

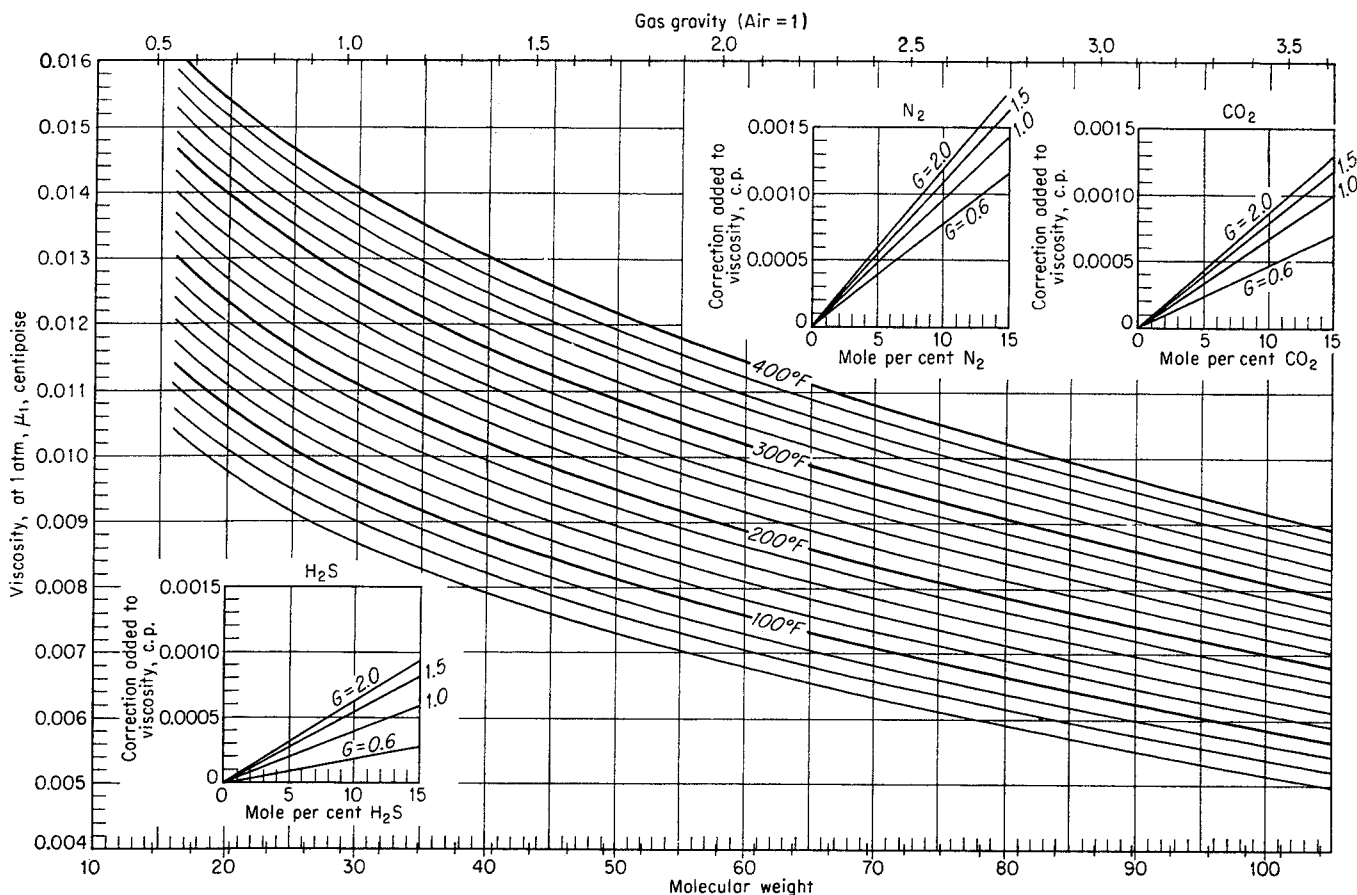


Fig. 4-98. Viscosity of gases at 1 atm pressure. (Carr, Kobayashi, and Burrows, 4-106. Courtesy AIME.)

carbons is to increase the viscosity of the hydrocarbon mixture.

Viscosity of Gases under Pressure

The references for viscosities of gases under pressure are given in Table 4-23. The work of Comings, Mayland, and Egly (4-107, 4-108) and of Carr (4-104, 4-105a) shows that the rolling-ball viscosimeter may give viscosities as much as 30 per cent too high. The available data have been correlated, with preference for the data taken on the Rankine viscosimeter (4-124), to give the viscosity of methane (Fig. 4-99) and of propane (Fig. 4-100). Figure 4-101 gives the data of Comings, Mayland, and Egly for ethylene (4-108).

As early as 1894, Onnes and deHaas (4-120, 4-121) recognized that the viscosities of homologues under corresponding states could be correlated. The theorem of corresponding states has been further developed and applied to nonpolar gases by several authors (4-130, 4-108, 4-106, 4-100, 4-107, 4-137). Only one of these correlations will be presented here.

Figures 4-102 and 4-103 present the gas-viscosity correlation of Carr (4-104, 4-105) based on the original correlation of Comings, Mayland, and Egly (4-108)

for pure, nonpolar gases. Carr et al. extended the correlation of Comings et al. to higher pressures and to complex mixtures of nonpolar gases (4-104, 4-105, 4-105a). The ratio μ/μ_1 of the viscosity at high pressure to the viscosity at 1 atm is shown as a function of the reduced pressure P_R and of the reduced temperature T_R .

$$\text{Here } T_R = \frac{\text{temperature, absolute scale}}{\text{critical temperature, absolute scale}}$$

$$P_R = \frac{\text{pressure, absolute scale}}{\text{critical pressure, absolute scale}}$$

$$\mu = \text{viscosity of gas at reduced temperature } T_R \text{ and reduced pressure } P_R$$

$$\mu_1 = \text{viscosity of gas at temperature } T_R \text{ and atmospheric pressure}$$

When mixtures are involved, the pseudocritical pressures and temperatures of typical natural gases may be estimated from gas gravity alone from Fig. 4-22, which is based on typical natural gases.

The correlation of Ueyhara and Watson (4-137) relates the reduced viscosity $\mu_R = \mu/\mu_c$ by graphical means, using the reduced pressure and reduced temperature as variables. A method is provided for predicting the critical viscosity μ_c for pure components, and a combination rule for mixtures is suggested.