Lab #8
Refrigeration

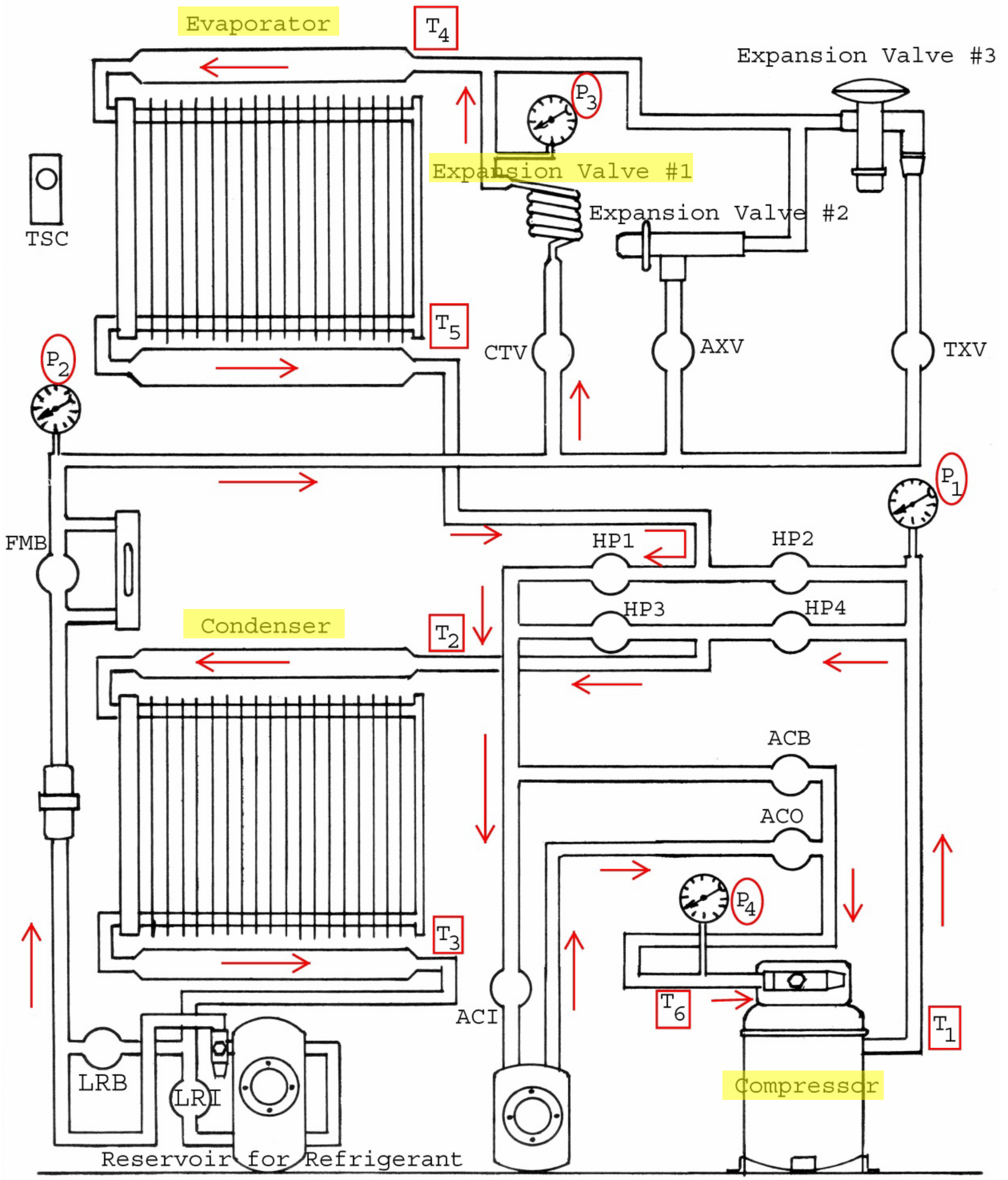
Outline

- Goals of lab
- Schematic of experimental setup
- Pressure-enthalpy diagram for R-12
- Pressure-enthalpy table for R-12
- Vapor compression refrigeration system
- P, T, H, and phase changes in a vapor compression refrigeration cycle

