

Evaporator coils & fans

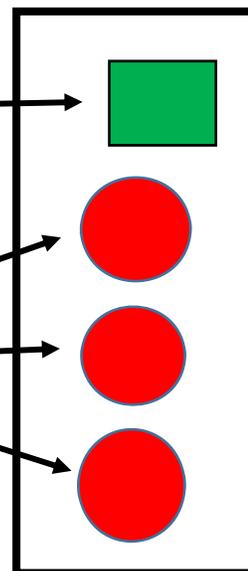
I think this is a good first step in terms of understanding the basic components that make up the system and their juxtaposition with each other. But it does not tell us a lot about the details of how the system is assembled. Refrigeration systems are really interesting but somewhat complex compared to a chilled water cooling system for instance, and there are some critical details to address if you really want to understand this system and identify potential issues.

Questions considerations to address include:

1. There appear to be a number of evaporators associated with one compressor. They seem to be serving the same zone, so I suspect they are in parallel and if they are there are some piping details that need to be done correctly to make that work.
2. How is the defrost cycle accomplished?
3. Is there a head pressure control system on the condenser?
4. Is there hot gas bypass on the evaporator side?
5. What specialties are included and where are they piped in the system (things like sight glasses, solenoid valves, filter/dryers, isolation valves, etc.)
6. Are the elevation changes in the system significant enough and the (Continued below)

Compressor

Condenser coils & fans



(Continued from above)

turn down requirements significant enough to require double suction risers?

8. Are the expansion valves externally or internally equalized?
9. Does each evaporator have its own expansion valve, solenoid valve, etc. or is a common metering connection serving all evaporators?
10. Is there really only one compressor? It seems like that could make them a little exposed in terms of lost product if it were to fail.
11. Are their distributors on the evaporator coils?

Understanding that is quite an undertaking, but once you have gone through it, it will tend to stick with you. I learned by reading the Trane Refrigeration Manual a lot combined with the support of mentors and one of my very first field tech projects that involved a built up refrigeration system serving an ice rink facility to make ice in the winter and cool the facility in the summer.

I think you still have to purchase the Trane refrigeration manual (vs. a free download), but it was worth the price, at least the last time I checked. Having said that, the free version of Roy Dossatt's book that I mention in the resource list is at least as good, if not better in terms of being written in layman's terms. Copeland also makes their refrigeration manual available at no cost (also on the reading list). I have not read it cover to cover, but it is very similar to the Trane manual.

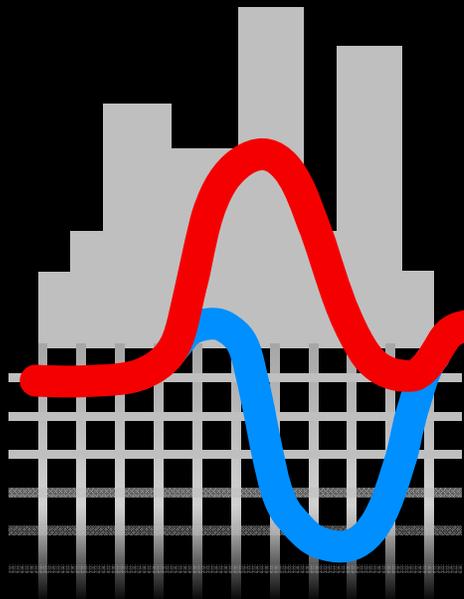
Another good resource is the article on the pH diagram along with the various Sporlan hardware manuals I uploaded to the website as follow up information from the November class. The PH diagram is kind of like a psych chart for refrigeration processes and you can understand a lot about them by plotting them out on it. The Sporlan information is just really, good, solid, well illustrated documentation about how various refrigeration components work.

So, one way or the other, I think you have the textbook you need for doing this and really digging into the system.

In terms of mentoring, you have Ryan and I; probably me I suspect since I'm not sure Ryan has done much refrigeration piping design and will refer you to me if you call to set up something. We can do it in person on the day before the class or via *GoToMeeting*, as you know.

And you obviously have a field project to apply what you are learning too. I think this project is good one for that since it is not exactly "vanilla" in that I think the system will have a few more gizmos and nuances than a DX circuit on a package system. But it does not seem to be overly huge and complex and I think you will be able to get your head around it.

I realize this might all seem a bit overwhelming but I think if you started by reading about a basic refrigeration cycle (yours will be very similar to the air-cooled chiller in the slides I will insert after this) and understanding what the components are by reading about them in the Sporlan literature and then went out and found those parts on your system, you will begin to feel comfortable, especially if you did a one-on-one session or two to answer questions.



Facility Dynamics

ENGINEERING

Vapor Compression Refrigeration

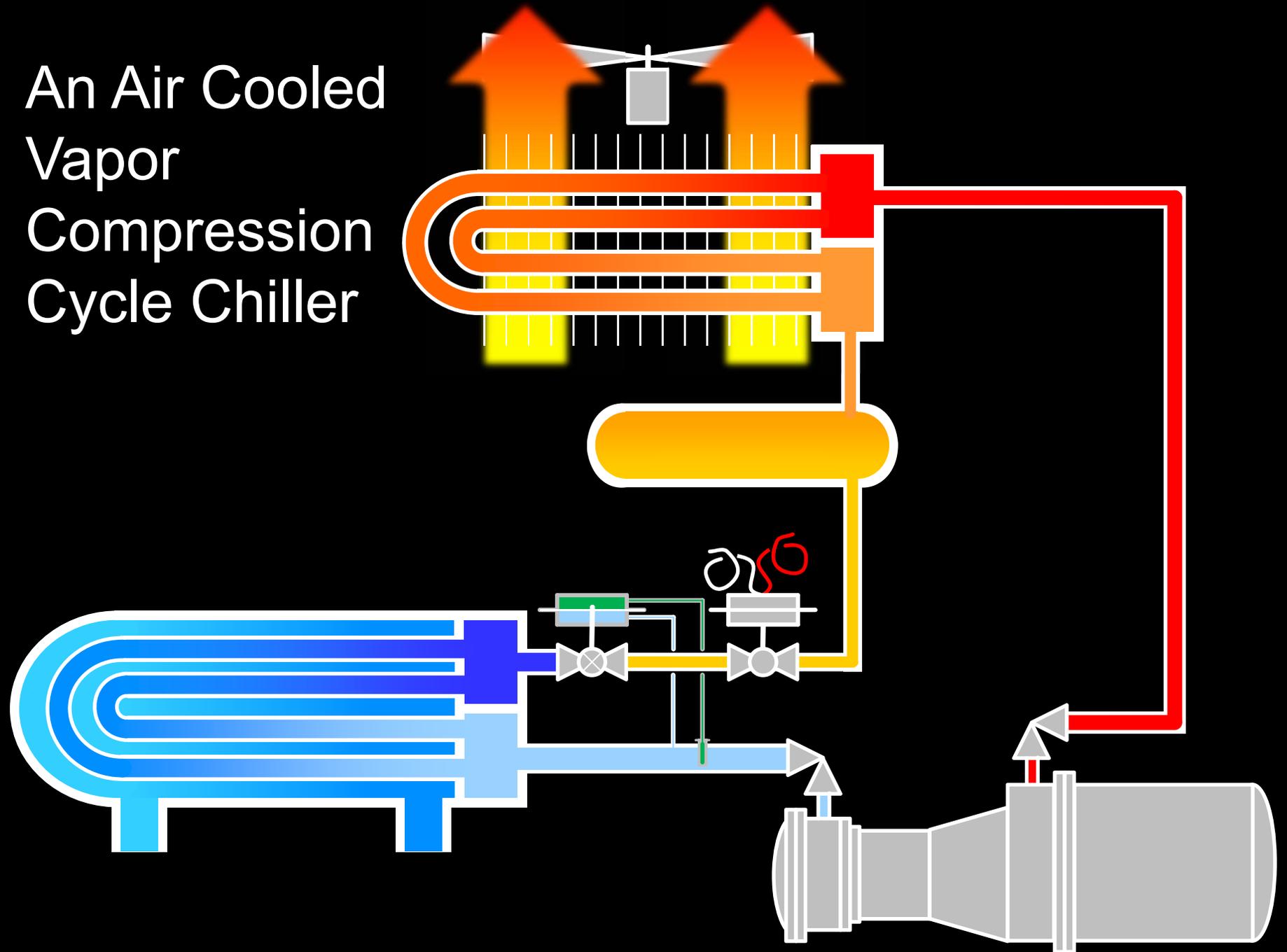
Leveraging Phase Changes in Saturated Systems to Provide Cooling

Presented By:

David Sellers

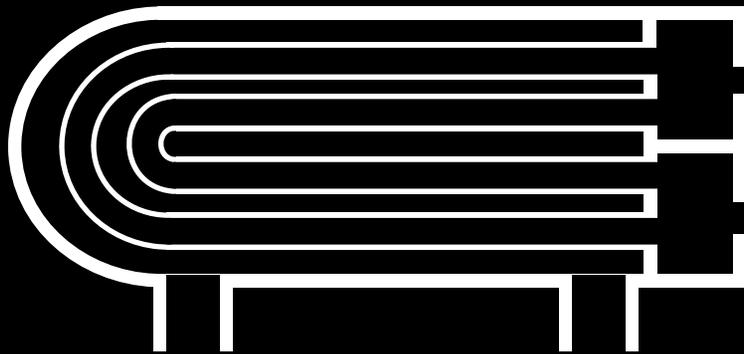
Senior Engineer, Facility Dynamics Engineering

An Air Cooled Vapor Compression Cycle Chiller



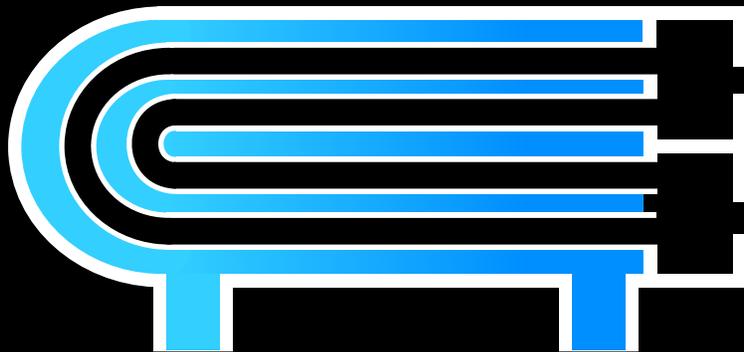
An Air Cooled Vapor Compression Cycle Chiller

Start with a heat exchanger;
a.k.a the evaporator



An Air Cooled Vapor Compression Cycle Chiller

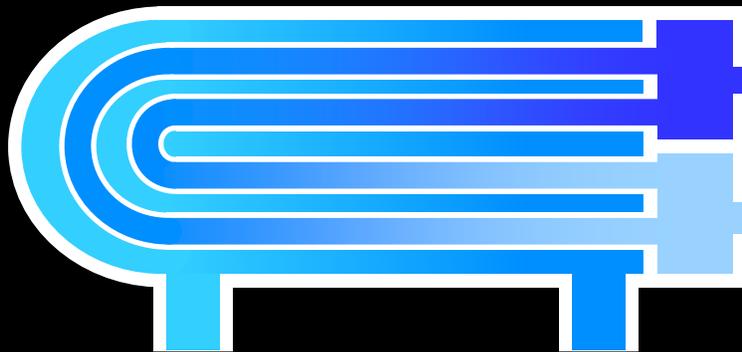
Start with a heat exchanger;
a.k.a the evaporator



Add the fluid you want to cool on
one side of the heat transfer surface

An Air Cooled Vapor Compression Cycle Chiller

Start with a heat exchanger;
a.k.a the evaporator



Place a refrigerant
on the other side
of the heat transfer
surface

Add the fluid you want to cool on
one side of the heat transfer surface

Refrigerant

- Substance used to absorb heat from the item or area to be cooled
- Vapor compression cycles leverage the latent heat of vaporization of the refrigerant
 - Energy that changes the liquid to a vapor
 - The evaporator functions as a saturated system

Saturated Systems



Phase Changes and Saturated Systems

Phase changes absorb a lot of energy

- Melting ice – 144 Btu/lb
- Heating water – 1Btu/lb-°F
- Converting water to steam – 971 Btu/lb
- Superheating steam – 0.5 Btu/lb

(all parameters are at atmospheric pressure)

Phase Changes and Saturated Systems

At saturation:

- The substance exists in both a liquid and vapor state
- At a constant pressure, the temperature of the substance will not change until:
 - It is fully converted to a liquid (removing energy), or
 - It is fully converted to a vapor (adding energy)

Phase Changes and Saturated Systems

An Experiment

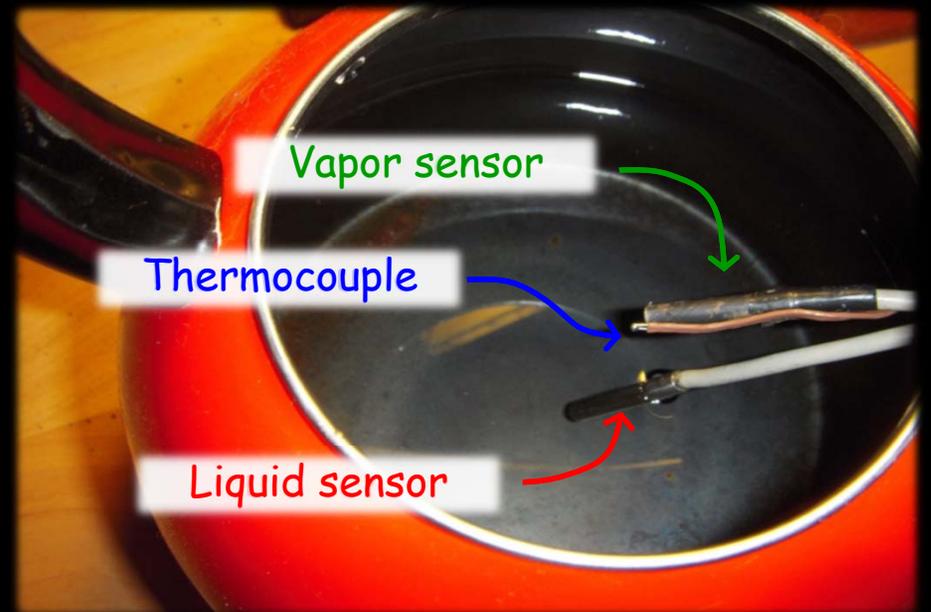
- Heat water in a low pressure boiler
- Monitor:
 - Water temperature
 - Vapor temperature over the water surface
 - Power
- Plot the results



