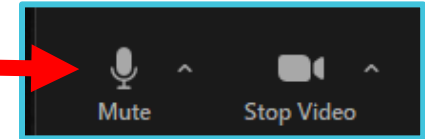
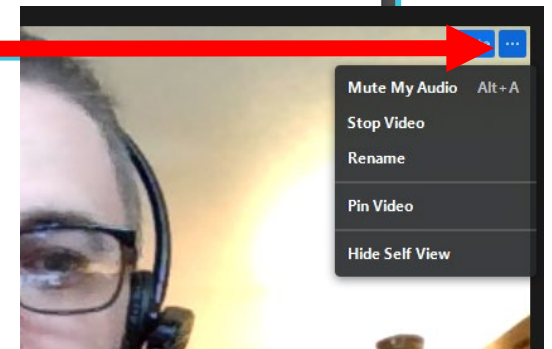
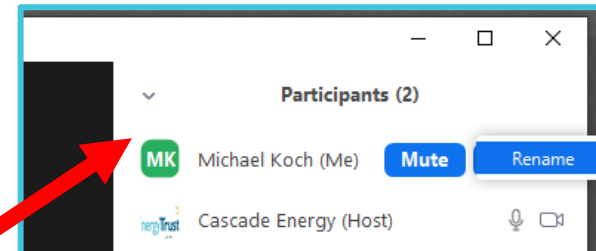


# Using Zoom!

**Mute yourself!** Have a question? Use the chat feature.  
*Controls accessed at the bottom*

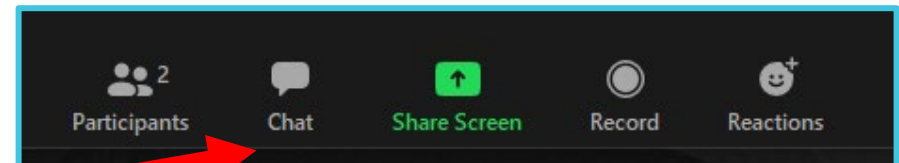


**Rename yourself:** "Name (Company)"  
*Right click on your picture or 3 dots*  
**OR**  
*Controls accessed at the right after clicking 'Participants' at bottom.*



**For Tyson renaming!**  
Tyson - Fresh Meats  
Tyson - Prepared Foods  
Tyson - Poultry

**Access Chat at the bottom**



*This session will be recorded for those not in attendance!*



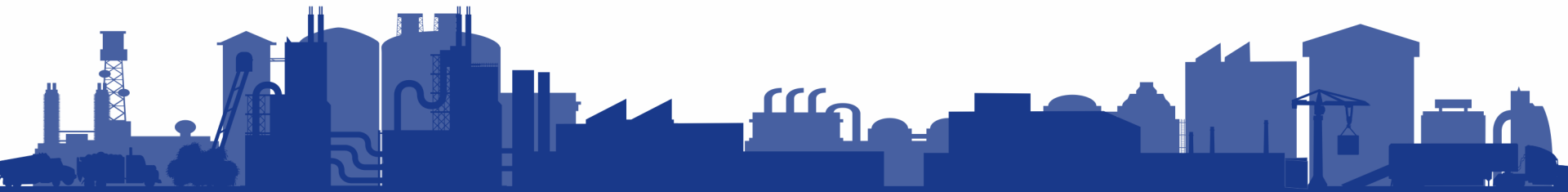
# REFRIGERATION SYSTEM VIRTUAL IN-PLANT TRAINING

**SESSION 5 – FEB 7, 2023**

# 2 Truths and a Lie

Take the  
Poll

# Session 5: Evaporators





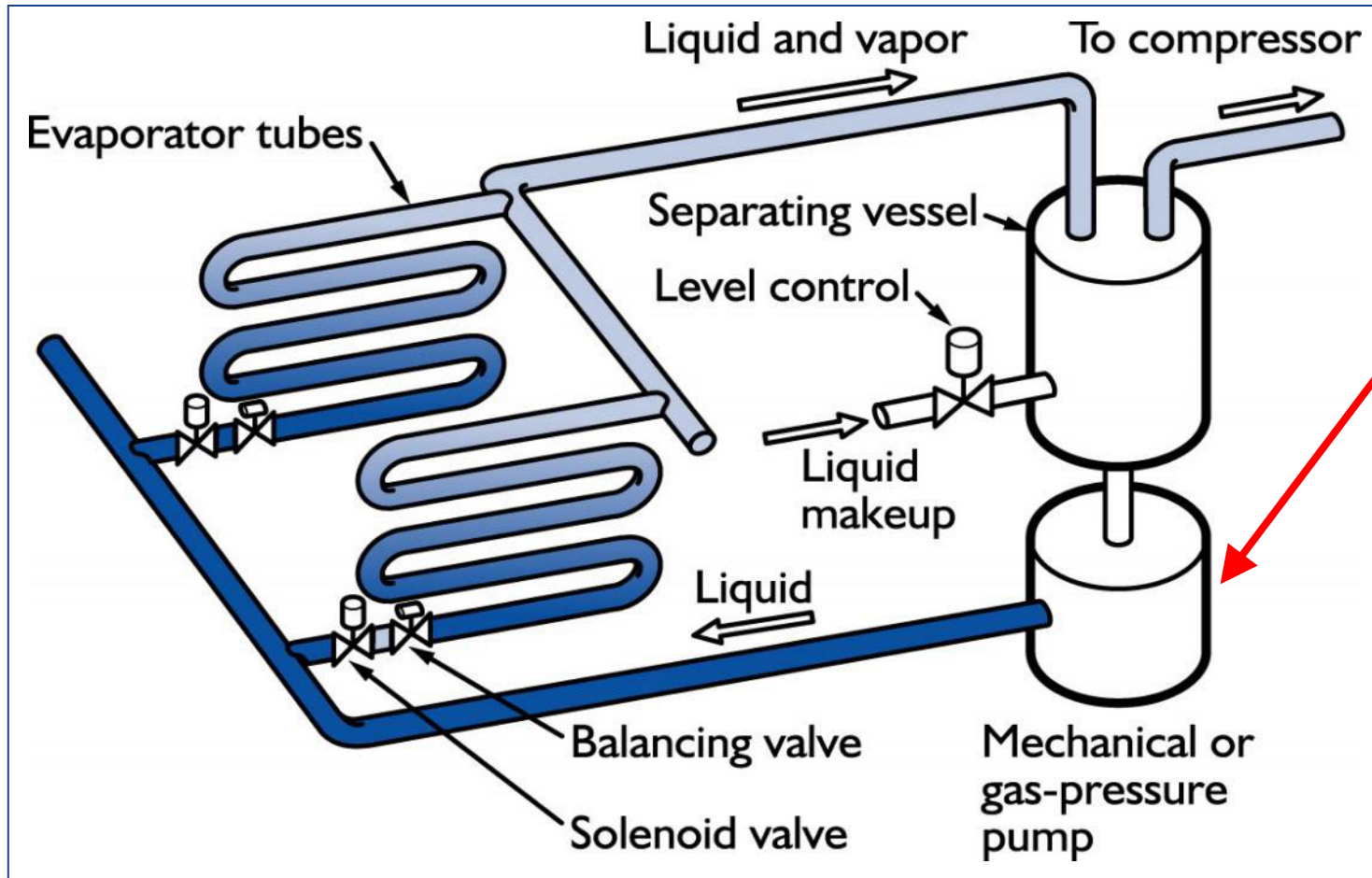
# Today's Agenda – Session 5

- Evaporator Basics
- Troubleshooting Problems
- Valve Groups
- Evaporator Tool and Check Sheet
- Q & A + Energy Opportunity Development

# Evaporator Types and Control Basics



# Liquid Recirculated or Overfeed



Typically a centrifugal pump. Philips pumper drum design uses gas pressure

# Liquid Overfeed Evaporator Capacity Control

## Capacity Control

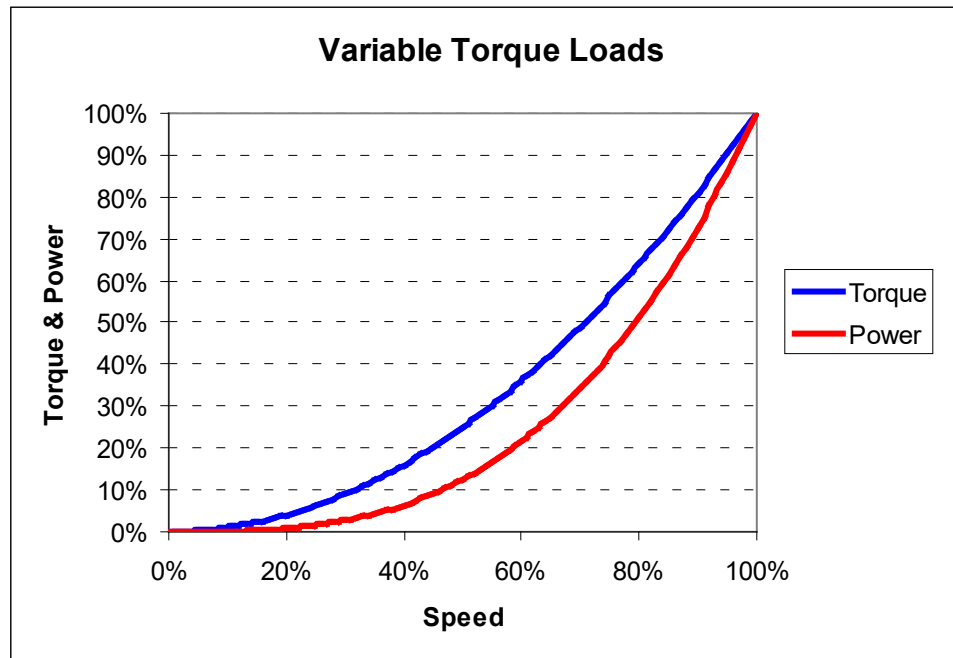
- a) Constant fan operation (cycle liquid solenoid)
- b) Fan cycling
- c) Variable speed - VFDs



# Fans—Variable Torque Loads

## Fans follow “affinity” or “cubic” law

- Capacity  $\sim$  speed, power  $\sim$  speed<sup>3</sup> !!!!!
- Example at 50% speed: capacity is 50%, power is 12.5%



