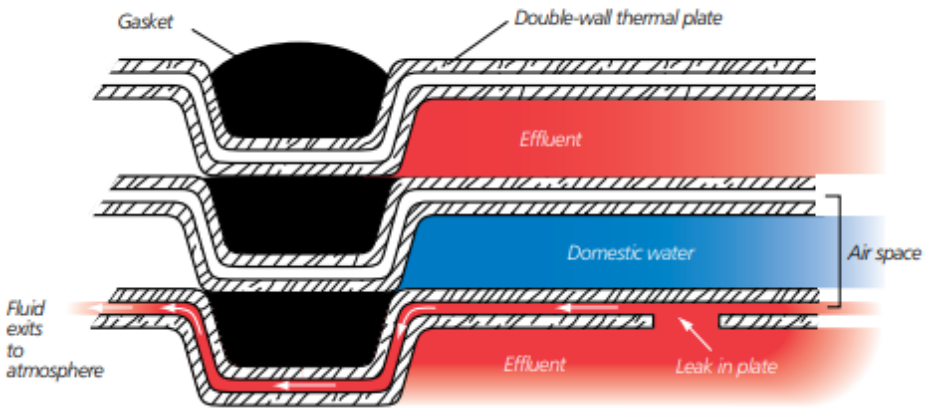
Wall Setting

- Double or single wall
- Wide Gap

Plate Mix

- TL, TM, TK, TLX, XL, XM, XK





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GASKET OPTIONS

EPDM HT

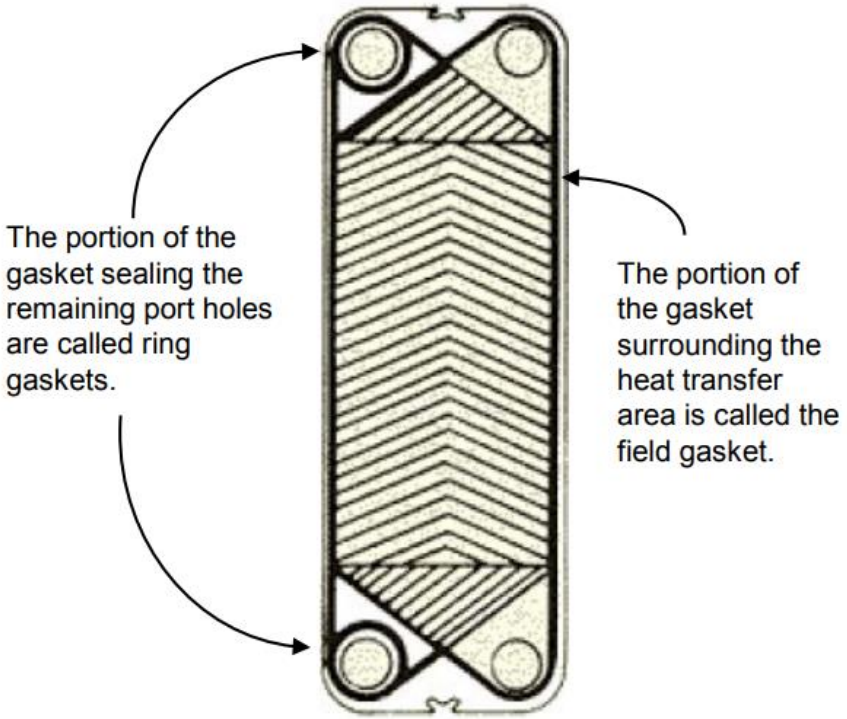
- 150C (302F)

Nitrile HT

- Default gasket material
- 110C-140C (230F-284F)

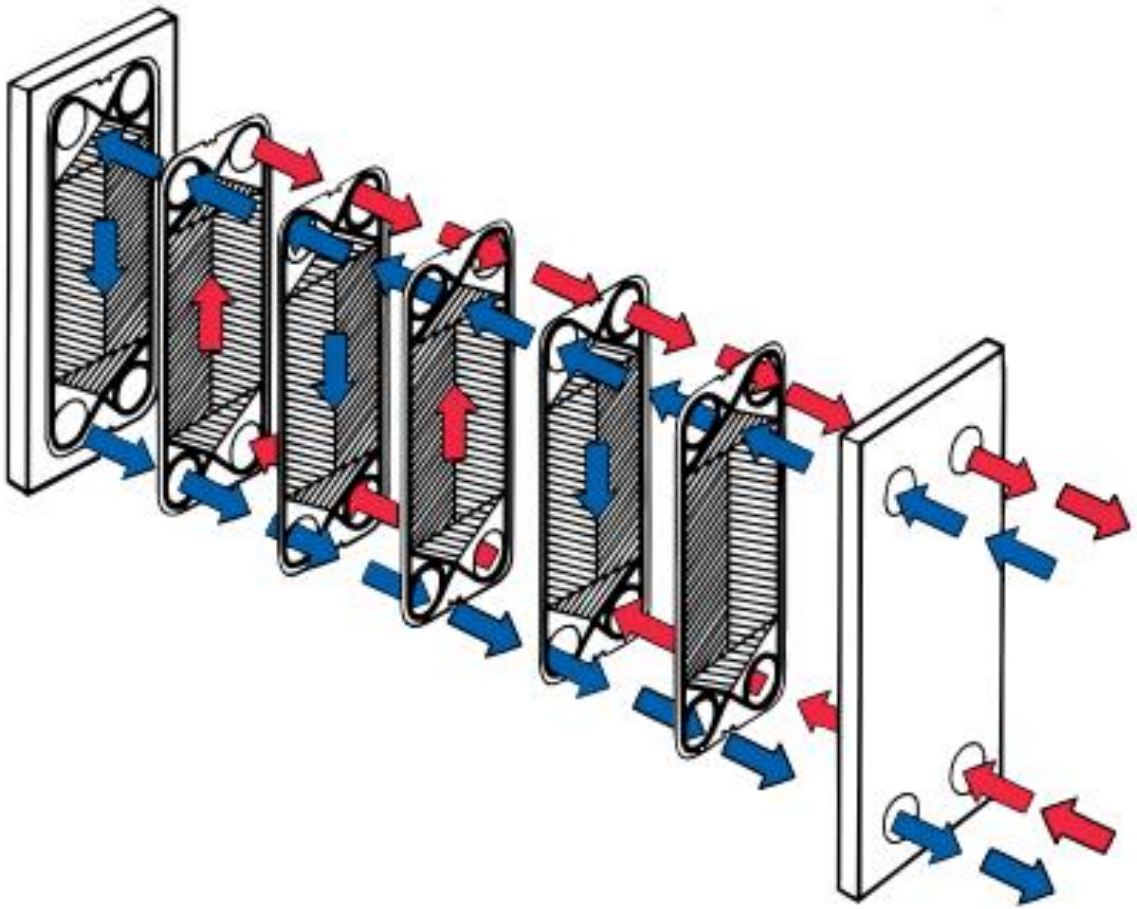
Viton IND

- 170C (338F)



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OPERATION



FLUID VELOCITY

- Plate heat exchangers typically have velocities in the 10 to 15 FPS range due to pressure drop limitations.

- At 2-1/2 to 3 FPS there is a much greater chance for deposits

- Try to avoid flow differences greater than 4:1 (Hot/Cold Side)





FOULING FACTOR





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ACCESSORIES

-Port Strainer

-Insulation Kit

-Automatic Back-Flush System

-Drip Pan

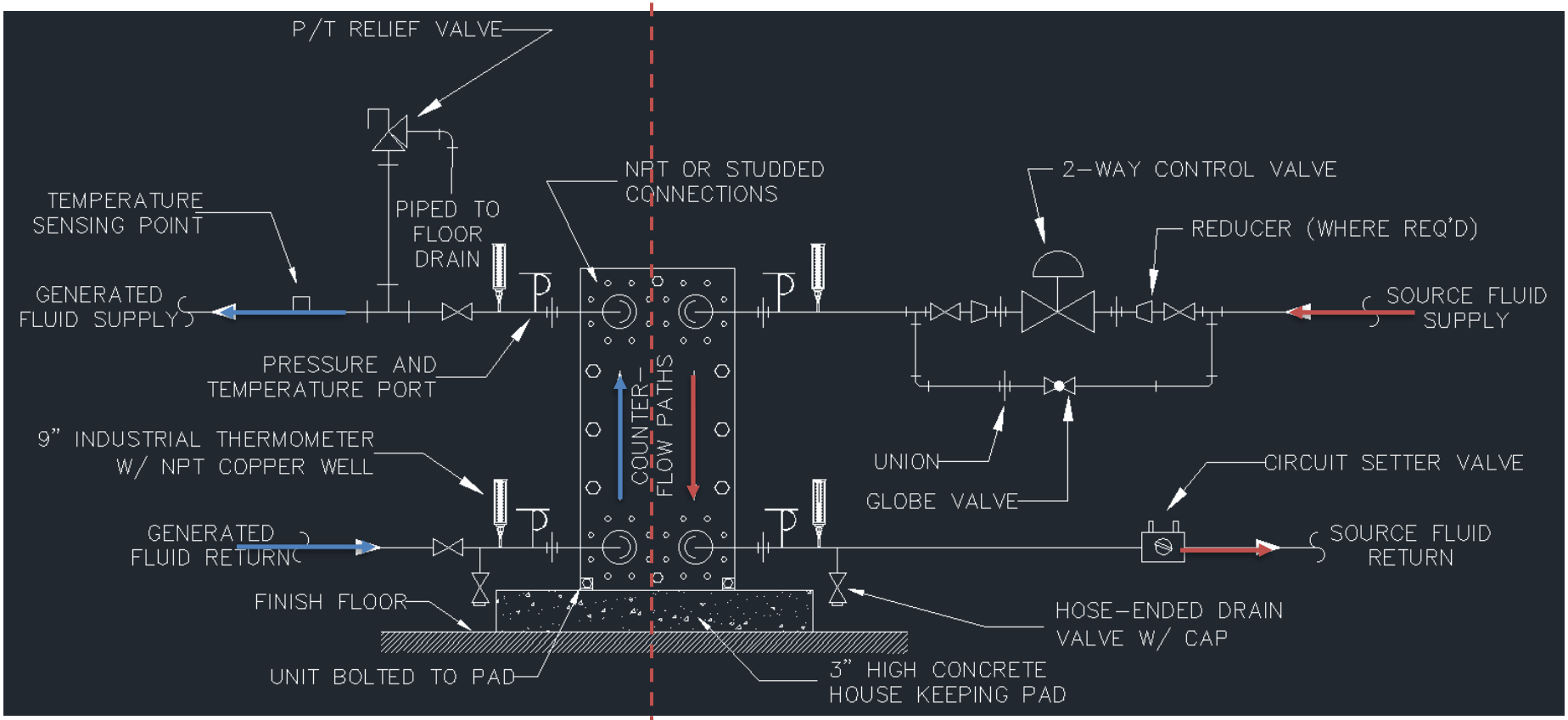






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PIPING LAYOUT – PLATE & FRAME



Cold Side
(30% P. Glycol)

Hot Side
(Water)

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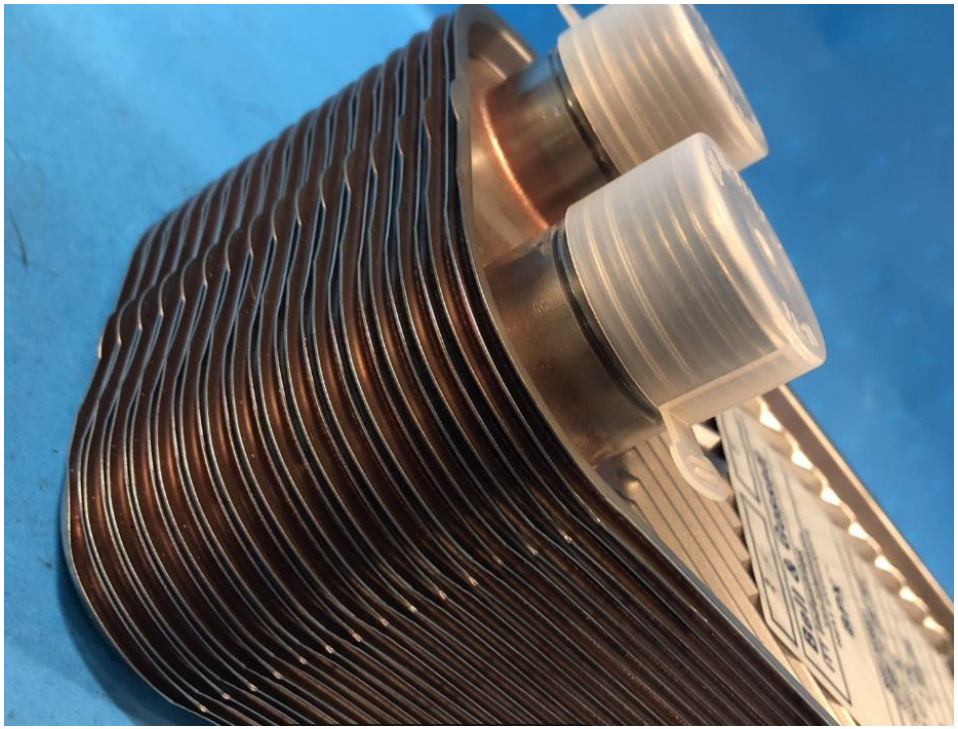




BRAZED PLATE HEAT EXCHANGER (BPX)

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BRAZED PLATE CONSTRUCTION

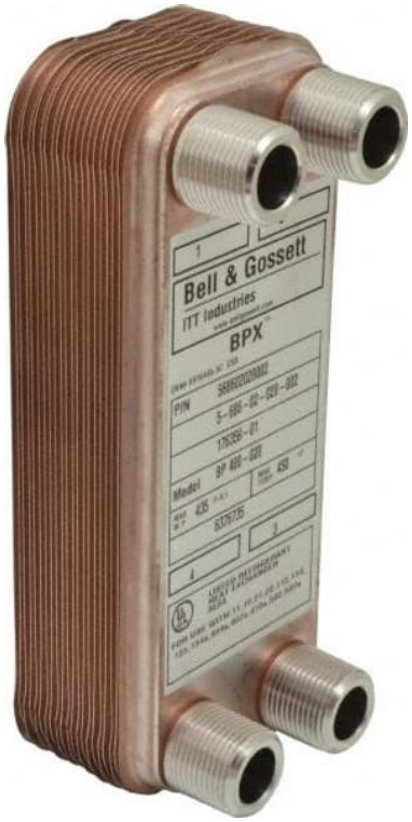




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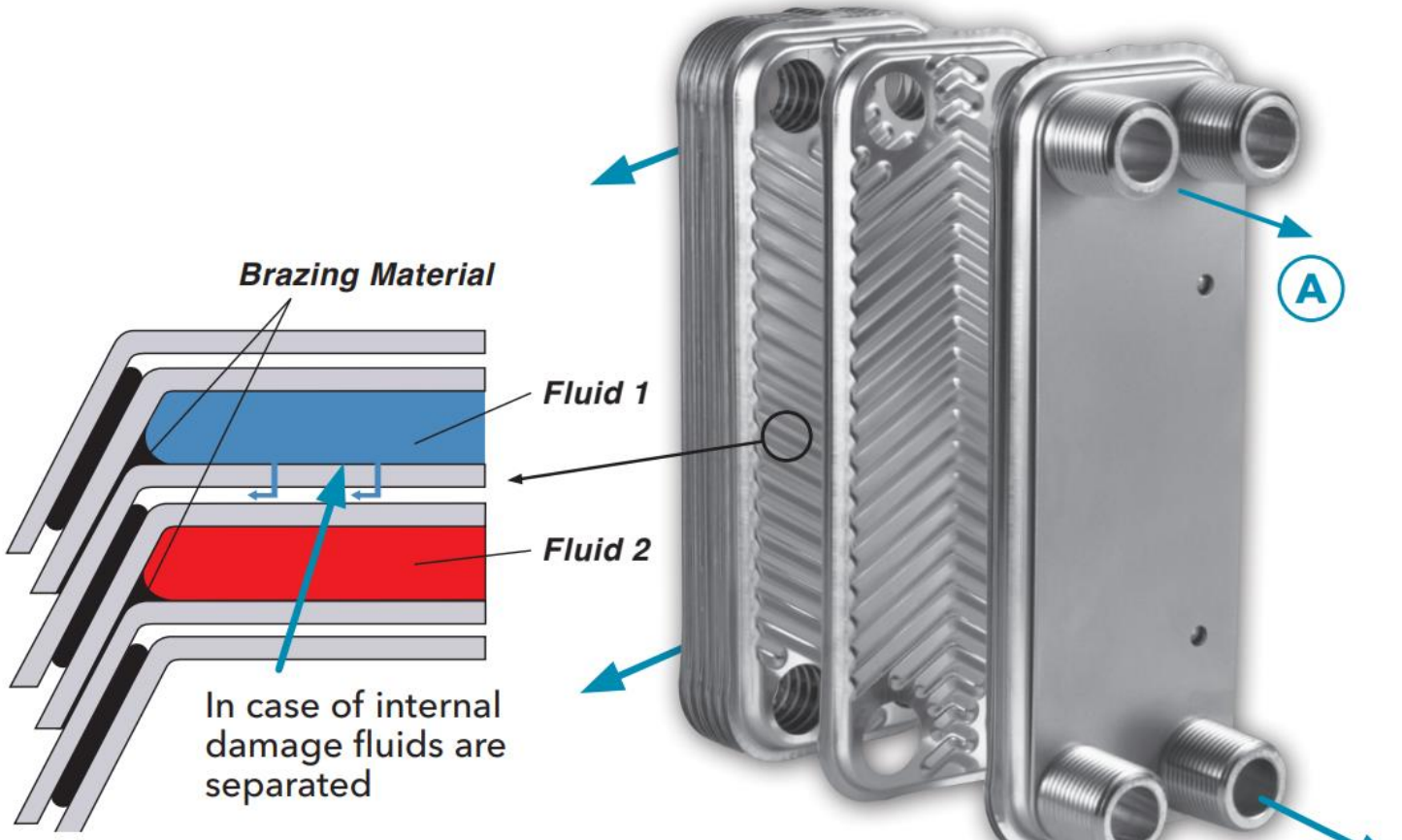
MAINTENANCE

- Not Serviceable
- Back-flush with chemical cleaning agent
- Standard sizes carried by local suppliers



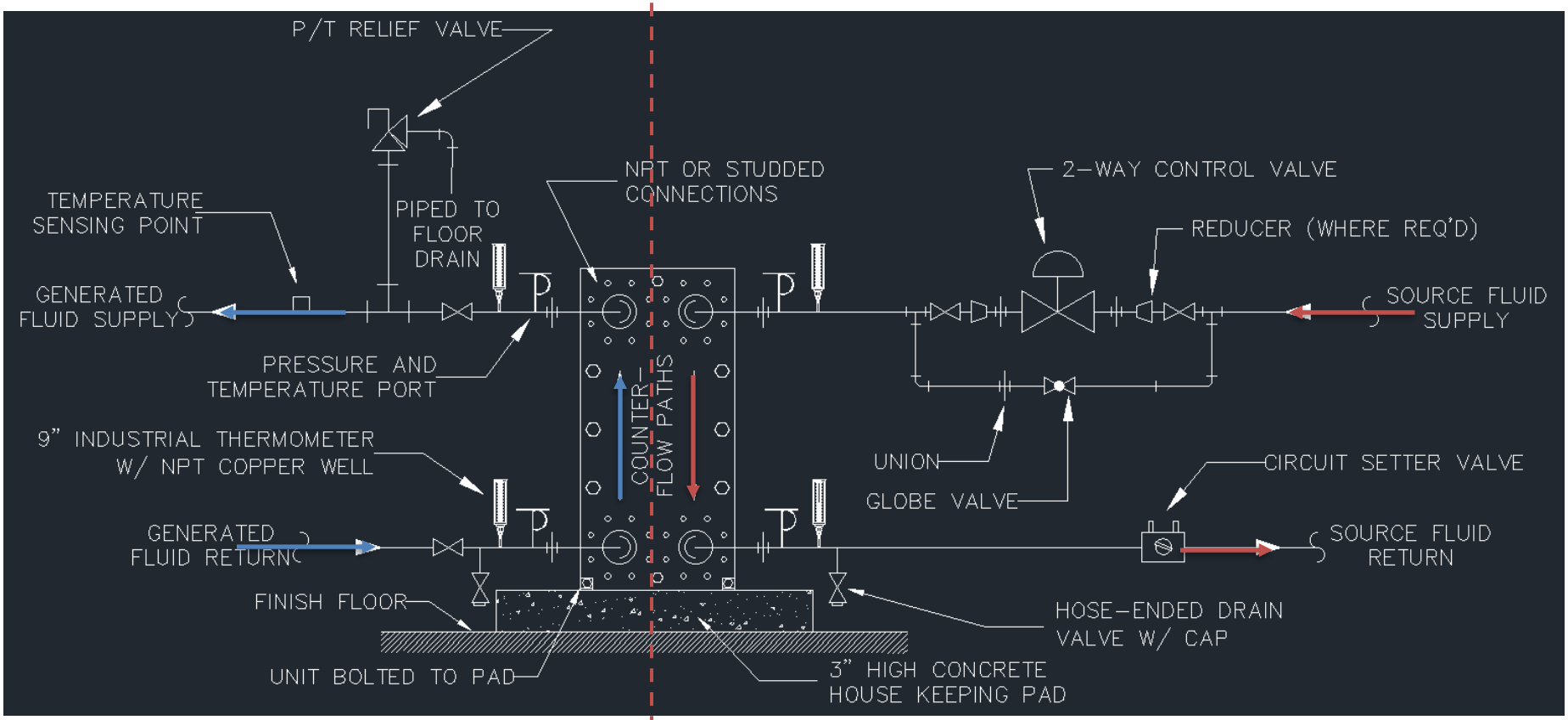
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BRAZED PLATE – DOUBLE WALL



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PIPING LAYOUT – BRAZED PLATE

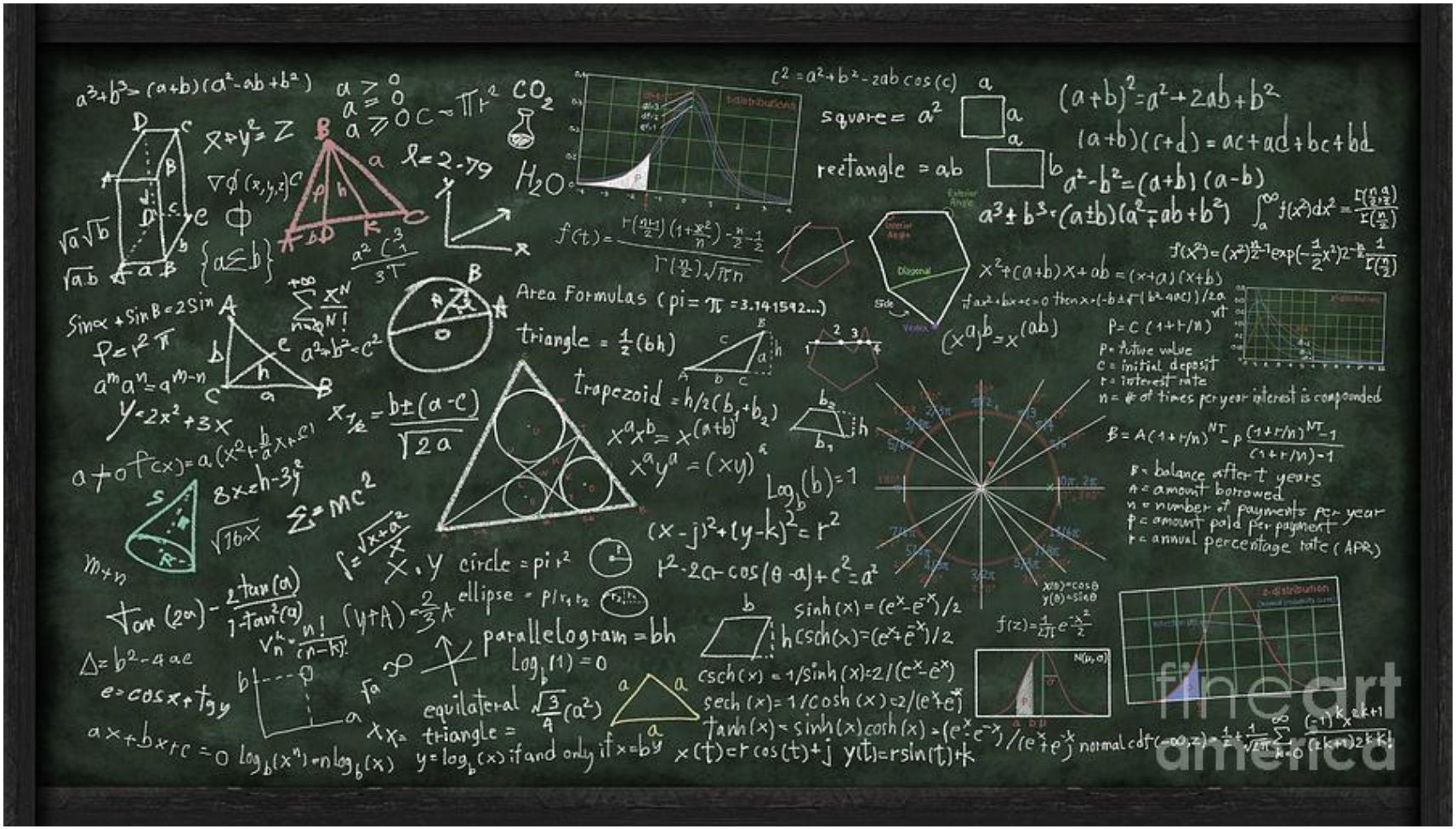


Cold Side
(30% P. Glycol)

Hot Side
(Water)

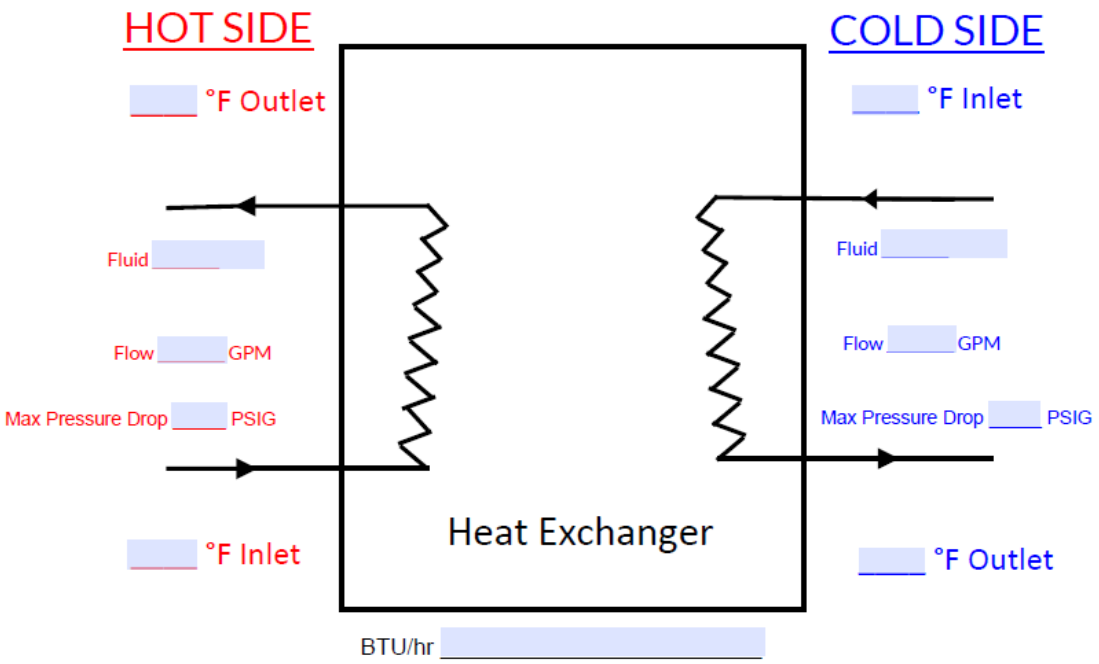
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APPLICATIONS



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APPLICATIONS – STEAM TO WATER (HEATING)

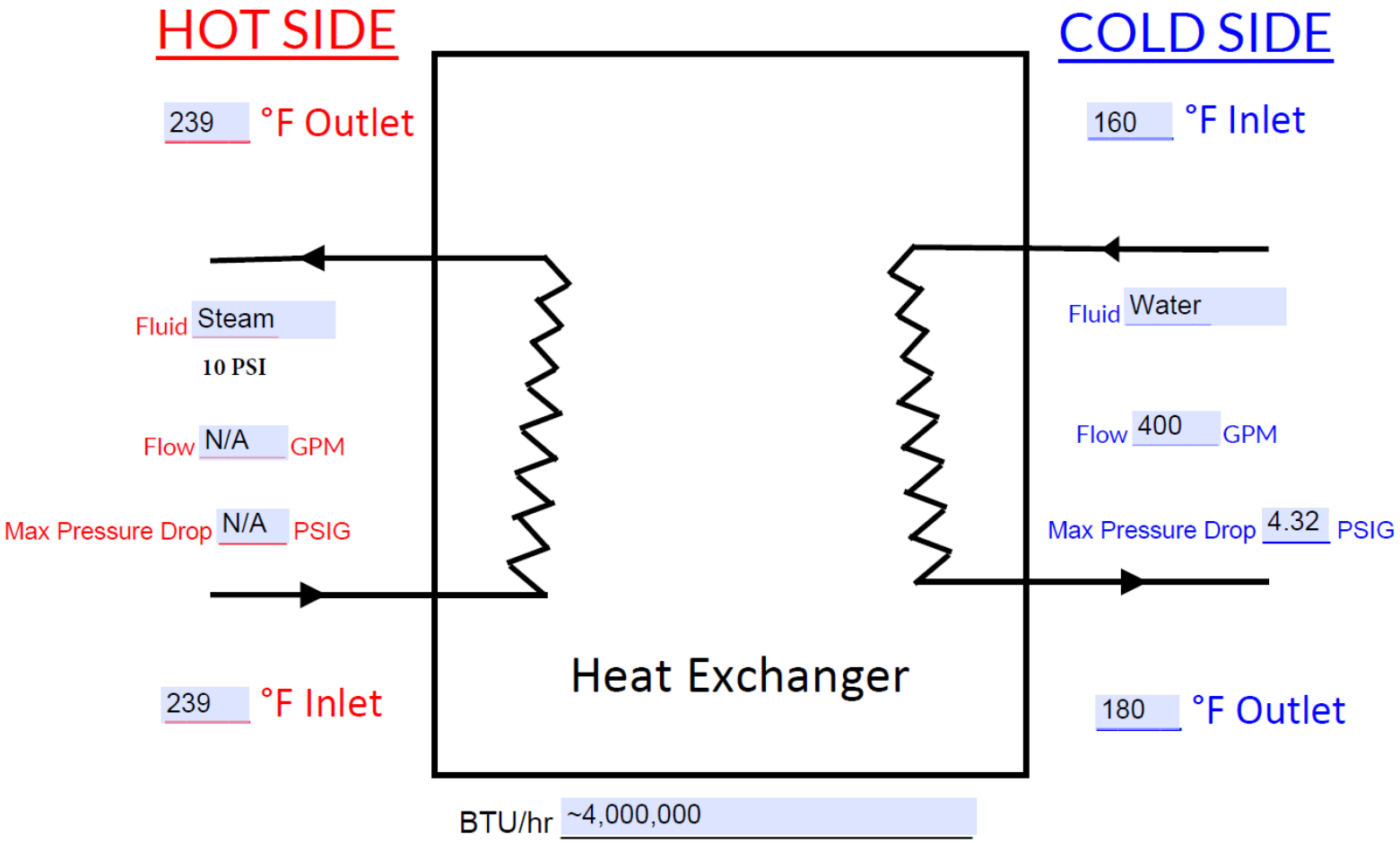


Need:

A. Both fluids: water, glycol (type and % concentration)
B. 5 of 7 parameters (not including pressure drop)
(if giving flow and temperatures on both inlet and outlet of one fluid, do not give BTU)

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APPLICATIONS – STEAM TO WATER (HEATING)



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APPLICATIONS – STEAM TO WATER (HEATING)



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APPLICATIONS – STEAM TO WATER (HEATING)

Results:

Model: SU 144-2

Surface Area: 118.8 Ft²

LMTD: 68.2°F

Size: 14” Diameter, ~4 FT long

Bell & Gossett™

Shell & Tube Heat Exchanger Specification Sheet

175 Standard Parkway
Cheektowaga, New York 14227
1-888-488-4404
www.xylem.com/bellgossett

Customer		Date	Friday, October 24, 2025
Inquiry Number	2025-10-24-15:44	Item Number	NA

Performance of One Unit: SU-144-2 **Units Connected in Parallel:** 1

	Shell Side	Tube Side
Fluid Name	Steam	Water
Total Flow	4,080.39 lb/hr	400 GPM
Inlet Temperature	238.7 °F	160.0 °F
Outlet Temperature	238.7 °F	180.0 °F
Operating Pressure	10 PSIG	0 PSIG
Pressure Drop, Allow./Calc	4.94 / 0.25 PSIG	4.32 / 0.79 PSIG
Velocity	66.94 ft/s	4.71 ft/s
Density	0.06 lb/ft3	60.82 lb/ft3
Viscosity, Mean	0.01 cp	0.38 cp
Viscosity, Wall	0.01 cp	0.37 cp
Specific Heat	0.5 Btu/lbm,°F	1.0 Btu/lbm,°F
Thermal Conductivity	0.01 Btu/ft,h,°F	0.38 Btu/ft,h,°F
Specified Fouling Factor	0.000000 hr,ft2,°F/Btu	0.000500 hr,ft2,°F/Btu

Total Heat Exchanged	3,906,667.93 Btu/h
LMTD	68.21 °F
Overall Heat Transfer Coefficient, Clean/Dirty	845.69/576.72 Btu/hr,ft2,°F
Overall Heat Transfer Coefficient, Service	481.65 Btu/hr,ft2,°F
Surface Area	118.8 ft2
Excess Surface Area	19.74 %

Construction

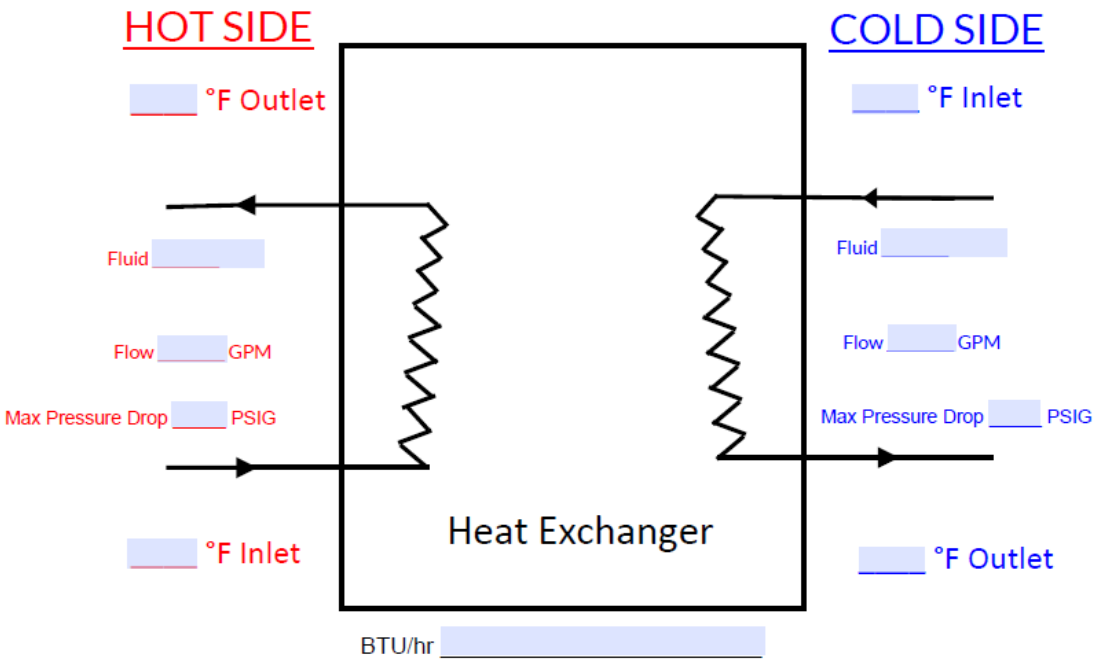
	Shell Side	Tube Side
Number of Passes	1	2
Design Pressure	150PSI	125PSIG
Design Temperature	375(°F)	375(°F)
Inlet Connection (Location) Type	6.0 in FLG 150#	6.0 in NPT
Outlet Connection (Location) Type	2.0 in NPT	6.0 in NPT

Tube Material / Diameter	COPPER / 3/4 in
No. Tubes / Gauge / Length / Pitch	150 / 20 BWG / 48 / 15/16 TRI
Shell Material	STEEL
Head Type/Material	CAST IRON
Tubesheet Material	STEEL
Baffle Material	STEEL
Gasket Material	Elastagraph
Tube to Tubesheet Joint	Roller Expanded
Approvals	ASME Sect VIII Div 1 w/U stamp.