Phase Changes and Saturated Systems

An Experiment

- Monitoring temperature



Phase Changes and Saturated Systems

An Experiment

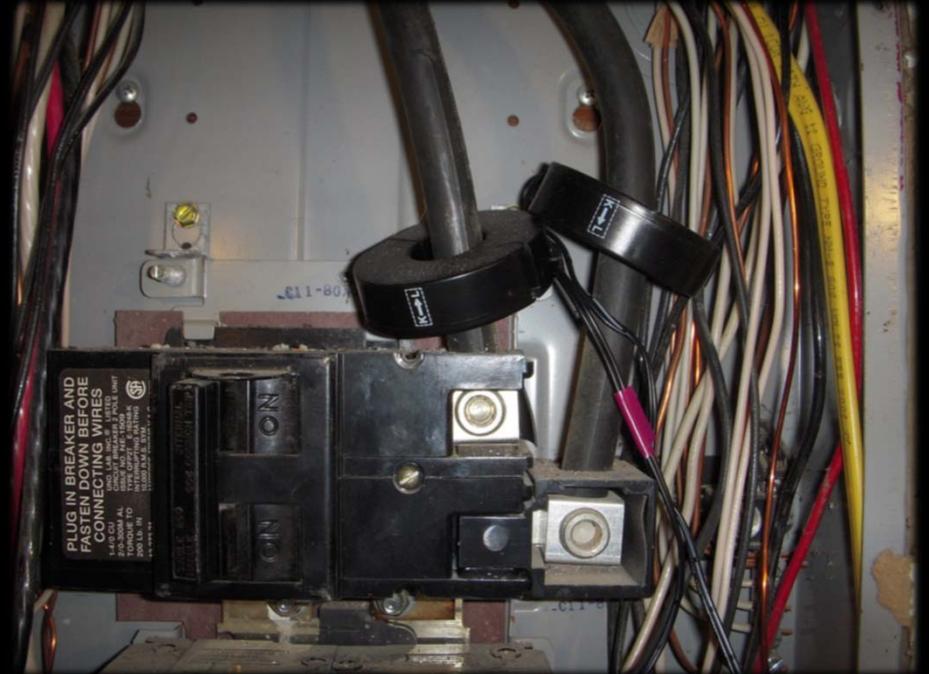
- Monitoring power



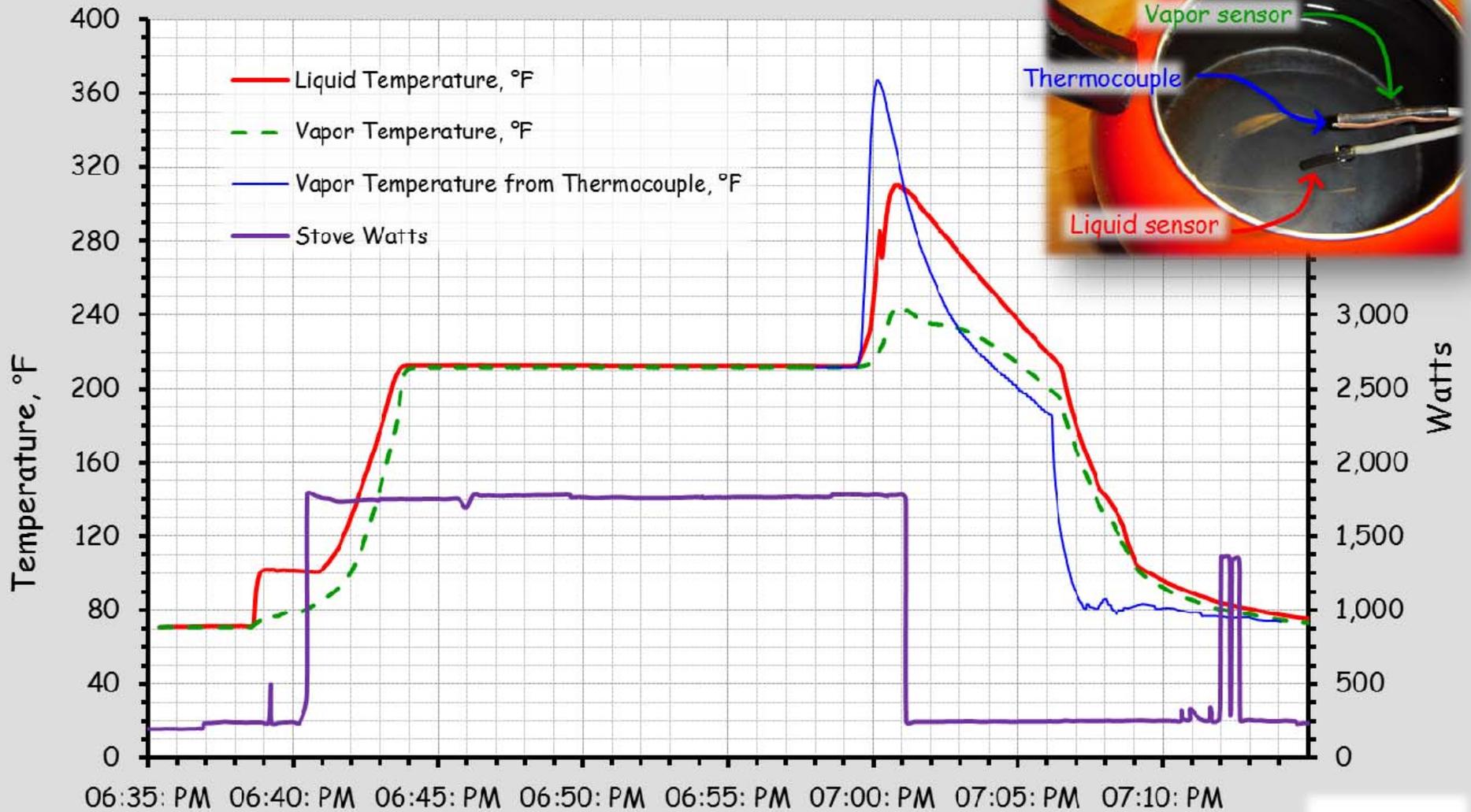
Phase Changes and Saturated Systems

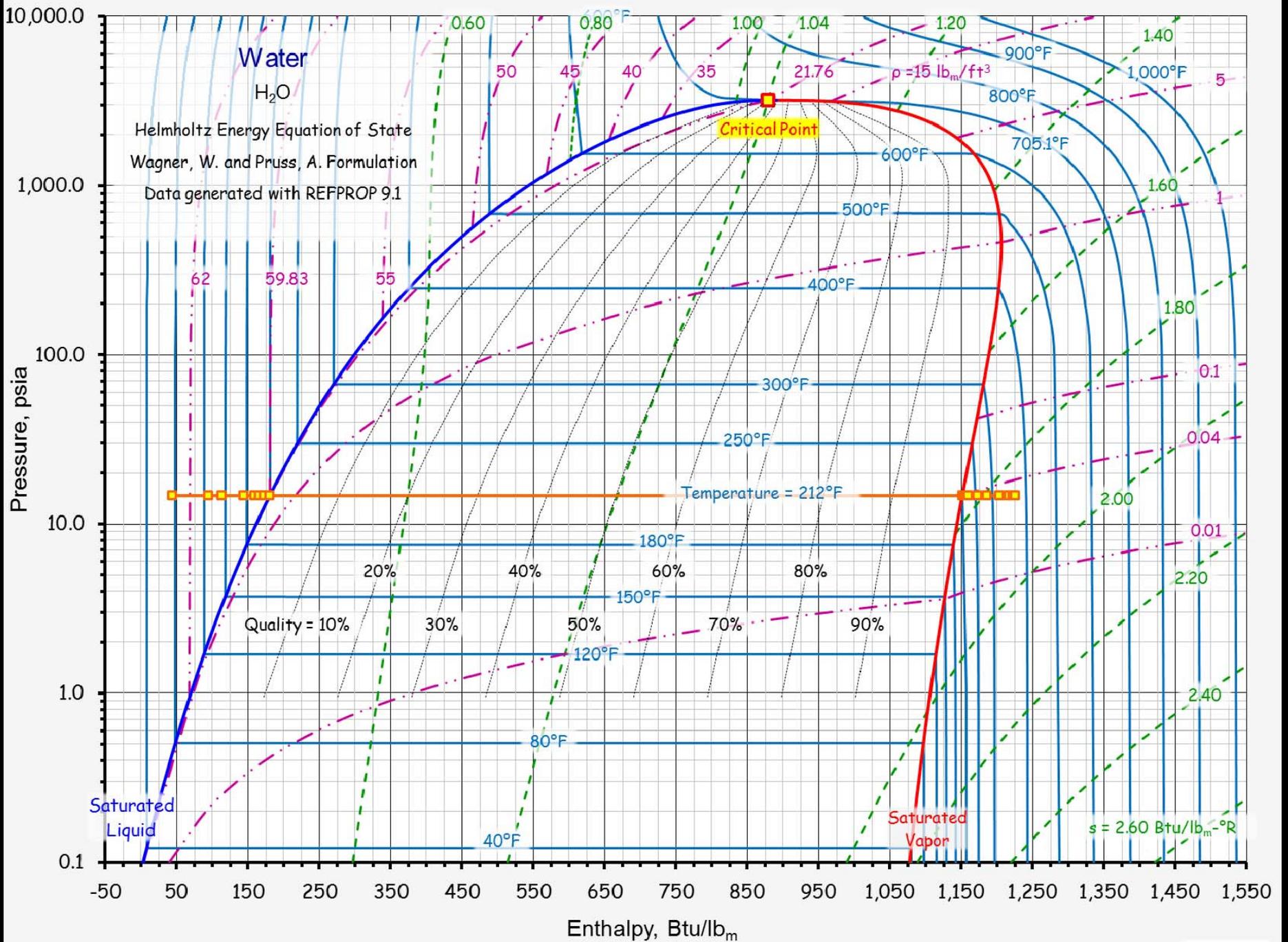
An Experiment

- Monitoring power



Temperatures in a Saturated System as it Transitions from Subcooled Liquid to Superheated Vapor