# Individual vs. Group VFD Control



10 hp



10 hp

# Individual Evaporator Control

**Evaporator 1:**

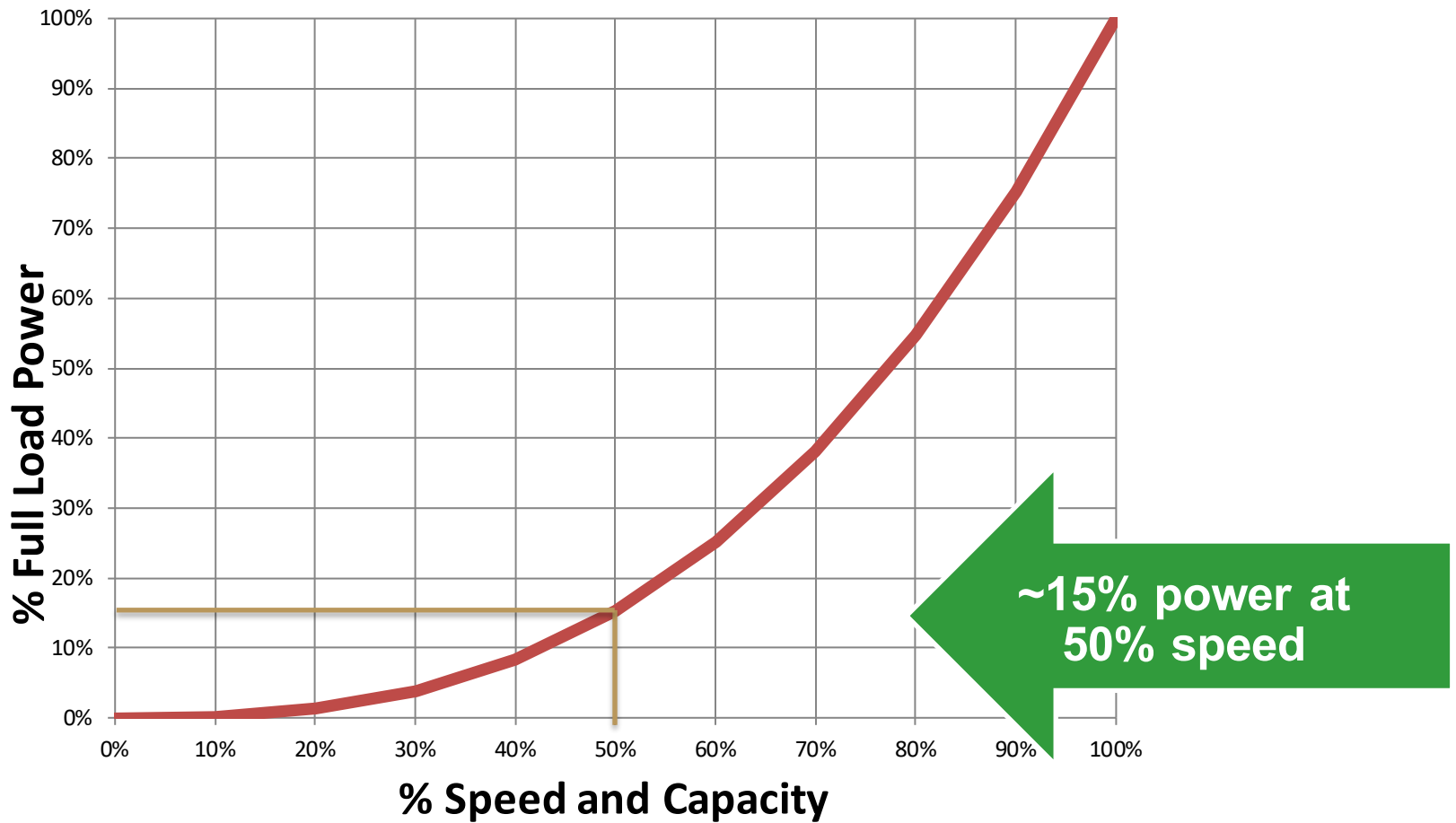
**100% speed =  
10 hp**

**Evaporator 2:**

**0% speed =  
0 hp**

**Case 1: 10 hp total**

# VFD Grouped Fan Control





# VFD Grouped Fan Control



**Evaporator 1:**

**50% speed =  
1.5 hp**

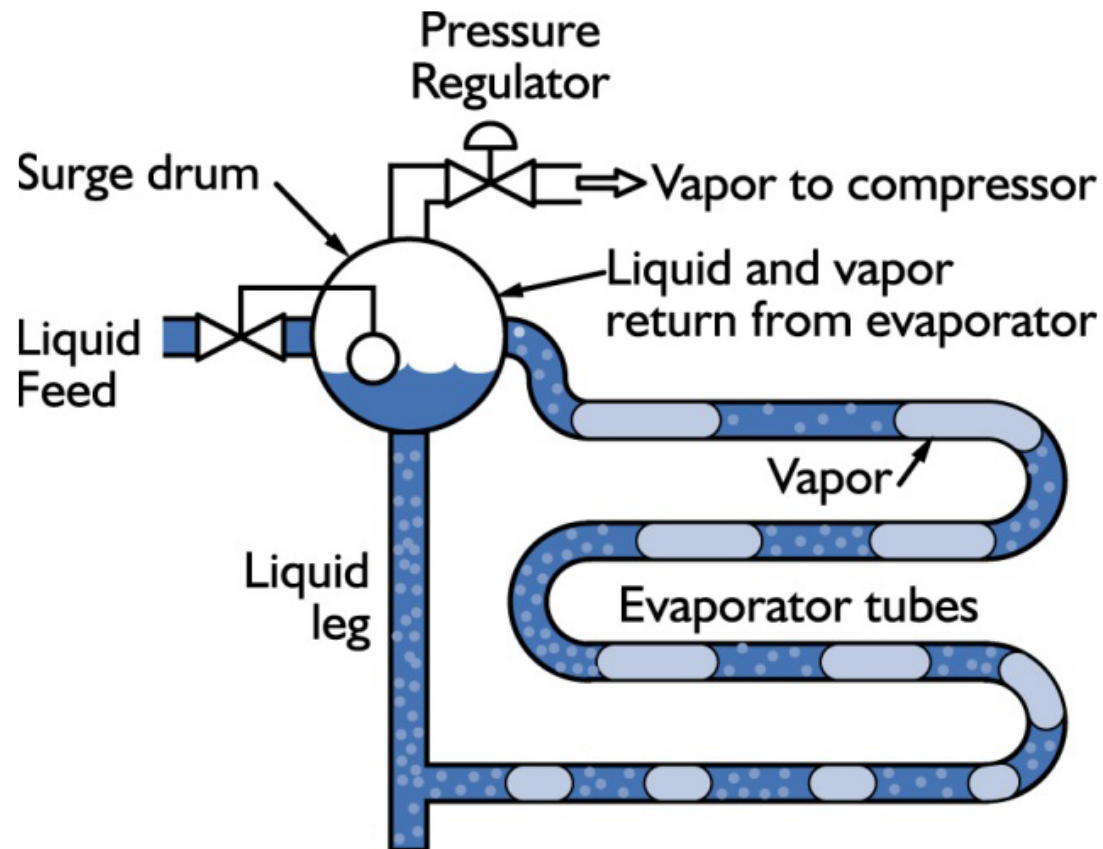


**Evaporator 2:**

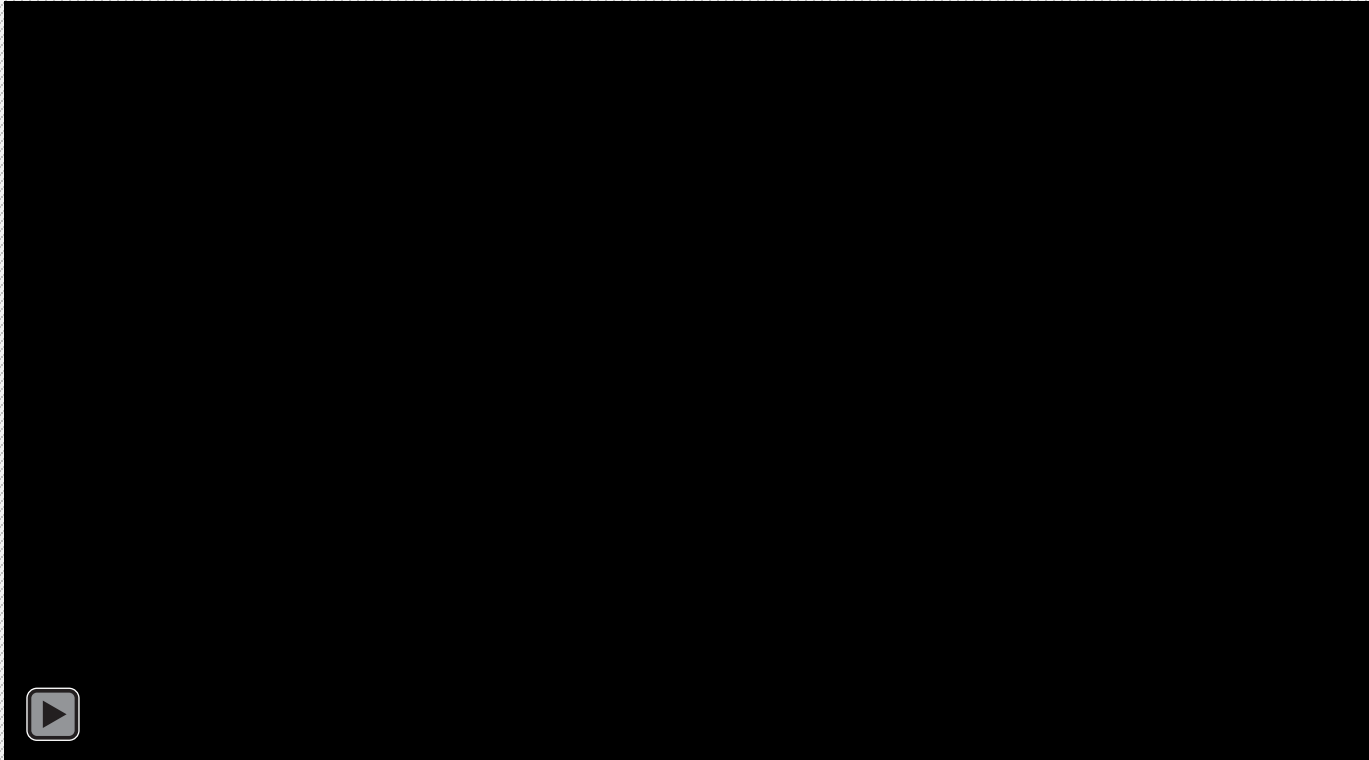
**50% speed =  
1.5 hp**

**Case 2: 3 hp total**

# Flooded Design



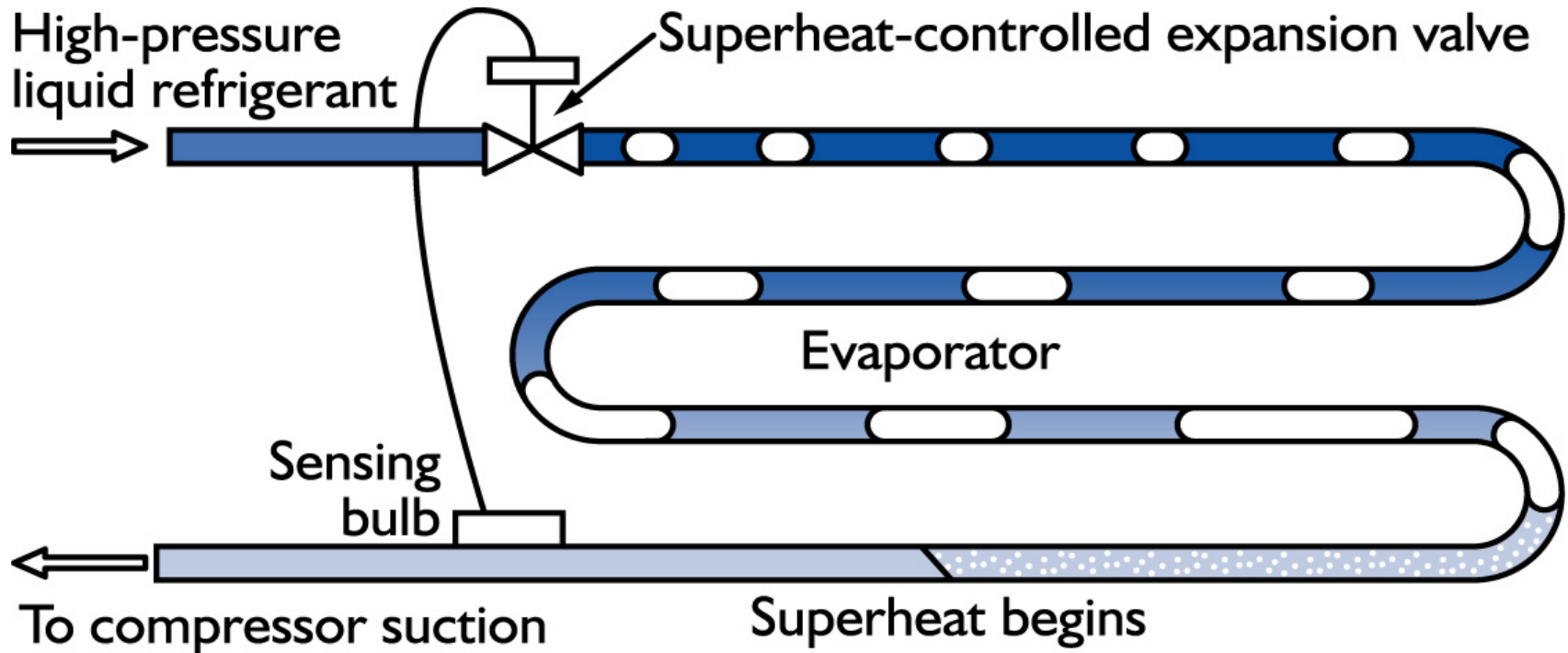
