

2.1) Using Tables to Evaluate the State of a Substance

Terminology

**State Principle:** Number of independent properties required to identify the state of a substance

**Simple Compressible Substance:** Uniform, pure, and nonreactive

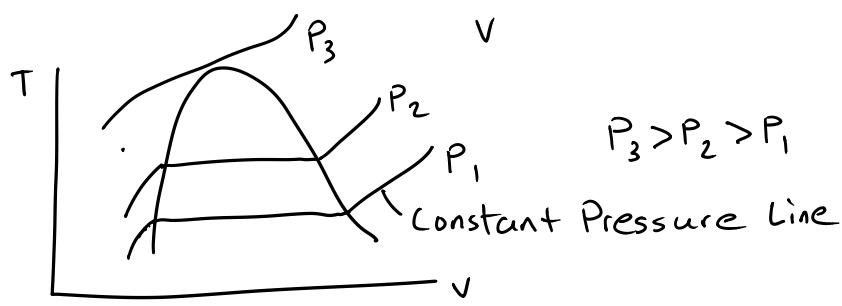
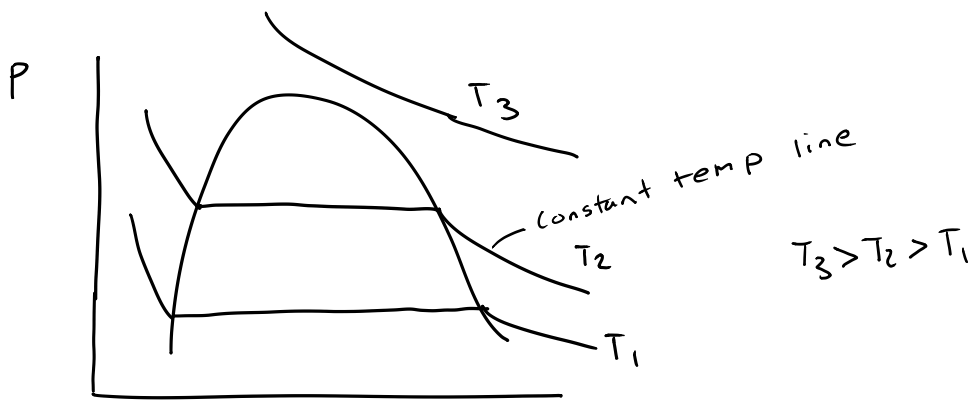
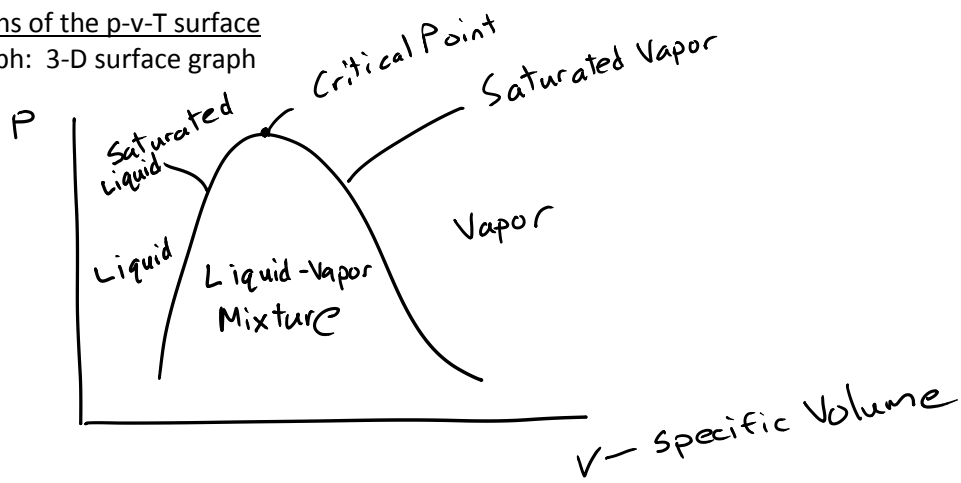
**Phases:** Solid, liquid, and vapor

**Triple Point:** All phases exist at that state

**Saturation State:** State at which phase change begins or ends

Projections of the p-v-T surface

p-v-T graph: 3-D surface graph



Quality of a Two-Phase Liquid-Vapor Mixture

$$X = \frac{m_{\text{vapor}}}{m_{\text{total}}} = \frac{m_{\text{vapor}}}{m} = \frac{m_{\text{vapor}}}{m_{\text{vapor}} + m_{\text{liquid}}}$$

Quality

$X \Rightarrow 0$  to  $1$   
 sat liquid                      sat vapor

Using Tables to Evaluate Properties

Appendix -> Tables

Water

Tables A-2 and A-3 (Two-phase liquid-vapor mixture)

Tables A-4 (Superheated vapor)

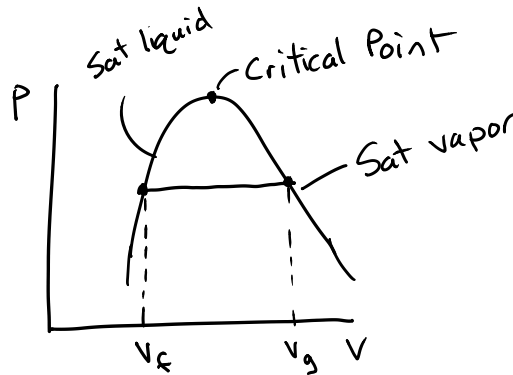
Tables A-5 (Subcooled or compressed liquid)

E -> English Units (Table A-2E)

No E -> SI Units (Table A-2)

Saturation Tables

A-2 and A-3



Two-Phase Liquid-Vapor Mixture

$$\bar{V} = \bar{V}_{\text{liquid}} + \bar{V}_{\text{vapor}}$$

$$v = \frac{V}{m} = \frac{\bar{V}_{\text{liquid}} + \bar{V}_{\text{vapor}}}{m}$$

$$\underbrace{v_{\text{liquid}}}_{v_f} = \frac{\bar{V}_{\text{liquid}}}{m_{\text{liquid}}} \quad \underbrace{v_{\text{vapor}}}_{v_g} = \frac{\bar{V}_{\text{vapor}}}{m_{\text{vapor}}}$$

$$\bar{V}_{\text{liquid}} = v_f m_{\text{liquid}} \quad \bar{V}_{\text{vapor}} = v_g m_{\text{vapor}}$$

$$v = \frac{V_{\text{liquid}}}{m} + \frac{V_{\text{vapor}}}{m}$$

$$= \frac{v_f m_{\text{liquid}}}{m} + \frac{v_g m_{\text{vapor}}}{m}$$

$\frac{m_{\text{vapor}}}{m} = X$  (Quality)

$$\frac{m_{\text{liquid}}}{m} = 1 - X$$

$$v = (1 - X)v_f + Xv_g$$

$$v = v_f + X(v_g - v_f) \quad \text{or} \quad X = \frac{v - v_f}{v_g - v_f}$$

Could also use  $u$

$$u = u_f + X(u_g - u_f) \quad \text{or} \quad X = \frac{u - u_f}{u_g - u_f}$$

Enthalpy (H)

$$H = \bar{U} + p\bar{V} \quad \text{or} \quad h = u + pv$$

(specific enthalpy)

$$h = h_f + X(h_g - h_f) \quad \text{or} \quad X = \frac{h - h_f}{h_g - h_f}$$

Linear Interpolation

- Used to approximate values between rows and columns in the tables

