Sizing & Selection

Noise Prediction

Introduction

Control valve noise is generated by turbulence created in the valve and radiated to the surroundings by the downstream piping system. Major sources of control valve noise are mechanical vibration of the valve components, and hydrodynamic and aerodynamic fluid noise.

Mechanical noise can result from vibrations caused by the random pressure fluctuations within the valve body and fluid impingement upon the valve plug. Vibration can also be produced by valve components resonating at their natural frequency. Resonant vibration produces high levels of stress that may produce fatigue failure of the part. Noise produced by mechanical vibration is usually well below 100 dBA and is described as a mechanical rattling. Mechanical noise is usually secondary to the damage that may result to the vibrating part. In general, mechanical noise can be eliminated through proper valve design and normally is not encountered in control valve service.

Hydrodynamic noise is caused by the turbulence of liquid flow, cavitation, and flashing. Liquid flow noise is generated by the turbulent velocity fluctuations that result from the rapid deceleration of the fluid that occurs as the flow area increases downstream of the vena contracta. Liquid flow noise is generally low and is not considered a noise problem.

Noise is also produced by the implosion of gas or vapor bubbles returning to the liquid state in the cavitation process. Cavitation noise may be described as a “rattling sound,” as if gravel were being carried in the fluid stream. Usually, cavitation noise is highly localized to the region immediately downstream of the vena contracta. Reduction or elimination of cavitation is usually necessary to reduce physical damage to valve parts and the piping system, and to reduce the SPL (sound pressure level).

Flashing noise occurs when a portion of the fluid vaporizes without the subsequent bubble collapse that occurs in cavitation. Noise results from the deceleration and expansion of the two-phase flow stream. Generally, flashing noise is significantly lower than cavitation noise, but erosion is often a serious problem.

Aerodynamic noise is the major source of valve noise for gaseous service. It is created through complex mechanics. The noise level is generally a function of flow stream velocity.

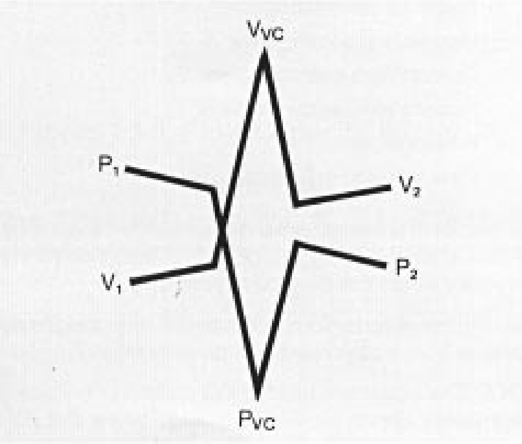

**Figure 13-1:
Velocity Profile vs. Pressure Profile**

Gas flowing through a control valve experiences an acceleration as it approaches the vena contracta. Figure 13-1, showing the velocity profile super-imposed over a pressure profile, illustrates how the velocity increases and decreases passing through a valve. High noise levels can be generated even though the outlet velocity may be as low as Mach 0.4. Aerodynamic noise levels can be above 100 dBA and reach as high as 150 dBA in certain services.

Noise reaching an observer is also dependent upon the reflective surfaces surrounding the valve, pipe size and schedule, and the distance from the valve that the noise is observed.

The predicted noise level is for a valve without insulation in a non-reflective environment. Reflective surfaces can increase valve noise, which can be estimated as follows:

For a valve installed near a reflective surface (a hard floor or wall), add 3 dBA. For a valve installed near two reflective surfaces (a hard floor and wall), add 6 dBA. If the valve is near three reflective surfaces (two hard walls and hard floor), add 9 dBA. A valve installed in a small room with all reflective walls, floor, and ceiling can easily produce noise levels 30 or 40 dBA above that which the valve would produce in an area free of reflective surfaces.

Piping Noise and Valtek Computer Capabilities

Piping system noise, unless low-noise or MegaStream valves are used, is predominantly from control valves. When these special trim valves are used, flow noise through the piping may be significant. Several computer programs are available from Valtek to assist engineers in predicting the noise generated by a piping system.

