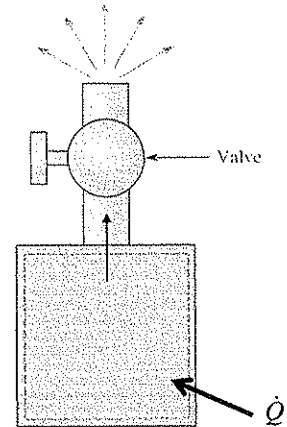


A rigid tank with a volume of 18 ft<sup>3</sup> contains superheated steam at 580 psia and 1000°F. A valve on the tank is suddenly opened and steam is allowed to escape until the pressure in the tank becomes 150 psia. While the steam is escaping, heat is simultaneously added to the tank in a manner that causes the specific enthalpy inside the tank to remain constant throughout the process. Determine the total heat transfer required.



$$\dot{Q} - \dot{W} + \dot{m}_i \left( h_i + \frac{V_i^2}{2g_c} + \frac{g}{g_c} z_i \right) - \dot{m}_e \left( h_e + \frac{V_e^2}{2g_c} + \frac{g}{g_c} z_e \right) = \frac{dE_G}{dt}$$

$$\frac{dE_G}{dt} = \frac{d}{dt} (U + \cancel{K} + \cancel{PE})$$

so,

$$\dot{Q} - h_e \dot{m} = \dot{U}$$

$$\int \dot{Q} dt - \int h_e d\dot{m} = \int dU$$

rewritten:

$$Q_{12} - h_e (\Delta m) = m_2 U_2 - m_1 U_1$$

note:

$$m = \frac{V}{v}$$

"GIVEN: A rigid tank filled with steam being emptied"

Vol = 18[ft^3]  
 P\_1 = 580[psia]  
 T\_1 = 1000[F]  
 P\_2 = 150[psia]

"FIND: Heat transferred"

"SOLUTION:"

"The First Law for the emptying process is,"

$$Q_{12} - h_e(m_1 - m_2) = m_2 u_2 - m_1 u_1$$

"The masses can be found from the volume of the tank and the specific volumes,"

$$m_1 = \text{Vol}/v_1$$

$$m_2 = \text{Vol}/v_2$$

"PROPERTIES:"

f\$ = 'steam\_iapws'  
 v\_1 = volume(f\$,P=P\_1,T=T\_1)  
 u\_1 = intenergy(f\$,P=P\_1,T=T\_1)  
 h\_1 = enthalpy(f\$,P=P\_1,T=T\_1)

$$h_e = h_1$$

$$h_2 = h_1$$

"The initial enthalpy of the tank"

"The enthalpy in the tank is constant due to Q\_12"

v\_2 = volume(f\$,P=P\_2,h=h\_2)  
 u\_2 = intenergy(f\$,P=P\_2,h=h\_2)

## SOLUTION

Unit Settings: Eng F psia mass deg

|                      |                        |                        |
|----------------------|------------------------|------------------------|
| f\$ = 'steam_iapws'  | h1 = 1519 [Btu/lb_m]   | h2 = 1519 [Btu/lb_m]   |
| he = 1519 [Btu/lb_m] | m1 = 12.32 [lbm]       | m2 = 3.178 [lbm]       |
| P1 = 580 [psia]      | P2 = 150 [psia]        | Q12 = 1432 [Btu]       |
| T1 = 1000 [F]        | u1 = 1362 [Btu/lb_m]   | u2 = 1361 [Btu/lb_m]   |
| Vol = 18 [ft^3]      | v1 = 1.461 [ft^3/lb_m] | v2 = 5.664 [ft^3/lb_m] |

No unit problems were detected.

## KEY VARIABLES

Q12 = 1432 [Btu] *Heat input to the container to maintain h = constant*