# Flooded Design



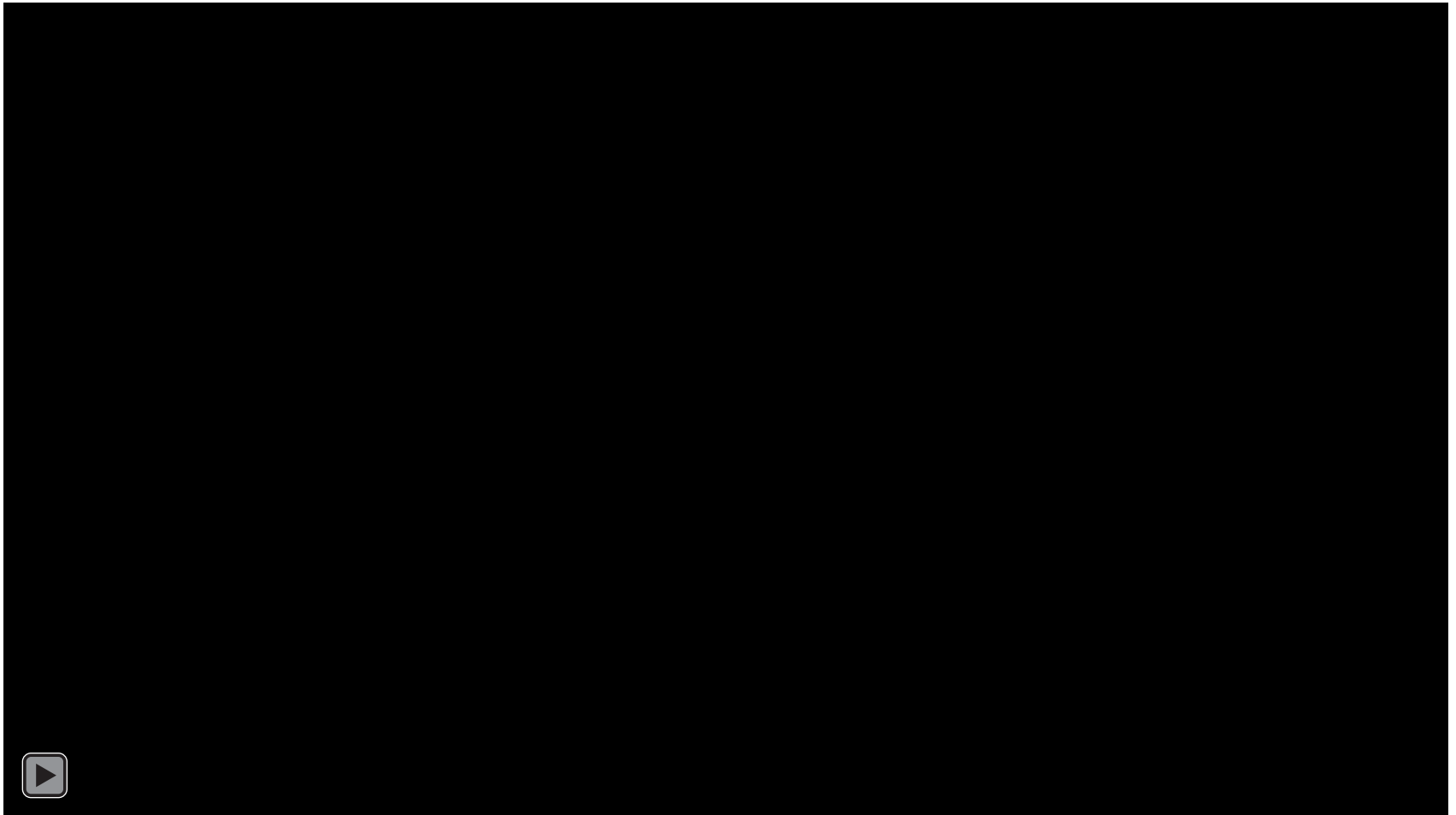
# Sample Flooded Coil



# Direct Expansion

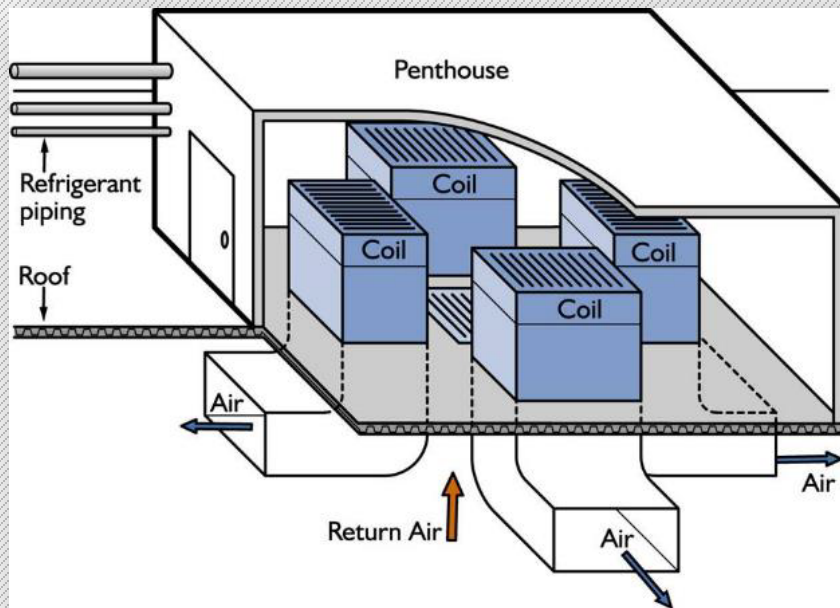


# Direct Expansion



# Typical Evaporator Configurations

## Penthouse



## Ceiling Hung



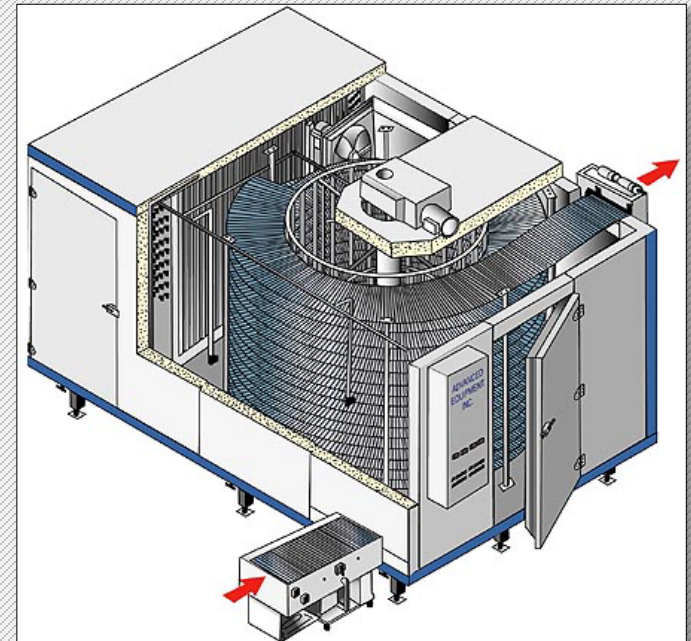


# Typical Evaporator Configurations

## Freeze Tunnel



## Spiral Freezer





# Flooded Liquid Cooling Evaporators

- Shell and tube
- Plate and frame
- Falling film
- Ice builders



# Liquid Cooling

- Tighter approaches with liquid cooling, 5-6°F
- Back pressure regulator controls common
- Fixed regulator or motorized