APPLICATIONS – STEAM TO WATER (HEATING)

Change:	Model #	Size	Surface Area	Cost Index
Original	**SU 144-2**	**14” Dia, ~4FT**	**118.8 Ft²**	**1**
Increase ΔP (6.5psi)	SU 144-2	14” Dia, ~4FT	118.8 Ft²	1
Decrease ΔP (0.5 psi)	SU 163-2	16” Dia, ~3FT	119.2 Ft²	1.28
Reduce Steam (5 PSI)	SU 145-2	14” Dia, ~5FT	148.3	1.12
Fouling Factor .0005 ➔ .001	SU 162-2	16” Dia, ~5FT	157.6	1.24

APPLICATIONS - SNOWMELT

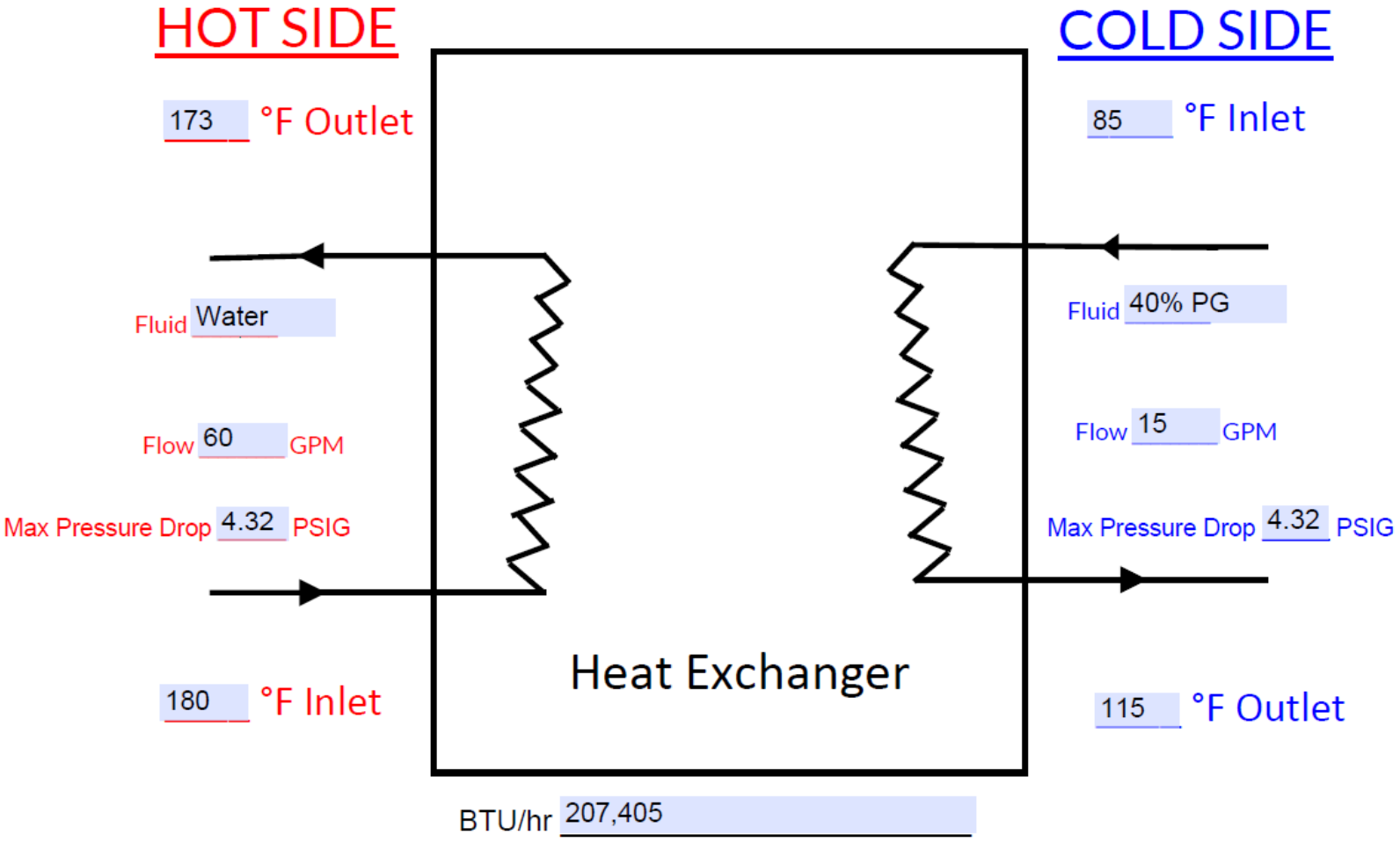


Need:

A. Both fluids: water, glycol (type and % concentration)
B. 5 of 7 parameters (not including pressure drop)
(if giving flow and temperatures on both inlet and outlet of one fluid, do not give BTU)

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APPLICATIONS - SNOWMELT



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APPLICATIONS - SNOWMELT

Quote Information

Project Name:	
Quote No.:	085994
Revision No. :	
Item No.:	

Application Type and Units of Measure

Units of Measure:	○ SI ◉ US
Product Brand:	◉ Bell & Gossett
Product Type	◉ Brazed ○ Gasketed PHE ○ U-Tube ○ Tank Heater ○ Pre-Eng S&T
Application Type	◉ Single Phase ○ Refrigerant Condenser ○ Refrigerant Evaporator (DX/Flooded) ○ Steam Condenser
Quote Type	◉ Thermal Sizing

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APPLICATIONS - SNOWMELT

Heat Exchanger Type Brazed

Please check and enter data for 5 of the 7 input parameter boxes, then run a thermal balance before proceeding to mechanical details. The user shall verify fluid/material compatibility.

		Hot Side			Cold Side		
Heat Load	☑ 207,405.00 Btu/h						
Fluid List		Water More			Propylene Glycol More		
Concentration (%)					40 ☑ Vol Concentration		
Flow Rate	☑ 60.00 GPM			☐ 15.05 GPM			
In/Out Temperature	☑ 180.00	☐ 172.91 °F		☑ 85.00	☑ 115.00 °F		
Max Pressure Drop	10.00 PSI			10.00 PSI			
Operating Pressure	0.0 PSI Gauge			0.00 PSI Gauge			
Fouling Factor	0.000000 hr,ft2,°F/Btu			0.000000 hr,ft2,°F/Btu			

Excess Surface 0.00 %

Type Of Run ◉ Selection ○ Performance ○ Rating

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APPLICATIONS – SNOWMELT

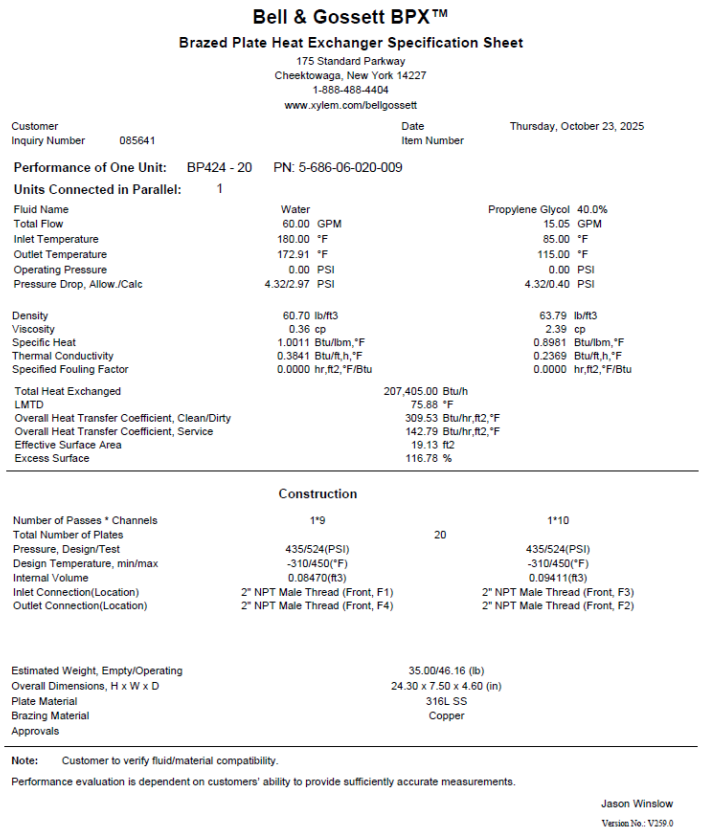
Results:

Model: BP424-20

Surface Area: 19.13Ft²

LMTD: 75.88°F

Size: 24.30” x 7.50” x 4.60”



Bell & Gossett BPX™

Brazed Plate Heat Exchanger Specification Sheet

175 Standard Parkway
Cheektowaga, New York 14227
1-888-468-4404
www.xylem.com/bellgossett

Customer
Inquiry Number 085641
Date Thursday, October 23, 2025
Item Number

Performance of One Unit: BP424 - 20 PN: 5-686-06-020-009

Units Connected in Parallel: 1

Fluid Name	Water		Propylene Glycol	40.0%
Total Flow	60.00	GPM	15.05	GPM
Inlet Temperature	180.00	°F	85.00	°F
Outlet Temperature	172.91	°F	115.00	°F
Operating Pressure	0.00	PSI	0.00	PSI
Pressure Drop, Allow./Calc	4.32/2.97	PSI	4.32/0.40	PSI
Density	60.70	lb/ft3	63.79	lb/ft3
Viscosity	0.36	cp	2.39	cp
Specific Heat	1.0011	Btu/lbm,°F	0.8981	Btu/lbm,°F
Thermal Conductivity	0.3841	Btu/ft,h,°F	0.2369	Btu/ft,h,°F
Specified Fouling Factor	0.0000	hr,ft2,°F/Btu	0.0000	hr,ft2,°F/Btu

Total Heat Exchanged	207,405.00	Btu/h
LMTD	75.88	°F
Overall Heat Transfer Coefficient, Clean/Dirty	309.53	Btu/hr,ft2,°F
Overall Heat Transfer Coefficient, Service	142.79	Btu/hr,ft2,°F
Effective Surface Area	19.13	ft2
Excess Surface	116.78	%

Construction

Number of Passes * Channels	1*9	1*10
Total Number of Plates	20	
Pressure, Design/Test	435/524(PSI)	435/524(PSI)
Design Temperature, min/max	-310/450(°F)	-310/450(°F)
Internal Volume	0.08470(ft3)	0.09411(ft3)
Inlet Connection(Location)	2" NPT Male Thread (Front, F1)	2" NPT Male Thread (Front, F3)
Outlet Connection(Location)	2" NPT Male Thread (Front, F4)	2" NPT Male Thread (Front, F2)

Estimated Weight, Empty/Operating	35.00/46.16 (lb)
Overall Dimensions, H x W x D	24.30 x 7.50 x 4.60 (in)
Plate Material	316L SS
Brazing Material	Copper
Approvals	

Note: Customer to verify fluid/material compatibility.

Performance evaluation is dependent on customers' ability to provide sufficiently accurate measurements.

Jason Winslow

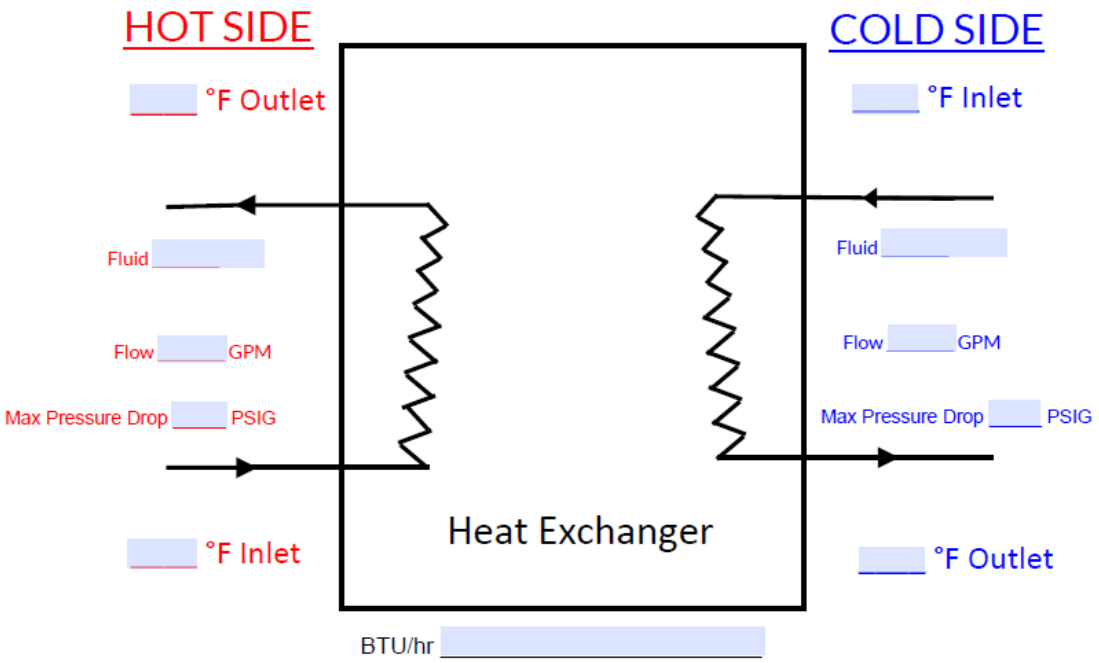
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APPLICATIONS - SNOWMELT

Change:	Model #	Physical Size (in)	Surface Area (sq ft)	Cost Index
Initial Selection	**BP424-20**	**24.30 x 7.50 x 4.60**	**19.13**	**1.0**
Allowable Pressure Drop (15 FT / 6.5 PSI)	BP424-20	24.30 x 7.50 x 4.60	19.13	1.0
Allowable Pressure Drop (5 FT / 2.1 PSI)	BP424-30	24.30 x 7.50 x 5.75	29.76	1.19
Change Approach (Boiler Side 140F)	BP424-30	24.30 x 7.50 x 5.75	29.76	1.19

APPLICATIONS – COOLING TOWER

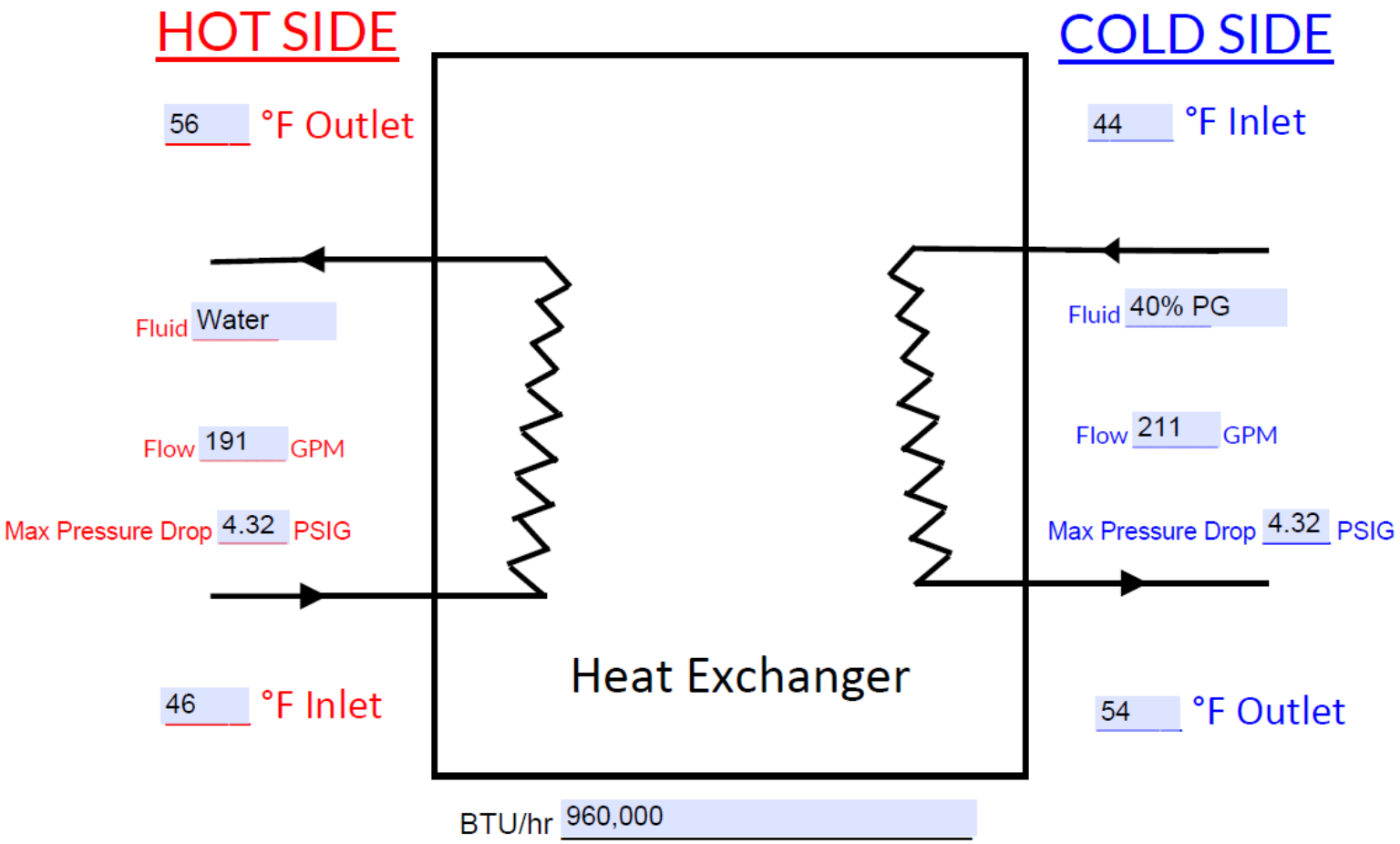


Need:

A. Both fluids: water, glycol (type and % concentration)
B. 5 of 7 parameters (not including pressure drop)
(if giving flow and temperatures on both inlet and outlet of one fluid, do not give BTU)

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APPLICATIONS – COOLING TOWER



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APPLICATIONS – COOLING TOWER

Quote Information

Project Name:	
Quote No.:	086060
Revision No. :	
Item No.:	

Application Type and Units of Measure

Units of Measure:	○ SI ◉ US
Product Brand:	◉ Bell & Gossett
Product Type	○ Brazed ◉ Gasketed PHE ○ U-Tube ○ Tank Heater ○ Pre-Eng S&T
Product Sub Type	◉ Regular GPHE ○ Wide Gap GPHE
Industry Type ?	○ AHRI Standard 400 for HVAC ? ○ Commercial Heating & Cooling ○ Industrial ◉ ASHRAE 90.1 Water Side Economizer ?
Application Type	◉ Single Phase ○ Steam Condenser Note: must use Industrial industry type
Quote Type	◉ Thermal Sizing

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APPLICATIONS – COOLING TOWER

Heat Exchanger Type Gasketed PHE

Please check and enter data for 5 of the 7 input parameter boxes, then run a thermal balance before proceeding to mechanical details. The user shall verify fluid/material compatibility.

		Hot Side		Cold Side	
Heat Load	☑ 960,000.00 Btu/h				
Fluid List		Water		Propylene Glycol	
Concentration (%)				40 ☑ Vol Concentration	
Flow Rate	☐ 191.22 GPM			☐ 210.77 GPM	
In/Out Temperature	☑ 56.00 ☑ 46.00 °F			☑ 44.00 ☑ 54.00 °F	
Max Pressure Drop	4.32 PSI			4.32 PSI	
Operating Pressure	0.0 PSI Gauge			0.00 PSI Gauge	
Fouling Factor	0.000000 hr,ft2,°F/Btu			0.000000 hr,ft2,°F/Btu	
Design Pressure	150.00 PSI			150.00 PSI	

Excess Surface 0.00 %

Type Of Run ◉ Selection ○ Rating

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APPLICATIONS – COOLING TOWER

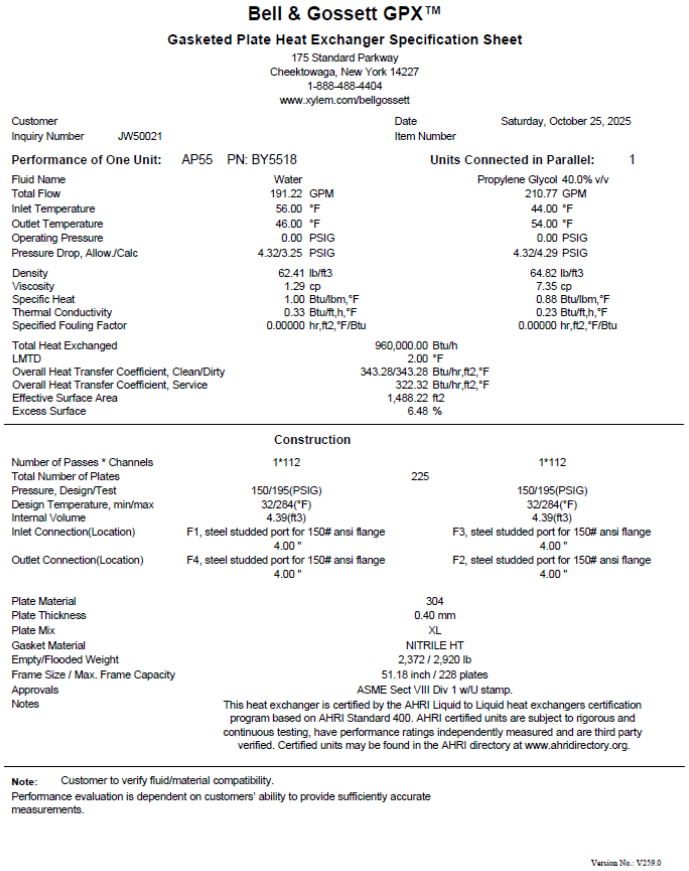
Results:

Model: AP55

Surface Area: 1488.22 Ft²

LMTD: 2°F

Size: 51.18” Frame – 225 Plates



Bell & Gossett GPX™

Gasketed Plate Heat Exchanger Specification Sheet

175 Standard Parkway
Cheektowaga, New York 14227
1-888-488-4404
www.xylem.com/bellgossett

Customer		Date	Saturday, October 25, 2025
Inquiry Number	JW50021	Item Number	

Performance of One Unit: AP55 PN: BY5518 **Units Connected in Parallel:** 1

Fluid Name	Water	Propylene Glycol 40.0% v/v
Total Flow	191.22 GPM	210.77 GPM
Inlet Temperature	56.00 °F	44.00 °F
Outlet Temperature	46.00 °F	54.00 °F
Operating Pressure	0.00 PSIG	0.00 PSIG
Pressure Drop, Allow./Calc	4.32/3.25 PSIG	4.32/4.29 PSIG
Density	62.41 lb/ft3	64.82 lb/ft3
Viscosity	1.29 cp	7.35 cp
Specific Heat	1.00 Btu/lbm,°F	0.88 Btu/lbm,°F
Thermal Conductivity	0.33 Btu/ft,h,°F	0.23 Btu/ft,h,°F
Specified Fouling Factor	0.00000 hr,ft2,°F/Btu	0.00000 hr,ft2,°F/Btu

Total Heat Exchanged	960,000.00 Btu/h
LMTD	2.00 °F
Overall Heat Transfer Coefficient, Clean/Dirty	343.28/343.28 Btu/hr,ft2,°F
Overall Heat Transfer Coefficient, Service	322.32 Btu/hr,ft2,°F
Effective Surface Area	1,488.22 ft2
Excess Surface	6.48 %

Construction

Number of Passes * Channels	1*112	1*112
Total Number of Plates	225	
Pressure, Design/Test	150/195(PSIG)	150/195(PSIG)
Design Temperature, min/max	32/284(°F)	32/284(°F)
Internal Volume	4.39(ft3)	4.39(ft3)
Inlet Connection(Location)	F1, steel studded port for 150# ansi flange 4.00 "	F3, steel studded port for 150# ansi flange 4.00 "
Outlet Connection(Location)	F4, steel studded port for 150# ansi flange 4.00 "	F2, steel studded port for 150# ansi flange 4.00 "

Plate Material	304
Plate Thickness	0.40 mm
Plate Mix	XL
Gasket Material	NITRILE HT
Empty/Flooded Weight	2,372 / 2,920 lb
Frame Size / Max. Frame Capacity	51.18 inch / 228 plates
Approvals	ASME Sect VIII Div 1 w/U stamp.
Notes	This heat exchanger is certified by the AHRI Liquid to Liquid heat exchangers certification program based on AHRI Standard 400. AHRI certified units are subject to rigorous and continuous testing, have performance ratings independently measured and are third party verified. Certified units may be found in the AHRI directory at www.ahridirectory.org.

Note: Customer to verify fluid/material compatibility.
Performance evaluation is dependent on customers' ability to provide sufficiently accurate measurements.

Version No.: V259.0

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APPLICATIONS – COOLING TOWER

Change:	Model #	Frame Size	Plate Count (Actual / Max)	Cost Index
Initial Selection	**AP55**	**51.18”**	**225 / 228**	**1.0**
Allowable Pressure Drop (15 FT / 6.5 PSI)	AP55	51.18”	189 / 228	0.88
Allowable Pressure Drop (20 FT / 8.7 PSI)	AP55	51.18”	189 / 228	0.88
Change Approach (3F)	AP55	39.37”	130 / 162	0.68
Change Approach (4F)	AP55	39.37”	102 / 162	0.59

APPLICATIONS – POOLS

Materials of Construction

Commercial:

- Shell & Tube: Cu/Ni Tubes
- Plate & Frame: Titanium

Residential Applications:

- BPX: Nickel Brazed

Locate upstream of chemical injection equipment

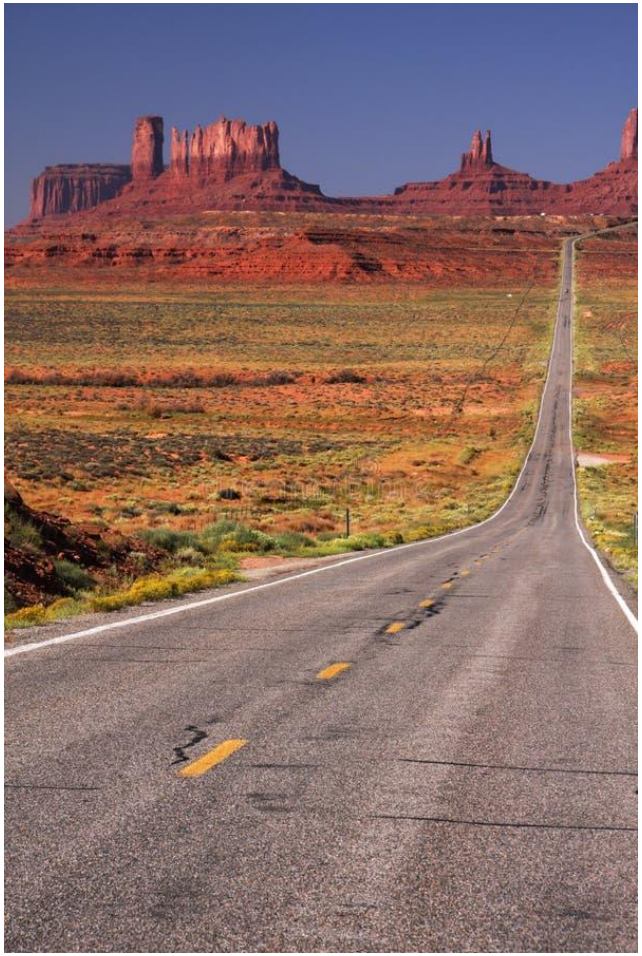


APPLICATION REFERENCE

Application:	Shell & Tube	Plate & Frame	Brazed Plate
Steam Energy Source	Yes	No	No
Compact Size	Depends	Yes	Yes
Temperature Cross	No	Yes	Yes
Low Approach Temp	No	Yes	Yes
Snowmelt	Yes	Yes	Yes
Pool	Yes w/ Cu/Ni Tubes	Yes w/ Titanium	Yes w/ Nickel Braze
Chilled Water	No	Yes	Yes
HW Heating	Yes	Yes	Yes
Heat pump / Geothermal	No	Yes	Yes
Domestic	Yes	Yes	No

CLOSING THOUGHTS

- Roadmap
  - Fundamentals
  - Types of HX
  - Application Strategies
- Riding Shotgun
  - R.L. Deppmann



QUESTIONS???

