MEBS6006 Environmental Services I

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Supplementary Calculation on Refrigeration Cycles

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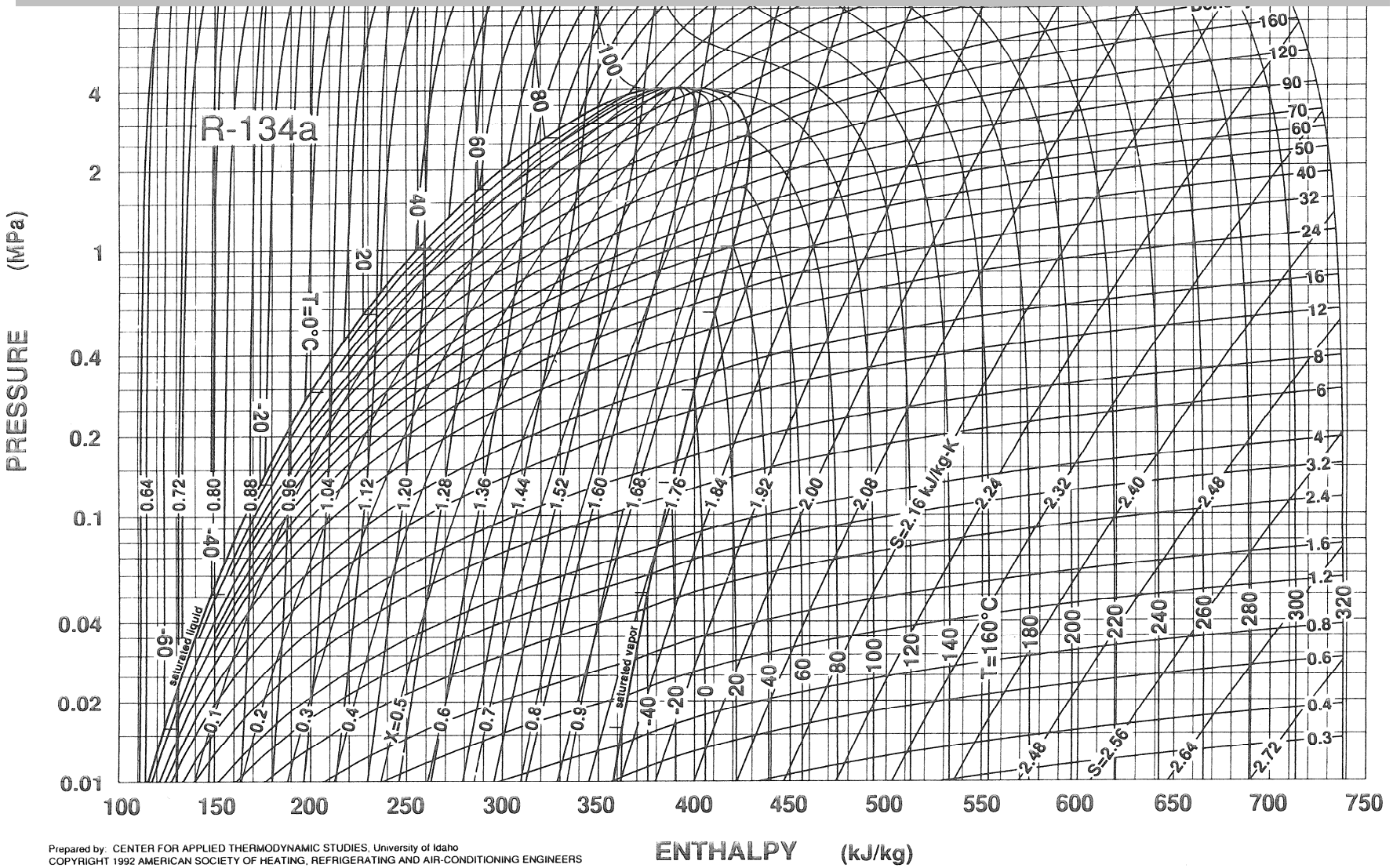
Supplementary Calculation on Refrigeration Cycles

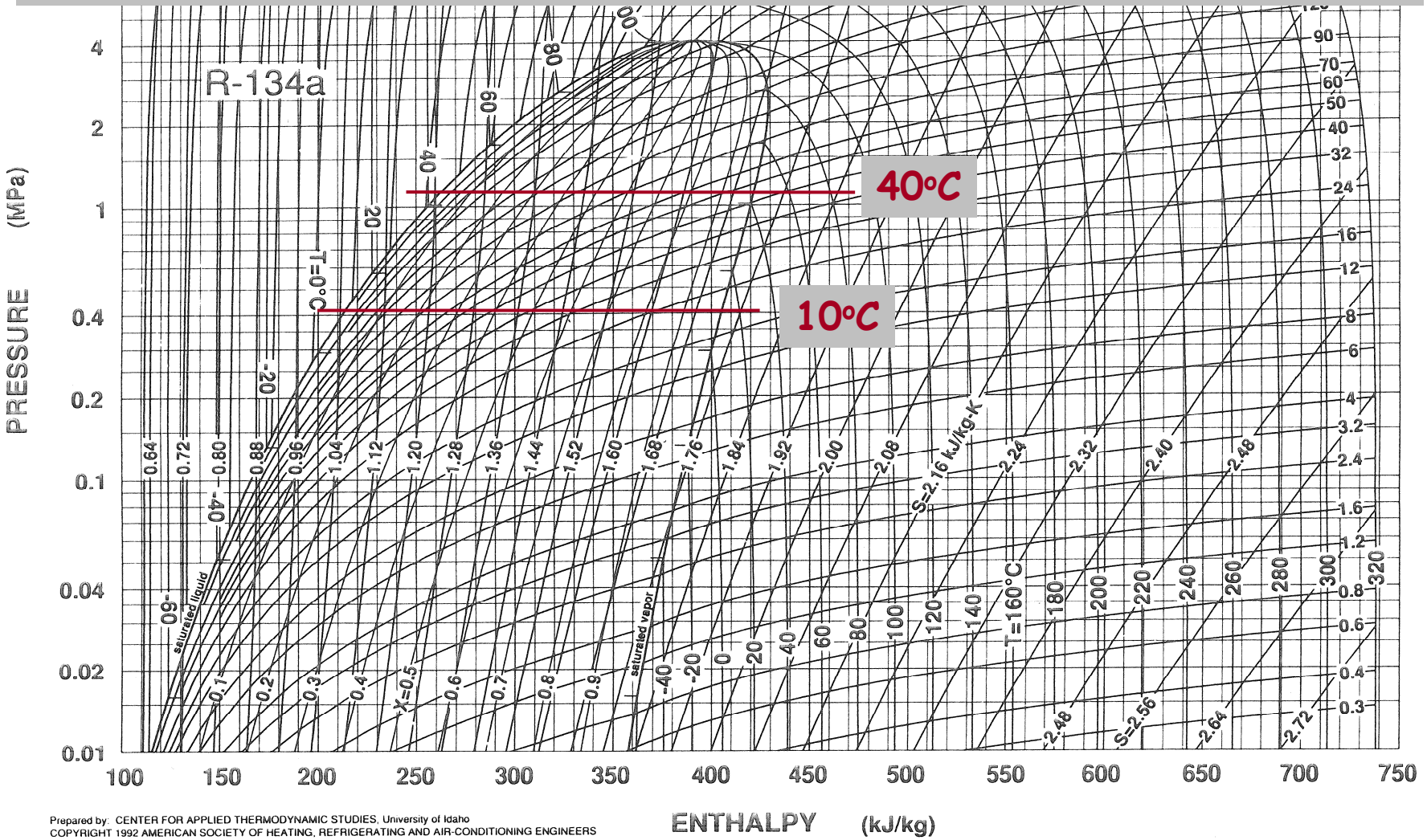
- Consider a refrigeration cycle using R134a is plotted based on the following information:
  - Condenser temperature = 45^{o}C
  - Evaporator temperature = 10^{o}C
  - Sub-cooling at condenser = 3^{o}C
  - Superheating at evaporator = 3^{o}C
  - Compressor efficiency = 90%
- The refrigeration cycle for single stage compression is plotted
- The refrigeration effect and the COP are to be found.

