Valve Selection

The proper sizing of a valve is one of the most important factors in the ability of a loop to maintain control. A valve that is too small is not able to provide the desired capacity during peak load conditions, while a valve that is too large will tend to overshoot the control point and operate with the valve plug too close to the seat, resulting in undue wear of the plug and seat.

Valve Coefficient (C_V)

The valve coefficient (**C_V**) is mathematically determined through an evaluation of the system service conditions. This factor can be used to select a valve body of the appropriate port size. In almost all cases, the valve should be of a smaller size than the pipeline into which it will be installed. To avoid undue wear, a valve body of the smallest possible port size should be selected; however, the valve should never be less than half the pipeline size, as this will cause extreme mechanical stress to the pipeline.

Service Conditions

The specifier should be knowledgeable of the service conditions of the application in order to properly determine the actuator and valve requirements.

Medium
The composition of the fluid passing through the valve.

Temperature (*T*)
The temperature of the medium passing through the valve. This measurement is required to properly specify the materials used to manufacture the valve.

Flow (*q* or *W*)
The volume of fluid passed through the valve as required by the particular application. Flow is usually expressed as either gallons per minute (***q***), or pounds per hour (***W***). Water and other liquids are usually measured in gallons per minute, while steam and other gases are usually measured in pounds per hour. This measurement is required to correctly determine the valve coefficient (C_V).

Inlet Pressure (Upstream Pressure or P_1)
The pressure (psia) of the medium flowing into the valve body. This measurement is required to correctly determine the valve coefficient (C_V) and valve close-off capability.

Outlet Pressure (Downstream Pressure or P_2)
The pressure (psia) of the medium flowing through a fully opened valve to the process. The outlet pressure from the valve is determined by the process or equipment that is being fed by the valve, and is not caused by the valve itself. This measurement is required to correctly determine the valve coefficient (C_V) and valve close-off capability.

Differential Pressure (Pressure Drop or ΔP)
The difference between the inlet and outlet pressures (P_1-P_2). Usually, a reduction in the media pressure as it flows through the valve port is required in order to regulate the process. This measurement is required to correctly determine the valve coefficient (C_V) and valve close-off capability.

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Valve Selection

continued

Other Considerations

- **Specific Gravity** — The ratio between the weight of the flow medium at the flow temperature and that of a defined standard substance (water or air). The specific gravity may be required to correctly determine the valve coefficient (C_V).

  Liquids (G_f) water = 1.0 @ 39°F (4°C)
  Gases (G_g) air = 1.0 @ 60°F (18°C) and 14.7 psia

- **Viscosity** — The degree of thickness of a liquid. Extremely thick process media can create high friction as it passes through the valve. In most instances a sizing correction factor is not required. Please consult the factory when the flow medium is of a viscosity of 40 centistokes or greater.

- **Steam Superheat** — The number of degrees Fahrenheit (T_{sh}) above the saturation temperature of steam at a given pressure. Superheated steam is created when saturated steam is further heated from another source after leaving the water from which it is formed. This measurement is required to correctly determine the valve coefficient (C_V).

Valve Sizing Equations

The following formulas can be used to determine the C_V requirement for a specific set of service conditions,

where:

C_V = valve coefficient
G_f = liquid specific gravity at flow temperature (water = 1.0)
G_g = gas specific gravity (air = 1.0)
P_1 = inlet pressure (psia)
P_2 = outlet pressure (psia)
ΔP = inlet pressure minus outlet pressure (psi)
q = liquid flow in gallons per minute (gpm)
T_{sh} = steam superheat (°F)
W = gas flow in pounds per hour (pph)

Cavitation

Water and Other Liquids

Cavitation takes place when the pressure through a valve drops to or below the vapor pressure of a liquid, causing it to vaporize and rapidly expand in gas form. Vapor bubbles flow downstream where the fluid velocity decreases and the surrounding pressure increases. The vapor bubbles then collapse or implode, causing sudden condensation and producing shock waves that may result in excessive noise, vibration, erosion or mechanical damage to valve and/or piping. In most liquid applications, the outlet pressure (psia) should be no less than one-third the inlet pressure (psia). Where extremely large differential pressures are required, the use of multiple valves in series will reduce the possibility of cavitation.

