PROBLEM 3.59

KNOWN: Data are provided for Refrigeration 134a in a closed, rigid tank exposed to solar radiation.

FIND: For the process of the refrigerant, determine the initial temperature, final pressure, and Q.

SCHEMATIC & GIVEN DATA:

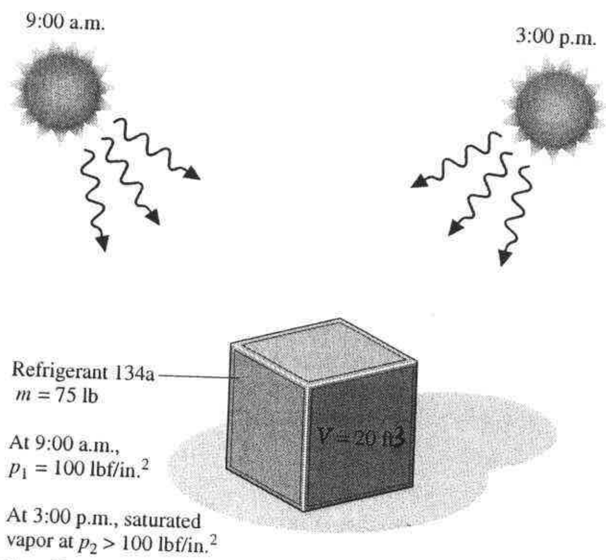
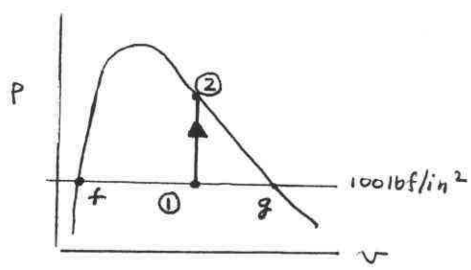


Fig. P3.59



ENGR. MODEL

1. The R134a in the tank is the closed system.
2. For the system, $W = 0$.
3. Kinetic and potential energy effects play no role.

ANALYSIS: At the initial state, $v_1 = \frac{V}{m} = \frac{20\,ft^3}{75\,lb} = 0.2667\,\frac{ft^3}{lb}$. Since $v_f < v_1 < v_g$, the initial state is in the two-phase, liquid-vapor region. Further, since mass and volume are each constant, there is no change in specific volume for the process: $v_2 = v_1$.

(a) Since the initial state is a two-phase, liquid-vapor mixture at $100\,lbf/in^2$, the initial temperature is the corresponding saturation temperature. From Table A-11E, $T_1 = 79.17°F$. ← T_1

(b) Interpolating in Table A-11E with $v_2 = v_g = 0.2667\,ft^3/lb$, we get $P_2 = 174.4\,lbf/in^2$ and $u_2 = 107.93\,Btu/lb$. ← P_2

(c) Reducing an energy balance $\Delta U + \cancel{\Delta KE} + \cancel{\Delta PE} = Q_{12} - \cancel{W_{12}}$, we get

$$Q_{12} = m(u_2 - u_1)$$

Finding u_1 requires the quality at state 1. That is, with v_f and v_g from Table A-11E at $100\,lbf/in^2$,

$$x_1 = \frac{v_1 - v_f}{v_g - v_f} = \left(\frac{0.2667 - 0.01332}{0.4747 - 0.01332}\right) = 0.549$$

Then, $u_1 = u_f + x_1(u_g - u_f) = 36.75 + (0.549)(103.68 - 36.75) = 73.49\,Btu/lb$

Finally,

$$Q_{12} = 75\,lb(107.93 - 73.49)\frac{Btu}{lb} = 2583\,Btu$$ ← Q_{12}