R134a PH diagram



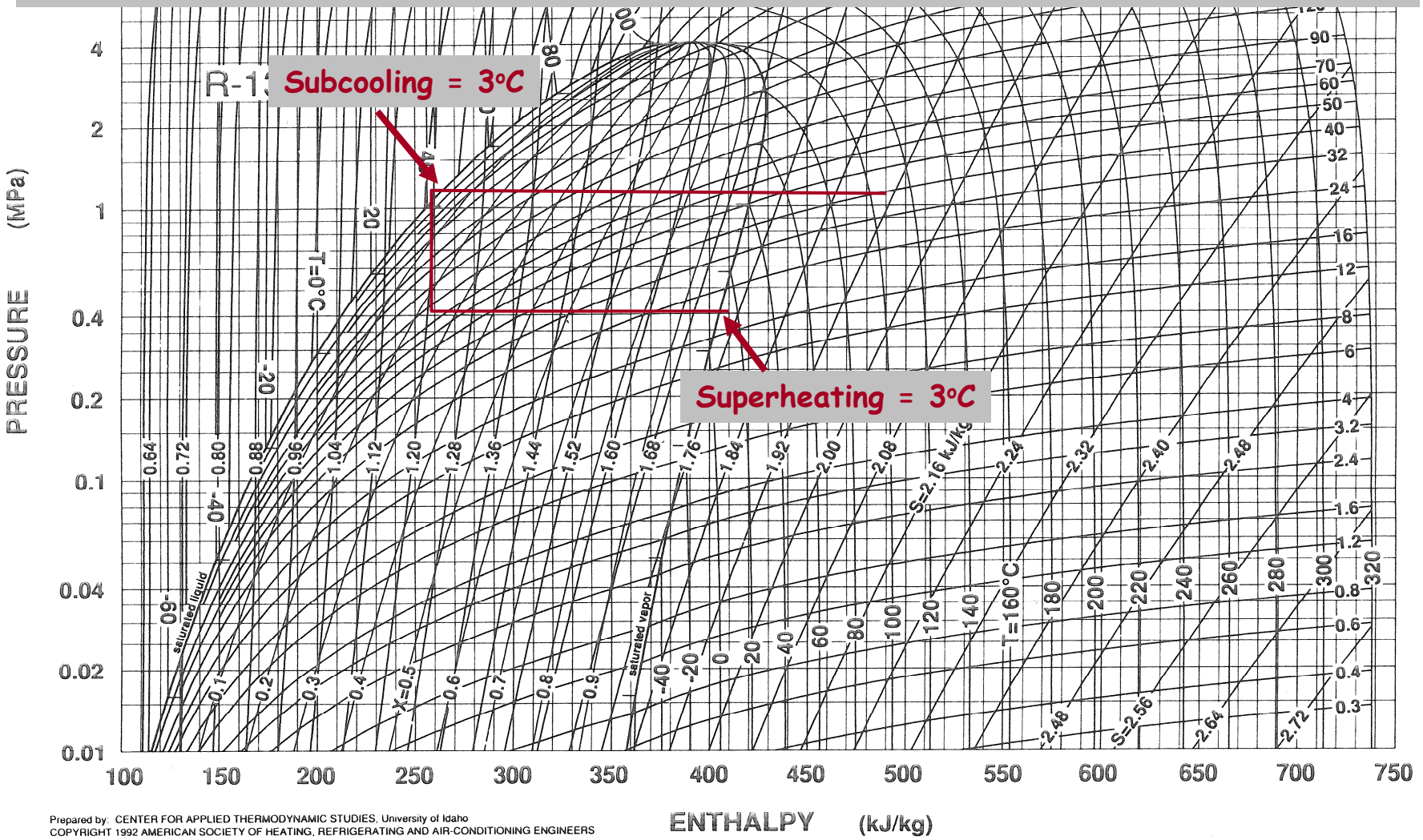
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 1: Plot the condenser and evaporator pressure line (based on temperature)



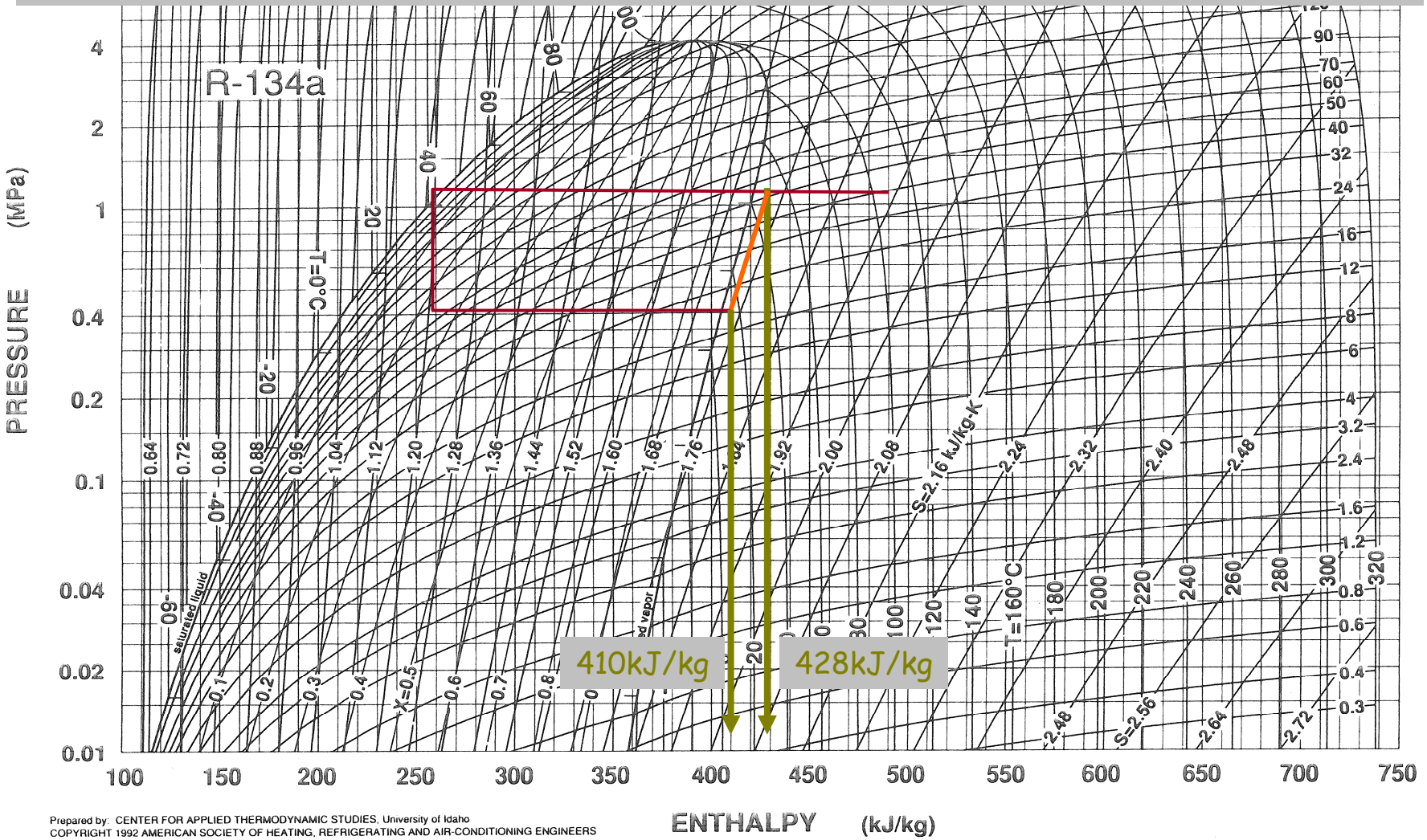
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 2: Locate the sub-cooling and superheating points