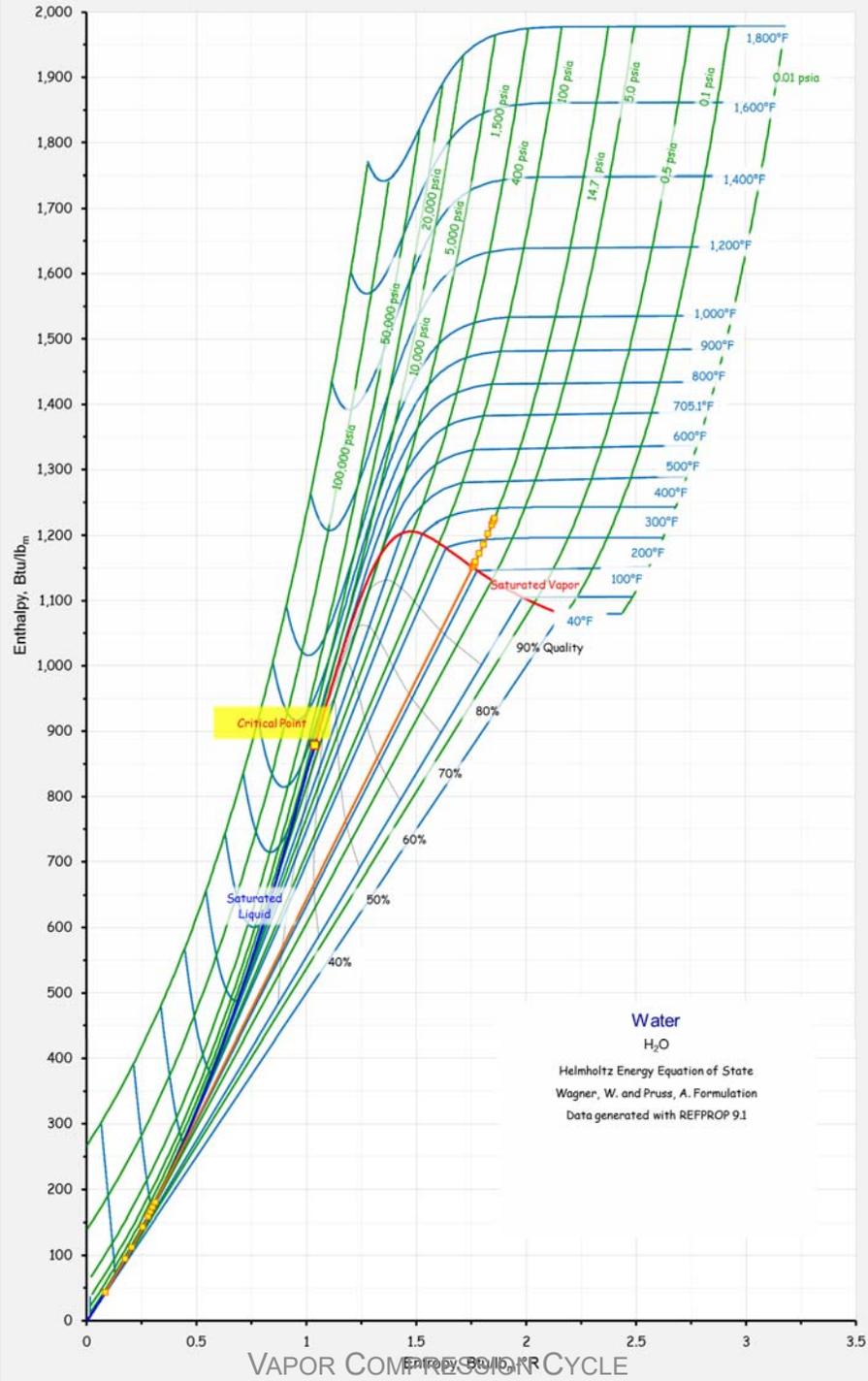


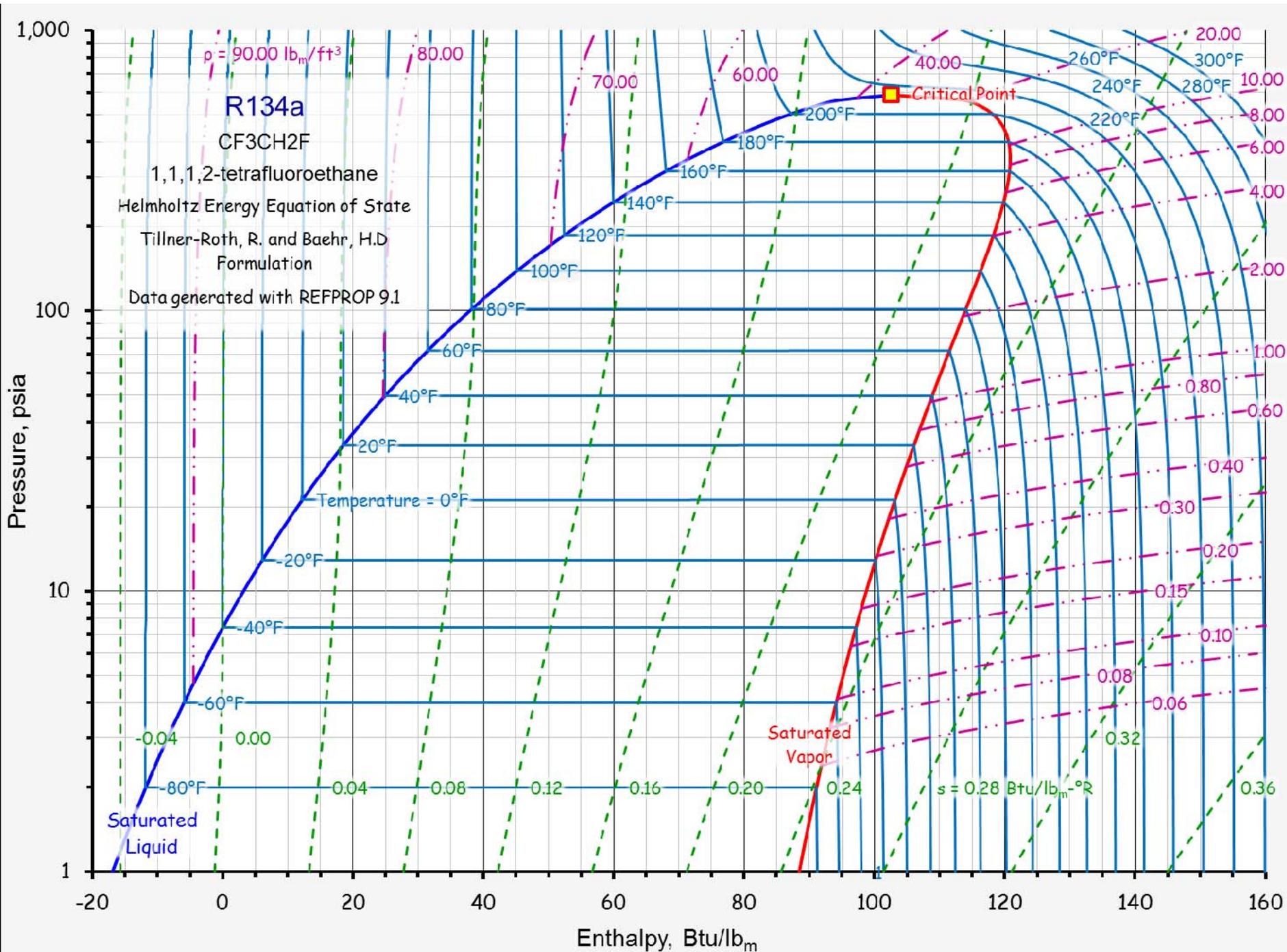


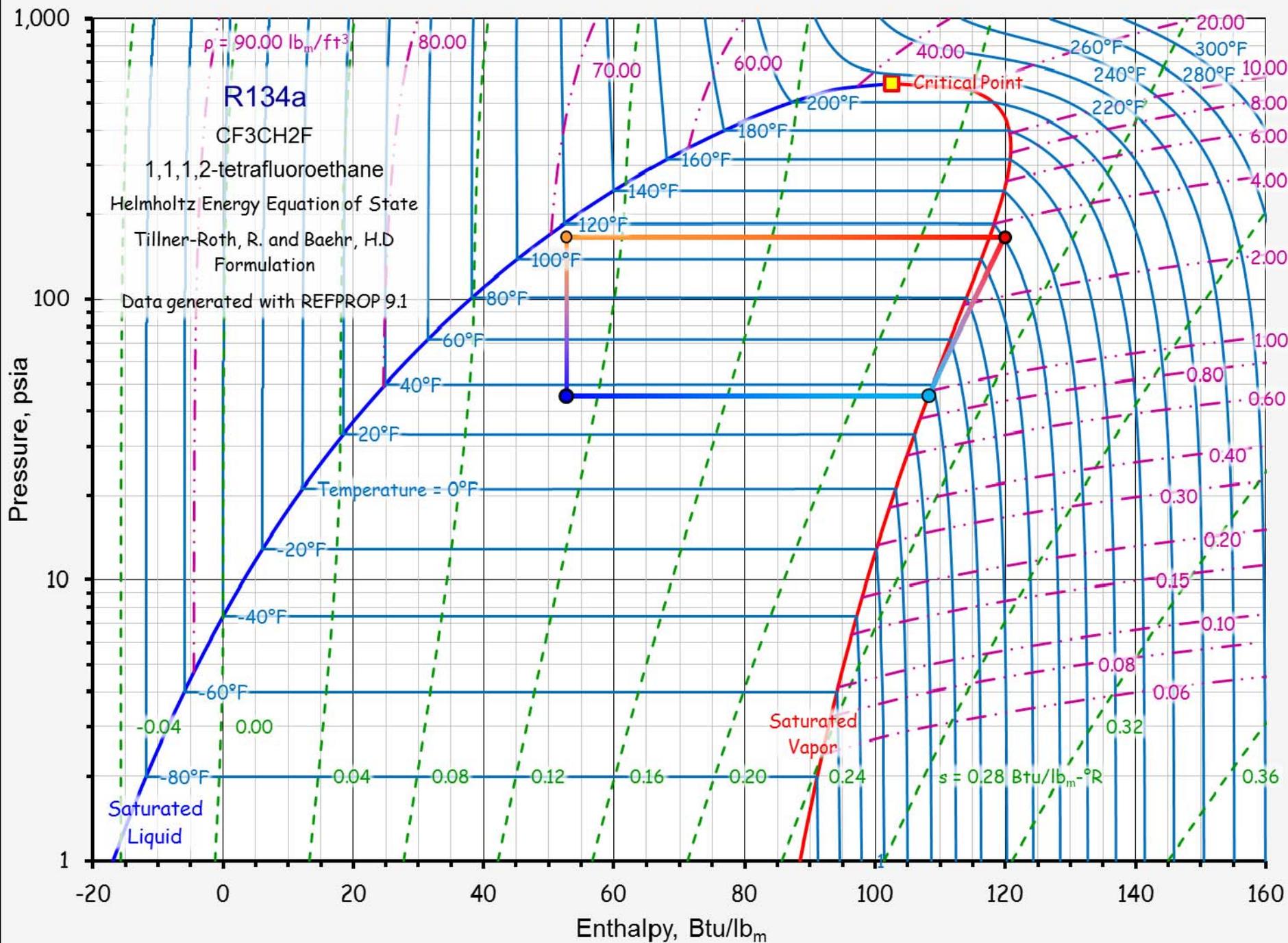
Water
 H_2O
 Helmholtz Energy Equation of State
 Wagner, W. and Pruss, A. Formulation
 Data generated with REFPROP 9.1



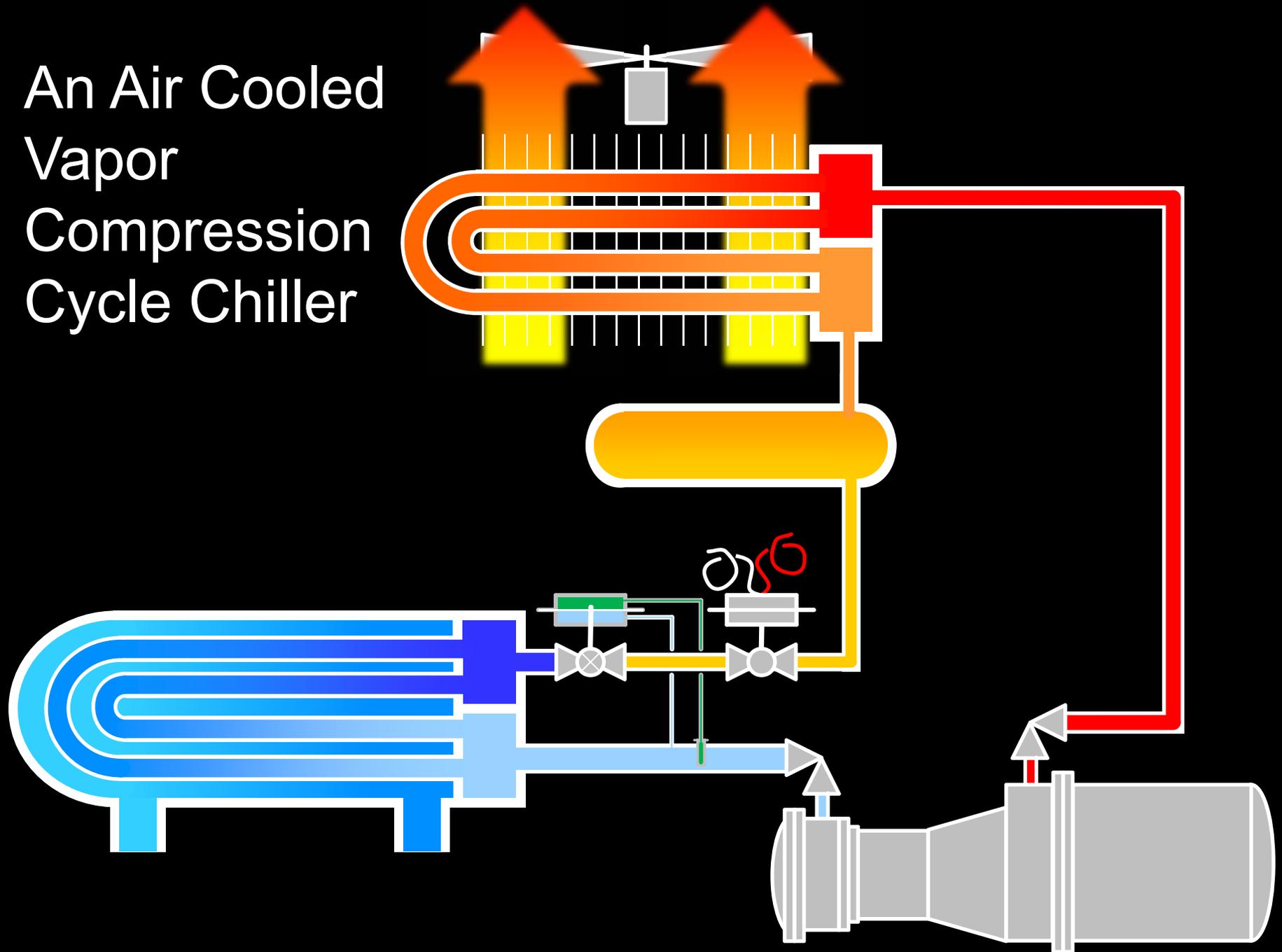
VAPOR COMPRESSION CYCLE



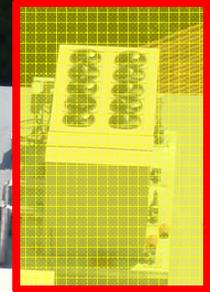




An Air Cooled Vapor Compression Cycle Chiller



Le Conte Hall Air Cooled Chiller



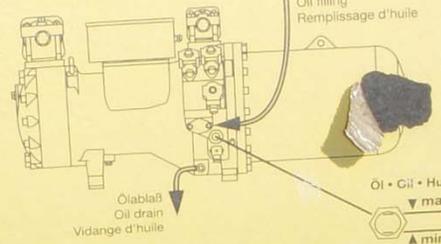
The Compressor



The Crankcase Heater

Öl • Oil • Huile:
BSE 170 (CPI SOLEST 170)

Nicht mit anderen Schmierstoffen mischen!
Do not mix with other lubricants!
Ne pas mélanger avec d'autres lubrifiants!

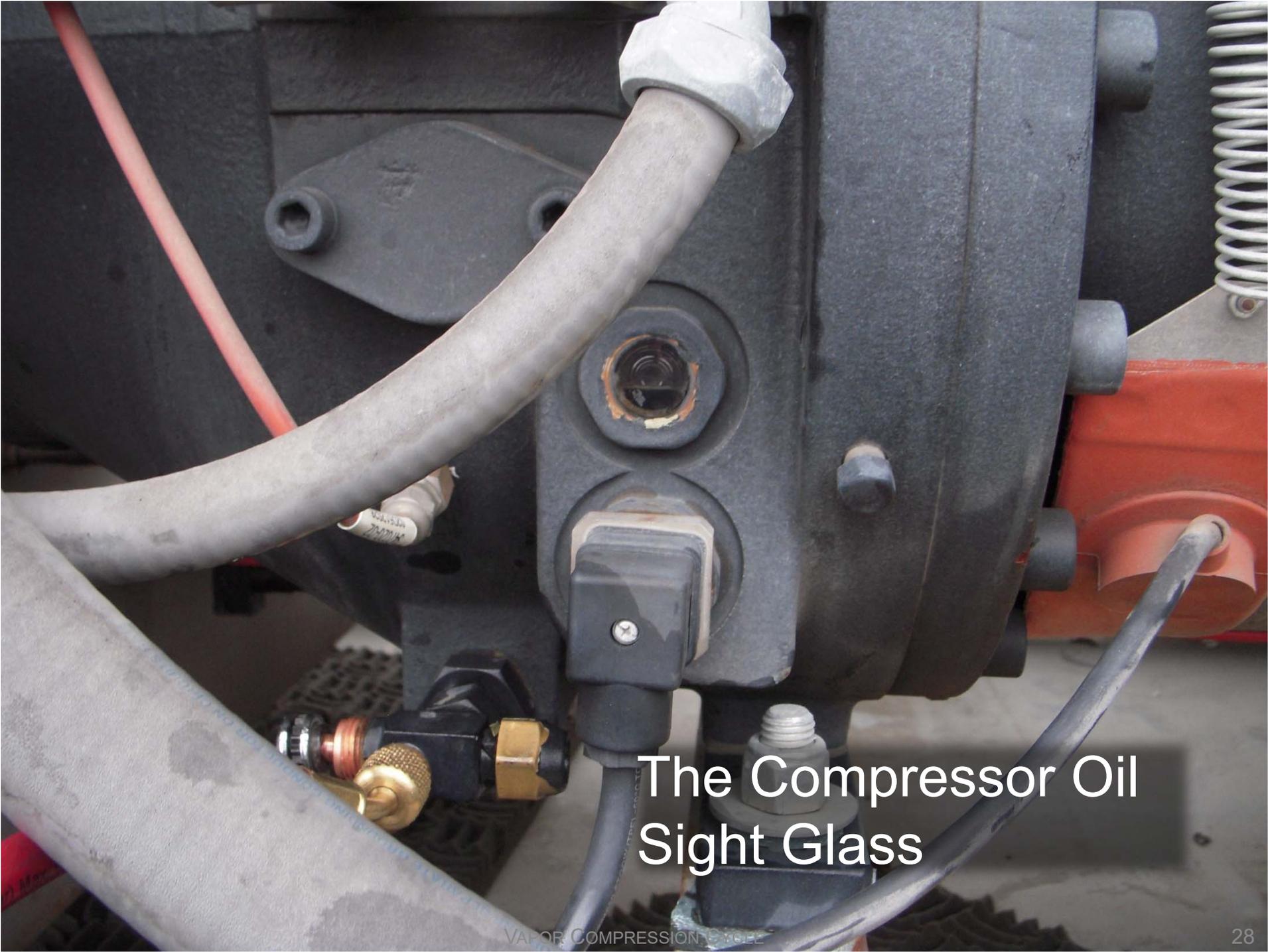


Ölfüllung
Oil filling
Remplissage d'huile

Ölablaß
Oil drain
Vidange d'huile

Öl • Oil • Huile:
▼ max.
▲ min.

378 113-06

A close-up photograph of a mechanical component, likely a compressor, showing an oil sight glass. The sight glass is a small, clear window in a metal housing, used to check the oil level. It is surrounded by various pipes, hoses, and electrical components. A white plastic cap is visible on a pipe above the sight glass. A red hose is on the left, and a blue hose is on the right. The metal housing is dark grey or black. The text "The Compressor Oil Sight Glass" is overlaid in white on the bottom right of the image.

The Compressor Oil
Sight Glass

Refrigerant Oil and Pump



EMKARATE® RL The Leader in Refrigeration Lubricants
 PCE Lubricant for use with HFC refrigerants such as R-134a, R-404A, R-507,
 R-402C, R-410A, CO2 and HCFC refrigerants such as R-22 and blends.