The following parameters are required to use the charts and tables:

- Required valve sizing coefficient, C_V
- Upstream pressure, psia, P_1
- Downstream pressure, psia, P_2
- Flowing temperature of fluid, T_1
- Flowing fluid
- Pipe size and schedule

The predicted noise value can be considered accurate to ± 5 dBA when the outlet velocity is less than sonic and is correct for single throttling point trims only.

Potential noise reductions with special trim designs are available from Valtek representatives or factory.

NOTE: The equations used in this bulletin only apply to noise levels above 70 dBA (any level below this point usually does not require low noise trim).

Hydrodynamic Noise Prediction

Valtek hydrodynamic noise prediction techniques are based upon the empirical equation.

$$dBA = DP_S + C_S + R_S + K_S + D_S \qquad (13.1)$$

Where: dBA = Sound pressure level
DP_S = Pressure drop factor
C_S = Flow capacity factor
R_S = Ratio factor
K_S = Pipe attenuation factor
D_S = Distance factor

The total sound pressure level is easily found by finding DP_S, C_S, R_S, K_S, and D_S from Figures 13-2 through 13-5 and Tables 13-I and 13-II and then substituting them into the noise equation.

To obtain DP_S and R_S, it is first necessary to calculate the pressure drop ratio, DP_F, where

$$DP_F = \frac{\Delta P}{P_1 - P_V} \qquad (13.2)$$

Where: DP_F = Pressure drop ratio
ΔP = Pressure drop, psi
P_1 = Upstream pressure, psia
P_V = Vapor pressure, psia

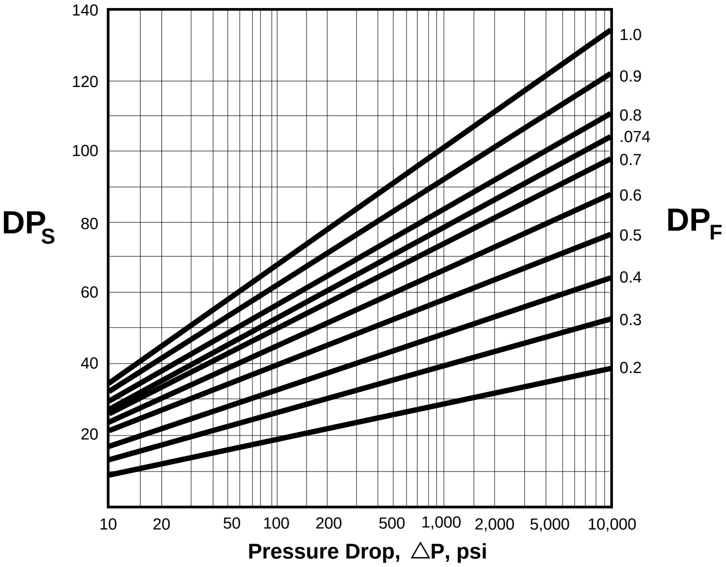

Figure 13-2: Pressure Drop Factor, DP_S

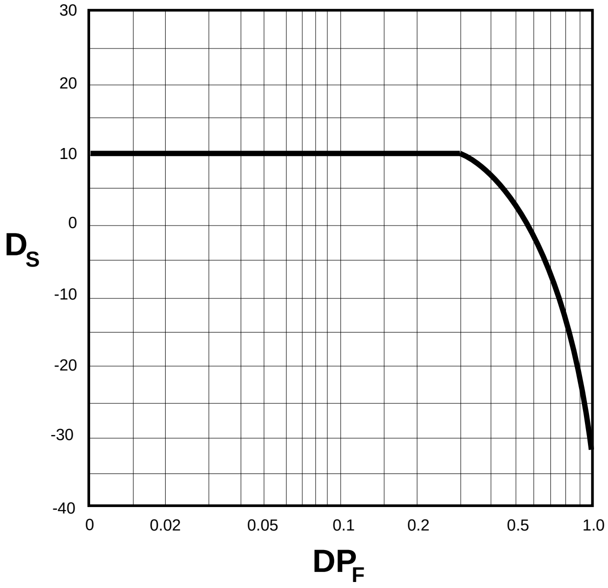

Figure 13-3: Ratio Factor, R_S

If DP_F calculated is greater than 1, flashing is occurring in the valve. Valtek liquid noise prediction techniques do not apply to flashing service.

