

# Pipe Selection and Friction Loss Calculation (2019 Course Update)

An Online Continuing Education Course for Engineers

**Course Number: M-3062**

**Credit: 3 Hours / 3 PDH / 3 CPD**

# Pipe Selection and Friction Loss Calculation (2019 Course Update)

Manuel Calzada, P.E.

## Table Of Contents

Introduction .....	2
Compressible And Incompressible Fluids.....	3
Pressure Drop Calculations .....	4
• Basic Fluid Dynamics In Pipes.....	4
• Energy Requirements To Pump A Fluid Through A Pipe.....	11
• Calculation Of Friction Coefficients In Pipes .....	18
○ Comments on the Moody Diagram.....	22
• Pressure Drop Due To Fittings And Valves In A Pipe .....	26
• Pressure Drop Due To Changes In Pipe Diameter.....	36
• Recommended Fluid Velocities In Pipes.....	39
Flow Calculator Samples.....	40
Appendix.....	44

## Introduction

This course is designed to cover the necessary material to design and evaluate piping systems. This course is intended to be one of a series of courses that covers different areas of practical aspects of fluid mechanics. This is the first course of the series and covers the primary areas of water piping, including friction in pipes, diameter selection of pipes and pump power requirements. The next courses will cover more specific piping applications, such as flows in parallel pipes, open and closed piping systems, cooling towers, pipe insulation, and heat exchangers.

These courses are designed to build gradually in concepts. The first course starts with the concept of the difference between compressible and incompressible fluids, and then it covers the concept of fluid friction inside a pipe including the effects of potential and kinetic fluid energy. Once this idea is understood, the calculation of the friction coefficient and the impact of pipe fittings and valves and power through pumps on the overall piping system is introduced. In addition to the course material, the author included a set of calculators in an excel spreadsheet that can be used as tools and significantly simplify the calculation of friction in pipes and reduce the amount of trial and error required to estimate pipe diameters.

Other courses provided by PDHengineer.com cover pump calculations, so in this course, only power requirements for piping systems are included. If the student is interested in pursuing further studies on pumps, it is suggested that he/she considers any of those excellent courses.

## Compressible And Incompressible Fluids

In reality, all fluids are compressible to a certain degree. However, some fluids are very sensitive to variations of pressure and temperatures while others are much less sensitive. For all practical purposes, compressible fluids are those fluids whose density changes 'significantly' over the process. When a fluid experiences a small change in density and that change does not affect in any significant way the outcome of the process, then the fluid can be considered as an incompressible fluid. For example, designing air ducts for HVAC systems would fall in this category. Even though the air is a compressible fluid, the density changes of the air along the duct are not significant and therefore can be ignored with little error and great simplicity in the calculations. On the other hand, the design of high pressure compressed air piping system where the density of the air changes, can produce a significant amount of error by considering the air as an incompressible fluid. Good judgment is necessary in most cases.

# Pressure Drop Calculations

## Basic Fluid Dynamics In Pipes

As an incompressible fluid flows through a pipe, a friction force along the pipe wall is created against the fluid that will decrease the pressure of the fluid as it moves through the pipe.

The following figure represents a section of fluid inside the pipe. As the fluid flows from left to right, there are a series of forces that act on the element or section of fluid of area  $A$  and thickness  $dx$ . The conservation of momentum requires that the sum of all the forces equal the change in momentum.

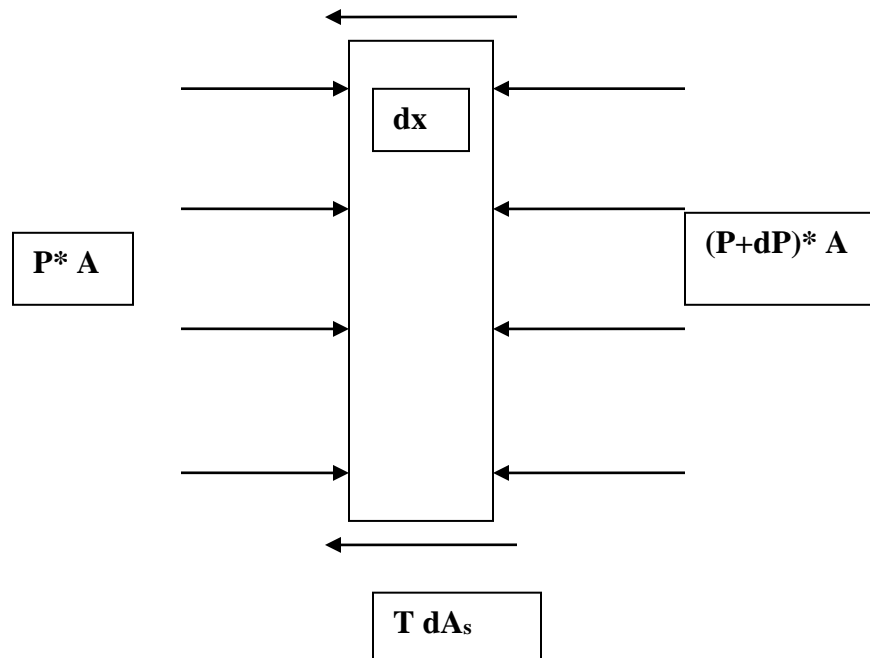


Figure 1

Since the velocity of an incompressible fluid inside the pipe of constant diameter is constant, the following equation can be written:

$$P A - (P+dP) A - T dA_s = 0 \quad \text{Eqn. 1}$$

Where

**P** is the initial pressure acting on the fluid element

**P+dP** is the pressure acting on the other side of the fluid element

**A** is the cross-sectional area of the element

**T** is the wall shear stress due to friction acting on the fluid

**A<sub>s</sub>** is the peripheral area over which the shear stress acts.

Equation 1 can be written as:

$$A dP + T dA_s = 0$$

Where

$$A = \pi D^2 / 4$$

$$A_s = \pi D dx$$

Where  $D$  is the element diameter, and  $dx$  is the width of the element.

From here we get the following expression:

$$dP + T (4 dx / D) = 0 \qquad \text{Eqn 2}$$

In general, if the pipe is not circular, the value used for the diameter ( $D$ ) is the hydraulic diameter or  $D_h$ , and it is defined as:

$$D_h = (4 * \text{cross-sectional area of flow}) / (\text{perimeter wetted by fluid})$$

The following example will illustrate the calculation of the hydraulic diameter in the case of a pipe that is not circular.

### Example 1

- a) Calculate the hydraulic diameter of a pipe with a diameter of 9 inches flowing half full.
- b) Calculate the hydraulic diameter of a pipe with a diameter of 9 inches flowing 3/4 full.

### Solution

- a) The cross-sectional area of a pipe with a diameter of 9 inches flowing half full is  $(1/2)\pi D^2/4 = (1/2)9\pi/4$ . The perimeter of a pipe with a diameter of 9 inches flowing half full is  $9\pi/2$ .