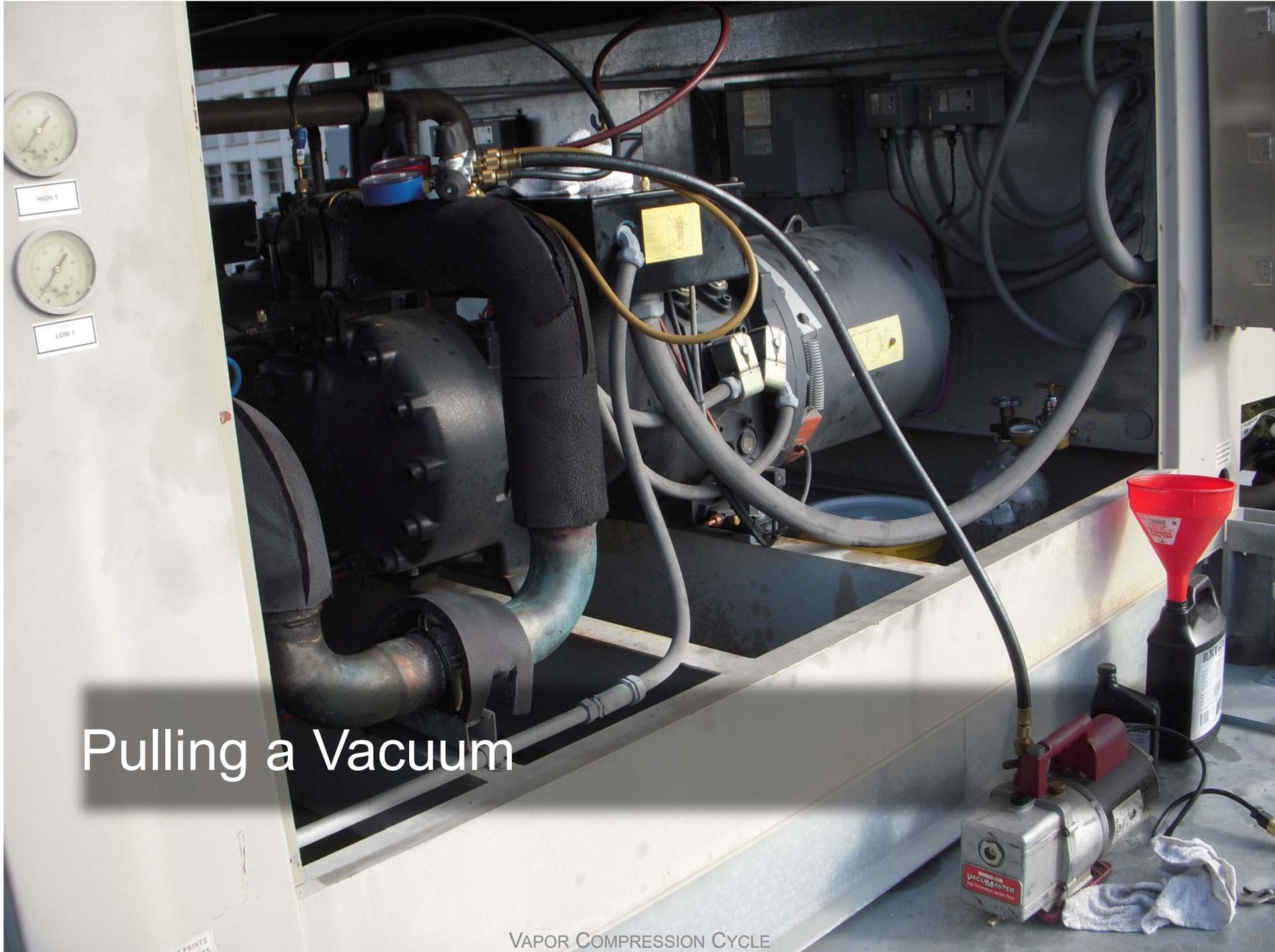
HANDLING GUIDELINES
CONTAINS POLYOL ESTER
 PCE Lubricant will absorb moisture from air. Minimize exposure to air. Keep container closed between uses. Shout and eye contact. Use of impermeable gloves and eye protection is recommended.
 For additional handling instructions, read the Emergency Material Safety Data Sheet.

Worldwide Approvals
 EMKARATE® RL has been selected more compressor manufacturer approvals than any other synthetic refrigeration lubricants worldwide.
 CPI Engineering Services offers a complete line of Emkarate synthetic ester refrigeration lubricants from ISO 1 to ISO 220. When is not available, the table below may be used as a guide in selecting the correct lubricant.

	EMKARATE® RL SERIES					
	RL 22K	RL 22H	RL 40K	RL 68K	RL 100K	RL 170H / RL 220H
RECIPROCATING	+	+	+	+	+	+
CENTRIFUGAL	+	+	+	+	+	+
SCREW	+	+	+	+	+	+
SCREW	+	+	+	+	+	+
SCROLL	+	+	+	+	+	+

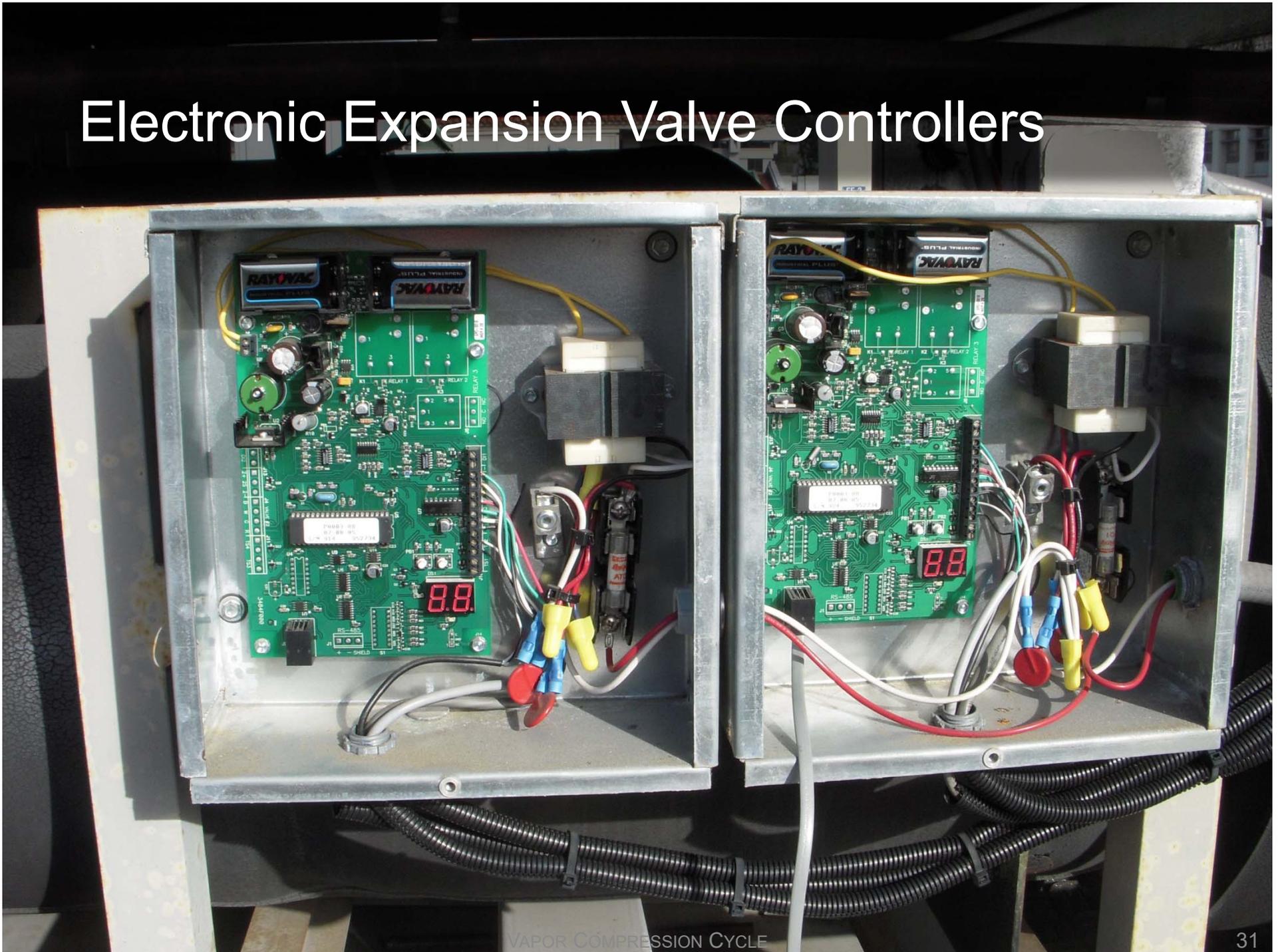
CPI Engineering Services, Inc.
 A Division of The Lubrizol Corporation
 2200 Jones Garage Road
 Solon, OH 44136
 Phone: 380.486.2100
 Fax: 380.486.2210

