



Properties of Reservoir Fluids (PGE 362)

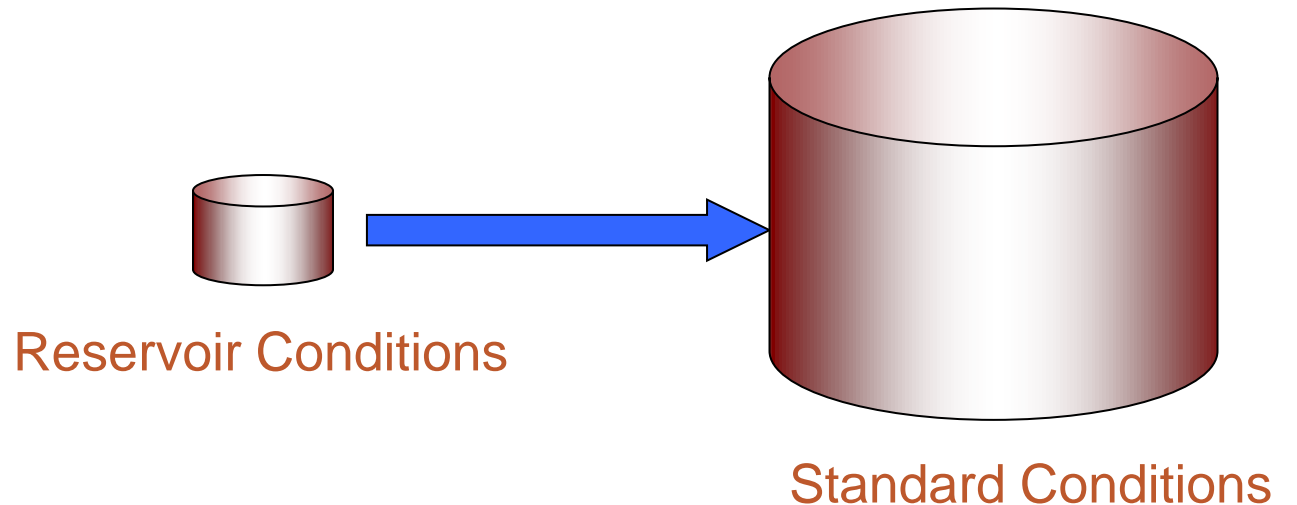
Reservoir Fluids Characteristics

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20-12-2016

Gas Properties

Gas Formation Volume Factor (B_g):

The volume of gas at reservoir conditions required to produce one standard volume of gas at the surface condition.



Gas Properties

Gas Formation Volume Factor (B_g):

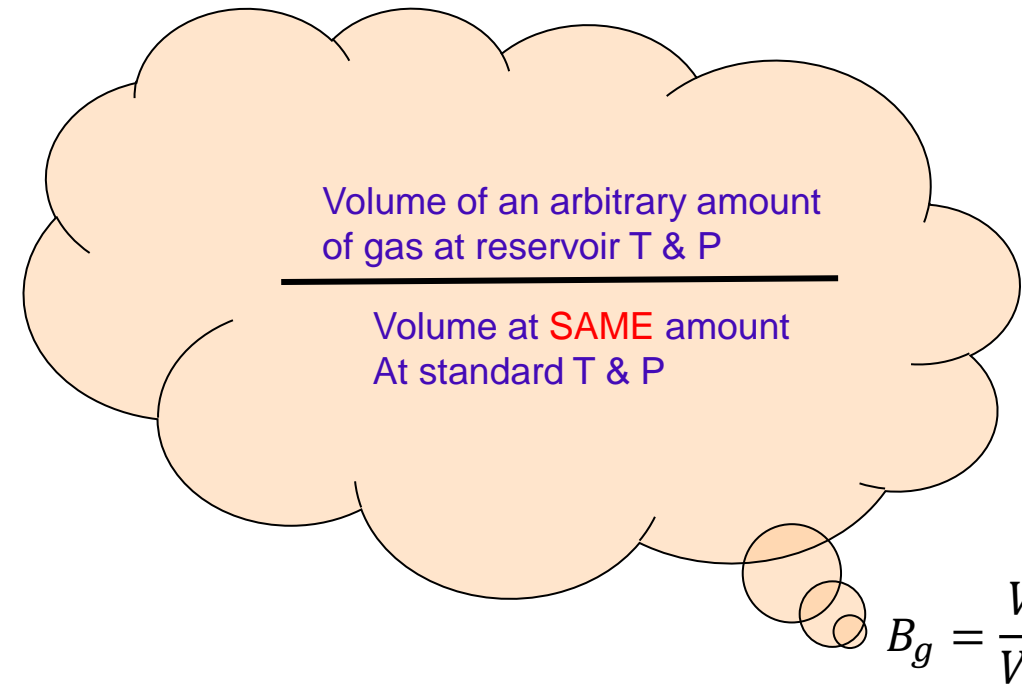
$$B_g = \frac{V_R}{V_{SC}} = \frac{\frac{znRT}{P}}{\frac{nRT_{SC}}{P_{SC}}}$$

