Industrial Ammonia Heat Pumps in Food Processing

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Business Director - Heat Pumps

AMERICA ATMOsphere the Business Case natural refrigerants

VILTER® Since 1867

EMERSON™ Climate Technologies

Introduction – Food Processing

- Considerable Refrigeration Loads
  - Heat Absorbed and Rejected to Atmosphere
  - Low Grade Heat: 70°F to 90°F
- Significant Hot Water Loads
  - 130°F to 160°F Water used for Sanitizing
- Ammonia is Typically Used as the Refrigerant in Food Processing Facilities
  - Exceptional Refrigerant Characteristics
  - Low Cost

Opportunity – Ammonia Heat Pumps

- Converts the Waste Heat of Ammonia Refrigeration into Useable Heat
- Offsets Fossil Fuels Burned to Produce Hot Water
- Savings
  - Heat Energy Reduced by 30% to 70%, or more
    - Corresponding Reduction of GHG Emissions
    - Energy Cost Savings from 30% to 90%
  - Condenser Water Consumption Reduced by 10 mil. to 30 mil. gallons per year
    - Waste Water Reduction
    - Reduction of Water Treatment Chemicals

Limitations – Ammonia Heat Pumps

- **Compressors are Limited by Pressure**

IEA Heat Pump Centre
The IEA Heat Pump Programme's Information Centre

Ammonia is not yet used in high-temperature industrial heat pumps because there are currently no suitable high-pressure compressors available (40 bar maximum). If efficient high-pressure compressors are developed, ammonia will be an excellent high-temperature working fluid. **(circa 2008)**

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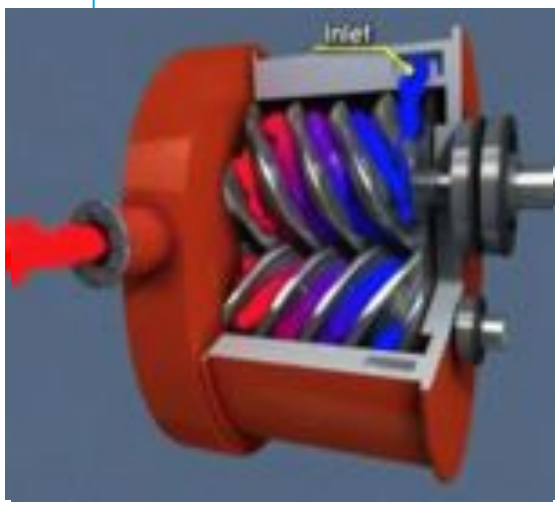
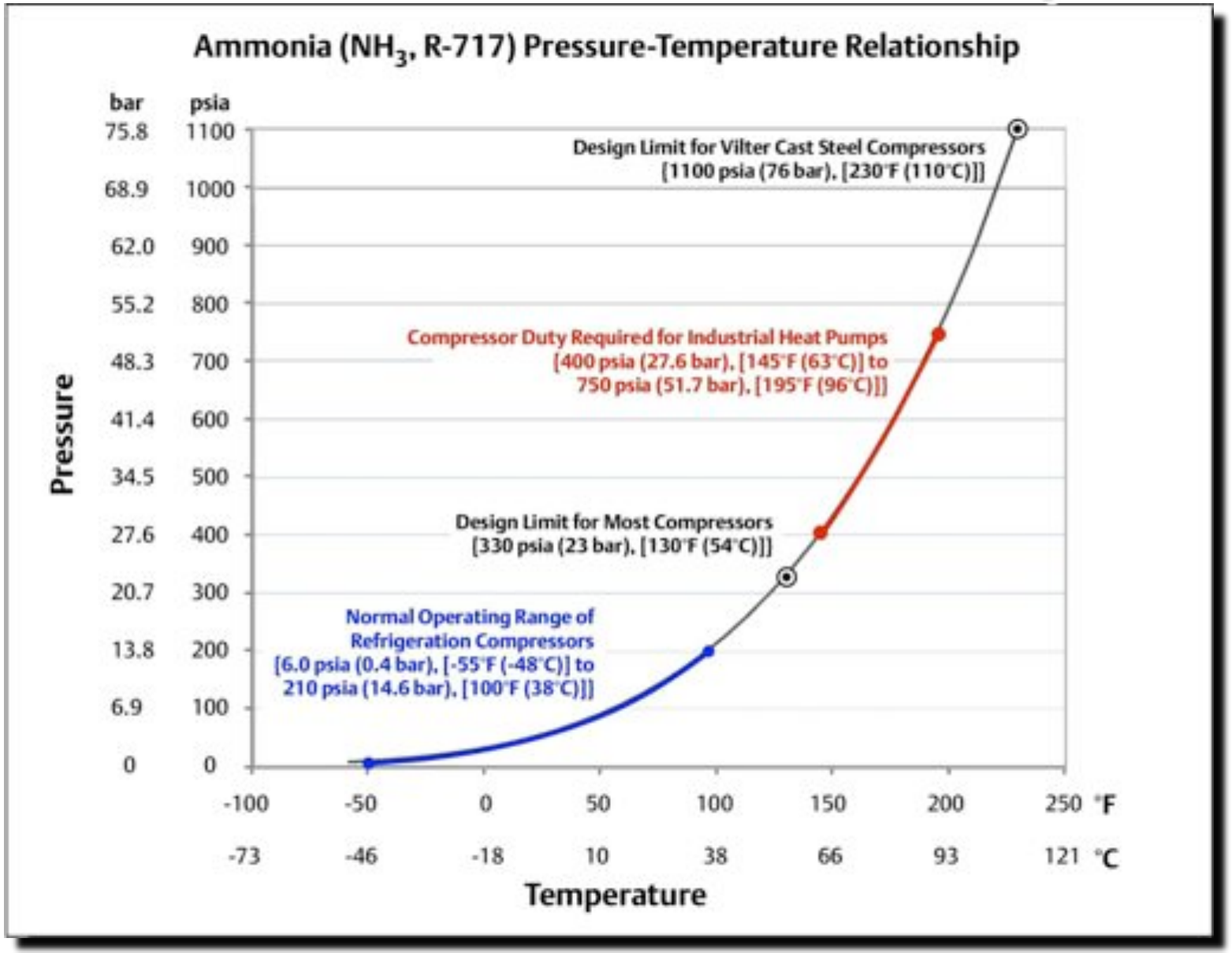