www.emkarateRL.com



Pulling a Vacuum

Electronic Expansion Valve Controllers



A Refrigerant Sight Glass



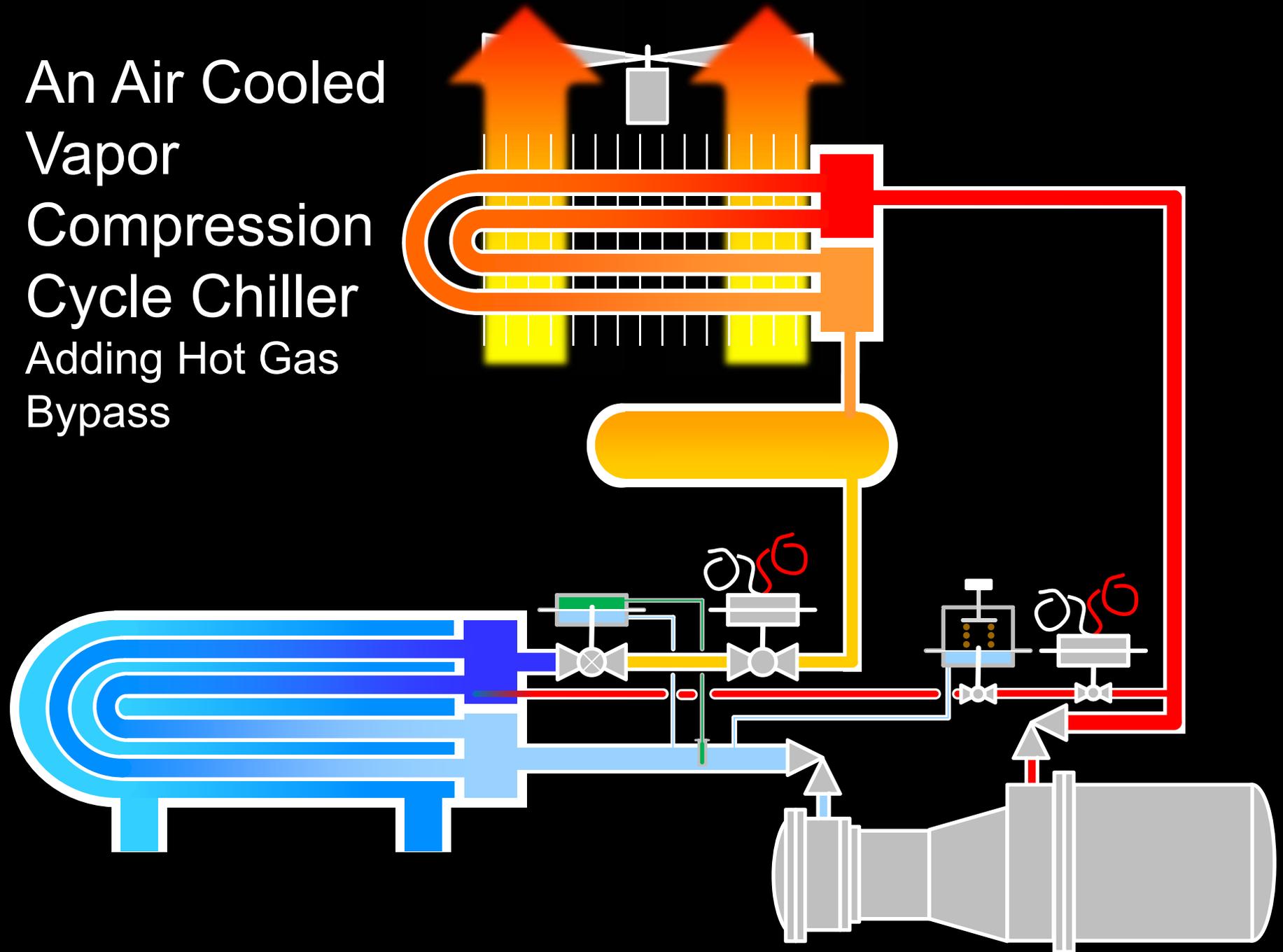


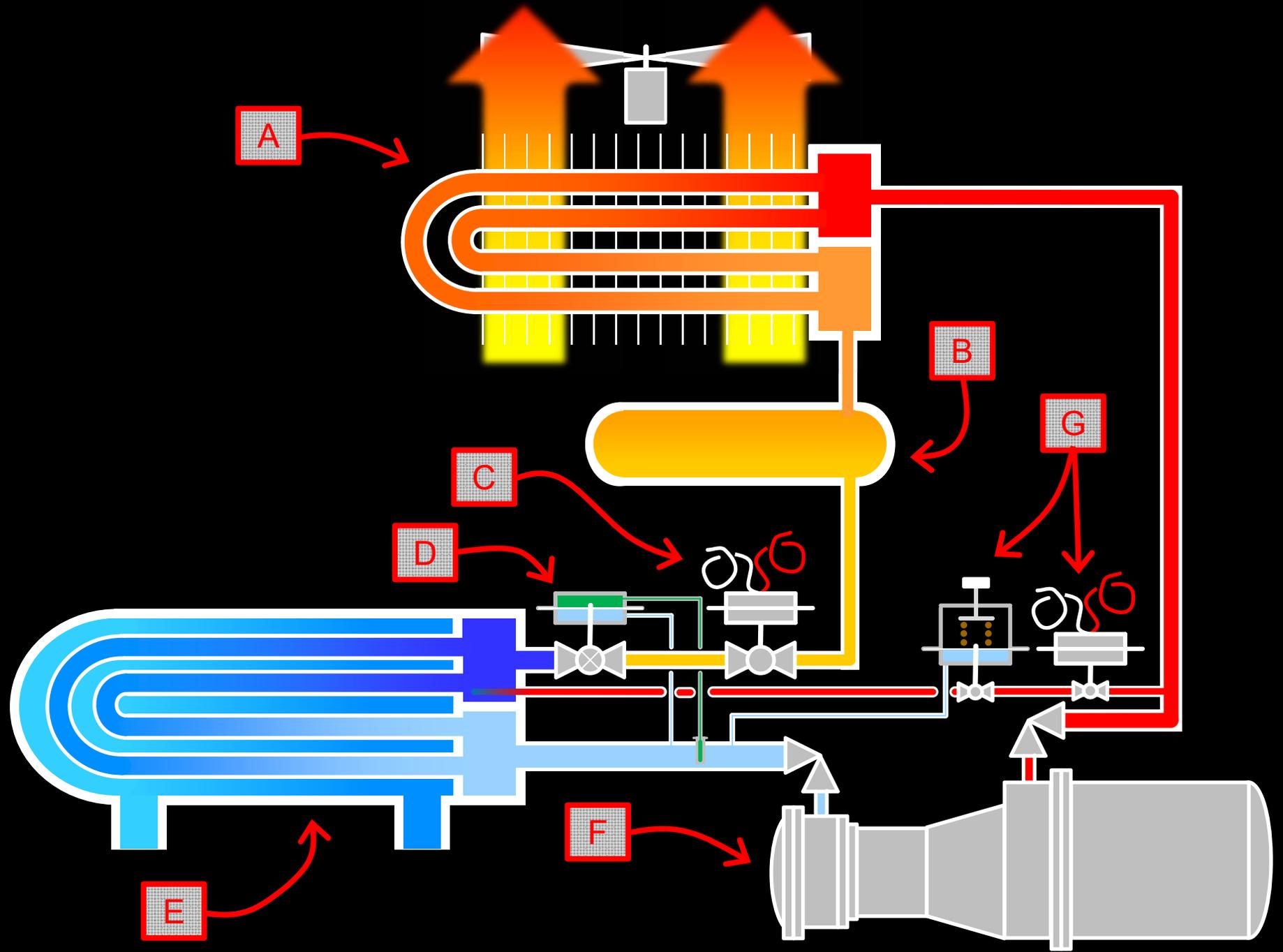
Typical Control Switches



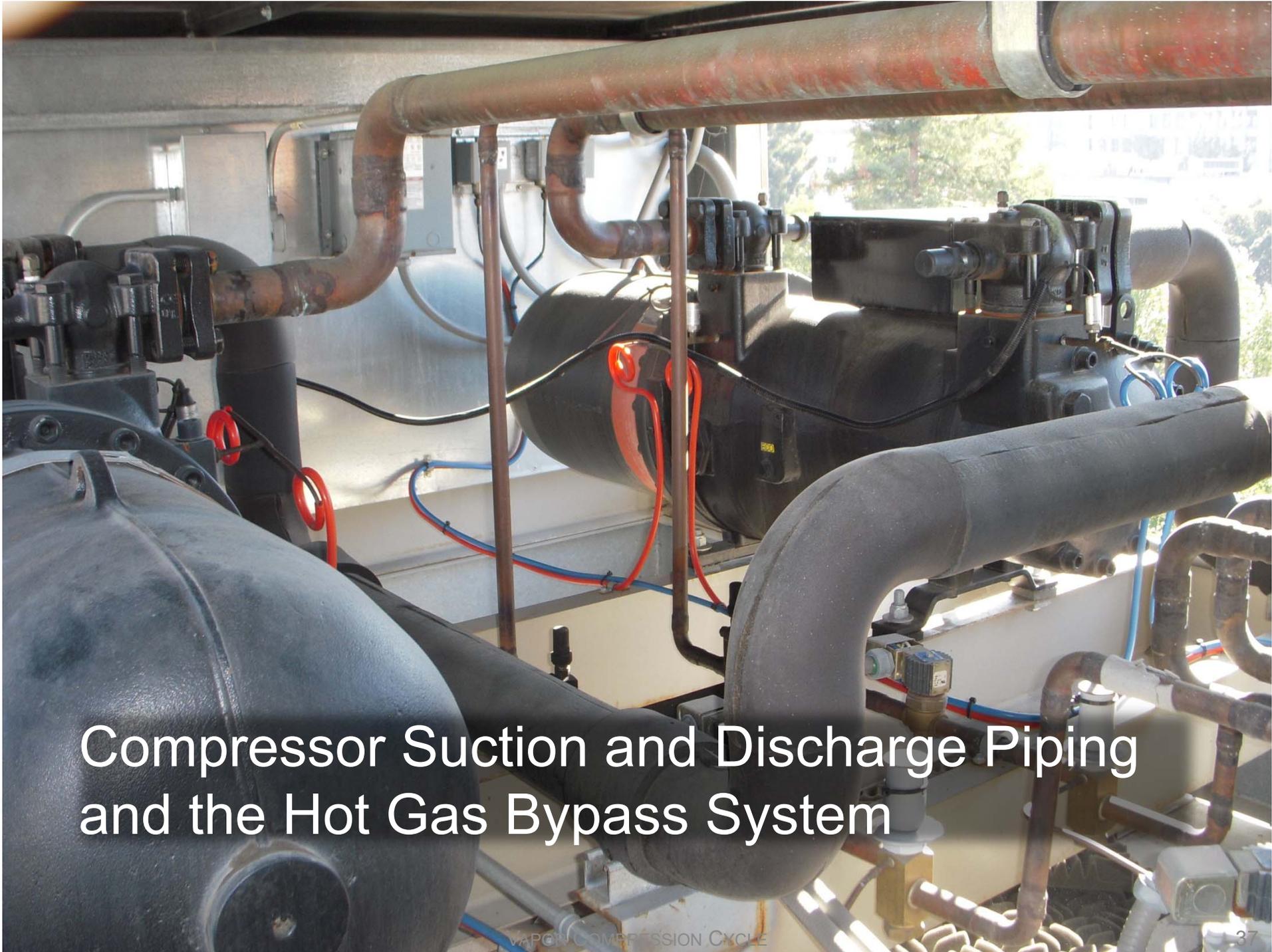
Piping Connections at the Evaporator

An Air Cooled
Vapor
Compression
Cycle Chiller
Adding Hot Gas
Bypass





VAPOR COMPRESSION CYCLE



Compressor Suction and Discharge Piping and the Hot Gas Bypass System

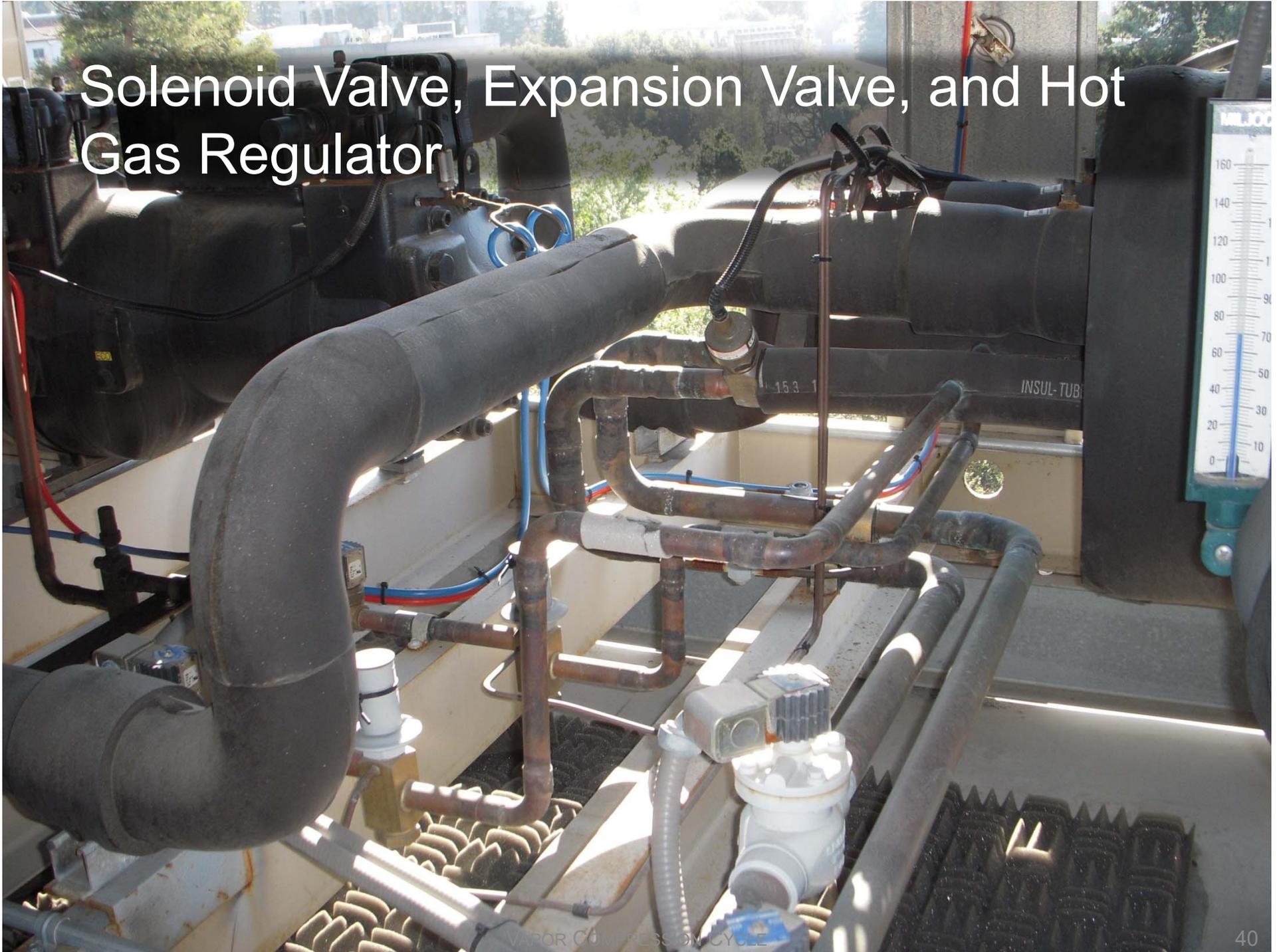
Piping To and From the Condenser and Filter Dryer Assemblies



Piping to the Evaporator

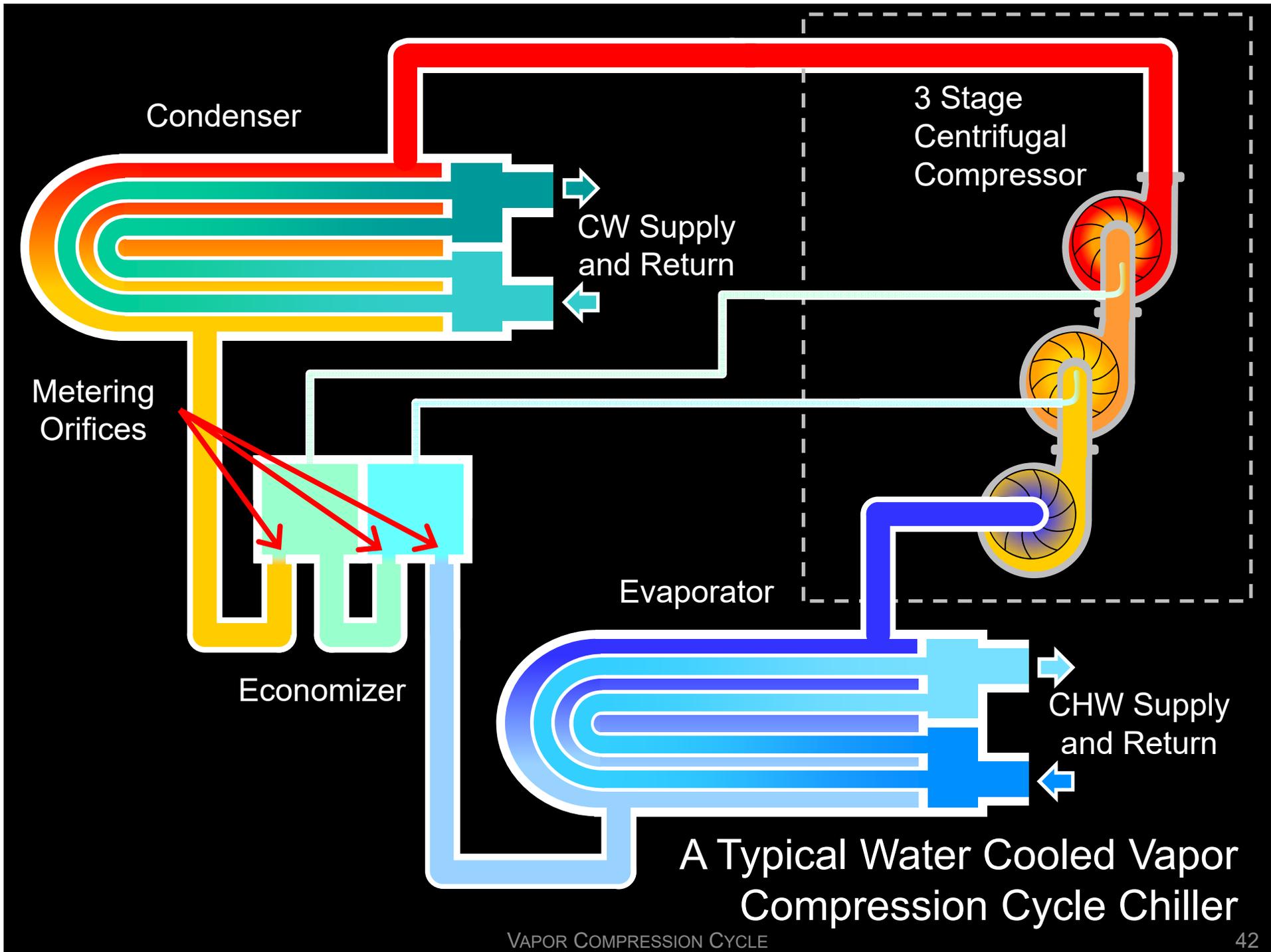


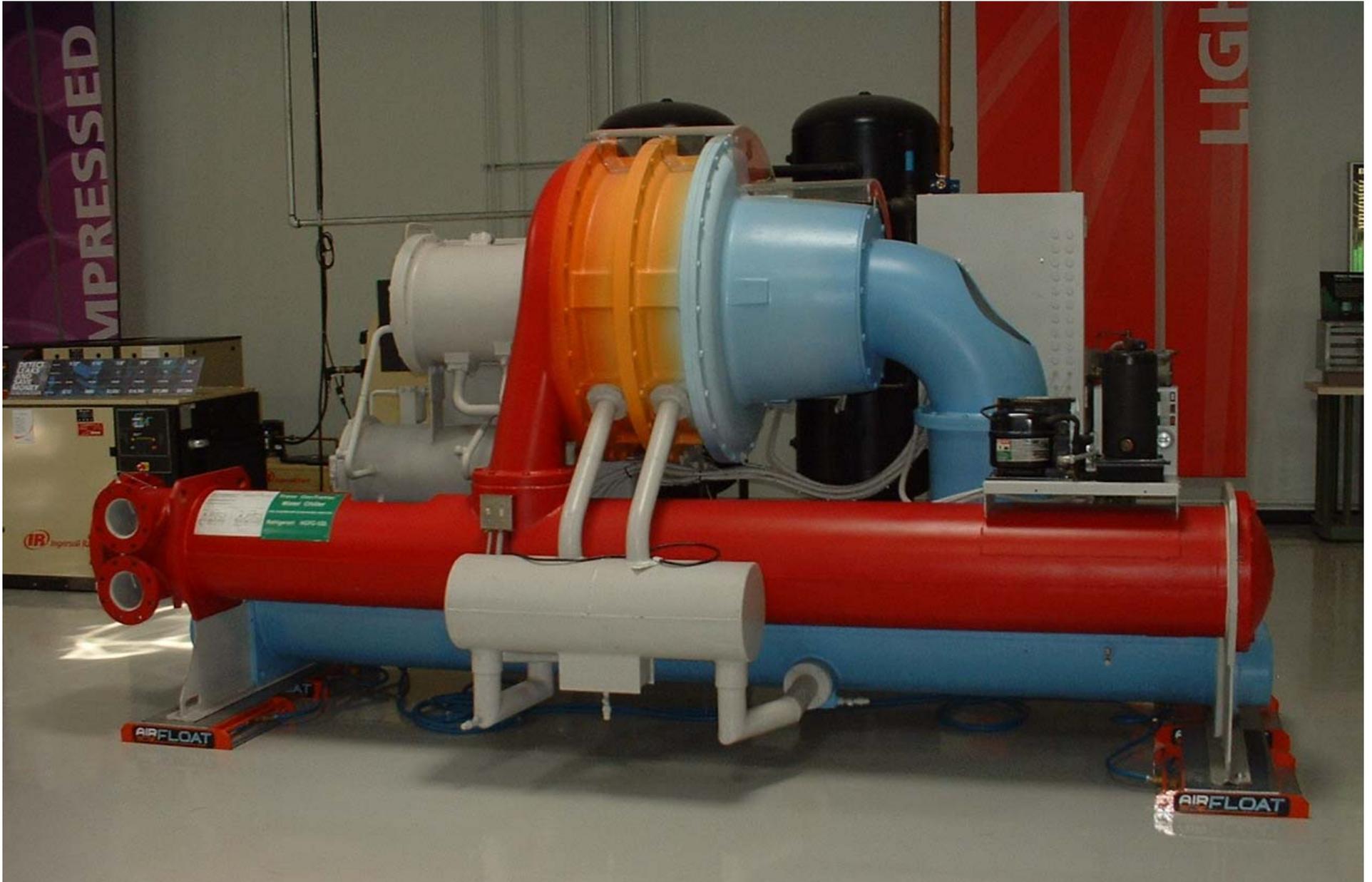
Solenoid Valve, Expansion Valve, and Hot Gas Regulator