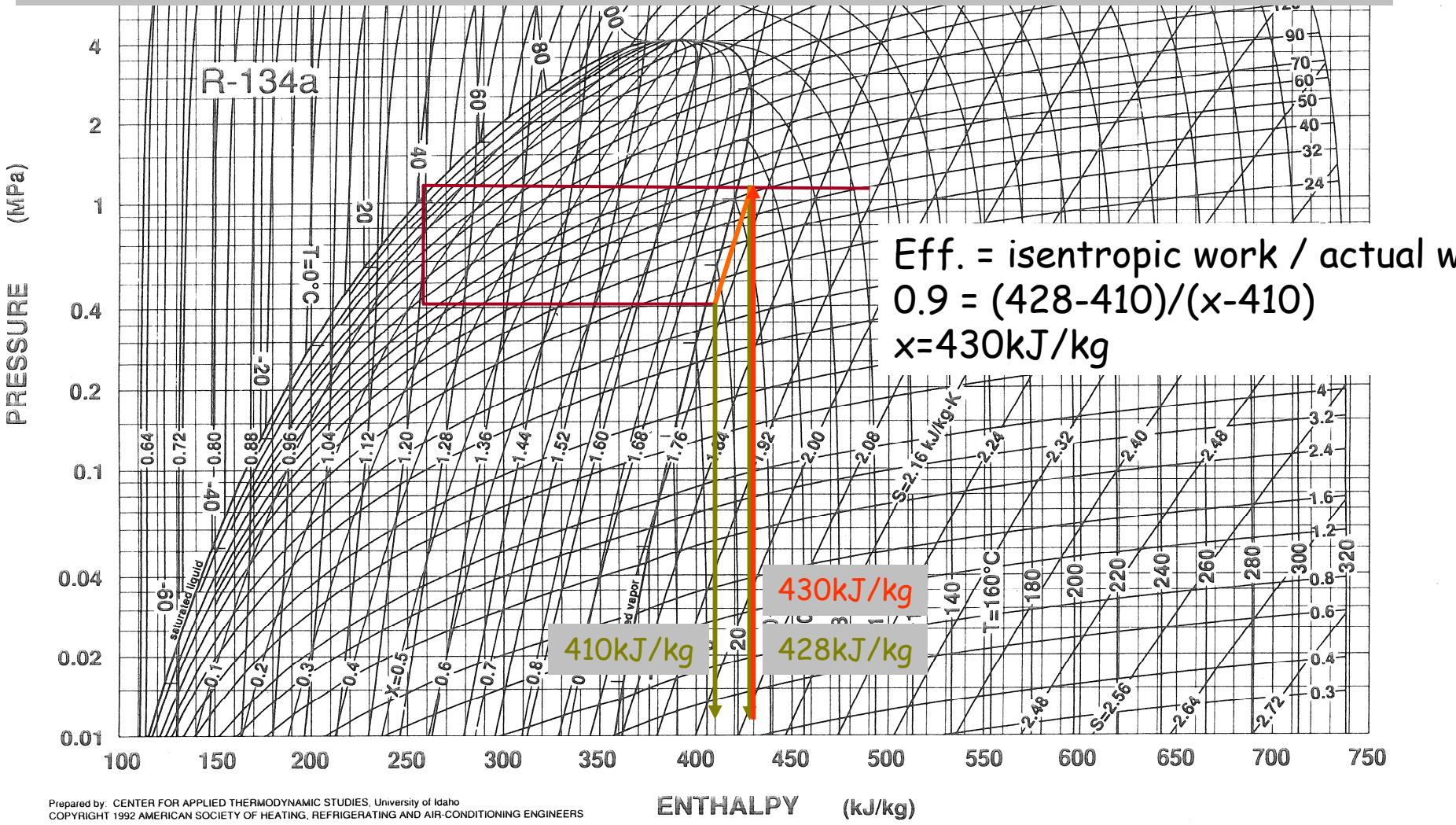
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 3: Plot the isentropic line & determine the enthalpy of the refrigerant



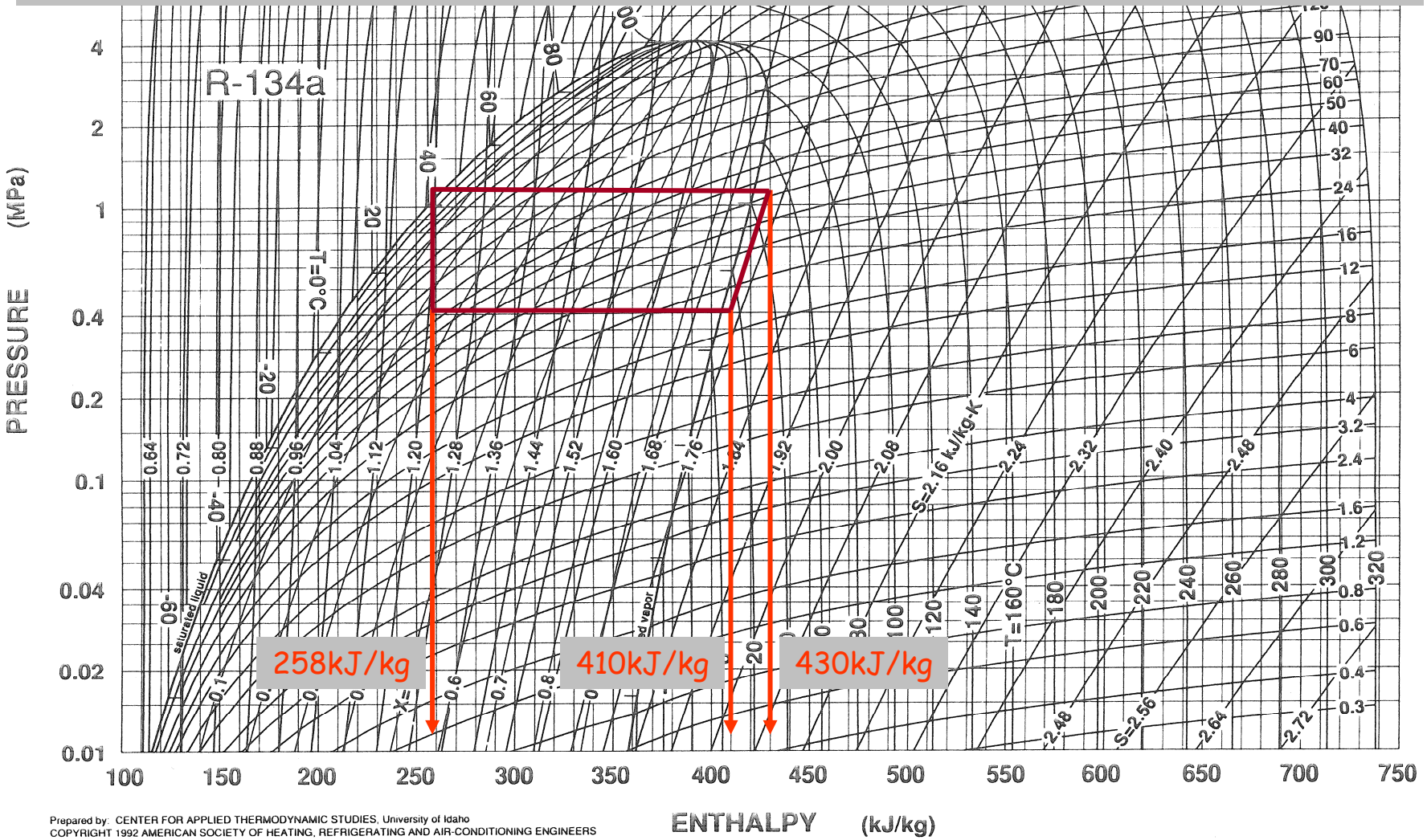
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 4: Determine the actual work based on compressor efficiency