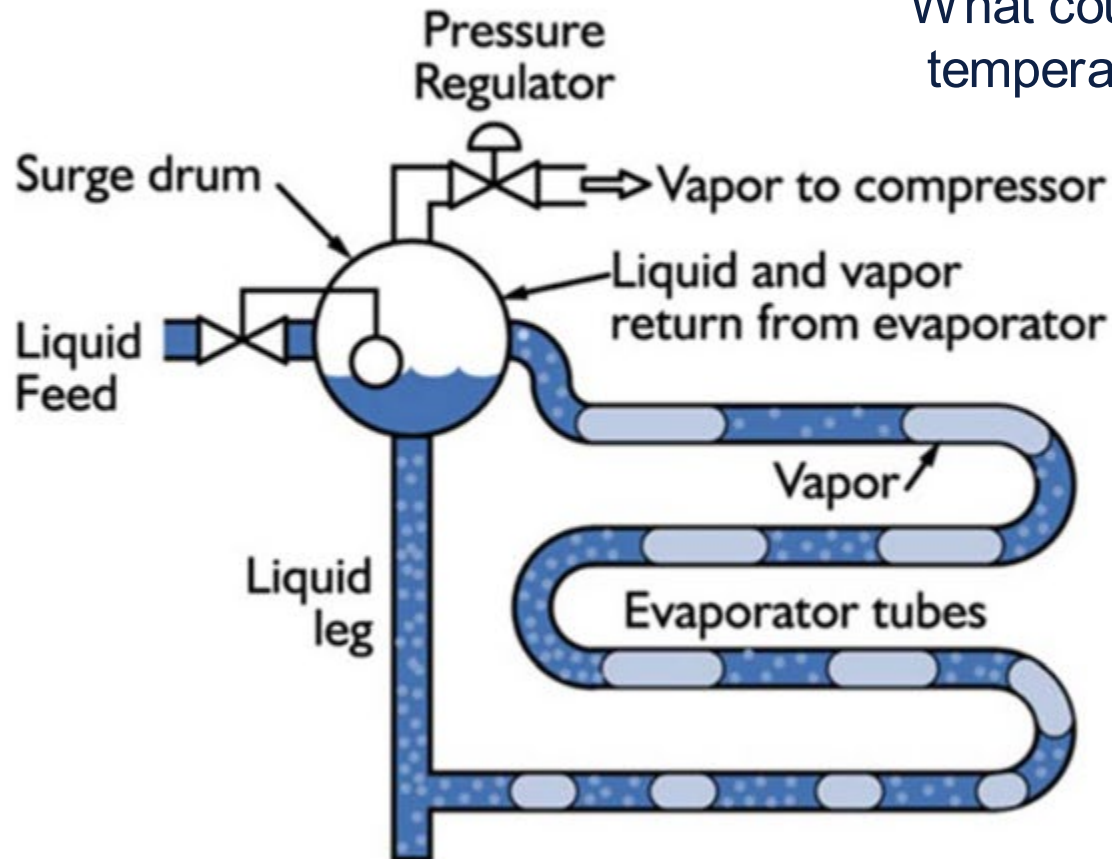
# Liquid Pumping



## What type of evaporator is this?

EVAPORATOR QUESTION CARD #01

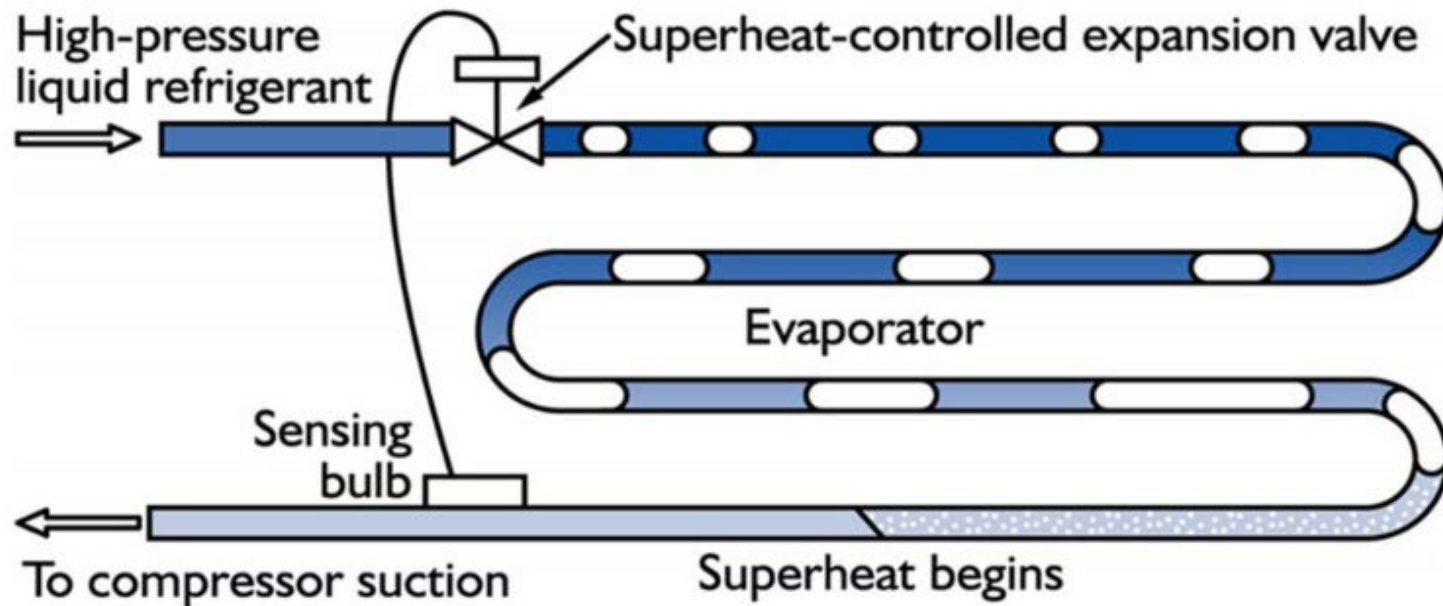
What could be used for temperature controls?



## What type of evaporator is this?

EVAPORATOR QUESTION CARD #03

What could be used for  
temperature controls?





## What is the total evaporator power draw?

EVAPORATOR QUESTION CARD #08



**5 x 1 hp fans, each at 90% Speed**

## Which scenario provides more capacity?

EVAPORATOR QUESTION CARD #10

### Scenario 1



**10 hp — 100% Speed**



**10 hp — off**

### Scenario 2



**10 hp — 50% Speed**



**10 hp — 50% Speed**

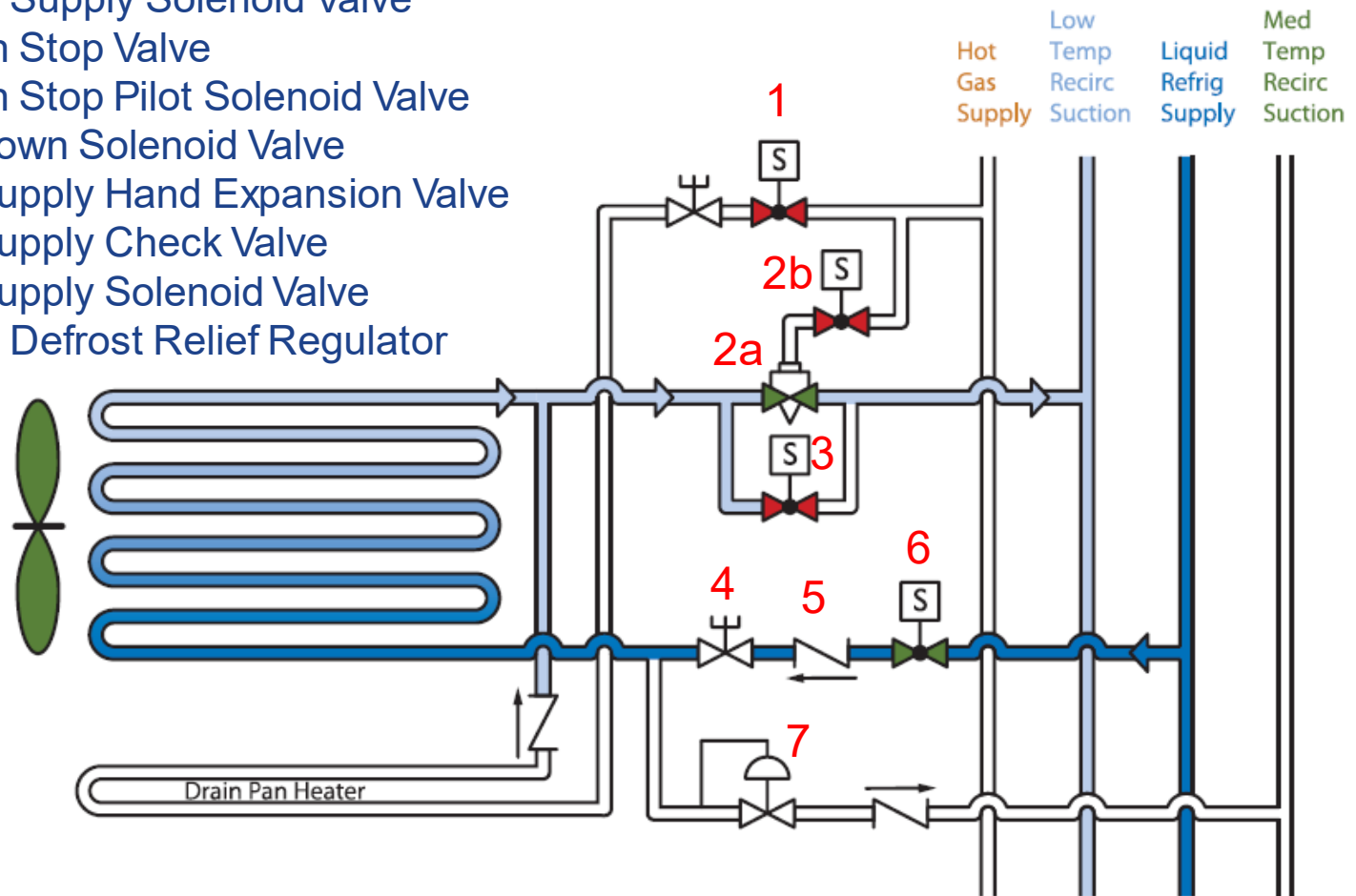
# Identify and Troubleshoot Poor Performance