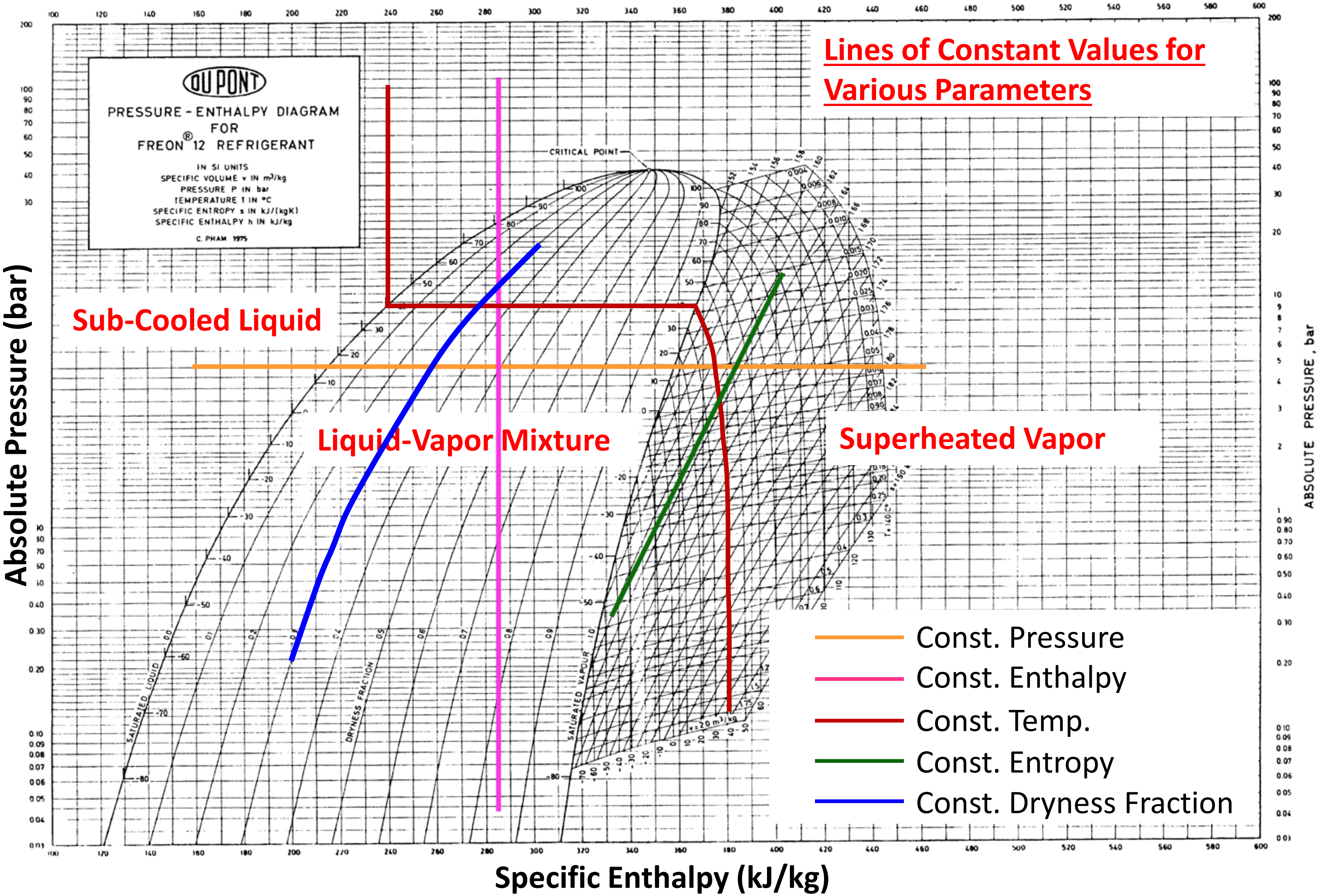
Goals of Lab

- To get acquainted with a vapor-compression refrigeration system
- To be able to use pressure-enthalpy diagrams and tables
- To determine the C.O.P. of a vapor-compression refrigeration system

