UNIT V

Compressibility factor

Ideal gasses follow the formula $PV = mRT$, but real gasses fall on a spectrum of compressibility, denoted by z. This is a ratio of the actual volume of a gas to the volume that is predicted by an ideal gas version at a given temperature and pressure.

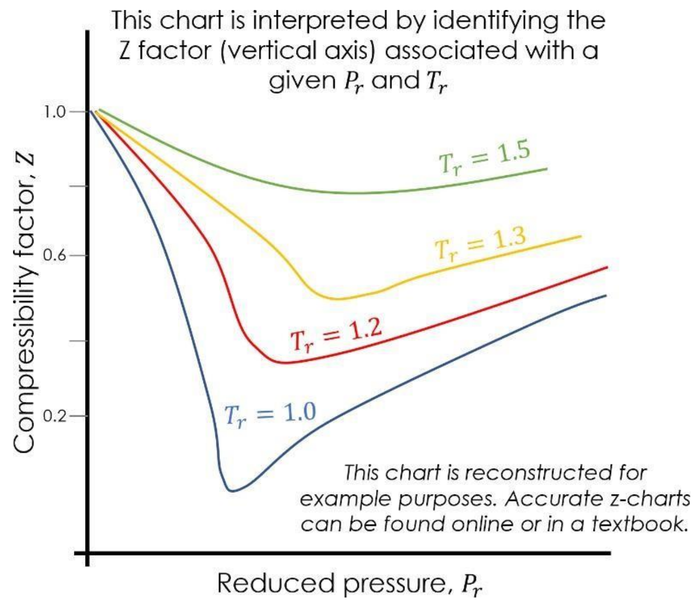
Z may be greater than or less than 1. A value of 1 indicates an ideal gas.

$$Z = \frac{V}{\frac{mRT}{P}} = \frac{PV}{mRT}$$

Subscript R indicates "reduced", and subscript C indicates "critical". These are used to create a general graph that can be applied to any gas, rather than graphs specifically for each type of gas.

$$P_R = \frac{P}{P_C} = \text{Reduced Pressure}$$

$$T_R = \frac{T}{T_C} = \text{Reduced Temperature}$$


This chart is interpreted by identifying the Z factor (vertical axis) associated with a given P_r and T_r
1.0
0.6
0.2
Compressibility factor, Z
$T_r = 1.5$
$T_r = 1.3$
$T_r = 1.2$
$T_r = 1.0$
This chart is reconstructed for example purposes. Accurate z-charts can be found online or in a textbook.
Reduced pressure, P_r

Once the compressibility factor is known, the modified ideal gas equation can beused tocontinue solving a given problem:

$$Pv = zRT$$

The ideal-gas equation is very simple and thus very convenient to use. Gases deviate from ideal-gas behavior significantly at states near the saturation region and the critical point. This deviation from ideal-gas behavior at a given temperature and pressure can accurately be accounted for bythe introduction of a correction factor called the compressibility factor *Z*. It is defined as:

$$Z = \frac{Pv}{RT} \qquad (2\text{-}17)$$

$$Pv = ZRT \qquad (2\text{-}18)$$

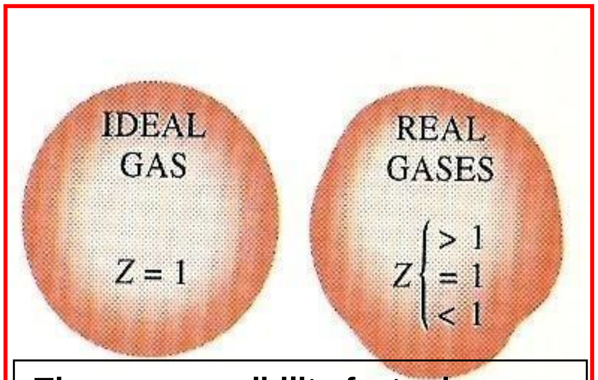
or, it can also be expressed as:

$$Z = \frac{v_{\text{actual}}}{v_{\text{ideal}}} \qquad (2\text{-}19)$$

where $v_{\text{ideal}} = RT/P$. Obviously, $Z = 1$

For ideal gases. For real gases *Z* can be greater than or less than unity(Fig.2-55).

Gases behave differently at a given temperature and pressure, but they behave very much the same at temperatures and pressures normalized with respect to their critical temperatures and pressures.

