Measuring the flow of liquids is a critical need in many industrial plants. In some operations, the ability to conduct accurate flow measurements is so important that it can make the difference between making a profit or taking a loss. In other cases, inaccurate flow measurements or failure to take measurements can cause serious (or even disastrous) results.

With most liquid flow measurement instruments, the flow rate is determined inferentially by measuring the liquid's velocity or the change in kinetic energy. Velocity depends on the pressure differential that is forcing the liquid through a pipe or conduit. Because the pipe's cross-sectional area is known and remains constant, the average velocity is an indication of the flow rate. The basic relationship for determining the liquid's flow rate in such cases is:

Q = V x A   
  
where   
  
Q = liquid flow through the pipe   
  
V = average velocity of the flow   
  
A = cross-sectional area of the pipe

Other factors that affect liquid flow rate include the liquid's viscosity and density, and the friction of the liquid in contact with the pipe.

Direct measurements of liquid flows can be made with positive-displacement flowmeters. These units divide the liquid into specific increments and move it on. The total flow is an accumulation of the measured increments, which can be counted by mechanical or electronic techniques.

***Reynolds Numbers***

The performance of flowmeters is also influenced by a dimensionless unit called the Reynolds Number. It is defined as the ratio of the liquid's inertial forces to its drag forces.

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| **Figure 1:**Laminar and turbulent flow are two types normally encountered in liquid flow Measurement operations. Most applications involve turbulent flow, with R values above 3000. Viscous liquids usually exhibit laminar flow, with R values below 2000. The transition zone between the two levels may be either laminar or turbulent. | The equation is:  R = 3160 x Q x Gt  D x   where:  R = Reynolds number  Q = liquid's flow rate, gpm  Gt = liquid's specific gravity  D = inside pipe diameter, in.   = liquid's viscosity, cp |

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| The flow rate and the specific gravity are inertia forces, and the pipe diameter and viscosity are drag forces. The pipe diameter and the specific gravity remain constant for most liquid applications. At very low velocities or high viscosities, R is low, and the liquid flows in smooth layers with the highest velocity at the center of the pipe and low velocities at the pipe wall where the viscous forces restrain it. This type of flow is called laminar flow. R values are below approximately 2000. A characteristic of laminar flow is the parabolic shape of its velocity profile, Fig. 1.  However, most applications involve turbulent flow, with R values above 3000. Turbulent flow occurs at high velocities or low viscosities. The flow breaks up into turbulent eddies that flow through the pipe with the same average velocity. Fluid velocity is less significant, and the velocity profile is much more uniform in shape. A transition zone exists between turbulent and laminar flows. Depending on the piping configuration and other installation conditions, the flow may be either turbulent or laminar in this zone. |

**FLOWMETER TYPES**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Differential Pressure** | **Positive Displacement** | **Velocity** | **Mass** | **Open-Channel** |
| [Orifice Plate](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Orifices)  [Venturi Tube](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Venturi)  [Flow Tube](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Flow%20Tube)  [Flow Nozzle](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Flow%20Nozzle)  [Pitot Tube](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Pitot)  [Elbow Tap](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Elbow)  [Target](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Target)  [Variable-Area(Rotameter)](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Variable-area) | [Reciprocating Piston](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Reciprocating%20Piston)  [Oval Gear](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Oval-gear)  [Nutating Disk](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Nutating-disk)  [Rotary Vane](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Rotary-vane) | [Turbine](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Turbine)  [Vortex Shedding](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Vortex)  [Swirl](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Swirl)  [Conada Effect & Momentum Exchange](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Conada)  [Electromagnetic](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Electromagnetic)  [Ultrasonic, Doppler](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Doppler)  [Ultrasonic, Transit-Time](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Time-of-travel) | [Coriolis](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Coriolis)  [Thermal](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Coriolis) | [Weir](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Weirs)  [Flume](http://www.maxiflo.co.kr/english/technology/flowmetertypes.htm#Flumes) |