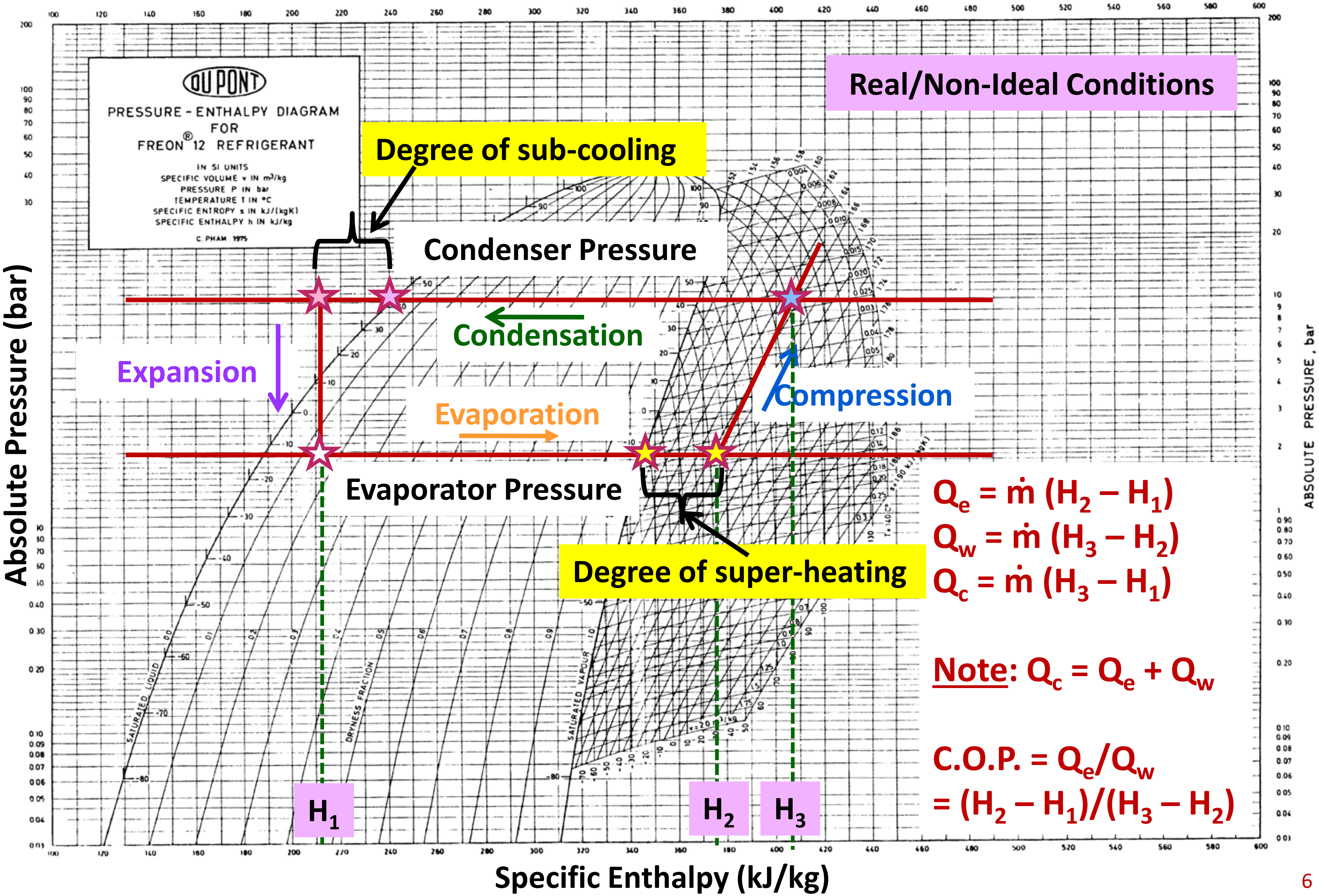
Schematic of Experimental Setup



Pressure-Enthalpy Diagram for R-12



Pressure-Enthalpy Diagram for R-12



$Q_e = \dot{m}\,(H_2 - H_1)$

$Q_w = \dot{m}\,(H_3 - H_2)$

$Q_c = \dot{m}\,(H_3 - H_1)$

Note: $Q_c = Q_e + Q_w$

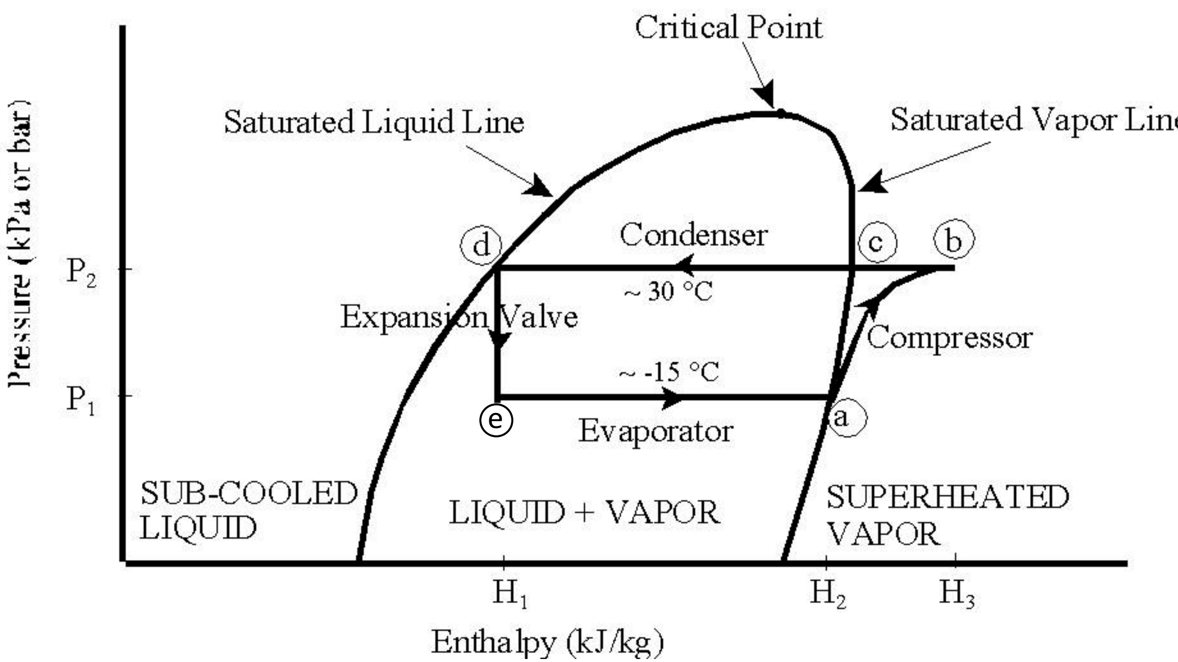
C.O.P. $= Q_e/Q_w$

$= (H_2 - H_1)/(H_3 - H_2)$

Pressure-Enthalpy Table for R-12

t (°C)	P (kPa)	Enthalpy (kJ/kg) h_f	h_g
−60	22.62	146.463	324.236
−55	29.98	150.808	326.567
−50	39.15	155.169	328.897
−45	50.44	159.549	331.223
−40	64.17	163.948	333.541
−35	80.71	168.396	335.849
−30	100.41	172.810	338.143
−28	109.27	174.593	339.057
−26	118.72	176.380	339.968
−24	128.80	178.171	340.876
−22	139.53	179.965	341.780
−20	150.93	181.764	342.682
−18	163.04	183.567	343.580
−16	175.89	185.374	344.474
−14	189.50	187.185	345.365
−12	203.90	189.001	346.252
−10	219.12	190.822	347.134
−9	227.04	191.734	347.574
−8	235.19	192.647	348.012
−7	243.55	193.562	348.450
−6	252.14	194.477	348.886
−5	260.96	195.395	349.321
−4	270.01	196.313	349.755
−3	279.30	197.233	350.187
−2	288.82	198.154	350.619
−1	298.59	199.076	351.049
0	308.61	200.000	351.477
1	318.88	200.925	351.905
2	329.40	201.852	352.331
3	340.19	202.780	352.755
4	351.24	203.710	353.179
5	363.55	204.642	353.600

