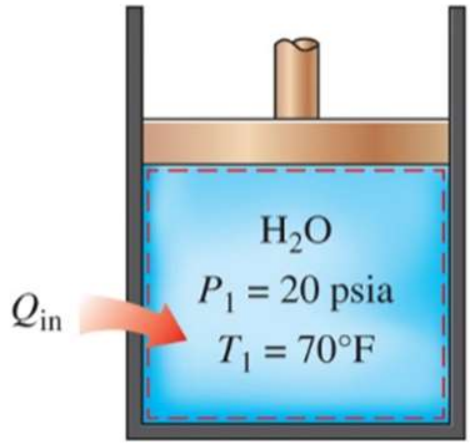
Given: $kJ := 1000J$

A piston cylinder device initially contains 3 lbm of liquid water at 20 psia and 70°F. The water is now heated at constant pressure by the addition of 3450 Btu of heat.

Required:

Determine the entropy change of the water during this process.



Solution:

The mass of water is defined as

$$m_w := 3lbm$$

The initial conditions are defined as

$$P_1 := 20psi \qquad T_1 := 70\,°F = 529.67 \cdot R$$

The amount of heat added is defined as

$$Q_{in} := 3450Btu$$

The final pressure is

$$P_2 := P_1 = 20 \cdot psi$$

Going to Table A-4E @ $T_1 = 70 \cdot °F$ shows

$$P_{sat} := 0.36334psi$$

Since $P_1 > P_{sat}$ the state is a compressed liquid. Going to Table A-7E shows that the tables are inadequate and the state will be approximated as a saturated liquid. Thus, going back to Table A-4E @ $T_1 = 70 \cdot °F$ shows

$$s_f := 0.07459 \frac{Btu}{lbm \cdot R} \qquad h_f := 38.08 \frac{Btu}{lbm}$$

The state 1 properties are then

$$s_1 := s_f = 0.075 \cdot \frac{Btu}{lbm \cdot R} \qquad h_1 := h_f = 38.08 \cdot \frac{Btu}{lbm}$$

<u>1st Law</u> for system with no changes in ke and pe

$$\Delta E_{sys} = \Sigma E_{in} - \Sigma E_{out}$$

$$\Delta U + \Delta KE + \Delta PE = Q_{in} - W_b$$

$$\Delta U + W_b = \Delta H = m \cdot \Delta h = Q_{in}$$

$$m_w \cdot \left(h_2 - h_1\right) = Q_{in}$$

$$h_2 := \frac{Q_{in}}{m_w} + h_1 = 1188.1 \cdot \frac{Btu}{lbm}$$

Going to Table A-5E @ $P_2 = 20 \cdot psi$ shows

$$h_g := 1156.2 \frac{Btu}{lbm}$$

Solution (contd.):

Since $h_2 > h_g$ the state is superheated. Going to Table A-6E @ $P_2 = 20 \cdot \text{psi}$ and $h_2 = 1188.1 \cdot \frac{\text{Btu}}{\text{lbm}}$ shows that interpolation is needed. This is shown below.

$$h_a := 1181.9 \frac{\text{Btu}}{\text{lbm}} \qquad h_b := 1201.2 \frac{\text{Btu}}{\text{lbm}}$$

$$s_a := 1.7679 \frac{\text{Btu}}{\text{lbm} \cdot \text{R}} \qquad s_b := 1.7933 \frac{\text{Btu}}{\text{lbm} \cdot \text{R}}$$

$$s_2 := \frac{h_2 - h_a}{h_b - h_a} \cdot \left(s_b - s_a\right) + s_a = 1.776 \cdot \frac{\text{Btu}}{\text{lbm} \cdot \text{R}}$$

The change in entropy for the process may then be found by

$$\boxed{\Delta S := m_w \cdot \left(s_2 - s_1\right) = 5.104 \cdot \frac{\text{Btu}}{\text{R}}}$$