Twin Screw	Single Screw
High Bearing Loads	Balanced Loads
Challenged at High Pressures	Suited for High Pressures

Limitations – Ammonia Heat Pumps



Industrial Heat Pump Design Parameters

PROJECT: Kraft Foods, Oscar Mayer Plant; Davenport, Iowa, USA

OBJECTIVE: Use an Industrial Ammonia Heat Pump to replace a Direct Contact Water Heater

Direct Contact Water Heater

- **Capacity = 7.013 MMBtu**
- **Average Flow Rate = 170 gpm**
- **Average Inlet Temperature = 62.5°F**
- **Outlet Temperature = 145°F**
- **Fuel: Natural Gas**
- **Efficiency: 97%**
- **Hourly Operating Cost = $50.61**

Industrial Heat Pump Design Parameters

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Ammonia Heat Pump

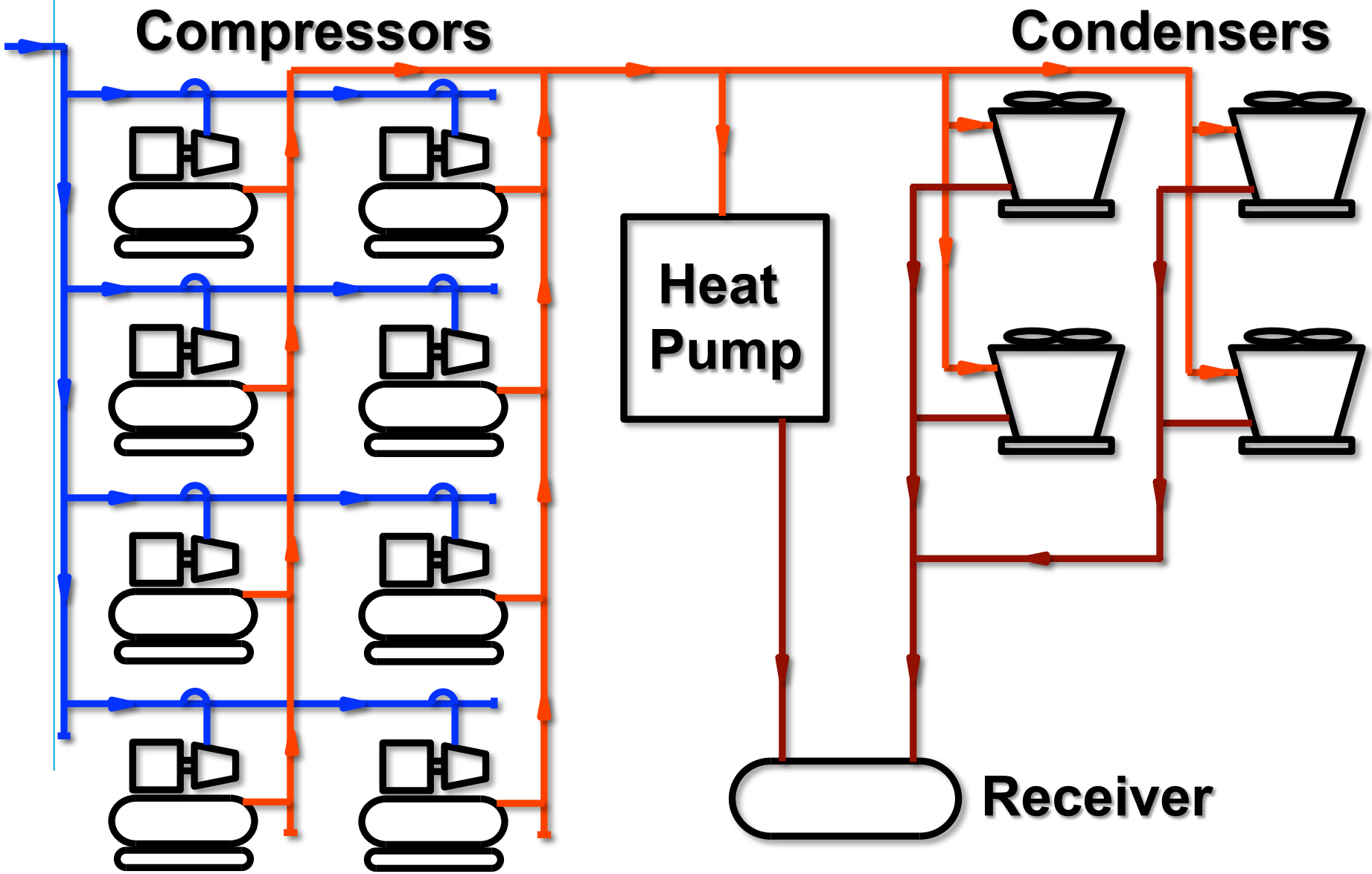
- ***Summer***: 205 GPM, 65F to 145F
- 8,200 MBH/3.41 = 2,405kW
- Suction = 160 psig
  Condensing = 510 psig
- Power = 594 HP/1.34 = 443kW
- COP = 2,405/443 = 5.43

