AREN 2110
Property Tables Information and Exercises

INTERPOLATION

You may sometimes have to calculate one or more properties of a substance at a state that is "between" states given in the rows of the property tables. For example, suppose you need to calculate the temperature of saturated liquid water (x = 0) at 4.7 MPa. Table A-5 (Saturated Water – Pressure Table) shows in the first three columns for the next lower and higher pressures:

P (MPa)	T_s (°C)	v_f (m³/kg)
4	250.40	0.001252
5	263.99	0.001286

You can assume that the changes in properties are all linearly proportional and use linear interpolation to estimate.

$$\frac{4.7 - 4}{5 - 4} = \frac{T - 250.40}{263.99 - 250.40}$$
$$T = 259.9°C$$

Linear interpolation works for estimating any thermodynamic intensive property in any phase for tabulated materials.

For superheated refrigerant at 1.4 MPa and T = 72 °C, the enthalpy can be estimated by interpolation using the rows from Table A-13 for 1.4 MPa:

T (°C)	v_f (m³/kg)	u (kJ/kg)	h (kJ/kg)
70	0.001252	262.17	295.31
80	0.001286	272.87	307.10

$$\frac{72 - 70}{80 - 70} = \frac{h - 295.31}{307.1 - 295.31}$$
$$h = 297.7 \text{kJ/kg}$$

Problems

1. For water, using the thermodynamic property tables in the appendices (A-4, A-5, and A-6) find:

   a) The phase of water at 8 MPa and 400 °C AND the specific volume and specific internal energy for water. Are temperature and pressure independent? Why?

400 °C is greater than T_s at 8 MPa, therefore substance is superheated vapor. From Table A-6: v = 0.03432 m³/kg, u = 2,863.8 kJ/kg.

Pressure and temperature are independent since the pure substance is a single phase (vapor).

   b) The specific internal energy, u, for superheated steam at 10 MPa and 620 °C?

620 °C is greater than T_s at 10 MPa, therefore substance is superheated vapor. Need to interpolate in Table A-6 between state properties at 600 and 650 °C.:

$$\frac{620 - 600}{650 - 600} = \frac{u - 3241.7}{3338.2 - 3241.7}$$

u = 3,280.3 kJ/kg

   c) The specific enthalpy of saturated liquid water at 100 kPa. The specific enthalpy, h, of liquid water at 20 °C and 100 kPa.

   1. h = h_f@100 kPa = 417.46 kJ/kg

   2. h = h_f@20 °C = 83.96 kJ/kg

   d) The phase AND the specific internal energy of water at 0.2 MPa with specific volume of 0.80 m³/kg.

At 0.2 MPa, v_f < 0.8 m³/kg < v_g. Therefore substance is a saturated liquid vapor mixture.

Need quality, x, using Table A-5: $x = \dfrac{0.8 - 0.001061}{0.8857 - 0.00161} = 0.90$

$$u = x(u_{fg}) + u_f = 0.90(2025) + 504.49 = \text{2,333.3 kJ/kg}$$

2. For refrigerant, R-134a, using the thermodynamic property tables in the appendices (A-11, A-12, and A-13) find:

    a) The <u>change</u> in specific enthalpy during condensation of saturated vapor to saturated liquid at 30 °C.

    $$\Delta h = -h_{fg} \text{ @ 30 °C. From Table A-11: } \Delta h = -\text{ 172.0 kJ/kg}$$

    b) The <u>total</u> volume of 2 kg of R-134a after expansion from mixture to saturated vapor at 0.12 MPa.

    $$V = 2 \text{ kg}*v_g \text{ @0.12 MPa. From Table A-12:}$$
    $$V = 2 \text{ kg} *0.1614 \text{ m}^3/\text{kg} = 0.3228 \text{ m}^3$$

    c) The phase AND the temperature of R-134a at 0.5 MPa with specific enthalpy of 300 kJ/kg.

300 kJ/kg > h_f @ 0.5 MPa, therefore refrigerant is superheated vapor. From Table A-13, T = 60 °C (actually h @ 60 °C is 299.95 kJ/kg, but this is too close to bother to interpolate.)

    d) The phase of R-134a at 0.5 MPa with specific enthalpy of 71.33 kJ/kg AND the temperature.

71.33 kJ/kg = h_f @ 0.5 MPa (Table A-12), so refrigerant is saturated liquid and T = T_s = 15.74 °C.