The Equations of State

Equations that relate the pressure, temperature, and specific volume of a substance. They predict the p-v-T relationship of a "**gas**" reasonably well within selected regions.

Example: Ideal gas equation:

$Pv = RT$, where R is the gas constant

$R = \frac{\overline{R}}{M}$, where $\overline{R}$ is the universal gas constant (8.314 kJ / (kmole $\cdot$ K)

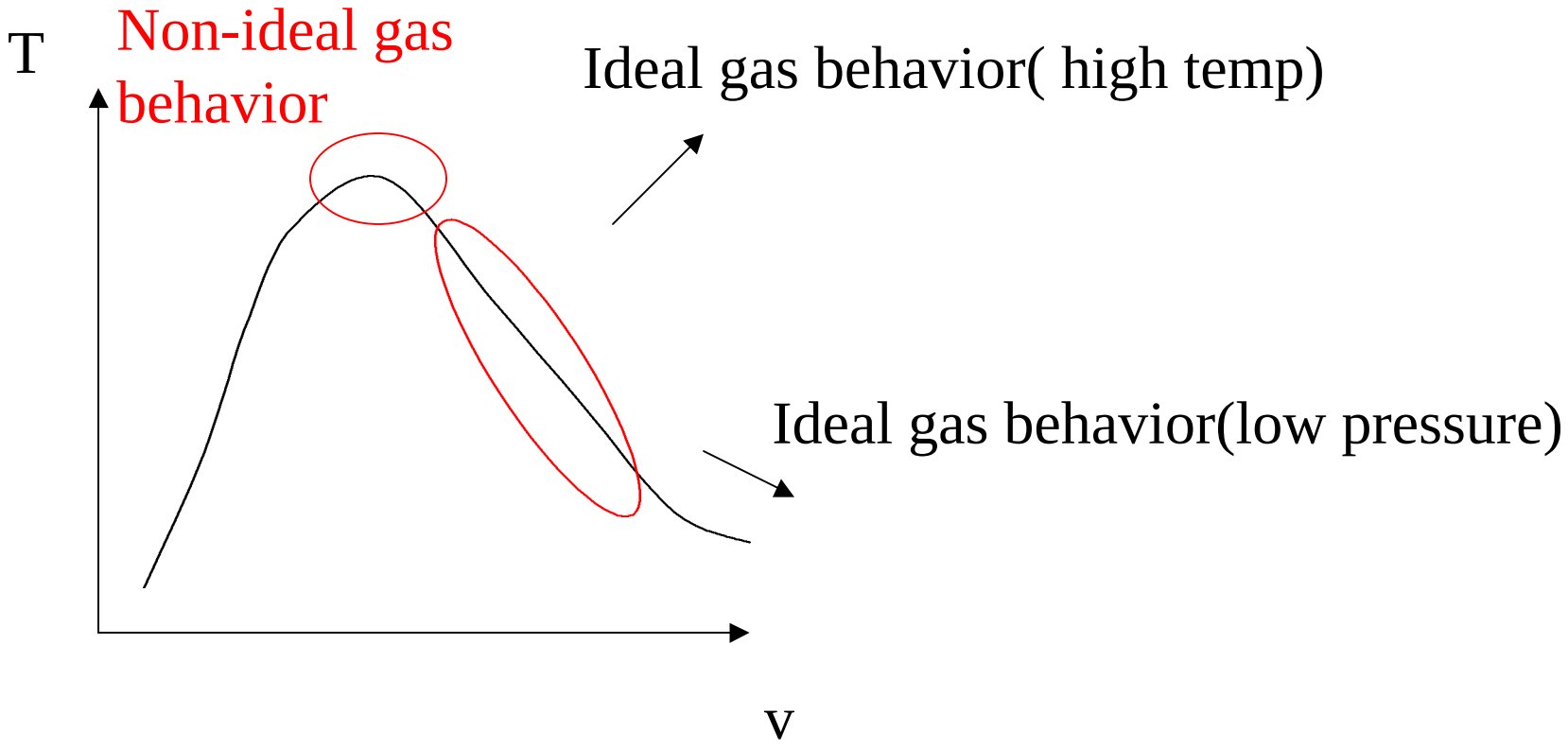
M is the molar mass, defined as the mass of one mole of a substance.

Example: M = 28 kg / kmol for nitrogen (since its molar mass is 28)

M = 32 kg / kmol for oxygen (O_2 with a molar mass of 32)

Note: many gases such as air, oxygen can be treated as ideal gases. However, dense gases such as water vapor and refrigerant vapor should not be treated as ideal gas. Use property table instead.