- ***Winter***: 135 GPM, 60F to 145F
- 5,738 MBH/3.41 = 1,682kW
- Suction = 105 psig
  Condensing = 510 psig
- Power = 562 HP/1.34 = 419kW
- COP = 1,682/419 = 4.01

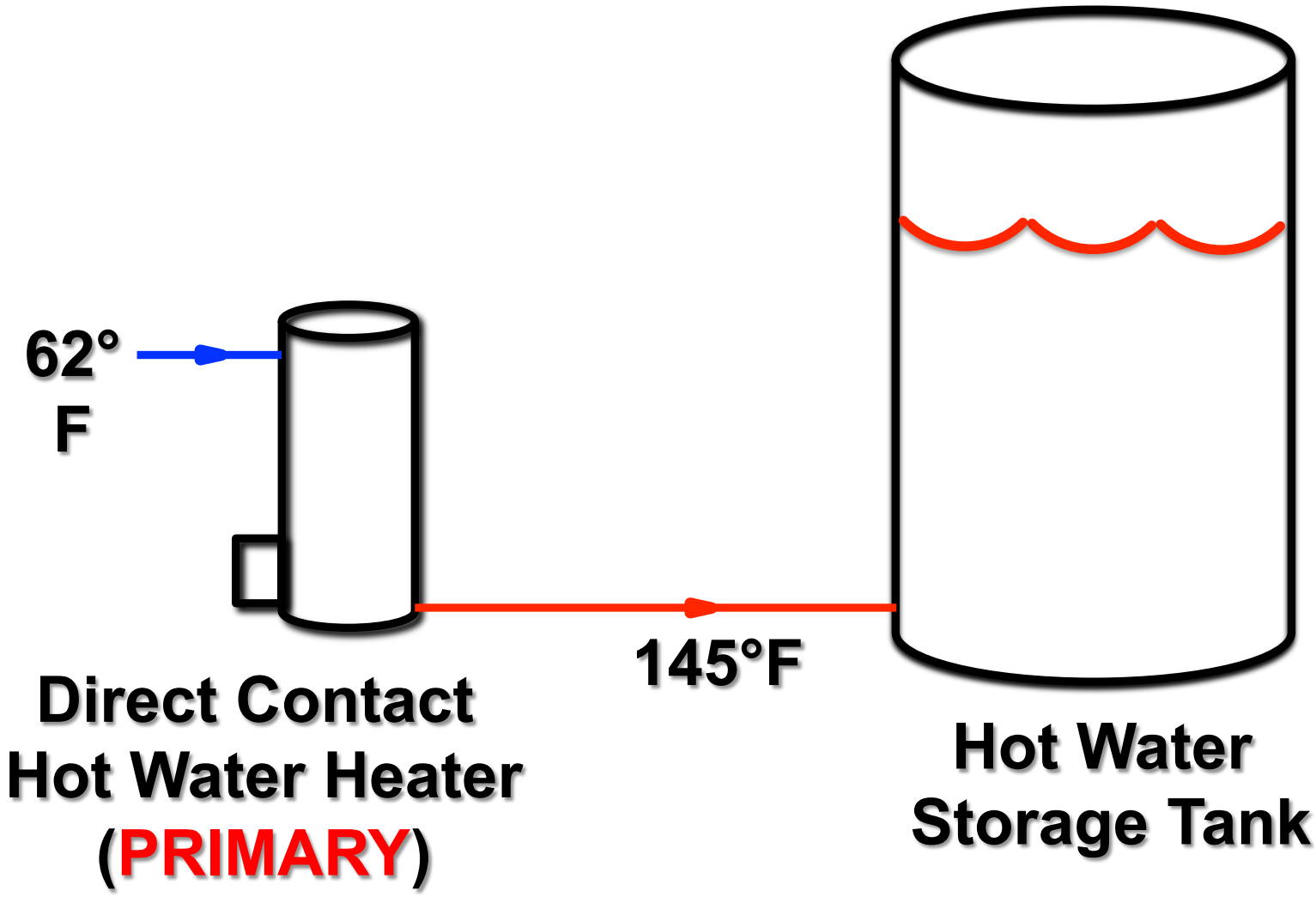
Average COP = 4.7

Average Hourly Operating Cost = $19.40

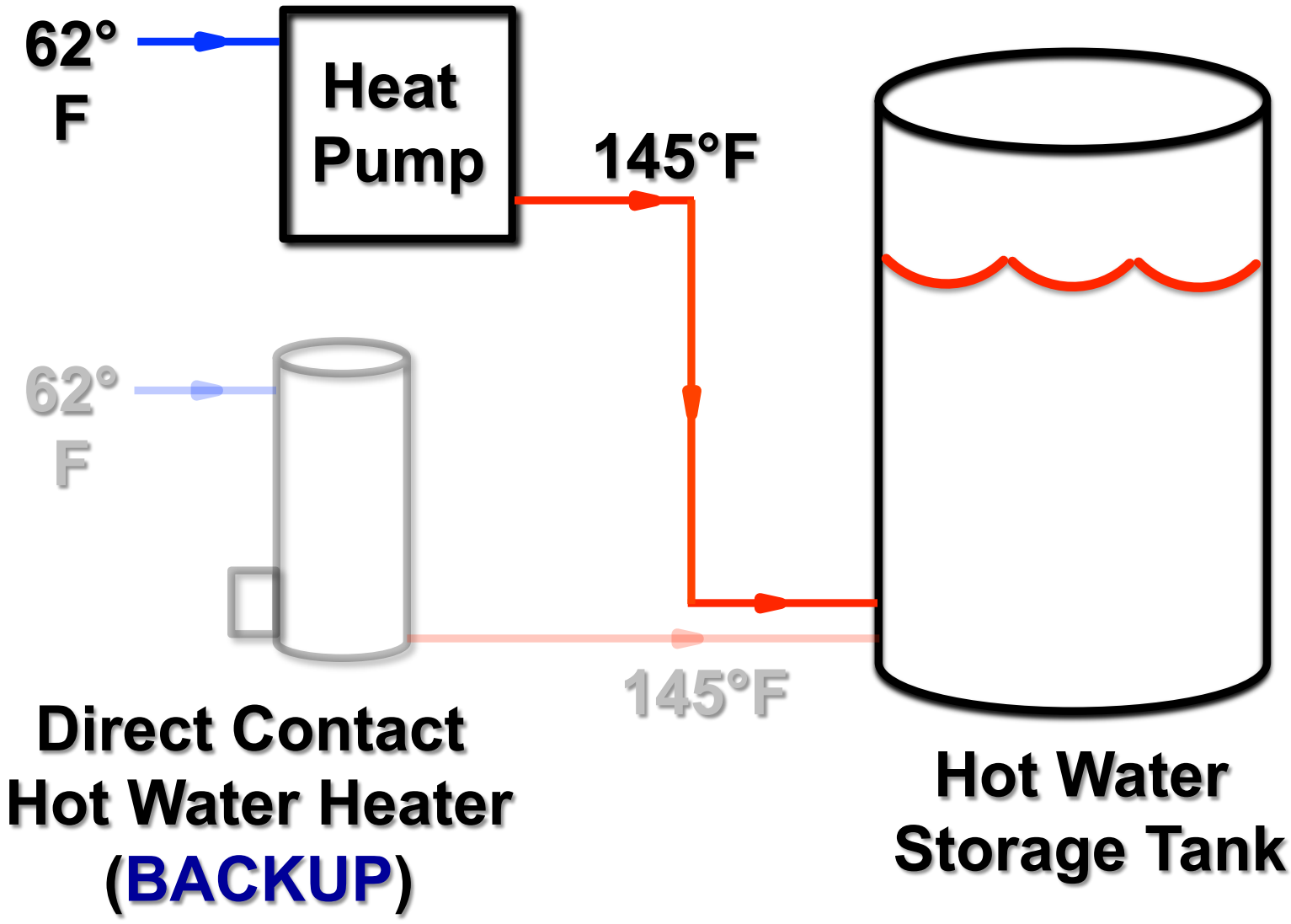
Industrial Heat Pump - Refrigeration



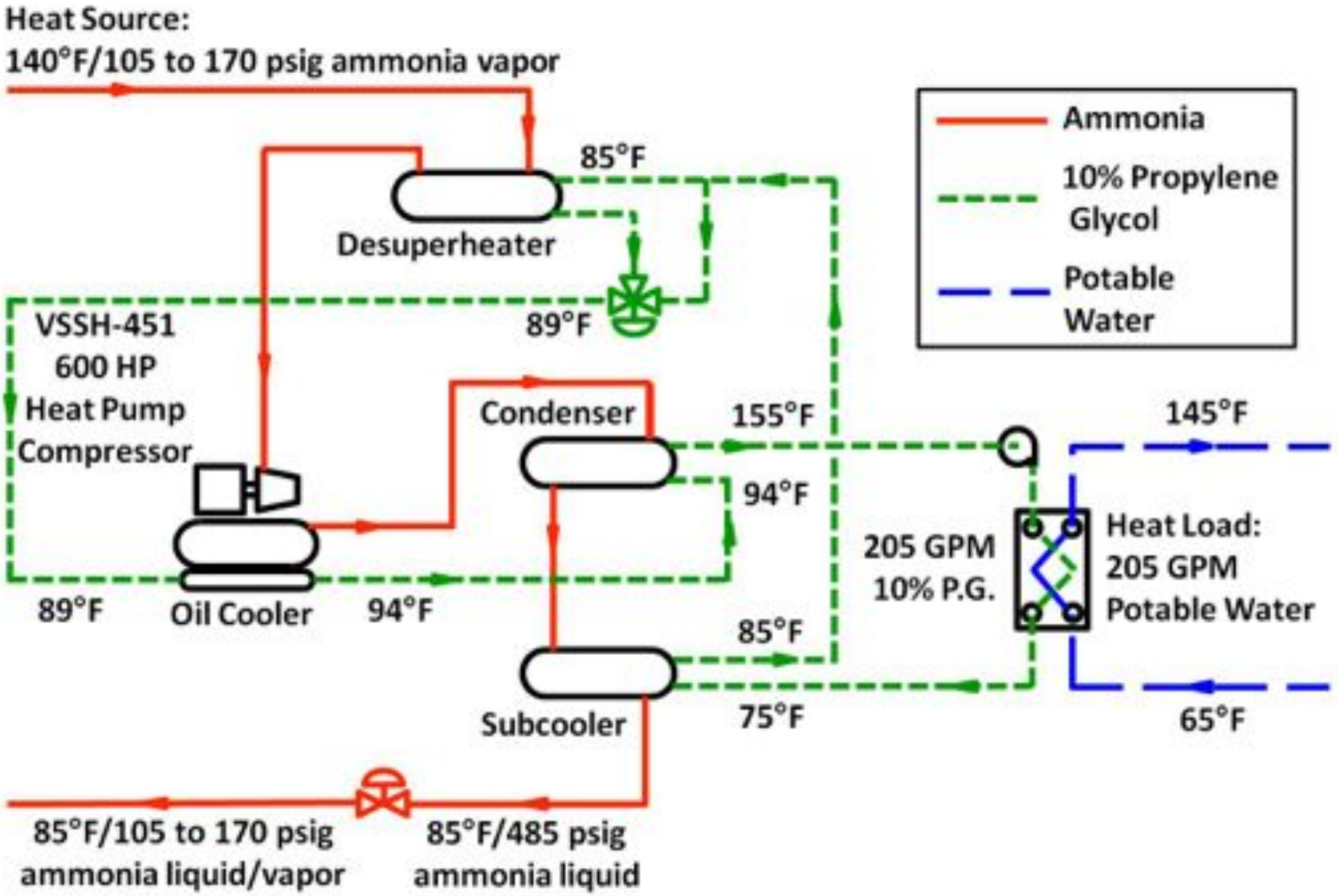
Industrial Heat Pump - Hot Water