THANK YOU

Mike Kennedy – mkennedy@deppmann.com
Jason Winslow – jwinslow@deppmann.com



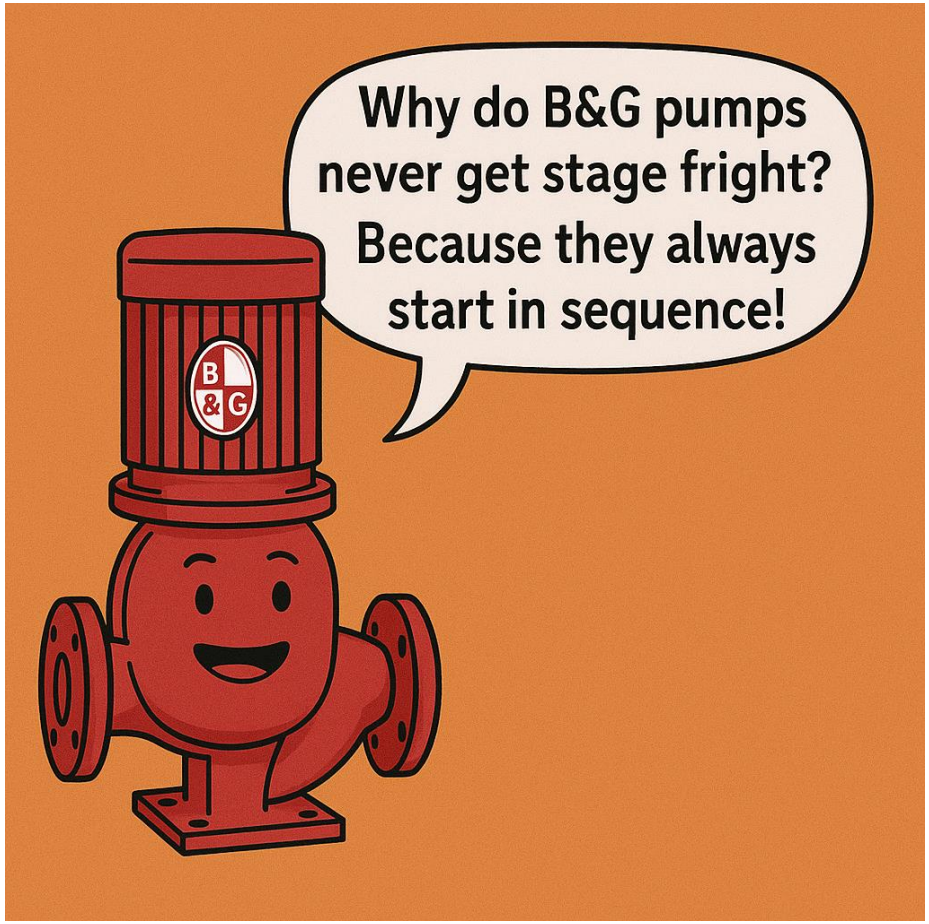
AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break	
9:45-10:45 –	Domestic Hot Water Recirculation Systems –	Ryan Groves
10:45-11:00 –	Break	
11:00-12:00 –	Exploring Heat Exchangers –	Mike Kennedy & Jason Winslow
12:00-1:00 –	Lunch	
1:00-2:00 –	**From 0 to 60Hz: The Basics of VFDs –**	**Nick Tabar**
2:00-2:15 –	Break	
2:15-3:15 –	F & T Steam Basics –	Mark Fine & Nick Tafelski
3:15-3:30 –	Break	
3:30-4:30 –	Practical Water Quality Testing –	Andrew Ward

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LUNCH

RETURN AT 1:00PM



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AGENDA

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FROM 0 TO 60HZ: THE BASICS OF VFDS

Nick Tabar, PE, MBA, CPD
R. L. Deppmann | Northern Ohio Sales Engineer
ASPE Region 2 AYP Liaison
NOSHE YP Co-Chair

C: (440) 409-5676
E: ntabar@deppmann.com



Agenda

Introduction

- Who is Nick Tabar?

VFD 101: Theory

- Standard Motors
- Parts of a VFD
- How a VFD Works

VFD 102: Control Concepts and Key Definitions

- Variable Torque
- Pump Affinity Laws
- PID

Bell and Gossett Specific Selection Notes

- Selecting the Largest Impeller Size
- Hydrovar X Integrated Pumps

Who is Nick Tabar?

Education

- 2016: Graduated from Gannon University with a Bachelor of Science in Mechanical Engineering
- 2024: Graduated from Youngstown State University with a Master of Business Administration

Credentials and Societies

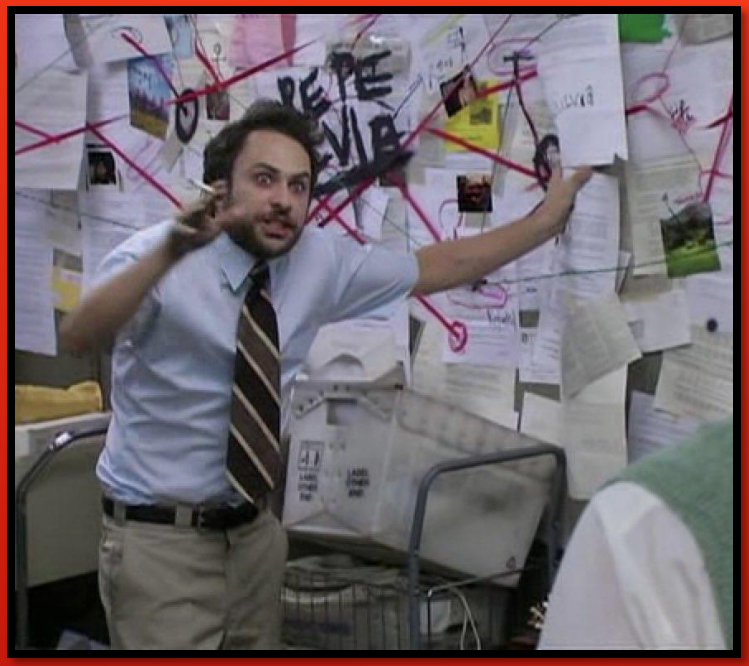
- 2019-2023: ASPE Young Professionals Liaison (Cleveland Chapter)
- 2020: Certified Plumbing Designer (ASPE).
- 2020: NOSHE Young Professionals Co-Chair.
- 2021: Professional Engineer (OH).
- 2023: ASPE Young Professionals Liaison (Region 2)

Experience

- 2016: Plumbing Engineer.
- 2022: Sales Engineer at R. L. Deppmann.



SECTION 1

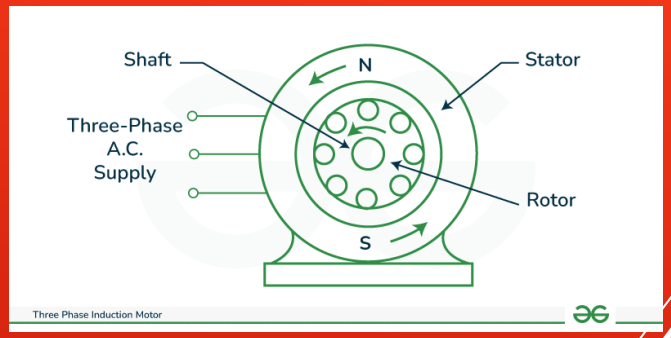


VFDs 101

Theory

3-Phase AC Induction Motor Operation

- **Synchronous Speed** is the speed of the rotating magnetic field in the motor.
- $N_s = \frac{120\,x\,f}{P}$, where
  - N_s = Synchronous Speed, rpm
  - f = frequency, Hz
  - P = number of poles
- In the US, we use 60Hz as our frequency.
  - Therefore, we can calculate the following:
    - A 2-pole motor gives us a speed of 3600rpm
    - A 4-pole motor gives us a speed of 1800rpm
    - A 6-pole motor gives us a speed of 1200rpm



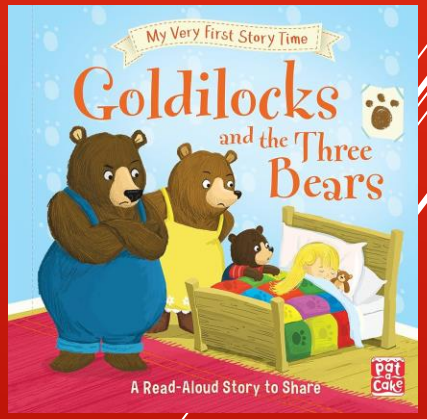


Photo Credit: geeksforgeeks.org

3-Phase AC Induction Motor Operation

- **Slip** is defined as the difference between synchronous speed and operating speed, at the same frequency, expressed in rpm or percent/ratio of synchronous speed.
- $S = \frac{N_S - N_r}{N_S}$, where
  - $S =$ Slip, usually expressed as percentage or decimal
  - $N_S =$ Synchronous Speed, rpm
  - $N_r =$ Actual Rotor Speed, rpm
- Because of this, most 1800rpm motors range from 1725rpm to 1760rpm depending on the amount of slip.
- Why is there slip? What would happen if there was no slip?

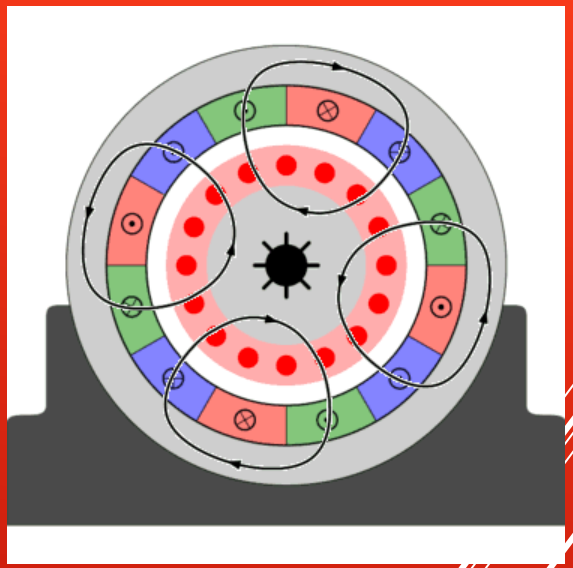




Photo Credit: https://commons.wikimedia.org/wiki/File:Asynchronmotor_animation.gif

What Does this Mean?

- Based on the synchronous speed formula, we can only change the speed of the motor by:
  - Physically changing the number of poles in a motor.
    - This would mean separate windings, but that would only give one speed per set of windings.
  - Electrically change the slip characteristics of the motor.
    - This would limit the speed to the upper range of the synchronous speed.
  - Changing the frequency of the power supplied to the motor.
    - Introducing… VFD's!

$$N_s = \frac{120\ x\ f}{P}$$

$$S = \frac{N_S - N_r}{N_S}$$



Photo Credit: xylem.com

VFD – Simple Operation

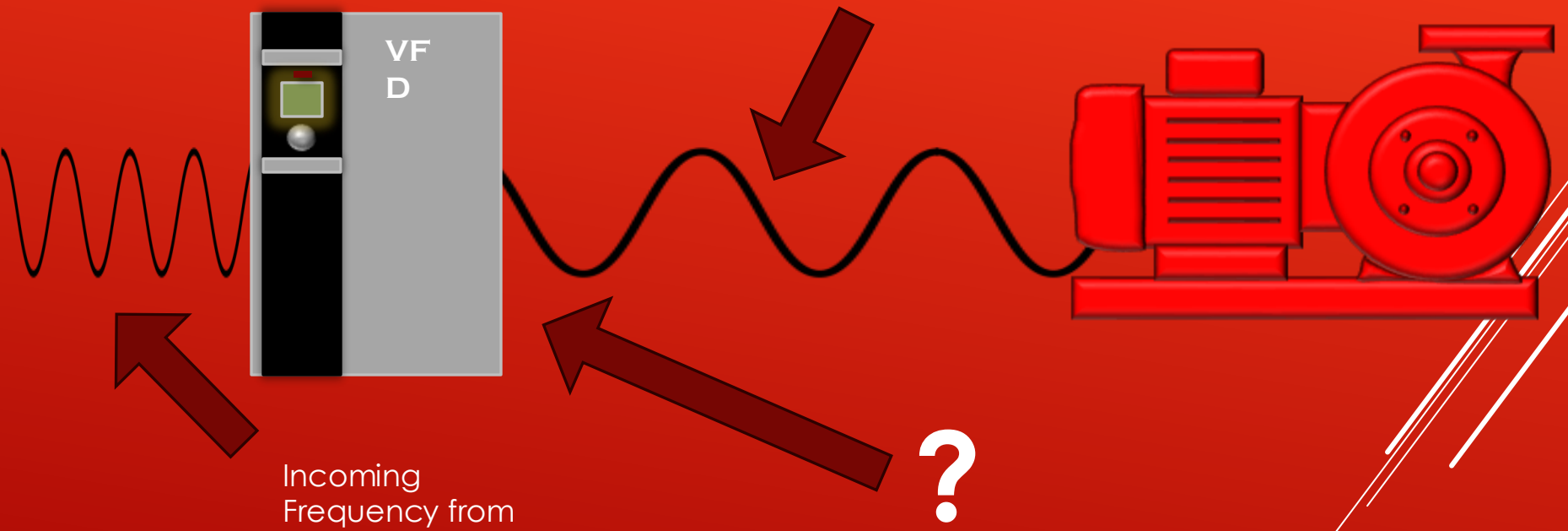
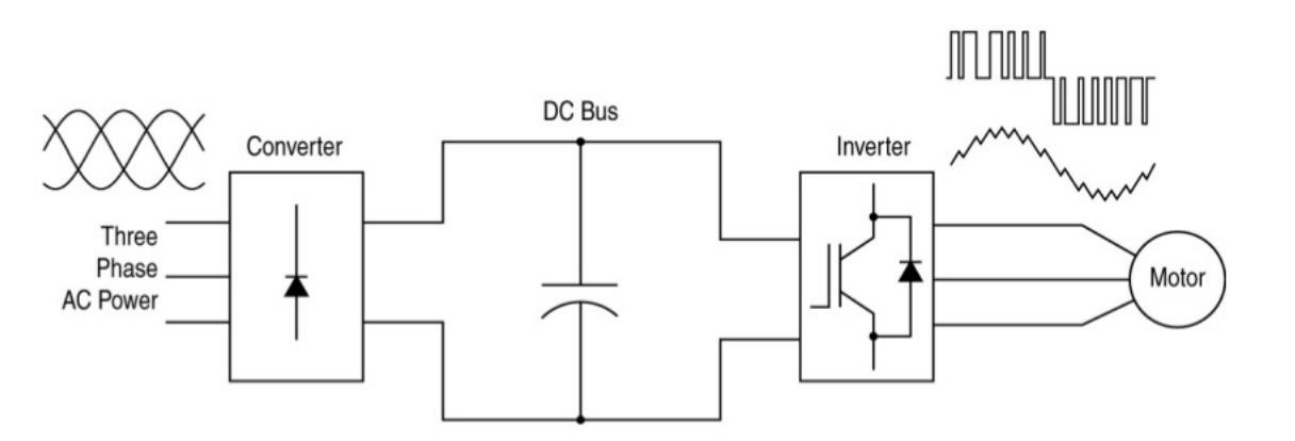
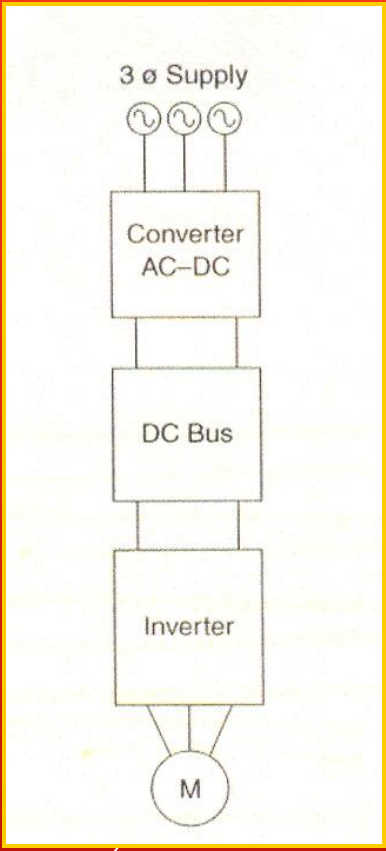


Photo Credit: xylem.com

VFD Block Diagram

- Three Main Sections
  - Converter or Rectifier (AC to DC)
  - DC Bus (filters and stores energy)
  - Inverter (creates AC at desired frequency)
- Output frequency determines motor speed.
- Internal controller monitors and adjusts drive performance.

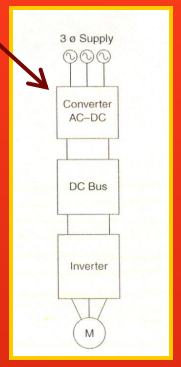




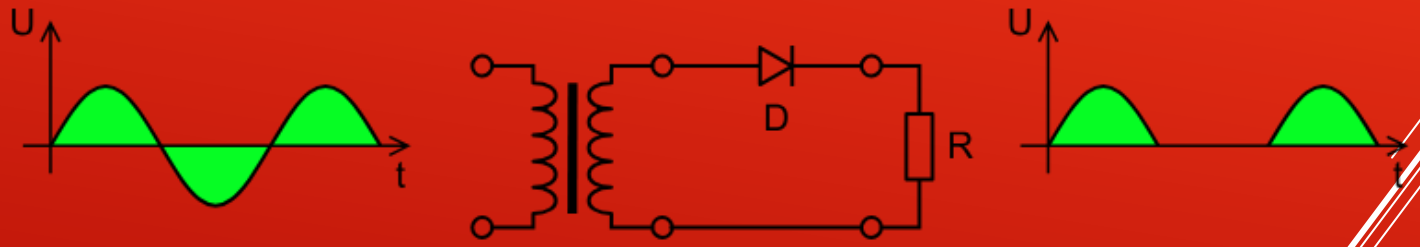
Converter or Rectifier

- First stage of the VFD: AC to DC conversion
- Uses "diodes" to allow current in one direction only
  - Act as electronic check valves
- Half-wave rectifier passes only the positive side of the waveform
- Full-wave rectifier passes both halves for more efficient output
- Prepares power for filtering in the DC Bus, the next section





Half-Wave Rectifier



Full-Wave Rectifier

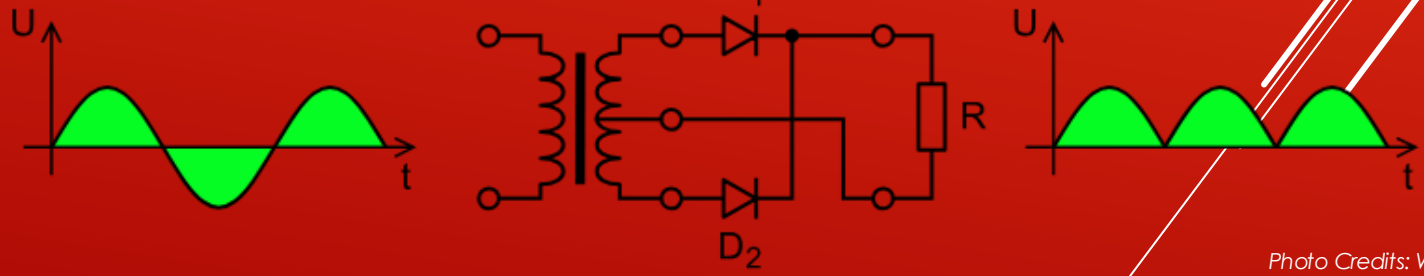
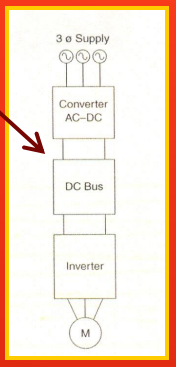
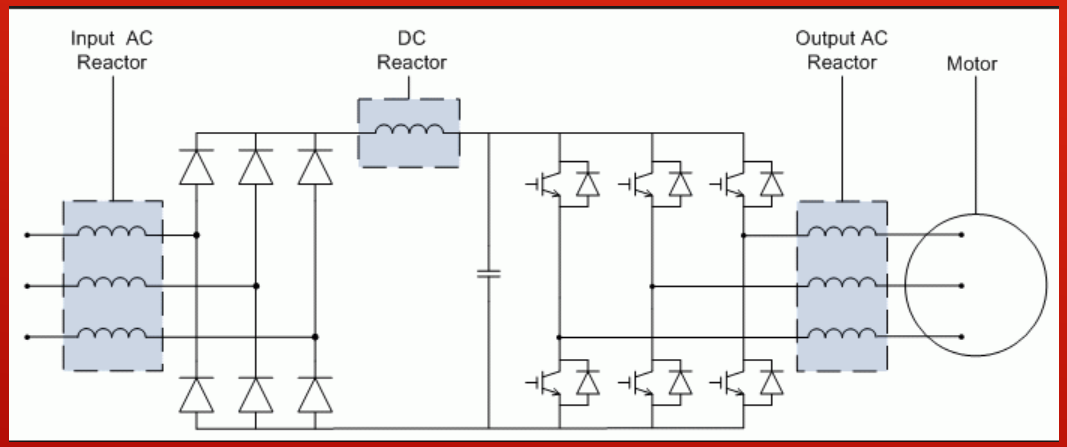


Photo Credits: Wdwd

DC Bus

- Smooths ripple from rectifier using capacitor banks
- Reduces harmonic distortion fed back to the power grid
- Some manufacturers use DC Bus Reactors, while others often use input line reactors
- Prepares stable DC voltage for the inverter section





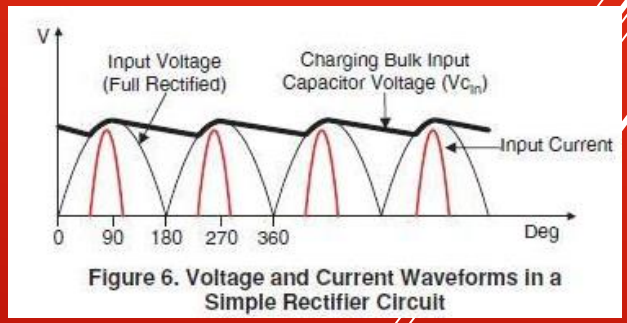
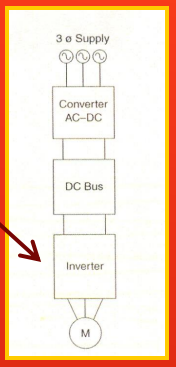
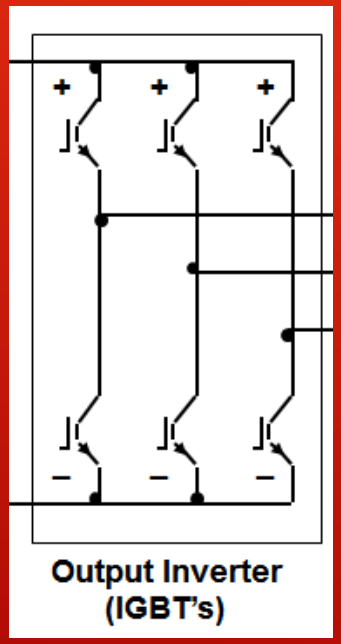


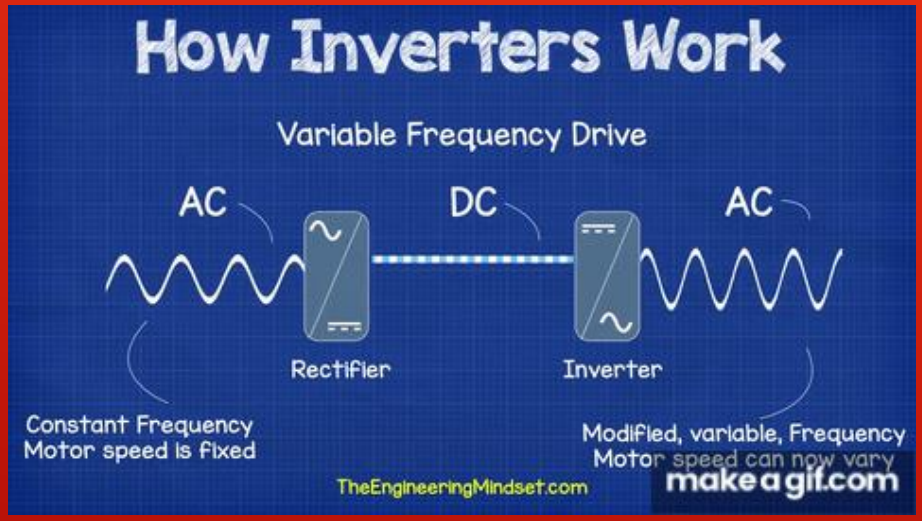
Figure 6. Voltage and Current Waveforms in a Simple Rectifier Circuit

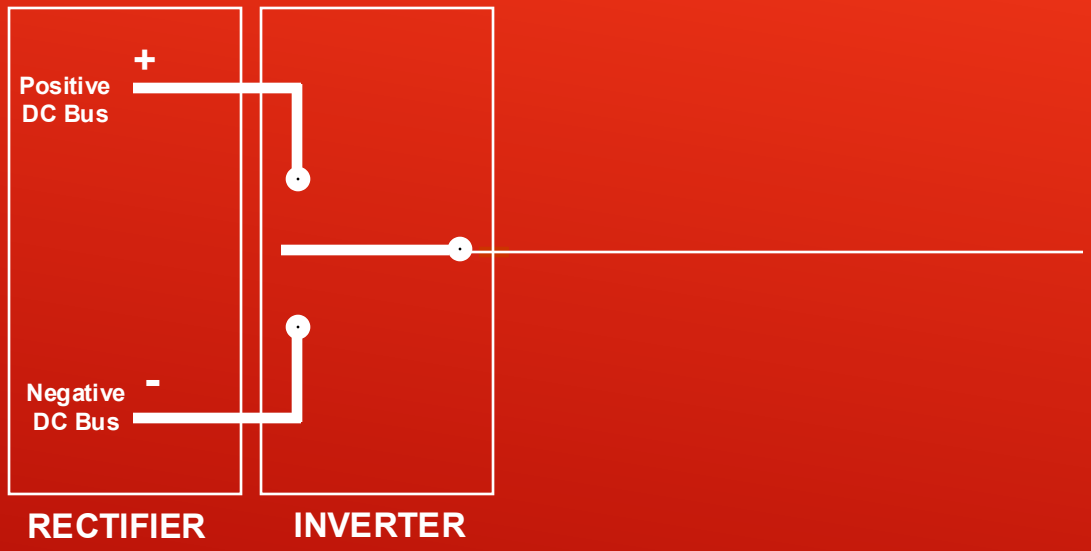
Inverter

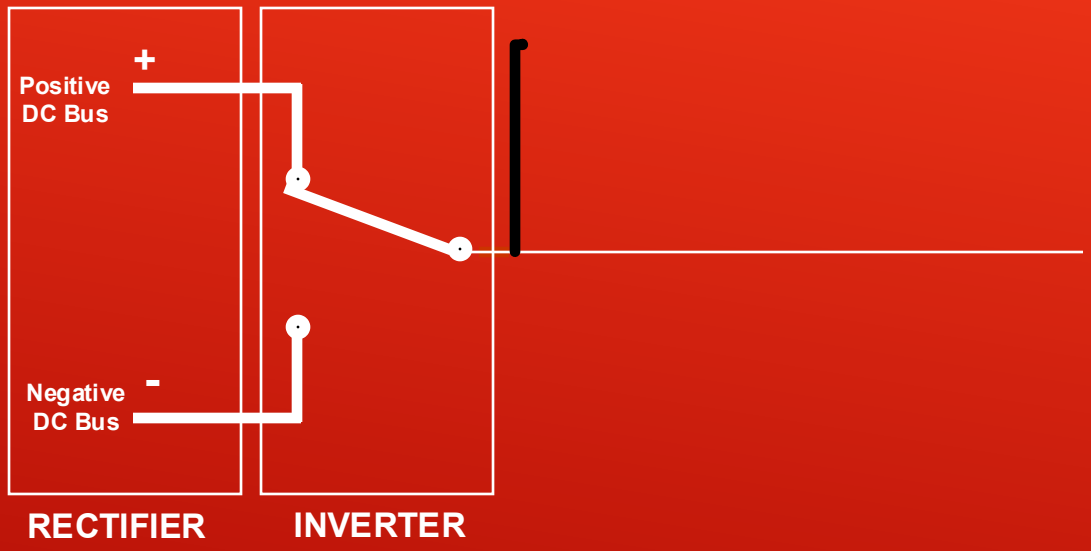
- Converts DC from the bus back into AC at variable frequency.
- Uses 6 Insulated Gate Bipolar Transistors (IGBTs).
- Each IGBT acts like a remote-controlled switch.
- IGBTs are opened and closed rapidly to create AC waveforms.