Water

where:

q = liquid flow in gallons per minute (gpm)
ΔP = inlet pressure minus outlet pressure (psi)

$$C_V = \frac{q}{\sqrt{\Delta P}}$$

example:

medium = water
q = 160 U.S. gallons per minute
ΔP = 25 [100 psia inlet – 75 psia outlet]

$$C_V = \frac{160}{\sqrt{25}} \quad \text{or} \quad C_V = \frac{160}{5} \quad \text{or} \quad C_V = 32$$

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Other Liquids

where:

q = liquid flow in gallons per minute (gpm)
ΔP = inlet pressure minus outlet pressure (psi)
G_f = liquid specific gravity at flow temperature (water = 1.0)

$$C_V = q\sqrt{\frac{G_f}{\Delta P}}$$

example:

medium = methyl alcohol @ 68°F
q = 160 U.S. gallons per minute
ΔP = 25 [100 psia inlet – 75 psia outlet]
G_f = 0.79

$$C_V = 160\sqrt{\frac{0.79}{25}} \quad \text{or} \quad C_V = 160 \times 0.1778 \quad \text{or} \quad C_V = 28.4$$

Saturated Steam

where:

W = gas flow in pounds per hour (pph)
P_1 = inlet pressure (psia)
P_2 = outlet pressure (psia)
ΔP = inlet pressure minus outlet pressure (psi)

$$C_V = \frac{W}{2.1\sqrt{\Delta P(P_1 + P_2)}}$$

example:

medium = saturated steam
W = 4000 pph
P_1 = 100 psia
P_2 = 75 psia
ΔP = 25 [100 psia inlet – 75 psia outlet]

$$C_V = \frac{4000}{2.1\sqrt{25(100 + 75)}} \quad \text{or} \quad C_V = \frac{4000}{138.9} \quad \text{or} \quad C_V = 28.8$$

Critical Drop (ΔP)

Steam and Other Gases

Steam and gases are compressible fluids. Their maximum velocity through the valve is limited to the speed of sound. When the outlet pressure (psia) is equal to one-half or less of the inlet pressure (psia), the fluid velocity through the valve reaches the speed of sound, and flow cannot be further increased by a reduced outlet pressure. This is known as a choked flow condition. When this condition exists, the valve should be sized using the critical drop.

Critical Drop (ΔP) = $\frac{P_1}{2}$

example:

Inlet Pressure (P_1)	**=**	**90 psia**		
Outlet Pressure (P_2)	**=**	**35 psia**		
Differential Pressure (ΔP)	**=**	**55 psia**		
Critical Drop (ΔP)	**=**	**90 / 2**	**=**	**45 psia**

The actual differential pressure (55 psia) is greater than the critical drop (45 psia); therefore choked flow is probable and the valve should be sized using the critical drop as ΔP.

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Superheated Steam

where:

W = gas flow in pounds per hour (pph)
P_1 = inlet pressure (psia)
P_2 = outlet pressure (psia)
ΔP = inlet pressure minus outlet pressure (psi)
T_{sh} = steam superheat (°F)

$$C_V = \frac{W(1 + 0.0007T_{sh})}{2.1\sqrt{\Delta P(P_1 + P_2)}}$$

example:

medium = superheated steam
W = 4000 pph
P_1 = 100 psia
P_2 = 75 psia
ΔP = 25 [100 psia inlet - 75 psia outlet]
T_{sh} = 50°F

$$C_V = \frac{4000(1 + 0.0007(50))}{2.1\sqrt{25(100 + 75)}} \quad \text{or} \quad C_V = \frac{4140}{138.9} \quad \text{or} \quad C_V = 29.8$$

Other Gases

where:

W = gas flow in pounds per hour (pph)
P_1 = inlet pressure (psia)
P_2 = outlet pressure (psia)
ΔP = inlet pressure minus outlet pressure (psi)
G_g = gas specific gravity (air = 1.0)

$$C_V = \frac{W}{3.22\sqrt{\Delta P(P_1 + P_2)G_g}}$$

example:

medium = ammonia @ 68°F
W = 4000 pph
P_1 = 100 psia
P_2 = 75 psia
ΔP = 25 [100 psia inlet – 75 psia outlet]
G_g = 0.596

$$C_V = \frac{4000}{3.22\sqrt{25(100 + 75)0.596}} \quad \text{or} \quad C_V = \frac{4000}{164.4} \quad \text{or} \quad C_V = 24.3$$