Liquid

Is the state fixed by 2 known properties?

Y → Appendix

N → Is it incompressible? Small change in C_p with T in A-19

Y → Eqs 3.20

$C_p = C_v$ $\quad k = \frac{c_p}{c_v}$

$$u_2 - u_1 = c(T_2 - T_1)$$

$$h_2 - h_1 = c(T_2 - T_1) + \underline{v(p_2 - p_1)}$$

N → Is the temperature fixed?

Y → Eqs 3.11 to 3.13

$$v(T,p) \approx v_f(T)$$

$$u(T,p) \approx u_f(T)$$

$$h(T,p) \approx h_f(T) + \underline{v_f(T)[p - p_{sat}(T)]}$$

Two Phase Liquid-Vapor

State must be fixed by 2 known properties.
P and T not independent.

Quality is used to relate all properties in the vapor dome.

$$x = \frac{u - u_f}{u_g - u_f}$$

$$v = (1-x)v_f + xv_g = v_f + x(v_g - v_f)$$

$$u = (1-x)u_f + xu_g = u_f + x(u_g - u_f)$$

$$h = (1-x)h_f + xh_g = h_f + x(h_g - h_f)$$

Vapor

Is the vapor in the appendix A2 –A18? (water, R-22, R134a, Ammonia, Propane)

Y → Is the state fixed by 2 known properties?

Y → Appendix

N → Is it ideal? Z≈1 or P_R<0.05, T_R>1.5 $\quad Z = \frac{pv}{RT}$

Y → Pv=RT, u=u(T), h=h(T), A22-A23

N → Compressibility, Fig A-1, A-2, A-3, Eqs 3.27-3.29

$$p_R = p/p_c \qquad T_R = T/T_c \qquad v_R' = \frac{\bar{v}}{\bar{R}T_c/p_c}$$

Is it polytropic? $pV^n = constant$

Y → Eqs 3.27-3.29

N → Is C_p & C_v constant with T in A20?

$n = 1$

$$\int_1^2 p\,dV = mRT \ln\frac{V_2}{V_1}$$

$n \neq 1$

$$\int_1^2 p\,dV = \frac{mR(T_2 - T_1)}{1-n} \qquad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{(n-1)/n} = \left(\frac{V_1}{V_2}\right)^{n-1}$$

N → Eqs 3.40-3.47

$$c_p(T) = c_v(T) + R$$

$$u(T_2) - u(T_1) = \int_{T_1}^{T_2} c_v(T)\,dT \qquad c_p(T) = \frac{kR}{k-1}$$

$$h(T_2) - h(T_1) = \int_{T_1}^{T_2} c_p(T)\,dT \qquad c_v(T) = \frac{R}{k-1}$$

Y → Eqs 3.50-3.51

$$u(T_2) - u(T_1) = c_v(T_2 - T_1)$$

$$h(T_2) - h(T_1) = c_p(T_2 - T_1)$$