# Valve and Regulator Descriptions

- 1 – Hot Gas Supply Solenoid Valve
- 2a – Suction Stop Valve
- 2b – Suction Stop Pilot Solenoid Valve
- 3 – Bleed Down Solenoid Valve
- 4 – Liquid Supply Hand Expansion Valve
- 5 – Liquid Supply Check Valve
- 6 – Liquid Supply Solenoid Valve
- 7 – Hot Gas Defrost Relief Regulator



# Impact of Poor Evaporator Performance

- Loose temperature control
- Lower suction pressure (more lift)
- More fan operation
- Increased system power

Take the  
Poll

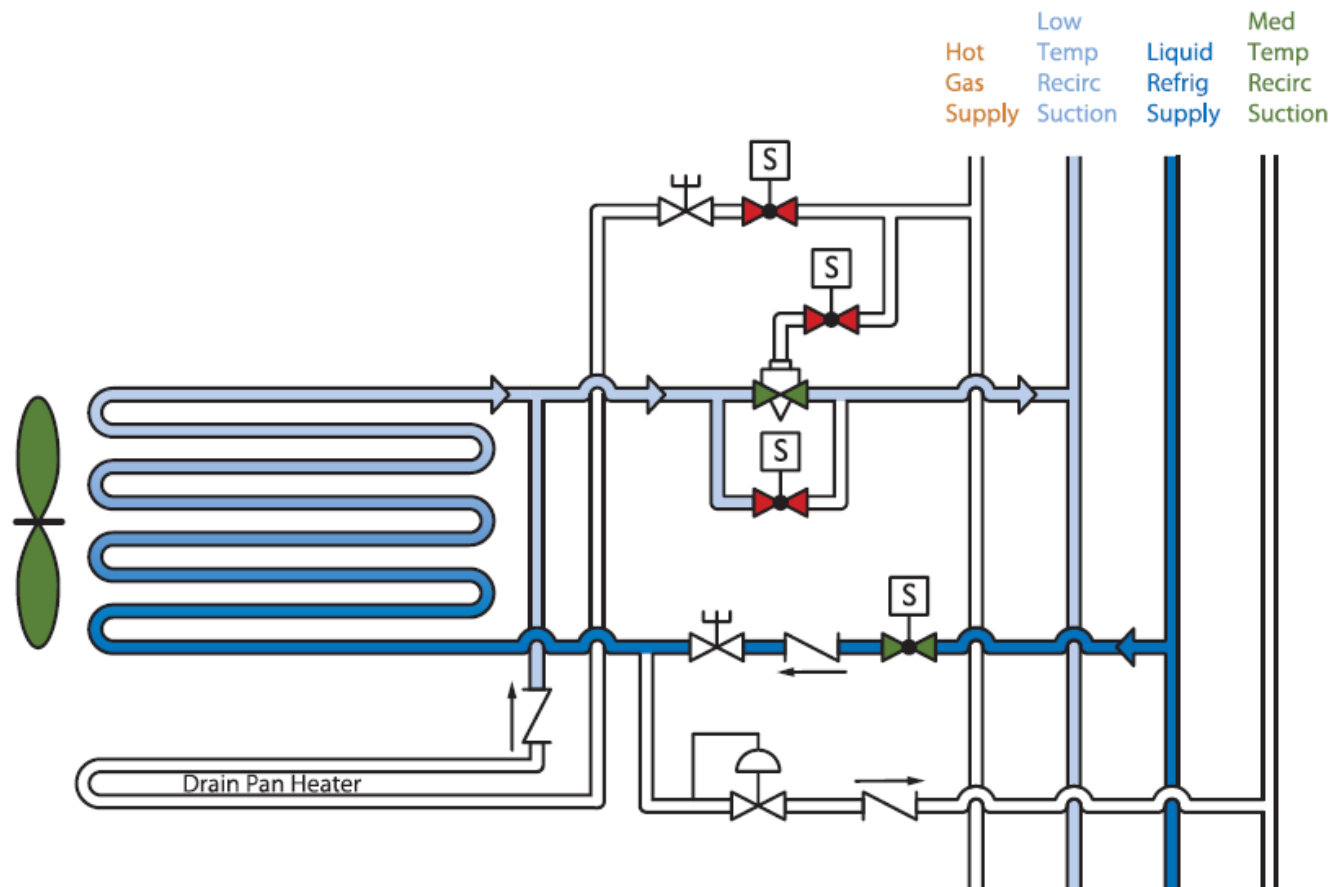
# Three Keys of Evaporator Performance

Liquid

