Engineering Information For PDC Butterfly Valves

Valve Sizing:

Cv sizing is the most widely used method for valve sizing, today. By using the Cv method, the proper valve size can be accurately determined for most applications when any three of the four following conditions are known or assumed: valve size, maximum flow, inlet pressure or maximum delta P.

By using the Cv formulas listed below in conjunction with the Cv factors for PDC butterfly valves and the maximum allowable pressure drops for PDC valves listed for each valve class, the proper PDC butterfly valve for each application can be determined. In addition to the standard Cv equations other forms of the equation are listed for determining flow or the delta P for PDC valves.

Critical Flow:

When calculating the required valve Cv, the formula to be used is dependent on the flowing media and if the pressure drop is critical or subcritical.

Critical flow conditions exist when the line pressure reaches the vapor pressure of a flowing liquid, or approximately 1/2 of the absolute inlet pressure for gases or vapors. In the case of liquids, the result of critical flow is flashing or cavitation. Critical flow of gases produce sonic velocity. If pressure drop across valve, in open position, exceeds 0.1 times inlet pressure consult factory.

	Subcritical Flow	**Critical Flow**
For liquids:	DELTA P $< C_f^2(P_1-P_v)$	DELTA P $\geqslant C_f^2(P_1-P_v)$
For gases:	DELTA P $< 0.5\ C_f^2P_1$	DELTA P $\geqslant 0.5\ C_f^2P_1$

Where:

C_f= Critical flow factor, a dimensionless expression of the pressure recovery ratio in a control valve.While there are small variations in the C_f value for each valve size as determined by flow tests, for simplicity, the following values are assigned to PDC metal swing-thru butterfly valves.
At 60 deg. open C_f= 0.65 and at 90 deg. open C_f =0.55.

P_1 = Inlet pressure, psia

P_V = Vapor pressure of fluid at flowing temperature, psia

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Sizing for:

- Liquids
- Gases
- Saturated Steam Service
- Vapor Flow (other than steam)

Sizing For Liquids

SUBCRITICAL FLOW

$$C_v = Q\sqrt{\frac{G}{DELTA\ P}}$$

$$Q = C_v\sqrt{\frac{DELTA\ P}{G}}$$

$$DELTA\ P = G\left(\frac{Q}{C_v}\right)^2$$

Where:
C_v = Flow coefficient (number of U.S. gallons of water flowing through a valve with a pressure drop of 1 psig)

G = Specific gravity of flowing media at system temperature. (water = 1 @ 60 deg. F.)

DELTA P = Pressure drop, P1 -P2, psig

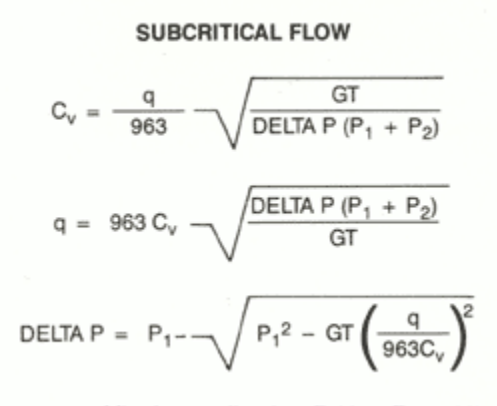
C_f = Critical flow factor (0.65 @ 60 deg.; 0.55 @ 90 deg.)

P_1 = Inlet pressure, psia

P_2 Outlet pressure, psia

Q = Flow, gallons per minute, GPM

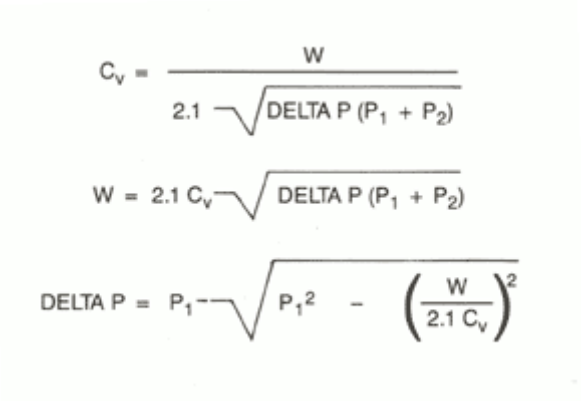
Sizing for Gases:



Where:
T = Absolute temperature of flowing media,
deg. R (deg. F + 460)

q = Flow, standard cubic feet per hour, SCFH

Sizing for Saturated Steam Service:



Where:
W = Flow, lbs./hr.