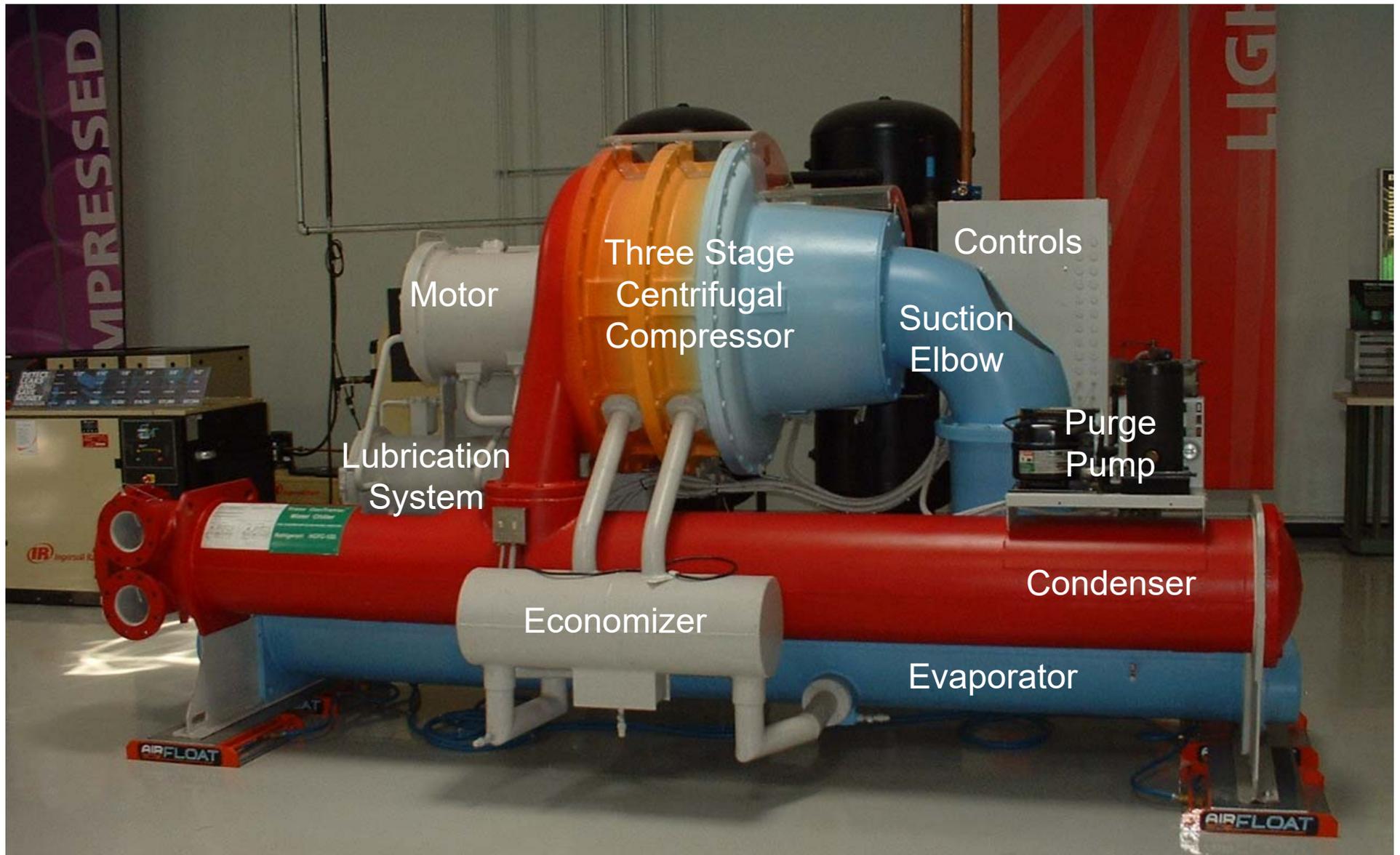
Taking a Closer Look at Hot Gas Bypass







A Water Cooled Centrifugal Chiller



A Water Cooled Centrifugal Chiller

Inside the Condenser

Tubes

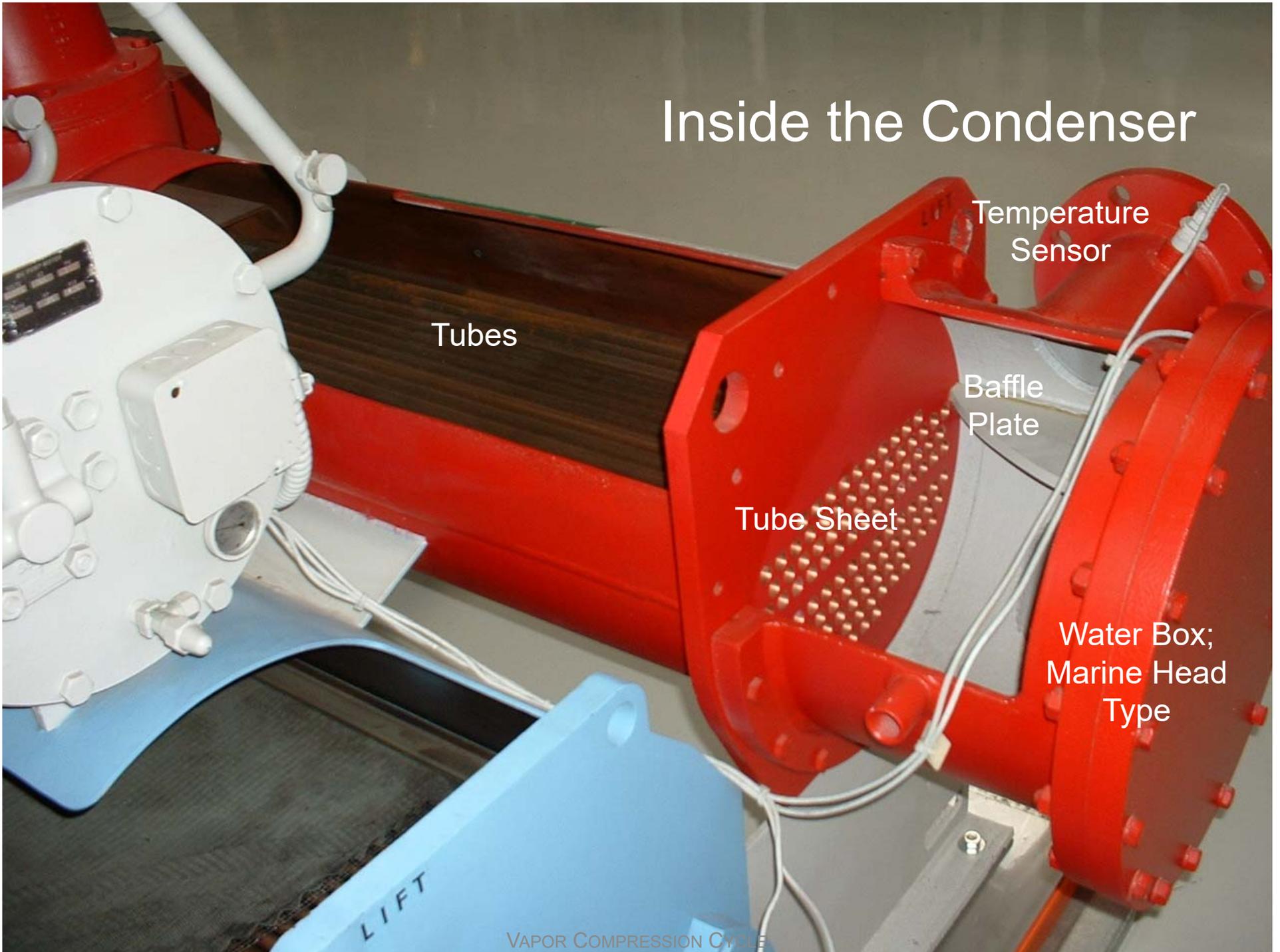
Temperature
Sensor

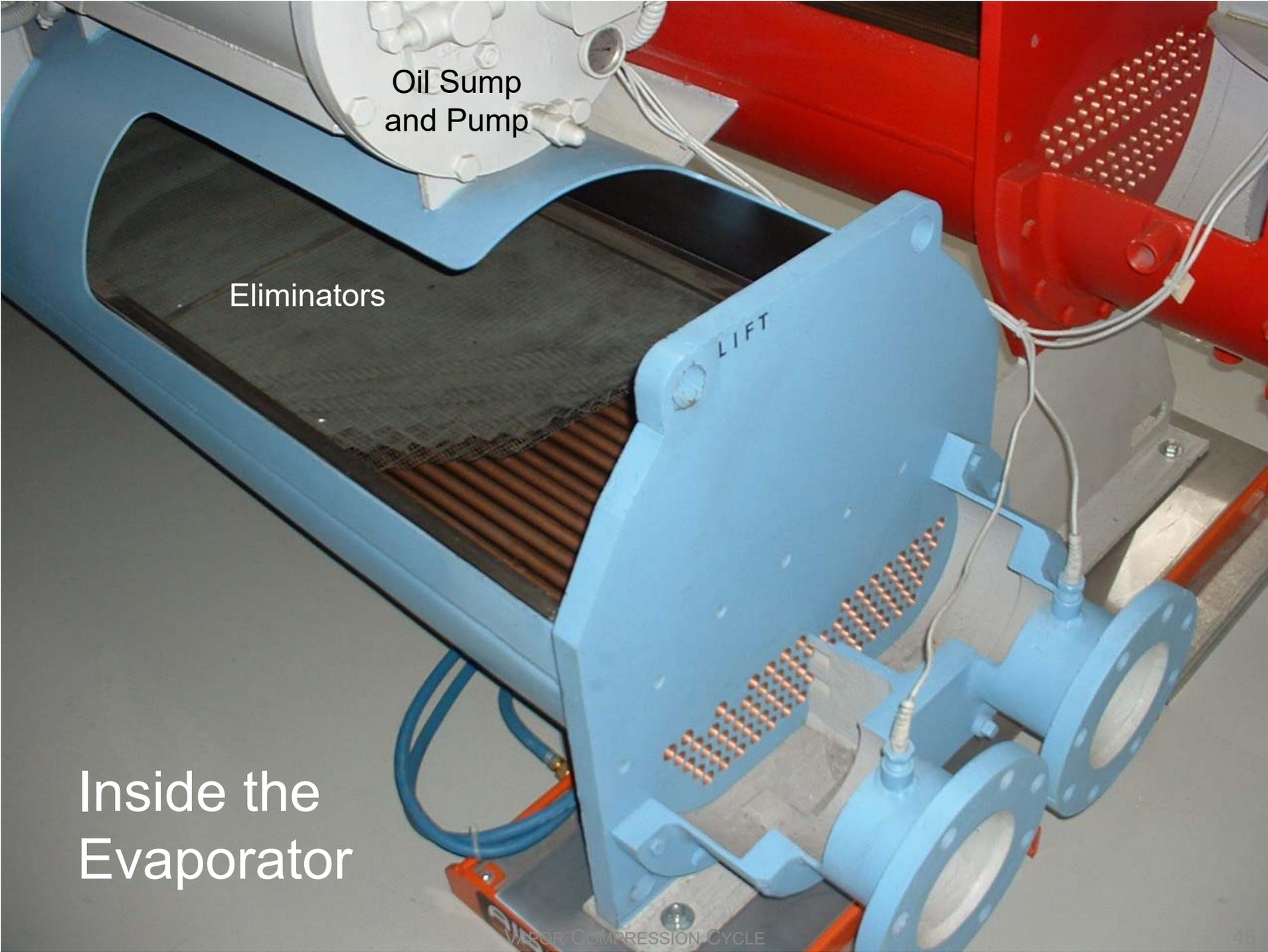
Baffle
Plate

Tube Sheet

Water Box;
Marine Head
Type

LIFT



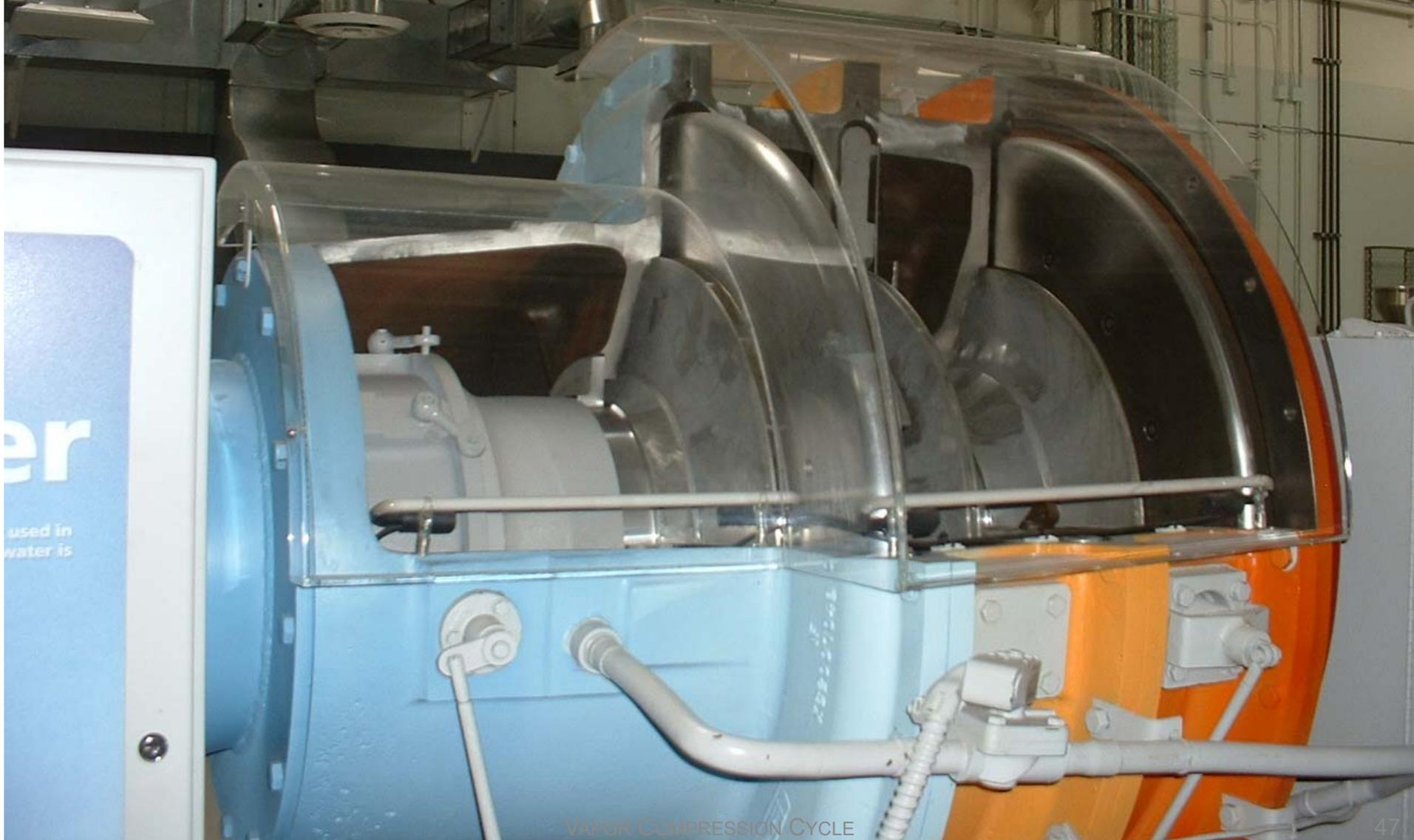


