Pipe Flows – Pipe Systems

https://americanvintagehome.com/advice-for-older-homes/need-swap-galvanized-pipes/

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$$\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_{out}=\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_{in}-H_L+H_S$$

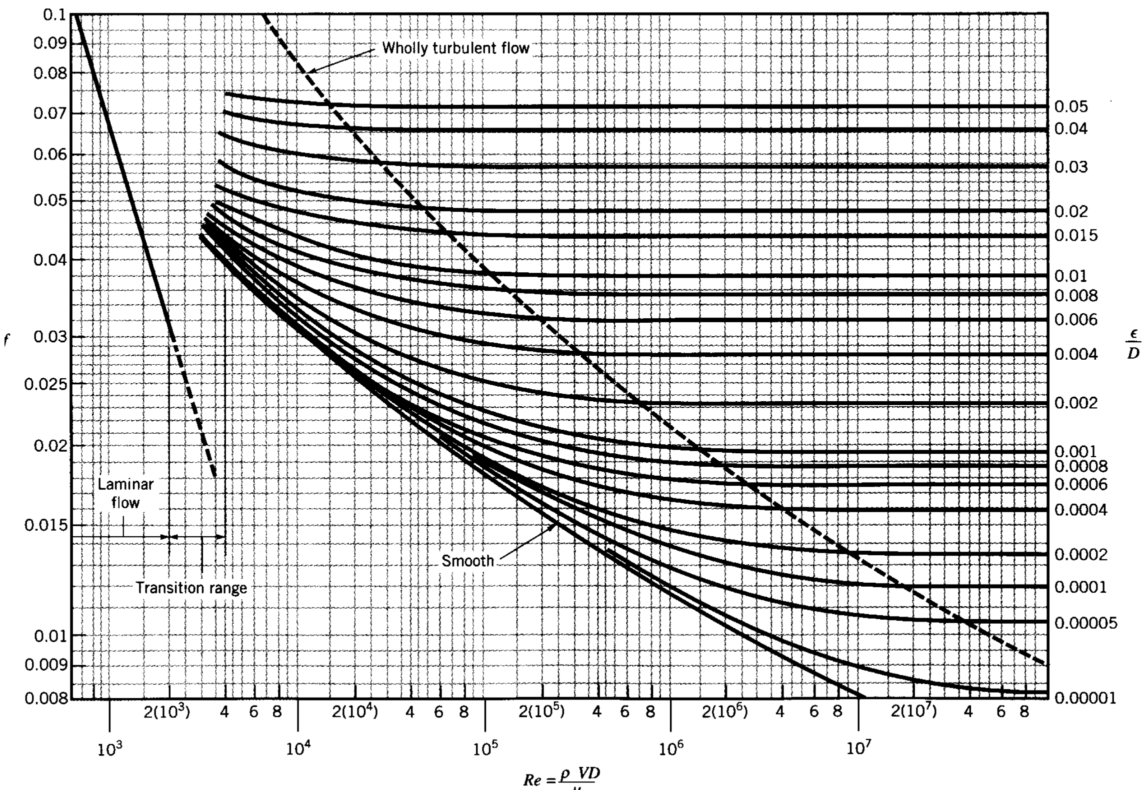
where

$$\alpha=\begin{cases}2 & Re_D<2300\text{ (laminar)}\\ 1 & Re_D>2300\text{ (turbulent)}\end{cases}$$

$$H_S=\frac{\dot{W}_{S,on\ CV}}{\dot{m}g} \qquad H_L=\sum_{\forall\text{losses}}k_i\frac{\bar{V}_i^2}{2g}$$

$$k\equiv\frac{\Delta p}{\frac{1}{2}\rho\bar{u}^2} \qquad k_{\text{major}}=f_D\left(\frac{L}{D}\right) \qquad k_{\text{minor}}: \text{ Look up values from tables.}$$

$$f_{D,\text{laminar}}=\frac{64}{Re_D} \qquad f_{D,\text{turbulent}}=f\left(Re_D,\frac{\epsilon}{D}\right) \quad \text{(Use the Moody plot or Haaland or Colebrook formulas.)}$$



