Settling in the Turbulent Region. In the turbulent region, inertial forces are predominant, and the effect of the first two terms in the drag coefficient equation [Eq. (5–19)] is reduced. For settling in the turbulent region, a value of 0.4 is used for the coefficient of drag. If a value of 0.4 is substituted into Eq. (5–21) for C_d, the resulting equation is

$$v_p = \sqrt{3.33g\left(\frac{\rho_p - \rho_w}{\rho_w}\right)d_p} \approx \sqrt{3.33g(sg_p - 1)d_p} \tag{5–24}$$

The use of Eqs. (5–18) through (5–22) is illustrated in Example 5–5.

EXAMPLE 5–5 **Determination of Particle Terminal Settling Velocity** Determine the terminal settling velocity for a sand particle with an average diameter of 0.5 mm (0.00164 ft), a shape factor of 0.85, and a specific gravity of 2.65, settling in water at 20°C (68°F). At this temperature, the kinematic viscosity value given in Appendix C is 1.003×10^{-6} m^2/s (1.091×10^{-5} ft^2/s).

Solution

1. Determine the terminal settling velocity for the particle using Stokes' law [(Eq. (5–22)].

$$v_p = \frac{g(sg_p - 1)d_p^2}{18\,\nu}$$

$$= \frac{(9.81\ m/s^2)(2.65 - 1)(0.5 \times 10^{-3}\ m)^2}{18(1.003 \times 10^{-6}\ m^2/s)} = 0.224\ m/s$$

2. Check the Reynolds number [Eq. (5–20)] (include the shape factor ϕ).

$$N_R = \frac{\phi v_p d_p}{\nu} = \frac{0.85(0.224\ m/s)(0.5 \times 10^{-3}\ m)}{(1.003 \times 10^{-6}\ m^2/s)} = 94.9$$

The use of Stokes' law is not appropriate for Reynolds number > 1.0. Therefore, Newton's law [Eq. (5–18)] must be used to determine the settling velocity in the transition region (see Fig. 5–21). The drag coefficient term in Newton's equation is dependent on the Reynolds number, which is a function of the settling velocity. Because the settling velocity is not known, an initial settling velocity must be assumed. The assumed velocity is used to compute the Reynolds number, which is used to determine the drag coefficient, which is used in the Newton equation to calculate the settling velocity. A solution is achieved when the initial assumed settling velocity is approximately equal to the settling velocity resulting from Newton's equation. The solution process is iterative, as illustrated below.

3. For the first assumed settling velocity, use the Stokes' law settling velocity calculated above. Using the resulting Reynolds number, also determined previously, compute the drag coefficient.

$$C_d = \frac{24}{N_R} + \frac{3}{\sqrt{N_R}} + 0.34 = \frac{24}{94.9} + \frac{3}{\sqrt{94.9}} + 0.34 = 0.901$$