SC: $P=14.65$ psia, $T= 520$ °R, $z= 1.0$

$$B_g = \frac{P_{SC}}{T_{SC}} \frac{zT}{P} = \frac{14.65}{(520)} \frac{zT}{P} = 0.0282 \frac{zT}{P} \frac{\text{res cu ft}}{\text{scf}}$$

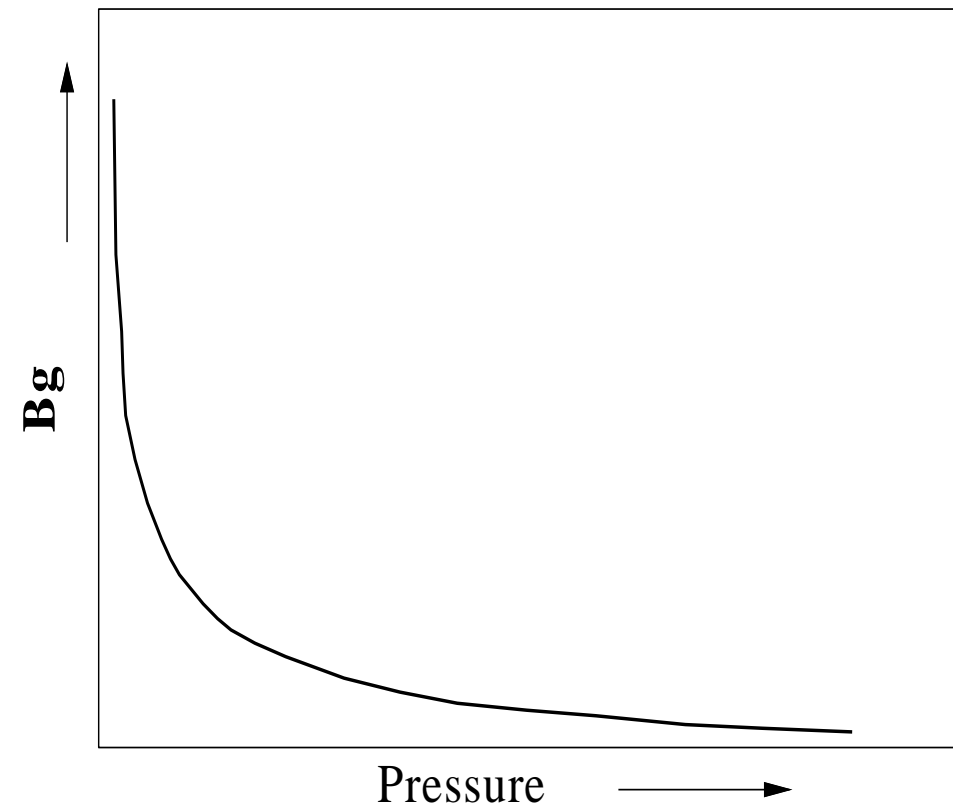
$$B_g = 0.00502 \frac{zT}{P} \frac{\text{res bbl}}{\text{scf}}$$

$$B_g = 5.02 \frac{zT}{P} \frac{\text{res bbl}}{\text{Mscf}}$$



Gas Properties

Gas Formation Volume Factor (B_g):
Typical shape of B_g



Gas Properties

Gas Formation Volume Factor (B_g):

Example:

A gas has a specific gravity of 0.74. Calculate its formation volume factor at 210° F and 2300 psia.

Solution:

$$T_c = 396^\circ \text{ R}, P_c = 665 \text{ psia}$$

$$T_r = \frac{460+210}{396} = 1.69, P_r = \frac{2300}{665} = 3.46, z = 0.86$$

$$B_g = 0.00502 \frac{(0.86)(670)}{(2300)} = 0.00126 \frac{\text{res bbl}}{\text{scf}} = 1.26 \frac{\text{res bbl}}{\text{Mscf}}$$

Gas Properties

Gas Viscosity (μ_g):

Viscosity is a measure of the resistance to flow exerted by a fluid.

Units:

Dynamic (μ): Poise (p) = g mas/(sec cm)

or centipoise (cp) = g mas/(100 sec cm)

