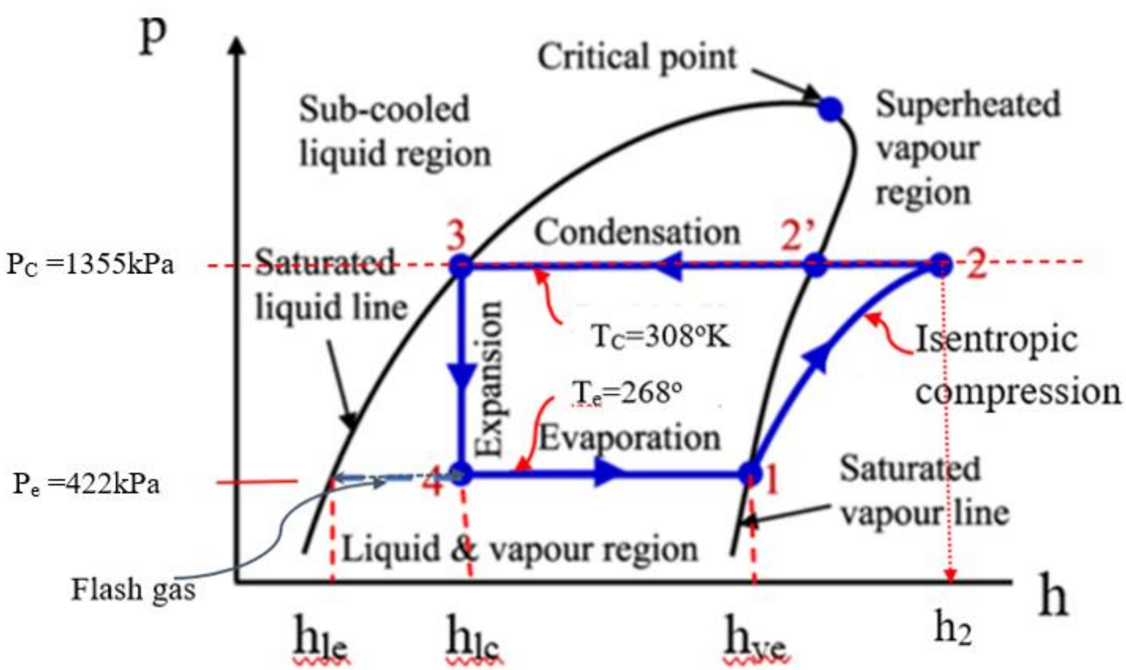
# Lecture fifteen

e.g.: A refrigerator producing 15kw of refrigeration operates at an evaporator temperature of (-5°C) & condenser temperature of (35°C). calculate:

a) $\dot{m}$, b) $\dot{\upsilon}$, c) W, d) $Q_{out}$, e) f, f) cop, if the refrigerant used is R-22.

Sol:




Points 1&3 from table only & ($h_3$=$h_4$).[point 2 from chart].

From table: $P_c$=1355kPa & $P_e$=422kPa.

$h_1$= 403.15kJ/kg (saturated vapour).

$h_4$=$h_3$=243.1kJ/kg (saturated liquid).

$h_2$=434 kJ/kg from P-h diagram.

To obtain ($h_2$), extend the horizontal straight line at ($T_c$=308°K or $P_c$=1355kPa) to the superheated vapour region, then locate point (1) on the saturated vapour line at intersection with line ($T_e$=268°K). Then follow the isentropic compression curve until intersecting with line ($T_C$=308°K). Locate point (2) & read ($h_2$).

a) $\dot{m} = \frac{X}{Q_{ref.}} = \frac{15}{h_1 - h_4} = \frac{15}{403.15 - 243.1} = 0.0937$kg/sec.

b) $\dot{\upsilon} = \dot{m}(\upsilon_g)_1 = 0.0937 * 55.325 * 10^{-3} = 0.00518$ m³/sec., [ $(\upsilon_g)_1 = 55.325 * 10^{-3}$ m³/kg from table at -5°C].

c) $W = \dot{m}(h_2 - h_1) = 0.0937\ (434 - 403.15) = 2.89$ kw.

d) $Q_{out} = \dot{m}(h_2 - h_3) = 0.0937\ (434 - 243.1) = 17.887$kw.

e) $f = \frac{h_3 - h_{le}}{h_1 - h_{le}}$ , saturated liquid at -5°C →$h_{le}$=194.15kJ/kg.