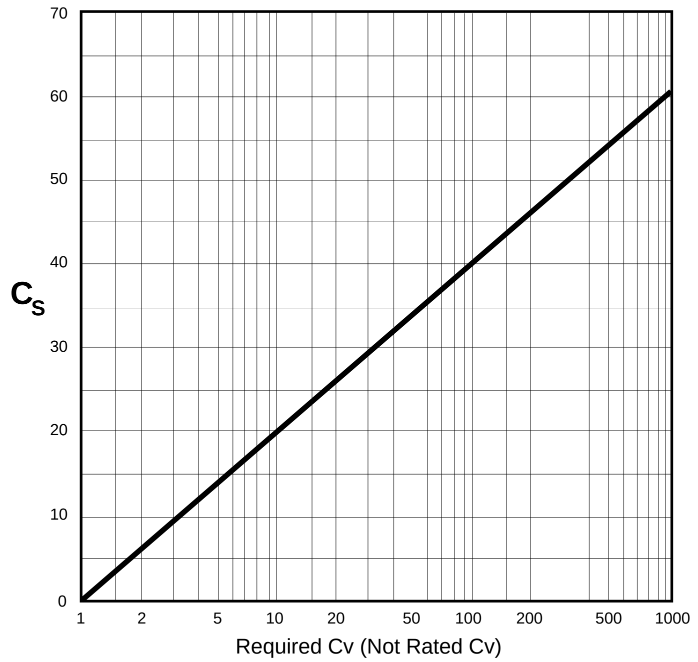

Figure 13-4: Flow Capacity Factor, C_S

Liquid Example

Given: 2-inch Valve
Liquid .... Water
P_1 .... 300 psig
P_2 .... 90 psig
P_V .... 29.89 psia
Required C_V 34.8
Line Size .... 2-inch Schedule 40

Calculate DP_F

$$DP_F = \frac{P_1 - P_2}{P_1 - P_V} = \frac{314.7 - 104.7}{314.7 - 29.89} = 0.74$$

From the tables

DP_S = 60
C_S = 31
R_S = -10
K_S = 0
D_S = 0 (at a distance of 3 feet from the valve)
dBA = 60 + 31 - 10 + 0 = 81 dBA

Table 13-I: Distance Factor, D_S

Distance of personnel from noise source in feet	D_S
3	0
6	-5
12	-10
24	-15
48	-20
96	-25

NOTE: *This factor is affected by the type of noise source and reflecting surfaces around the valve, but is reasonable for most situations.*

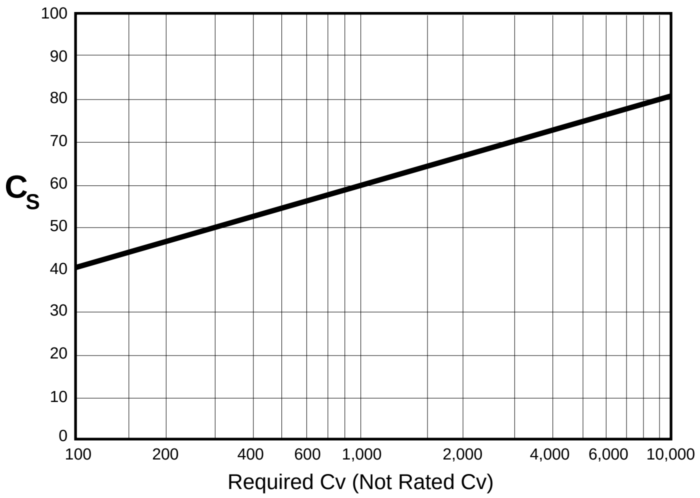

Figure 13-5: Flow Capacity Factor, C_S

Table 13-II: Pipe Attenuation Factor, K_S (Liquids Only)