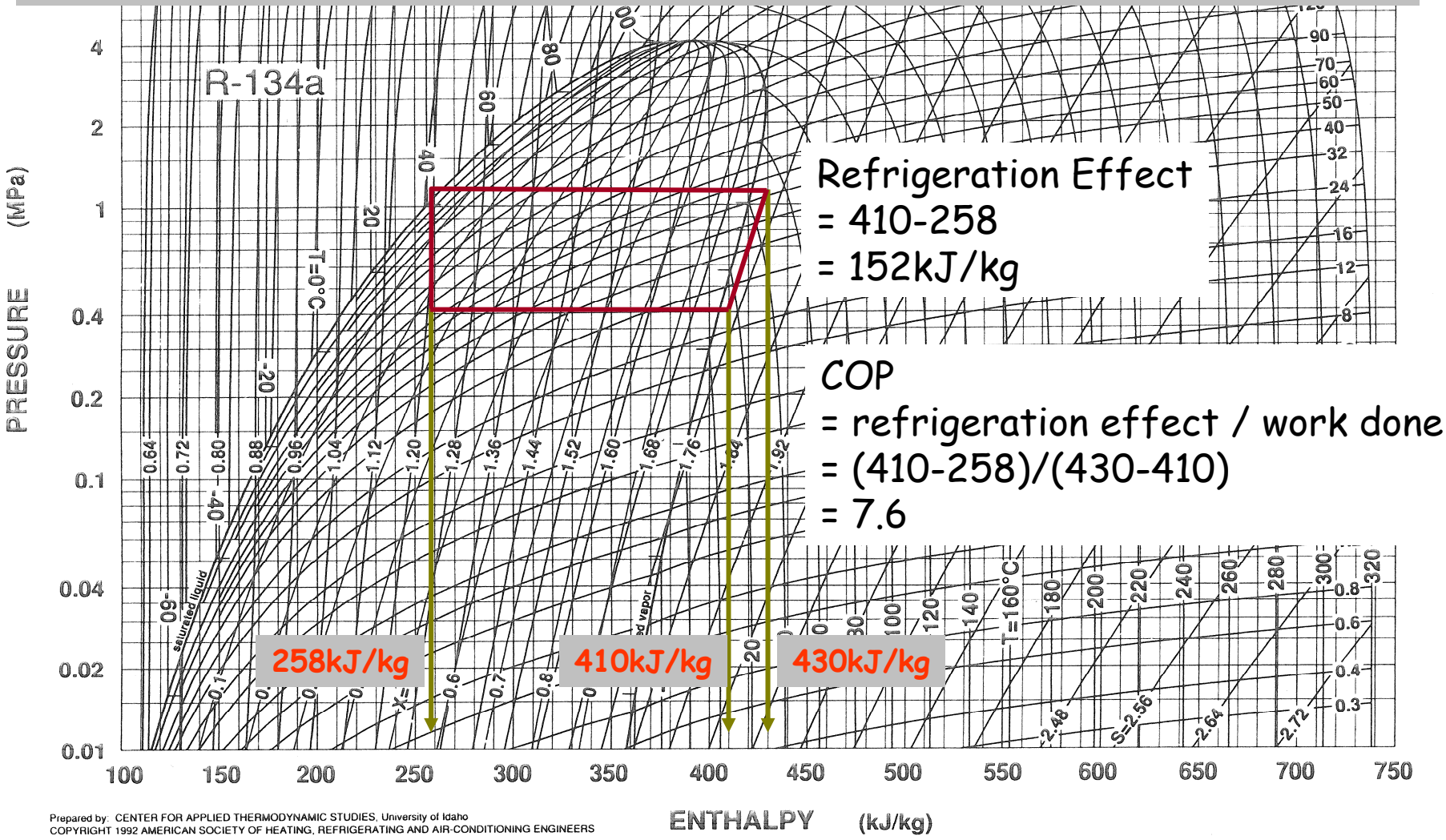
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 5: Complete the refrigeration cycle and identify the enthalpy of all the points



Pressure–Enthalpy Diagram for Refrigerant 134a

Step 6: Calculate the refrigeration effect and COP

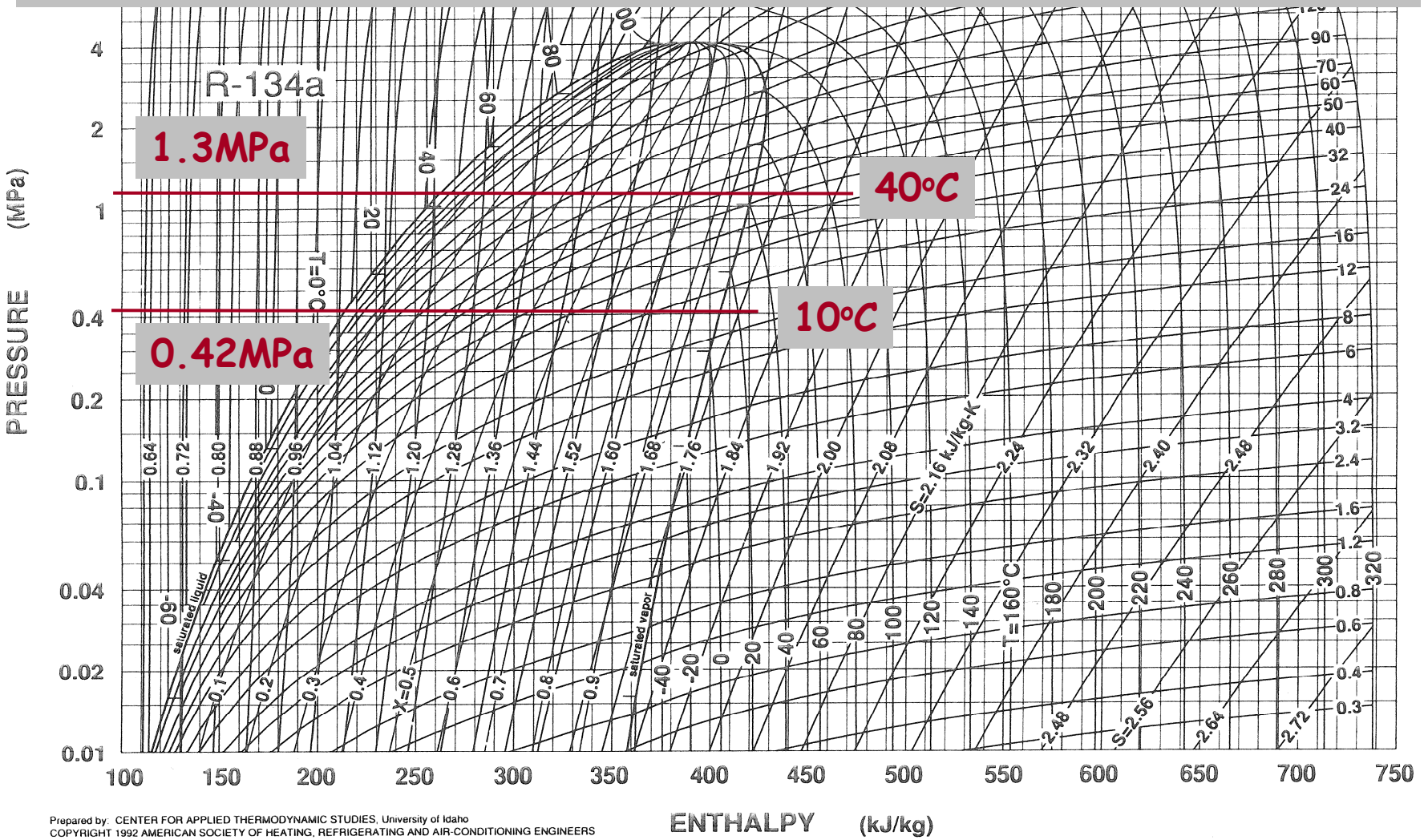


Pressure–Enthalpy Diagram for Refrigerant 134a

Supplementary Calculation on Refrigeration Cycles

- With the same set of design data but using two stage compression
- What will be the refrigeration effect and COP?