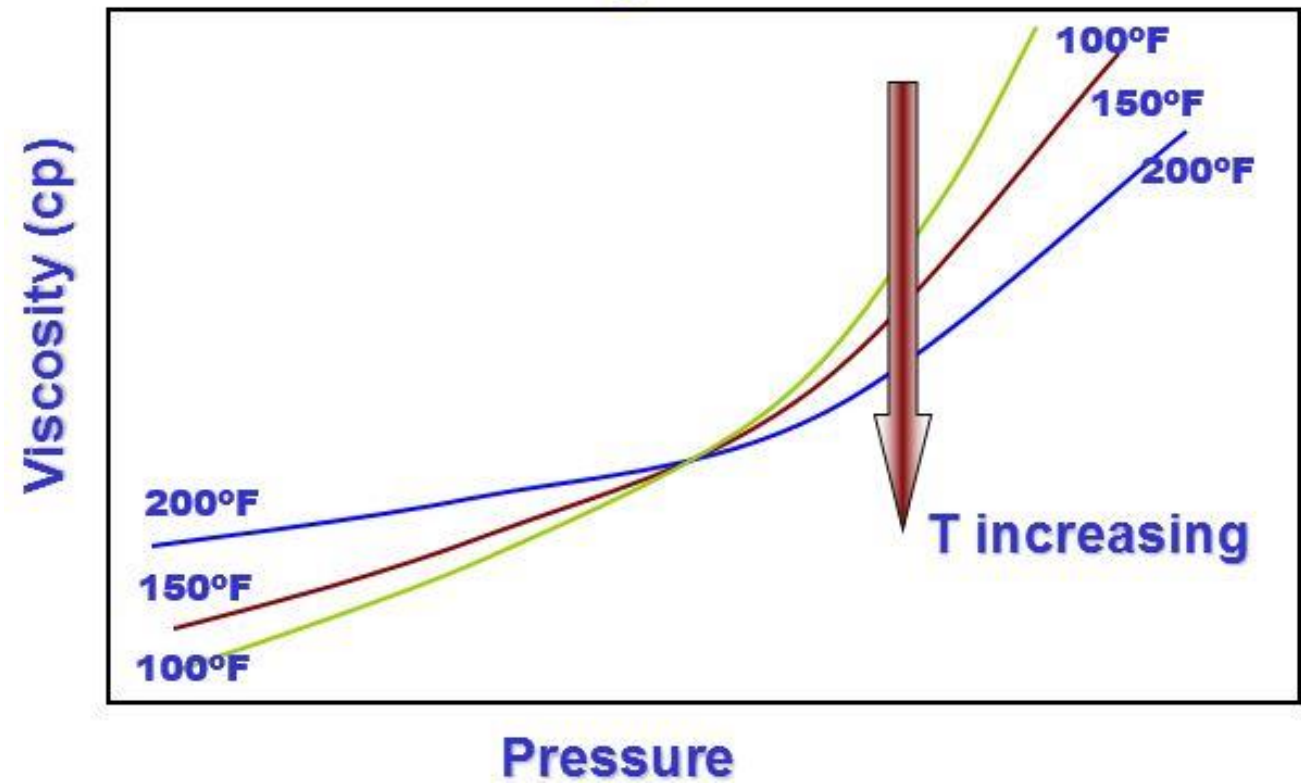
SI unit : Pascal second (Pa s) = 1 kg/(m s) = 10 p

Kinematic (ν): viscosity/density : centipoise/gm/cc (cp/g/cc)

Gas Properties

Gas Viscosity (μ_g):