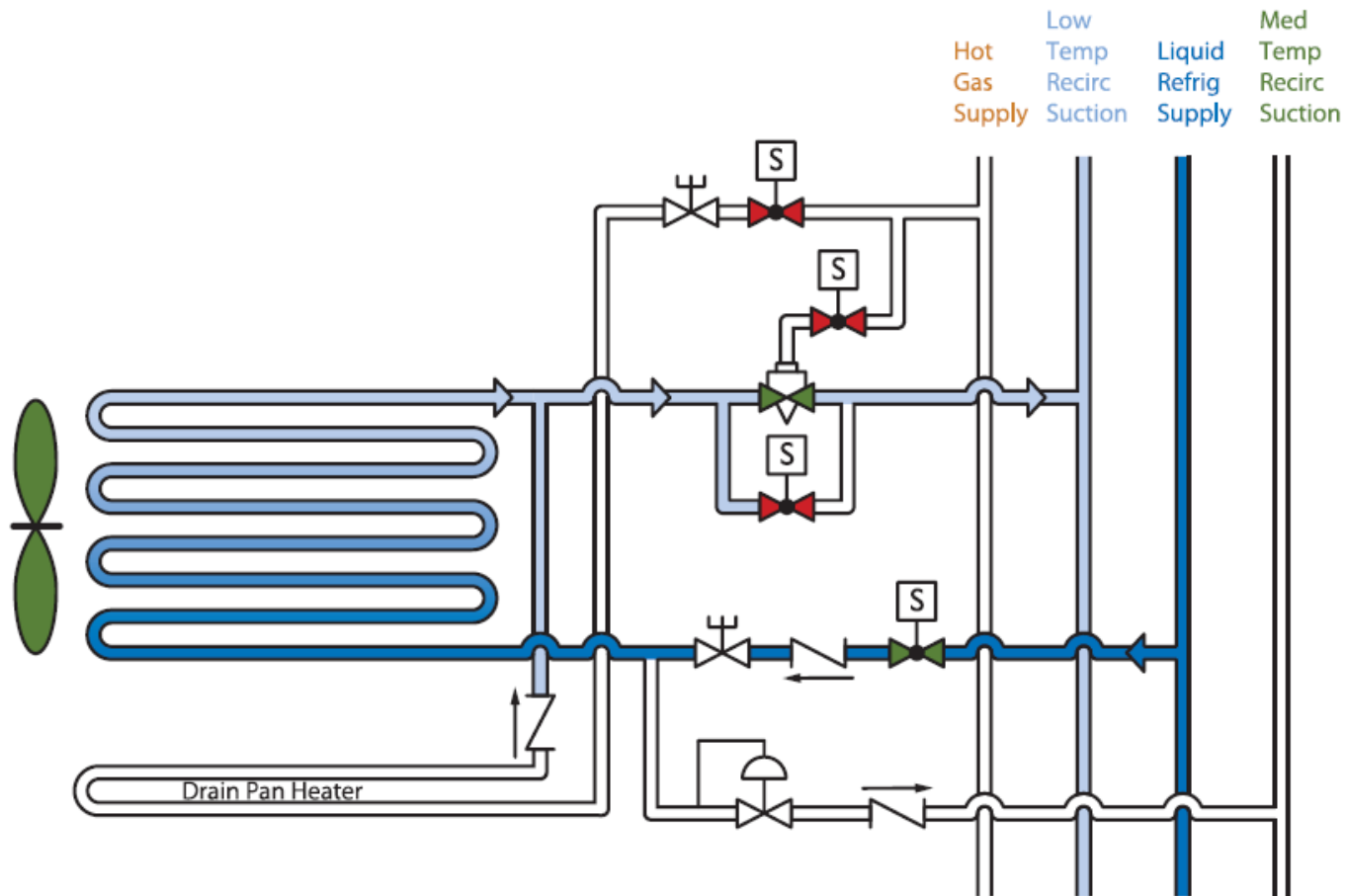
Suction

Air

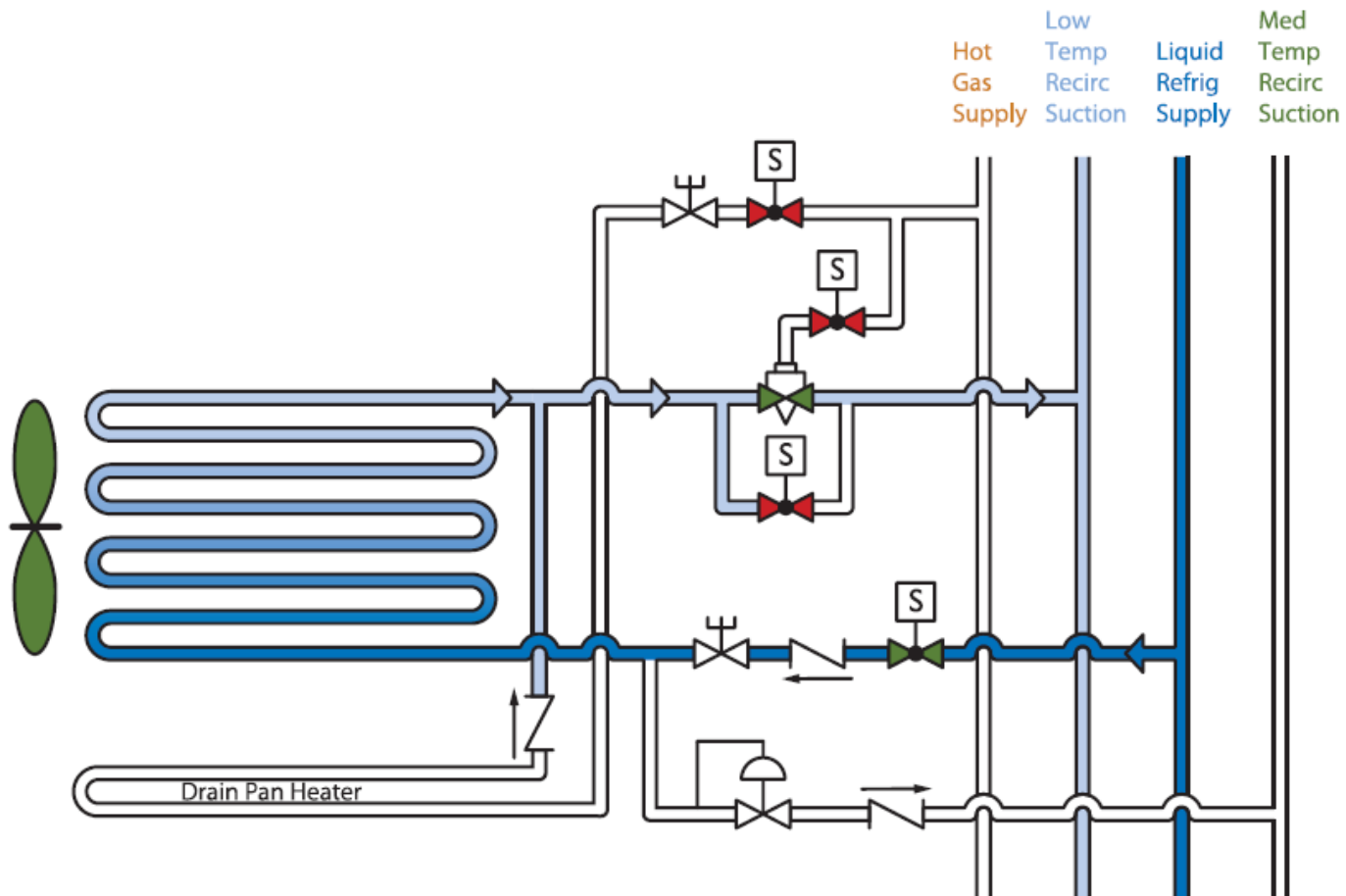
# Liquid



# Suction



# Air



# Contaminants—Water

- Gives a temperature penalty
- Forces lower suction (more lift)

## Higher Temperatures Due To Water

Suction Pressure	Sat. Temp.	PERCENT WATER		
		2.5%	5%	10%
44.1 Psig	29.5°	30°	31°	32.5°
29.4 Psig	16.0°	17.0°	17.5°	19.5°
0 Psig	-28.0°	-27.5°	-27°	-25°
8.9" Hg	-40.5°	-40°	-39°	-37.5°

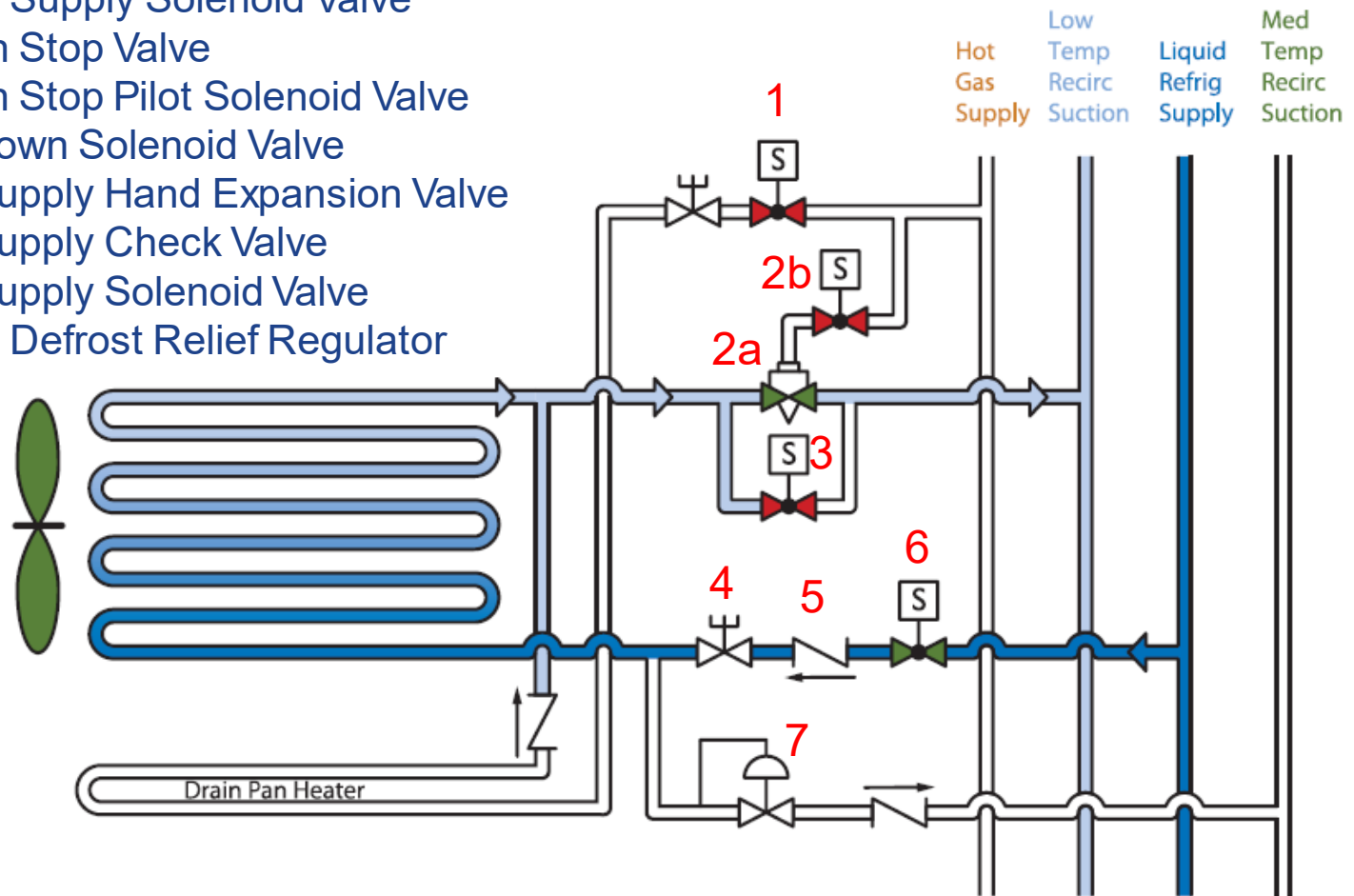
# Contaminants—Oil

- Reduces evaporator capacity
- Especially bad for DX coils
- Can cause defrost problems



