

Given:

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

$$m_w := 3 \text{ lbm}$$

The initial conditions are defined as

$$P_1 := 20 \text{ psi} \quad T_1 := 70 \text{ }^\circ\text{F} = 529.67 \text{ }^\circ\text{Ra}$$

The amount of heat added is defined as

$$Q_{in} := 3450 \text{ BTU}$$

The final pressure is

$$P_2 := P_1 = 20.00 \text{ psi}$$

Going to Table A-4E @ $T_1 = 70.00 \text{ }^\circ\text{F}$ shows

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

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 @ $T_1 = 70.00 \text{ }^\circ\text{F}$ shows

$$s_f := 0.07459 \frac{\text{BTU}}{\text{lbm } ^\circ\text{Ra}} \quad h_f := 38.08 \frac{\text{BTU}}{\text{lbm}}$$

The state 1 properties are then

$$s_1 := s_f = 0.07459 \frac{\text{BTU}}{\text{lbm } ^\circ\text{Ra}} \quad h_1 := h_f = 38.08 \frac{\text{BTU}}{\text{lbm}}$$

1st Law for system with no changes in ke and pe

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

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

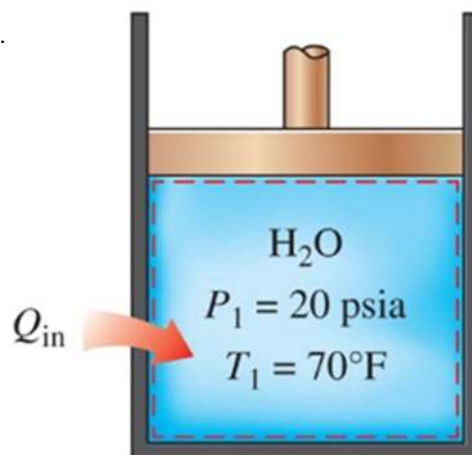
$$\Delta U + W_b = \Delta H = m \cdot \Delta h = Q_{in}$$

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

$$h_2 := \frac{Q_{in}}{m_w} + h_1 = 1188 \frac{\text{BTU}}{\text{lbm}}$$

Going to Table A-5E @ $P_2 = 20.00 \text{ psi}$ shows

$$h_g := 1156.2 \frac{\text{BTU}}{\text{lbm}}$$



Solution (contd.):

Since $h_2 > h_g$, the state is superheated. Going to Table A-6E @ $P_2 = 20.00$ psi and $h_2 = 1188 \frac{\text{BTU}}{\text{lbm}}$ shows that interpolation is needed. This is shown below.

$$\begin{aligned}
 h_a &:= 1181.9 \frac{\text{BTU}}{\text{lbm}} & h_b &:= 1201.2 \frac{\text{BTU}}{\text{lbm}} \\
 s_a &:= 1.7679 \frac{\text{BTU}}{\text{lbm} \cdot ^\circ\text{Ra}} & s_b &:= 1.7933 \frac{\text{BTU}}{\text{lbm} \cdot ^\circ\text{Ra}} \\
 s_2 &:= \frac{h_2 - h_a}{h_b - h_a} \cdot (s_b - s_a) + s_a = 1.776 \frac{\text{BTU}}{\text{lbm} \cdot ^\circ\text{Ra}}
 \end{aligned}$$

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

$$\Delta S := m_w \cdot (s_2 - s_1) = 5.104 \frac{\text{BTU}}{^\circ\text{Ra}}$$