FLUIDE DESIGN

PIPE FRICTION CALCULATION

The average velocity v in a pipe is calculated based on the formula [1] and the appropriate units are indicated in parentheses. (see the last page for a table of all the symbols)

$$v(ft/s) = 0.4085 \frac{q(USgal./\min)}{D^2(in)^2} \qquad [1]$$

The Reynolds Re number is calculated based on formula [2].

$$R_e = 7745.8 \frac{v(ft/s)D(in)}{n(cSt)} \qquad [2]$$

If the Reynolds number is below 2000 than the flow is said to be in a laminar regime. If the Reynolds number is above 4000 the regime is turbulent. The velocity is usually high enough in industrial processes to make the flow regime turbulent. The viscosity of many fluids can be found in the Cameron Hydraulic data book. The viscosity of water at 60F is 1.13 cSt.

If the flow is laminar then the friction parameter f is calculated with the laminar flow equation [3].

$$f = \frac{64}{R_e} \qquad [3]$$

If the flow is turbulent then the friction parameter f is calculated based on the Swamee-Jain equation [4].

$$f = \frac{0.25}{\left(\log_{10}\left(\frac{e}{3.7\,D} + \frac{5.74}{R_e^{0.9}}\right)\right)^2} \qquad [4]$$

In the turbulent flow regime the friction factor f depends on the absolute roughness of the pipe inner wall. Table 1 provide some values for various materials.

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PIPE MATERIAL	Absolute roughness ε (ft)
Steel or wrought iron	0.00015
Asphalt-dipped cast iron	0.0004
Galvanized iron	0.0005

Table 1

The friction factor $\Delta H_{FP}/L$ is calculated with the Darcy-Weisback equation [5]

$$\frac{\Delta H_{FP}}{L}\left(\frac{ft \quad fluid}{100\,ft \quad pipe}\right) = 1200 \;\; f \;\; \frac{(v(ft/s))^2}{D \;\; (in) \;\times\;\; 2g \;\; (ft/s^2)} \qquad [5]$$

g=32.17 ft/s^2

The pipe friction loss ΔH_{FP} is calculated with equation [6]

$$\Delta H_{FP}\,(ft\ fluid) = \frac{\Delta H_{FP}}{L}\left(\frac{ft \quad fluid}{100\,ft \;\; pipe}\right) \times \frac{L(ft\ pipe)}{100} \qquad [6]$$

Example calculation

Calculate the pipe friction loss of a 2 1/12" schedule 40 (2.469" internal pipe diameter) new steel pipe with a flow rate of 149 gpm for water at 60F and a pipe length of 50 feet. The roughness is 0.00015 ft and the viscosity is 1.13 cSt.

The average velocity v in the pipe is:

$$v(ft/s) = 0.4085 \times \frac{149}{2.469^2} = 9.98 \qquad [1']$$

The Reynolds Re number is:

$$R_e = 7745.8 \times \frac{9.98 \times 2.469}{1.13} = 1.69 \times 10^5 \qquad [2']$$

The friction parameter f is:

$$f = \frac{0.25}{\left(\log_{10}\left(\frac{0.00015 \;\; \times 12}{3.7 \times 2.469} + \frac{5.74}{(1.69 \times 10^5)^{0.9}}\right)\right)^2} = 0.02031 \qquad [4']$$

The friction factor $\Delta H_{FP}/L$ is calculated with the Darcy-Weisback equation [5]

$$\frac{\Delta H_{FP}}{L}\left(\frac{ft \quad fluid}{100\,ft \quad pipe}\right) = 1200 \times 0.02031 \times \frac{9.98^2}{2.469 \times 2 \times 32.17} = 15.34 \qquad [5']$$

The pipe friction loss ΔH_{FP} is:

$$\Delta H_{FP}\,(ft\ fluid) = 15.34 \times \frac{50}{100} = 7.67 \qquad [6']$$

Symbols

Variable nomenclature		Imperial system (FPS units)
D	pipe diameter	in (inch)
Re	Reynolds number	non dimensional
q	flow rate	USgpm (gallons per minute)
ΔH_{FP}	friction head loss in pipes	ft (feet)
ν	viscosity	CSt (centistokes)
ε	pipe roughness	Ft (feet)
v	velocity	ft/s (feet/second)
L	pipe length	ft (feet)
f	friction parameter	Non dimensional
$\Delta H_{FP}/L$	friction factor	feet of fluid/100 ft of pipe
g	acceleration due to gravity (32.17 ft/s^2)	ft/s^2 (feet per second square)