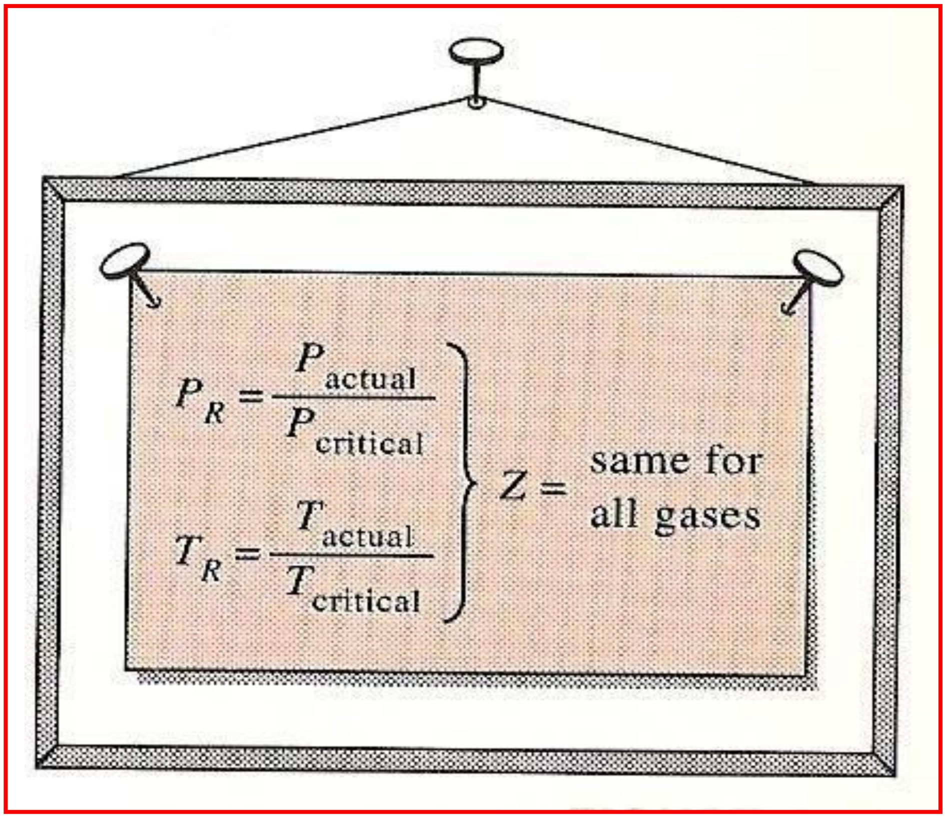


The compressibility factor is unity for ideal gases.

$$P_R = \frac{P}{P_{cr}} \quad \text{and} \quad T_R = \frac{T}{T_{cr}}$$

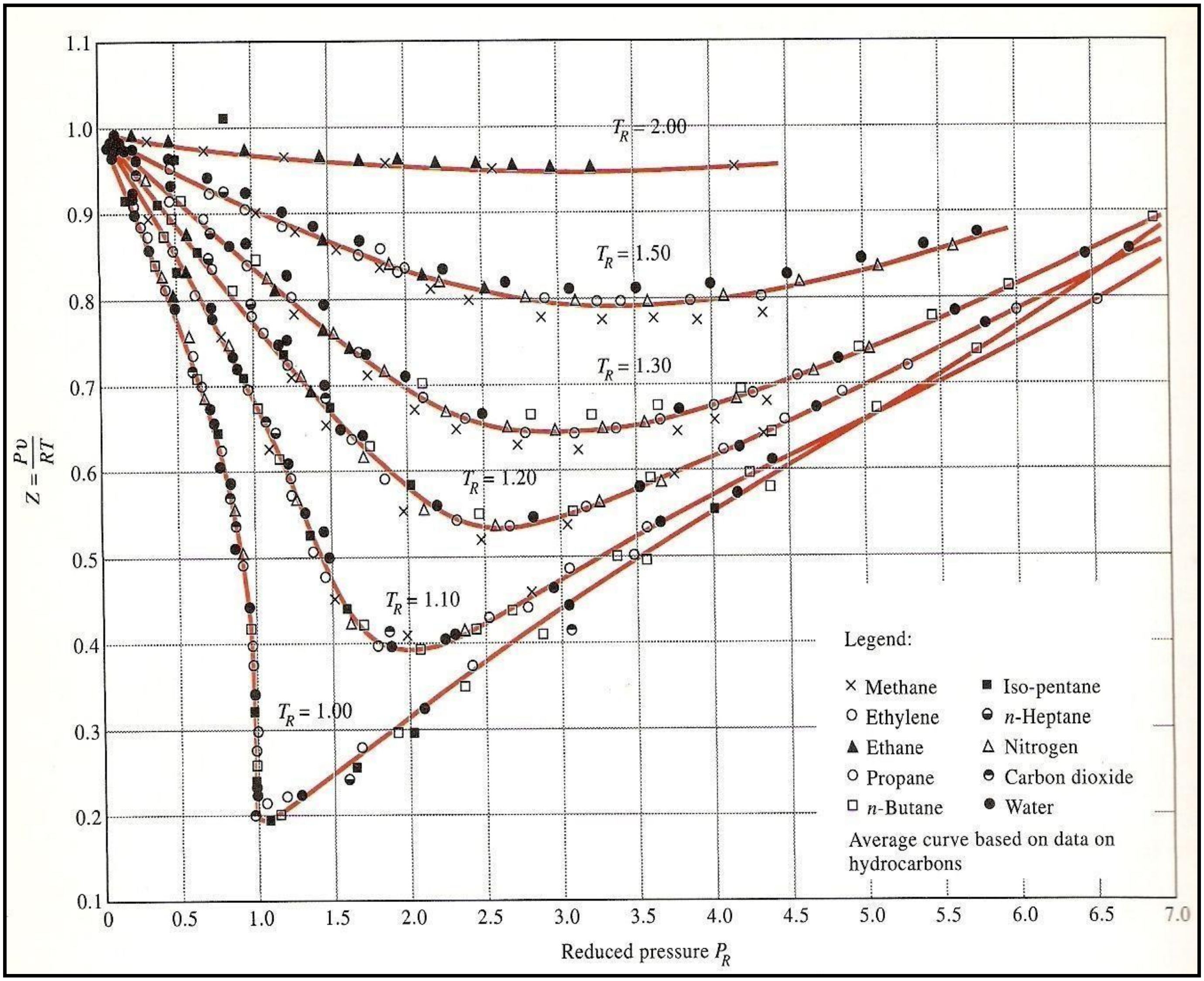
Here, P_R = reduced pressure, T_R = reduced temperature