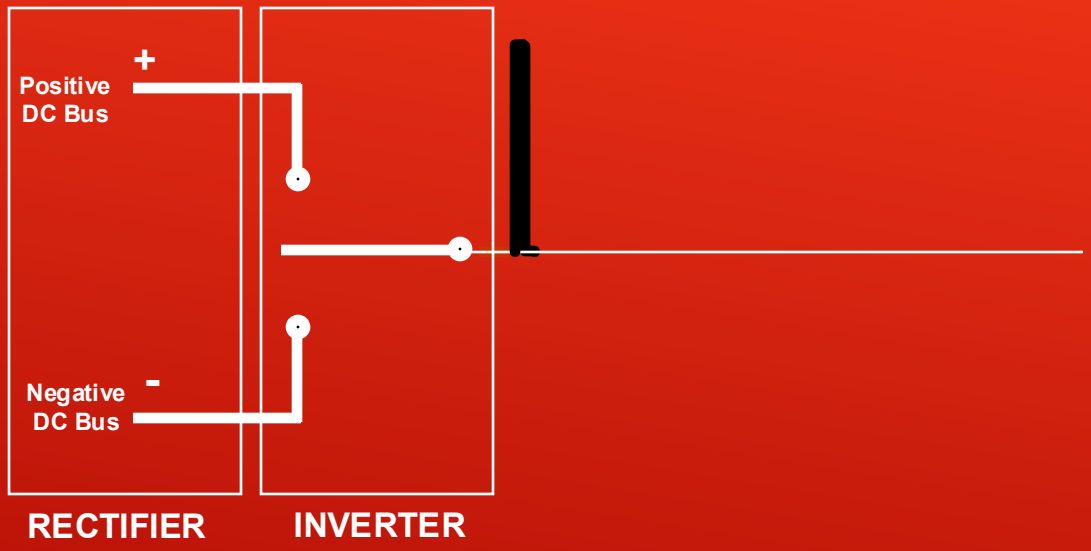


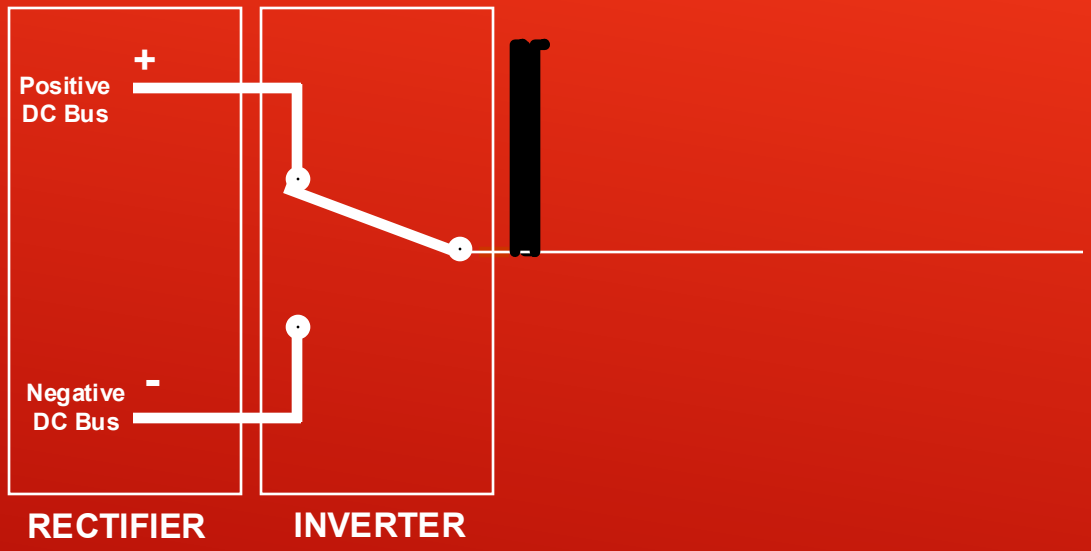


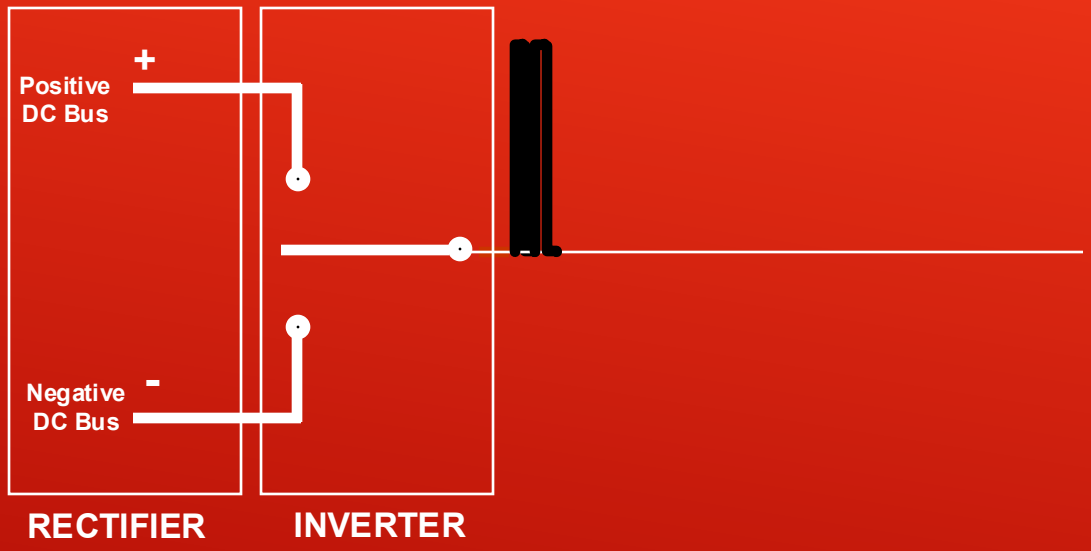


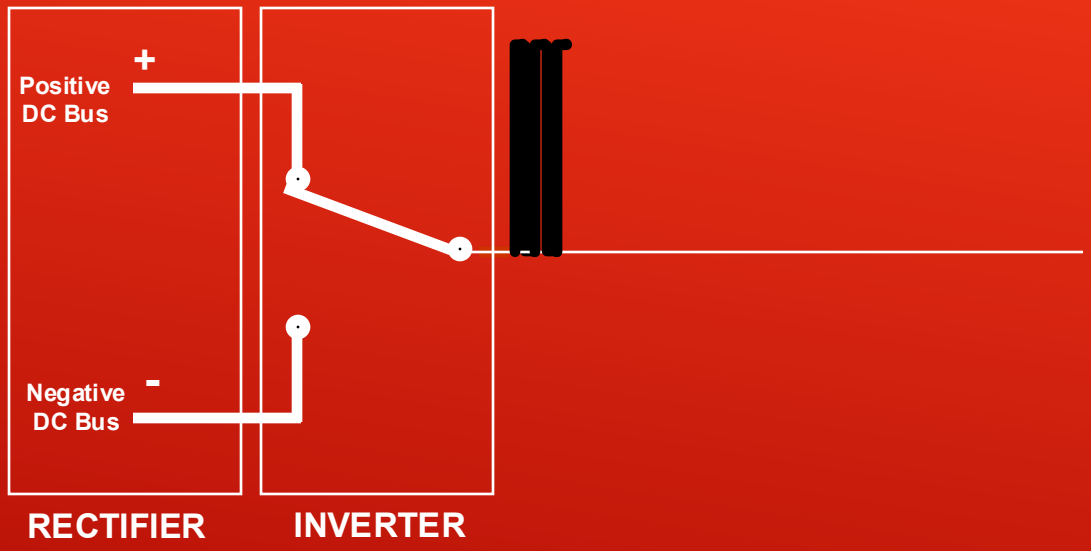

+
Positive
DC Bus
-
Negative
DC Bus
RECTIFIER
INVERTER

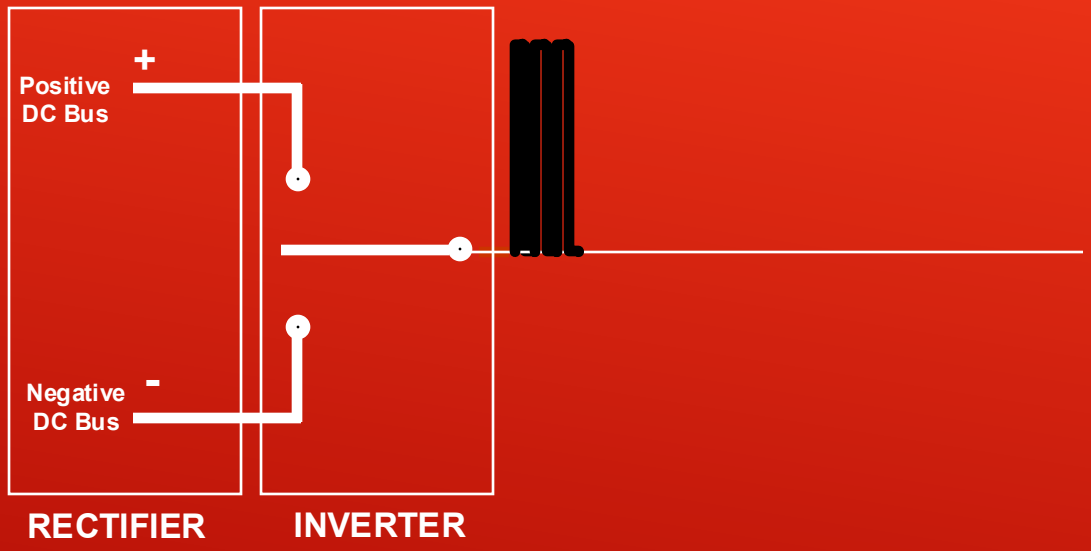

+
Positive
DC Bus
-
Negative
DC Bus
RECTIFIER
INVERTER

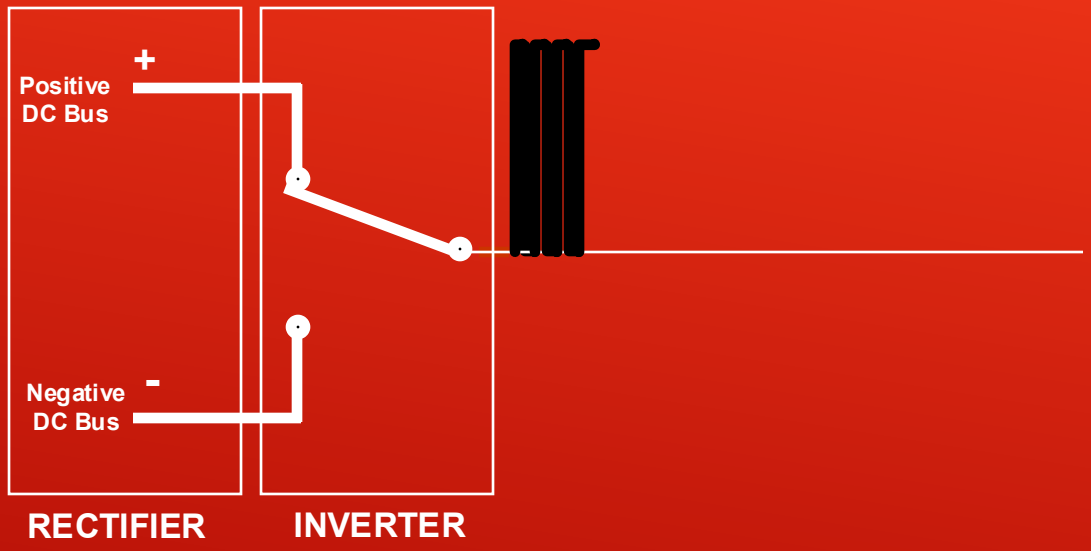

+
Positive
DC Bus
-
Negative
DC Bus
RECTIFIER
INVERTER

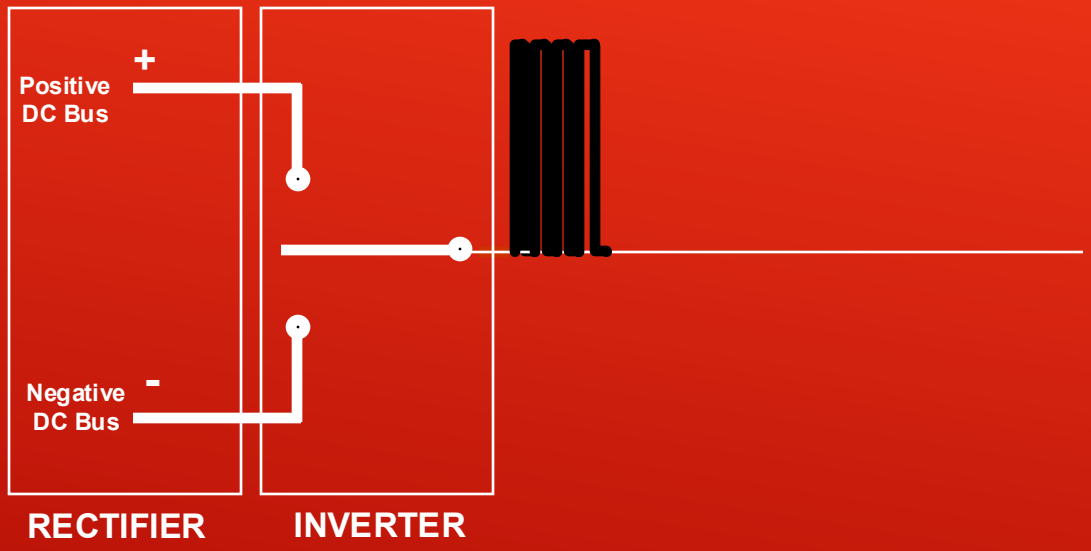

+
Positive
DC Bus
Negative
DC Bus
-
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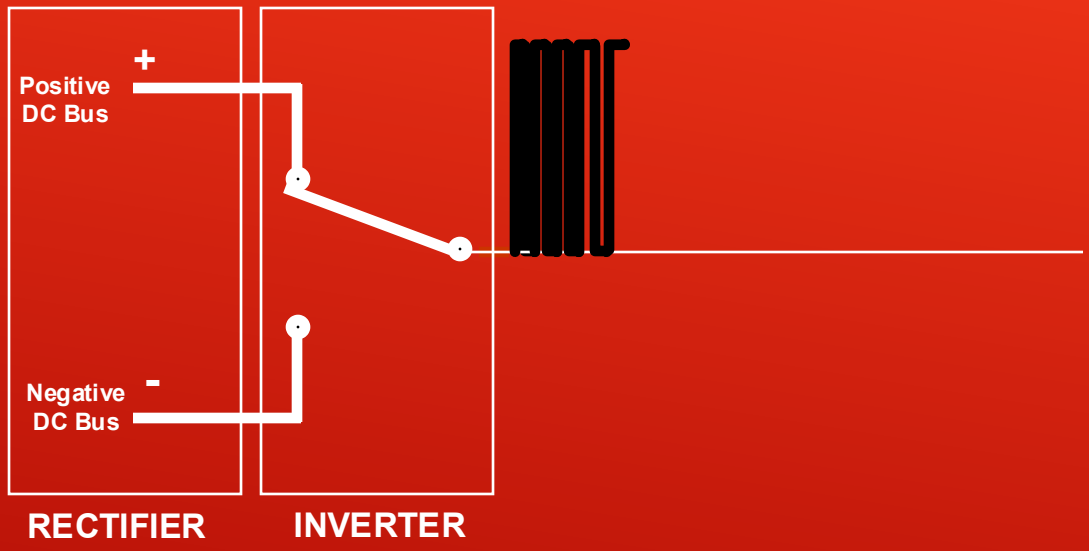

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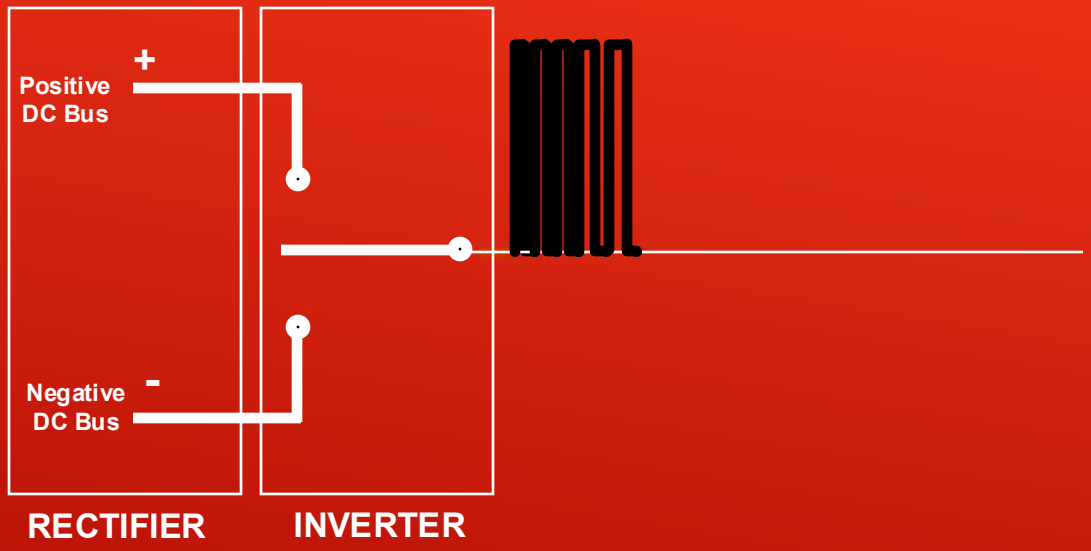

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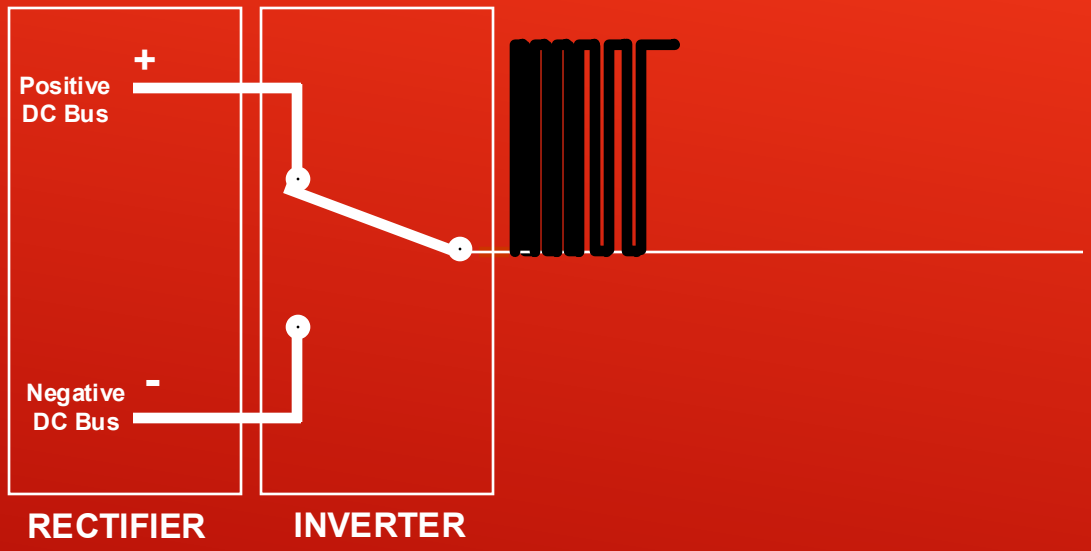

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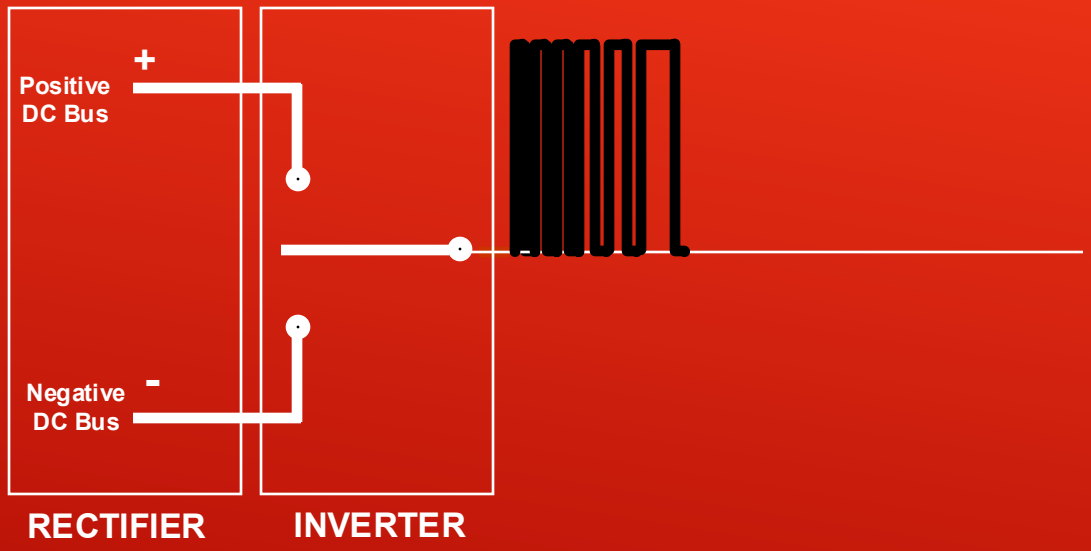

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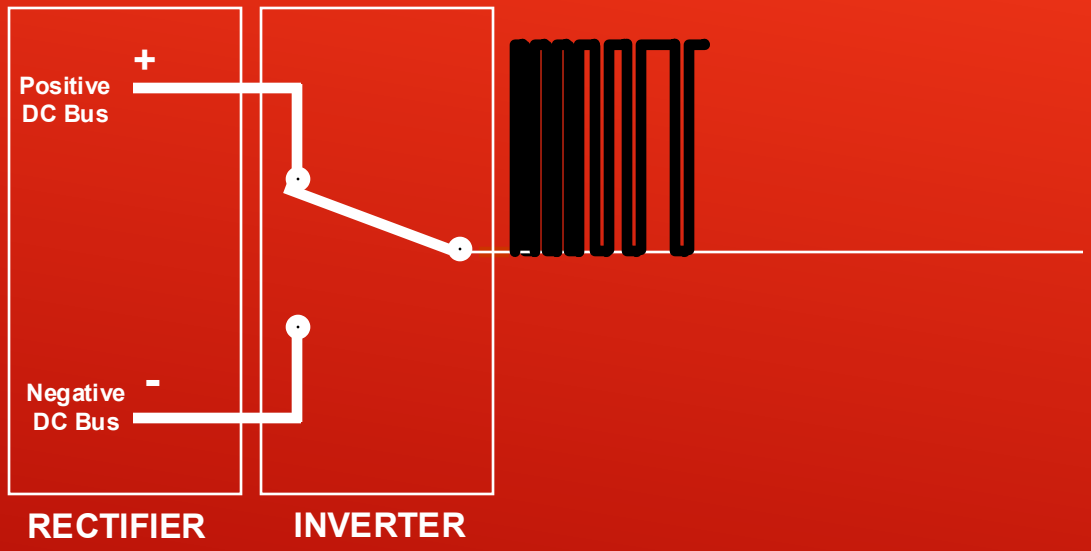

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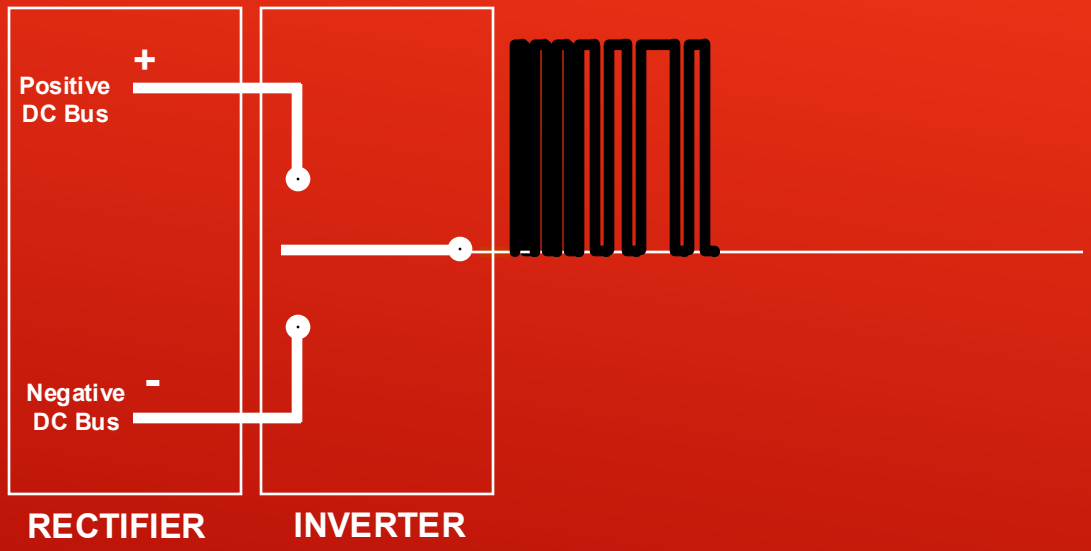

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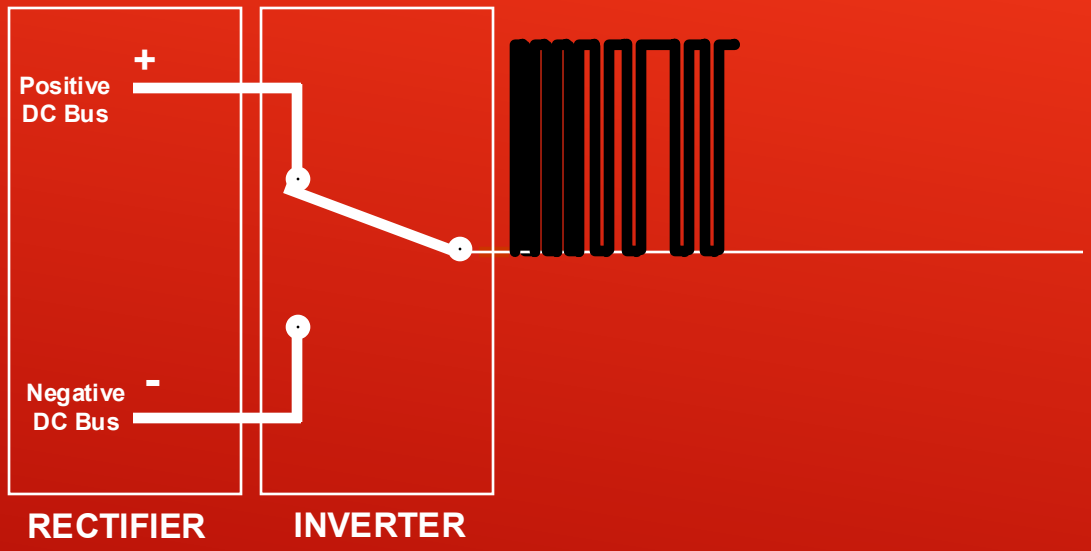

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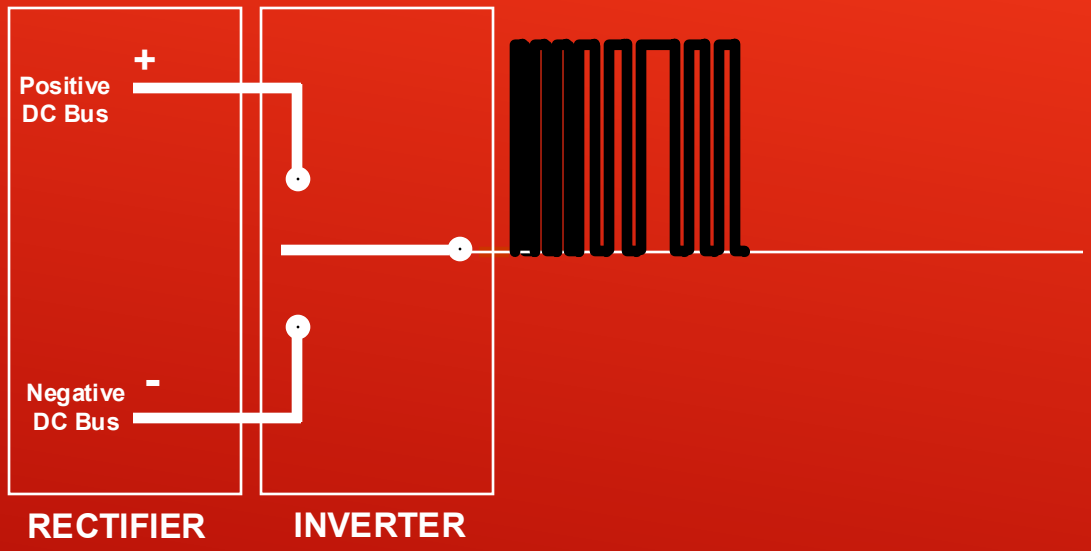

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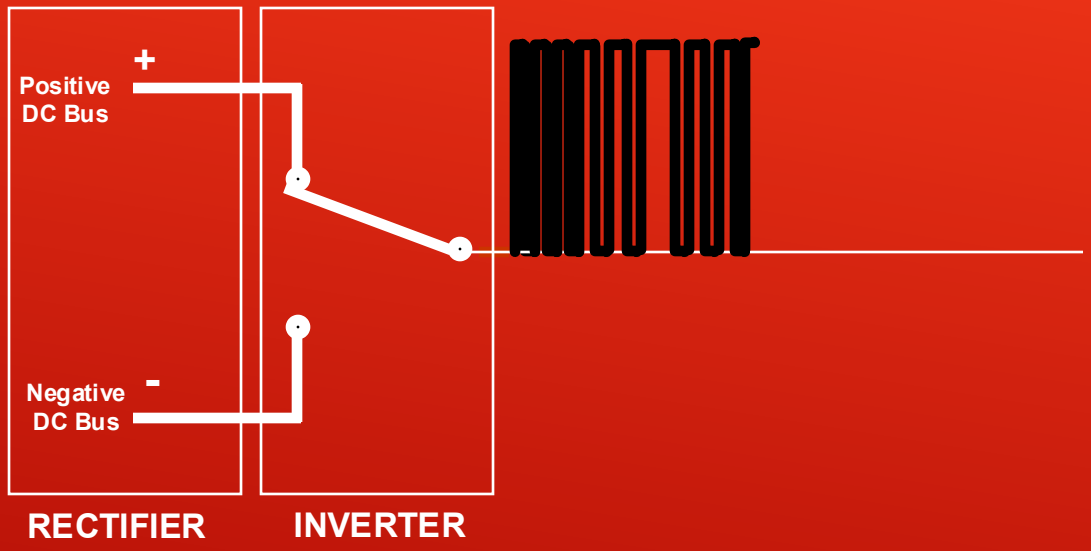

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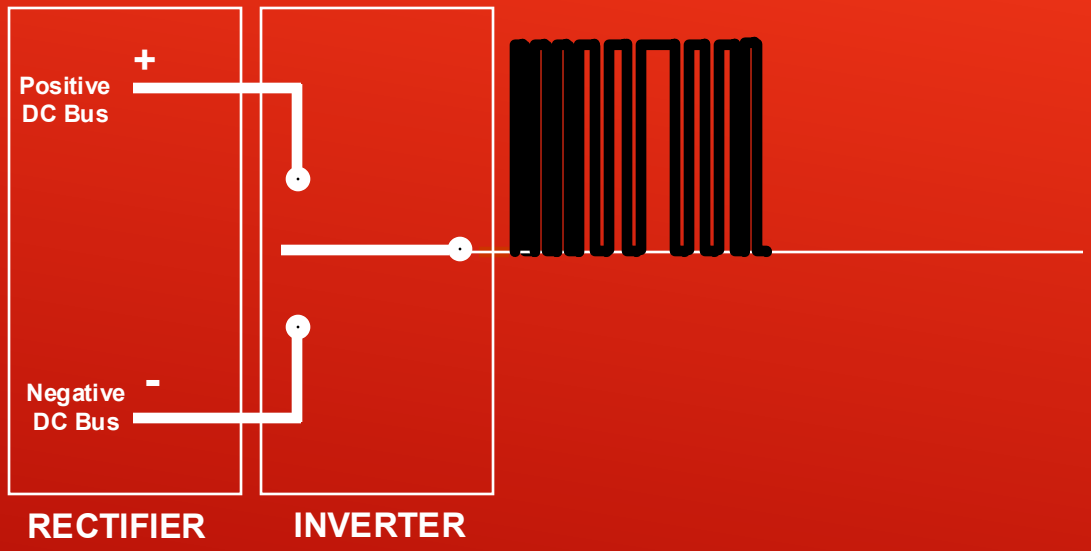

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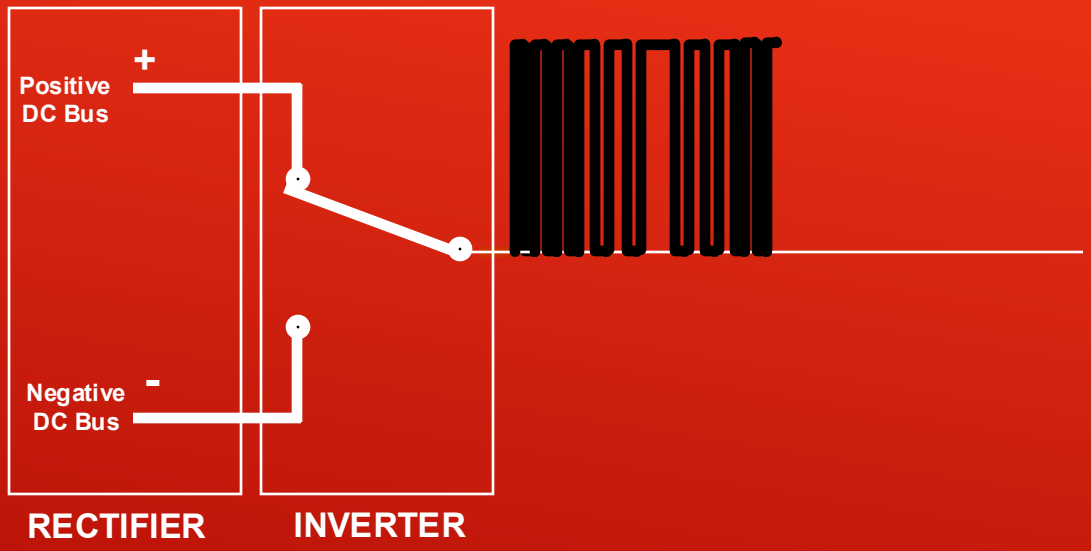

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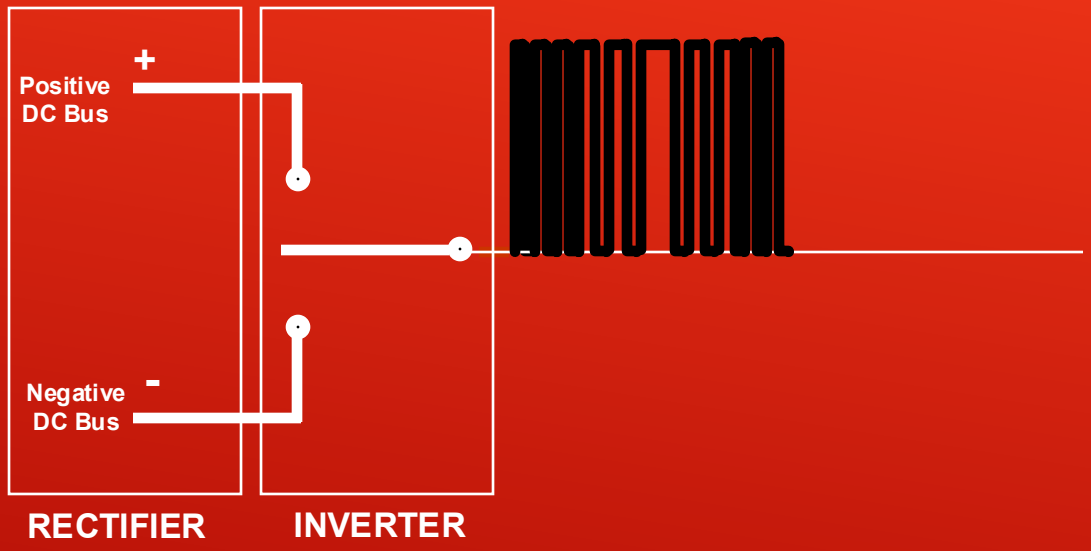

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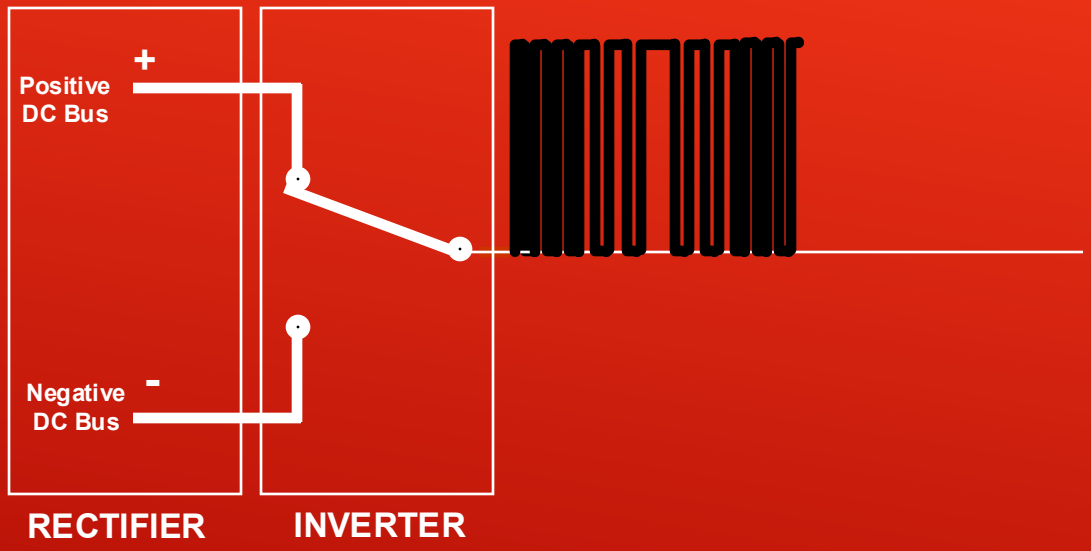