# Valve and Regulator Descriptions

- 1 – Hot Gas Supply Solenoid Valve
- 2a – Suction Stop Valve
- 2b – Suction Stop Pilot Solenoid Valve
- 3 – Bleed Down Solenoid Valve
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- 5 – Liquid Supply Check Valve
- 6 – Liquid Supply Solenoid Valve
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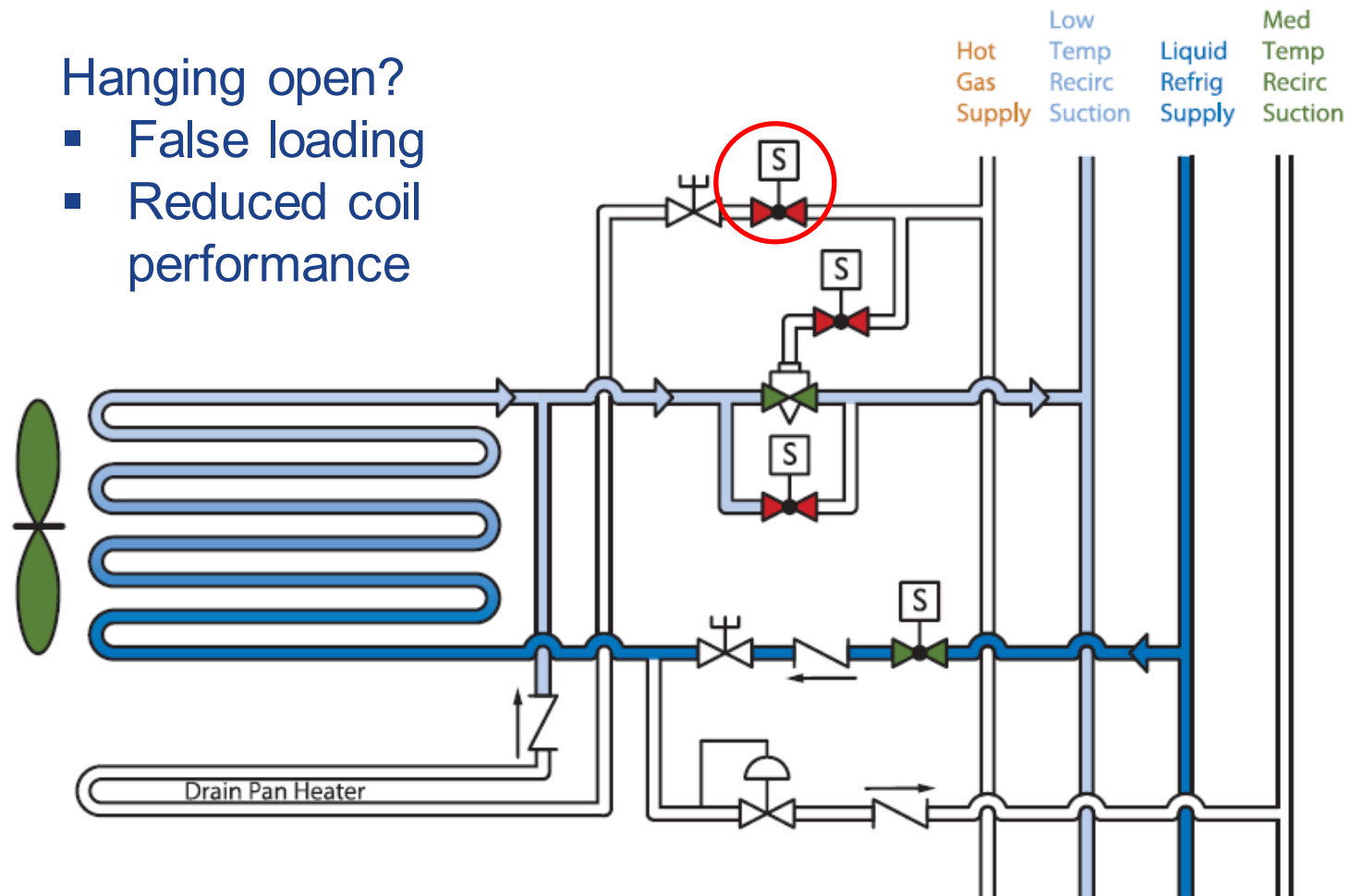


Take the  
Poll

# Hot Gas Solenoid Valve

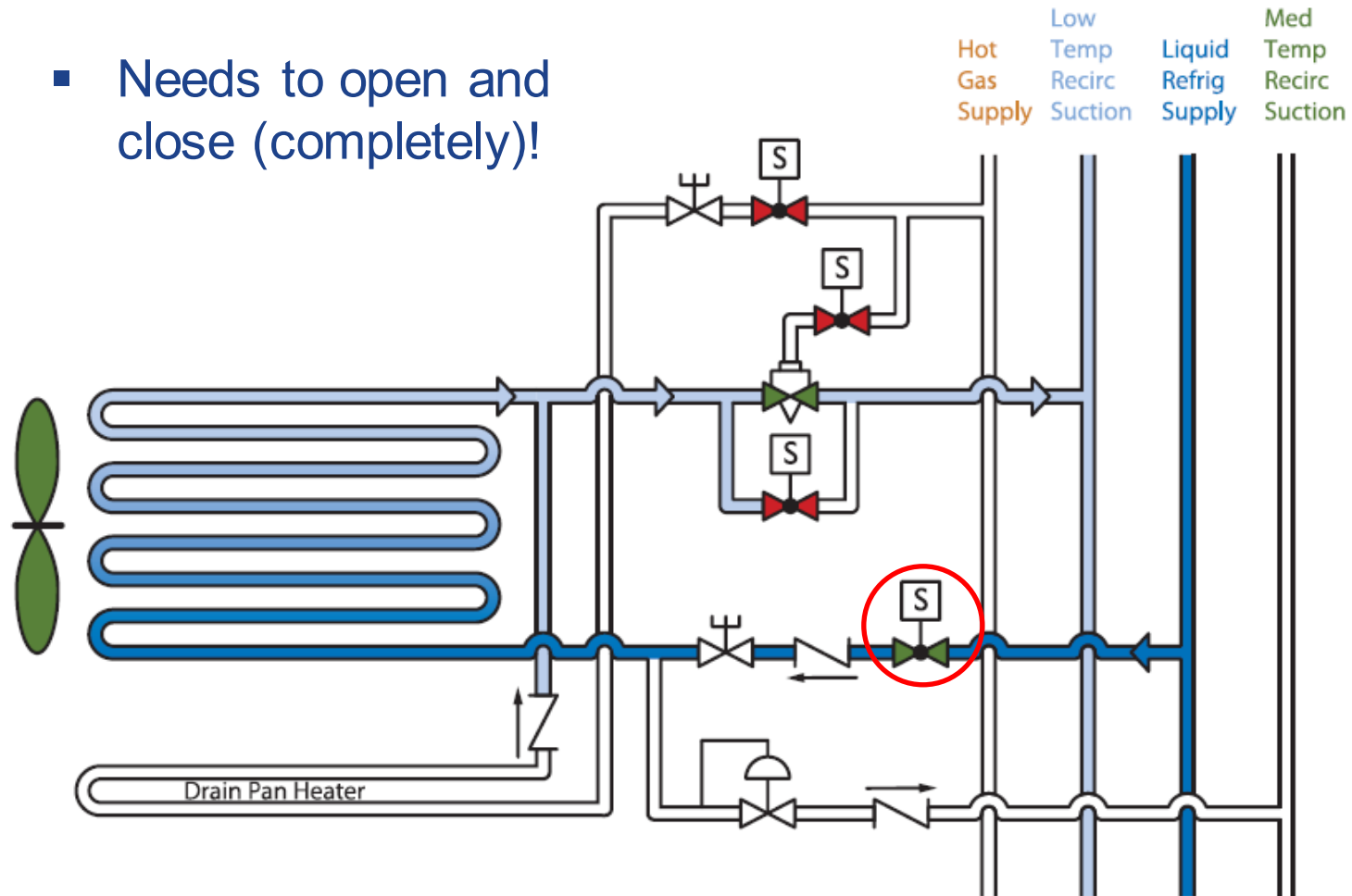
Hanging open?

- False loading
- Reduced coil performance



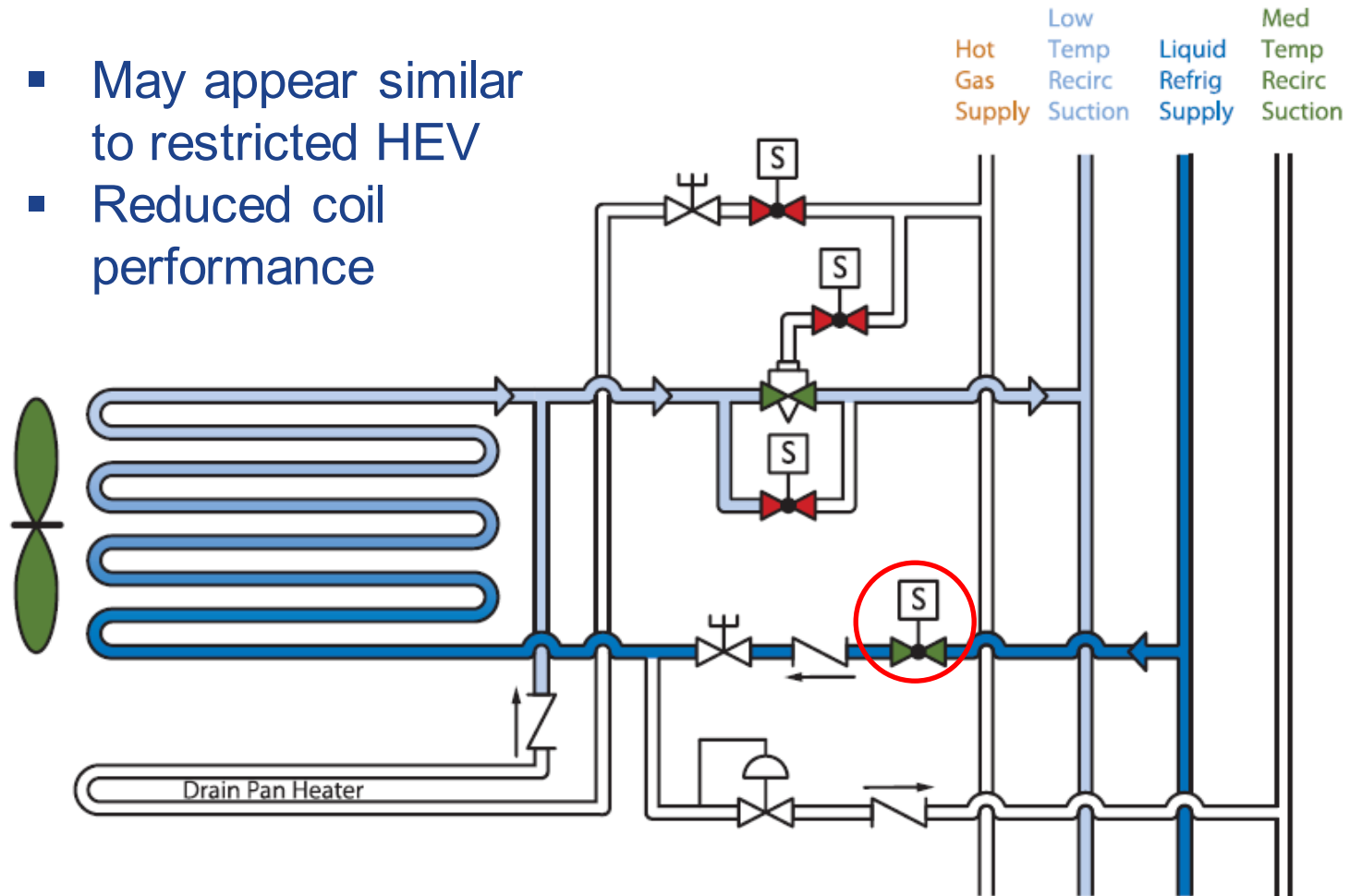
# Liquid Solenoid Valve

- Needs to open and close (completely)!



