Simple Excel worksheet predicts control valve aerodynamic noise

Reader responses to a recent Valve World article about hydrodynamic noise in control valves have prompted Jon Monsen to prepare a similar solution for aerodynamic noise in control valves.

By Jon Monsen

About the author

Jon F. Monsen, PhD, PE, is a control valve technology specialist with more than 45 years of experience in the control valve industry. He has lectured nationally and internationally on the subjects of control valve application and sizing and is the author of the book *Control Valve Application Technology: Techniques and Considerations for Properly Selecting the Right Control Valve*. He currently hosts a web site, www.Control-Valve-Application-Tools.com where he freely shares articles, training and professional development materials, and Excel worksheets that might be of interest to those who use or specify control valves. He can be reached at cvapptools@gmail.com.

An article recently published in Valve World presented an easily constructed Excel sheet that estimates hydrodynamic noise in control valves[1]. A number of people have asked me if there is something similar available for aerodynamic noise. It turns out that Hans D. Baumann, an internationally recognszed control valve expert who has spent many years investigating control valve noise mechanisms and theory and who developed the method in Reference 1, also has a similar simplified method for estimating control valve aerodynamic noise. He has kindly given me permission to use it as a basis for an Excel worksheet which is the subject of this article.

The IEC standard

IEC 60534-8-3 Edition 3.0 is almost universally recognised as the preferred method for predicting control valve aerodynamic noise, and most control valve manufacturers include it in their control valve sizing and selection applications. For the user who wants to make quick noise predictions or to construct their own valve sizing application, programming the IEC noise standard can be a daunting task. For example, I have constructed an Excel sheet that exactly implements the IEC standard. It consists of 261 lines of formulas, a task that many would not have the time or enthusiasm for. Thus the justification for a simplified noise prediction method. Reliable valve noise test data is difficult to find unless you are a valve manufacturer, and in that case you tend not to share it. I did find ten noise tests that I believe to be reliable, and using this simplified noise prediction method, the average absolute error was 3.3 dB(A). Control valve noise prediction methods normally claim an accuracy of plus or minus 5 dB(A).

Calculation method

The calculation method is shown in Table 1. The method presented here is simple enough to be imple-

mented with a pocket calculator or one of the many calculator apps available for cell phones, but once one has constructed the Excel sheet, the calculations can be done even more quickly. We refer to this as the ABC method, partly because the term "ABC" is often recognised as something that is simple, and also because the main noise calculation is divided into three parts, named A, B and C. The balance of this article describes how to construct an Excel sheet that will implement these calculations. Screen 1 is an Excel worksheet that implements the calculations. To construct the worksheet, start by entering the text shown in black, all of which is simply plain text. Everything shown in green is the result of formulas that are entered in those cells. Column D, Rows 5 through 16, is where the user's process and valve data are entered. The numbers shown in red are the sample process and valve data that were used in the sample calculation. To test the worksheet, if you enter these sample data you should get the calculation results shown in green on Screen 1. The formulas for all the calculations rely on the cells in Column D having the names to their left in Column C. To name them, highlight both Columns C and D, rows 5 through 31. Select the Excel "Formulas" tab, select "Create from Selection" then check "Left column" and click "OK." Now all the cells in Column D, Rows 5 through 31 will have the names in the cells to their left. This makes it possible for all the formulas to use the actual names of each variable instead of simply cell references. For example, the inlet pressure, P_1, appears in all the formulas that depend on it as "P_1" instead as simply "D5." You can do this in one step. Excel will ignore any cells that have nothing in them. There are also formulas in B5, 6, 8 and 10. The worksheet includes the ability to change the engineering units of inlet and outlet pressure, the gas sonic velocity and the downstream pipe diameter. The choices of engineering units are made by entering a conversion factor in Column D, Rows 20, 21 and 22. The available options are listed in Column A Rows 20, 21 and 22. The user's selection entries
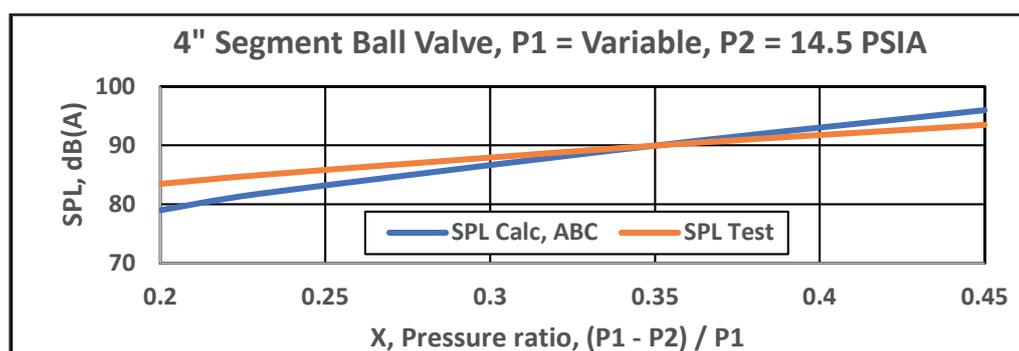