P-H Diagram for Ideal Conditions

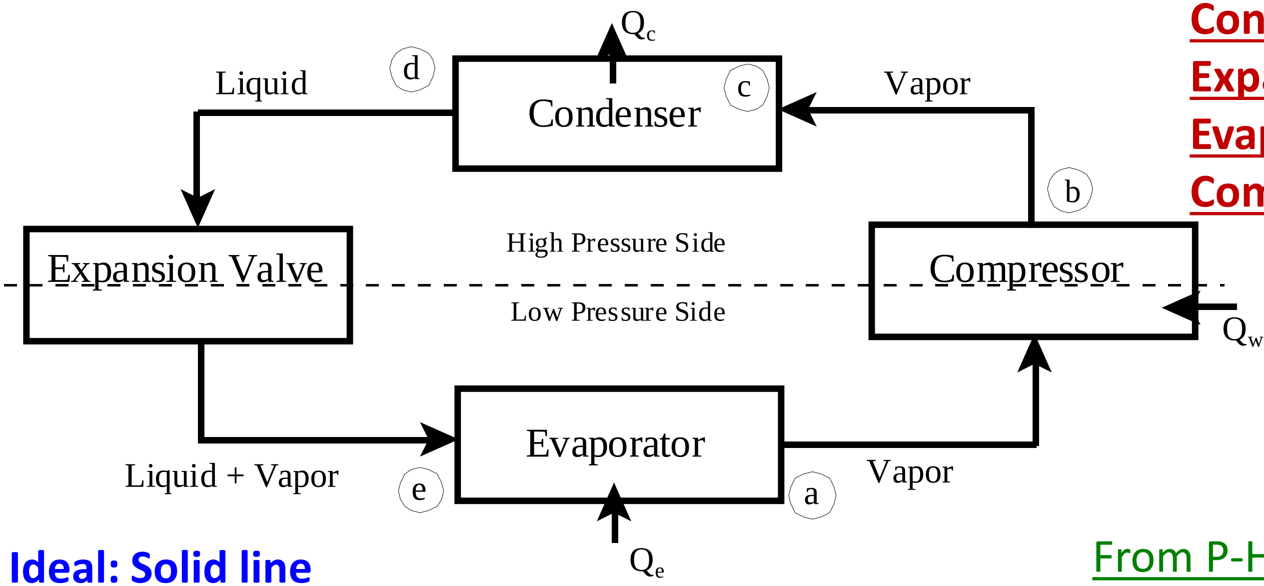


$H_1 = h_f$ based on temperature at 'd' (exit of condenser)

$H_2 = h_g$ based on temperature at 'a' (exit of evaporator)

Note 1: If there is super-heating in the evaporator, H_2 can not be obtained from P-H table
Note 2: If there is sub-cooling in the condenser, H_1 can not be obtained from P-H table
Note 3: For ideal or non-ideal conditions, H_3 can not be obtained from P-H table
(For the above 3 conditions, use the P-H Diagram to determine the enthalpy value)

Vapor Compression Refrigeration System



Condensing: Constant Pr. (P_2)

Expansion: Constant Enthalpy (H_1)

Evaporation: Constant Pr. (P_1)

Compression: Constant Entropy (S)