Step 1: plot the condenser and evaporator pressure line (based on temperature) and determine the pressure



Pressure–Enthalpy Diagram for Refrigerant 134a

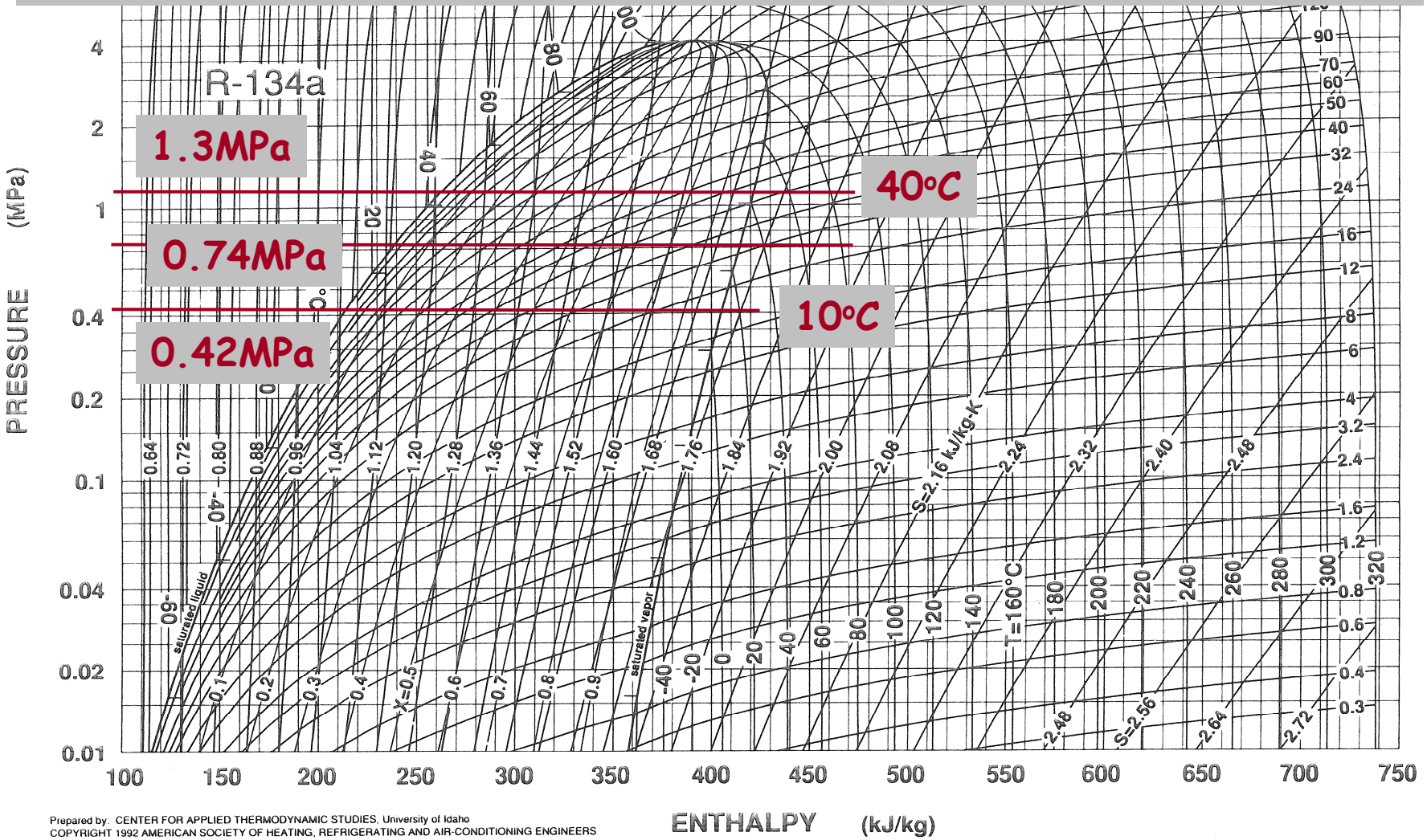
- Determine the inter-stage pressure

$$P_i = \sqrt{P_{cond} \cdot P_{evap}}$$

$$P_i = \sqrt{1300000 \cdot 420000}$$

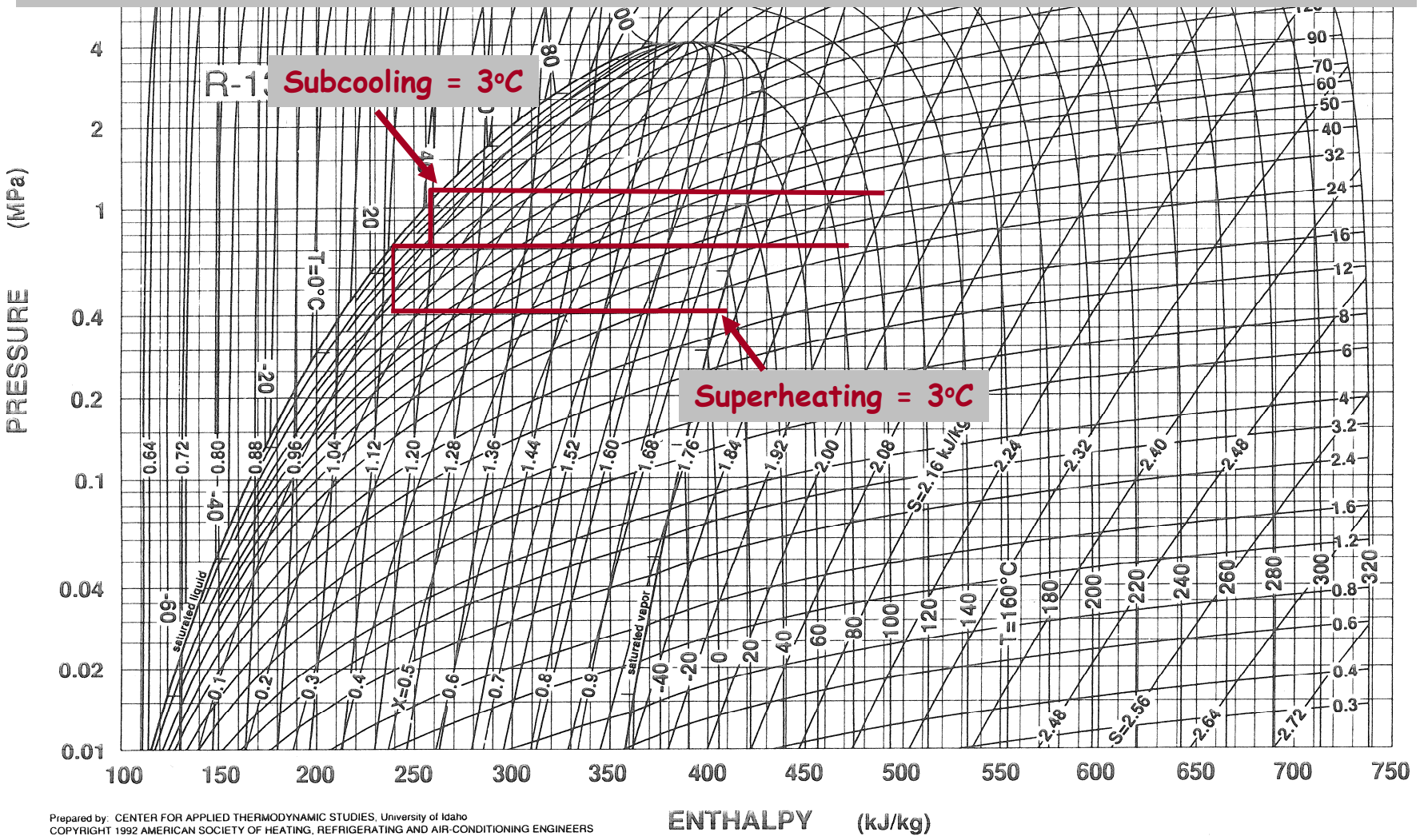
$$P_i \cong 740000$$

Step 2: plot the inter-stage pressure line



