3.3.5 Gas Viscosity. Viscosity of reservoir gases generally ranges from 0.01 to 0.03 cp at standard and reservoir conditions, reaching up to 0.1 cp for near-critical gas condensates. Estimation of gas viscosities at elevated pressure and temperature is typically a two-step procedure: (1) calculating mixture low-pressure viscosity μ_{gsc} at p_{sc} and T from Chapman-Enskog theory[3,6] and (2) correcting this value for the effect of pressure and temperature with a corresponding-states or dense-gas correlation. These correlations relate the actual viscosity μ_g at p and T to low-pressure viscosity by use of the ratio μ_g/μ_{gsc} or difference $(\mu_g - \mu_{gsc})$ as a function of pseudoreduced properties p_{pr} and T_{pr} or as a function of pseudoreduced density ρ_{pr}.

Gas viscosities are rarely measured because most laboratories do not have the required equipment; thus, the prediction of gas viscosity is particularly important. Gas viscosity of reservoir systems is often estimated from the graphical correlation $\mu_g/\mu_{gsc} = \mathrm{f}(T_r, p_r)$ proposed by Carr *et al.*[42] (**Fig. 3.11**). Dempsey[43] gives a polynomial approximation of the Carr *et al.* correlation. With these correlations, gas viscosities can be estimated with an accuracy of about ±3% for most applications. The Dempsey correlation is valid in the range $1.2 \leqq T_r \leqq 3$ and $1 \leqq p_r \leqq 20$.

The Lee-Gonzalez gas viscosity correlation (used by most PVT laboratories when reporting gas viscosities) is given by[44]

$$\mu_g = A_1 \times 10^{-4} \exp\left(A_2 \rho_g^{A_3}\right), \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.65a)$$

$$\text{where } A_1 = \frac{\left(9.379 + 0.01607 M_g\right) T^{1.5}}{209.2 + 19.26 M_g + T},$$

$$A_2 = 3.448 + \left(986.4/T\right) + 0.01009 M_g,$$

$$\text{and } A_3 = 2.447 - 0.2224 A_2, \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.65b)$$

with μ_g in cp, ρ_g in g/cm^3, and T in °R. McCain[19] indicates the accuracy of this correlation is 2 to 4% for $\gamma_g < 1.0$, with errors up to 20% for rich gas condensates with $\gamma_g > 1.5$.