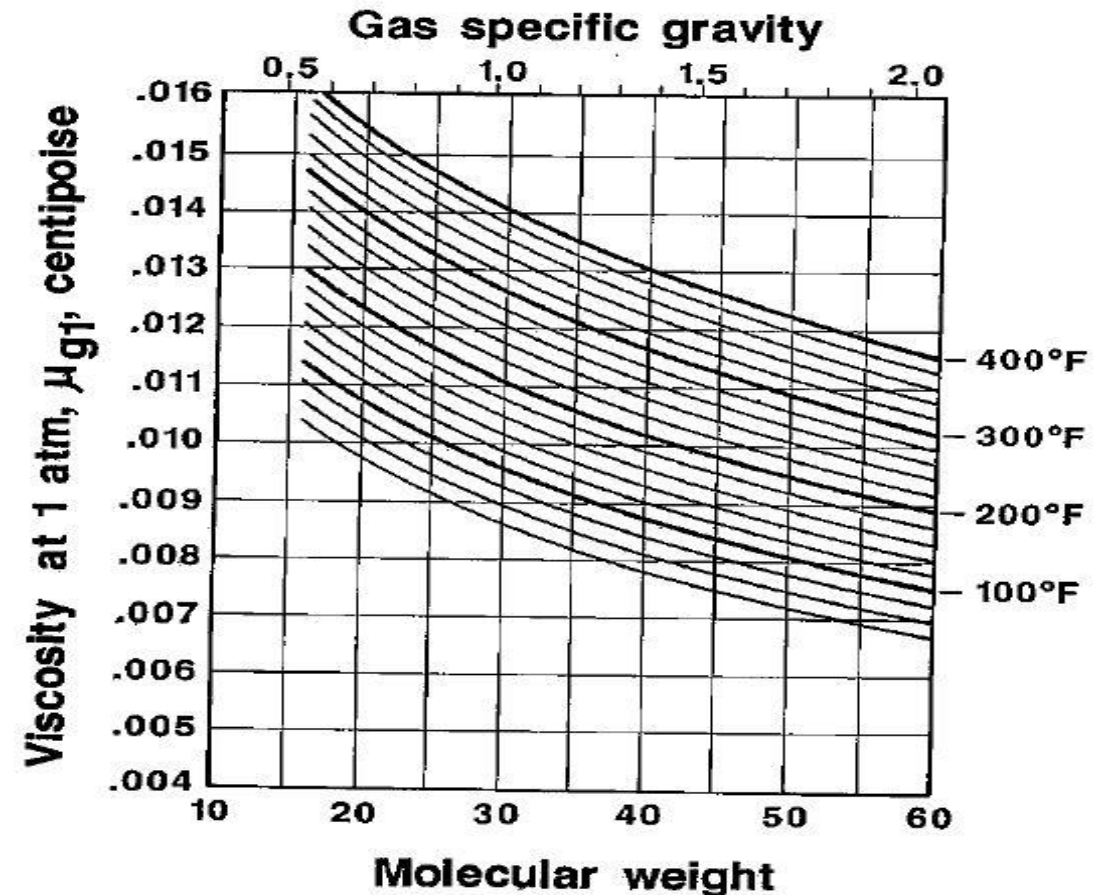
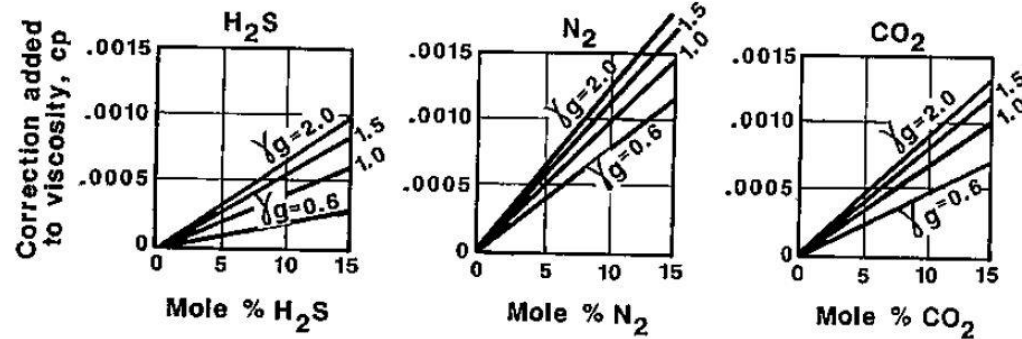
Typical shape:



Gas Properties

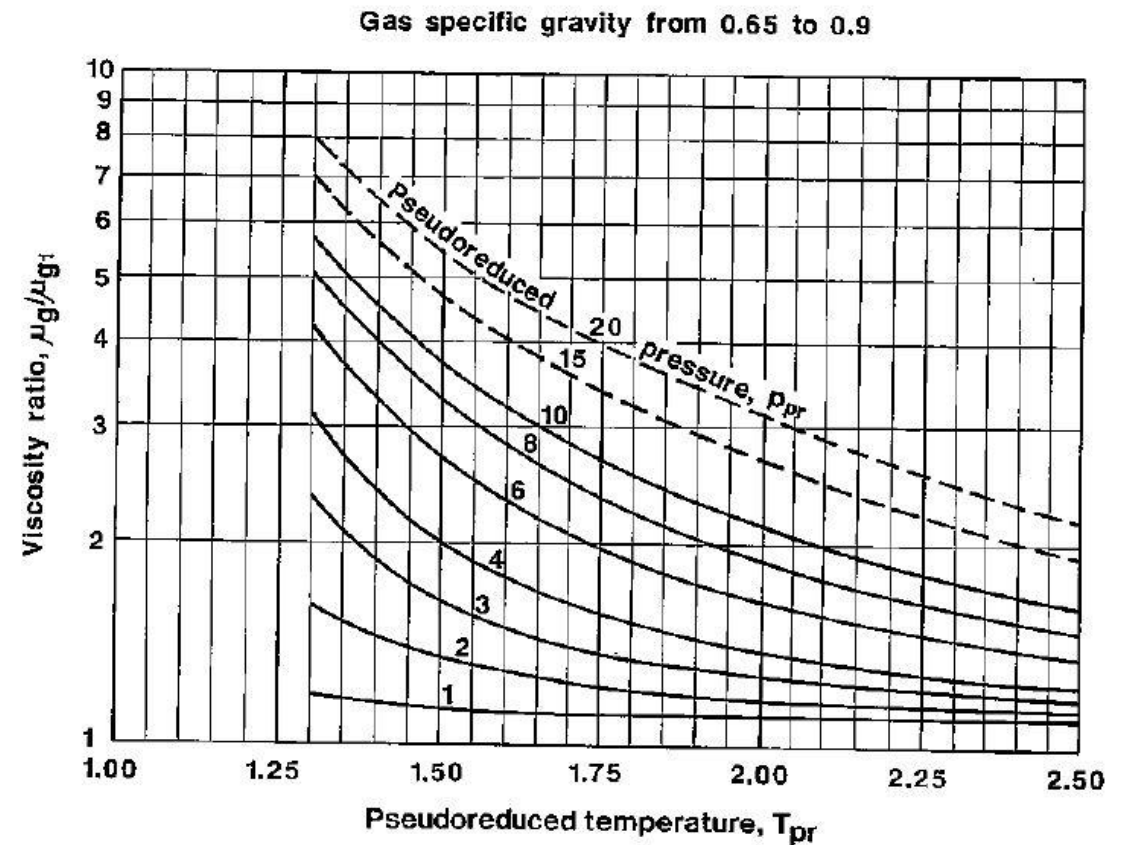
Gas Viscosity (μ_g):

