

Valve Sizing Calculations (Traditional Method)

Introduction

Fisher® regulators and valves have traditionally been sized using equations derived by the company. There are now standardized calculations that are becoming accepted worldwide. Some product literature continues to demonstrate the traditional method, but the trend is to adopt the standardized method. Therefore, both methods are covered in this application guide.

Improper valve sizing can be both expensive and inconvenient. A valve that is too small will not pass the required flow, and the process will be starved. An oversized valve will be more expensive, and it may lead to instability and other problems.

The days of selecting a valve based upon the size of the pipeline are gone. Selecting the correct valve size for a given application requires a knowledge of process conditions that the valve will actually see in service. The technique for using this information to size the valve is based upon a combination of theory and experimentation.

Sizing for Liquid Service

Using the principle of conservation of energy, Daniel Bernoulli found that as a liquid flows through an orifice, the square of the fluid velocity is directly proportional to the pressure differential across the orifice and inversely proportional to the specific gravity of the fluid. The greater the pressure differential, the higher the velocity; the greater the density, the lower the velocity. The volume flow rate for liquids can be calculated by multiplying the fluid velocity times the flow area.

By taking into account units of measurement, the proportionality relationship previously mentioned, energy losses due to friction and turbulence, and varying discharge coefficients for various types of orifices (or valve bodies), a basic liquid sizing equation can be written as follows

$$Q = C_v \sqrt{\Delta P / G} \quad (1)$$

where:

- Q = Capacity in gallons per minute
- C_v = Valve sizing coefficient determined experimentally for each style and size of valve, using water at standard conditions as the test fluid
- ΔP = Pressure differential in psi
- G = Specific gravity of fluid (water at 60°F = 1.0000)

Thus, C_v is numerically equal to the number of U.S. gallons of water at 60°F that will flow through the valve in one minute when the pressure differential across the valve is one pound per square inch. C_v varies with both size and style of valve, but provides an index for comparing liquid capacities of different valves under a standard set of conditions.

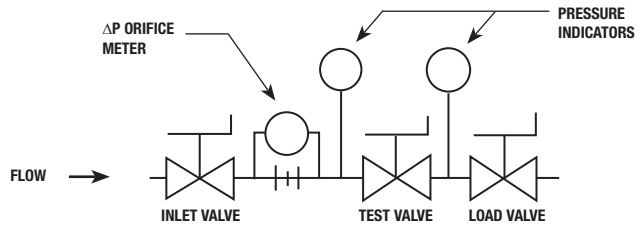


Figure 1. Standard FCI Test Piping for C_v Measurement

To aid in establishing uniform measurement of liquid flow capacity coefficients (C_v) among valve manufacturers, the Fluid Controls Institute (FCI) developed a standard test piping arrangement, shown in Figure 1. Using such a piping arrangement, most valve manufacturers develop and publish C_v information for their products, making it relatively easy to compare capacities of competitive products.

To calculate the expected C_v for a valve controlling water or other liquids that behave like water, the basic liquid sizing equation above can be re-written as follows

$$C_v = Q \sqrt{\frac{G}{\Delta P}} \quad (2)$$

Viscosity Corrections

Viscous conditions can result in significant sizing errors in using the basic liquid sizing equation, since published C_v values are based on test data using water as the flow medium. Although the majority of valve applications will involve fluids where viscosity corrections can be ignored, or where the corrections are relatively small, fluid viscosity should be considered in each valve selection.

Emerson Process Management has developed a nomograph (Figure 2) that provides a viscosity correction factor (F_v). It can be applied to the standard C_v coefficient to determine a corrected coefficient (C_{vr}) for viscous applications.

Finding Valve Size

Using the C_v determined by the basic liquid sizing equation and the flow and viscosity conditions, a fluid Reynolds number can be found by using the nomograph in Figure 2. The graph of Reynolds number vs. viscosity correction factor (F_v) is used to determine the correction factor needed. (If the Reynolds number is greater than 3500, the correction will be ten percent or less.) The actual required C_v (C_{vr}) is found by the equation:

$$C_{vr} = F_v C_v \quad (3)$$

From the valve manufacturer's published liquid capacity information, select a valve having a C_v equal to or higher than the required coefficient (C_{vr}) found by the equation above.