Excel® Worksheets for Predicting

Aerodynamic Noise in Control Valves

In accordance with IEC 60534-8-3 Ed: 3.0

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DISCLAIMER

These worksheets are distributed on an as-is basis. The author does not assume any liability for their use. It is the user's responsibility to determine their applicability to their application.

Worksheet protection

I have protected the worksheets to prevent accidental changes to the formulas and calculation method. It is still possible to see the formulas that are used so that those who are interested can verify the calculation method, or use my calculation method and formulas in their own worksheet or other programming environments. If you want to make changes to the worksheet, there is no password, simply select "Unprotect Sheet" from the Excel "Review" tab, but you do so at your own risk.

If you design your own worksheet or other program using my formulas and calculation methods, leave my name off, as I don't want credit for any errors you may introduce.

About the worksheets

These worksheets calculate aerodynamic noise in control valves based on IEC 60534-8-3 Ed: 3.0, **INDUSTRIAL-PROCESS CONTROL VALVES – Part 8-3: Noise considerations – Control valve aerodynamic noise prediction method.**

If you are not interested in details about the worksheets and how they work, you can skip directly to the **Using the Worksheets** section.

The interested user can compare the worksheet calculations with the step-by-step calculations given in Annex A of the Standard, Examples 1 through 5. The Exception is Example 6 where the Standard, in Equation 38, has, in error, used the corresponding equation from Edition 2 of the Standard, which returns a value considerably different than the equation in Edition 3 of the Standard. To clarify, Equation 38 is shown correctly both in the main body of the Standard and in Example 6 in Appendix A, but it is the calculated value in Example 6 of Appendix A where the wrong equation has been used.

My comparison has shown very close agreement with Appendix A of the Standard. Most of the worksheet's calculations are either exactly on with each step of the Appendix, or at most are within 1/2% or less. In cases where the worksheet is not in exact agreement with the calculations in the Annex, doing a hand calculation with the precedents of a step from the Annex usually do not agree exactly with what the Annex gives for that calculation. It is my opinion that sometimes the Annex uses rounded values for subsequent calculations and other times uses the un-rounded values of precedents. In any case, the final SPL results given in that Standard are rounded to zero decimal places (which is reasonable) and the worksheet's rounded results (rounded to zero decimal places) agree exactly. This is the case for Examples 1 through 5. It is also the case for example 6 when the worksheet is modified manually to use the incorrect value for Equation 38.

Comparing the worksheet calculations with hand calculations or with the calculations in Annex A of the Standard to confirm that the worksheets do, indeed, follow the Standard has a significant benefit. Once this has been done, the calculations from the worksheet can be compared to the calculations of a manufacturer's proprietary valve sizing program (where the actual calculation method is hidden) to confirm that the manufacturer's software does, indeed, follow the Standard.

The User Interface ("UI") tab is, with one exception mentioned below, the only one most users will need to use. The "Calcs" tab is where all the calculations take place, but the casual user does not need to be concerned with these calculations.
The possible exception is the "Density, Molecular Mass" tab. The Standard requires the input of both the density and molecular mass of the flowing gas. Very often both of these properties will have been given. If either of those parameters has not been given, since these parameters are related, the user can find the missing of these two parameters in the "Density, Molecular Mass" tab based on known parameters input by the user on the "UI" tab.

The Standard only supports one set of engineering units, (kg/s, Pa, K, kg/m3, m/s, m).

Just below the Unser Interface area is a "**Unit Selection for user interface**" where the user can select the engineering units they wish to use. In the area to the right of the user interface is the **Conversion from user interface units to Units required by the IEC Standard** area**.** in this area, the user's selected engineering units are converted to the Standard's supported engineering units. From that point forward, all calculations are carried out in the units supported by the Standard.

To the right of the "**Conversion from user interface units to Units required by the IEC Standard"** is the calculation of the Piping geometry factor (F_P) and the combined liquid pressure recovery factor and piping geometry factor (F_{LP}). These two factors are defined in:
ANSI/ISA-75.01.01-2012 (60534-2-1 MOD) Industrial-Process Control Valves - Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions. The equation numbers in Column Y are for equations found in that Standard.

No attempt has been made to include multistage low noise valves in the calculations. There are many proprietary designs available with different capabilities and the necessary parameters for a noise calculation are likely to be difficult to obtain from valve manufacturers. If you see a noise problem in your calculations you should contact one or more manufacturers for their recommendations and their noise predictions.

The Standard includes a calculation for determining the value of F_d based on valve internal dimensions. I suspect that the main appeal of these worksheets will be to end users, who, would not have access to valve internal dimensions, so I have not included the calculation for F_d, but instead required that F_d be entered from manufacturer's literature.