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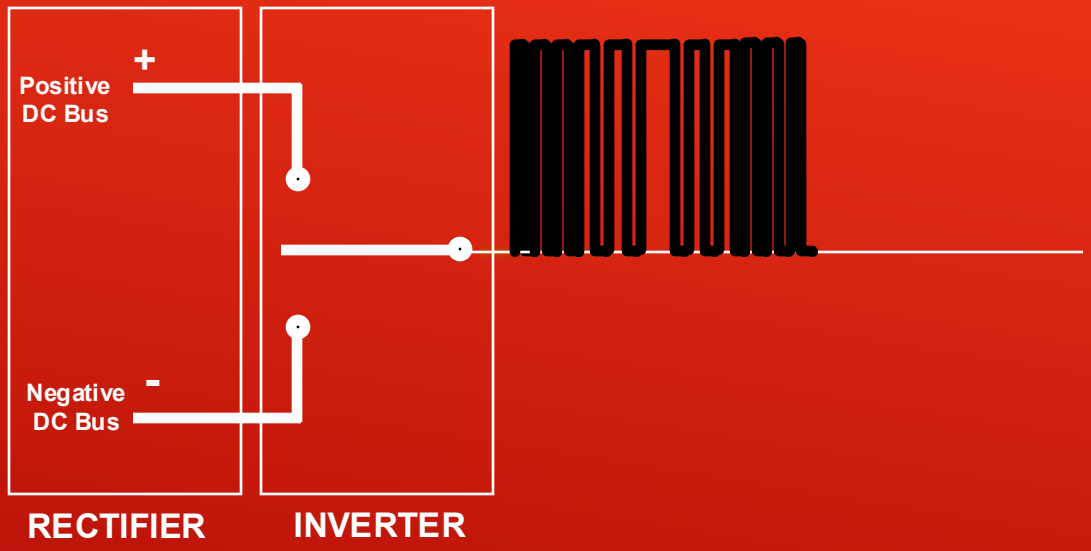

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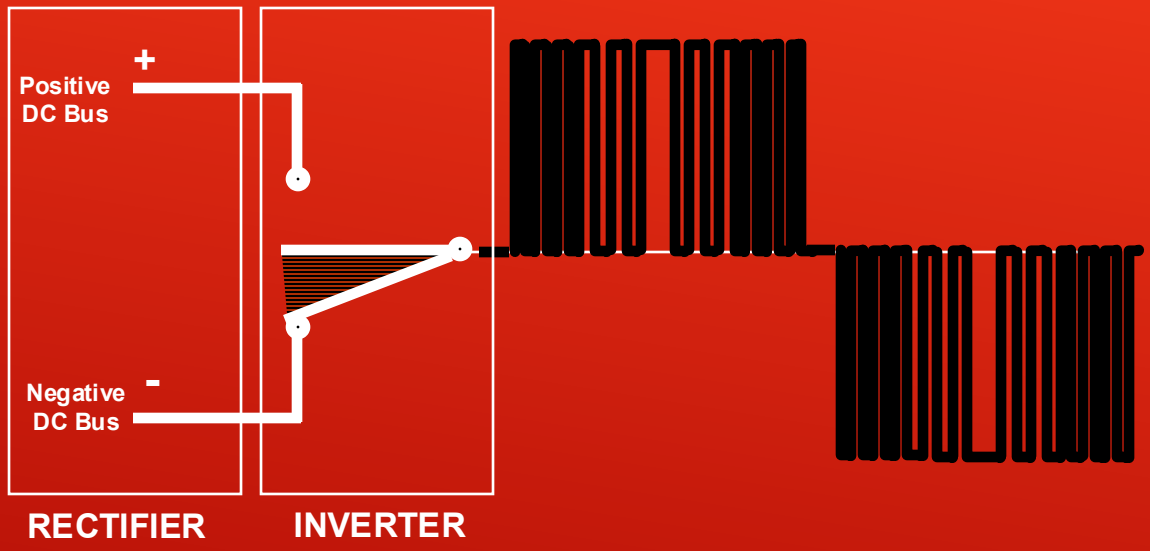

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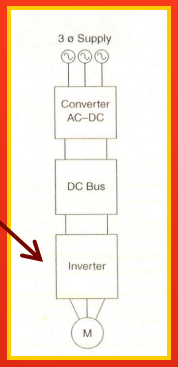

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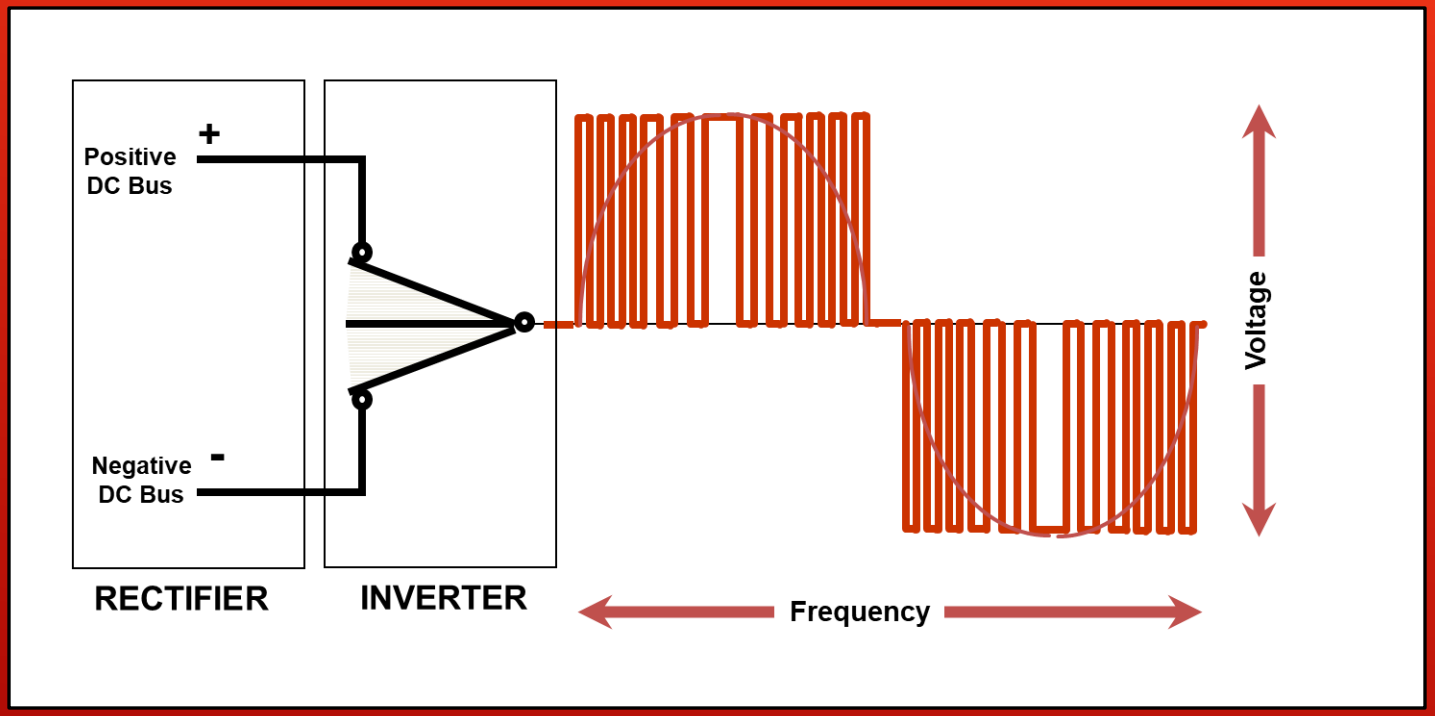

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Wave Summary

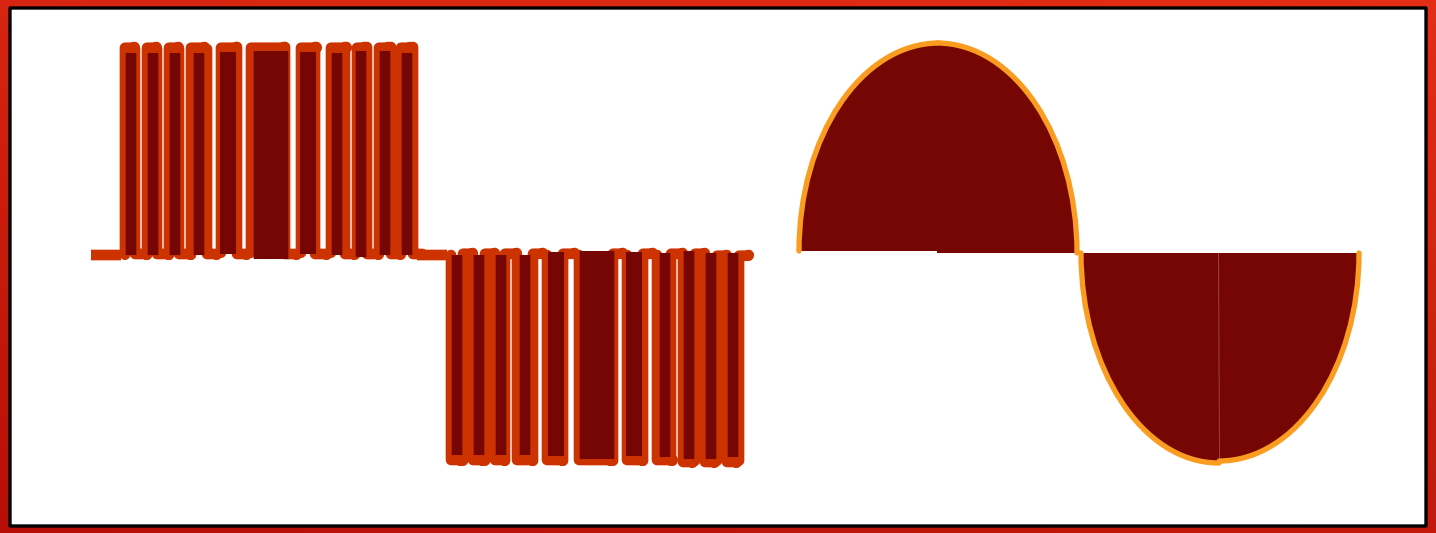
- The area under the square-wave pulses approximates the area under a sine wave.





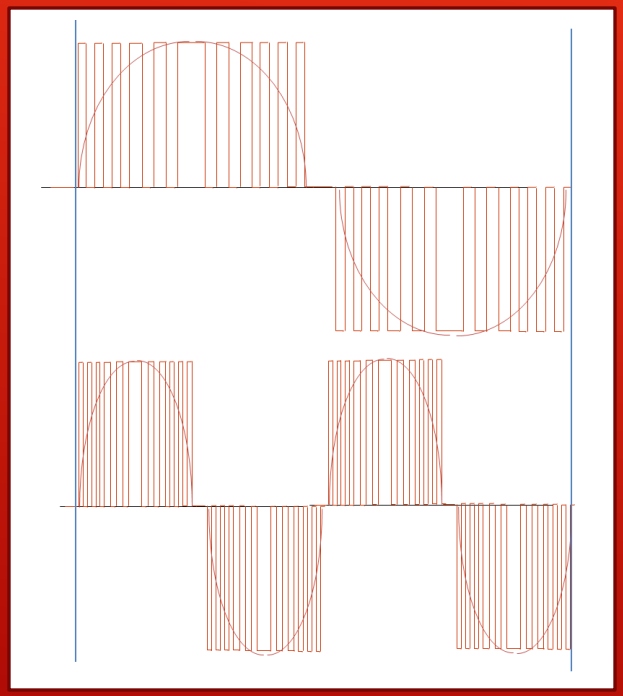
Wave Summary

- The wave pattern on the left that is generated by the VFD is seen by the pump as a smooth wave as seen on the right.



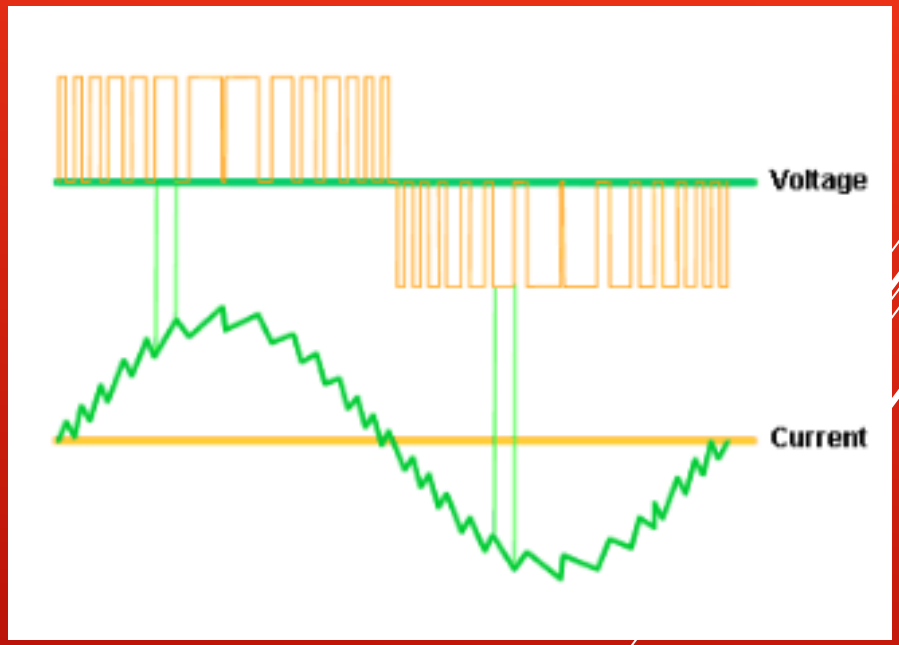
Wave Summary

- How often you switch from positive pulses to negative pulses dictates the frequency output!
- Voltage and Current waveforms of a VFD as viewed on an oscilloscope



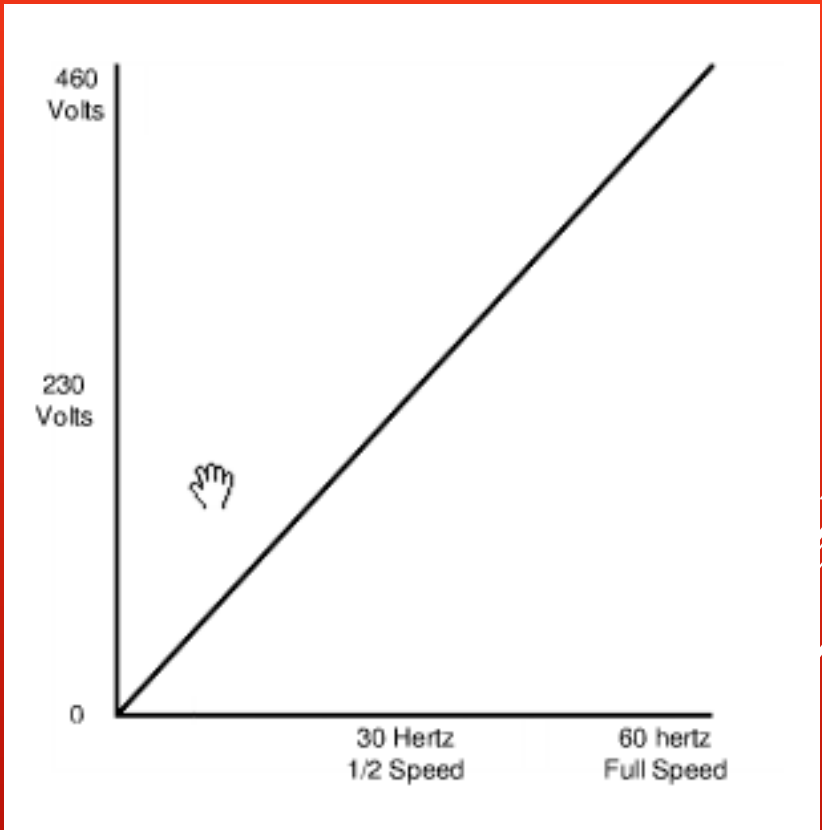
30hz

60hz



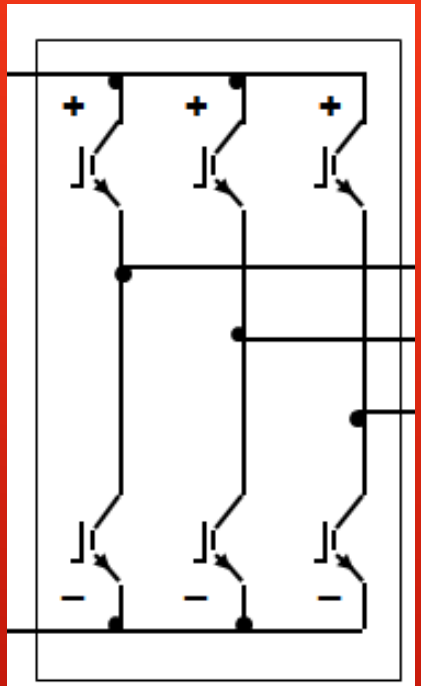
Voltage and Frequency Relationship

- When the frequency applied to the motor is reduced, the applied voltage must also be reduced to limit the current drawn by the motor at the reduced frequency.
- VFDs almost always maintain a constant volts/HZ ratio from 0-60hz as shown by the graph here.
- There are special circumstances where this can vary such as a large fan that might require a low end boost of voltage to get it spinning.



Carrier Frequency

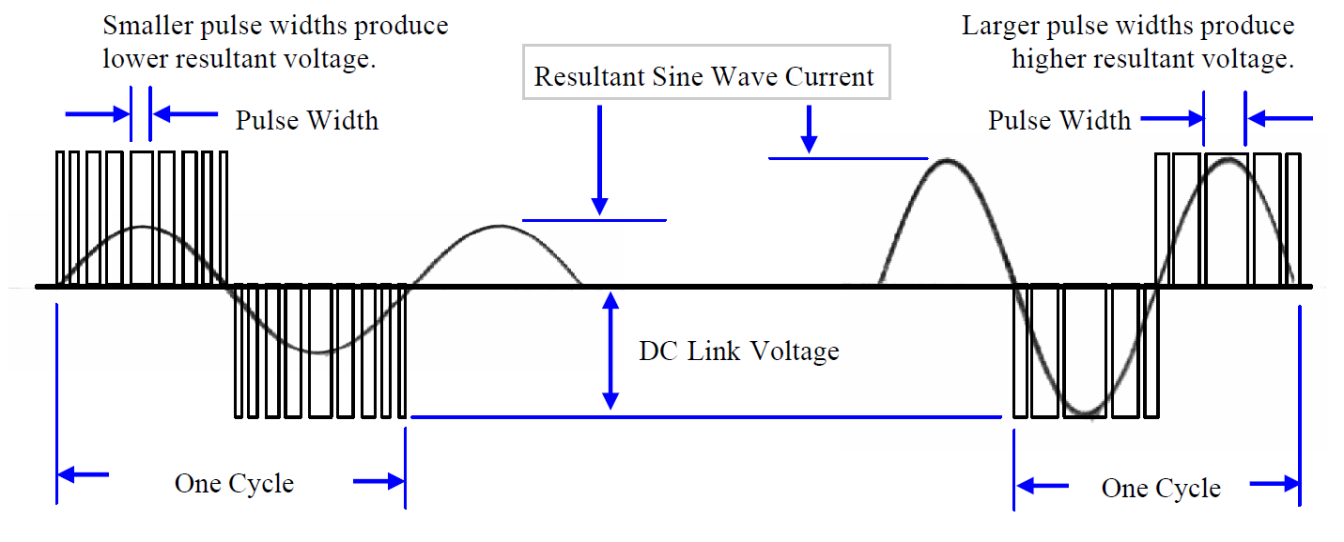
- How fast the switch of the IGBT can be turned on and off is known as the **carrier frequency**.
  - This is usually measured in kHz ranging from 2.5 to 10kHz.
  - Lower Carrier Frequencies…
    - Lower carrier frequencies are better on the motor windings (slower vibrations)
    - Lower carrier frequencies can cause nuisance audible noise in the motor.
  - Higher Carrier Frequencies…
    - Higher carrier frequencies can overheat the VFD.
  - Ultimately, the engineer must find a balance between carrier frequency and noise.

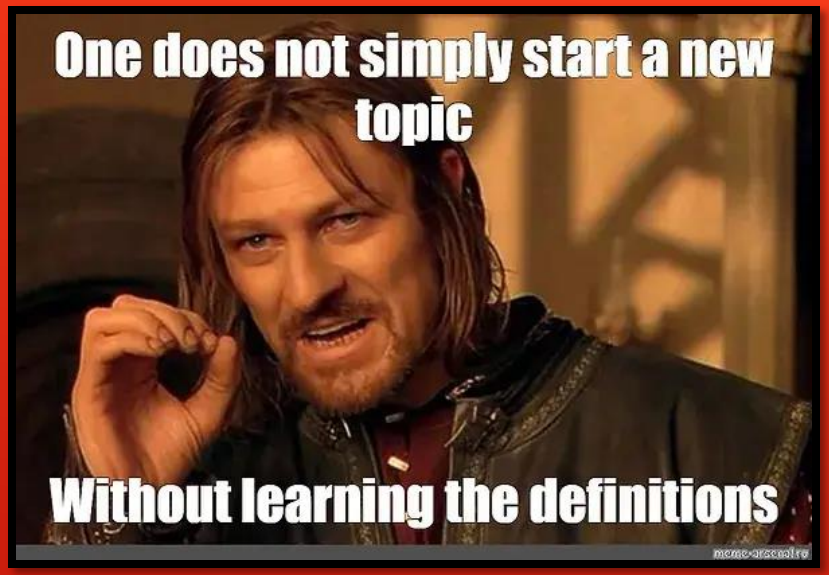


Output Inverter (IGBT's)

Voltage/Hertz Relationship and PWM Review

- The VFD DC Link Voltage is constant.
- Smaller pulse widths produce lower resultant voltage.
- Larger pulse widths produce higher resultant voltage.
- Alternating Current (AC) output is created by reversing the polarity of the voltages.
- How fast this reversing is done determines the frequency.



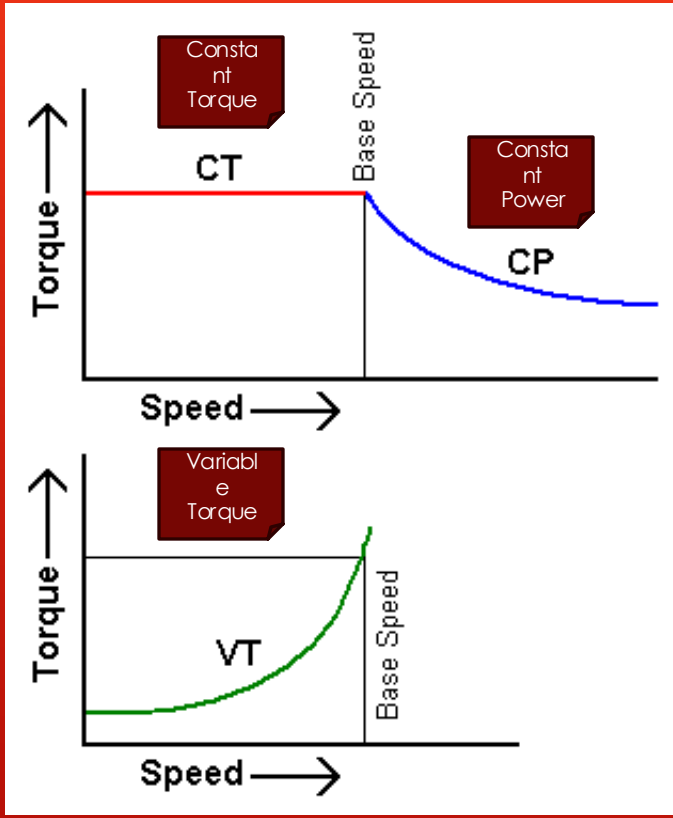


SECTION 2

VFD 102

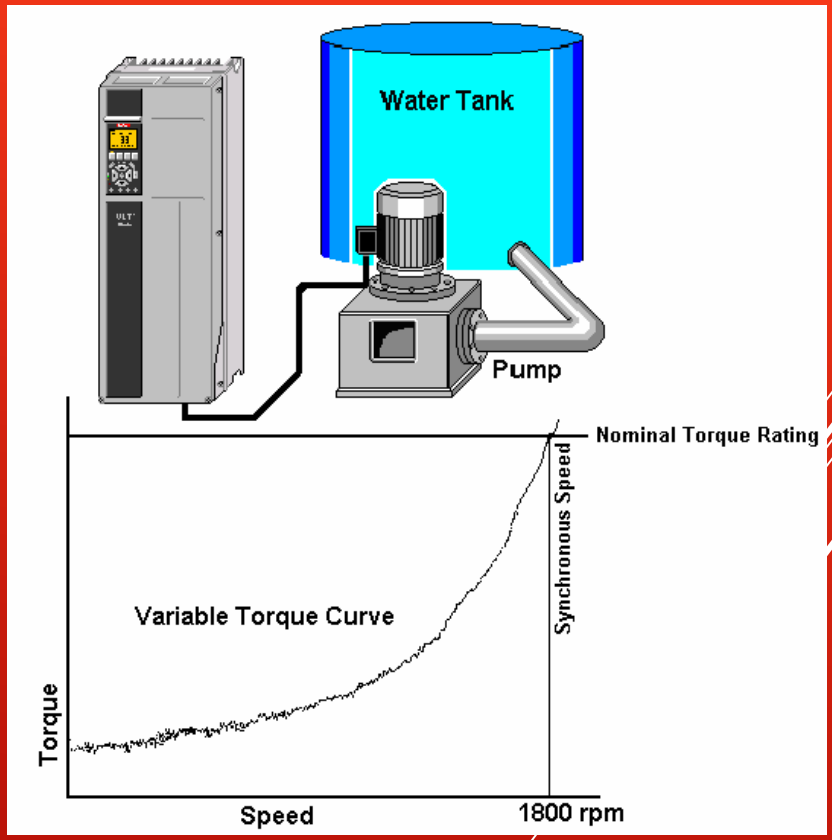
Control Concepts and Key Definitions

Application Torque Curves



Variable Torque

- **Variable Torque** applications require a variable level of torque throughout a process of different speeds.
- Lower Speed = Lower Torque required
  - Pumps
  - Fans



Pump / Fan Affinity Laws

- Flow is proportional to shaft speed.
  - Half the speed = half the flow
- Pressure is proportional to the square of the shaft speed
  - Half the speed = quarter of the head
- Power is proportional to the cube of the shaft speed
  - Half the speed = eighth of the power
- This is where there can be significant cost savings with VFDs!

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2} = \frac{D_1}{D_2}$$

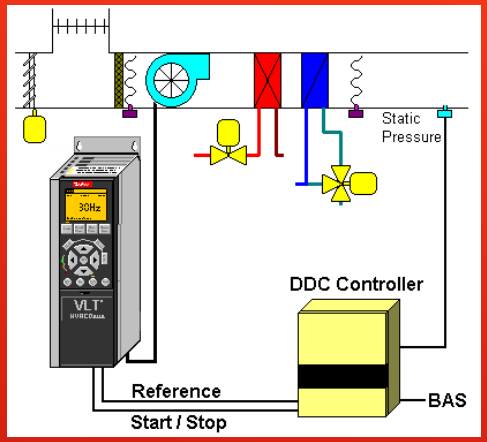
$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2 = \left(\frac{D_1}{D_2}\right)^2$$

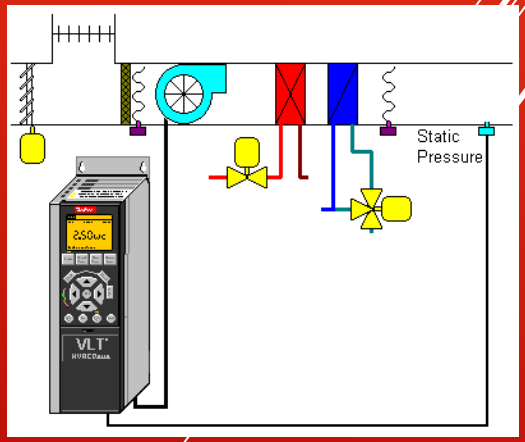
$$\frac{HP_1}{HP_2} = \left(\frac{N_1}{N_2}\right)^3 = \left(\frac{D_1}{D_2}\right)^3$$

Where: Q = Flow, in m^3/hr or GPM
N = Speed, RPM
H = Head in m-kg force/kg mass or ft-lb force/lb mass
Hp = Power in kW or BHP
D = Impeller diameter in mm or inches

Open Loop vs. Closed Loop

- Open Loop
  - The Building Automation System (BAS) or DDC controller sends a speed reference signal (e.g., 0–10 V or 4–20 mA) to the VFD.
  - The VFD adjusts motor speed based only on the reference, without feedback from the system.
  - Simpler setup but less responsive to real-time changes in pressure or flow.
  - Common in systems where the BAS handles all PID logic.
- Closed Loop
  - The VFD receives direct feedback from a pressure or flow sensor.
  - The drive performs its own PID control to maintain the setpoint.
  - More responsive and self-correcting — the drive continuously adjusts speed to match actual system demand.
  - Reduces reliance on BAS and simplifies tuning for pressure-based systems.





Control Action

Normal Control (Reverse Acting)

As the incoming signal increases, the output speed decreases.

- Think of a pressure booster system…
- When the pressure of the system exceeds setpoint, the pump will slow down to bring down the system pressure.

Inverse Control (Direct Acting)

As the incoming signal increases, the output speed increases.

- Think of a chilled water system with ice injection…
- When temp of chilled water supply rises above setpoint, the speed of the injection pump will increase to bring in more ice water and decrease system supply temp.

Control Signals

Analog Signal

Varying signal like a volume knob or dimmer switch usually 0-10Vdc or 4-20mA signal.

- Analog Input (AI) – (VFD is listening)
  - Tells the VFD what speed to run at.
- Analog Output (AO) – (VFD is talking)
  - Tells the BMS what speed the VFD is operating at.

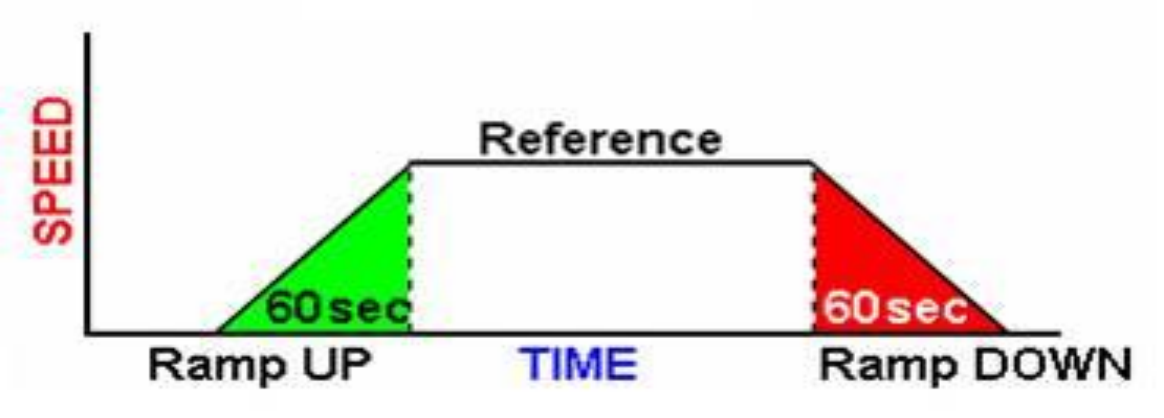
Digital Signal

On or off signal (like a standard light switch)

- Digital Input (DI) – (VFD is listening)
  - Start the VFD from the BMS.
- Digital Output (DO) – (VFD is talking)
  - VFD closes a switch and tells the BMS the VFD is operating.

Reference – Acceleration and Deceleration Times

- Reference is the speed that the VFD wants to operate at currently.
- Ramp up times must be fast enough to respond to the system, but not too fast to overload the drive. Remember, large fans can take a minute to get to full speed without overloading the VFD current limit setting.
- Ramp down time must be fast enough to respond to the system, but not too fast to prevent high DC bus faults. A motor connected to high inertia loads actually act like a generator and feed power back into the DC bus and cause nuisance faults.



Critical Frequency

- Mechanical Resonance
  - Tendency of a mechanical system to respond at a greater amplitude when the frequency of its oscillations matches the system's natural frequency of vibration than it does at other frequencies.
    - Singer with the wine glass
    - Galloping Gertie – Tacoma Narrows Bridge Collapse
- Pumps and Fans have the same natural critical frequencies!
  - The VFD can be programmed to skip over these frequencies to avoid prolonged operation at these natural frequencies to avoid catastrophic failure of system components.





