Water hammer - a general discussion

Flowing water, due to its inertia, develops sharp rises in pressure when suddenly interrupted, as by a valve being closed too quickly. The energy of the moving water column is expended in a series of sharp periodic waves of high pressure, followed by equal periods of subnormal pressure. These waves often produce a series of sounds, not unlike the blows of a hammer, from which is derived the name “water hammer”.

The initial shock wave develops the maximum pressure - each succeeding shock diminishing in intensity as the energy of the moving water is expended in overcoming the friction of the pipe wall, stretching the pipewall, and compressing the water column.

The period of times between shocks is proportional to the length of the pipe ahead of the valve, and the velocity of the wave propagation.

The velocity of wave propagation varies for different pipes, being highest in the more rigid pipes. In ordinary sizes and thicknesses of cast iron and steel pipe used in water mains, the velocity of wave propagation is approximately 3600 to 4000 feet per second. One time period is the time required for the wave to travel the length of straight run pipe ahead of the valve and return or twice this length in feet divided by the values given above. Any valve closure is less than this time results in maximum pressure rise for the velocity interrupted.

The maximum pressure rise has been found by experiment to reach values in pounds per square inch as high as 50 to 54 times the velocity in feet per second interrupted. On this basis, a velocity of 5 feet per second closed off in less than one time period would show a peak surge pressure of from 250 to 270 p.s.i.

Severe water hammer is a serious hazard and often may cause a rupture of piping components, service pipe failures, joint failures and other damage to the system.

Water hammer may be controlled by various means, such as surge supressors, relief valves, and slow closing gat or cone type valves. Moreover, complex lines complicate the problem, and a survey by engineers trained in surge control may be necessary where unusual conditions are encountered. Kents handbook offers the following formula for time in seconds to close a gate valve in order that no water hammer may result.

$T = .027L$

$P - p$

Where T - time in seconds; L-length of pipe before the valve, in feet; V-velocity of flow; P-pressure in pipe at no flow, p.s.i.; and p-pressure in the pipe at full flow.

Since the first 80% of gate travel has little effect in reducing the velocity, most of the above time should be taken in the last 20% of travel or closure.

Conversion of common inch fractions to inch decimals to millimeter decimals (for dual dimensioned drawings)

	Decimal Values				
	Actual	4 Place		3 Place	
	in.	in.	mm	in.	mm
1/64	.015625	.0156	0.397	.016	0.41
1/32	.03125	.0312	0.794	.031	0.79
3/64	.046875	.0469	1.191	.047	1.19
1/16	.0625	.0625	1.588	.062	1.57
5/64	.078125	.0781	1.984	.078	1.98
3/32	.09375	.0938	2.381	.094	2.39
7/64	.109375	.1094	2.778	.109	2.77
1/8	.1250	.1250	3.175	.125	3.18
9/64	.140625	.1406	3.572	.141	3.58
5/32	.15625	.1562	3.969	.156	3.96
11/64	.171875	.1719	4.366	.172	4.37
3/16	.1875	.1875	4.762	.188	4.78
13/64	.203125	.2031	5.159	.203	5.16
7/32	.21875	.2188	5.556	.219	5.56
15/64	.234375	.2344	5.953	.234	5.94
1/4	.2500	.2500	6.350	.250	6.35
17/64	.265625	.2656	6.747	.266	6.76
9/32	.28125	.2812	7.144	.281	7.14
19/64	.296875	.2969	7.541	.297	7.54
5/16	.3125	.3125	7.938	.312	7.92
21/64	.328125	.3281	8.334	.328	8.33
11/32	.34375	.3438	8.731	.344	8.74

	Decimal Values				
	Actual	4 Place		3 Place	
	in.	in.	mm	in.	mm
23/64	.359375	.3594	9.128	.359	9.12
3/8	.3750	.3750	9.525	.375	9.52
25/64	.390625	.3906	9.922	.391	9.93
13/32	.40625	.4062	10.319	.406	10.31
27/64	.421875	.4219	10.716	.422	10.72
7/16	.4375	.4375	11.112	.438	11.13
29/64	.453125	.4531	11.509	.453	11.51
15/32	.46875	.4688	11.906	.469	11.91
13/64	.484375	.4844	12.303	.484	12.29
1/2	.5000	.5000	12.7	.500	12.7
33/64	.515625	.5156	13.097	.516	13.11
17/32	.53125	.5312	13.494	.531	13.49
35/64	.546875	.5469	13.891	.547	13.89
9/16	.5625	.5625	14.288	.562	14.27
37/64	.578125	.5781	14.684	.578	14.68
19/32	.59375	.5938	15.081	.594	15.09
39/64	.609375	.6094	15.478	.609	15.47
5/8	.6250	.6250	15.875	.625	15.88
41/64	.640625	.6406	16.272	.641	16.28
21/32	.65625	.6562	16.669	.656	16.66
43/64	.671875	.6719	17.066	.672	17.07

	Decimal Values				
	Actual	4 Place		3 Place	
	in.	in.	mm	in.	mm
11/16	.6875	.6875	17.462	.688	17.48
45/64	.703125	.7031	17.859	.703	17.86
23/32	.71875	.7188	18.256	.719	18.26
47/64	.734375	.7344	18.653	.734	18.64
3/4	.7500	.7500	19.050	.750	19.05
49/64	.765625	.7656	19.447	.766	19.46
25/32	.78125	.7812	19.844	.781	19.84
51/64	.796875	.7969	20.241	.797	20.24
13/16	.8125	.8125	20.638	.812	20.62
53/64	.828125	.8281	21.034	.828	21.03
27/32	.84375	.8438	21.431	.844	21.44
55/64	.859375	.8594	21.828	.859	21.82
7/8	.8750	.8750	22.225	.875	22.22
57/64	.890625	.8906	22.622	.891	22.63
29/32	.90625	.9062	23.019	.906	23.01
59/64	.921875	.9219	23.416	.922	23.42
15/16	.9375	.9375	23.812	.938	23.83
61/64	.953125	.9531	24.209	.953	24.21
31/32	.96875	.9688	24.606	.969	24.61
63/64	.984375	.9844	25.003	.984	24.99
1	1.0000	1.0000	25.4	1.000	25.4