**Volume Flow Rate**

The volume flow rate Q, given by the equation below, is the volume of liquid that can pass through the cross-sectional area of a pipe over a given time interval.

The volume flow rate equation relates the cross-sectional area of the pipe (area of a circle of a given diameter if the pipe is round) and the time over which the flow occurs expressed usually as a velocity in feet per second.

***Flow Rate Q = A x V or V = Q/A***

or

**Flow Rate Q = Volume / Time**

where

* *Flow Rate Q = flow rate in ft3 / second* or cubic feet per second  
    
  or if we are using S.I. units, Q = flow rate in M*3* / second or cubic meters per second
* Area A = cross sectional area flow in sq. ft. of the pipe is given by two equivalent formulas: *Using the diameter of the pipe:  
    
  A = π x D2/4   
    
  where pi or π = 3.1416*  
    
  D = Diameter or *D2* = diameter squared   
    
  Using the traditional formula for area of a circle we use the radius of the circle.  
    
  From algebra we learned that the area of a circle  
    
  A = π r*2*   
    
  where r is the radius (half the diameter) of the circle   
    
  Because 2 x radius or 2r is exactly equal to D or diameter, both formulas are equivalent.
* *V = velocity in ft/sec* - for systems where V varies use the average fluid velocity in the pipe either in feet per second or in meters per second.   
    
  If we use feet per second then the volume flow rate will be in cubic feet per second  
    
  If we use meters per second then the volume flow rate will be in cubic meters per second. Or if you want cubic liters per second just divide meters/second by 1000.

**Examples of Pipe Volume Flow Rates**

***Q = A x V* for 1 meter per second through a 1-meter pipe**

Shelly Weinberg, one of the greatest teaches I [DF] ever met, teaching at IBM's System Research Institute, was conducting a course in queuing theory. To demonstrate a service time optimization algorithm that looked daunting, Shelly asked us to pick any number and he would demonstrate how easy the calculation was.

The class sat mute, frozen.

"OK" Shelly said, "We'll pick ONE. ONE's a good number, right?"

In honor of Shelly Weinberg, let's set everything in the volume flow rate equation to 1 and see what happens.

A = 1 square meter cross sectional area of pipe

V = 1 meter per second flow rate

V = A x V or 1 x 1 = M*3* / second

*The flow of a fluid traveling at an average velocity of a 1 meter per second through a pipe with a 1 square meter cross-sectional area is 1 cubic meter per second* - volumetric flow rate before considering fluid density.

***Q = A x V* for 1 foot per second through a 1-inch diameter pipe**

*A = π x D2/4*

A = 3.1416 x 1 / 4

A = 3.1416

V = 1 ft. per second

*Q = 3.1416 x 1*

*Q = 3.14 = ft3 / second or 3.14 cubic feet per second of volume flow rate*

For building water supply systems and many other applications the above flow rate calculation is sufficient, but it is not accurate for all types of fluids of various densities.

**Add Fluid Density to Flow Rate Calculations to Get Kilograms per Second Flow Rates**

If we need to add consideration of fluid density on flow rates, Omega (cited below) explains:

***W = rho x Q***

where

* W = flow rate
* rho = fluid density
* Q = flow rate calculated before considering density

The flow rate will be 1 kilogram per second when 1 cubic meter per second of a fluid with a density of 1 kilogram per cubic meter is flowing.

As we've reported elsewhere under improving water flow in buildings or "perceived water pressure", doubling the pipe diameter increases the liquid carrying capacity of the pipe by a factor of 4.