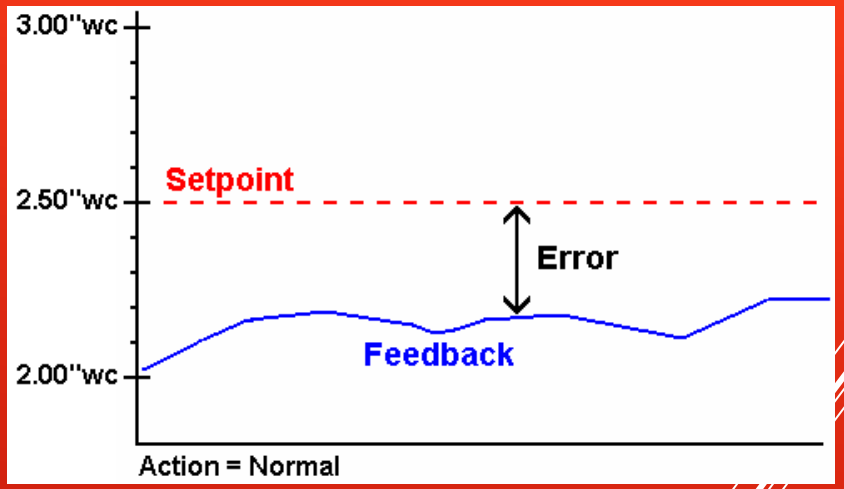
Limits & Safeties

- Minimum / Maximum Speed
  - For pumps, this is going to be approximately 30% to 100% of the speed for the motor (18Hz – 60Hz)
  - For fans, this can be lower if the motor is enclosed in fan housing.
- Current
  - VFD acts as Electronic Thermal Overload
- Phase to Phase & Ground Fault Protection
  - Monitors each output leg to motor
- Heat
  - VFDs create heat; need a heatsink or fans to cool.
- Voltage
  - Spikes in incoming voltage can damage or cause low or high DC Bus faults.



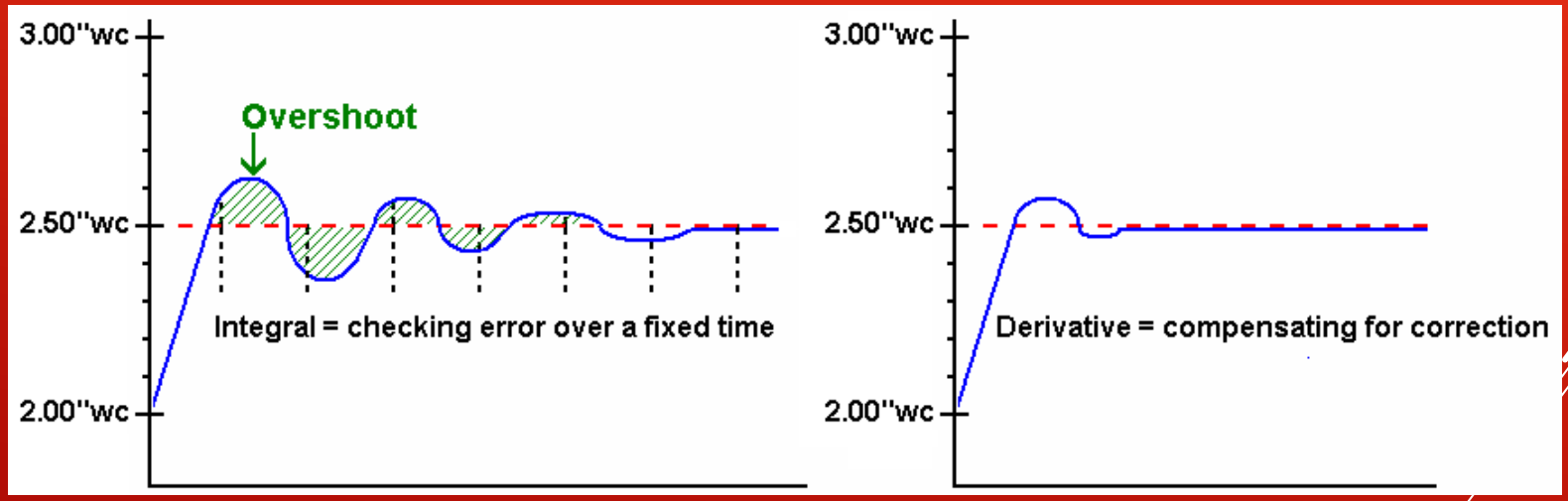
Setpoint, Error, and Proportional Gain

- Setpoint, or reference, is the desired value for a controlled variable; for example 2.5" wc
- Error, or offset, is the amount of feedback or process variable is from setpoint at any given time; for example, .35" wc
- Proportional Gain (P) is a multiplier times the error or offset.
  - Too low of a P will result in the system never reaching setpoint.
  - Too high of a P will result in the system going from way too high to way too low and oscillating or hunting.



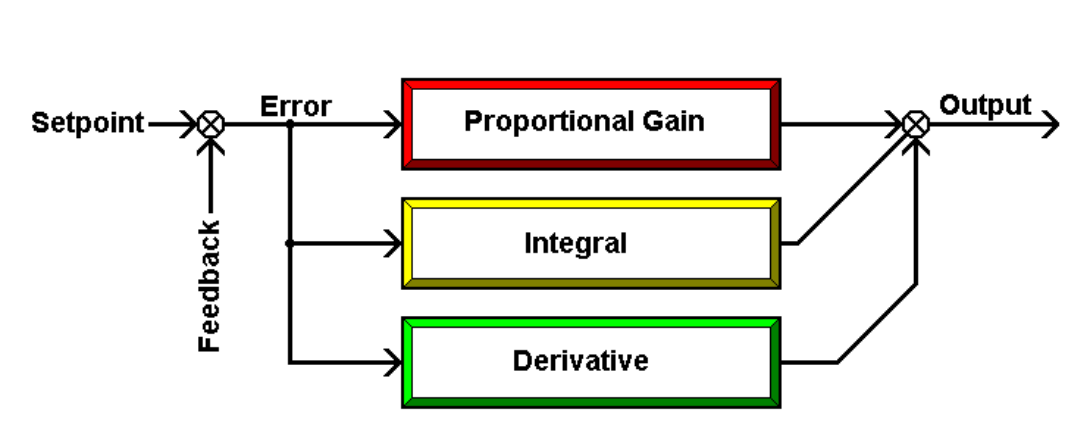
Integral & Derivative

- Integral checks the offset over a period of time and makes corrections.
  - Looks at the past history of the error to determine what to output.
  - Eliminates the steady state error of P only control.
- Derivative checks the offset and corrects for the speed of the integral correction.
  - Rate of change correction
    - Faster rate of change from setpoint requires a quicker response.
    - Slower rate of change from setpoint requires a slow response.



PID

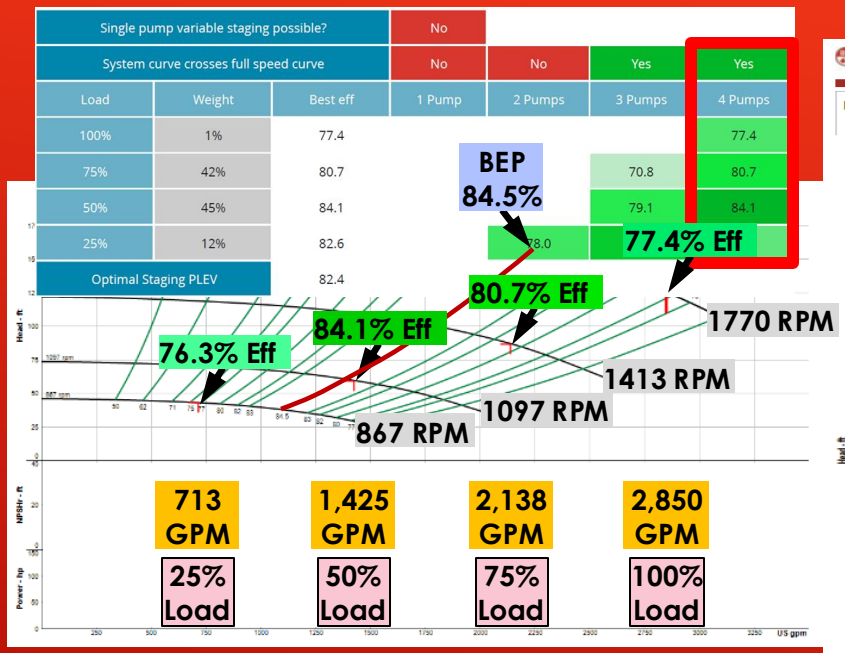
- Summary: Think of PID as a cruise control for the VFD. Your car knows when it is over the set speed and slows down, and also knows when it is going slower than the set speed and speeds up.
  - Cruise Control and a VFD contain these three features:
    - Proportional Gain
    - Integral
    - Derivative
  - The ways these terms are combined may be different.



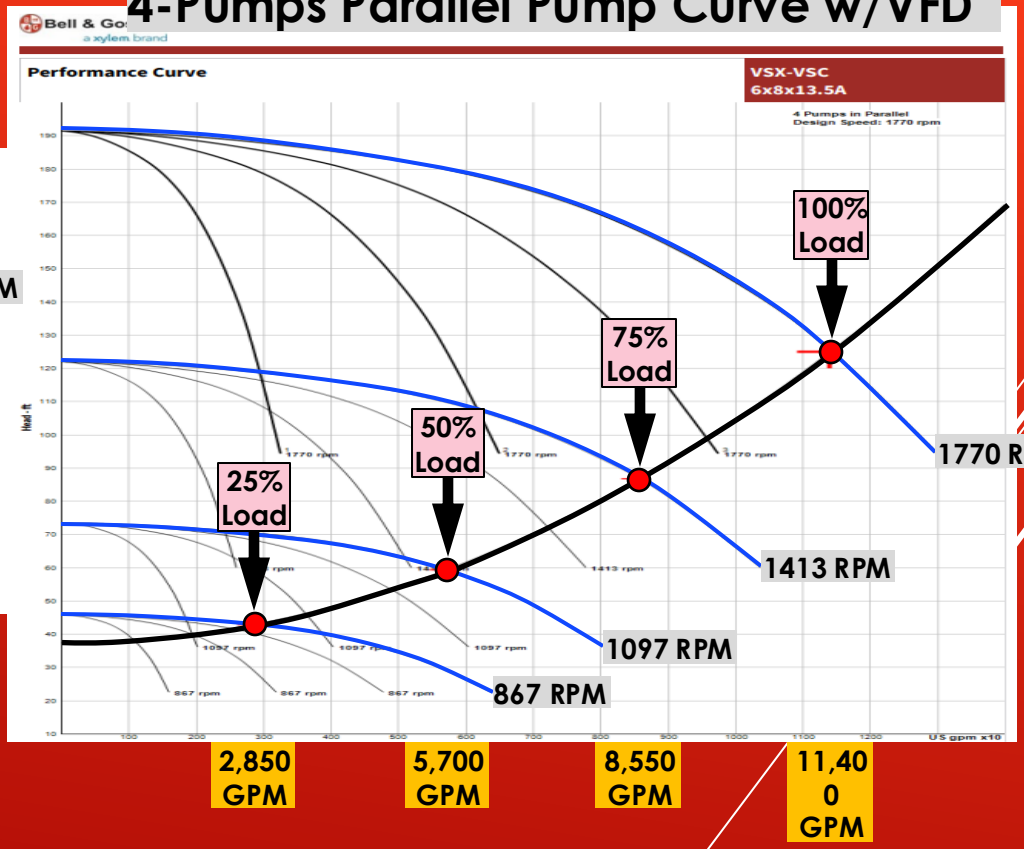
Some Other Benefits of VFDs

- System Stress Reduction
  - Hydraulic
    - Slow start and stop reduces water hammer in system.
  - Electrical
    - Normal across the line starting current (inrush) of a motor is 500-700% of its normal operating current which can cause dimming of lights or surrounding equipment issues and breaker trips.
      - Slow start reduces this to a non issue.
  - Mechanical
    - Typical motor connected across the line accelerates to full synchronous speed in less than two seconds. This creates additional radial loads on the pump shaft and bearings.
      - Slow start reduces these radial loads.
- Single Phase to Three Phase Conversion
  - Using single phase input to the VFD rectifier section allows use of variable speed applications where only single phase power exists
    - Need to upsize VFD to twice the HP – for example, using a 5hp three phase motor will require a 10hp VFD. This is due to the single phase input has to supply all of the power (input current) to the DC bus so the output section can drive the 5HP three phase motor.
    - The input power supply to the VFD would also have to be sized for 10hp current draw.
    - Danfoss offers this as an option, but it does shorten the life of the DC bus capacitors as they have to work harder to make smooth DC power.

Parallel Pumping



Single Pump Curve w/VFD





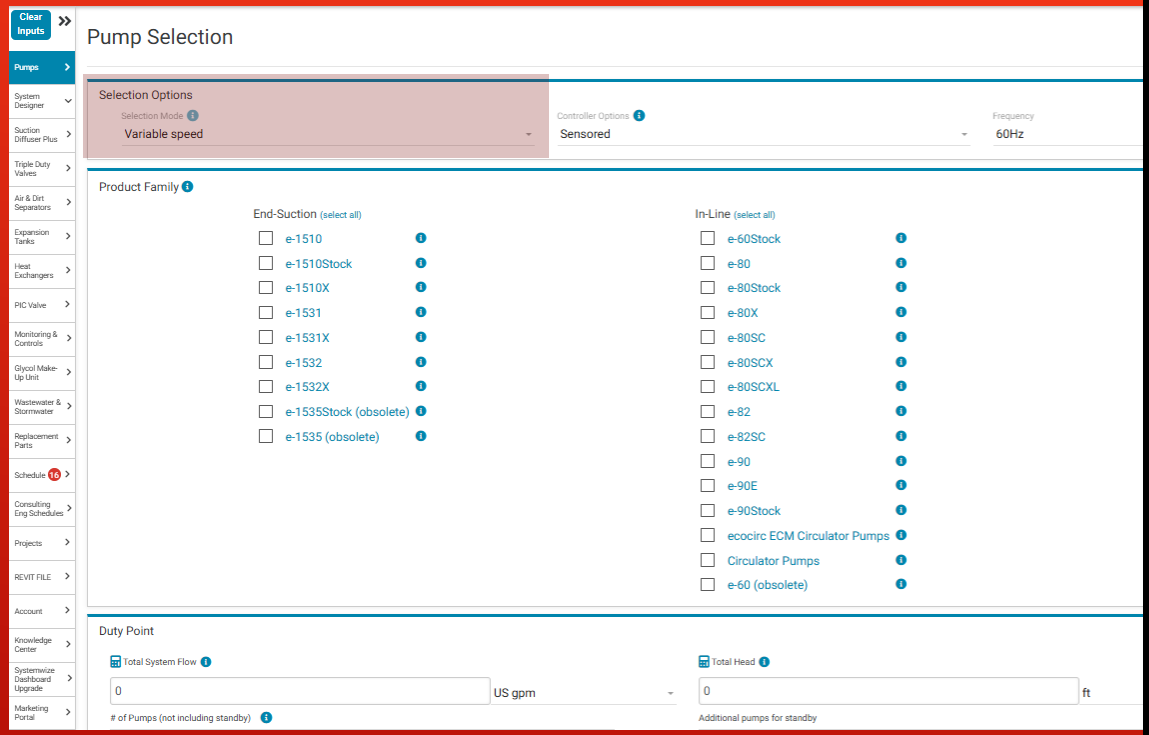
SECTION 3

Bell & Gossett Specific Selection Notes

Selection Notes: Should I Specify the Largest Impeller?

- When specifying a hydronic pump to operate with a VFD, consider selecting the maximum impeller diameter that is non-overloading across the full variable-speed curve.
- Example: A pump originally selected at 650 GPM and 55 ft head at full speed (11 HP, 8.625" impeller) was re-evaluated under variable speed and found that a 9.25" impeller at 1606 RPM achieved the same flow & head with slightly improved efficiency (~85.3% vs 84.7%).
- Benefits of using the larger impeller with variable speed:
  - Slight increase in efficiency (~0.5%) at no additional cost.
  - Built-in extra capacity (head/flow margin) if system demands increase in future.
  - Consistent pump curve representation aligns with VFD operation for better coordination.
- Specification recommendations:
  - Use a variable-speed selection tool (e.g., manufacturer's software) when choosing the pump.
  - Specify the largest impeller diameter that remains non-overloading at VFD speeds.
  - Add a "pump speed at design" column in the schedule alongside motor speed to aid commissioning/maintenance.
  - Include a note on the schedule such as: "Pump designed to operate as variable speed. Provide maximum impeller diameter that is non-overloading for the scheduled motor horsepower."
- Key takeaway: While the efficiency gain may be modest, specifying the largest non-overloading impeller in a VFD application provides improved performance, future flexibility, and alignment with variable-speed operation — for no extra up-front cost.

Selection Notes: Selection Options



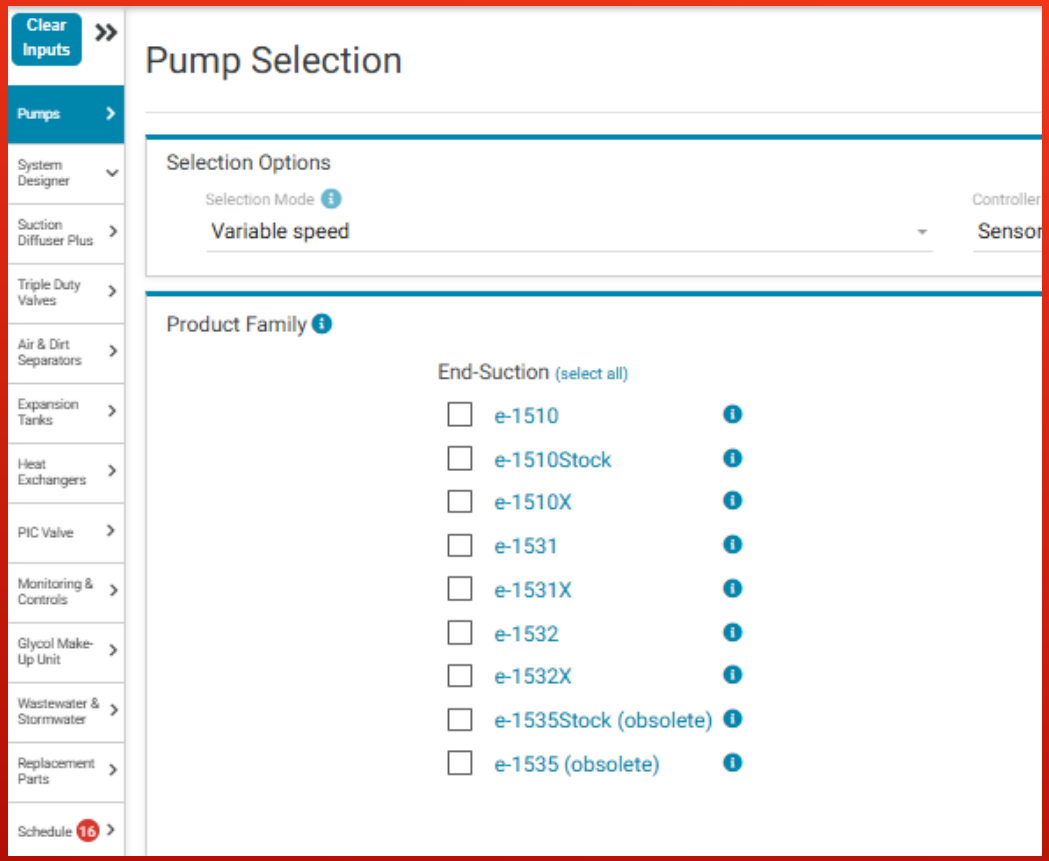
Selection Modes

Constant speed: Classic pump selection criteria using flow and head to select a pump model and appropriate impeller trim to meet duty point. When sorting by Best Efficiency Point you can compare pump efficiencies for each model operating at motor nameplate RPM. A variable frequency drive may or may not be applied to this pump in the field.

Variable speed: Enhanced pump selection where a variable frequency drive is assumed to be applied to the pump. The software will select the largest impeller trim available for the selected motor in order to maximize duty point and part load efficiencies. When sorting by Best Efficiency Point you will compare pump efficiencies for each model at the designated operating RPM. However, by sorting by Part Load Efficiency Value you will get a better understanding of the overall efficiency of the pump along the system curve as demand varies. Selecting Variable Speed allows the user to further select Sensored or Sensorless control. Variable Speed also enables the Overspeed feature. A Control Head value will be pre-populated at 40% of design head for sensorless operation and 30% of design head for sensored operation. Operating Costs are available to quantity the energy cost savings of the different control modes.

All pumps in product family at BEP head and flow Pump selection where constant speed selection options are displayed for all models in the chosen product family at maximum trim and best efficiency head and flow. The list can be limited by selecting specific motor speeds in the motor setting section. Utilize the column sorting function to sort by pump size, flow, horsepower, etc. to find the model you are looking for. You can utilize the actions column for quick access to documentation for each pump, or select a row for a full view of model performance information.

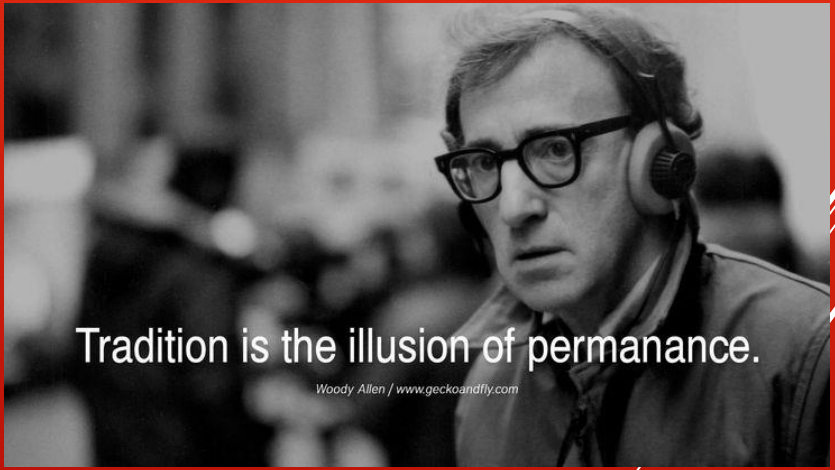
Selection Notes: Selection Options



Bell & Gossett Standard Pump + Wall Mounted VFD

- Benefits
  - Easy for direct replacement projects
  - Tradition!
- Drawbacks
  - Requires costly wall space in a mechanical room.
  - Two separate submittals for pump and VFD; potential confusion with the electrical engineer.





Bell & Gossett New e-1510x Smart Pump



Bell & Gossett New e-1510x Smart Pump

Six standard features of Series



True back pullout

Ease in service is assured, while piping and motor remain undisturbed. Extended delays for repairs are virtually eliminated.



Solid-foot mounted Volute

All Series e-1510X Smart Pumps are provided as standard with an integrally cast volute foot located directly beneath the pump volute. This integrally cast foot ensures that the alignment between the volute and motor assembly is maintained.



Center drop-out spacer coupling

Spacer Coupling
Unlike conventional jaw type or rigid style couplings, a center drop-out spacer coupling allows removal of the bearing frame and rotating element without disturbing the pump end pipe alignment or motor electrical connections.



Stainless steel impellers

e-1510X impellers are precision cast stainless steel providing extremely smooth surface finishes and tight dimensional tolerances to further yield higher efficiencies. Stainless steel impellers are also more resilient than bronze impellers, providing owners with longer lasting maximum efficiency levels.



OSHA-compliant coupling guard

The coupler guard complies with OSHA 1910.219. The guard offers increased protection against potential injuries and is standard on all e-1510X Smart Pumps. The guards include slotted viewing windows for easy inspection.

Internally self-flushing mechanical seal

This standard feature ensures maximum seal face lubrication, heat dissipation and debris removal without vulnerable, external flush tubing.

Bell & Gossett New e-1510x Smart Pump



Separate quick connect components allow users to replace the drive or the motor independently. The integrated electrical socket requires no additional wiring, allowing a true plug and play solution versus buying a new motor and drive combination.



Bell & Gossett Hydrovar X Options



FROM 0 TO 60HZ: THE BASICS OF VFDS

Nick Tabar, PE, MBA, CPD
R. L. Deppmann | Northern Ohio Sales Engineer
ASPE Region 2 AYP Liaison
NOSHE YP Co-Chair

C: (440) 409-5676
E: ntabar@deppmann.com

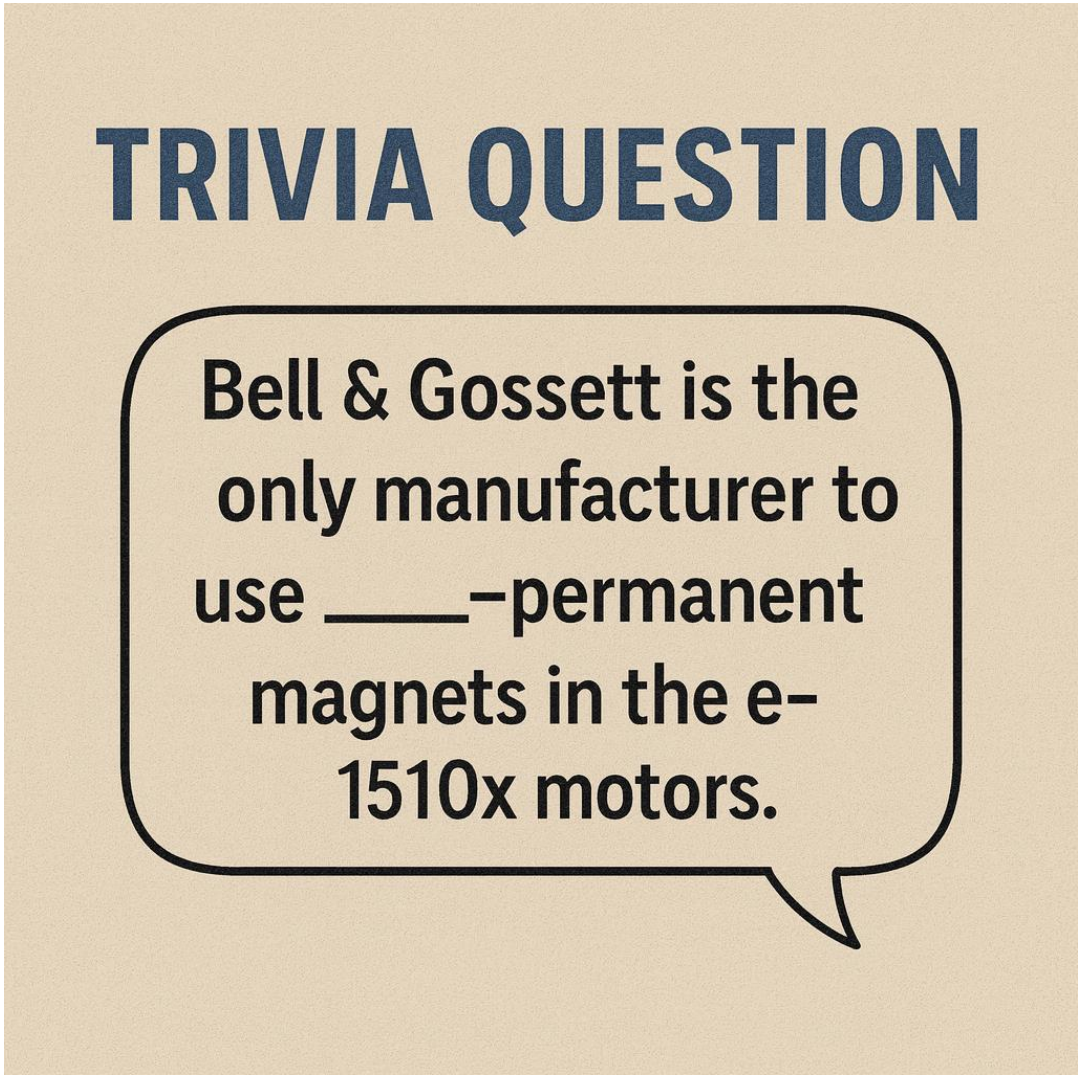


AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break	
9:45-10:45 –	Domestic Hot Water Recirculation Systems –	Ryan Groves
10:45-11:00 –	Break	
11:00-12:00 –	Exploring Heat Exchangers –	Mike Kennedy & Jason Winslow
12:00-1:00 –	Lunch	
1:00-2:00 –	From 0 to 60Hz: The Basics of VFDs –	Nick Tabar
2:00-2:15 –	Break	
2:15-3:15 –	**F & T Steam Basics –**	**Mark Fine & Nick Tafelski**
3:15-3:30 –	Break	
3:30-4:30 –	Practical Water Quality Testing –	Andrew Ward

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BREAK & TRIVIA



RETURN AT 2:15PM

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F & T STEAM BASICS – OVERVIEW OF FUNDAMENTAL CONCEPTS

Mark Fine & Nick Tafelski
R.L. Deppmann

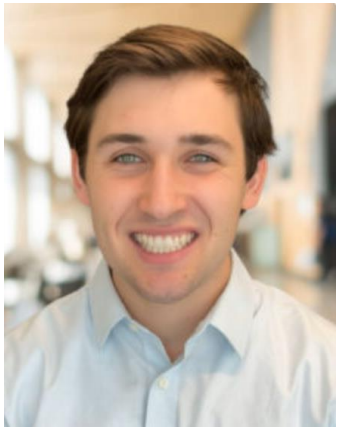


INTRODUCTION

Mark Fine, LEED AP, Engineering Sales

Nick Tafelski, Sales Engineer





DEPPMANN

WHO WE ARE

Since 1927, R.L. Deppmann has offered the top product brands in HVAC and plumbing systems. Our product lines are selected for their mix of technological advances coupled with dependable trouble-free operation.

- Boilers & Water Heaters
- Pumps & Accessories
- Hydronic Systems
- Snowmelt
- Plumbing Systems
- Glycol Options
- Steam / Condensate Systems
- Control & Measurement

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WHAT IS STEAM?

Steam: Water that is heated to its boiling point and converted into vapor, carrying large amounts of heat energy

- It moves fast, expands, and can be dangerous if not handled right.
- Steam systems are all about **pressure, temperature, and flow**.



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WHY USE STEAM?

- **Efficient Heat Transfer:** Steam carries more energy per pound than hot water, allowing rapid, uniform heating across long distances.
- **Versatile and Controllable:** Easily distributed and regulated for heating, humidification, sterilization, and process applications.