	Pipe Schedule						
	10	20	30	40	60	80	100
0.5				0		-5	
0.75				0		-5	
1.0				0		-6	
1.5				0		-6	
2				0		-6	
3				0		-7	
4				0		-7	
6				0		-8	
8		4	3	0	-3	-9	-8
10		5	3	0	-5	-9	-9
12		6	2	-1	-6	-10	-11
14	6	3	0	-2	-6	-11	-12
16	6	3	0	-4	-8	-12	-13
18	5	3	-2	-6	-9	-13	-15
20	5	0	-4	-6	-10	-14	-16
24	5	0	-6	-8	-12	-15	-19
30	3	-4	-7	-8		-15	
36	3	-4	-7	-9		-15	
42		-4	-7			-15	

	Pipe Schedule					
	120	140	160	STD.	XS	XXS
0.5			-11	0	-5	-15
0.75			-11	0	-5	-15
1.0			-12	0	-6	-15
1.5			-12	0	-6	-14
2			-12	0	-6	-14
3			-13	0	-7	-16
4	-9		-13	0	-7	-14
6	-10		-14	0	-8	
8	-12	-13	-18	0	-9	
10	-13	-14	-19	0	-7	
12	-14	-15	-20	0	-6	
14	-15	-16	-22	0	-4	
16	-16	-18	-24	0	-4	
18	-18	-19	-25	0	-4	
20	-19	-21	-26	0	-4	
24	-21	-23	-27	0	-4	
30			-27	0	-4	
36			-27	0	-4	
42						

Aerodynamic Noise Prediction

Valtek aerodynamic noise prediction techniques are based upon the empirical equation:

$$dBA = V_S + P_S + E_S + T_S + G_S + A_S + D_S \tag{13.3}$$

Where: dBA = Sound pressure level
V_S = Flow factor
P_S = Pressure factor
E_S = Pressure ratio factor
T_S = Temperature correction factor
G_S = Gas property factor
A_S = Attenuation factor
D_S = Distance factor

The noise can be determined by finding V_S, P_S, E_S, T_S, G_S, A_S, and D_S from Figures 13-6 through 13-9 and Tables 13-I, 13-III and 13-IV, then substituting them into the noise equation.

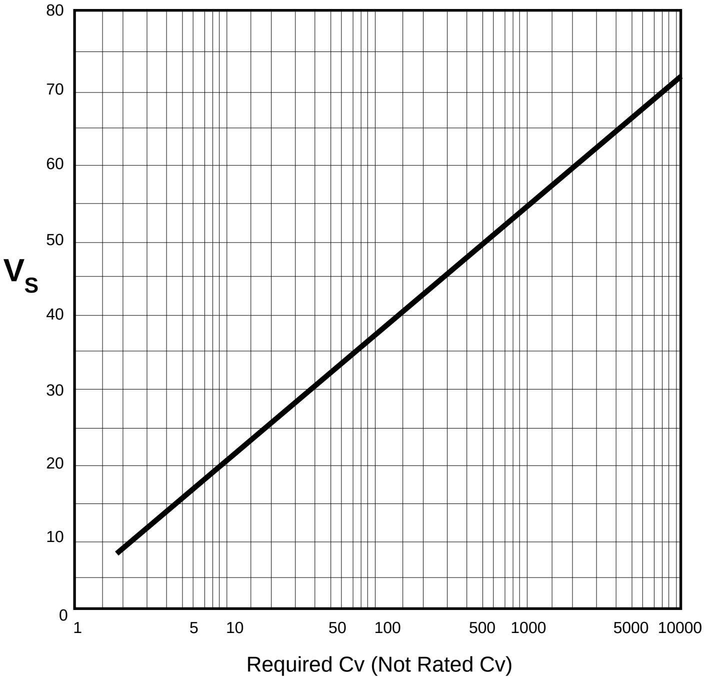

Figure 13-6: Flow Factor, V_S

Table 13-III: Temperature Correction Factor, T_S

Flowing temp. of gas	T_S
70°F	0
100°F	0
200°F	-1
300°F	-1.5
500°F	-2
700°F	-3
1000°F	-3.5
1200°F	-4