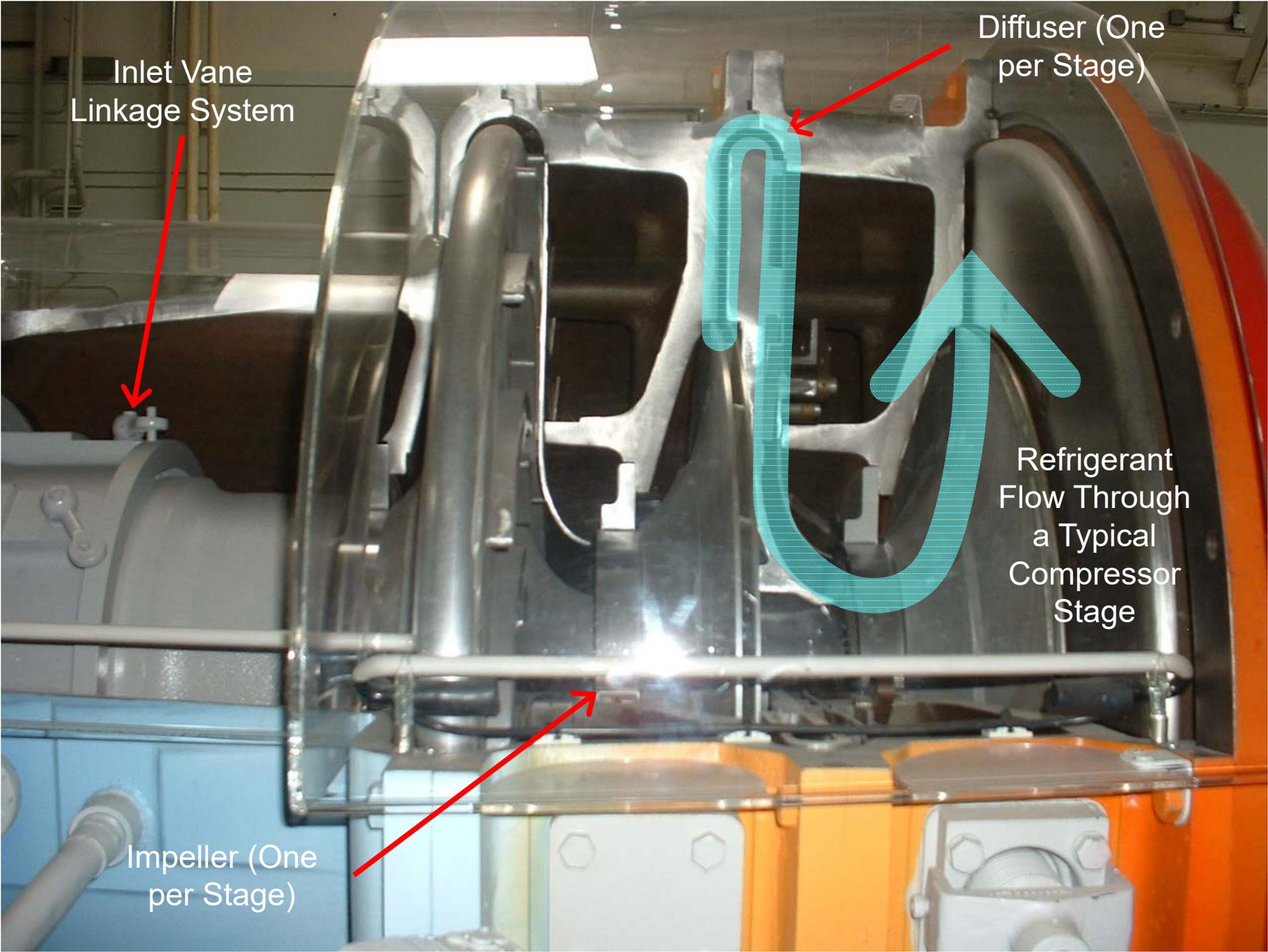
Oil Sump
and Pump

Eliminators

Inside the
Evaporator

Inside the 3 Stage Compressor





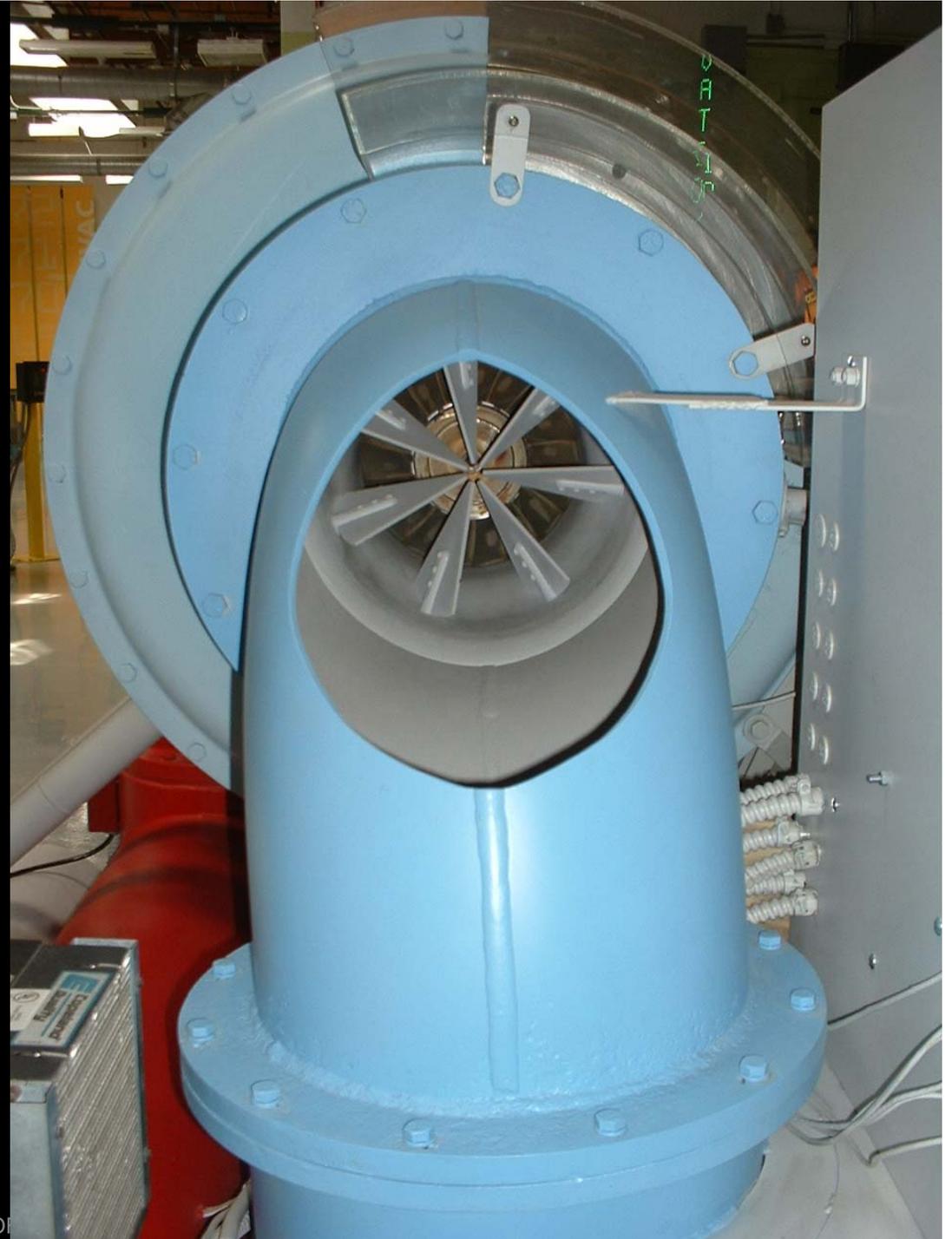
Inlet Vane
Linkage System

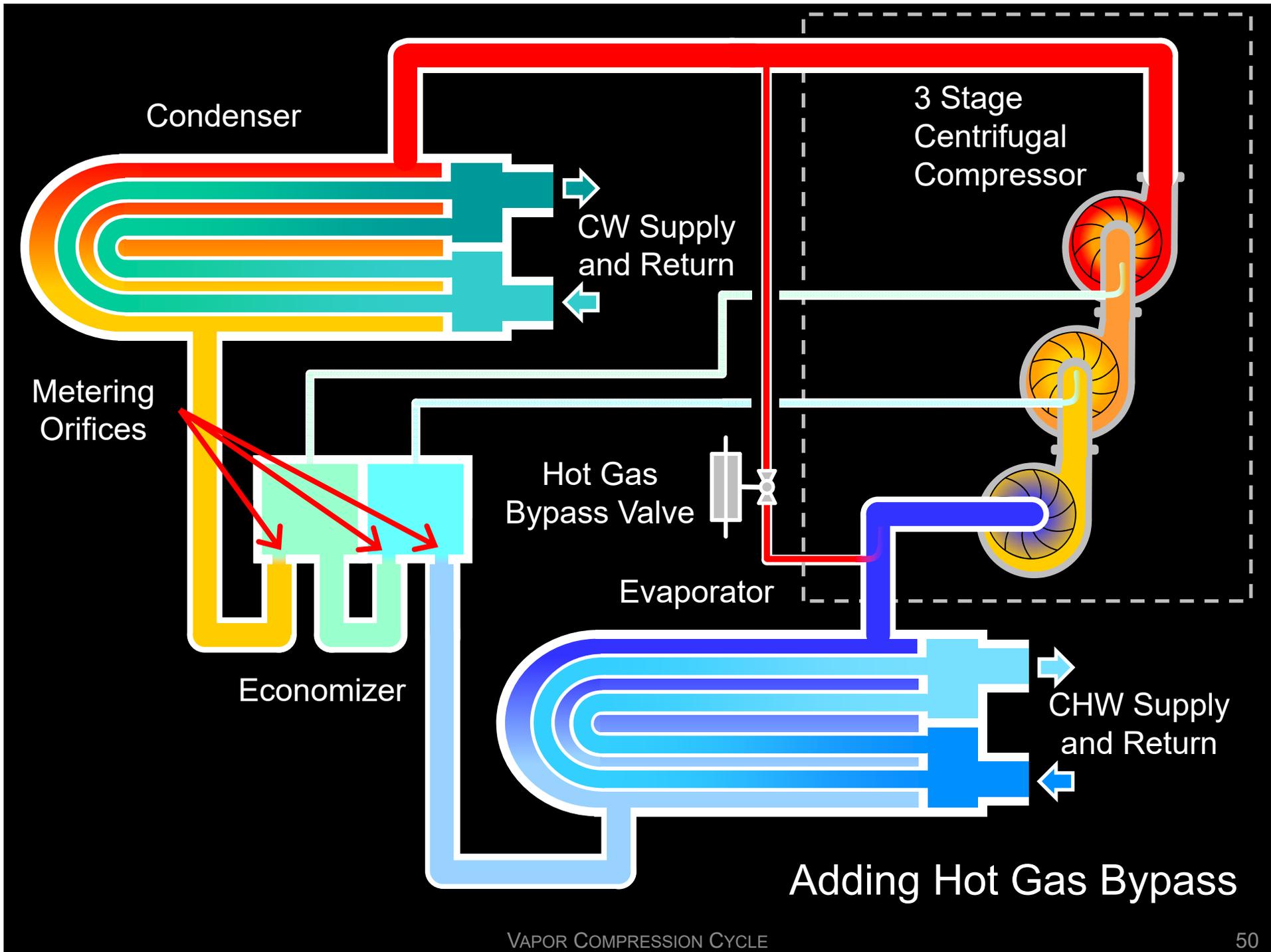
Diffuser (One
per Stage)

Refrigerant
Flow Through
a Typical
Compressor
Stage

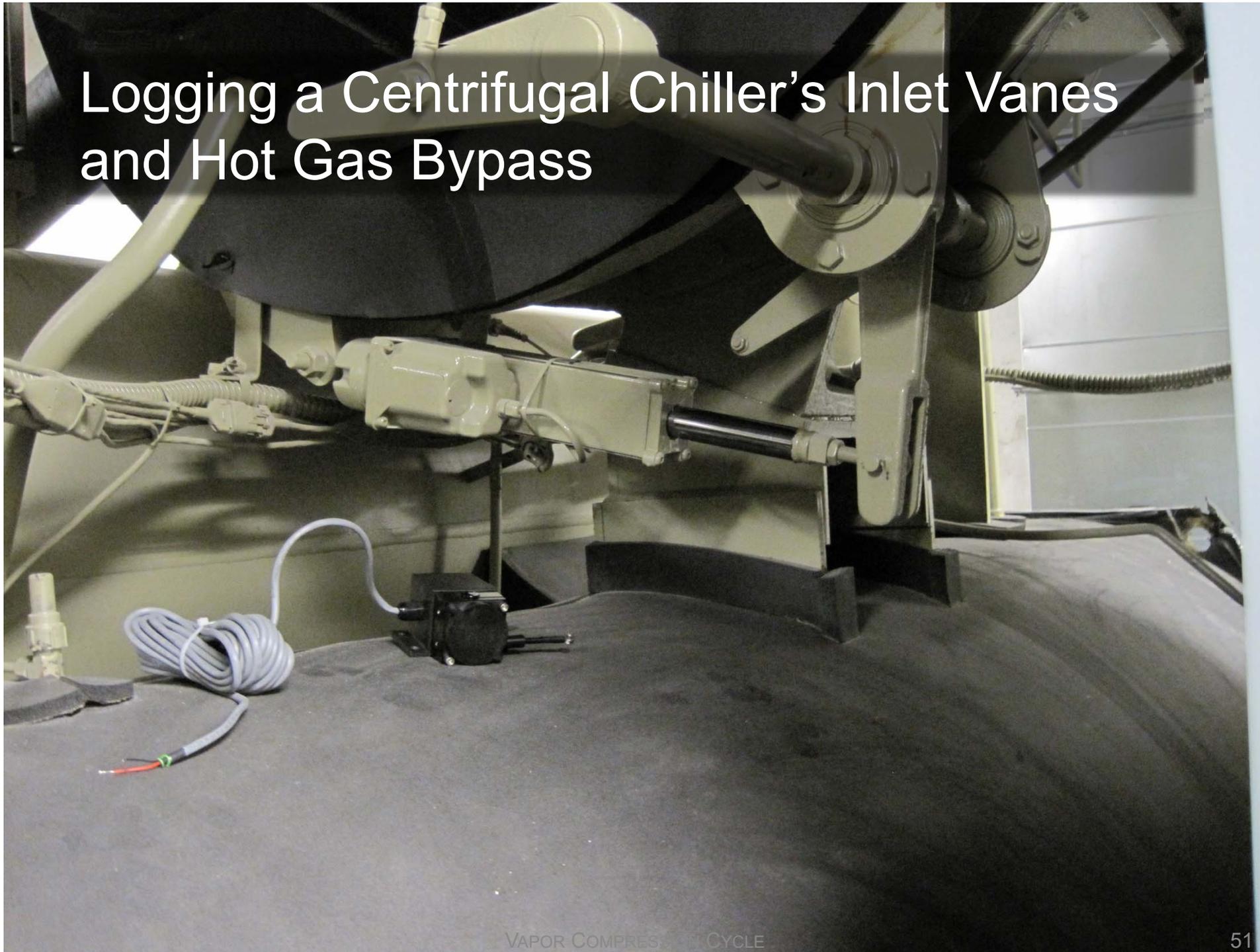
Impeller (One
per Stage)