Pressure–Enthalpy Diagram for Refrigerant 134a

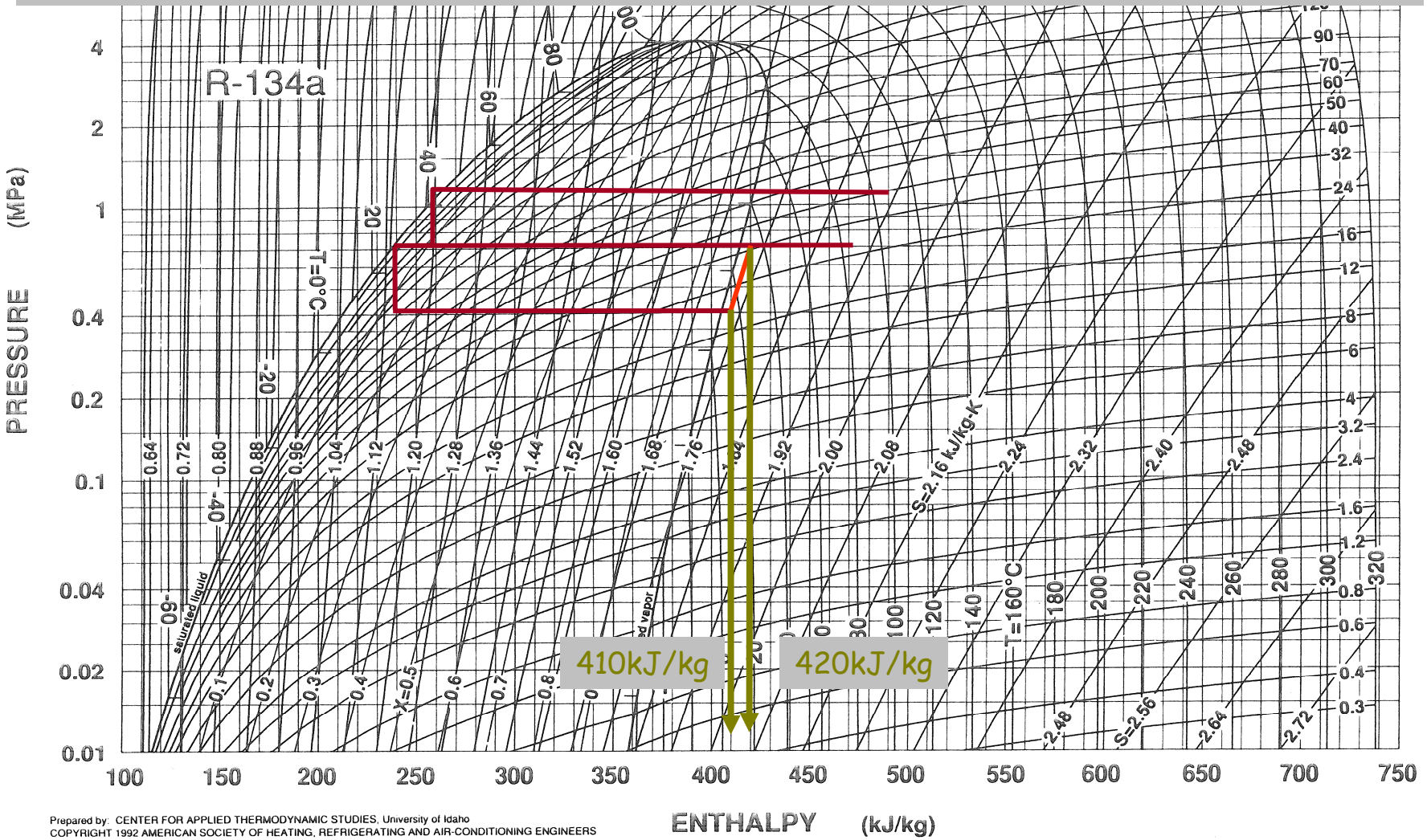
Step 3: Locate the subcooling and superheating



Prepared by: CENTER FOR APPLIED THERMODYNAMIC STUDIES, University of Idaho

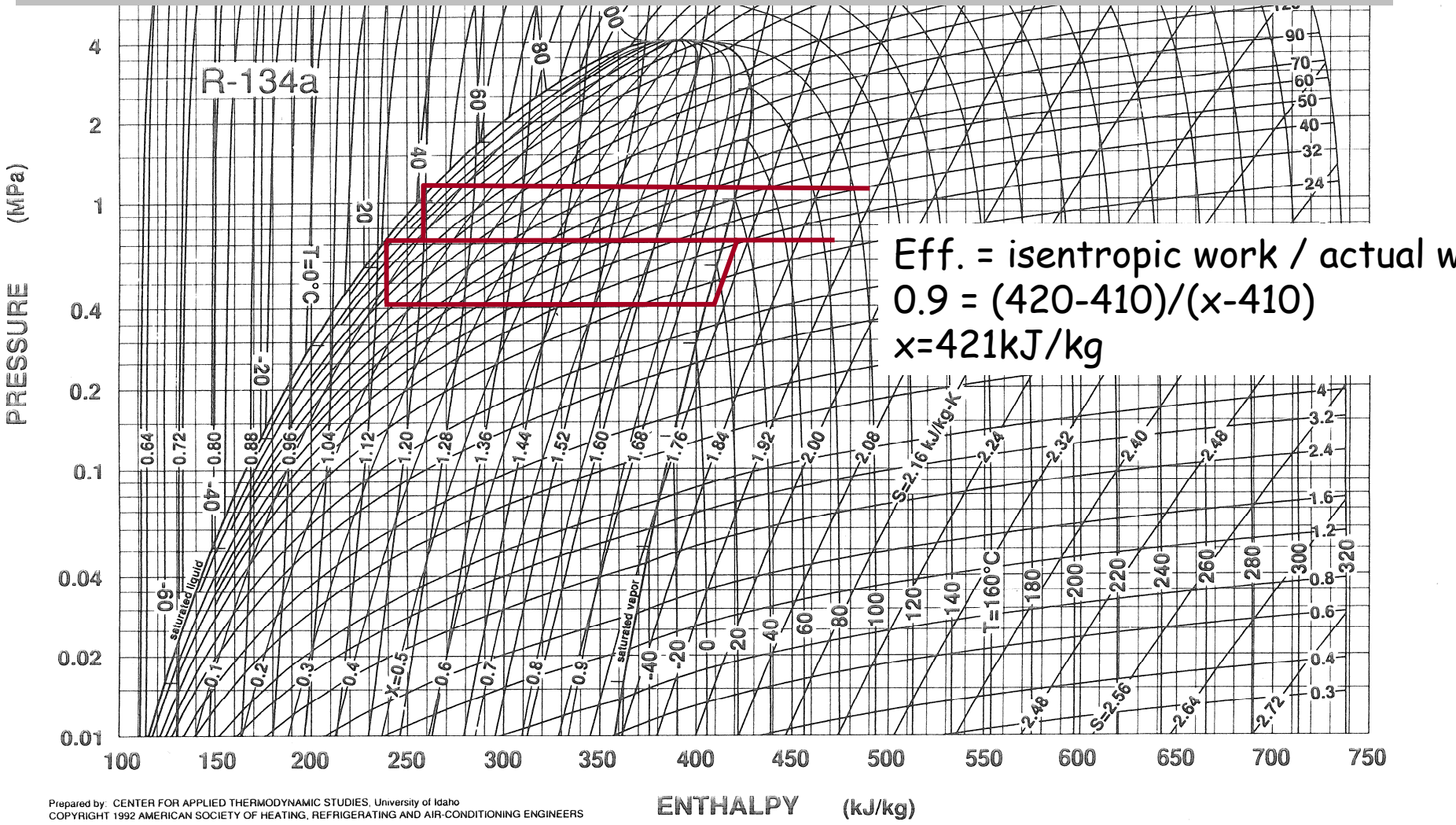
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 4: Plot the isentropic line & determine the enthalpy of the refrigerant (1st stage)