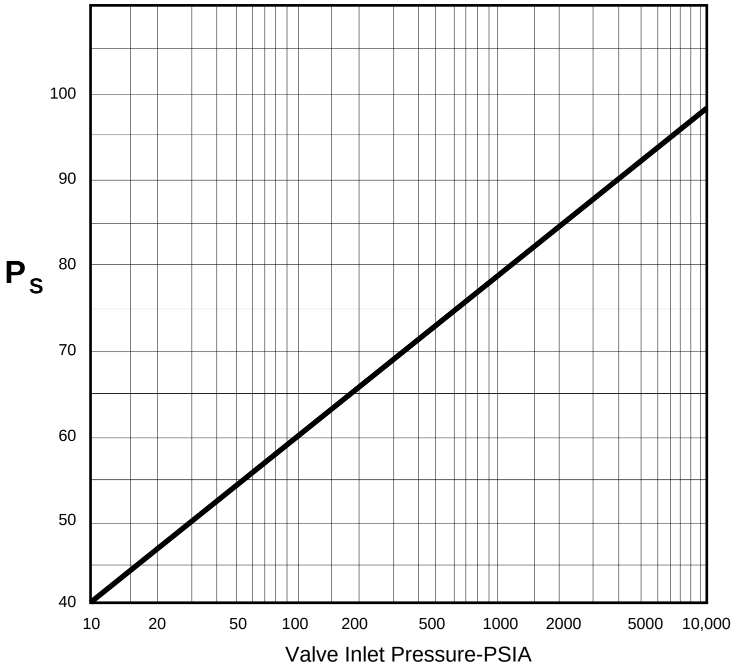

Figure 13-7: Pressure Factor, P_S

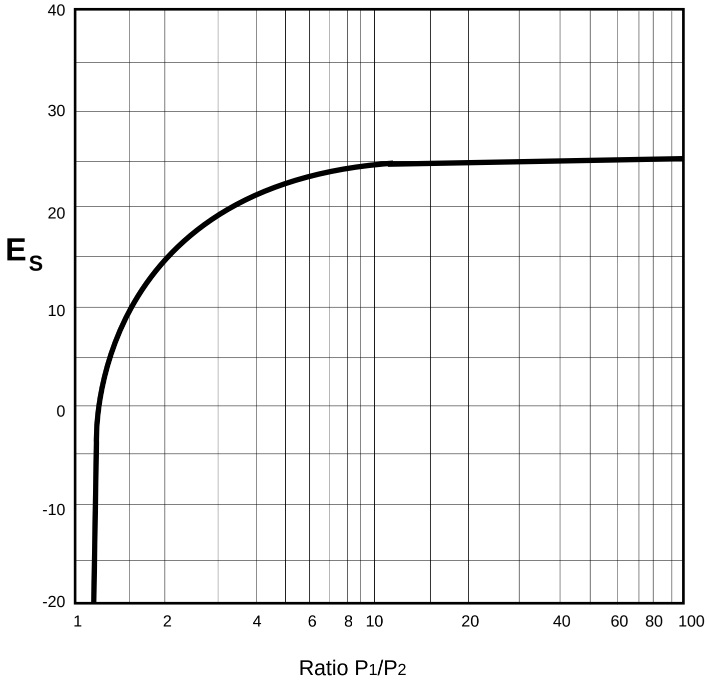

Figure 13-8: Pressure Ratio Factor, E_S

Gaseous Example

Given: 4-inch valve

Fluid	Steam
Temperature	450°F
P_1	125 psig
P_2	15 psi
C_V	46.2
Pipe Size	4-inch Schedule 40
Molecular Weight	18.02

Calculate P_1/P_2:

$$P_1/P_2 = \frac{139.7}{29.7} = 4.70$$

From the tables and charts

V_S = 31
P_S = 61
E_S = 22.5
T_S = -2
G_S = -1.0
A_S = -18.0
D_S = 0 (at a distance of 3 feet from the valve)
dBA = 31 + 61 + 22.5 - 2 - 1 - 18.0 + 0 = 93.5

The predicted noise level is for a valve in a non-reflective environment without insulation.