Inlet Vanes and Suction Elbow





Logging a Centrifugal Chiller's Inlet Vanes and Hot Gas Bypass



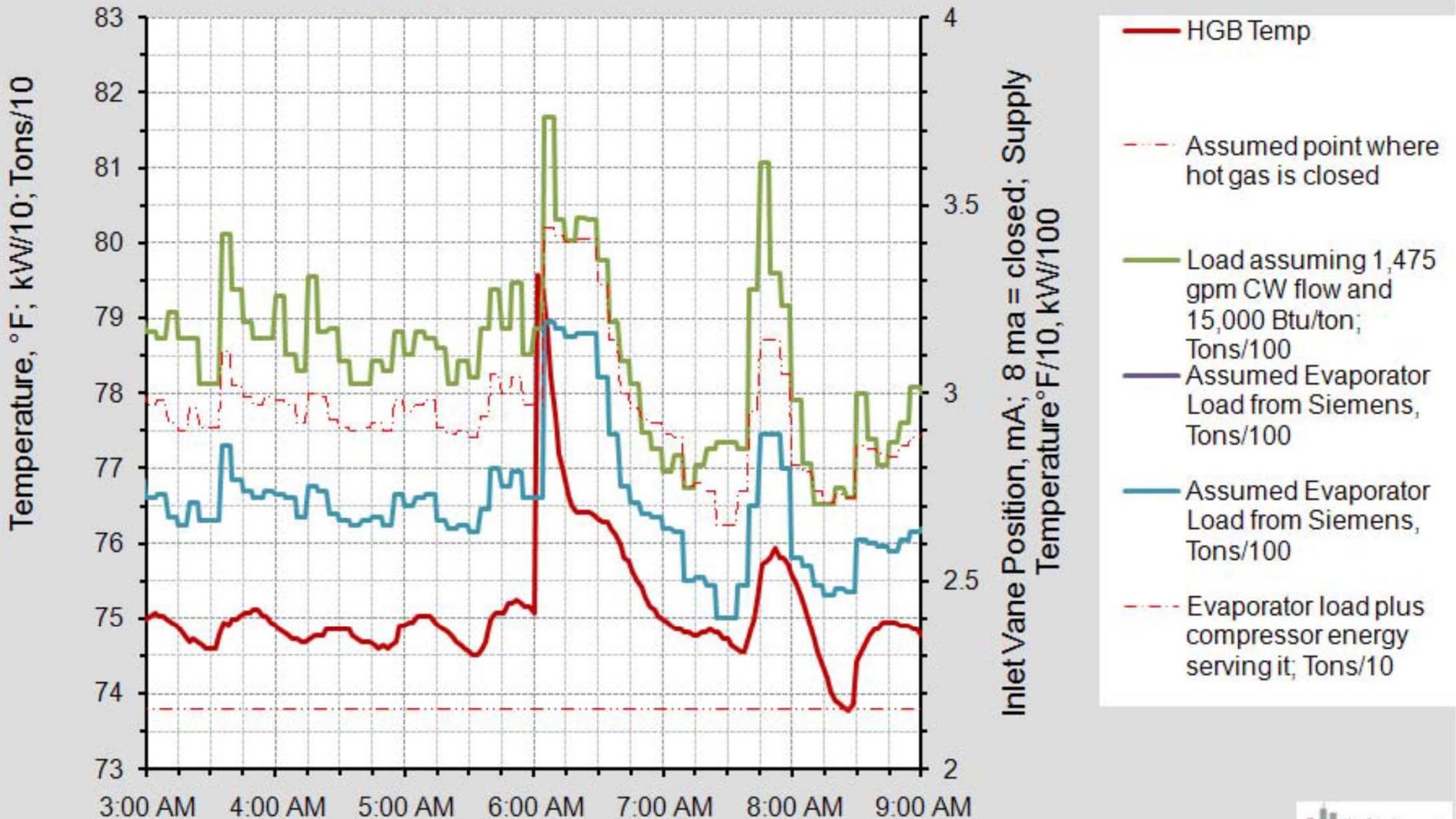


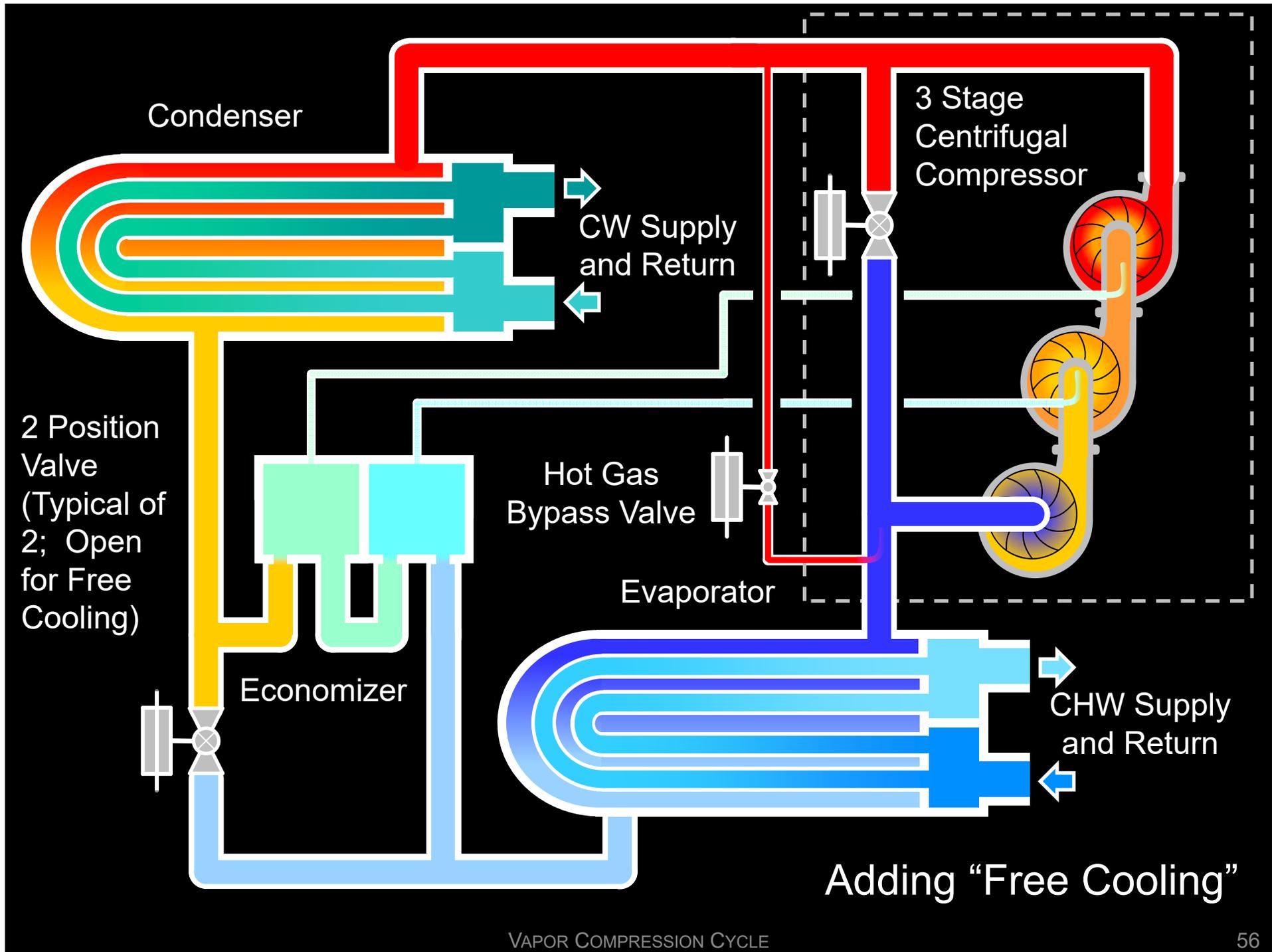


RT1MA-18-FB-420E-C28A-9
OUTSIDE 4.200A
CELESTRON
MADE IN CHINA
CE

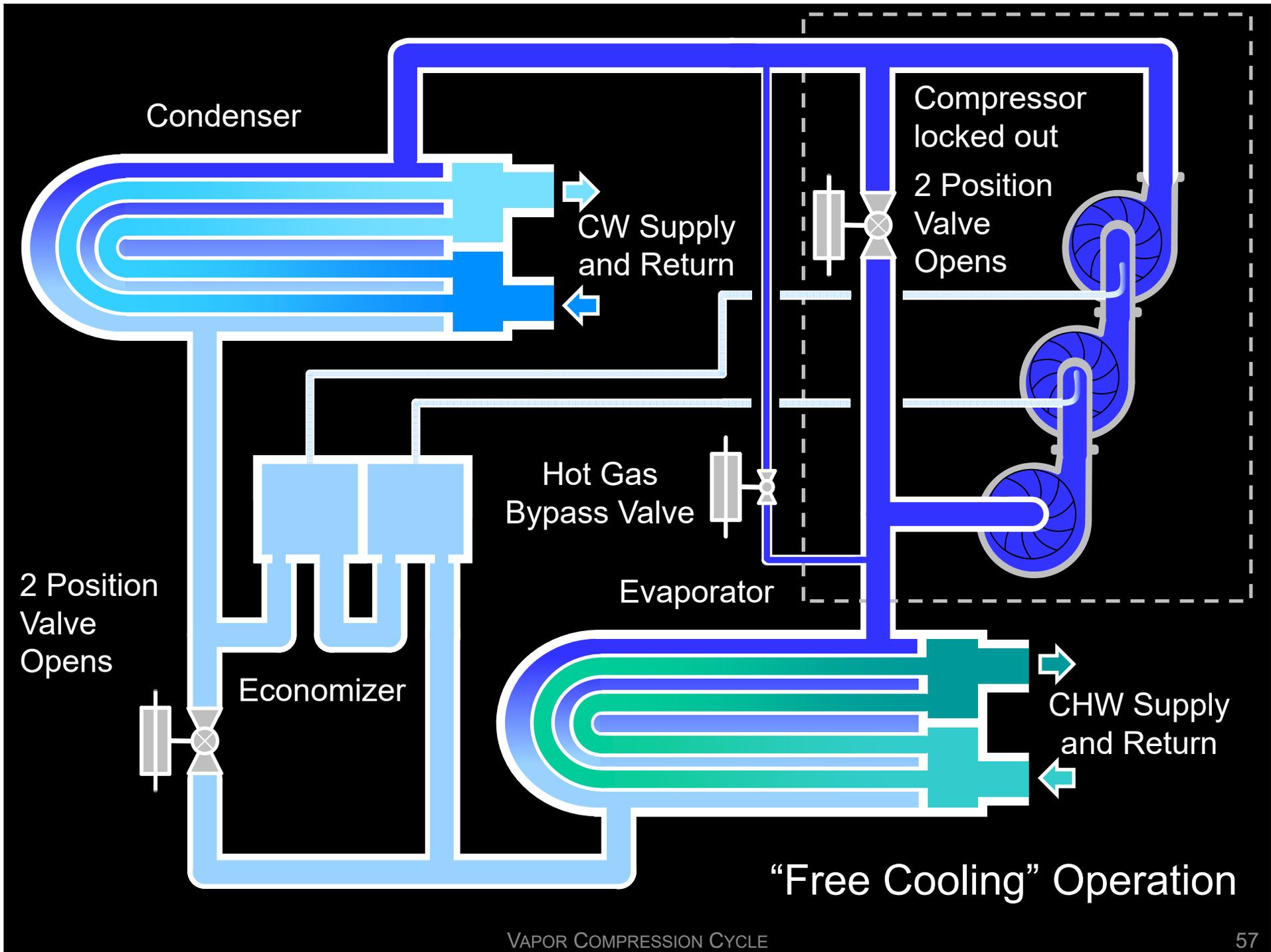


Chiller Performance at Start-up August 9, 2010





Adding "Free Cooling"



Compressor

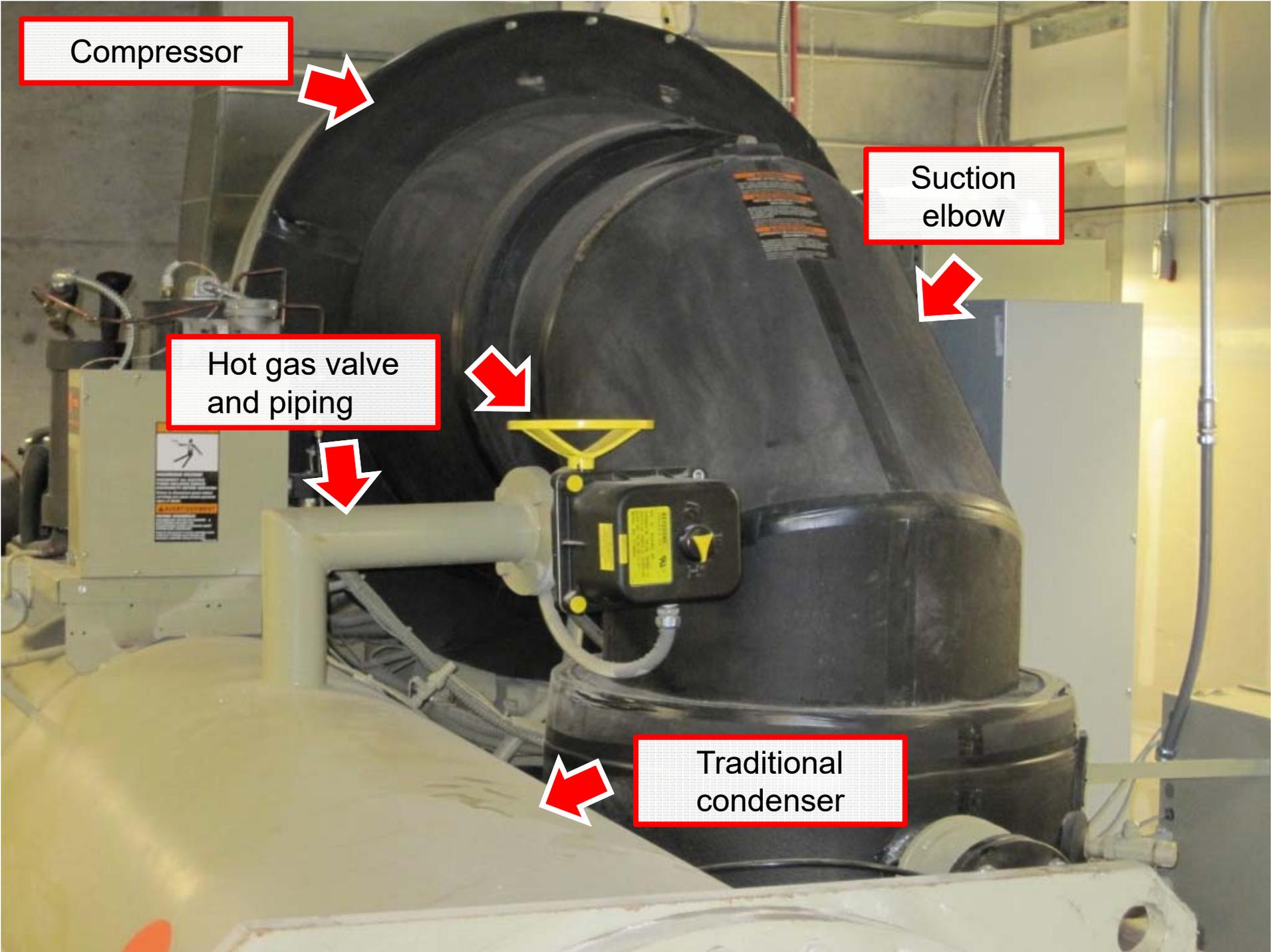
Hot gas valve
and piping

Suction
elbow

Heat recovery
condenser

Traditional
condenser

Evaporator



Compressor



Suction elbow



Hot gas valve and piping



Traditional condenser