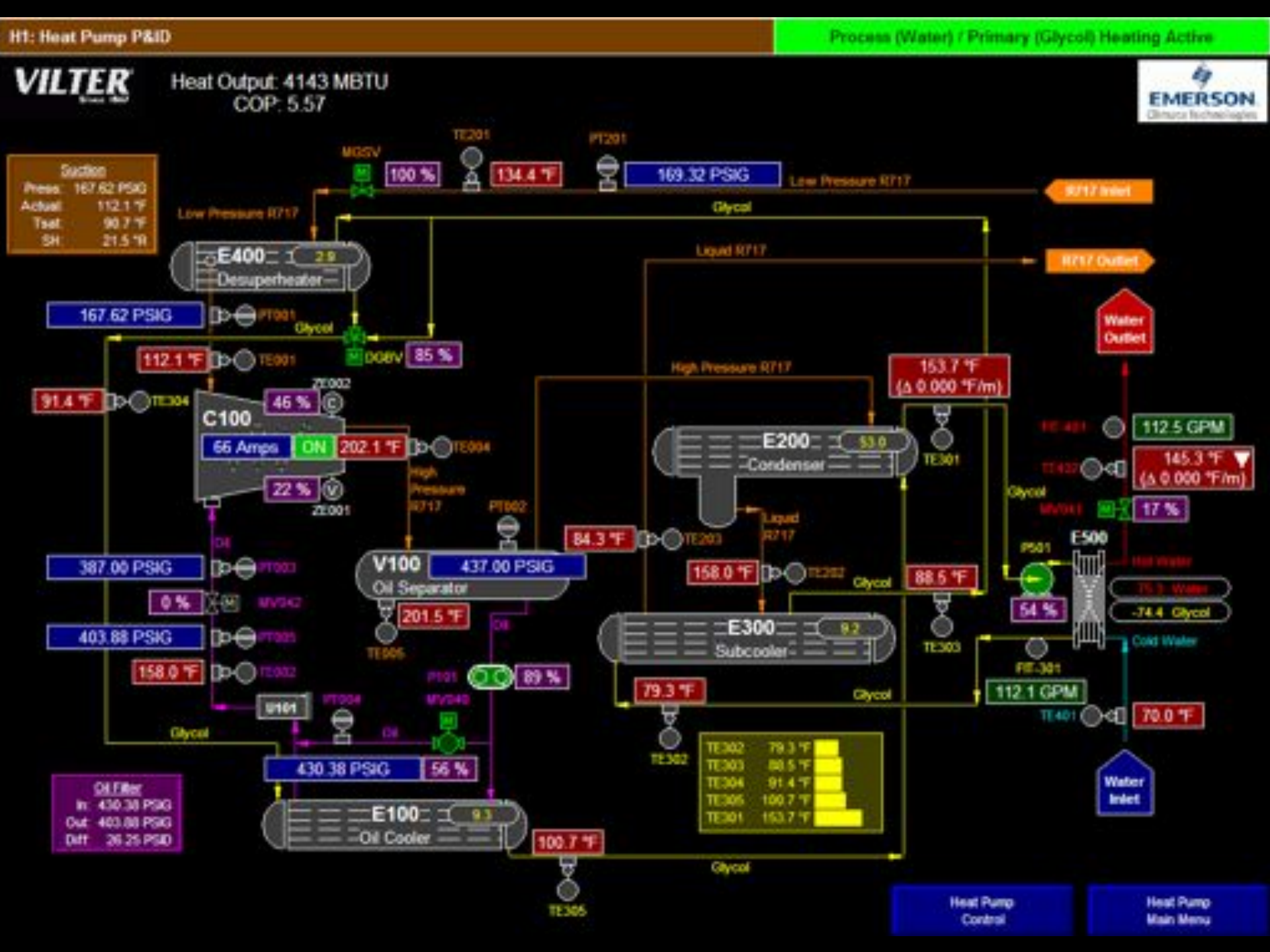


Industrial Heat Pump - Hot Water



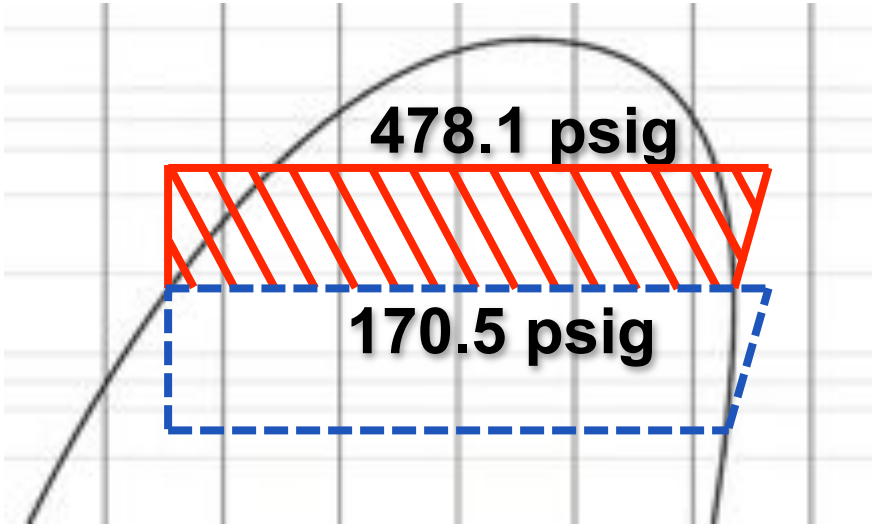
Industrial Heat Pump - Schematic




H1: Heat Pump P&ID
Process (Water) / Primary (Glycol) Heating Active
VILTER
Heat Output: 4143 MBTU
COP: 5.57
EMERSON
Suction
Press: 167.62 PSIG
Actual: 112.1 °F
Tsat: 90.7 °F
SH: 21.5 °R
MGSV
100 %
TE201
134.4 °F
PT201
169.32 PSIG
Low Pressure R717
R717 Inlet
Glycol
