Fluid Power Design Data Sheet

Evolution MOTION SOLUTIONS

REVISED SHEET 17 - EVOLUTION DESIGN DATA FILE

HOW TO USE FLOW COEFFICIENTS (Cv) FOR HYDRAULIC FLUIDS

In case you have forgotten how to use the Cv flow coefficient (flow factor) for selecting valve size, this data sheet will review the use of Cv coefficients for hydraulic fluids. Cv information for compressed air is in Data Sheet 22.

Some manufacturers publish Cv coefficients for describing the volume of flow that can be put through their valves without exceeding a certain maximum pressure loss. Cv flow coefficient ratings have several advantages: they provide a means of comparing the flow capacities of different brands of valves; they simplify the job of selecting an adequately sized valve without wasteful oversizing; and they allow the designer to predict with reasonable accuracy just how a newly designed system will perform.

WHAT IS THE CV FLOW COEFFICIENT?

In the U.S. system of units, the Cv coefficient is the number of U.S. gallons per minute of water that will pass through a given orifice area at a pressure drop of 1 PSI.

An orifice or valve passage that has a Cv coefficient of 1.00 will pass 1 GPM of water (specific gravity 1.0) with a pressure drop of 1 PSI. To pass 2 GPM of water at the same pressure drop, the valve orifice would have to have a Cv of 2.0, etc.

The definition of Cv is based on water, which has a G (specific gravity) = 1.0. Fluids with other gravities will flow at different rates. For example, heavier fluids will have a greater pressure loss through the same valve passage. The viscosity of the fluid will also affect its flow rate through a valve. Fluids with higher viscosity will have a higher pressure drop than water, which has a viscosity of about 35 SSU.

HOW IS CV DETERMINED FOR A VALVE?

The valve manufacturer must determine the Cv coefficients experimentally, by actual test. These tests are usually conducted with water. The published Cv coefficient should then be corrected by the user for specific gravity and viscosity of their fluid.

(See back side of sheet for instructions on the use of this chart)

TABLE 1 - PSI PRESSURE DROPS FOR CV FLOW COEFFICIENTS FOR A FLOW OF 1 GPM
Multiply table values time the square of the actual flow through the valve

Before using this chart, take the published Cv of your valve and correct it (if neccessary) for viscosity of your fluid. See details on back side of this sheet. This table plots Cv factors against pressure drop for a flow of 1 GPM through the valve. Find the pressure drop opposite your corrected Cv factor, then multiply this times the square of the flow of 1 GPM. Find the pressre drop at a flow of 16 GPM at the same Cv = 2.20.

$$0.250 \times \sqrt{16^2} = 64 \text{ PSI}$$

For values of Cv not listed in the table, use this formula for a flow of 1 GPM.

$$\text{PSI (for 1 GPM flow)} = 1 \div Cv^2$$

Information in this data sheet is based on a flow equation published by the Fluid Controls Institute. Certain approximations in the formula may cause the results to vary due to pressure conditions, fluids, or valve configurations. The approximate flow equation is:

$$Cv = GPM \times \sqrt{G} \div \sqrt{PSI}$$

Corrected Cv	PSI Drop per GPM	Corrected Cv	PSI Drop per GPM	Corrected Cv	PSI Drop per GPM
0.10	100	3.00	0.111	7.50	0.018
0.15	44	3.10	0.104	7.75	0.017
0.20	25	3.20	0.098	8.00	0.016
0.25	16	3.30	0.092	8.25	0.015
0.30	11	3.40	0.087	8.50	0.014
0.35	8.16	3.50	0.082	8.75	0.013
0.40	6.25	3.60	0.077	9.00	0.012
0.50	4.00	3.70	0.073	9.50	0.011
0.60	2.78	3.80	0.069	10.0	0.010
0.70	2.04	3.90	0.066	11.0	0.008
0.80	1.56	4.00	0.063	12.0	0.007
0.90	1.24	4.25	0.055	13.0	0.006
1.00	1.00	4.50	0.049	14.0	0.005
1.20	0.694	4.75	0.044	16.0	0.004
1.40	0.510	5.00	0.040	18.0	0.003
1.60	0.391	5.25	0.036	22.0	0.002
1.80	0.309	5.50	0.033	30.0	0.001
2.00	0.250	5.75	0.030	35.0	0.0008
2.20	0.207	6.00	0.028	40.0	0.0006
2.40	0.174	6.25	0.026	45.0	0.0005
2.60	0.148	6.50	0.024	50.0	0.0004
2.70	0.137	6.75	0.022	60.0	0.0003
2.80	0.128	7.00	0.020	70.0	0.0002
2.90	0.119	7.25	0.019	90.0	0.0001

HOW TO USE Cv COEFFICIENTS

The most common usage of the Cv flow coefficient is to predict the pressure loss to be expected across a valve while fluid is flowing through it. The Cv rating published by the valve manufacturer is used for this determination.

If the Cv is stated in terms of water flow, it must be corrected for viscosity and specific gravity of other fluids. However, if the Cv rating is specifically stated as for a certain fluid and viscosity, this means that adjustments have already been made. The pressure drop in relation to the GPM flow may then be determined directly from Table 1.

If no definite fluid is specified, it can be assumed that the Cv rating is for water flow. Since both the viscosity and specific gravity of a fluid affect the pressure drop through a valve orifice, corrections must be made for all other fluids.

