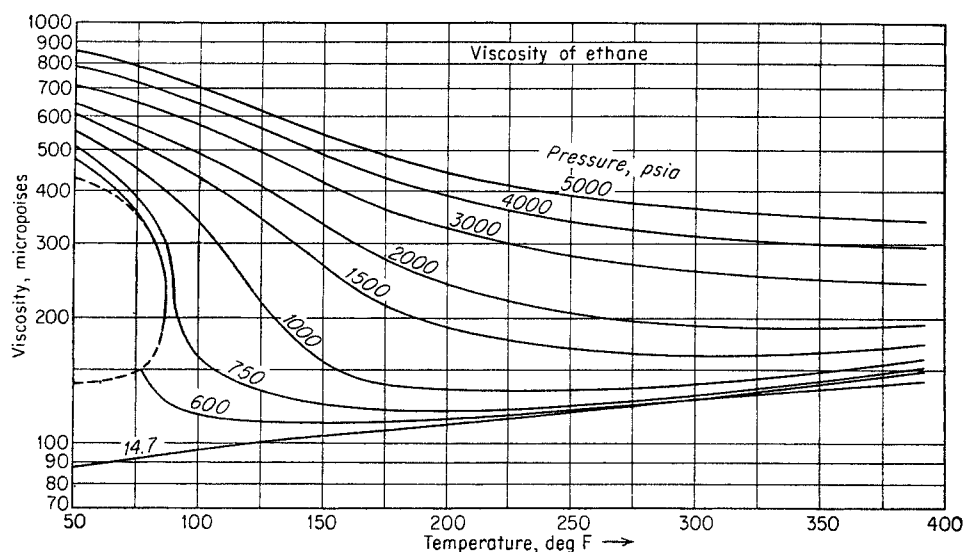


Fig. 4-96. Viscosity of ethane. (Data of Smith and Brown, 4-130.)



The prediction of the viscosities of complex hydrocarbon mixtures under pressure is dependent on the prediction of the viscosities of mixtures at 1 atm. Methods of predicting the viscosities of gaseous mixtures at 1 atm that apply to hydrocarbons have been presented by Bicher and Katz (4-101), Herning and Zipperer (4-111), and by Hirschfelder et al. (4-39). The last is based on the theoretical work of Chapman and Cowling (4-24). The calculations are quite involved and not generally suited to routine engineering calculations for mixtures. The computational methods of Hirschfelder et al. have been adapted to graphical and nomographical solutions by Bromley and Wilke (4-103).

Herning and Zipperer (4-111) proposed the following rule to calculate the viscosity of a mixture of gaseous components:

$$\mu_m = \frac{\sum_{i=1}^n \mu_i x_i \sqrt{M_i}}{\sum_{i=1}^n x_i \sqrt{M_i}} \quad (4-49)$$

where μ_m = viscosity of mixture

μ_i = viscosity of component i

x_i = mole fraction of i

M_i = molecular weight of component i

Equation (4-49) affords a simple and reliable means for calculating the viscosity of natural gas mixtures whose analyses are known. The application of Eq. (4-49) to both binary and complex mixtures encountered in natural gases has been verified by Carr (4-104, 4-105) and by Carr, Burrows, and Kobayashi (4-106). Figure 4-98 is recommended for predicting the viscosity of gases composed primarily of hydrocarbons. It provides a rapid and reliable method for ob-

taining the viscosity of gases at 1 atm pressure from a knowledge of the gas gravity and temperature alone. Insert plots on Fig. 4-98 show corrections to the hydrocarbon-viscosity value which may be applied to take into account the presence of low concentrations of hydrogen sulfide, nitrogen, and carbon dioxide. The effect of the presence of each of the nonhydro-

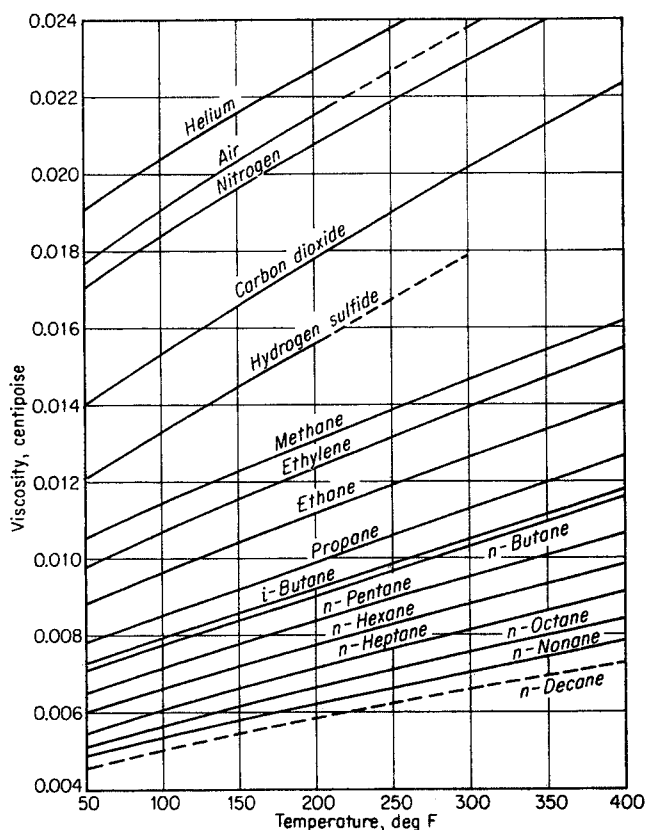


Fig. 4-97. Viscosity of gases at atmospheric pressure. (Carr, Kobayashi, and Burrows, 4-106. Courtesy AIME.)