Liquid R717
R717 Outlet
E400
2.9
Desuperheater
167.62 PSIG
PT001
Glycol
112.1 °F
TE001
D08V
85 %
91.4 °F
TE304
ZE002
46 %
C100
66 Amps
ON
202.1 °F
TE004
22 %
ZE001
High Pressure R717
PT002
153.7 °F
(Δ 0.000 °F/m)
E200
53.0
Condenser
TE301
Water Outlet
112.5 GPM
145.3 °F
(Δ 0.000 °F/m)
17 %
84.3 °F
TE203
Liquid R717
158.0 °F
TE202
387.00 PSIG
PT003
0 %
MV042
V100
437.00 PSIG
Oil Separator
201.5 °F
TE005
403.88 PSIG
PT005
158.0 °F
TE032
PI01
89 %
V101
PT004
MV049
Oil
E300
9.2
Subcooler
79.3 °F
TE302
88.5 °F
TE303
PI501
54 %
E500
Hot Water
75.3 Water
-74.4 Glycol
Cold Water
FE-301
112.1 GPM
TE401
70.0 °F
Water Inlet
TE302 79.3 °F
TE303 88.5 °F
TE304 91.4 °F
TE305 100.7 °F
TE301 153.7 °F
Oil Filter
In: 430.38 PSIG
Out: 403.88 PSIG
Diff: 26.25 PSID
430.38 PSIG
56 %
E100
9.3
Oil Cooler
100.7 °F
TE305
Heat Pump Control
Heat Pump Main Menu