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COMMON APPLICATIONS

Buildings:

- Schools & Universities
- Hospitals
- Commercial Facilities
- Industrial Processes



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HIGH VS LOW PRESSURE STEAM

Low-Pressure Steam (<15 psig)

Applications:

- Building heating
- Humidification
- Domestic water heating



High-Pressure Steam (>15 psig)

Applications:

- Industrial processes
- Sterilization
- Power generation
- Large-scale heating systems

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STEAM SYSTEM EQUIPMENT

Boiler



Flash



Feedwater Tank



DA Tank

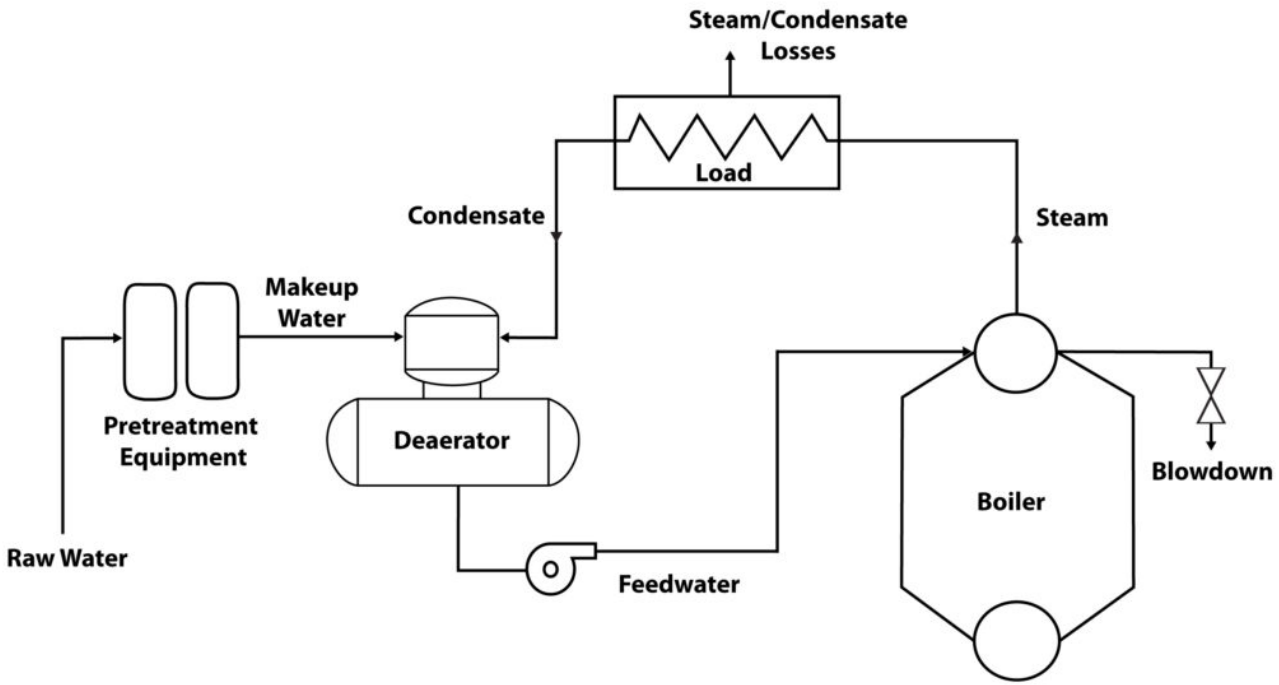


Condensate Tank



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BASIC STEAM SYSTEM

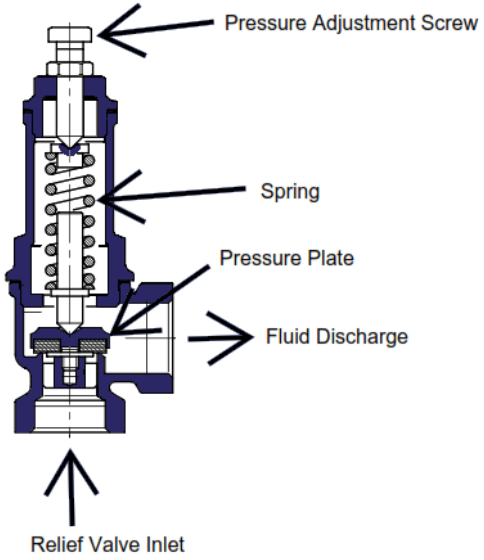


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STEAM SAFETY: PRESSURE RELIEF VALVES

Purpose: Protect equipment from overpressure

- Open automatically at set pressure; reseat when safe
  - Last line of defense against explosions
- Required by ASME code on all boilers and pressure vessels
- Must be properly sized to BTU rating, installed, and tested regularly



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STEAM SAFETY: BLOWDOWN

Purpose: Remove impurities, sludge, and dissolved solids that build up in a steam boiler over time

- Prevents scale and corrosion
- Maintains water quality and boiler efficiency
- Extends boiler life
- Keeps heat transfer surfaces clean



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CONDENSATE FORMATION AND MANAGEMENT

Condensate: Water formed when steam loses heat and returns to liquid

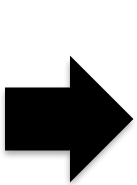
- Still contains heat energy

Returning condensate saves energy, water, and treatment costs

Damage concerns:

- Corrosion
- Water Hammer







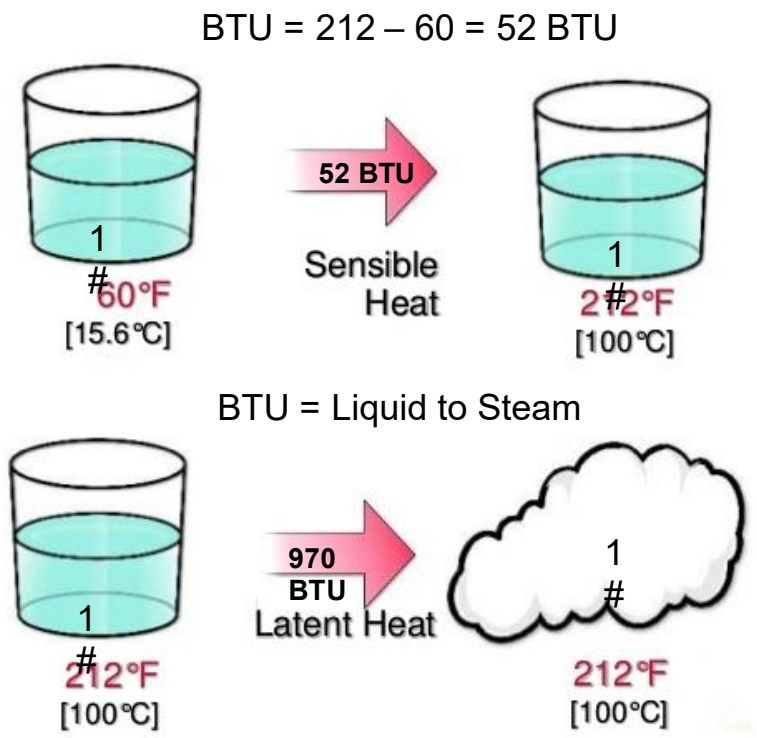
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SENSIBLE HEAT VS LATENT HEAT

Sensible Heat: Heat that changes the **temperature** of a substance but **not its state**

Latent Heat: Heat that causes a **change of state** without **changing temperature**

- Energy stored or released during phase change



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STEAM TABLES

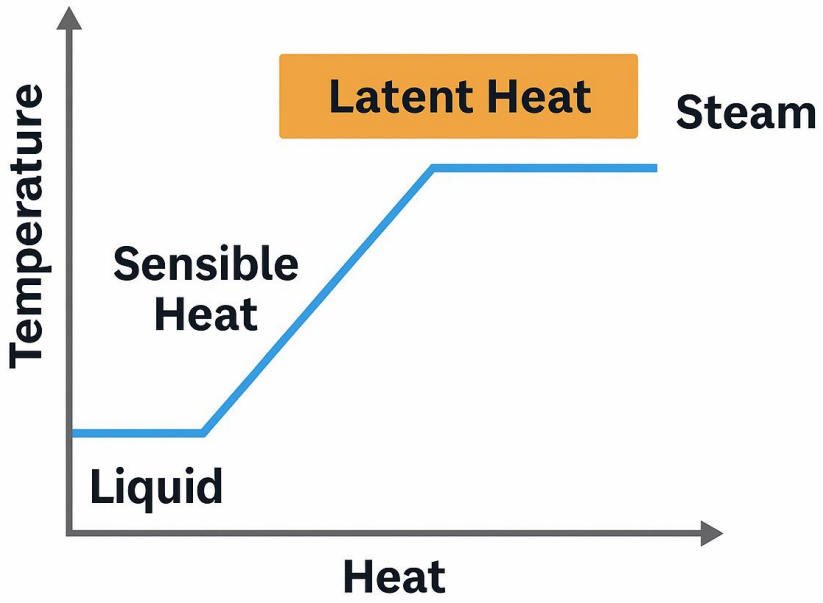
Steam systems are all about **pressure**, **temperature**, and **flow**.

PROPERTIES OF SATURATED STEAM

	GAUGE PRESSURE	ABSOLUTE PRESSURE (psia)	STEAM TEMP (°F)	HEAT OF SAT. LIQUID (Btu/lb)	LATENT HEAT (Btu/lb)	TOTAL HEAT OF STEAM (Btu/lb)	SPECIFIC VOL. OF SAT. LIQUID (cu ft/lb)	SPECIFIC VOL. OF SAT. STEAM (cu ft/lb)
INCHES OF VACUUM	29.743	0.08854	32.00	0.00	1075.8	1075.8	0.096022	3306.00
	29.515	0.2	53.14	21.21	1063.8	1085.0	0.016027	1526.00
	27.886	1.0	101.74	69.70	1036.3	1106.0	0.016136	333.60
	19.742	5.0	162.24	130.13	1001.0	1131.0	0.016407	73.52
	9.562	10.0	193.21	161.17	982.1	1143.3	0.016590	38.42
	7.536	11.0	197.75	165.73	979.3	1145.0	0.016620	35.14
	5.490	12.0	201.96	169.96	976.6	1146.6	0.016647	32.40
	3.454	13.0	205.88	173.91	974.2	1148.1	0.016674	30.06
	1.418	14.0	209.56	177.61	971.9	1149.5	0.016699	28.04
	0.0	14.696	212.00	180.07	970.3	1150.4	0.016715	26.80
	1.3	16.0	216.32	184.42	967.6	1152.0	0.016746	24.75
	2.3	17.0	219.44	187.56	965.5	1153.1	0.016768	23.39
	5.3	20.0	227.96	196.16	960.1	1156.3	0.016830	20.09
	10.3	25.0	240.07	208.42	952.1	1160.6	0.016922	16.30
	15.3	30.0	250.33	218.82	945.3	1164.1	0.017004	13.75
	20.3	35.0	259.28	227.91	939.2	1167.1	0.017178	11.90
	25.3	40.0	267.25	236.03	933.7	1169.7	0.017145	10.50
	30.3	45.0	274.44	243.36	928.6	1172.0	0.017209	9.40
	40.3	55.0	287.07	256.3	919.6	1175.9	0.017325	7.79
	50.3	65.0	297.97	267.5	911.6	1179.1	0.017429	6.66
	60.3	75.0	307.60	277.43	904.5	1181.9	0.017524	5.82
	70.3	85.0	316.25	286.39	897.8	1184.2	0.017613	5.17
	80.3	95.0	324.12	294.56	891.7	1186.2	0.017696	4.65
	90.3	105.0	331.36	302.10	886.0	1188.1	0.017775	4.23

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SENSIBLE HEAT VS LATENT HEAT CHART



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STEAM TRAPS

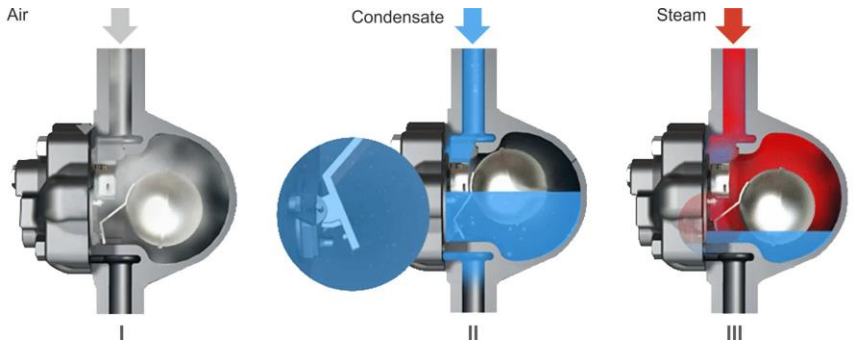
Steam Traps: Removes condensate and air from a steam system **without losing live steam**

How traps work:

“Opens” to vent air & other non-condensables

“Closes” to prevent passage of steam vapor

“Opens” to drain condensate from piping & heat transfer devices



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TYPES OF STEAM TRAPS



Float
And
Thermostatic



Inverted Bucket



Thermostatic



Thermodisc

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FLOAT & THERMOSTATIC

F&T Traps

- Low-pressure heating systems & heat exchangers with continuous condensate flow

Applications:

- Unit heaters
- Heat exchangers
- AHU Coils
- Drip Traps



“H” Pattern



“I” Pattern



“C” Pattern

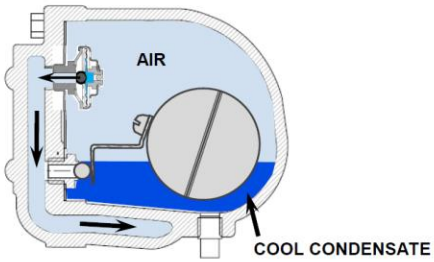
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F&T MECHANISM

Key Features:

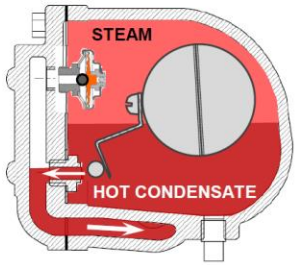
- Float handles continuous drainage
- Thermostatic element vents air during startup
  - *Must select correct Seat Pressure*

"COLD" System Startup



- Thermostat "Open"
- Air Venting
- Condensate level low
- Float down, Orifice "Closed"

"HOT" System Operating



- Thermostat "Closed"
- No Air Venting
- Condensate level high
- Float up, Orifice "Open"

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INVERTED BUCKET TRAPS

Inverted Bucket Traps

- Medium to high-pressure systems with steady condensate loads

Applications:

- High Pressure
- Condensate “Lift”
- Process Equipment
- Steam Separators
- Laundry Equipment



B0 – B2



B3 – B4



B6

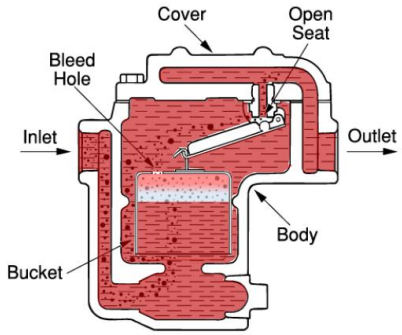
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INVERTED BUCKET MECHANISM

Key Features:

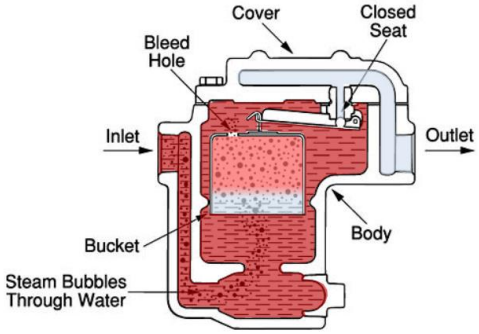
- Operates on density difference between steam & condensate
- Resistant to dirt and water hammer

"COLD" System Startup



- **Must be manually primed**
- **Air Venting through Bleed Hole**
- **Steam level low**
- **Bucket down, Seat "Open"**

"HOT" System Operating



- **Steam/Air collecting under bucket**
- **No Air Venting**
- **Steam level high**
- **Bucket up, Seat "Closed"**

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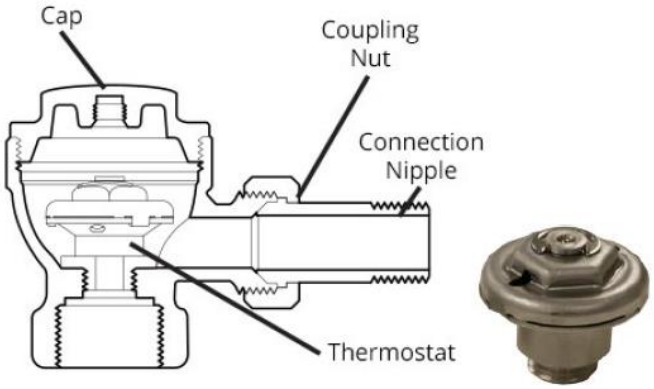
THERMOSTATIC TRAPS

Thermostatic Traps

- Tracing lines & systems where condensate load varies & low water hammer

Applications:

- Vacuum Systems
- Large Radiators
- Schools
- Hospitals
- Homes



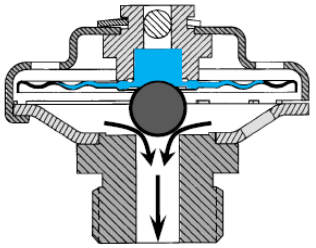
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THERMOSTATIC MECHANISM

Key Features:

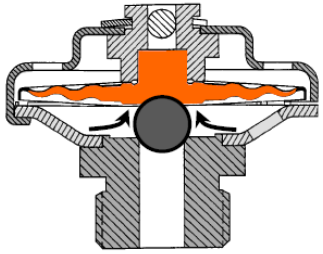
- Operates based on temperature difference between steam & condensate
  - Alcohol mixture vaporizes/condenses
- Excellent for removing air and non-condensables

"Open"



"Diaphragm Contracted"

"Closed"



"Diaphragm Expanded"

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THERMODISC TRAPS

Thermodisc Traps

- High-pressure or outdoor systems with intermittent condensate flow

Applications:

- High Pressure
- Outdoor Drip Traces
- Steam Heat Trace





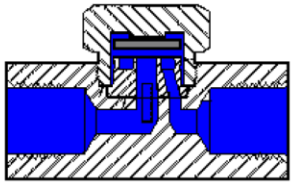
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THERMODISC MECHANISM

Key Features:

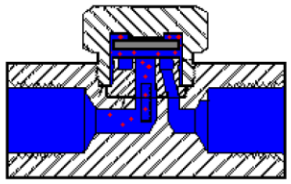
- Compact, rugged design with few moving parts
- Tolerates superheat and freezing conditions

"COLD" Full Open



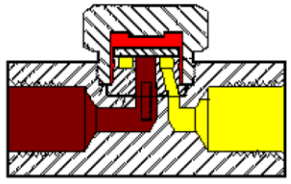
- Disc off seat
- Held open by force of entering condensate

"Cycling" to Close



- Flash steam develops
- Enters at high velocity
- Drops pressure below disc
- Applies pressure on top of disc

"HOT" Full Close



- Disc snaps closed
- Line pressure above disc
- Flash steam condenses above disc
- Pressure drops, disc pushed off seat

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STEAM TRAP TESTING

- No single test method works best for all steam traps — different designs and operating conditions require different testing approaches.

Test Methods:

1. Visual
2. Temperature
3. Ultrasound

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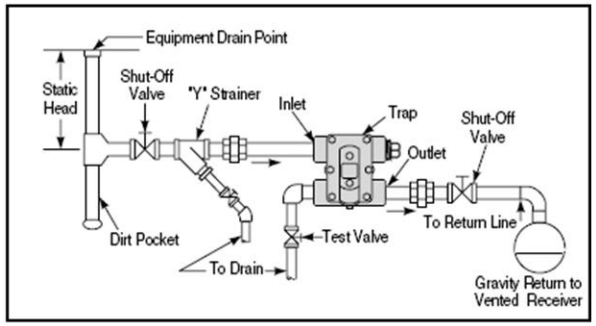
VISAL TESTING

Helps identify:

1. Blow through traps
2. Severe Steam Leakage

<u>Considerations</u>:

- Requires understanding of **flash steam vs. live steam**
- Safety concerns due to venting hot steam



Testing-Tee



Steam Cloud

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TEMPERATURE TESTING

Types of Temperature Devices:

1. Contact - Measures temperature by direct contact
    - Requires a clean surface and time to stabilize.
2. Non-Contact (Infrared):
    - Uses infrared energy for instant readings without surface prep.

Considerations:

- Helps verify system operating conditions.
- IR devices can give false readings on the low-pressure side if nearby traps have failed.



Non-Contact



Contact

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ULTRASOUND TESTING

Most accurate and versatile method

How It Works: Uses high-frequency sound waves (heard through a stethoscope module) to detect trap operation and leaks.

Advantages:

- Identifies failed open traps and minor steam leakage
- Detects subtle changes in trap behavior that other methods may miss.



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STEAM TRAP SURVEY

Include steam trap surveys in your preventive maintenance program

- Check traps annually!!!



Record Key Details:

- Location, trap type, and manufacturer
- Steam pressure and pipe size
- Assign trap ID numbers for tracking
- Red tag all failed traps

Why It Matters:

- Enables accurate reporting of energy loss and cost impact
- Regular surveys can save thousands in wasted steam each year

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HOW MUCH STEAM IS LOST?

Model	Size in.	Orifice Size in. (mm)
FT015H-3	3/4	.253 (6.4)
FT015H-4	1	.253 (6.4)
FT015H-5	1 1/4	.312 (8)
FT015H-6	1 1/2	.500 (13)
FT015H-8	2	.687 (17)
FT030H-3	3/4	.235 (6)
FT030H-4	1	.235 (6)
FT030H-5	1 1/4	.253 (6.4)
FT030H-6	1 1/2	.438 (11)
FT075H-3	3/4	.166 (4.2)
FT075H-4	1	.166 (4.2)
FT125H-3	3/4	.125 (3.2)
FT125H-4	1	.125 (3.2)
FT175H-3	3/4	.106 (2.7)
FT175H-4	1	.106 (2.7)

Steam Flow Through Orifices Discharging To Atmosphere

	Steam Flow (lbs./hr.) when steam gauge pressure is:											
Orifice Diam.	5 psi	10 psi	15 psi	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi	200 psi	250 psi	300 psi
1/32	.47	.58	.70	.94	1.53	2.12	2.7	3.3	3.9	5.1	6.3	7.4
1/16	1.86	2.3	2.8	3.8	6.10	8.5	10.8	13.2	15.6	20.3	25.1	29.8
3/32	4.20	5.3	6.3	8.45	13.8	19.1	24.4	29.7	35.1	45.7	56.4	67.0
1/8	7.5	9.4	11.2	15.0	24.5	34.0	43.4	52.9	62.4	81.3	100.0	119.0
5/32	11.7	14.6	17.6	23.5	38.3	53.1	67.9	82.7	97.4	127.0	156.0	186.0
3/16	16.7	21.0	25.3	33.8	55.1	76.4	97.7	119.0	140.0	183.0	226.0	268.0
7/32	22.9	28.7	34.4	46.0	75.0	104.0	133.0	162.0	191.0	249.0	307.0	365.0
1/4	29.8	37.4	45.0	60.1	98.0	136.0	173.0	212.0	250.0	325.0	401.0	477.0
9/32	37.8	47.4	56.9	76.1	124.0	172.0	220.0	268.0	316.0	412.0	507.0	603.0
5/16	46.6	58.5	70.3	94.0	153.0	212.0	272.0	331.0	390.0	508.0	627.0	745.0
11/32	56.4	70.7	85.1	114.0	185.0	257.0	329.0	400.0	472.0	615.0	758.0	901.0
3/8	67.1	84.2	101.0	135.0	221.0	306.0	391.0	476.0	561.0	732.0	902.0	1073.0
13/32	78.8	98.8	119.0	159.0	259.0	359.0	459.0	559.0	659.0	859.0	1059.0	1259.0
7/16	91.4	115.0	138.0	184.0	300.0	416.0	532.0	648.0	764.0	996.0	1228.0	1460.0
15/32	105.0	131.0	158.0	211.0	344.0	478.0	611.0	744.0	877.0	1144.0	1410.0	1676.0
1/2	119.0	150.0	180.0	241.0	392.0	544.0	695.0	847.0	998.0	1301.0	1604.0	1907.0

Example:

- Cost of 1# of steam = 1 Cent

Ex 1: ¾" F&T Trap @ 15 psi

$$\frac{45\ \#}{\text{hour}} \times \frac{8760\ hour}{year} \times \$.01 = \$3942/year$$

Ex 2: 1½" F&T Trap @ 15 psi

$$\frac{180\ \#}{\text{hour}} \times \frac{8760\ hour}{year} \times \$.01 = \$15{,}768/year$$

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UTILITY REBATES

Consumers Energy
Count on Us®

Incentive Requested	
Equipment Type	**Incentive**
TU205 Steam Trap Repair or Replacement	$175.00 per Trap

DTE Energy
Save energy.
Save money.
Together we will.

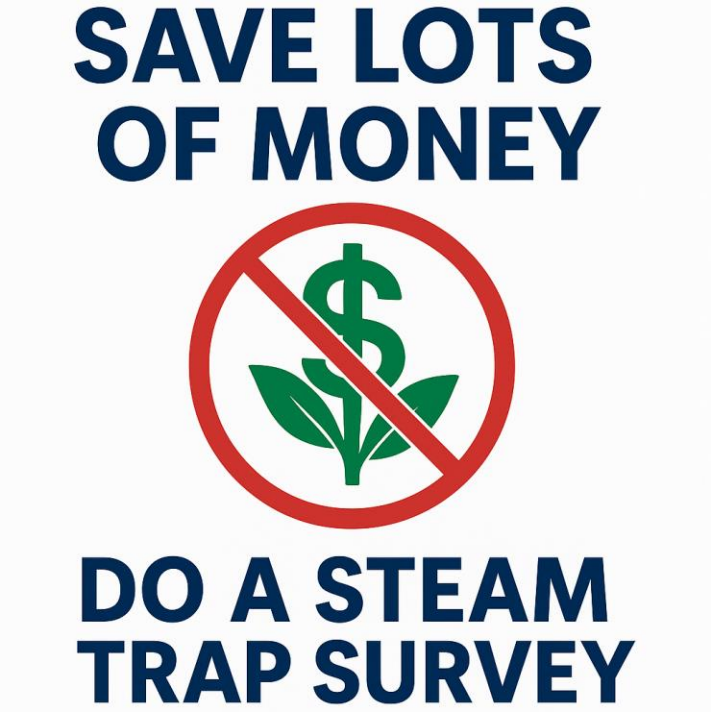
HVAC Gas Incentive Worksheet

Boilers and Furnaces

Equipment Type	Equipment Size MBH	Incentive	Unit	# of Units	Total Incentive
Boiler Modulating Burner Control Retrofit		$1,250.00	Unit		
Boiler Water Reset Control		$300.00	Unit		
High Efficiency Furnace 95% Efficient		$350.00	Unit		
High Efficiency Furnace 92% Efficient		$250.00	Unit		
High Efficiency Boilers (Space Heating)		$2.00	MBH		
Leaking Steam Trap Repair or Replacement		$100.00	Trap		

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CONCLUSION



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COMMON FIELD ISSUES AND BEST PRACTICES

1. Water hammer prevention
2. Capturing flash steam
3. Lifting condensate & return line backpressure
4. Pipe pitch
5. Strainer orientation
6. Pocket water
7. Oversized steam valves
8. Low-flow fixtures without resizing valves
9. Concentric vs eccentric valves
10. Branching off a steam main

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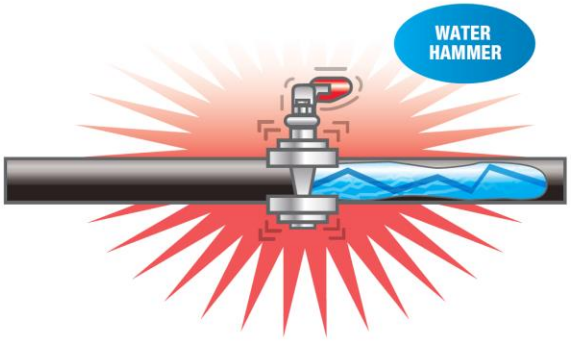
WATER HAMMER

Water Hammer: A shock wave/pressure surge that occurs when moving steam or condensate suddenly stops or changes direction

- Creates a loud bang & potential system damage
- Drip legs help prevent

Caused by:

1. Condensate buildup (maybe in traps)
2. Rapid valve closure



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FLASH STEAM AND FLASH TANKS

Flash Steam: Occurs when hot condensate discharges to a lower pressure, instantly evaporating into steam

Why its Bad:

- Wasted energy
- System damage

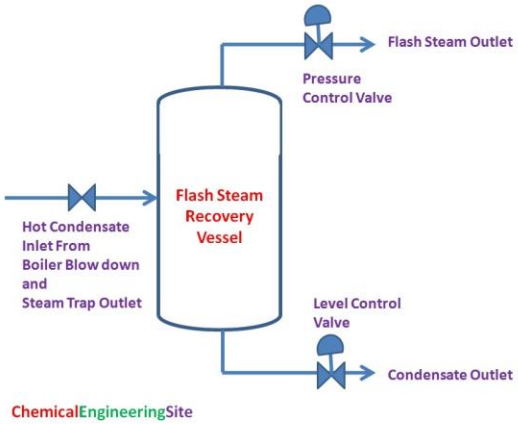


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FLASH TANKS

Flash Tanks: Separate flash steam from condensate safely at a controlled pressure.

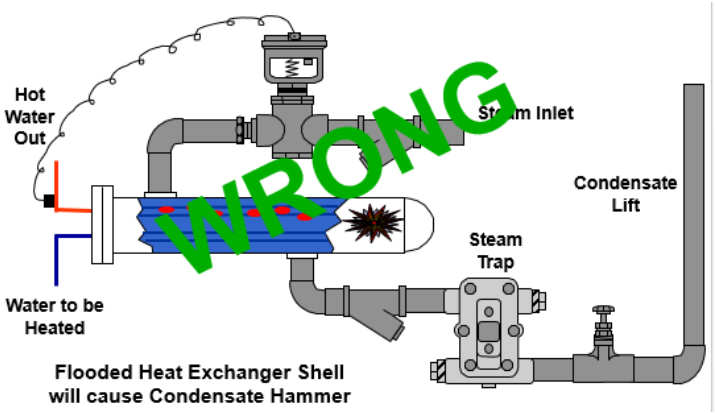
- Allow recovered steam to be reused in low-pressure systems or for heating applications
- Reduce energy loss and protect condensate return equipment from overpressure



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CONDENSATE PIPING DESIGN

Lifting condensate after modulating valves can lead to heat exchanger or coil issues



Simple Fixes:

- Gravity return
- Condensate return tank
- Proper slope & venting
- Correct pipe sizing

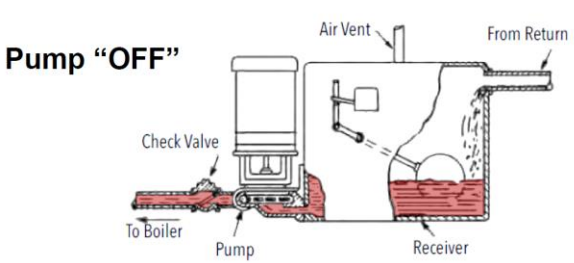
The back pressure created by lift is 2.31 ft/1 psi

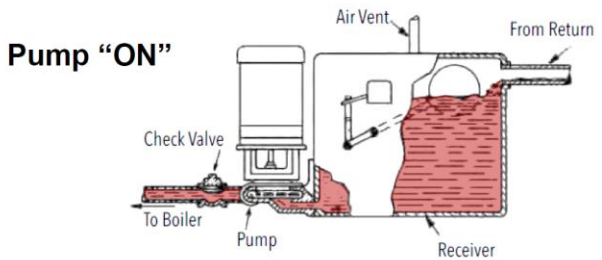
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RECEIVERS AND CONDENSATE PUMPS

Role of condensate receivers:

1. Storage
2. Lift to higher elevation
3. Return to feedwater tank
4. Maintain system balance
5. Reduce energy/water waste





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PIPE PITCHING

Steam pipes - Pitch away from the boiler

Condensate pipes - Pitch toward the receiver or trap

Flat/Backward pitch = Water hammer & poor drainage

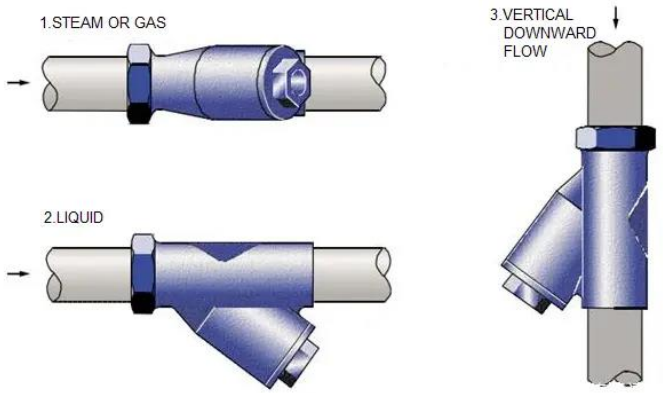


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STRAINERS – ORIENTATION MATTERS

Strainer orientation: Important for steam systems to prevent damage

- Strainers should be horizontal with the blowdown pointing down.
- Vertical strainers trap water and debris
  - Bad for flow and safety.
- Always check orientation before startup.



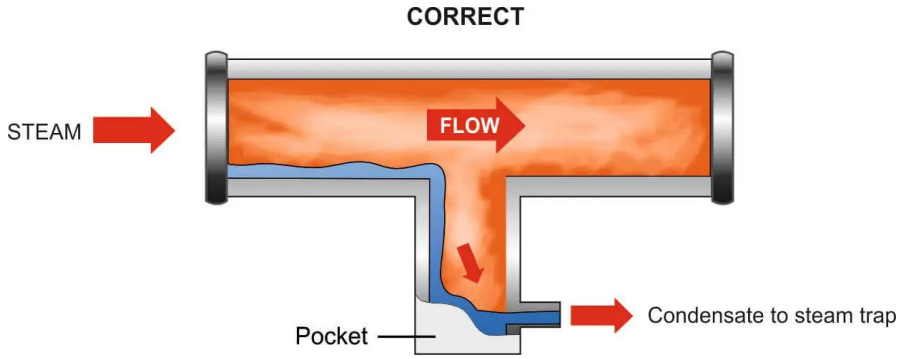
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POCKET WATER

Pocket Water - Water trapped in low spots that flashes to steam

Occurs in:

- Drip Legs
- Strainers
- In front of control valves
- Dead-end Branches
- Horizontal pipe



Causes hammering, valve damage, and safety risks

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VALVE SIZING

Oversized valves don't control well, they overshoot and hunt

- Temps spike to 160°F then crash to 80°F

Undersized valves doesn't give enough energy

Causing:

- Poor modulation
- Unstable control
- Short cycling

Short Cycling: A boiler turns on and off too frequently. This often due to oversized equipment, poor controls, or fluctuating demand.

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VALVE SIZING EXAMPLE

Properly Sized	Oversized Valve	Undersized Valve
		
Middle	Low	High

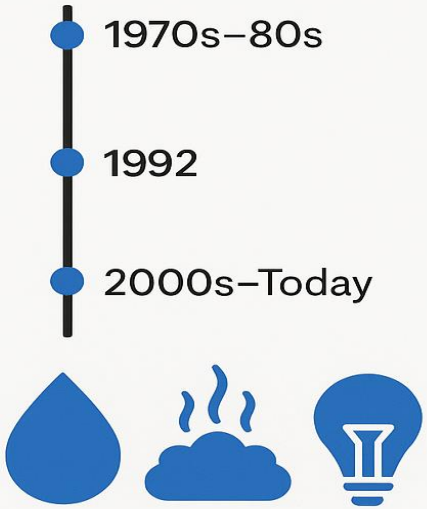
*Red valve indicator on stem helps identify properly sized valve

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LOW FLOW FIXTURE HISTORY

Low-Flow Fixtures — History & Impact

- 1970s–80s: Early conservation efforts began after energy crises.
- 1992: U.S. Energy Policy Act set national low-flow standards (1.6 GPF toilets, 2.5 GPM showers).
- 2000s–Today: Smarter designs with aerators, sensors, and EPA WaterSense certification
- Steam Impact:
  - Reduces hot water and steam demand.
  - Lowers condensate load and energy use.
  - Improves overall system efficiency.