Correlation:



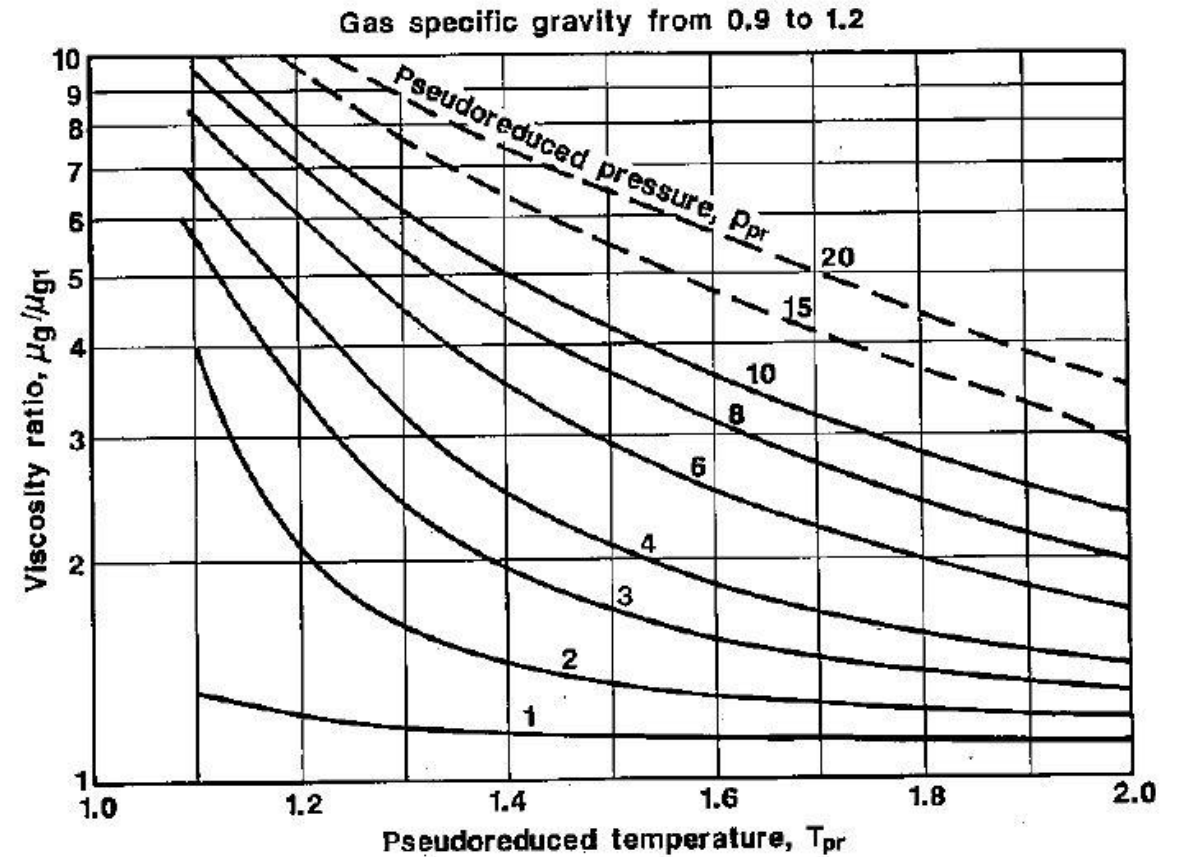
Gas Properties

Gas Viscosity (μ_g):
Correlation:



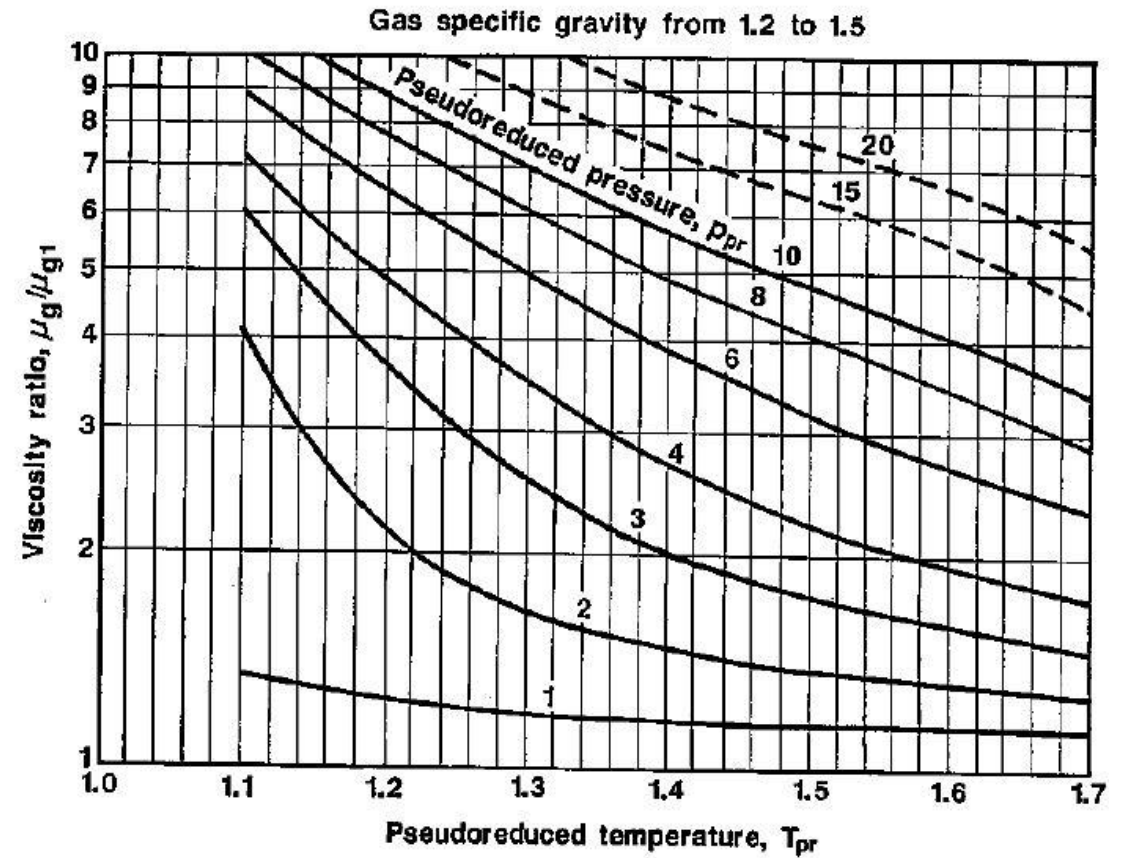
Gas Properties

Gas Viscosity (μ_g):
Correlation:



Gas Properties

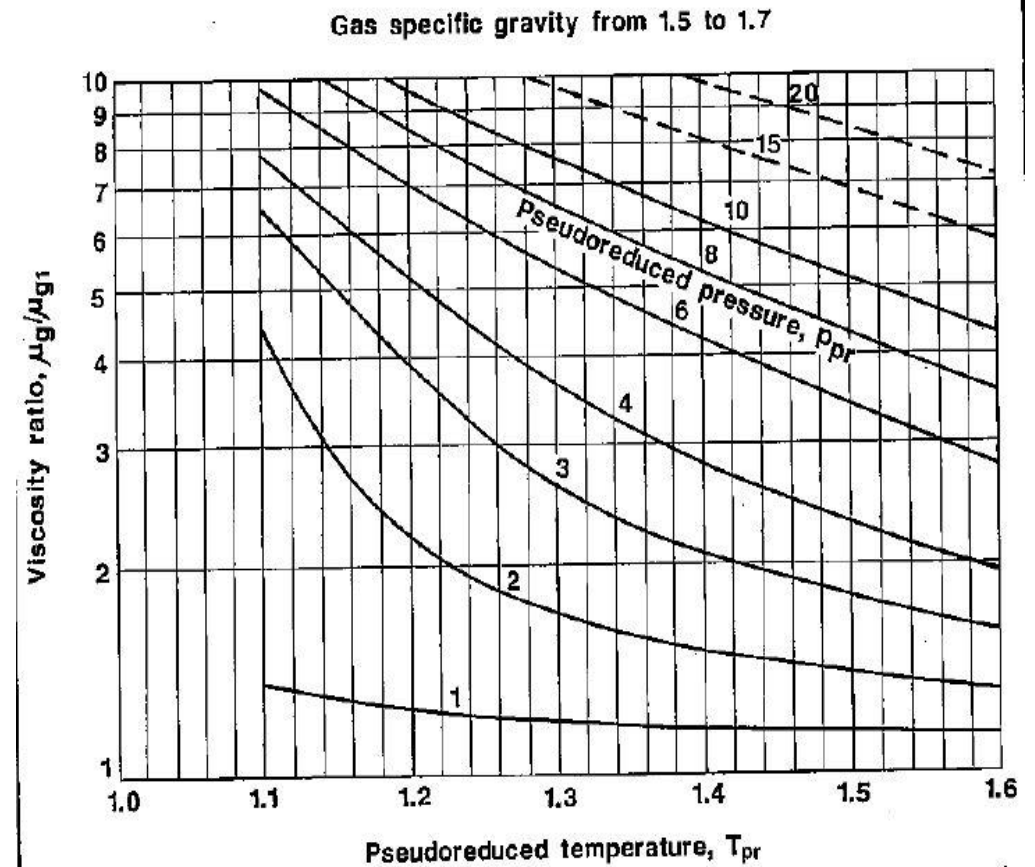
Gas Viscosity (μ_g):
Correlation:



Gas Properties

Gas Viscosity (μ_g):

Correlation:



Gas Properties

Gas Viscosity (μ_g):

Correlation:

EXAMPLE 6–9: *Calculate the viscosity of the gas mixture given below at 200°F and a pressure of one atmosphere absolute.*

| Component | Composition, mole fraction |
|-----------|-------------------------------|
| Methane | 0.850 |
| Ethane | 0.090 |
| Propane | 0.040 |
| n-Butane | 0.020 |
| | <hr/> |
| | 1.000 |

Gas Properties

Gas Viscosity (μ_g):

Correlation:

Solution:

First, calculate the specific gravity of the gas.

$$M_a = \sum_j y_j M_j$$

| Component M_j | y_j | M_j | y_j |
|--------------------|-------|-------|-------|
| C ₁ | 0.85 | 16.04 | 13.63 |
| C ₂ | 0.09 | 30.07 | 2.71 |
| C ₃ | 0.04 | 44.10 | 1.76 |
| n-C ₄ | 0.02 | 58.12 | 1.16 |
| | 1.02 | M_a | 19.26 |

Second, determine viscosity.

$$\gamma_g = \frac{M_a}{29}$$

$$\mu_{g1} = 0.0125 \text{ cp at } 200^\circ\text{F, Figure 6-8}$$

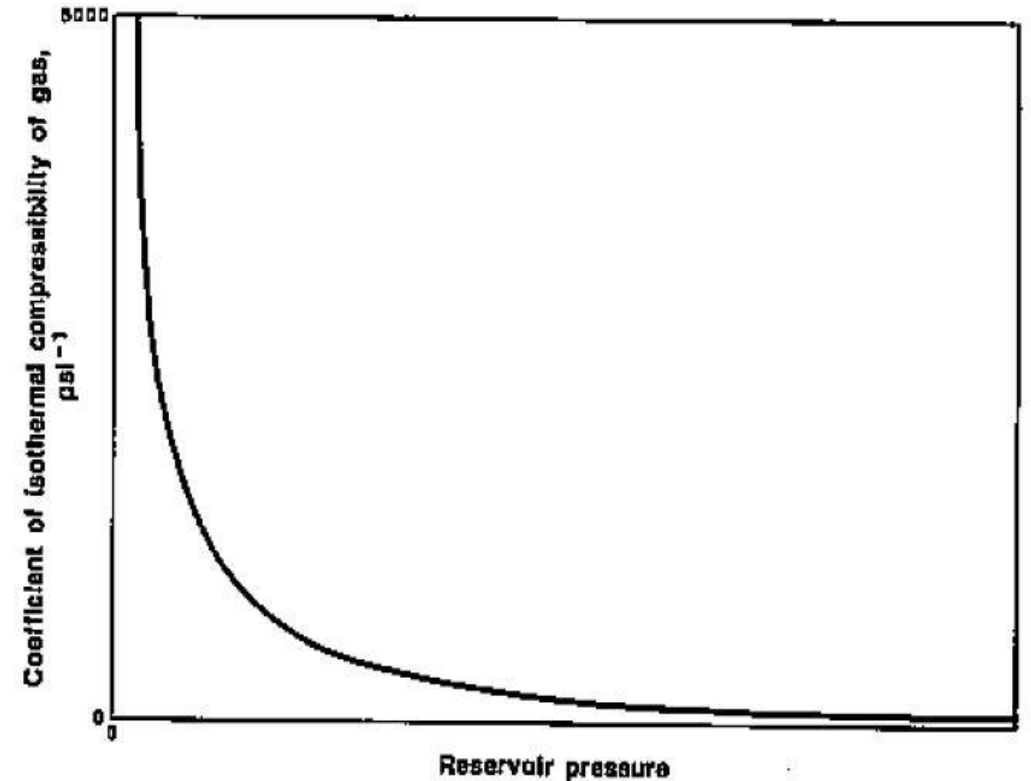
$$\gamma_g = \frac{19.26}{29} = 0.664$$

Gas Properties

Coefficient of Isothermal Compressibility of Gas (c_g):

The change in gas volume per change in pressure at constant temperature.

$$c_g = -\frac{1}{V} \left(\frac{\partial V}{\partial P} \right)_T$$



Gas Properties

Coefficient of Isothermal Compressibility
of Gas (c_g):