Figure 1. Comparison with an actual blowdown noise test.

Table 1. Calculation method

Initial intermediate calculations:
Pressure ratio, X = (P1 - P2) / P1
A = 25 log(D2) - 10 + 20 log(Cv / D2²)
B = 35 log(P1) - 35
C = 27 + 30 +30 log(X) + 20 log(Fd)
ΔF_L: if F_L < 0.7 then ΔF_L = 30 log(0.7 / F_L) otherwise,
ΔF_L=30 log(F_L / 0.7)
G = 20 log(ci / 1125) + 15 log(M / 28.97)
The final calculation combines the above intermediate calculations to obtain the estimated aerodynamic noise,
LpAe1m = A + B + C + ΔF_L + G – rw – ps

Nomenclature:
A: SPL due to downstream valve size and Cv
B: SPL due to upstream pressure
C: SPL due to pressure ratio and Fd
ΔF_L: SPL correction for F_L greater or less than 0.7
F_L: Valve Liquid pressure recovery factor at operating valve travel
P_1, P_2: pressure upstream and downstream of valve (psia)
D2: Pipe size downstream of valve (inch)
Cv: Valve flow coefficient at operating valve travel
Fd: Valve style modifier at operating valve travel
ci: Sonic velocity of the gas in feet per second. Air = 1125
M: Molecular mass of the gas. Air = 28.97
rw: SPL correction for globe valves, rw = 3. For all others rw = 0
ps: SPL correction for downstream pipe schedule

	A	B	C	D
1	**Control Valve Aerodynamic Noise**		Calculation method by Hans D. Baumann	
2	ABC Method		Worksheet by Jon F. Monsen	
3			**Name of cell**	
4	**Process Parameters**		**to the right**	**User Inputs**
5	Inlet pressure	psiA	P_1	116
6	Outlet pressure	psiA	P_2	58
7	Molecular mass (Air = 28.97)		M	28.97
8	Sonic velocity of the gas (Air = 1126 fps)	ft/sec	ci	1126
9	**Valve/Pipe Parameters**			
10	Downstream pipe diameter	inch	D_2	2
11	Valve capacity		C_v	54.5
12	Pressure recovery factor		F_L	0.82
13	Valve style modifier		F_d	0.25
14	**Modifiers**			
15	Downstream Pipe schedule (40=0, 80=4, 160=8)	dB	ps	0
16	Valve Style, rw (globe = 3, others = 0)	dB	rw	3
17	**Calculated SPL (LpAe₁ₘ)**	**dB(A)**	**SPL**	**92.5**
18				**User's**
19	**Engineering unit assignment**			**selection**
20	PRESSURE: psiA = 1; barA = 14.5 ; kPaA = 0.145		U_p	1
21	VELOCITY: ft/sec = 1; m/sec = 3.281		U_v	1
22	PIPE DIAMETER: inch = 1; mm = 0.03937		U_d	1
23				
24	**CALCULATIONS**			
25	x, Pressure ratio		X	0.50
26	ΔF_L		DELTA F_L	2.06
27	A	dB	A	20.21
28	B	dB	B	37.26
29	C	dB	C_	35.93
30	G, correction for gasses other than air		G	0.00
31	**LpAe1m = A+B+C+ΔF_L+G-rw-ps**	**dB(A)**	**LpAe1m**	**92.46**

Screen 1.

