Multipressure VC System

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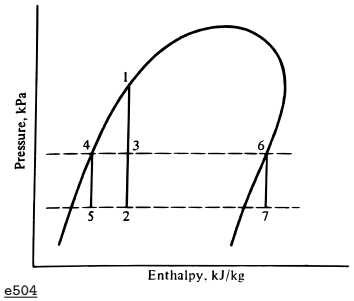
ME 415: Refrigeration & Building Mechanical Systems

Multipressure VC System

- A multipressure system is a refrigeration system that has two or more low-pressure side.
- A multipressure system may be found in a dairy where one evaporator operates at -35°C to harden ice cream while another evaporator operates at 2°C to cool milk.
- In process industries a two or three stage compression arrangement serves an evaporator operating at a low temperature of -20°C or lower.
- Two functions often integral to mutipressure systems are:
  1. Removal of flash gas
  2. Inter-cooling

Flash Gas Removal

When saturated liquid expands through an expansion device, fraction of vapour or flash gas progressively increases. Power is saved if developed flash gas is removed & re-compressed before complete expansion.



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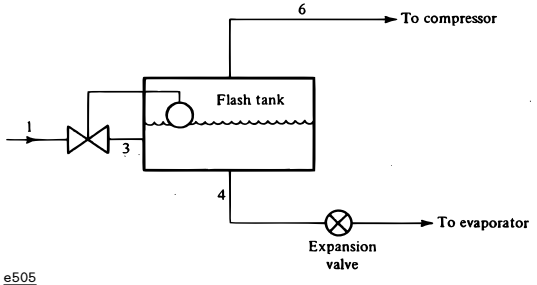

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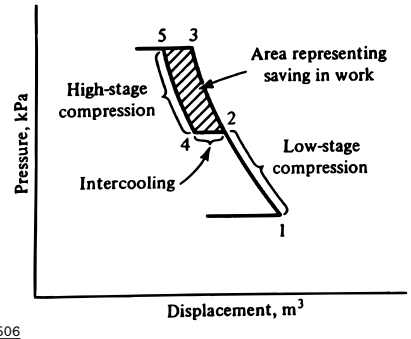
Inter-cooling



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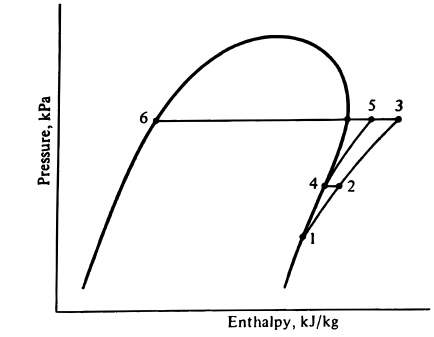

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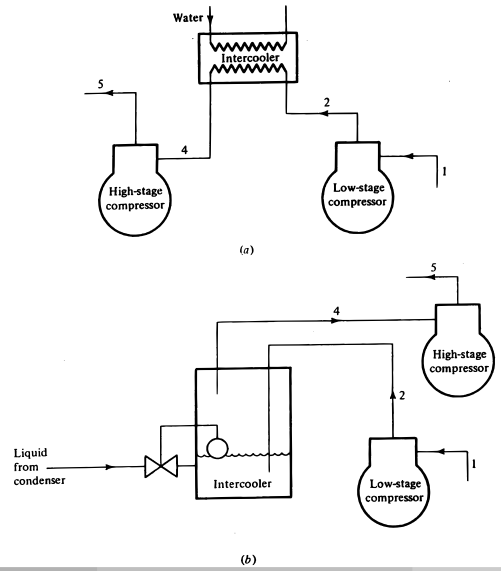
Inter-cooling between two stages of compression reduces the compression work. Inter-cooling can be done by