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LOW-FLOW FIXTURES

Impact of Low Flow Fixtures:

- System imbalance from flow restriction
- Steam valves matching new flow rate

Mark's Rule: Usually going down a valve size or two will fix issue

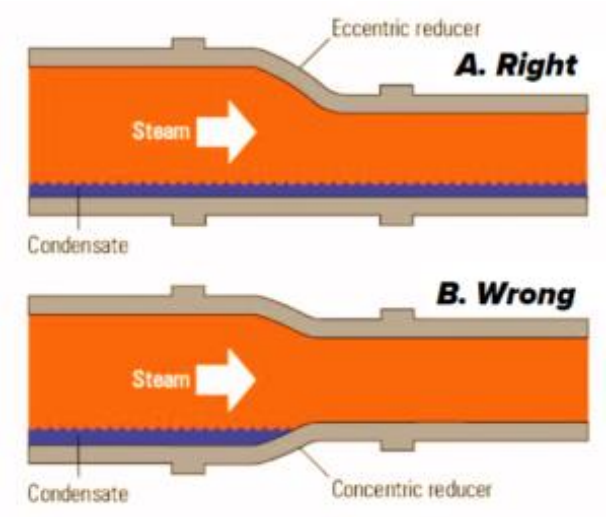


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ECCENTRIC VS CONCENTRIC FITTINGS

Concentric:

- Trap water at the bottom
- Leads to hammering and corrosion
- Centered, precise control, more wear



Eccentric:

- Keeps water from pooling
- Offset, smoother operation, better drainage
- Make sure to have flat side on top to prevent flash

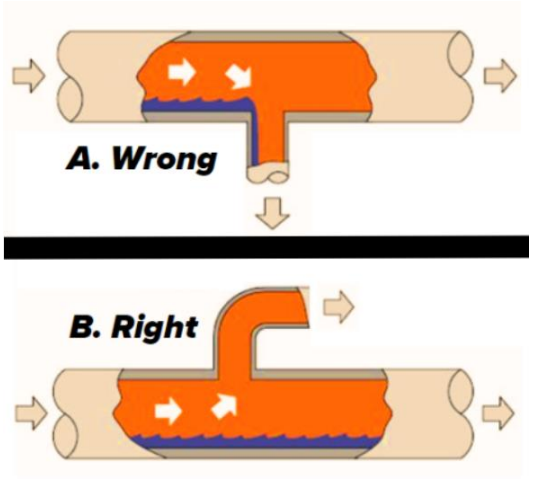
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BRANCHING OFF A STEAM MAIN

Delivering steam to a process or heat exchanger, it is essential to branch off from the top of the steam main

- Pulling steam from the bottom of the main can cause water in the application.
- This occurs because pulling from the bottom essentially creates a dip leg, It traps condensate as it tries to pass by.

- Always pull from the top of the main for dry, efficient steam delivery



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MAINTENANCE & SAFETY

Maintenance & Safety Tips

- Inspect traps & valves regularly
- Test safety relief valves
- Blow down boilers & strainers
- Insulation damage = energy loss
- Proper condensate return
- Record system pressures & temp



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TRAINING CUSTODIAL/MAINTENANCE STAFF

Online training

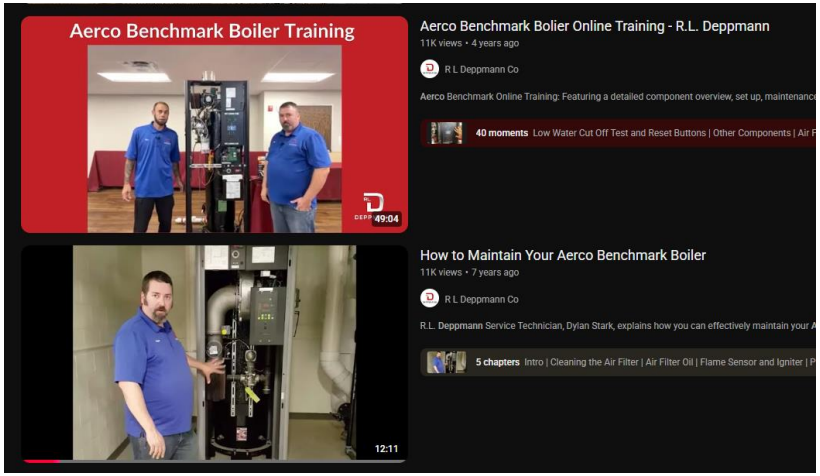
- Service Videos on Maintenance

Local Rep Training

- With manufacturer rep

Factory Training

- Online/in-person



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TRAINING CUSTODIAL/MAINTENANCE STAFF

Lunch & Learns

- Meet Reps
- On-site training
- Facilities directors, maintenance teams, techs
- Expand knowledge base



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SUMMARY / KEY TAKEAWAYS

Overall, steam is a very versatile for heating, sterilization, and process energy

- Make sure to have the proper safety practices and equipment in place
- Steam traps are important
- Removal of condensate is key
- Have proper maintenance systems in place
- A well-designed system = better efficiency = more money



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QUESTIONS



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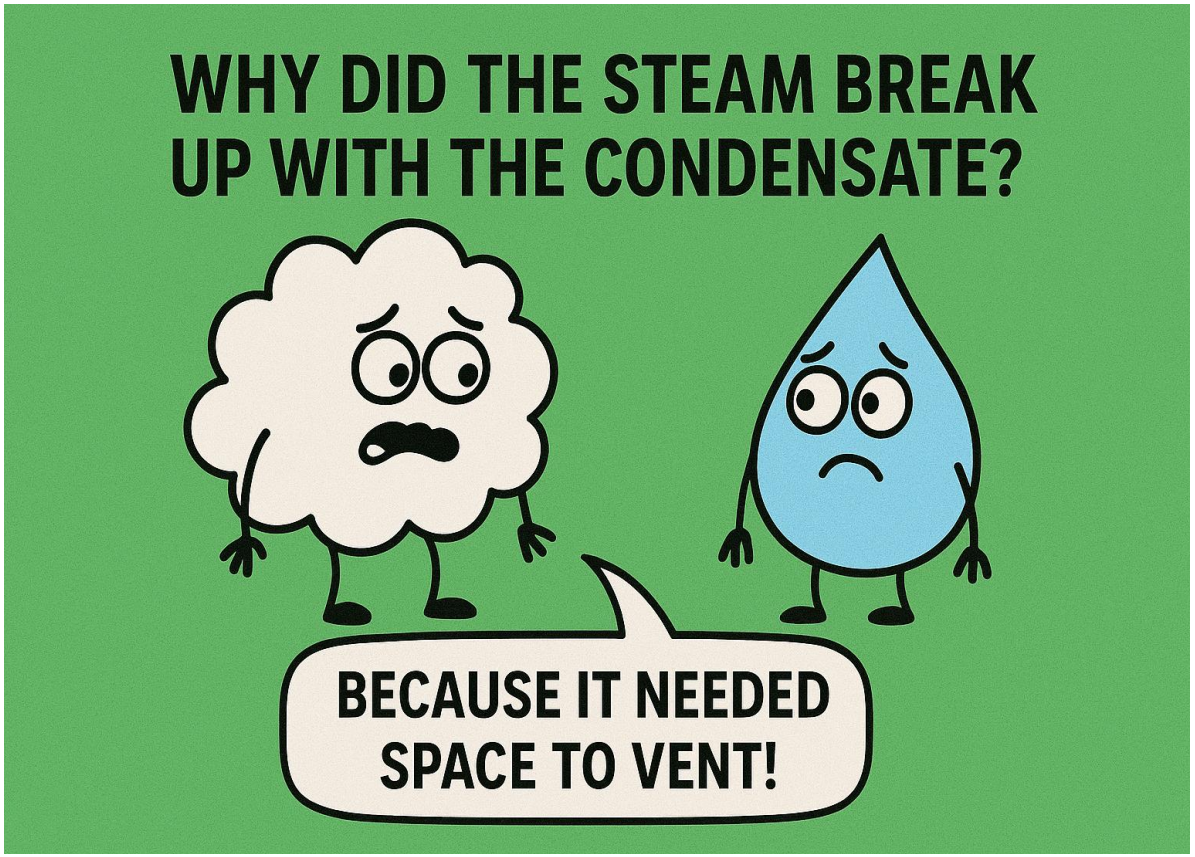
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AGENDA

8:30-9:30 –	The Lost Art of Parallel Pumping –	Brad Notter & Kyle Wefing
9:30-9:45 –	Break	
9:45-10:45 –	Domestic Hot Water Recirculation Systems –	Ryan Groves
10:45-11:00 –	Break	
11:00-12:00 –	Exploring Heat Exchangers –	Mike Kennedy & Jason Winslow
12:00-1:00 –	Lunch	
1:00-2:00 –	From 0 to 60Hz: The Basics of VFDs –	Nick Tabar
2:00-2:15 –	Break	
2:15-3:15 –	F & T Steam Basics –	Mark Fine & Nick Tafelski
3:15-3:30 –	Break	
3:30-4:30 –	**Practical Water Quality Testing –**	**Andrew Ward**

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BREAK & DAD JOKE



RETURN AT 3:30PM

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Protecting Plumbing and HVAC Assets

Presented by:

Andrew Ward & Chip Bidigare

Water Solutions Group

2025 Deppmann Academy

Agenda

- Introductions
- Domestic Water Systems
- Cooling Tower Open Systems
- Closed System
- Water Quality testing and analysis

Introductions

- Andrew Ward - Division Manager
- Chip Bidigare - Outside sales, Eastern Michigan

WATER SOLUTIONS GROUP

Water Solutions Group is a separate division of the R.L. Deppmann Company created to provide end users and engineers with a valuable resource in efforts to improve water quality. Our intimate knowledge of water systems positions WSG to be the first choice when evaluating operational issues that may arise because of poor water quality.



- Water monitoring, testing and analysis
- Product selection and solutions
- Site visits and after installation support
- Education and training

MEMBER Water Quality ASSOCIATION

Selecting water treatment solutions starts with testing

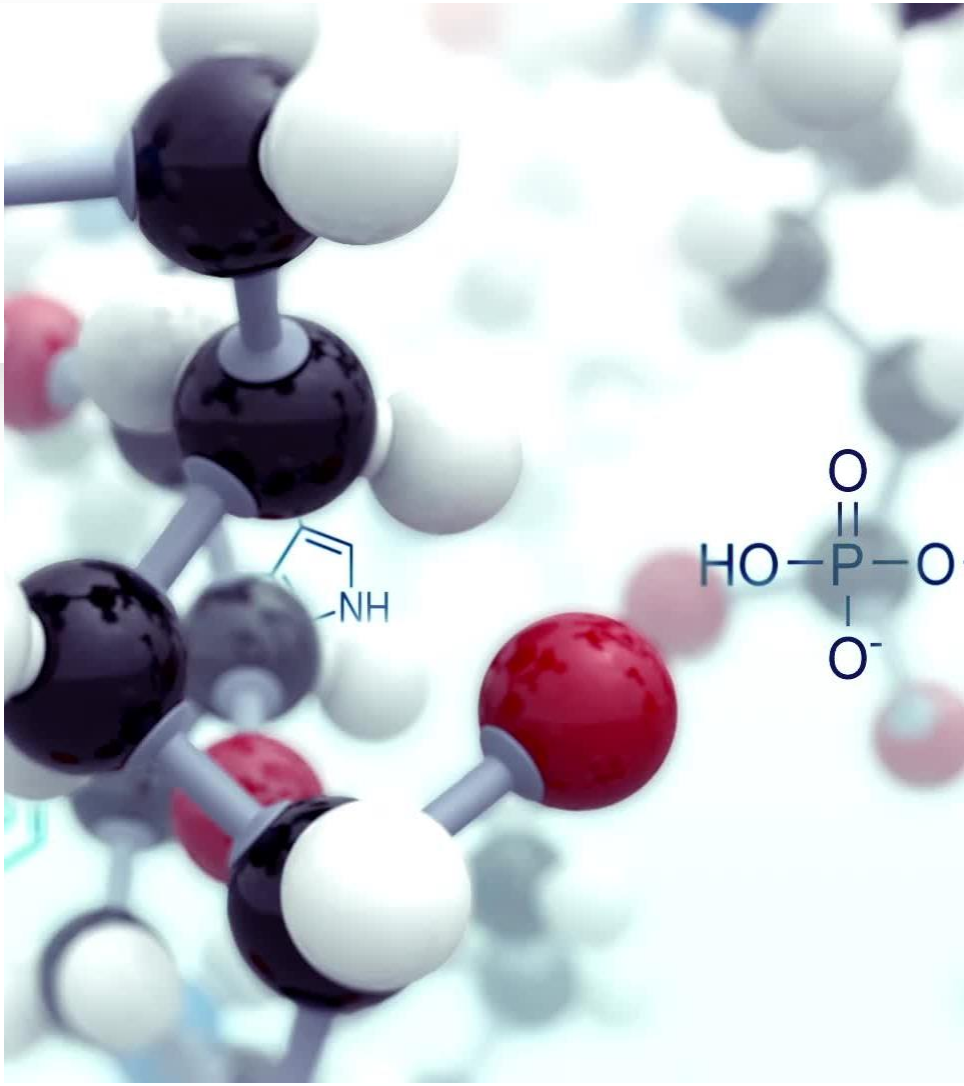


- To select the proper treatment for your facility, you cannot look at any one single parameter in a vacuum
- Water quality testing may be performed in the field or by a qualified testing laboratory
- Testing plan should be based on:
  - Local environmental conditions
  - Materials of construction
  - Inspection results (e.g. evidence of corrosion, scale)
  - Operating and usage considerations
  - Risk profile of the facility



Types of contaminants

- Ionic
  - Dissolved minerals (lead, copper, calcium, magnesium, sodium, iron, chloride)
- Organic
  - Chlorine, tannins, disinfection byproducts (DBPs), total organic carbon (TOC), volatile organic compounds (VOCs)
- Particulate
  - Sand, turbidity, oxidized iron
- Microbial
  - Cysts, total bacteria, *Legionella*

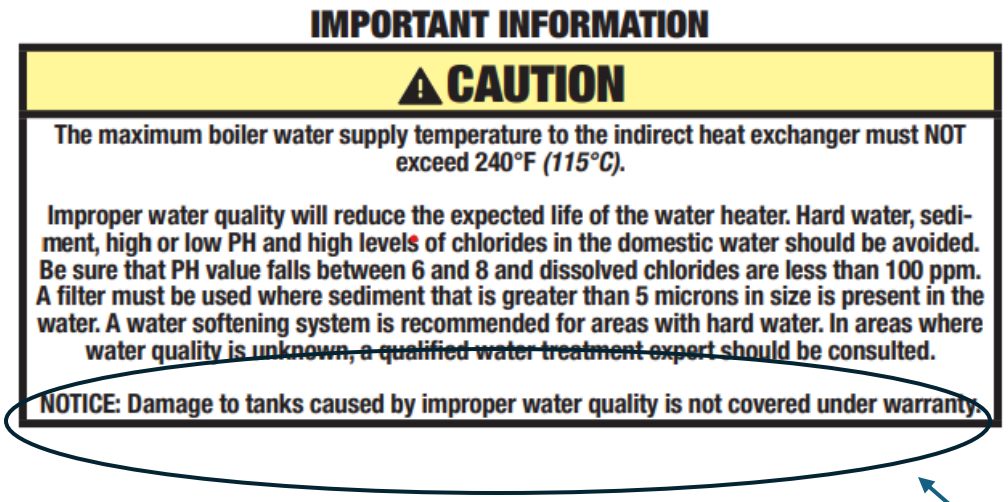


Addressing Facility Water Quality

- What do we need to do?
  - Ensure drinking water is safe for use and consumption
  - Protect plumbing and HVAC assets from damage due to inadequate water treatment
  - Meet sustainability goals

Absent or inadequate treatment leads to:

- Reduced efficiency
- Increased energy costs
- Environmental impact
- Failures outside of warranty
- System downtime
- Liability for remedial/replacements work and costs
- Damage to reputation



IMPORTANT INFORMATION

⚠ CAUTION

The maximum boiler water supply temperature to the indirect heat exchanger must NOT exceed 240°F *(115°C)*.

Improper water quality will reduce the expected life of the water heater. Hard water, sediment, high or low PH and high levels of chlorides in the domestic water should be avoided. Be sure that PH value falls between 6 and 8 and dissolved chlorides are less than 100 ppm. A filter must be used where sediment that is greater than 5 microns in size is present in the water. A water softening system is recommended for areas with hard water. In areas where water quality is unknown, a qualified water treatment expert should be consulted.

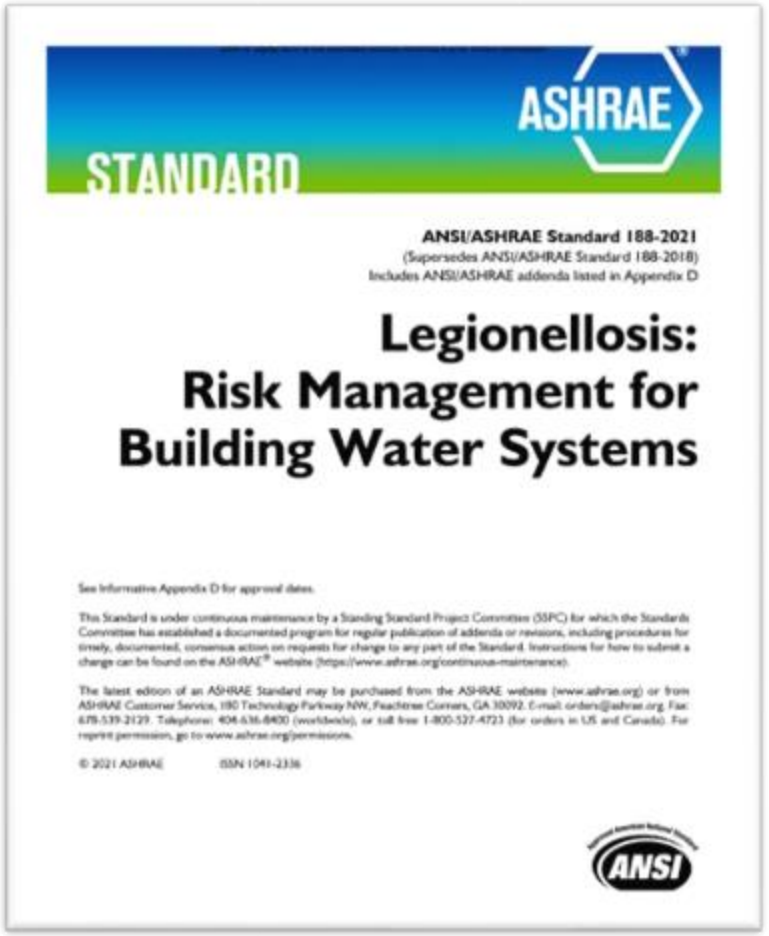
NOTICE: Damage to tanks caused by improper water quality is not covered under warranty.

Manufacturers of boilers, chillers, water heaters and other large mechanical equipment specify minimum feed water quality and operating conditions

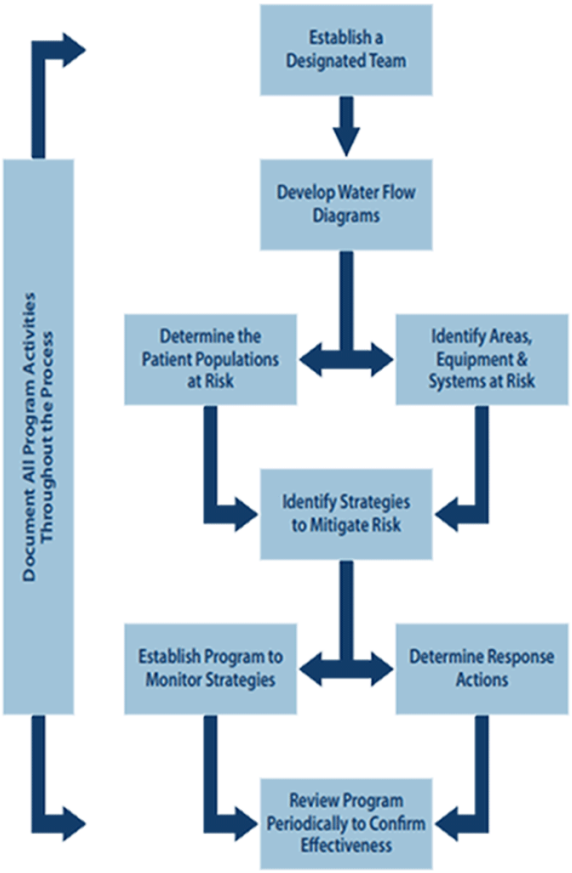
Manufacturers are increasingly voiding warranties for failures due to problem water quality.

All facilities can protect their plumbing and HVAC systems with more effective water management.

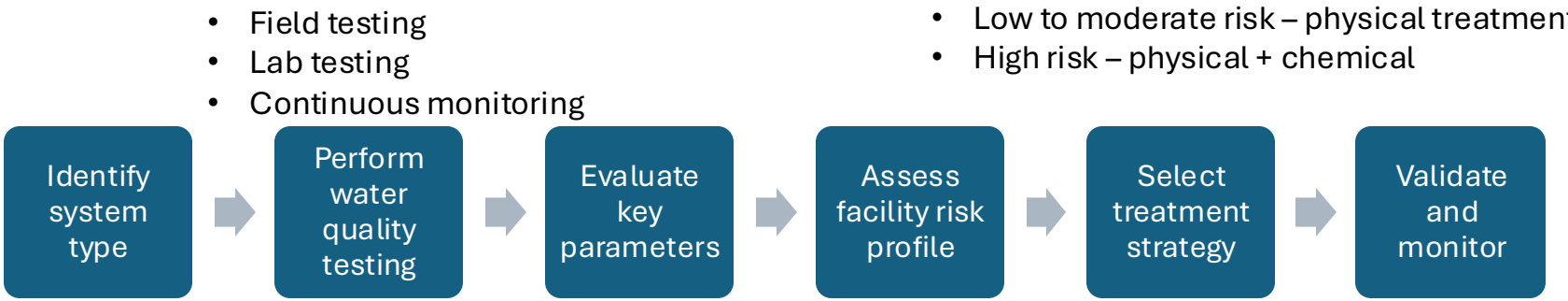
- The plumbing and HVAC industries encourage a **proactive** approach to water management to protect occupants of educational facilities



Water Management Programs



Selecting water treatment solutions



Domestic Water Systems

Effective water treatment

- Frequent maintenance or chemical treatment programs may be impractical or unaffordable
- Facilities are looking to reduce maintenance requirements while maintaining the life of plumbing and HVAC assets
  - Ex. Salt-free conditioners offer scale control without corrosion risks or discharge burden of traditional softeners
- Facilities that were built decades ago may have outdated plumbing and HVAC systems
  - These systems are more prone to corrosion, leaks, and inefficiency

The Safe Drinking Water Act

- What is it?
  - SDWA regulates community water systems
  - Most facilities receive water from a municipal source, which must meet EPA standards for contaminants like lead, copper, and bacteria
- What do we need to know?
  - Water quality may not be suitable for all purposes, and require water treatment
  - Water quality can degrade inside facilities due to aging plumbing, fixtures, or stagnation



Mitigation strategies for domestic water

- Heavy metals (lead and copper)
  - Replace lead service lines, solder, and brass fixtures
  - Install NSF/ANSI 53 or 58 filters at drinking fountains
  - Flush pipes regularly to reduce stagnation
- Microbial contamination
  - Chlorine or UV treatment
    - Maintain a chlorine residual ≥ 0.2 mg/L at the farthest tap
  - Submicron filtration
- PFAS
  - Use granular activated carbon (GAC) or reverse osmosis
- Nitrates
  - Use ion exchange softening or reverse osmosis
  - Protect wells from run off

Cooling tower water systems



Key strategies for cooling tower treatment

- Side-stream filtration
  - Removes suspended solids by filtering 3-10% of the recirculating water
  - Results in better heat transfer, reduced maintenance, improved chemical treatment efficiency
  - Employed for systems with high turbidity

Key strategies for cooling tower treatment

- Makeup water softening
  - Removes scale-forming ions and allows towers to operate at higher cycles of concentration (less frequent blowdown)
  - Scale reduces heat transfer efficiency and increases energy costs
  - Soft water can be more corrosive if not properly managed which is why partial softening or blending methods are utilized

Key strategies for cooling tower treatment

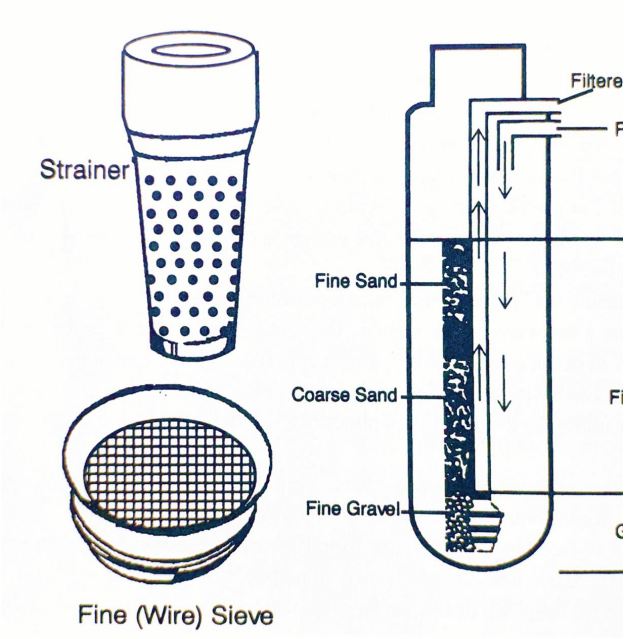
- Enhanced microbial control with a combination of UV and chemical treatment
- UV inactivates bacteria, viruses, and protozoa by damaging DNA
  - Lowers the biocide dosing demand
- Chemical biocides provide residual protection throughout the system
- ASHRAE 188 and Michigan EGLE emphasize multi-barrier approaches to *Legionella* control

Closed Systems



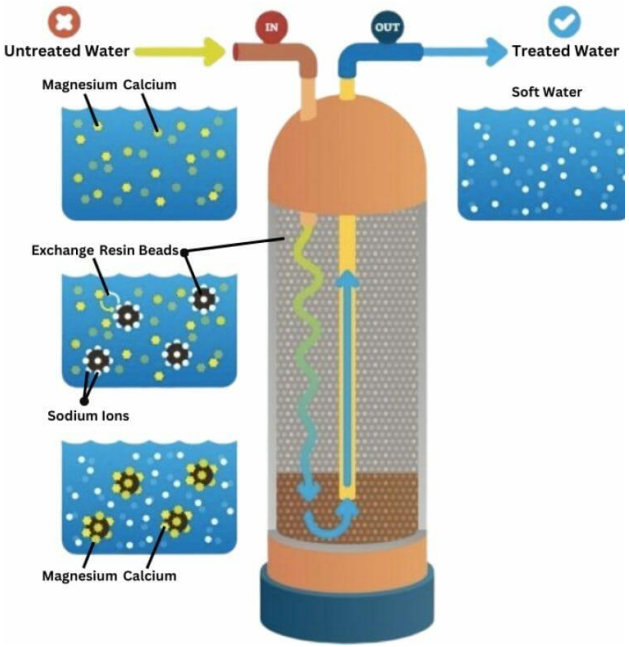
Filtration

- Accumulation of suspended solids leads to erosion of metals and increased wearing of pump seals, control valves, and piping
- Filtration can remove particulate matter or dissolved oxygen
- Filtering to sub-micron levels is effective at removing fine metal or magnetite particles <1 micron in size
- Side-stream filtration keeps main water flowing while removing suspended solids



Softening

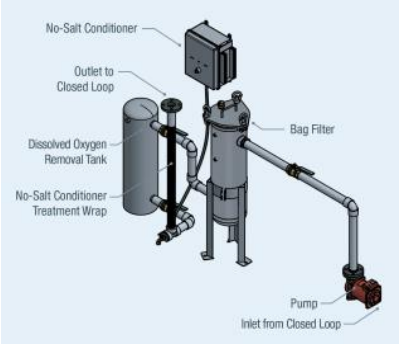
- Scale deposition prevention using ion-exchange softening
- Closed loop systems may require softening if total hardness exceeds 250 ppm (as $CaCO_3$) complexed with bicarbonates, sulphates, chlorides, or nitrates
- Softening resin uses a strong acid cation exchange process
- After the softening process, some boiler feed water treatment systems will utilize dealkalization to reduce alkalinity/pH



Side-stream skid packages

- Combination of sub-micron filtration, softening, and dissolved oxygen removal
- Removes deposits and prevents deposits from forming
- Reduced footprint, accessible connections for maintenance, ease of testing





Water Quality testing

Domestic water system testing ensures safe drinking water and regulatory compliance

Parameter	Frequency	Notes
Temperature	Monthly	Sample distal points
pH	Quarterly	Inline or grab sample; target 6.5-8.5
Free chlorine residual	Weekly	Target ≥0.2 mg/L; test representative taps
Total coliform/E. coli	Monthly	If chlorine <0.2 mg/L
Lead and copper	Annually	First-draw samples per EPA Lead and Copper Rule
Turbidity	Quarterly	>1 NTU may indicate sediment or biofilm
Iron, manganese	Semi-annually	Aesthetic and corrosion indicators
Hardness, alkalinity	Semi-annually	Supports corrosion and scaling control

Cooling tower water testing supports *Legionella* control and energy efficiency

Parameter	Frequency	Notes
Conductivity	Daily	Automation reduces manual testing
pH	Weekly	Target 7.0-8.5; adjust for biocide efficacy
Calcium hardness	Monthly	Scale risk
Alkalinity	Monthly	Supports scale prediction
Turbidity	Weekly	>50 NTU indicates biofilm
Legionella	Quarterly	Per ASHRAE 188 risk determination
Biocide residual	Weekly	Chlorine/bromine; verify dosing effectiveness
HPC	Monthly	Dip slide; tracks microbial load

Closed system monitoring prevents corrosion and extends equipment life

Parameter	Frequency	Notes
pH	Quarterly	Target depends on metallurgy
Conductivity	Quarterly	Detects contamination or leaks
Nitrate/molybdate	Quarterly	Corrosion inhibitor levels (if used)
Iron, copper	Semi-annually	Indicates active corrosion
Microbial activity	Semi-annually	Biofilm risk
Glycol concentration	Annually	If applicable
TDS	Quarterly	General contamination indicator

Water quality testing summary

Routine water quality testing:

- protects human health
- meets EPA/EGLE standards
- extends equipment life and preserves warranties
- reduces costly repairs and emergency shutdowns
- meets ASHRAE 188 compliance

System type	Key parameters	Risks mitigated	Testing frequency
Domestic water	pH, chlorine residual, lead/copper, turbidity, coliforms	Health risks, corrosion, compliance	Weekly to annually
Cooling towers	Conductivity, pH, hardness, turbidity, Legionella, biocide	Legionella, scaling, corrosion	Daily to quarterly
Closed loops	pH, conductivity, inhibitors (if used), iron/copper, HPC	Corrosion, biofilm, asset degradation	Quarterly to annually

Thank you!

Andrew Ward

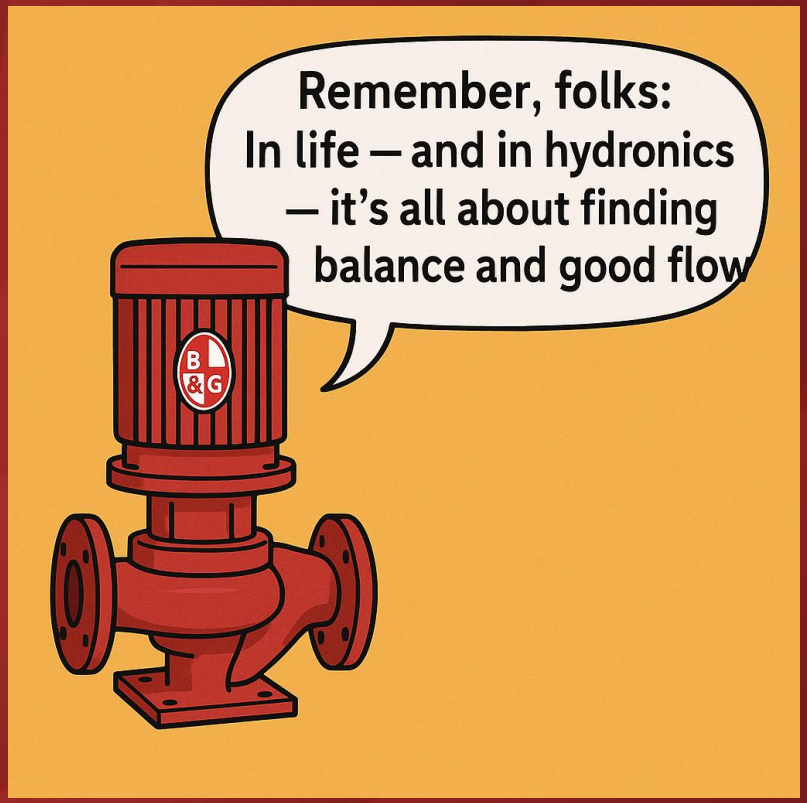
248-410-4028

award@deppmann.com

www.watersolutionspartner.com

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