53:171 Water Resources Engineering
Lesson 23: Water Distribution Systems

Pipe Roughness Coefficients

Table 12.1.1 Typical Coefficients of Pipe Friction for Design[a]

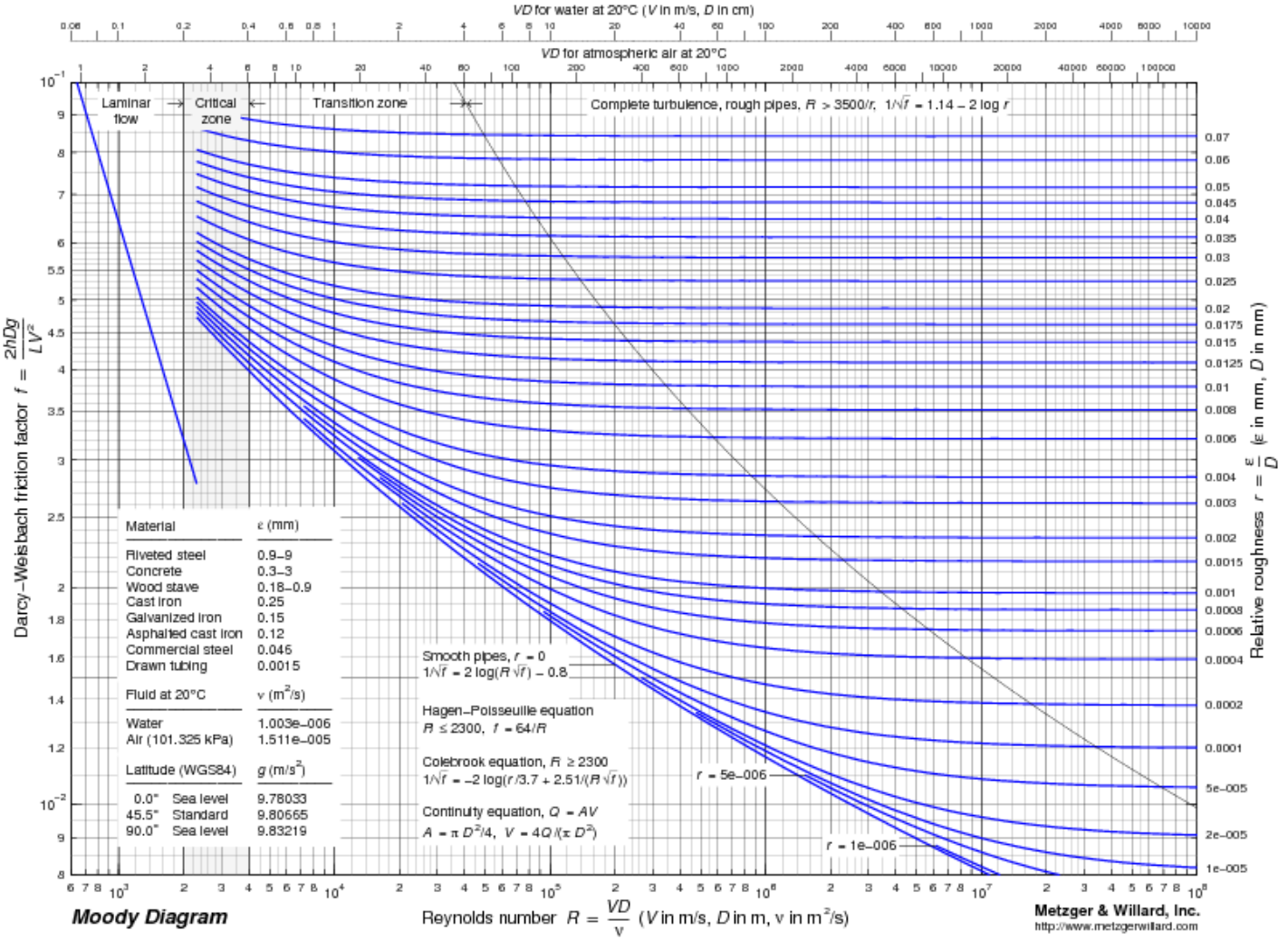
Material	Hazen–Williams C	Manning n^b	Moody Diagram k_s^b mm	Moody Diagram k_s^b in
New pipe or lining				
Smooth glass or plastic[c]	150	0.009	0.919	0.00075
Centrifugally spun cement-mortar lining[d]	145	0.009	0.028	0.0015
Cement-mortar lining troweled in place	140	0.009	0.076	0.003
Commercial steel or wrought iron	140	0.009	0.076	0.003
Galvanized iron	135	0.010	0.13	0.005
Ductile or cast iron, uncoated	130	0.010	0.19	0.0075
Asbestos–cement, coated	145	0.009	0.038	0.0015
Asbestos–cement, uncoated	140	0.009	0.076	0.003
Centrifugally cast concrete pressure pipe	135	0.010	0.13	0.005
Ten-State Standards (1978)				
Cement mortar or plastic lining	120	0.011	0.41	0.016
Unlined steel or ductile iron	100	0.011	1.5	0.060
Old pipe or lining [in moderate service (20 yr. or more), nonagressive water][e]				
Smooth glass or plastic	135	0.010	0.13	0.005
Centrifugally spun cement-mortar lining[f]	130	0.010	0.19	0.0075
Cement mortar troweled in place	125	0.010	0.28	0.011
Asbestos cement, coated	130	0.010	0.19	0.0075
Asbestos cement, uncoated	125	0.010	0.28	0.011
Ductile iron or carbon steel, uncoated	100	0.013	1.5	0.060
Centrifugally cast concrete pressure pipe	130	0.010	0.19	0.0075
Wood stave	110	0.012	0.89	0.035
Riveted steel	80	0.016	5.6	0.22
Concrete, formed	80	0.016	5.6	0.22
Clay (not pressurized)	100	0.013	1.5	0.060
Wrought iron	100	0.013	1.5	0.060
Galvanized iron	90	0.014	0.30	0.012