(a) with a water cooled condenser

(b) by using refrigerant: [i] flash inter-cooler [ii] sub-cooler

Inter-cooling Methods



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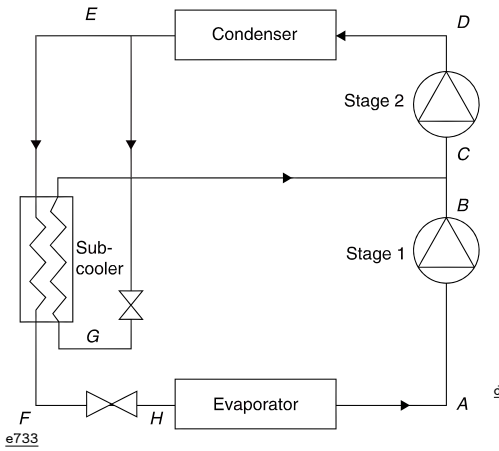
Inter-cooling with Subcooler



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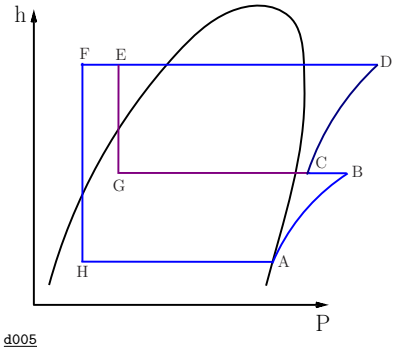

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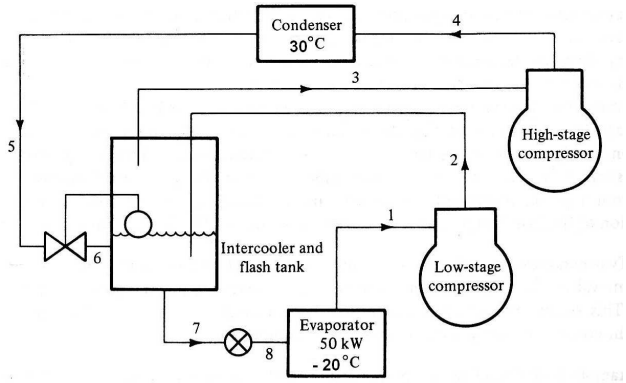
Example

Determine the COP of a 2-stage refrigeration system with flash gas removal. The system uses R134a as a refrigerant to produce 50 kW refrigeration effect. Given that, $T_{cond} = 30^oC$ and $T_{evap} = -20^oC$, and inter-cooler temperature is 0^oC.



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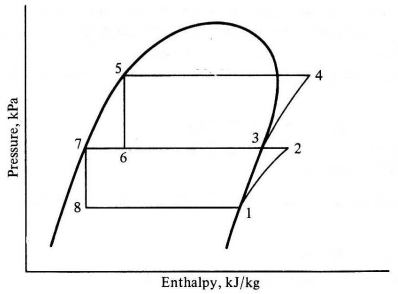

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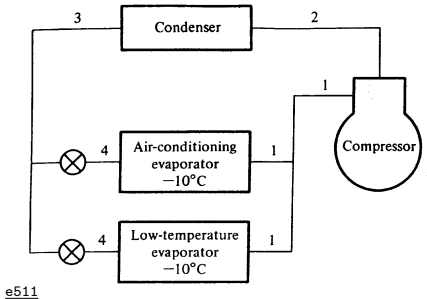
- $h_5 = h_6 = h_7 + x.(h_3 - h_7) \rightsquigarrow x = 0.21$
- RE = 50 kW $= m(1-x)(h_1 - h_8) \rightsquigarrow m = 0.339$ Kg/s
- $W_{12} = m(1-x)(h_2 - h_1) = 4.29$ kW
- $W_{34} = m(h_4 - h_3) = 6.80$ kW
- $W_{comp} = W_{12} + W_{34} = 11.09$ kW
- $COP = RE/W_{comp} = 4.50$
- *energy savings > 10% with multistaging & inter-cooling.*