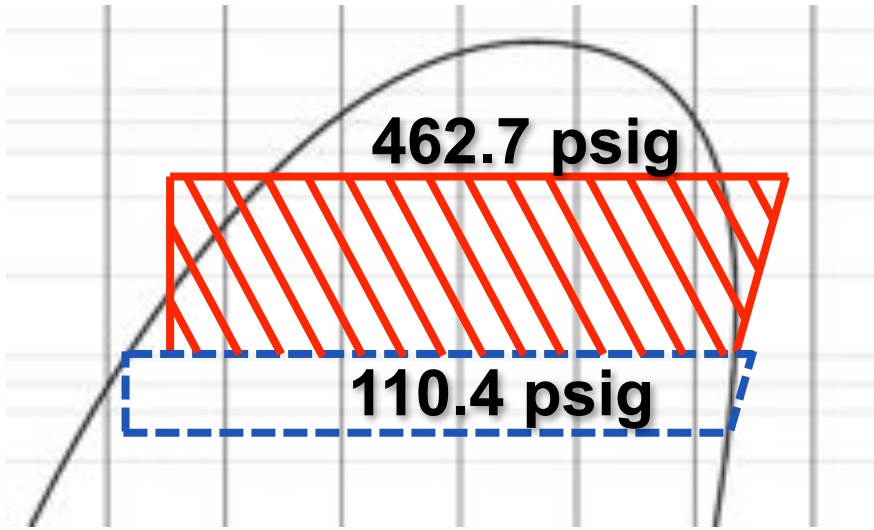
Actual Results
Industrial Ammonia Heat Pump - Kraft

Summer



8,080.6 MBH/3.41 = 2,369.5 kW
Power = 364.0 kW
COP = 2,369.5/364.0 = 6.51

Winter



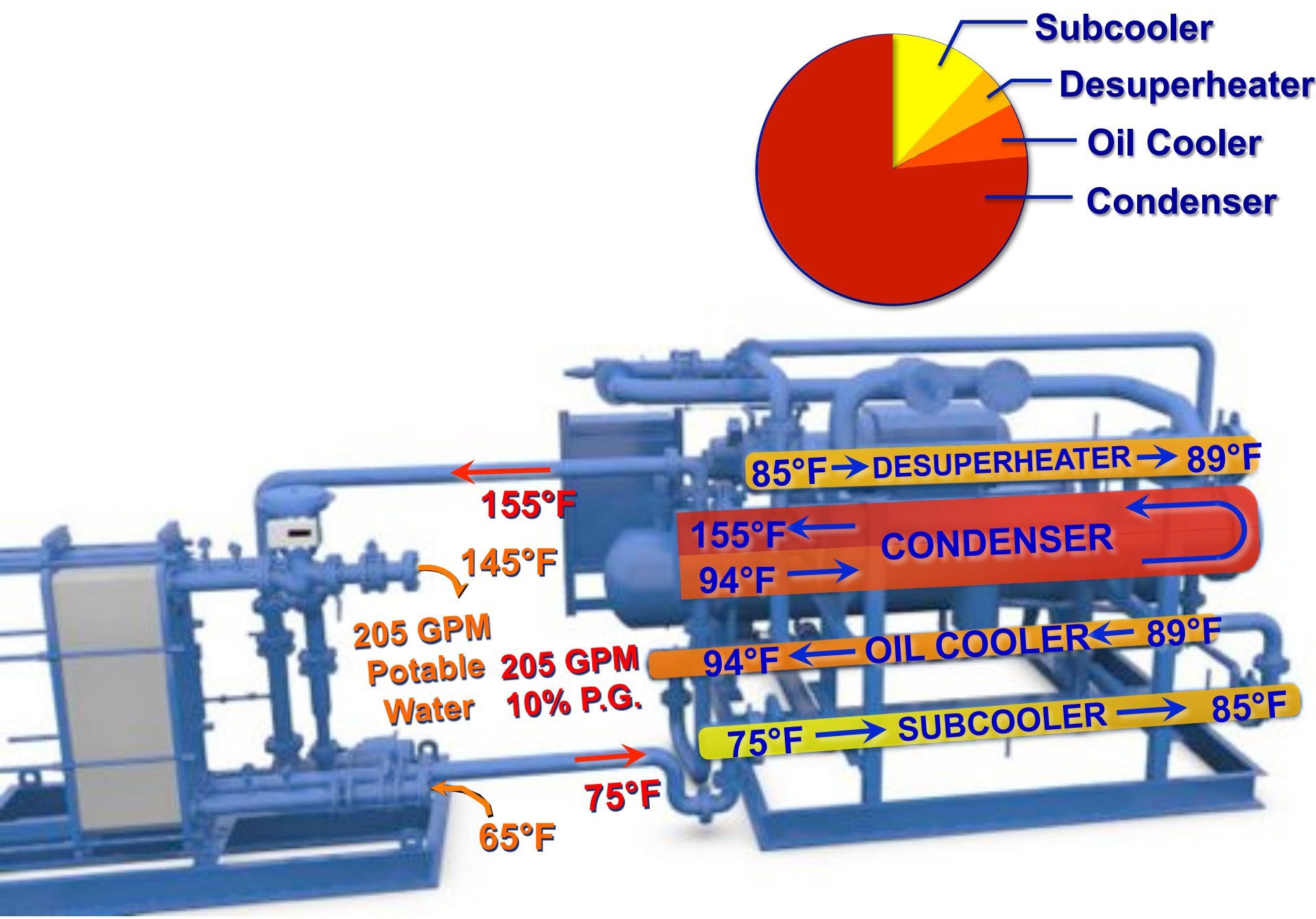
4,857.6 MBH/3.41 = 1,423.6 kW
Power = 336.9 kW
COP = 1,423.6/336.9 = 4.23