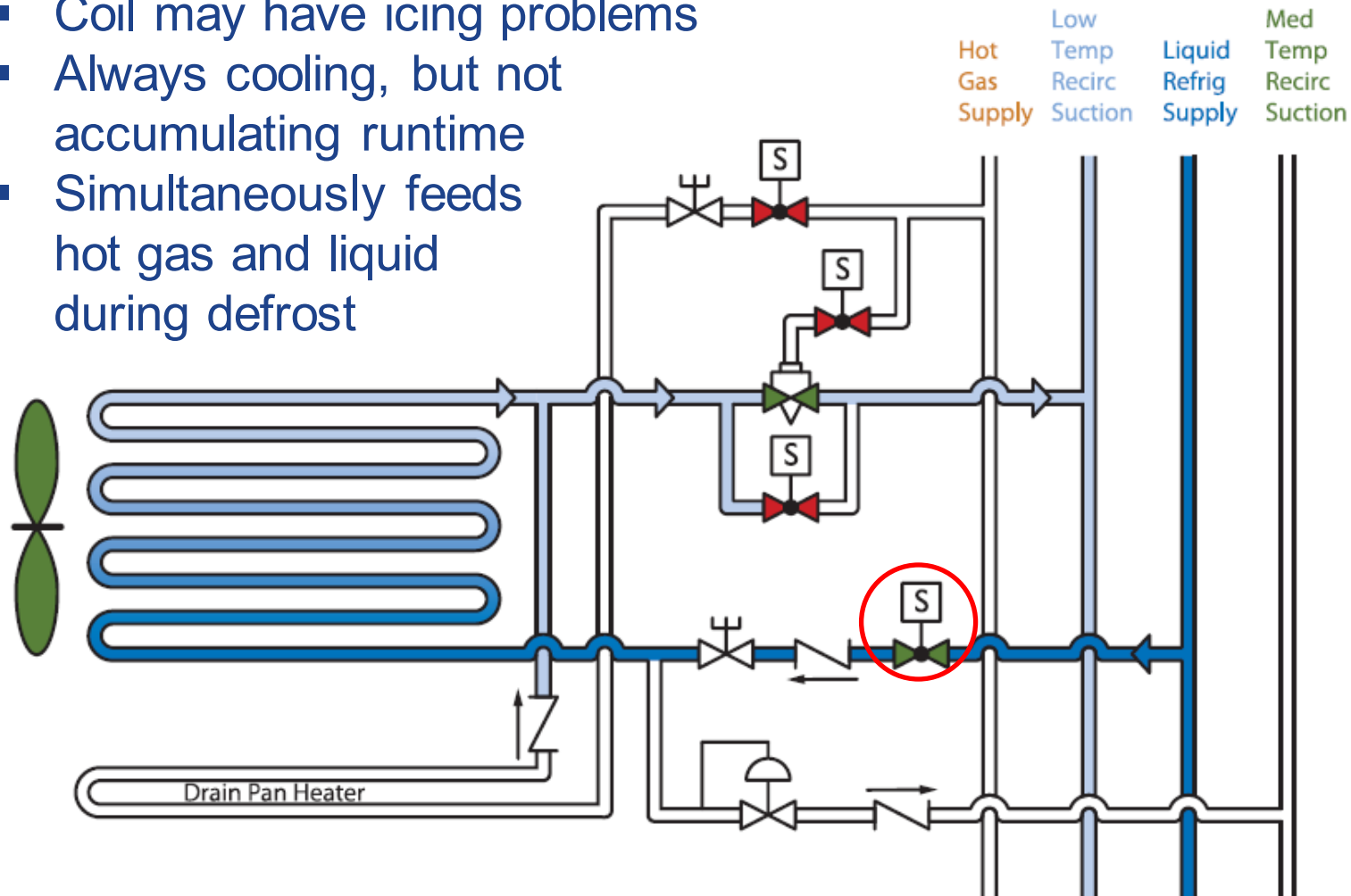
# Liquid Solenoid Valve Not Fully Opening

- May appear similar to restricted HEV
- Reduced coil performance



# Liquid Solenoid Valve Not Fully Closing

- Coil may have icing problems
- Always cooling, but not accumulating runtime
- Simultaneously feeds hot gas and liquid during defrost

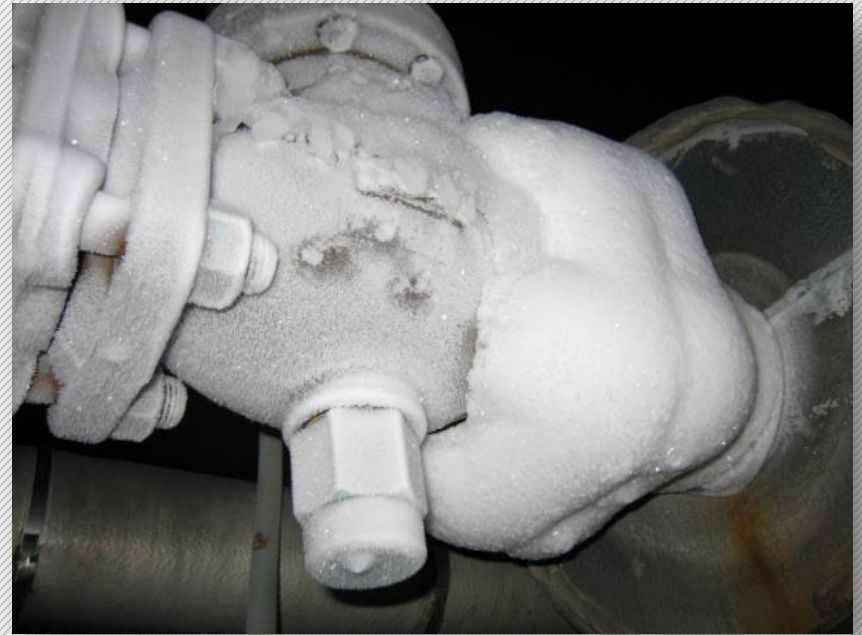


# What's Wrong With This Picture?





# What's Wrong With These Pictures?



# What's Wrong With This Picture?






# What's Wrong With This Picture?



# What's Wrong With This Picture?



# Evaporator Tool Review



## Ammonia Refrigeration Energy Efficiency Tool

Site Name: **ACME Widgets**

City: Moses Lake

State: Washington

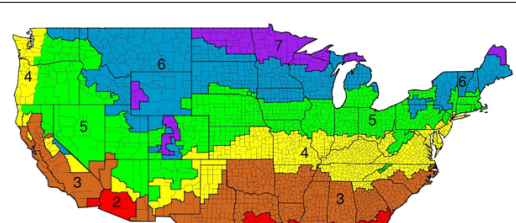
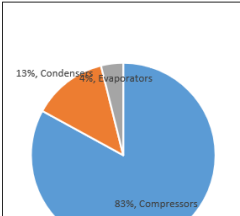
Contact: Jane Doe

Phone: 123-456-789

\$/kWh: \$0.080

Subsystem	Units Operating	Total Horsepower	Energy Consumption (kWh)	% of Total	Estimated Energy Cost
Compressors	3	600	2,943,122	83%	\$ 235,450
Condensers	3	113	466,551	13%	\$ 37,324
Evaporators	3	24	137,880	4%	\$ 11,030
<b>Totals</b>		<b>737</b>	<b>3,547,554</b>	<b>100%</b>	<b>\$ 283,804</b>

What's your climate like? **5**

## Evaporator Inventory

Zone Name	What Type of Load?	Meeting Room Temperature?	How Are the Fans Controlled?	Annual Zone Duty (%)	Nominal Capacity Per Coil (TR)	Design TD (°F)	Room Temp Setpoint (°F)	Suction or Fluid Temp (°F)	Number of Evaporator Coils	Number of Fans per Coil	Nameplate Power per Fan (HP)
1	Freezer	Never	Always On	100%		10	0	-15	2	3	3
2	Cooler	Sometimes	Always On	100%		10	34	20	2	3	0.5
3	Dock	Never	Always On	100%		10	40	20	2	3	0.5

# Evaporator Check

Evaporator Check		
Date:		Site:
Completed By:		Evaporator & Valve Group ID:
<b>1) Evaporator Visual Inspection:</b>		
Time Since Last Defrost:		
Time Until Next Defrost:		
Frost Loading (Clear, Light, Heavy):		
Dirt or Debris on Coil?	Yes No	
All Fans Working & Right Direction?	Yes No	
Sketch Frost Pattern:		
<b>2) Valve Group Inspection:</b>		
	Current State	Describe the Frost/Sweat Pattern Upstream & Downstream of Valve
Hot Gas Solenoid:	open closed	
Suction Stop:	open closed	
Suction Stop Pilot Solenoid:	open closed	
Bleed Down Solenoid:	open closed	
Liquid Supply Hand Expansion:	of turns	
Liquid Supply Solenoid:	open closed	
Hot Gas Defrost Back Pressure Regulator:	setting: psig	
<b>3) Evaporator Performance:</b>		
Evaporator TD:	°F	Evaporator ΔT: °F
Known coil performance issues and other notes:		
<p>1 – Hot Gas Supply Solenoid Valve  2a – Suction Stop Valve  2b – Suction Stop Pilot Solenoid Valve  3 – Bleed Down Solenoid Valve  4 – Liquid Supply Hand Expansion Valve  5 – Liquid Supply Check Valve  6 – Liquid Supply Solenoid Valve  7 – Hot Gas Defrost Relief Regulator</p> <p>Hot Gas Supply  Low Temp Recirc Suction  Liquid Recirc Suction  Med Temp Recirc Suction</p> <p>Drain Pan Heater</p>		

# Evaporator Homework

- One evaporator – Everything you can
  - Bonus – send in interesting pictures
- Fill in the Air Unit and Chillers sheets in Tool

Email to: [steve.koski@cascadeenergy.com](mailto:steve.koski@cascadeenergy.com)

# Next Steps

- Continue developing your list of energy saving opportunities!

- Reach out with questions or for help with analysis

*Stick around after this to ask questions!*

Go to kahoot.it

# Kahoot!

Join from your phone



# Open for Questions!

- Unmute yourself and ask away
- Send a chat
- Email: [steve.koski@cascadeenergy.com](mailto:steve.koski@cascadeenergy.com)

End of  
Session 5