

Given and Required:

Determine the specific volume of R-134a at 1 MPa and 50°C. Use the ideal gas equation and also use the compressibility chart. What is it listed as in the tables in the back of your textbook?

$$P_1 := 1 \text{ MPa} \quad T_1 := 50 \text{ }^\circ\text{C} = 323.15 \text{ K}$$

Solution:

Going to Table A-1 @ R-134a shows

$$R_{R134a} := 0.08149 \frac{\text{kJ}}{\text{kg K}} \quad T_{cr} := 374.2 \text{ K} \quad P_{cr} := 4.059 \text{ MPa}$$

Beginning with the IGL.

$$P \cdot V = m \cdot R \cdot T$$

Solving for specific volume yields

$$\left(v = \frac{V}{m} \right) = \frac{R \cdot T}{P} \quad \text{or} \quad v_a := \frac{R_{R134a} \cdot T_1}{P_1} = 0.02633 \frac{\text{m}^3}{\text{kg}}$$

To use the compressibility chart, the reduce temperature and pressure values, T_R and P_R , must be calculated. This is shown below.

$$T_R := \frac{T_1}{T_{cr}} = 0.8636 \quad P_R := \frac{P_1}{P_{cr}} = 0.2464$$

Going to Figure A-15 @ $T_R = 0.8636$ and $P_R = 0.2464$ shows

$$z := 0.84$$

Now the specific volume may be calculated with the compressibility factor accounted for. This is shown below.

$$v = \frac{V}{m} = z \frac{R \cdot T}{P} \quad \text{or} \quad v_b := z \cdot \frac{R_{R134a} \cdot T_1}{P_1} = 0.02212 \frac{\text{m}^3}{\text{kg}}$$

To look up the specific volume from the table, we start at Table A-12 @ $P := P_1 = 1 \text{ MPa}$ showing

$$T_{sat} := 39.37 \text{ }^\circ\text{C}$$

Since the temperature is greater than the saturation temperature at the pressure given (i.e. $T_1 < T_{sat}$), the state is superheated. Going to Table A-13 @ $P := P_1 = 1 \text{ MPa}$ and $TT^\circ\text{C}50$ shows

$$v_c := 0.021796 \frac{\text{m}^3}{\text{kg}}$$

Comparing the results of using the IGL and the method using compressibility chart to the table values shows the percent error as

$$\%e_a := \left| \frac{v_a - v_c}{v_c} \right| = 20.82 \% \quad \%e_b := \left| \frac{v_b - v_c}{v_c} \right| = 1.487 \%$$

It should be noted that the table value is considered the most accurate of the three methods and for this reason the other two methods are compared to it.