Ideal Gas Assumption



Note: for most gases

- Deviate from ideal gas in the vicinity of the critical point and saturated vapor line
- behaves like ideal gas at high temperature and low pressure regions

Compressibility Factor-A measure of deviation from the ideal gas

$$Z = \frac{Pv}{RT},\ Pv = ZRT$$ Z: compressibility factor, Z=1, ideal gas

$P_r = P/P_{cr}$

$T_r = T/T_{cr}$

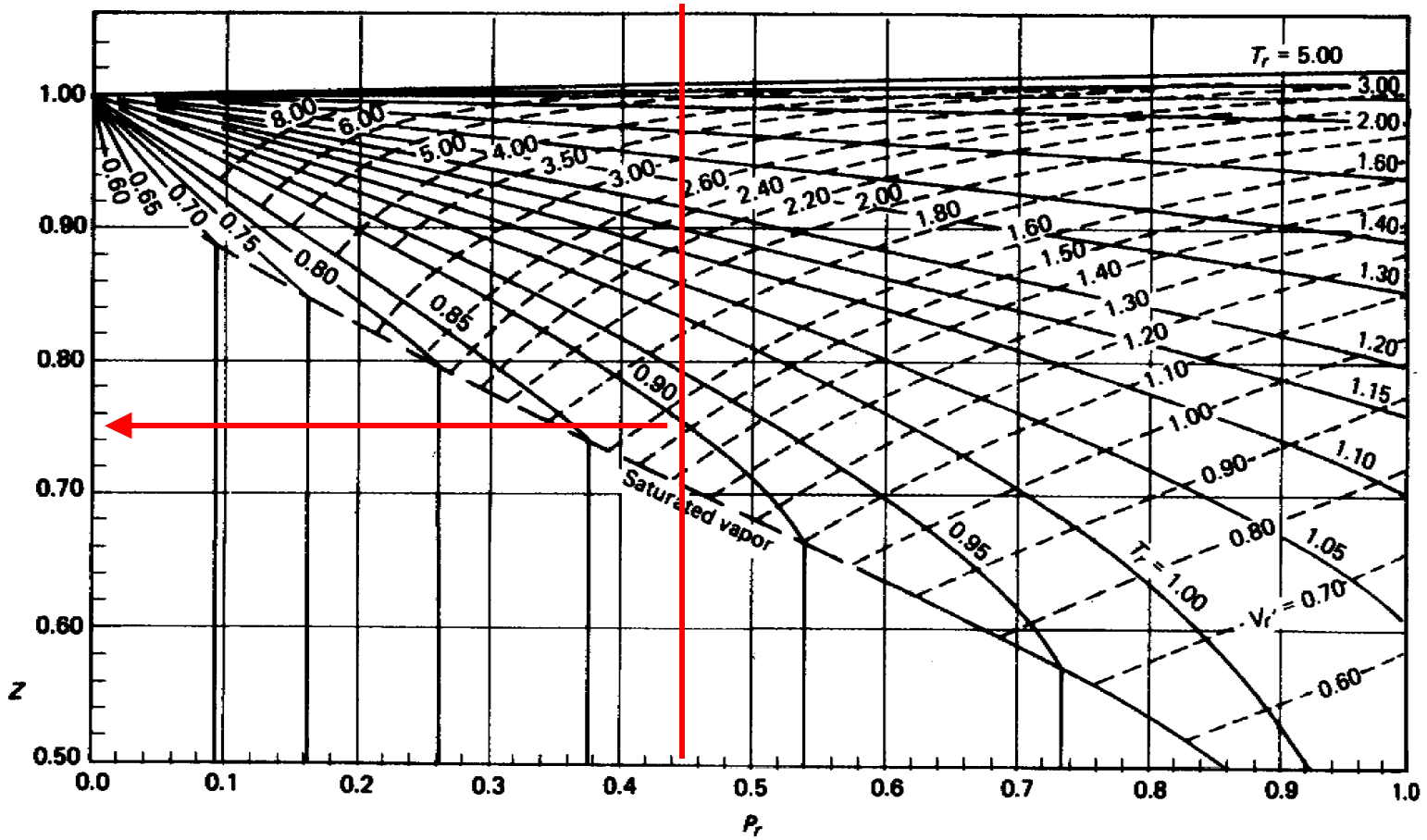


Fig A-3 ~~Fig. H-1~~ Compressibility Chart.

Example: steam T=310° C, P=10 MPa, T_{cr}=647.3K, P_{cr}=22.09 MPa (From Table A-1, p. 842); T_r=0.9, P_r=0.45, Z=0.75, different from ideal gas