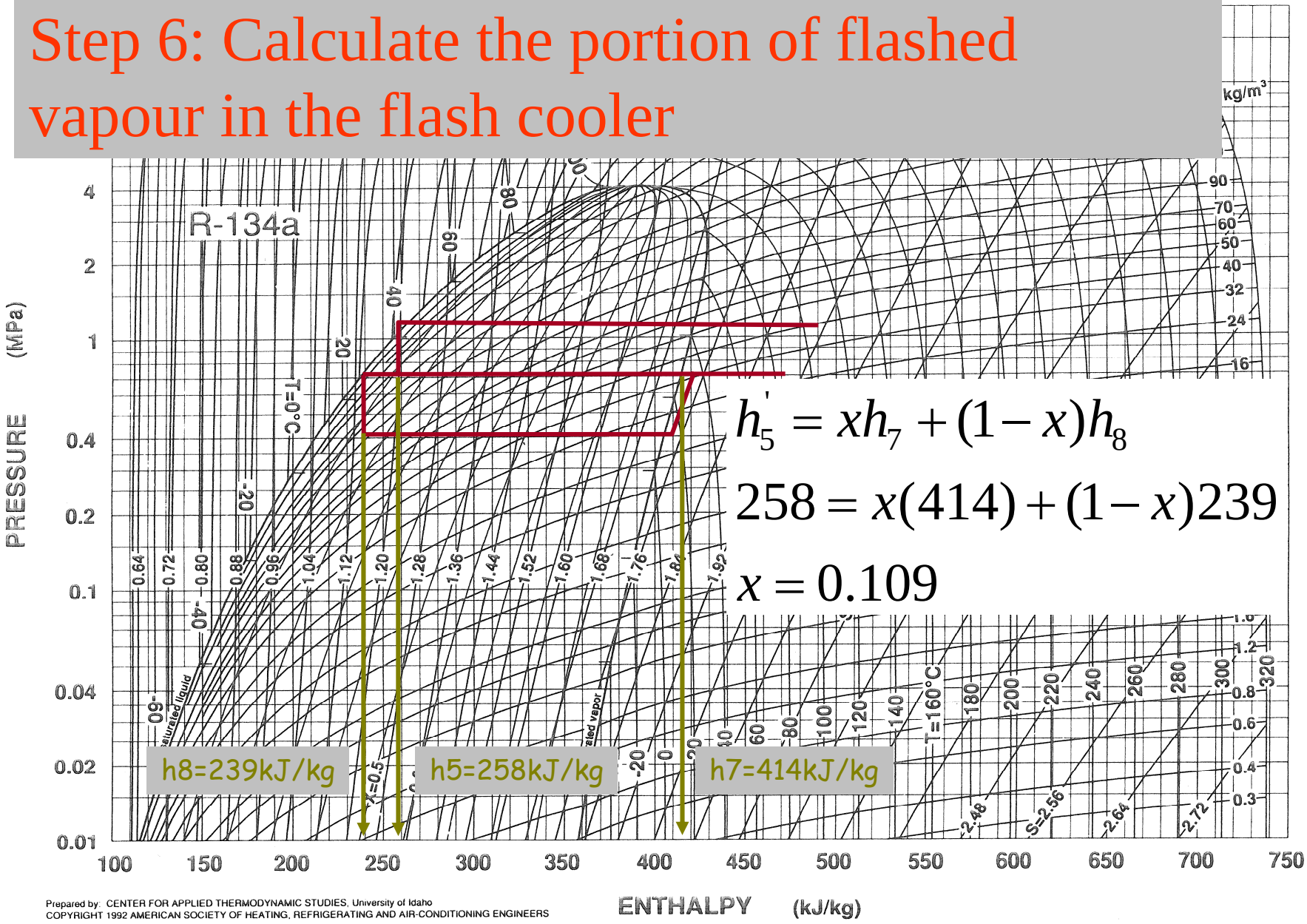
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 5: Determine the actual work based on compressor efficiency



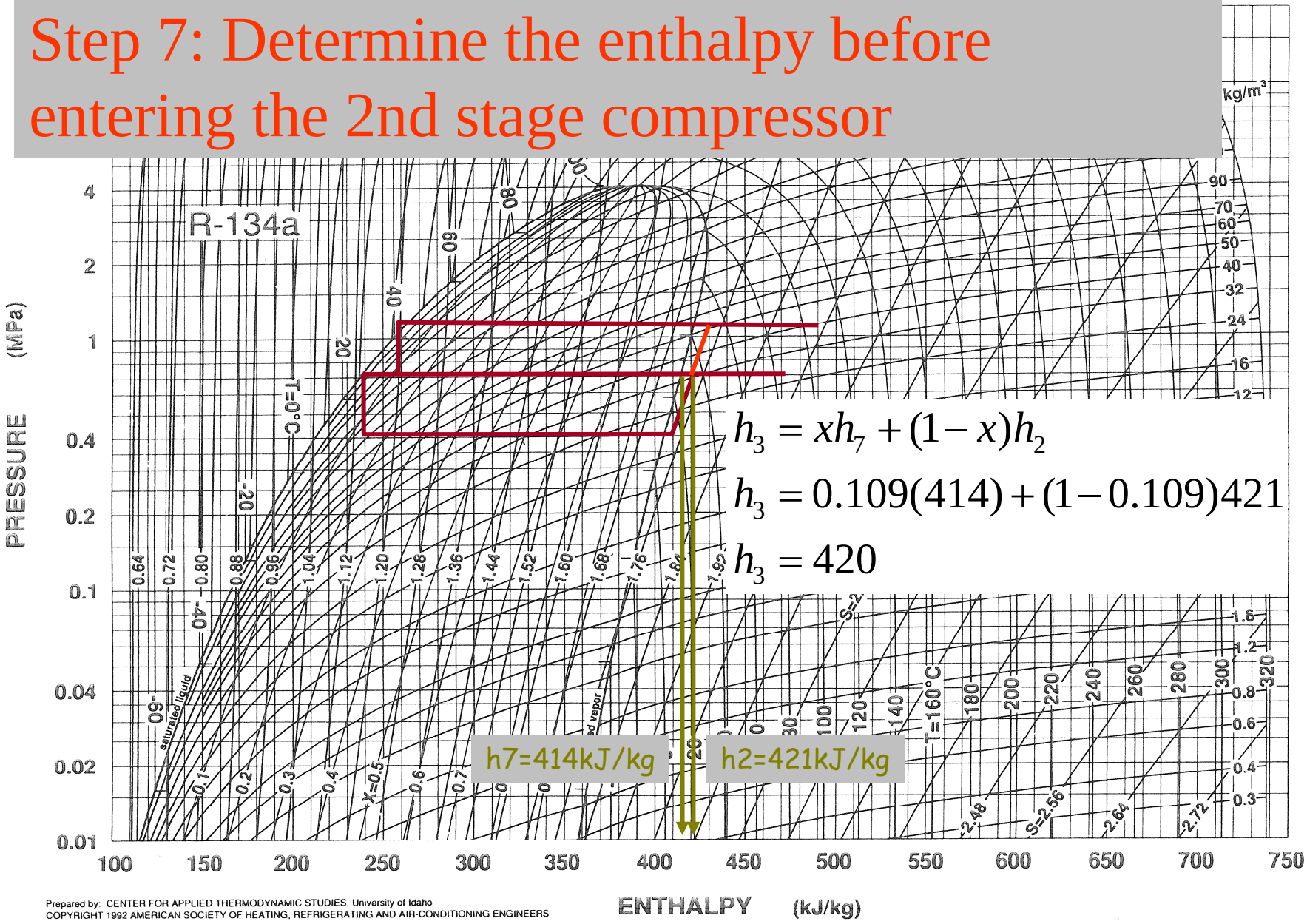
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 6: Calculate the portion of flashed vapour in the flash cooler