Add 7% to Cv for each 100° F of super heat.

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Standard Leakage Rate

Leakage Class Designation	Maximum Allowable Leakage	Test Medium	Test Procedures	Testing Procedures Required for Established Rating
I				No test required provided user and supplier so agree
II	0.5% of rated valve capacity	Air or water at 50° to 125° F	45 - 60 psig or maximum operating differential, whichever is lower	Pressure applied to valve inlet, with outlet open to atmosphere or connected to a low head loss measuring device, full normal closing thrust provided by actuator
III	0.1% of rated valve capacity	As above	As above	As above
IV	0.01% of rated valve capacity	As above	As above	As above
V	0.0005 ml per minute per inch of port diameter per psi differential	Water at 50° to 125° F (10° to 52°C)	Maximum service pressure drop across valve plug, not to exceed ANSI body rating (100 psig pressure drop min.)	Pressure applied to valve inlet after filling entire body cavity and connected piping with water and stroking valve plug closed. Use net specified max. actuator thrust, but no more, even if available during test. Allow time for leakage flow to stabilize.
VI	Not to exceed amounts shown in table 2* based on port diameter **Consult Factory*	Air or nitrogen at 50° to 125° F (10° to 52° C)	50 psig or maximum rated differential pressure across valve plug, whichever is lower	Actuator should be adjusted to operating conditions specified with full normal closing thrust applied to valve plug seat. Allow time for leakage flow to stabilize and use suitable leakage measuring device.

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Cv Data for Standard PDC Swing Thru Valve

VALVE SIZE	DISC ANGLE, DEGREES								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
2"	2	5	11	20	34	49	64	83	90
2.5"	4	8	20	34	56	84	126	178	194
3"	6	14	30	51	85	132	202	279	370
4"	13	28	54	98	159	257	391	550	747
5"	21	43	88	158	265	429	636	913	1,272
6"	30	63	126	228	382	632	955	1,370	1,999
8"	53	111	225	406	680	1,125	1,698	2,591	3,853
10"	83	174	351	635	1,063	1,759	2,655	4,052	6,361
12"	120	252	506	914	1,531	2,533	3,826	5,835	9,164
14"	143	302	606	1,096	1,835	3,035	4,584	6,992	10,981
16"	191	400	805	1,455	2,436	4,118	6,388	9,835	12,266
18"	244	513	1,032	1,865	3,123	5,279	8,185	12,608	15,725
20"	305	640	1,287	2,326	3,896	6,584	10,209	15,725	19,612
22"	372	781	1,570	2,838	4,753	8,033	12,456	19,186	23,929
24"	445	936	1,882	3,401	5,696	9,626	14,926	22,990	28,674
26"	526	1,105	2,221	4,015	6,723	11,364	17,619	27,139	33,848
28"	613	1,288	2,589	4,679	7,836	13,245	20,536	31,632	39,451
30"	706	1,485	2,985	5,395	9,035	15,270	23,676	36,468	45,484
32"	800	1,682	3,382	6,112	10,235	17,299	26,823	41,315	51,528
34"	907	1,906	3,832	6,926	11,599	19,603	30,395	46,817	58,392
36"	1,020	2,144	4,311	7,791	13,047	22,052	34,191	52,664	65,684
38"	1,140	2,396	4,818	8,707	14,581	24,644	38,211	58,855	73,405
40"	1,267	2,662	5,352	9,674	16,200	27,380	42,453	65,390	81,555
42"	1,400	2,942	5,915	10,691	17,904	30,260	46,919	72,268	90,134
44"	1,540	3,236	6,507	11,760	19,693	33,284	51,608	79,491	99,143
46"	1,687	3,544	7,126	12,879	21,568	36,453	56,520	87,057	108,580
48"	1,840	3,866	7,774	14,049	23,527	39,765	61,656	94,968	118,446
54"	2,340	4,916	9,885	17,865	29,910	50,566	78,403	120,762	150,617
60"	2,899	6,093	12,250	22,139	37,065	62,663	97,159	149,653	186,650