1 Compressor & 2 Evaporators System



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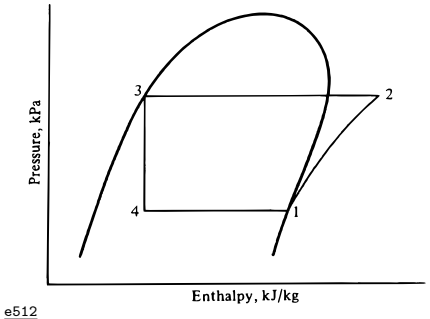

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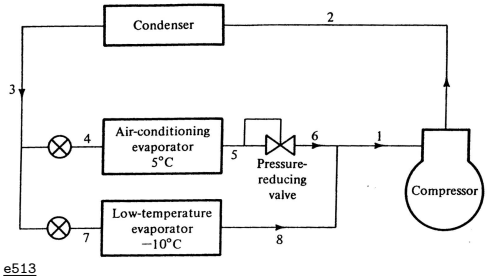
Evaporators are at same temperature



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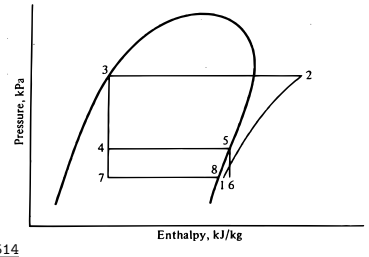

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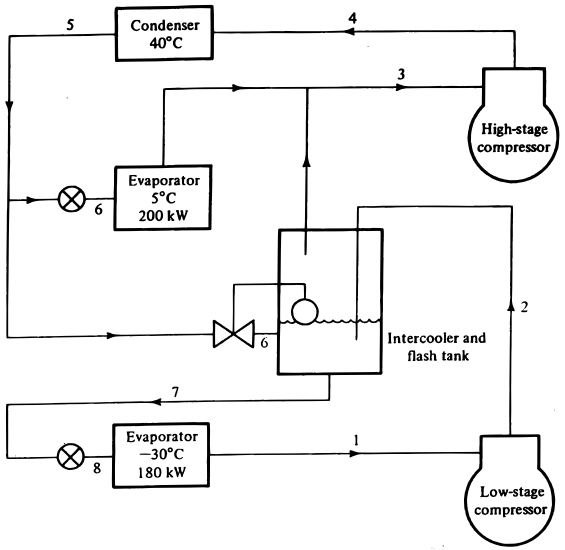
Evaporators are at different temperatures

2 Compressors & 2 Evaporators System



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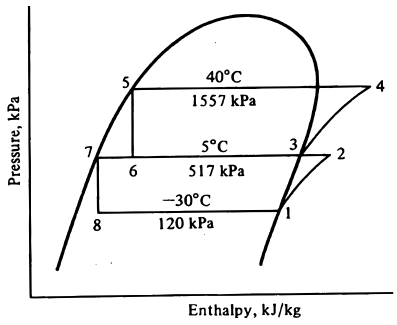

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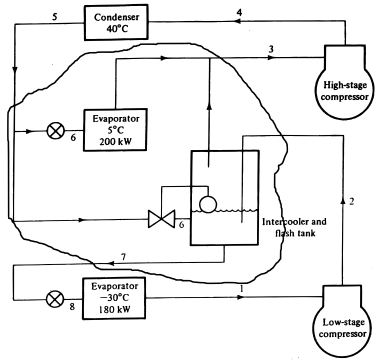

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- RE at -30°C = 180 kW = $m_1(h_1 - h_8) \rightsquigarrow m_1 = 0.15$ Kg/s, NH_3 system
- Mass balance: $m_1 = m_2 = m_7 = m_8$ & $m_3 = m_4 = m_5$
- Energy balance: $m_5 h_5 + 200 + m_2 h_2 = m_3 h_3 + m_7 h_7 \rightsquigarrow m_3 = 0.382$ Kg/s
- $W_{12} = 30.1$ kW, $W_{34} = 59.7$ kW, $W_{comp} = 89.8$ kW
- *If 1 single stage compressor serve each evaporator,*
  $W_{12} = 70.0$ kW, $W_{34} = 29.1$ kW, $W_{comp} = 99.1$ kW