HYDRAULIC CALCULATOR AND QUICK REFERENCE FLOW TABLES

INTRODUCTION

Hydraulic Calculator and Quick Reference Flow Table pocket slide device is a dual purpose instrument. Its primary function is to replace the friction loss and orifice flow tables used in conjunction with flow testing and analysis of water supplies and underground piping with a portable tool. A Hydraulic Calculator is included in PRC.14.1.2.1.2.A

The orifice flow tables are based on the formulas for flow through orifices (See PRC.12.0.1.)

$$Q = 29.84cd^2\sqrt{p} \quad (\text{SI Units})$$

$$Q = 0.0666cd^2\sqrt{p} \quad (\text{Metrics})$$

The flows indicated include discharge coefficient corrections for both Underwriters Playpipes (1⅛ and 1¾ in. (29 and 44 mm) sizes) and for hydrant outlets with smooth and rounded inlet edges (2½ in. (64 mm) and larger sizes). As a result, the hydrant coefficients shown on the calculator differ from those found in other sources such as the NFPA *Fire Protection Handbook*. When making adjustments to flow readings, the discharge coefficients shown on the AXA XL Risk Consulting calculator must be used.

The Hydraulic Calculator portion is based on the Hazen and Williams formula and is designed to simultaneously show the important factors involved in hydraulic problems. The accuracy is well within the limits given in hydraulic tables and the pitot, static and residual pressure readings observed during field testing. Pipe characteristic readings identify:

- Size of pipe
- Length of pipe
- Friction loss coefficient
- Flow in gallons per minute
- Velocity within pipe
- Friction loss in psi
- Friction loss in ft of water

C and D logarithmic slide rule scales are also included to perform simple multiplication and division.

INSTRUCTIONS

Quick Reference Flow Tables

When the size outlet matches one of the sizes on the table the flow can be read directly from the calculator. Adjustments for an outlet with different characteristics (such as a hydrant outlet with square sharp inlet edges) are made by multiplying the flow by the discharge coefficient (0.88 in this case).

It is a relatively simple matter to calculate the discharge for an opening having a size other than given in the table. This is done by multiplying the discharge in gallons per minute for one of the table size openings by the cross-sectional area of the opening through which the flow was actually made, and divided by the cross-sectional area for the tabular opening.

Example: Determine the flow through a 2.625 in. (67 mm) hydrant opening (smooth and round inlet edges) at 30 psi (2.1 bar) pitot pressure.

Solution: A pitot reading of 30 psi (2.1 bar) measured on a 2½ in. (63.5 mm) opening results in a flow of 920 gpm (3,483 L/min). This flow can be converted to that of a 2.625 in. (67 mm) outlet by multiplying the flow by a ratio of the squares of the diameters. This results in $(2.625)^2/(2½)^2 = 1.1$. Multiplying 920 gpm (3,483 L/min) $\times$ 1.1 gives 1012 gpm (3,831 L/min) which is the flow through a 2.625 in. (67 mm) opening at 30 psi (2.1 bar) pitot pressure.

The conversion factor for flowing through a 2.375 in. (60 mm) hydrant opening can be calculated in a similar manner and is 0.90 times the tabular flow for a 2½ in. (64 mm) opening.

Hydraulic Calculator

The hydraulic calculator enables the calculation of friction losses when water flows through underground water mains. The information required to determine the friction loss includes the size of pipe in inches, length of pipe in feet, flow in gallons per minute, friction loss (normally expressed in psi.) and coefficient of friction or “C” factor. Once any four of the items is known, the remaining item can be determined using the calculator.

To use the calculator, the four known items are aligned on the calculator by moving the insert, and the remaining item is read off the scale. The most common uses are to determine the friction loss when the pipe size, length, C factor and desired flow are known, and to determine the actual pipe “C” factor after a flow test has been made.

Example No. 1: Determine the friction loss in 500 ft (152 m) of 8 in. (200 mm) underground with an assumed coefficient of “C” = 100 and a flow of 1,500 gpm (5,678 L/min).

Solution: The slide is moved so that 1,500 gpm (5,678 L/min) lines up with “C” of 100 for 8 in. (200 mm) pipe. The resultant loss of 13.5 psi (0.9 bar) lines up opposite the 500 ft (152 m) length mark.

Example No. 2: Determine the coefficient of friction “C” for 8 in. (200 mm) underground pipe where a flow of 1,200 gpm (4,543 L/min) resulted in a friction loss of 17 psi (1.2 bar) over a 700 ft (213 m) length of underground.

Solution: A friction loss of 17 psi (1.2 bar) is lined up opposite a 700 ft (213 m) length. 1,200 gpm (4,543 L/min) gives a direct read-out of a “C” of approximately 85 for 8 in. (200 mm) underground.

Example No. 3: A plant having a public water supplied underground loop consisting of varying lengths of 8 in. (200 mm) and 10 in. (250 mm) underground installed over a span of many years. A yard flow at the side of the loop opposite the public connection revealed a static pressure of 85 psi (5.9 bar) and a residual pressure of 60 psi (4.1 bar) with 1,000 gpm (3,785 L/min) flowing. Determine the amount of water available at the same test points with a residual pressure of 40 psi (2.8 bar).

Solution: The “R” reference point (located between 6 in. (150 mm) and 10 in. (250 mm) pipe) is used in solving this problem. Line up the 1,000 gpm (3,785 L/min) flow beneath “R”. The friction loss at 1,000 gpm (3,785 L/min) is 25 psi (1.7 bar) , and this lines up with an equivalent pipe length of 1,900 ft (579 m). A residual pressure of 40 psi (2.8 bar) is a result of a 45 psi (3.1 bar) friction loss,

and the 45 psi (3.1 bar) friction loss is lined up with the previous equivalent length of 1,900 ft (579 m). The flow of 1,380 gpm (5,224 L/min) is read beneath the “R” reference point. This method of arriving at an equivalent flow at a projected residual pressure is a substitute for arriving at the same answer with $N^{1.85}$ graph paper.

Four Inch Pipe: The hydraulic Calculator can be used to calculate the friction loss in 4 in. underground piping. This loss is equal to 7.2 times the friction loss in the same length of 6 in. pipe.

Metric Units

The hydraulic calculator was designed for English units only. Calculations can be converted to metric equivalents by using the following conversion factors:

1 ft = 0.305 m	1 m = 3.28 ft
1 in. = 25.4 mm	1 mm = 0.039 in.
1 psi = 0.069 bar	1 bar = 14.5 psi
1 gpm = 3.78 L/min	1 L/min = 0.264 gpm