Minimum and Maximum Cv Values in Closed Position:

SIZE	2	2.5	3	4	5	6	8	10	12	14	16	18	20	22	24
MIN Cv	0.5	0.6	1.0	1.7	2.5	4.0	6.6	10.8	14.9	18.5	29	37	46	56	67
MAX Cv	1.6	2.1	2.7	4.0	5.4	7.5	11.3	16.6	22.0	26.0	48	58	70	82	96

SIZE	26	28	30	32	34	36	38	40	42	44	46	48	54	60
MIN Cv	52	61	70	80	91	102	114	126	140	154	168	184	234	334
MAX Cv	94	106	119	131	145	160	175	191	208	225	243	262	290	414

Sizing for Vapor Flow (Other Than Steam):

$$C_v = \frac{W}{K\sqrt{\text{DELTA P}\,(P_1 + P_2)}}$$

$$W = K\,C_v\sqrt{\text{DELTA P}\,(P_1 + P_2)}$$

$$\text{DELTA P} = P_1 - \sqrt{P_1^2 - \left(\frac{W}{KC_v}\right)^2}$$

Where:
K = Constant for vapor

Vapor	K
Freon 11	7.4
Freon 12	7.1
Freon 14	8.4
Freon 114	8.3
Ammonia	2.7
Dowtherm A	5.6

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Combined Torque Coefficient, Lb-In./PSI for Standard PDC Swing Thru Valves

VALVE SIZE	DISC ANGLE, DEGREES								
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**
2"	.3	.3	.4	.5	.6	.9	1.4	2.3	3
2.5"	.5	.5	.6	.8	1.1	1.5	2.4	4.2	6
3"	.7	.7	1	1.2	1.5	2.4	3.9	7	9
4"	1.7	1.7	2.2	2.8	3.7	5.6	8.5	17	24
5"	2.5	2.5	3.8	4.8	6.5	10	17	30	45
6"	3.8	3.8	5.3	7	10	17	29	52	75
8'	7.5	7.5	13	17	23	38	65	120	180
10"	17	17	25	34	47	79	140	250	370
12"	23	23	38	53	75	130	220	400	600
14"	37	37	60	80	120	190	310	590	850
16"	45	45	80	115	170	260	460	820	1,300
18"	70	70	130	175	260	460	700	1,200	1,800
20"	90	90	160	220	320	507	900	1,600	2,300
22"	122	122	215	297	434	714	1,215	2,156	3,100
24"	159	159	282	391	566	937	1,595	2,828	4,065
26'	205	205	362	499	725	1,202	2,005	3,627	5,215
28"	258	258	456	628	913	1,512	2,525	4,565	6,560
30"	319	319	564	777	1,130	1,872	3,125	5,651	8,120
32"	384	384	680	937	1,362	2,257	3,770	6,814	9,790
34"	464	464	820	1,130	1,644	2,723	4,545	8,219	11,810
36"	554	554	979	1,349	1,961	3,248	5,420	9,806	14,090
38"	654	654	1,157	1,593	2,317	3,838	6,405	11,585	16,645
40"	765	765	1,355	1,866	2,713	4,494	7,500	13,567	19,495
42"	889	889	1,574	2,168	3,152	5,222	8,710	15,763	22,650
44"	1,026	1,026	1,815	2,501	3,636	6,024	10,050	18,184	26,130
46"	1,176	1,176	2,080	2,867	4,168	6,904	11,520	20,814	29,945
48"	1,340	1,340	2,371	3,266	4,749	7,866	13,125	23,746	34,120
54"	1,921	1,921	3,427	4,684	6,809	11,279	18,805	34,050	48,925
60"	2,651	2,651	4,689	6,461	9,394	15,560	25,940	46,973	67,495

*In no case should actuator torque be less than the following values:

Valve Size	Minimum Torque
2" - 6"	50 LB-IN
8" - 14"	120 LB-IN
16" - 24"	200 LB-IN
26" - 30"	300 LB-IN
32" - 38"	400 LB-IN
40" - 48"	500 LB-IN
54"	750 LB-IN
60"	1000 LB-IN