The Z factor for all gases is approximately the same at the same reduced pressure and temperature (Fig. 2-56). This is called the principle of corresponding states.



The compressibility factor isthe same for all gases at the reduced pressure and temperature (principle of corresponding states).

The experimentally determined Z values are plotted against PR and TR for several gases. The gases seem to obey the principle of corresponding states reasonably well. By curve-fitting all the data, we obtain the generalized compressibilitychartwhich can be used for all gages.



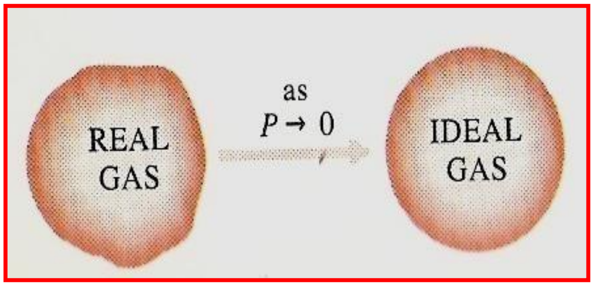
Comparison of *Z* factors for various gases.

The following observations can be made from generalized compressibility chart:

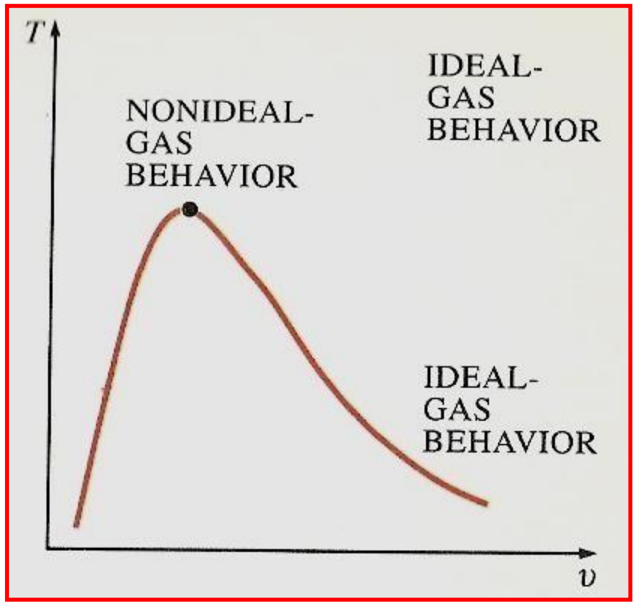
1. At very low pressures ($P_R \ll 1$), the gases behave as an idealgas regardless of temperature

2. At high temperatures ($T_R > 2$), ideal-gas behavior canassumedwith good accuracy regardless of pressure (exceptwhen $P_R \gg 1$).

3. The deviation of a gas from ideal-gas behavior is greatest inthe vicinity of the critical point



At very low pressures,all gases approach ideal-gas behavior (regardless of their temperature).



Gases deviate from the ideal-gas behavior most in the neighborhood ofthe critical point.