[a]For critical problems, consult the other sources
[b]Values are calculated from C coefficients for 300-mm (12-in) pipe, a velocity of 1.1–2.1 m/s (3.7–6.9 ft/s), and a temperature of 20°C (68°F).
[c]PVC, polyethylene, polypropylene, polybutylene, reinforced thermosetting resin pipe, and polyvinyl chloride.
[d]Average value for pipes 150 to 900 mm (6 to 36 in) diameter.
[e]For conservative design, reduce old pipe C values (and increase n values) by 0.02%/mm (0.5%/in) for pipe less than 450 mm (18 in).
Note that the Hazen–Williams and Manning equations predict headloss on the unsafe side for small pipes and/or low velocities.
[f]Conservative values for water pipe 150–500 mm (6–20 in).

Source: Sanks (1998).

Water properties (assumed)

γ	ρ	g	μ	ν
(N/m^3)	(kg/m^3)	(m/s^2)	(Pa s)	(m^2/s)
9789.0	998.2	9.80665	1.00E-03	1.00E-06


VD for water at 20°C (V in m/s, D in cm)
VD for atmospheric air at 20°C
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes, R > 3500/r, 1/√f = 1.14 – 2 log r
Darcy–Weisbach friction factor f = 2hDg/LV²
Relative roughness r = ε/D (ε in mm, D in mm)
Material | ε (mm)
Riveted steel 0.9–9
Concrete 0.3–3
Wood stave 0.18–0.9
Cast iron 0.25
Galvanized iron 0.15
Asphalted cast iron 0.12
Commercial steel 0.046
Drawn tubing 0.0015
Fluid at 20°C | ν (m²/s)
Water 1.003e–006
Air (101.325 kPa) 1.511e–005
Latitude (WGS84) | g (m/s²)
0.0° Sea level 9.78033
45.5° Standard 9.80665
90.0° Sea level 9.83219
Smooth pipes, r = 0
1/√f = 2 log(R √f) – 0.8
Hagen–Poisseuille equation
R ≤ 2300, f = 64/R
Colebrook equation, R ≥ 2300
1/√f = –2 log(r/3.7 + 2.51/(R √f))
Continuity equation, Q = AV
A = π D²/4, V = 4Q/(π D²)
r = 5e–006
r = 1e–006
Moody Diagram
Reynolds number R = VD/ν (V in m/s, D in m, ν in m²/s)
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