Valve Sizing

❖ **STEP 1: Define the system**

The system is pumping water from one tank to another through a piping system with a total pressure drop of 150 psi. The fluid is water at 70 ^{0}F. Design (maximum) flowrate of 150 gpm, operating flowrate of 110 gpm, and a minimum flowrate of 25 gpm. The pipe diameter is 3 inches. At 70 ^{0}F, water has a specific gravity of 1.0.

Key Variables: Total pressure drop, design flow, operating flow, minimum flow, pipe diameter, specific gravity

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❖ **STEP 2: Define a maximum allowable pressure drop for the valve**

The usual rule of thumb is that a valve should be designed to use 10-15% of the total pressure drop or 10 psi, whichever is greater.

For our system, 10% of the total pressure drop is 15 psi which is what we'll use as our allowable pressure drop when the valve is wide open.

❖ **STEP 3: Calculate the valve characteristic**

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

where:

Q = design flowrate(gpm)

G = specific gravity relative to water

ΔP = allowable pressuredrop across wide open valve

For our system,

$$C_v = 150\sqrt{\frac{1}{15}} = 38.7 \cong 39$$

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❖ STEP 4: Preliminary valve selection

- **Don't make the mistake of trying to match a valve with your calculated Cv value. The Cv value should be used as a guide in the valve selection, not a hard and fast rule.**
- Some other considerations are:
  - ✓ **Never use a valve that is less than half the pipe size,**
  - ✓ **Avoid using the lower 10% and upper 20% of the valve stroke. The valve is much easier to control in the 10-80% stroke range.**

Before a valve can be selected, decide what type of valve will be used.

For our case, we'll assume we're using an equal percentage, globe valve. The valve chart for this type of valve is shown below.

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❖ STEP 4: Preliminary valve selection

FLOW CHARACTERISTIC	VALVE SIZE		MAXIMUM TRAVEL	PORT DIA.	DESIGNS ED AND ET (FLOW DOWN)					DESIGN ES (FLOW UP)				
					Valve Opening, Percent of Total Travel									
					10	30	70	100	100	10	30	70	100	100
	DIN	Inches	mm	mm	C_v				F_L	C_v				F_L
Equal Percentage	DN 25	1, 1-1/4	19	33.3	.783	2.20	7.83	17.2	.88	.783	1.86	9.54	17.4	.95
	DN 40	1-1/2	19	47.6	1.52	3.87	17.4	35.8	.84	1.54	3.57	17.2	33.4	.94
	DN 50	2	29	58.7	1.66	4.66	25.4	59.7	.85	1.74	4.72	25.0	56.2	.92
	DN 65	2-1/2	38	73.0	3.43	10.8	49.2	99.4	.84	4.05	10.6	45.5	82.7	.93
	DN 80	3	38	87.3	4.32	10.9	66.0	136	.82	4.05	10.0	59.0	121	.89
	DN 100	4	51	111.1	5.85	18.3	125	224	.82	6.56	17.3	103	203	.91
	DN 150	6	51	177.8	12.9	43.3	239	394	.85	13.2	41.1	223	357	.86
	DN 200	8	76	203.2	27.0	105	605	818	.96	25.9	97.8	618	808	.85
					X_T				- - -	X_T				- - -
	DN 25	1, 1-1/4	19	33.3	.766	.587	.743	.667	- - -	.754	.763	.630	.721	- - -
	DN 40	1-1/2	19	47.6	.780	.716	.690	.679	- - -	.674	.694	.698	.793	- - -
	DN 50	2	29	58.7	.827	.774	.702	.687	- - -	.863	.849	.792	.848	- - -
	DN 65	2-1/2	38	73.0	.778	.678	.661	.660	- - -	.747	.745	.783	.878	- - -
	DN 80	3	38	87.3	.774	.682	.663	.675	- - -	.768	.761	.754	.757	- - -
	DN 100	4	51	111.1	.731	.643	.672	.716	- - -	.722	.739	.718	.822	- - -
	DN 150	6	51	177.8	.688	.682	.736	.778	- - -	.723	.767	.808	.816	- - -
	DN 200	8	76	203.2	.644	.636	.725	.807	- - -	.825	.681	.735	.827	

For our case, it appears the 2 inch valve will work well for our Cv value at about 80-85% of the stroke range. Notice that we're not trying to squeeze our Cv into the 1 1/2 valve which would need to be at 100% stroke to handle our maximum flow.

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❖ STEP 5: Check the Cv and stroke percentage at the minimum flow

Cv at minimum flowrate:

$$C_v = 25\sqrt{\frac{1}{15}} = 6.5$$

Referring back to our valve chart, we see that a Cv of 6.5 would correspond to a stroke percentage of around 35-40% which is certainly acceptable.

Notice that we used the maximum pressure drop of 15 psi once again in our calculation. Although the pressure drop across the valve will be lower at smaller flowrates, using the maximum value gives us a "worst case" scenario. If our Cv at the minimum flow would have been around 1.5, there would not really be a problem because the valve has a Cv of 1.66 at 10% stroke and since we use the maximum pressure drop, our estimate is conservative. Essentially, at lower pressure drops, Cv would only increase which in this case would be advantageous.

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❖ STEP 6: Check the gain across applicable flow rates

Gain is defined as:

$$\text{Gain} = \frac{\Delta\,\text{Flow}}{\Delta\,\text{Stroke or Travel}}$$

Now, at our three flow rat

Qmin = 25 gpm
Qop = 110 gpm
Qdes = 150 gpm

We have corresponding Cv values of 6.5, 28, and 39. The corresponding stroke percentages are 35%, 73%, and 85% respectively. Now we construct the following table:

Flow (gpm)	Stroke (%)	Change in flow (gpm)	Change in Stroke (%)
25	35	110-25 = 85	73-35 = 38
110	73		
150	85	150-110 = 40	85-73 = 12

Gain #1 = 85/38 = 2.2
Gain #2 = 40/12 = 3.3

The difference between these values should be less than 50% of the higher value.

0.5 of 3.3 = 1.65 and 3.3 - 2.2 = 1.10.

Since 1.10 is less than 1.65, there should be no problem in controlling the valve. Also note that the gain should never be less than 0.50. So for our case, our selected valve will do nicely!