FLUID POWER
Design Data Sheet

Revised Sheet 22 - Womack Design Data File

Cv (FLOW FACTORS) FOR COMPRESSED AIR

Design Data Sheet #17 showed charts for sizing hydraulic valves by using Cv (flow factor) ratings. The chart below gives the same information for compressed air. Sheet 17 should be reviewed for an explanation of Cv factor and other general information.

The chart below; although calculated for a valve having a Cv of 1.00, can be used equally well for any size valve on which the manufacturer has a published Cv factor, and will work for any application within the pressure range shown.

A 2-way valve has only one flow path, so there will be only one pressure drop across the valve from inlet to outlet.

A 4-way valve has two flow paths. If the Cv factor is the same for both paths, there will be about the same pressure loss through each. If the Cv factors are different, there will be a higher loss through the path with lower Cv factor.

The chart shows the relation between inlet pressure, outlet pressure and flow capacity for any orifice or valve passage which has a Cv factor of 1.00. On valves or orifices with other Cv factors, the flow capacity will be directly proportional to the Cv rating. For example, a valve with Cv of 4.00 will pass 4 times as much flow at the same pressure difference as shown in the chart.

SCFM AIR FLOW THROUGH A VALVE ORIFICE HAVING A Cv FACTOR OF 1.00

P2 Outlet PSIG	P1 - Inlet Pressure to the Valve												
	30 PSIG	40 PSIG	50 PSIG	60 PSIG	70 PSIG	80 PSIG	90 PSIG	100 PSIG	125 PSIG	150 PSIG	175 PSIG	200 PSIG	225 PSIG
20	15.2	23.5	29.3	35.1	41.1	46.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
25	11.2	27.3	29.3	35.1	41.1	46.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
30		31.0	27.1	35.1	41.1	46.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
35		34.7	24.2	33.0	41.1	46.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
40			20.4	30.3	38.9	46.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
45			14.7	27.0	36.3	44.9	52.7	58.7	73.3	88.0	103.0	117.0	132.0
50				22.5	31.9	42.2	50.7	58.7	73.3	88.0	103.0	117.0	132.0
55				16.2	29.4	39.3	48.2	56.5	73.3	88.0	103.0	117.0	132.0
60					24.5	35.9	45.4	54.1	73.3	88.0	103.0	117.0	132.0
65					17.5	31.6	42.1	51.5	72.3	88.0	103.0	117.0	132.0
70						26.3	38.3	48.3	70.0	88.0	103.0	117.0	132.0
75						18.8	33.8	44.7	67.8	88.0	103.0	117.0	132.0
80							28.0	40.7	64.9	86.0	103.0	117.0	132.0
85							19.9	35.8	62.0	83.8	103.0	117.0	132.0
90								29.6	58.8	81.2	102.0	117.0	132.0
95								21.0	54.9	78.5	99.6	117.0	132.0
100									50.7	75.8	97.3	117.0	132.0
110									40.3	69.0	92.3	113.0	132.0
120									23.6	60.9	86.1	108.0	129.0
130										50.7	79.2	103.0	124.0
140										36.6	71.1	96.7	119.0
150											61.0	89.7	114.0
160											48.1	81.2	107.0
170											28.0	71.2	99.7
180												59.0	91.3
190												42.4	81.6
200													69.7
210													54.8

Figures in the body of this chart show the amount of air which will flow thought an orifice which has a Cv (flow factor of 1.00. Values are given in SCFM (standard cubic feet per minute). To find flow capacity of a valve, multiply its Cv factor times the value shown in the chart.

Notice that flow is not proportional to delta P (pressure difference between inlet and outlet pressures). Flow does increase as delta P increases until the critical pressure ratio is reached. For air and other gases this critical ratio is reached when outlet pressure drops to less than 50% of inlet pressure. Flow at the critical pressure ratio is the maximum that can be passed through the orifice regardless of how much more the delta P may become. This can be seen in each column of the chart. When outlet pressure falls to less than 50% of inlet pressure, the flow levels off to a maximum for that value of inlet pressure. Only by increasing the inlet pressure can the flow capacity of the valve be increased.

Calculating Other Pressure Conditions

The chart was calculated from a formula published by the Fluid Controls Institute, Inc., 12 Bank St., Summit, NJ 07901, which, when simplified for a Cv of 1.00, compressed air (specific gravity of 1.00), and an air temperature of 80 to 100°F, reads as follows:

$$Q = 0.6875 \times \sqrt{P1 - P2} \times \sqrt{P1 - P2} \text{ in which:}$$

Q is the air flow in SCFM
P1 is the inlet pressure, PSIG
P2 is the outlet pressure, PSIG
Cv is understood to be 1.00 when using this formula

Other pressure conditions, within the above limitations can be calculated from the formula. Remember that for outlet pressures less than 50% of the inlet (below the critical ratio), use the critical pressure for P2 in the formula. For other gases and other ambient temperatures, use the original formula as published by the Fluid Controls Institute.