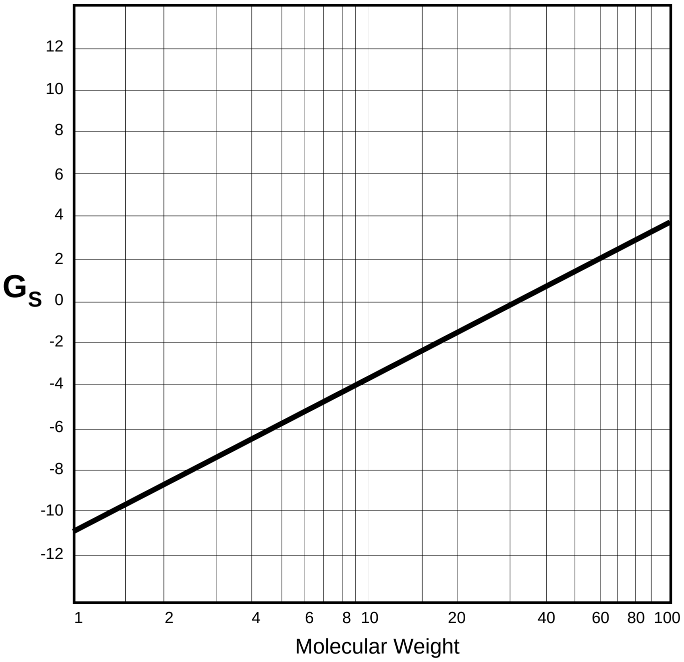

Figure 13-9: Gas Property Factor, G_S

Table 13-IV: Pipe Attenuation Factors, A_S (Gases Only)

	Pipe Schedule											
Pipe Size	10	20	30	40	60	80	100	120	140	160	Std.	XS	XXS
$^1/_2$				-8.0		-11.5				-13.1	-8.0	-11.5	-18.5
$^3/_4$				-10.0		-13.7				-17.0	-10.0	-13.7	-21.0
1				-11.4		-15.0				-18.8	-11.4	-15.0	-22.2
$1^1/_2$				-13.6		-17.6				-21.6	-13.6	-17.6	-25.5
2				-14.8		-19.2				-24.6	-14.8	-19.2	-27.4
3				-16.6		-20.8				-25.4	-16.8	-20.8	-29.1
4				-18.0		-22.4		-25.7		-28.0	-18.0	-22.4	-30.9
6				-20.0		-25.5		-28.8		-31.8	-20.0	-25.5	-34.1
8		-18.1	-19.4	-21.4	-24.3	-27.0	-29.1	-31.5	-33.1	-34.4	-21.4	-27.0	-34.0
10		-17.6	-20.3	-22.5	-26.6	-28.7	-31.2	-33.2	-35.3	-36.8	-22.5	-26.6	-35.3
12		-18.2	-21.8	-24.5	-28.5	-31.2	-33.8	-36.0	-37.4	-39.3	-24.5	-28.7	-36.0
14	-18.8	-21.6	-24.0	-26.0	-29.9	-32.9	-35.5	-37.7	-39.3	-40.8	-24.0	-28.5	
16	-19.5	-22.4	-24.8	-28.5	-32.0	-35.2	-37.7	-39.8	-41.9	-43.2	-24.8	-28.5	
18	-20.2	-23.1	-27.4	-30.7	-35.4	-37.2	-39.9	-42.1	-43.7	-45.3	-25.4	-29.0	
20	-20.8	-26.1	-29.8	-32.0	-36.0	-39.1	-41.8	-43.8	-45.7	-47.2	-26.1	-29.8	
24	-21.9	-27.1	-32.3	-34.9	-39.3	-42.3	-45.2	-47.3	-48.9	-50.5	-27.1	-29.5	
30	-26.1	-32.2	-35.1	-38.5	-42.7	-45.5	-48.3	-50.5			-26.0	-32.2	
36	-27.2	-33.3	-36.2	-42.0	-45.5	-48.5	-51.2				-26.4	-33.3	
42	-28.7	-37.0	-40.3	-44.5	-48.0	-50.7	-53.7				-26.7	-30.4	
48	-29.8	-39.0	-42.5	-46.5	-50.3	-53.0					-27.0	-30.5	
54	-30.5	-41.0	-44.3	-48.5	-52.2								
60	-31.2	-42.5	-45.7	-50.3	-53.5								