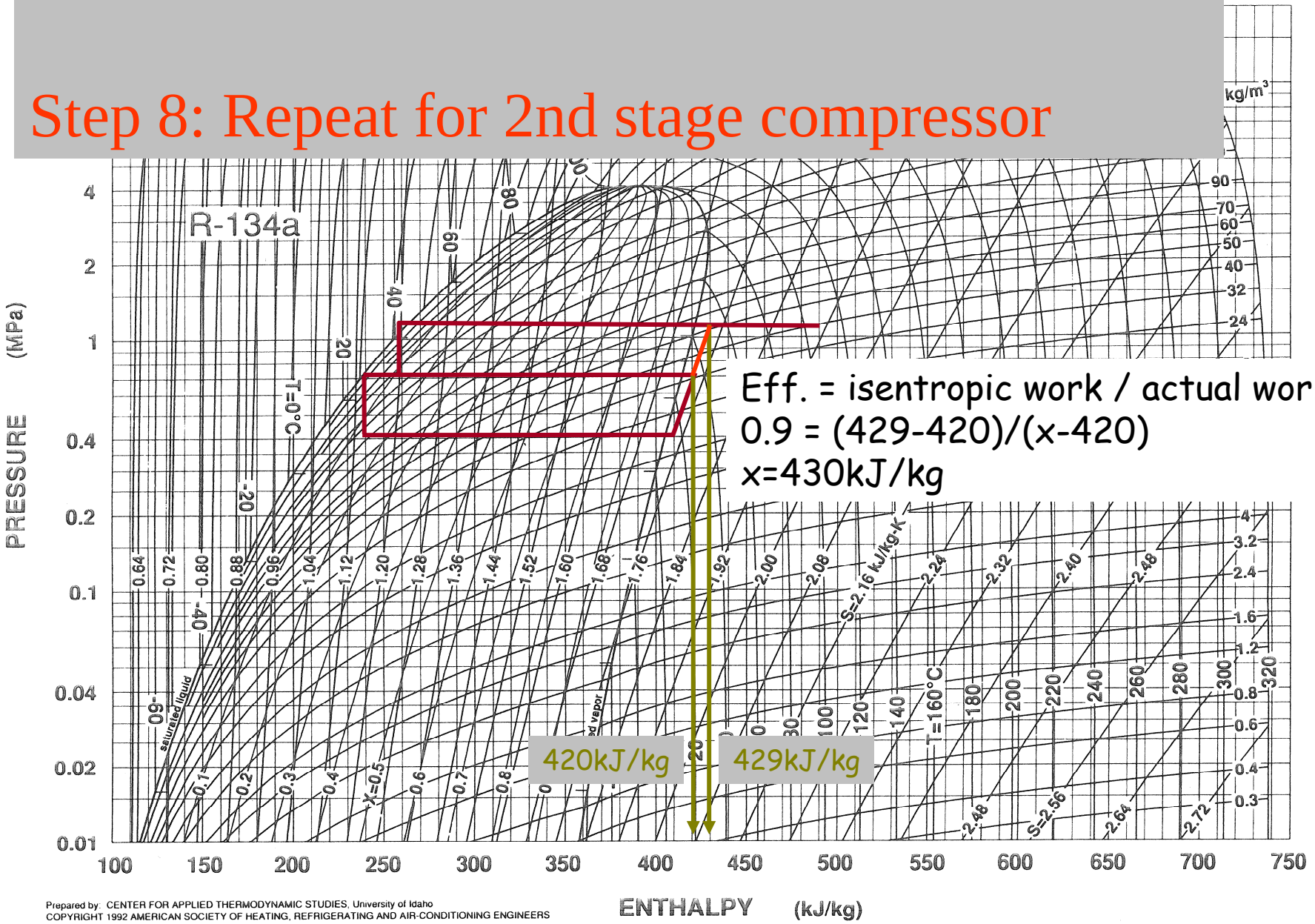
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 7: Determine the enthalpy before entering the 2nd stage compressor



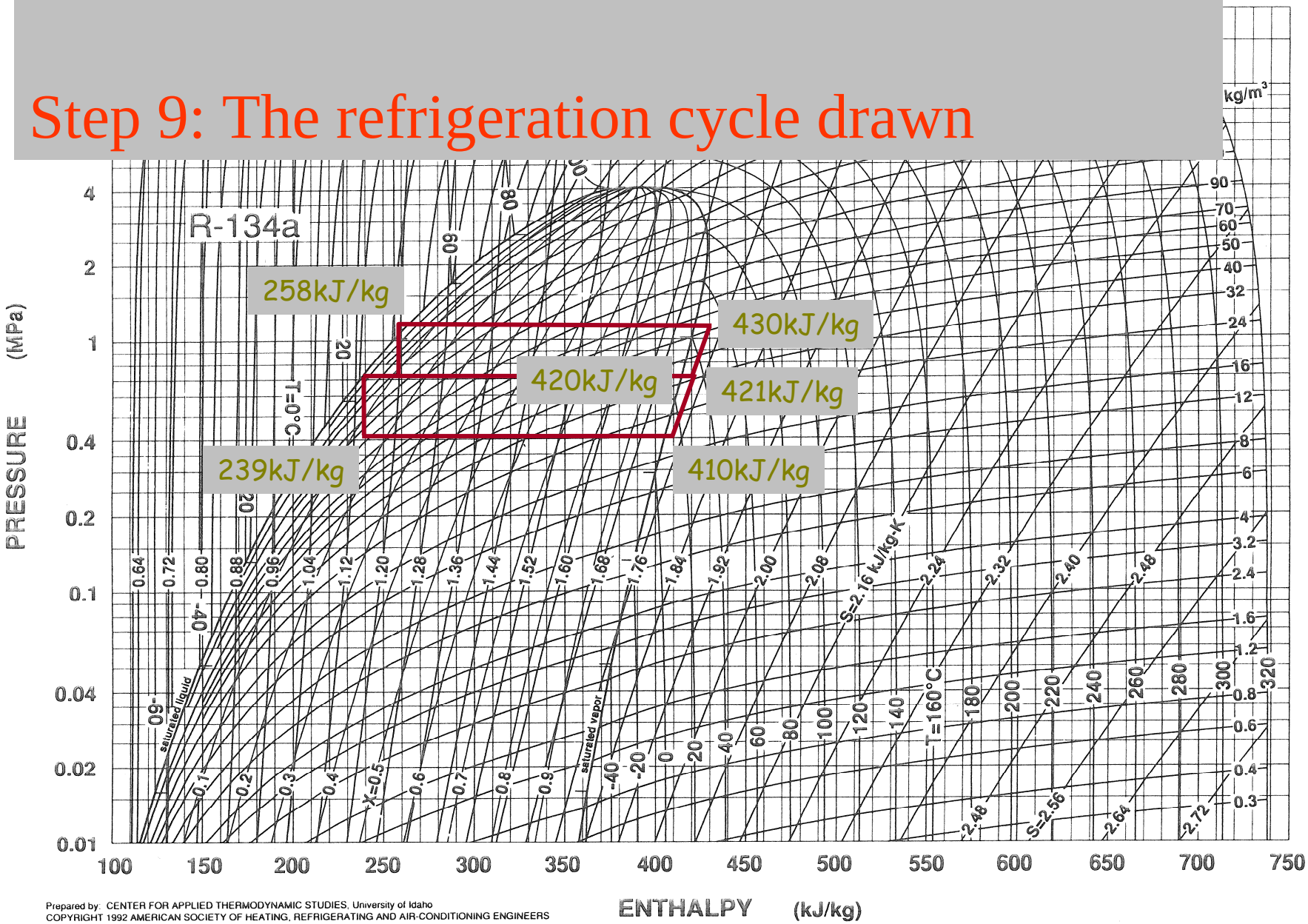
Pressure–Enthalpy Diagram for Refrigerant 134a

Step 8: Repeat for 2nd stage compressor



Pressure–Enthalpy Diagram for Refrigerant 134a

Step 9: The refrigeration cycle drawn



Pressure–Enthalpy Diagram for Refrigerant 134a

Supplementary Calculation on Refrigeration Cycles

- The refrigeration effect is determined

  = (1-0.109)(410-239) = 152.4kJ/kg

- The work done by the compressor

  = (1-0.109)(421-410)+(430-420)

  = 19.8kJ/kg

- The COP

  = 152.4 / 19.8 = 7.7

Q & A