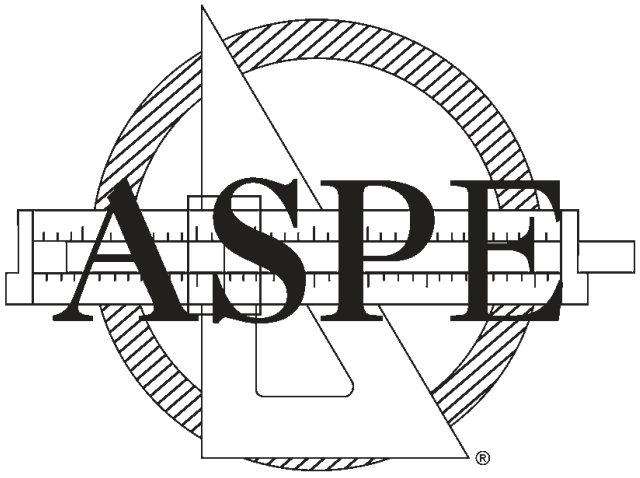
American Society of Plumbing Engineers

Plumbing Engineering & Design Handbook of Tables



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Shock Intensity

The intensity of a pressure wave is directly related to valve closure time.

Joukowsky's Formula:

Equation

$$P_r = \frac{wav}{144g}$$

where

P_r = Pressure rise above flow pressure, psi (kPa)
w = Specific weight of liquid, for water 62.4 lb/ft3 (1,000 kg/m3)
a = Velocity of pressure wave, fps (m/s)
v = Change in flow velocity, fps (m/s)
g = Acceleration due to gravity, 32 ft/s2 (9.8 m/s2)

The value of "a"

Equation

$$a = \frac{A_w}{(1 + KB)^{½}}$$

where

A_w = Velocity of sound in water, at room temperature approximately 4,900 fps (1,490 m/s)
K = Ratio of modulus of elasticity of the fluid to the modulus of elasticity of the pipe
B = Ratio of pipe diameter to pipe wall thickness

SIZING WATER PIPING

Hazen-Williams Formula

Equation

$$f = 0.2082 \left(\frac{100}{C}\right)^{1.85} \left(\frac{q^{1.85}}{d^{4.8655}}\right)$$

where

f = Friction head, ft of liquid/100 ft of pipe (m/100m)
C = Surface roughness constant (dimensionless)
q = Fluid flow, gpm (L/s)
d = Inside diameter of pipe, in. (mm)

Darcy-Weisbach Formula

Equation

$$h_f = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$

$$p = h_f \times \left(\frac{\phi}{144}\right)$$

where

h_f = friction head loss, ft of fluid
p = friction head loss, psi
f = coefficient of friction or friction factor, dimensionless (from Colebrook equation or Moody diagram)
L = length of pipe, ft
D = inside diameter of pipe, ft
V = average velocity of flow, fps
g = gravitational acceleration, 32.2 ft/sec/sec
ϕ = lbs/ft^3

For turbulent flow, "f" can be determined by the C.F. Colebrook Formula, Moody diagrams, or from manufacturers' data or various handbooks.

Colebrook Formula

Equation

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left[\left(\frac{\varepsilon}{3.7D}\right) + \left(\frac{2.51}{R\sqrt{f}}\right)\right]$$

$$\text{also, } R = \frac{VD}{v}$$

where

R = Reynolds number (Figure 5-9)
f = Friction Factor (dimensionless)
ε = Absolute roughness, in ft
D = Inside diameter of pipe, ft
V = Average pipe velocity, ft/sec
v = Kinematic Viscosity, ft^2/sec

Pressure Loss in Pipe Fittings and Valves

Equation

$$\Delta h = \frac{kV^2}{2g}$$

$$\Delta P = \left(\frac{Q}{C_v}\right)^2 \text{S.G.}$$

where

Δh = Fluid head (ft)
V = Velocity (ft/sec)
g = Acceleration of gravity (ft/sec2)
P = psi
Q = gpm
SG = Specific gravity (water = 1.0); for water, $\Delta h \times 0.43 = \text{psi}$
C_v = Flow through a valve where pressure loss of 1 psi occurs

Hazen-Williams Coefficient	
Material	**C**
Asbestos Cement	140
Black Steel, Dry	100
Black Steel, Wet	120
Brass	130 - 160
Brick sewer	100
Cast-Iron - new unlined (CIP)	130
Cast-Iron 10 years old	107 - 113
Cast-Iron 20 years old	89 - 100
Cast-Iron 30 years old	75 - 90
Cast-Iron 40 years old	64-83
Cast-Iron, asphalt coated	100
Cast-Iron, cement lined	140
Cast-Iron, bituminous lined	140
Cast-Iron, coal-tar enamel lined	145-150
Cast-Iron, wrought plain	100
Cast-Iron, riveted	110
Cement Lined Cast or Ductile Iron	140
Concrete	140
Concrete, Steel forms	140
Concrete, Wooden forms	120
Concrete, centrifugally spun	135
Copper	130 - 160
Copper (NFPA 13)	150
CPVC (NFPA 13)	150
Ductile Iron Pipe (DIP)	140
Fiber	140
Fibre-reinforced plastic (FRP)	150
Galvanized steel	120 - 140
Glass	130 - 160
Lead	130 - 140

*C = factor (friction loss coefficient) - the higher the C factor, the smoother the pipe.

Hazen-Williams Coefficient	
Material	**C**
PEX (NFPA 13)	150
Plastic	130 - 160
Polyethylene, PE, PEH	140 -160
PVC, CPVC	140 - 160
Smooth Pipes	150
Steel new unlined	140 - 150
Steel	120 - 140
Steel (NFPA13)	120
Steel. Galv. (NFPA13)	120
Steel, welded and seamless	120 - 140
Steel, interior riveted, no projecting rivets	100
Steel, projecting girth rivets	100
Steel, vitrified, spiral-riveted	90 - 100
Steel, corrugated	60
Tin	130
Unlined Cast or Ductile Iron	100
Vitrified Clays	110 -140
Wood Stave	110 - 120