	D
17	**=IFERROR(LpAe1m,"")**
25	**=((P_1*U_p)-(P_2*U_p))/(P_1*U_p)**
26	**=IF(F_L<0.7,30*LOG10(0.7/F_L),30*LOG10(F_L/0.7))**
27	**=25*LOG10(D_2*U_d)-10+20*LOG10(C_v/(D_2*U_d)^2)**
28	**=35*LOG(P_1*U_p)-35**
29	**=27+30+30*LOG(X)+20*LOG(F_d)**
30	**=20*LOG(ci*U_v/1126)+15*LOG(M/28.97)**
31	**=A+B+C_+DELTA_F_L+G-rw-ps**

Screen 2.

in D 20, 21 and 22 use formulas in Column B Rows 5, 6, 8 and 10 to reflect the engineering units that the user has selected. The user's selection of units also modifies the calculation formulas appropriately.

Next, enter the formulas shown on Screen 2 in the appropriate cells. This requires great care for the Excel sheet to work properly. If you have accurately entered the process and valve data, and the formulas, you will get the calculated results shown in green on Screen 1. Also enter the formulas that show the user's selected engineering units as shown on Screen 3. Figure 1 shows a comparison of an actual blowdown noise test and the calculations made with the Excel sheet described in this article.

Optional extras

As an option, you can add an additional column of noise calculations by doing the following: First copy all the data entries that are in Column D (Cells D5 through D16) into the same rows of Column E. This will make it easier to follow your progress as you copy and convert formulas from Column D to Column E.

Next, copy all the formula entries (the ones in green in Column D of Screen 1) and paste

	B
5	=IF(U_p<1,"kPaA",IF(U_p>1,"barA","psiA"))
6	=IF(U_p<1,"kPaA",IF(U_p>1,"barA","psiA"))
7	
8	=IF(U_v>1,"m/sec","ft/sec")
9	
10	=IF(U_d<1,"mm","inch")

Screen 3.

them into the same rows of Column E. At this point, Column E will be giving noise calculations for process data in Column D. Next, you will need to convert the formulas you have pasted into Column E to make them rely on the data that will be in Column E. This is not too difficult. For example, to convert the formula for X in Column E, click on E25 and you will see the formula from Column D in the formula bar at the top of your Excel sheet. The formula references input data to P_1 and P_2, but in Column D. You need to change these to the refer-ences for P_1 and P_2 to their equivalent in Column E.

To do this, first highlight P_1 in the formula bar. Then point to the source for P_1 in Column E (Cell E6). Then highlight P_2 in the formula bar and click on its source in Column E (Cell E7). Finally, highlight the second instance of P_1 and then click on its reference in Column E. Save this converted formula by pressing "Enter." You now have a formula in Column E for X, Pressure ratio in E25 that is based on the entered values of P_1 and P_2 that are entered in Column E.

Your converted formula should be "=(E6-E7)/E6". This needs to be done for all your copied formulas (Column D, Rows 21 and 25 through 30.

If you choose to perform the above steps, it will be extremely easy to extend the work-sheet to include any number of calculations that you choose. For example, if you want to add another eight calculations to the work-sheet, do the following:

1. Select Column E, cells (E25 through E31). (Excel will ignore any empty cells.)
2. Copy these cells (ctrl + C).
3. Click on Cell F21 and drag the pointer to M21
4. Paste (ctrl + V)

You would then have a worksheet that will calculate aerodynamic noise for ten sets of conditions.

The Excel worksheet described above can be downloaded at: www.Control-Valve-Application-Tools.com/worksheets

Reference

Reference 1. Excel-worksheet predicts control valve hydrodynamic noise, Valve World, July 2022 pp 44 – 45

Reference 1 can be viewed at: www.Control-Valve-Application-Tools.com/Articles