$Q_e = \dot{m}\,(H_2 - H_1)$

$Q_w = \dot{m}\,(H_3 - H_2)$

$Q_c = \dot{m}\,(H_3 - H_1)$

Note: $Q_c = Q_e + Q_w$

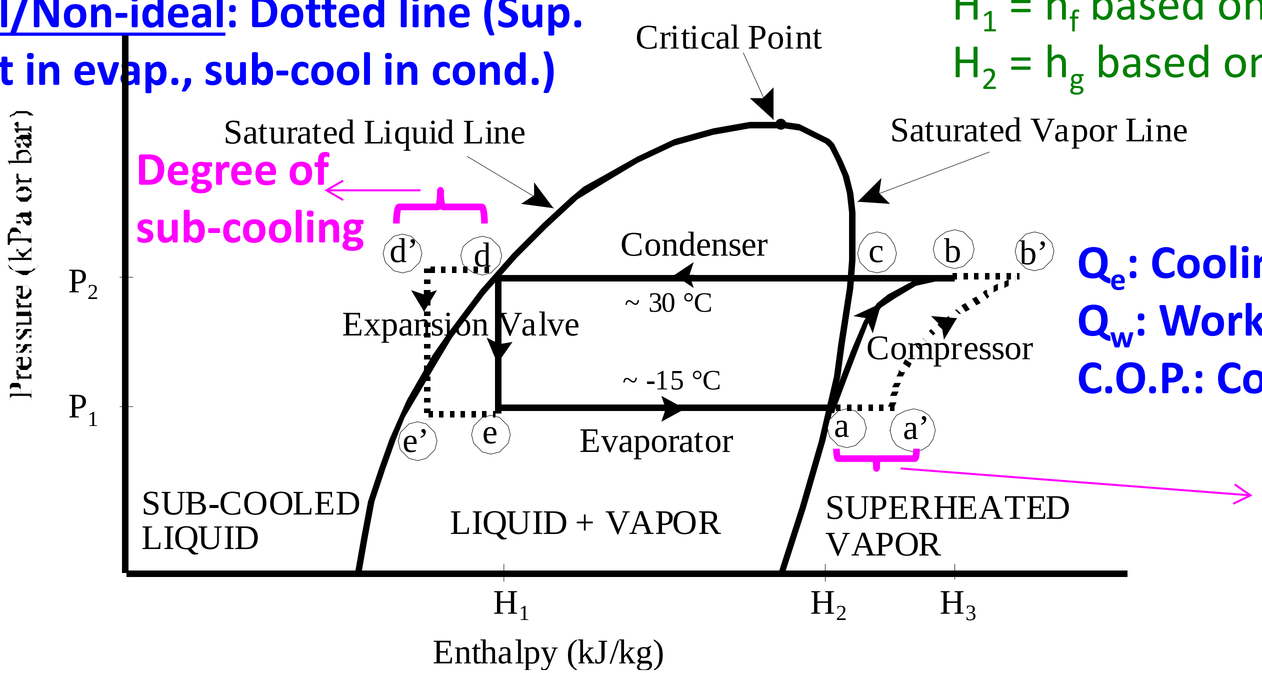
Ideal: Solid line

Real/Non-ideal: Dotted line (Sup. heat in evap., sub-cool in cond.)

From P-H Table (For Ideal Conditions)

$H_1 = h_f$ based on temp. at 'd' (exit of cond.)

$H_2 = h_g$ based on temp. at 'a' (exit of evap.)



C.O.P. $= Q_e/Q_w$

$= (H_2 - H_1)/(H_3 - H_2)$

Q_e: Cooling load rate (kW)

Q_w: Work done by compressor (kW)

C.O.P.: Coefficient of performance

Degree of superheating

P, T, H, and Phase changes in a Vapor Compression Refrigeration Cycle

Ideal Conditions

Component	Pressure	Temperature	Enthalpy	Phase of Refrigerant Inlet	Phase of Refrigerant Outlet
Evaporator	Constant	Constant	Increases	Liquid + Vapor	Vapor (On Dome)
Compressor	Increases	Increases	Increases	Vapor (On Dome)	Vapor (Sup. Heat)
Condenser	Constant	Decreases	Decreases	Vapor (Sup. Heat)	Liquid (On Dome)
Expansion Valve	Decreases	Decreases	Constant	Liquid (On Dome)	Liquid + Vapor

Real Conditions (Super-heating in Evaporator, Sub-cooling in condenser)

Component	Pressure	Temperature	Enthalpy	Phase of Refrigerant Inlet	Phase of Refrigerant Outlet
Evaporator	Constant	Increases	Increases	Liquid + Vapor	Vapor (Sup. Heat)
Compressor	Increases	Increases	Increases	Vapor (Sup. Heat)	Vapor (Sup. Heat)
Condenser	Constant	Decreases	Decreases	Vapor (Sup. Heat)	Liquid (Sub-Cool)
Expansion Valve	Decreases	Decreases	Constant	Liquid (Sub-Cool)	Liquid + Vapor