Ideal Gas Equation of State

$$p = n\overline{R}T$$

$\overline{R}$ =8.3144 (J/mol K), T(K), p(Pa) and n(mol/m^3).

$$p = nkT$$

k=1.380662E-23 (J/K), T(K), p(Pa) and n(**molecules**/m^3).

$$p = \rho RT$$

R(J/kg K), T(K), p(Pa) and ρ (kg/m^3).

$$\overline{R} = MR$$

$\overline{R}$ =8.3144 (J/mol K), M(kg/mol), R(J/kg K).

$$k = \overline{R}/Na$$

$\overline{R}$ =8.3144 (J/mol K), k=1.380662E-23 (J/K), Na=6.022045E23 (/mol).

This empirical relation has been found to accurately represent the behaviour of gases at low density.

The equation forms a pillar of much thermodynamic cycle analysis, thus it is important to determine its range of applicability. Analysing data for many gases has shown that as a rule the equation is valid for temperatures above twice the critical temperature (Fig.1) and pressures below five times the critical pressure (Fig.2).

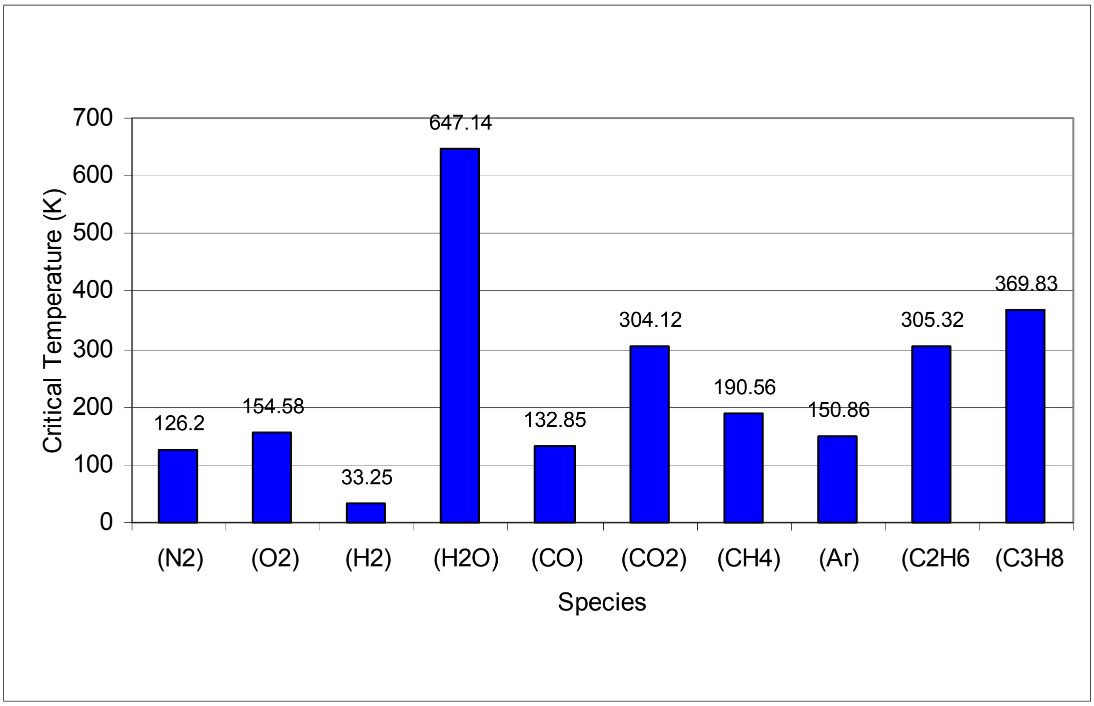

Figure 1. Critical Temperature

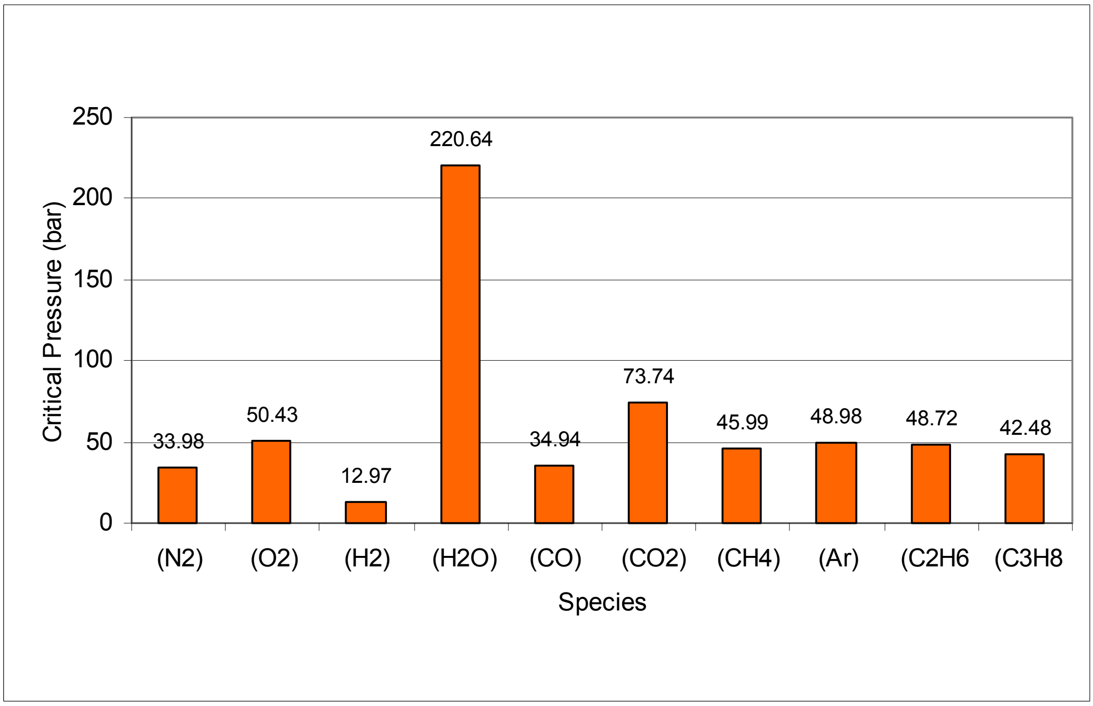

Figure 2. Critical Pressure

Combinations of lower temperature and/or higher pressure may also be in the range of validity, but require further consideration. Use of a generalized compressibility chart (through corresponding states arguments) gives a more accurate indication of applicability. Compressiblity (Z) is the ratio $p/n\overline{R}T$. Ideal gases have a compressibility of 1.

Insert compressibility chart

References

[1] R.E. Sonntag & G.J. Van Wylen, Introduction to Thermodynamics, John Wiley & Sons, Inc, 1991.

See also (from http://www.thermofluids.net/)
http://thermal.sdsu.edu/testcenter/javaapplets/realgas/