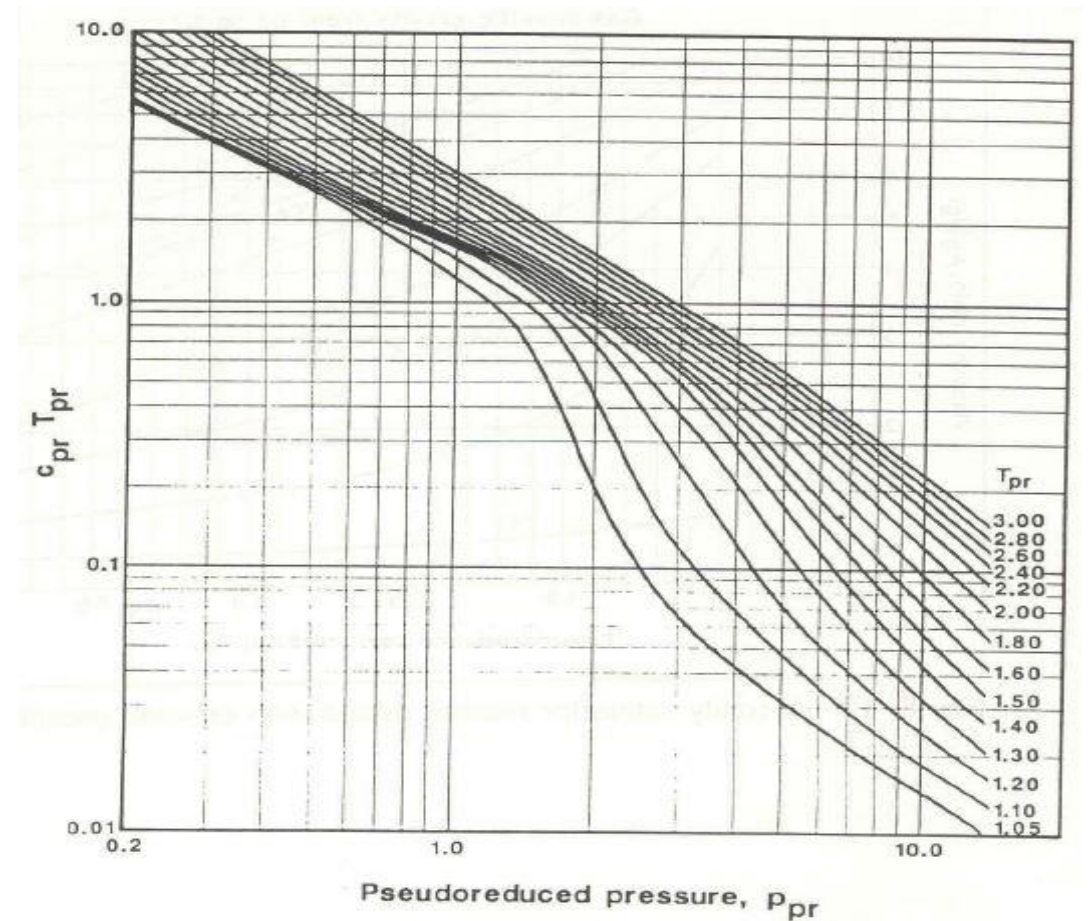
$$c_g = -\frac{1}{V} \left(\frac{\partial V}{\partial P} \right)_T$$

Ideal Gas: $V = \frac{nRT}{P} : \frac{\partial V}{\partial P} = -\frac{nRT}{P^2}$
$$c_g = -\left(\frac{P}{nRT} \right) \left(-\frac{nRT}{P^2} \right) = \frac{1}{P}$$

Real Gas: $V = \frac{znRT}{P} : \frac{\partial V}{\partial P} = nRT \frac{P \left(\frac{\partial z}{\partial P} \right)_T - z}{P^2}$
$$c_g = -\left(\frac{P}{znRT} \right) \left[nRT \frac{P \left(\frac{\partial z}{\partial P} \right)_T - z}{P^2} \right]$$
$$c_g = \frac{1}{P} - \frac{1}{z} \left(\frac{\partial z}{\partial P} \right)_T$$

Gas Properties

Coefficient of Isothermal Compressibility
of Gas (c_g):



Gas Properties

Coefficient of Isothermal Compressibility
of Gas (c_g):

Example:

Calculate the coefficient of isothermal compressibility of a dry gas with specific gravity of 0.818 at reservoir temperature of 220° F and 2100 psig.

Solution:

$$\begin{aligned}T_{pc} &= 406^\circ \text{ R} \\P_{pc} &= 647 \text{ psig} \\C_{pr} &= c_g p_{pc}\end{aligned}$$

$$T_{pr} = 1.68 \text{ and } p_{pr} = 3.27$$

using appropriate $c_{pr}T_{pr}$ chart.

$$c_{pr}T_{pr} = 0.528$$

$$c_{pr} = \frac{0.528}{1.68} = 0.314$$

$$c_g = \frac{c_{pr}}{p_{pc}} = \frac{0.314}{647 \text{ psia}} = 486 \times 10^{-6} \text{ psi}^{-1}$$