Examples of Use of the Chart

Example: Determine the valve Cv factor necessary to pass 55 SCFM at only a 5 PSIG pressure loss when valve is connected to an 80 PSIG air line.

Solution: Look down the 80 PSIG inlet pressure column and opposite the 75 PSIG outlet pressure line (a 5 PSIG drop through the valve). The chart, which is based on a Cv of 1.00, states that 18.8 SCFM will flow. To find necessary Cv for a 55 SCFM flow: 55 ÷ 18.8 = 2.93. Select a valve with at least a 2. 93 Cv and it will meet the flow conditions.

Example: Suppose a certain valve has a published Cv factor of 3.75. If this valve is connected to a 125 PSIG air line, find the pressure loss through it when it is passing a flow of 243 SCFM.

Solution: Since the chart is for a Cv of 1.00, first convert the 243 SCFM to the equivalent flow expected on a valve having a Cv of 1.00: Equiv. flow = 243 ÷ 3.75 = 64.8 SCFM. Look down the 125 PSIG column of the chart. The value of 64.9 SCFM opposite the 80 PSIG line comes very close. Since the chart shows an outlet pressure of 80 PSIG, the pressure loss through the valve is: 125 - 80 = 45 PSIG.

EXPLOSION PROOF SOLENOID VALVES

Availability of suitable valves may be a problem on air or hydraulic applications which operate in hazardous locations and require explosion proof solenoid valves.

For a valve to carry the official underwriters label (UL), the entire valve assembly, with solenoid operator in place, must have been submitted to the UL Laboratories for testing and approval. Each valve size, type, and model must be separately submitted. Some manufacturers who offer a large variety of sizes and types do not feel that the high cost of UL testing on each model is justified by the relatively small demand for such valves.

Some manufacturers have offered solenoid valves which they claim are built to UL specifications but which have not been submitted for approval and do not carry the label. Such valves may or may not be acceptable in a given situation.

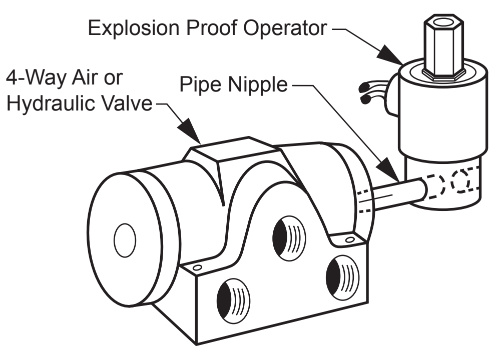

Figure 1. *Explosion Proof Operator.*

Figure 1. Miniature 3-way solenoid valves of the type pictured are available from several manufacturers with the official UL label of approval for certain classes and groups of hazardous service. Most of these valves are built for use on compressed air. They can be used as pilot operators for standard 4-way air valves, and for 4-way hydraulic valves which are equipped with air pilots. The outlet (cylinder) port on the 3-way valve can be connected to the end cap of the 4-way valve with ordinary piping. Wiring to the 3-way valve coil should follow all recommendations of the National Electrical Code, or of local ordinances regarding conduit connections and sealing.

Valves and other electrical components can be enclosed, when necessary, in an explosion proof box which is approved for the particular type of service. Electrical and fluid lines can be brought in through threaded connections provided in the box. Wiring and sealing should conform to the National Electrical Code.

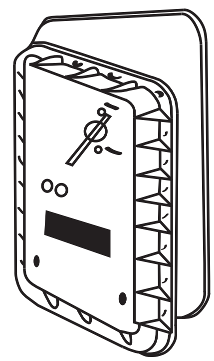

Figure 2. *Explosion Proof Encloures.*

Hazardous Locations and Atmospheres

First, locations are classified according to the general nature of the hazard, as follows:

Class I - Highly inflammable gases or vapors.
Class II - Combustible dust.
Class III - Combustible fibers or flyings.

Then, various atmospheric mixtures have been assigned ratings, Groups A, B, C, D, E, F, and G, according to specific characteristics such as flash point, explosion pressure, ignition temperature, etc. It is necessary that equipment be approved not only for the class of location (I, II, III), but also for the specific gas, vapor, or dust (group) that will be present. Example: Class 1, Group D.

For further information refer to the National Electrical Code. Copies may be purchased from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169, 617-770-3000, www.nfpa.org.

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