TABLE 3.1. *Roughness factor for various pipe materials.*

Pipe Material	ε, ft	ε, cm
Steel		
Commercial	0.00015	0.004 6
Corrugated	0.003–0.03	0.09–0.9
Riveted	0.003–0.03	0.09–0.9
Galvanized	0.0002–0.0008	0.006–0.025
Mineral		
Brick sewer, Cement–asbestos, Clays, Concrete	0.001–0.01	0.03–0.3
Wood stave	0.0006–0.003	0.018–0.09
Cast iron	0.00085	0.025
Asphalt coated	0.0004	0.012
Bituminous lined	0.000008	0.000 25
Cement lined	0.000008	0.000 25
Centrifugally spun	0.00001	0.000 31
Drawn tubing	0.000005	0.000 15
Miscellaneous		
Brass, Copper, Glass, Lead, Plastic, Tin	0.000005	0.000 15
Galvanized	0.0002–0.0008	0.006–0.025
Wrought iron	0.00015	0.004 6
PVC	Smooth	Smooth

Other forms of the Moody diagram have been developed in order to simplify calculations in problems where iterative methods (or trial and error) are required (i.e., volume flow rate Q unknown, diameter D unknown). Consider that in a piping problem, six variables can enter the problem: Δp (or Δh), Q, D, ν, L, and ε. Usually in the traditional type of problem, five of these variables are known and the sixth is to be found. When pressure drop Δp (or head loss $\Delta h = \Delta p g_c/\rho g$) is unknown, then the problem can be solved in a straightforward manner using the Moody diagram, as in Figure 3.3. When volume flow rate Q is unknown, use of the Moody diagram requires a trial-and-error procedure to obtain a solution. If a graph of f versus $\mathbf{Re}\sqrt{f}$ is available, however, then the unknown Q problem can be solved in a straightforward manner. Such a graph is provided in Figure 3.4.