$f = \frac{243.1 - 194.15}{403.15 - 194.15} = 0.234$

i.e. approximately 23% of liquid is vapourized at the expansion valve before entering the evaporator.

f) $Cop = \frac{h_1 - h_4}{h_2 - h_1} = \frac{403.15 - 243.1}{434 - 403.15} = 5.188$

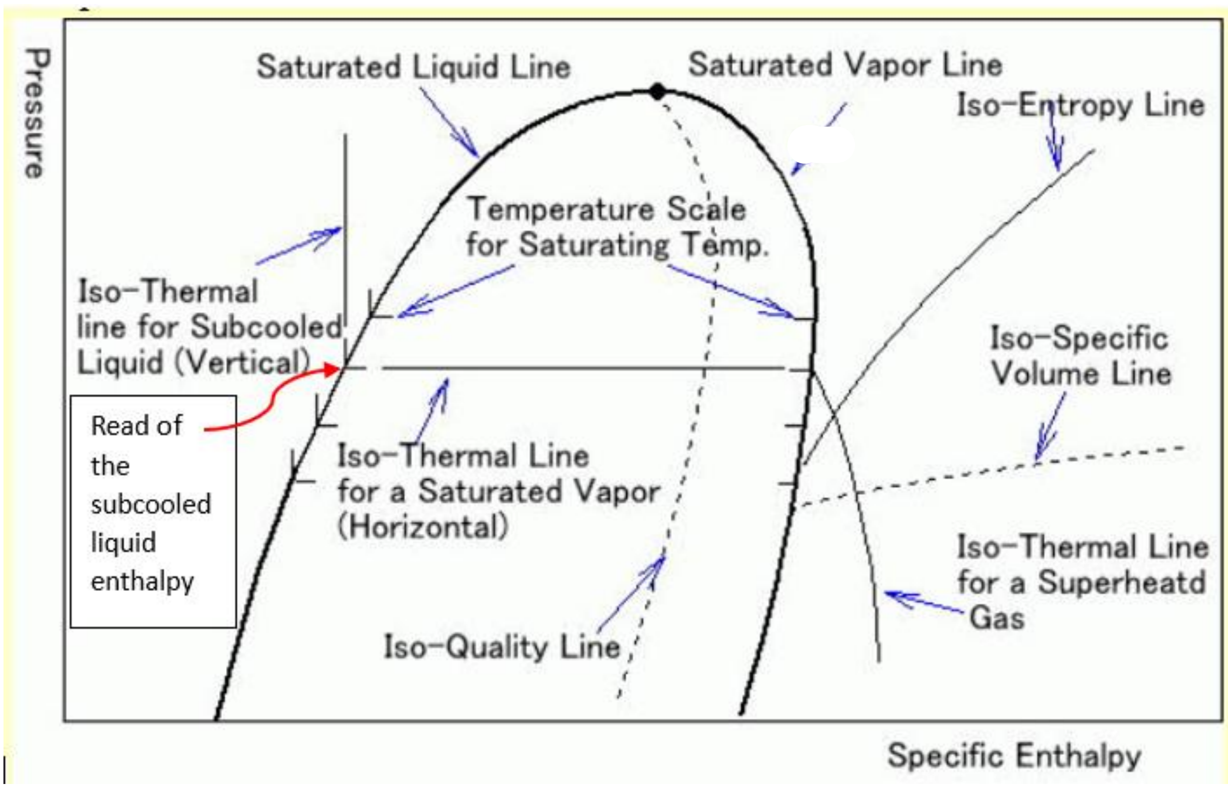
or $Cop = \frac{X}{W} = \frac{15}{2.89} = 5.19$

Recall $(Cop)_{Carnot.} = 6.7$

∴ Cop reduced in standard vap. Comp. cycle (ideal).

## 5- Refrigerant properties on a P-h diagram.

Pressure – enthalpy diagrams are the most used for refrigeration practice. They provide easier representation of the vapour-compression cycle.




Note:

1. temperature line is horizontal inside the phase envelope; vertical in subcooled region; drops to the right in superheated region.
   - In subcooled region enthalpy is read at the saturation temperature regardless of pressure. i.e. The temperature determines the enthalpy and not the pressure. Thus,

     $h_{\text{sub cooled liquid}} = h_{\text{saturated liquid at existing temp.}}$

2. Entropy lines steep & slope upward. Increase with increasing enthalpy & decreasing pressure.
3. Volume lines slope slightly upward to the right, increase with decreasing pressure.

   S = 1kJ/kg for saturated liquid at $0^oC$.

   h= 200kJ/kg for saturated liquid at $0^oC$.