Colebrook Formula: $\sqrt{\frac{1}{f}}\approx-2.0\log_{10}\left(\frac{\varepsilon/D}{3.7}+\frac{2.51}{\text{Re}_D\sqrt{f}}\right)$ Haaland Formula $\sqrt{\frac{1}{f}}\approx-1.8\log_{10}\left[\frac{6.9}{\text{Re}_D}+\left(\frac{\varepsilon/D}{3.7}\right)^{1.11}\right]$

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Average Roughness of Commercial Pipes

Material (new)	ft	mm
Riveted steel	0.003-0.03	0.9-9.0
Concrete	0.001-0.01	0.3-3.0
Wood stave	0.0006-0.003	0.18-0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Asphalted cast iron	0.0004	0.12
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)

Table of Minor Loss Coefficients

Component	K	Component	K
a. Elbows			
Regular 90°, flanged	0.3	e. Valves	
Regular 90°, threaded	1.5	Globe, fully open	10
Long radius 90°, flanged	0.2	Angle, fully open	2
Long radius 90°, threaded	0.7	Gate, fully open	0.15
Long radius 45°, flanged	0.2	Gate, ¼ closed	0.26
Regular 45°, threaded	0.4	Gate, ½ closed	2.1
		Gate, ¾ closed	17
b. 180° return bends		Swing check, forward flow	2
180° return bends, flanged	0.2	Swing check, backward flow	∞
180° return bends, threaded	1.5	Ball valve, fully open	0.05
		Ball valve, 1/3 closed	5.5
c. Tees		Ball valve, 2/3 closed	210
Line flow, flanged	0.2		
Line flow, threaded	0.9	f. Entrances	
Branch flow, flanged	1.0	Re-entrant	0.8
Branch flow, threaded	2.0	Sharp-edged	0.5
		Slightly rounded	0.2
d. Union, threaded	0.06	Well rounded	0.04
		g. Exits	
		Re-entrant, sharp-edged, slightly rounded, well-rounded	1

h. Sudden Contraction/Expansion:

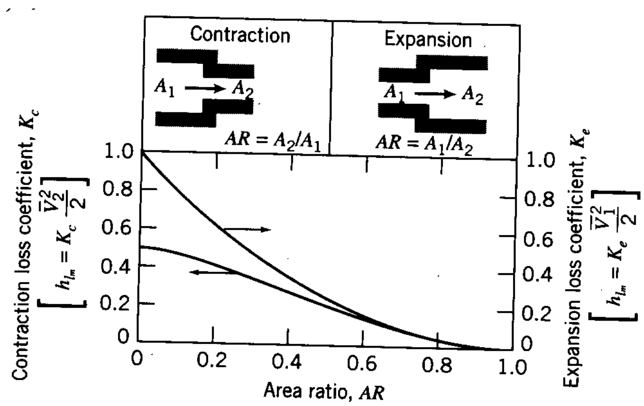

Fig. 8.15 Loss coefficients for flow through sudden area changes. (Data from [1].)

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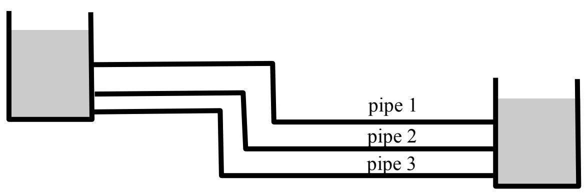
Types of Pipe Systems

Type I: The desired flow rate is specified and the required pressure drop must be determined. (Easiest to solve)

Type II: The desired pressure drop is specified and the required flow rate must be determined. (Often requires iteration since the Reynolds number is not known.)

Type III: The desired flow rate and pressure drop are specified and the required pipe diameter must be determined. (Often requires iteration since the Reynolds number and relative roughness are not known.)

Serial Pipe Systems



Parallel Pipe Systems