Actual Results
Industrial Ammonia Heat Pump - Kraft

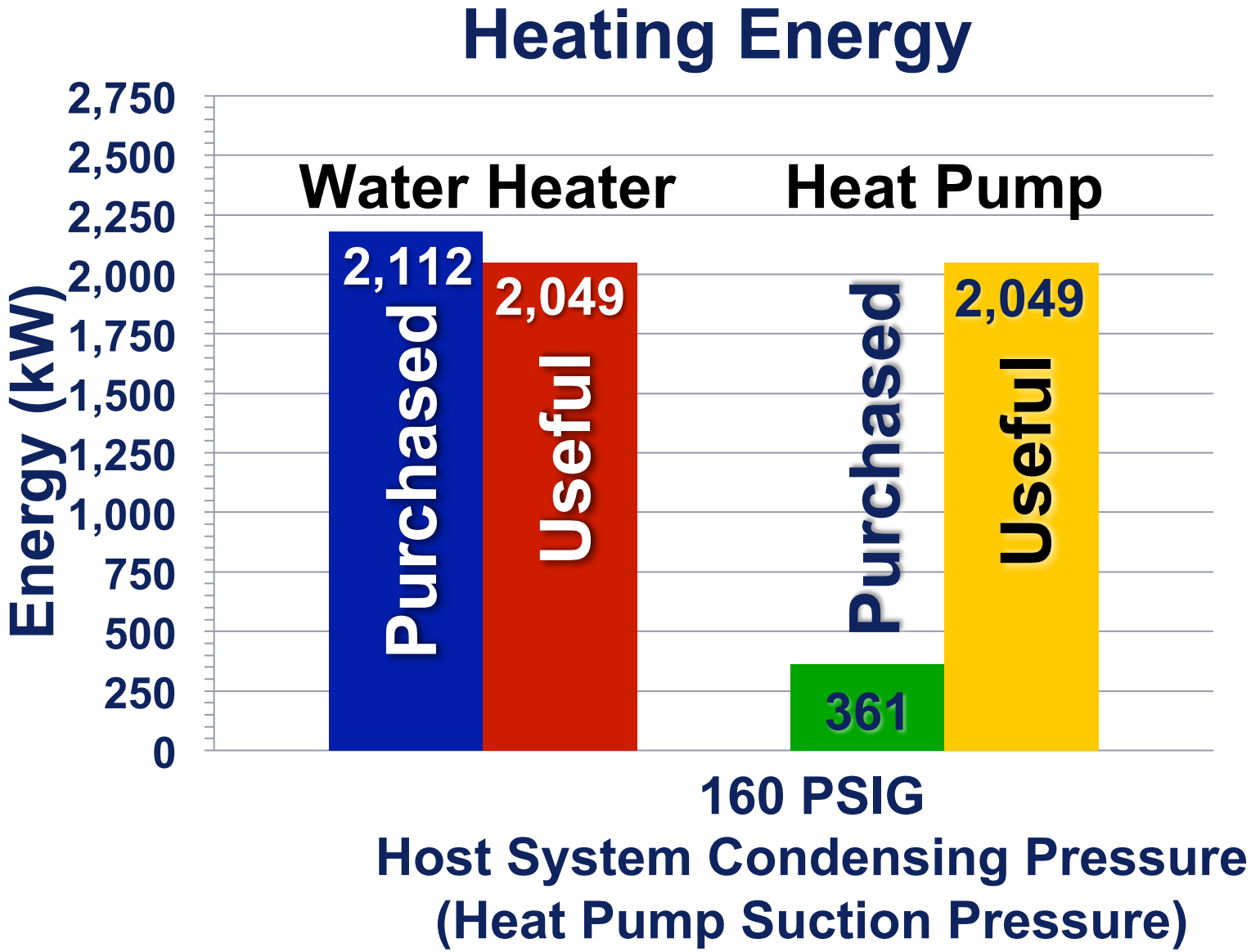
VSSH-451 at 66°F to 86°F Suction

Delivering 170 GPM Water at 145°F

Saving +$31/hour


Subcooler
Desuperheater
Oil Cooler
Condenser
85°F → DESUPERHEATER → 89°F
155°F
155°F ← CONDENSER
145°F
94°F →
205 GPM
Potable
Water
205 GPM
10% P.G.
94°F ← OIL COOLER ← 89°F
75°F → SUBCOOLER → 85°F
75°F
65°F

Actual Results
Industrial Ammonia Heat Pump - Kraft



Actual Results
Industrial Ammonia Heat Pump - Kraft

Annual Energy Cost Savings

Direct Contact Water Heating

- 60,115,909 MBH/year
- 97% Efficiency
- $7.00/1000 MBH
- 61,975,164 MBH/year
- Annual Oper. Cost = $433,826

Heat Pump Water Heating

- 3,518,946 kWh/year
- 96% Motor Efficiency
- $.045/kWh
- 3,665,569 kWh/year
- Annual Oper. Cost = $164,951

Annual Energy Cost Savings
= $433,826 - $164,951 = $268,875

35% Return on Investment

Industrial Ammonia Heat Pump - Kraft

RIGHT NOW

The world's leading food processors are not only saving 50 percent on energy costs, they're topping it off with a reduction in water consumption of 30 million gallons a year.

Thank You!

AMERICA ATMOsphere

the Business Case

natural refrigerants