STEP 1. Correction for Viscosity

Flow resistance is directly proportional to centistoke viscosity. If valve manufacturers give the Cv stokes for water flow, fluids with higher viscosity will have higher resistance to flow in proportion to their viscosity, as related to the viscosityof water.

Table 2 was prepared for conversion from water, which has a viscosity of 1.12 centistokes at 60°F, to fluids of higher viscosity. Factors in the third column may be used as dividers to convert a water Cv rating into a corrected Cv at higher viscosities or as multipliers to find the increase in flow resistance when using a more viscous fluid.

TABLE 2

SSU Vis.	Centi-stokes	Fac-tor
50	7 1/2	6.7
100	21	19
150	33	29
200	43	38
250	53	47
300	65	58
400	87	78
500	110	98
750	163	145
1000	215	192

Example: A valve has a published Cv of 5.4 on 60°F water. Find the corrected Cv for a viscosity of 150 SSU.

The factor from Table 2 is 29. The flow resistance will be 29 times greater on 150 SSU. The Cv may be adjusted by division: New Cv = 5.4 + 29 = .186. Use this in Table 1. To adjust from one SSU to another, from 100 to 150 SSU for example, take the ratio between the two factors: 29 + 19 = 1.53 increase in flow resistance

The viscosity to which you are correcting must be the viscosity at the operating temperature, not the rating at 100°F. No other temperature correction is necessary. No correction is needed for viscosities less than 50 SSU.

STEP 2. Using the Table 1

After correcting the Cv for viscosity in Step 1, go to Table 1 and find the pressure drop for a flow of 1 GPM. Then, follow the instructions alongside the table.

STEP 3. Correction for Specific Gravity

Flow resistance will be approximately in proportion to specific gravity of the fluid. Gravities of hydraulic fluids range from 0.9 for petroleum oil, through 1.00 for water, up to 1.20 for synthetic fluids. If the published Cv is for water, the pressure drop with hydraulic oil will be about 10% less than for water or with synthetic fluids will be about 20% higher.

EXAMPLE OF PRESSURE LOSS DETERMINATION BY CV RATING

On a certain valve, a Cv rating of 19.2 is published for water flow. Find the pressure drop through this valve on a 15 GPM flow of 200 SSU hydraulic oil.

First, convert the Cv from water to 200 SSU viscosity. Table 2 shows a correction factor of 16.

19.2 + 16 = 1.20

Next, go to Table 1 to determine pressure loss on a flow of 1 GPM. Table 1 shows a pressure drop of 0.694 PSI. For a flow of 15 GPM:

PSI drop = 0.694 x 152 = 156.2 PSI

Finally, deduct about 10% because of the lower specific gravity of hydraulic oil:

156.2 - 15.6 = 140.6 PSI (answer)

SI & METRIC Cv FLOW COEFFICIENTS

SI (international standard) Cv flow coefficients are the number of liters per minute of water that will pass through a given orifice or passage at a pressure drop of 1 bar. If the flow coefficient is given in SI units, it may be converted to U.S. units by dividing it by 54.9. Then, the procedure given in this data sheet may be followed to determine pressure drop through a valve, in PSI.

If the metric Cv is given in units of the number of liters per minute of water that will pass through an orifice at a pressure drop of 1 Newton per sq meter (Pascal), it may be converted to U.S. units by dividing it by 5.487 x 10^{-4}.

CONVERSIONS - MM TO INCHES

Conversion factor: 1 mm = 0.03937 inches. For other metric and SI conversions see Data Sheets 2, 21, and 25.

mm	Inches	mm	Inches	mm	Inches	mm	Inches
1	0.0394	26	1.0236	51	2.0079	76	2.9921
2	0.0787	27	1.0630	52	2.0472	77	3.0315
3	0.1181	28	1.1024	53	2.0866	78	3.0709
4	0.1575	29	1.1417	54	2.1260	79	3.1102
5	0.1969	30	1.1811	55	2.1654	80	3.1496
6	0.2362	31	1.2205	56	2.2047	81	3.1890
7	0.2756	32	1.2598	57	2.2441	82	3.2283
8	0.3150	33	1.2992	58	2.2835	83	3.2677
9	0.3543	34	1.3386	59	2.3228	84	3.3071
10	0.3937	35	1.3780	60	2.3622	85	3.3465
11	0.4331	36	1.4173	61	2.4016	86	3.3858
12	0.4724	37	1.4567	62	2.4410	87	3.4252
13	0.5118	38	1.4961	63	2.4803	88	3.4646
14	0.5512	39	1.5354	64	2.5197	89	3.5039
15	0.5906	40	1.5748	65	2.5591	90	3.5433
16	0.6299	41	1.6142	66	2.5984	91	3.5827
17	0.6693	42	1.6535	67	2.6378	92	3.6220
18	0.7087	43	1.6929	68	2.6772	93	3.6614
19	0.7480	44	1.7323	69	2.7165	94	3.7008
20	0.7874	45	1.7717	70	2.7559	95	3.7402
21	0.8268	46	1.8110	71	2.7953	96	3.7795
22	0.8661	47	1.8504	72	2.8347	97	3.8189
23	0.9055	48	1.8898	73	2.8740	98	3.8583
24	0.9449	49	1.9291	74	2.9134	99	3.8976
25	0.9843	50	1.9685	75	2.9528	100	3.9370