On the "Calcs" tab, I have repeated the parameters in the **Conversion from user interface units to Units required by the IEC Standard** area. This may seem redundant, but I have done this for two reasons. 1) It should be easier for the interested user to follow the stepbystep calculations by viewing only the "Calcs" tab, and 2) this gives flexibility in the future to easily incorporate these noise calculations into Excel control valve sizing worksheets.

How the Worksheet Works

Each variable, constant or formula cell, is assigned, as its name, the variable name to its immediate left, and it is this name that is used whenever that cell's contents are used in a subsequent formula. With this knowledge, the user can easily see the flow of the calculations by studying the worksheet. (The names of the variable, constant or formula cells in Column D each are followed by two periods (..) and a number (1, 2, 3, or 4) to identify it as being in Column D, E, F or G. For example, on the User Interface the variable "Inlet pressure" in Column D has the name "P_1..1".
On the Calcs tab, only the first column of calculations uses names for each variable. The other 3 columns use only cell number references.

There are two worksheets. One for flow in mass flow units and one for standard volumetric flow units. The Standard supports only mass flow units. The volumetric flow sheet is identical to the mass flow sheet except that flow is entered in standard volumetric flow units. On the **Conversion from user interface units to Units required by the IEC Standard** volumetric flow units are converted to mass flow units. From that point on, the calculations of both sheets are identical.

The conversion from standard volumetric flow to mass flow is based on Crane's *Flow of Fluids* book where:

$W = \rho_a G Q$ where W is the mass flow, ρ_a is the density of air at standard temperature and pressure, G is the specific gravity of the flowing gas, and Q is the volumetric flow at standard conditions. The Volumetric flow (at standard temperature and pressure) worksheet includes conversions for flow in both scfh and m^3/h, and also, for standard reference temperatures of either 0C (32F) or 15C (60F).

Using the Worksheet

If the engineering units on the UI (User Interface) tab of the worksheets do not agree with your given data, scroll down to the **Unit Selection for user interface** area that is below the user interface. Type the option number into the blue **Flag value** column for the units you want to use that is listed in the **Options** column. The **Flag Value** does two things. 1) It changes the appropriate label in Column B of the user interface. 2) It implements the correct unit conversion factor in Columns S through V so that your chosen engineering unit is converted to the units that are required by the Standard. Note that changing the **Flag #** for Density changes both the units for the process density and for the “Density of pipe material.” Immediately below the user interface area in Column A is listed the density of steel pipe in both kg/m^3 and lbm/ft^3.

Enter the required process data in Column D (and optionally also E, F and G). The **Calculated results** fields will remain blank until all the required data (with the exception of the “**TAG”** field) is entered in the blue fields.

Ideally, valve parameters like F_L, F_d, A_η and St_p should be obtained from valve manufacturer’s literature. For preliminary calculations, you can use the typical data included at the end of this instruction. Before purchasing a valve, I recommend contacting your supplier(s) giving them a copy of your calculations and asking for their comment and recommendations. In the end, it is the valve supplier, who has intimate knowledge of their products, that should stand behind their recommendation.

The Standard requires both inlet density and molecular mass. Since these are related, if you only know one of these, once you have entered Inlet pressure and temperature and either molecular mass or inlet density, you can find the other parameter on the “Density, Molecular Mass” tab. You will most likely not know the compressibility factor of the process gas at process conditions. Using a compressibility factor of 1.0 is usually satisfactory. Small errors in gas density or molecular mass only have small effects on the calculated sound pressure level (SPL). If you are given specific gravity and not molecular mass, you can enter the specific gravity on the “Density, Molecular Mass” tab to get the corresponding molecular mass.,

Typical Liquid Pressure Recovery Factors (F_L)

	F_L at % of Rated Flow Capacity (C_v or K_v)					
Valve type	10	20	40	60	80	100
Globe, parabolic plug Flow-to-open	0.96	0.96	0.96	0.95	0.91	0.89

Globe, 4 V-port cage Flow into center	0.97	0.97	0.97	0.95	0.90	0.90
Multi-stage globe	0.99	0.99	0.99	0.99	0.99	0.99
Eccentric rotary plug Flow-to-open	0.91	0.89	0.85	0.82	0.78	0.76
Segment ball Flow into ball face	0.94	0.93	0.89	0.80	0.75	0.42
Full Ball Standard port	0.91	0.91	0.90	0.85	0.77	0.67
90 degree butterfly Shaft downstream	0.87	0.85	0.80	0.75	0.66	0.58

Typical Valve Style Modifier (F_d)

	F_d at % of Rated Flow Capacity (C_v or K_v)					
Valve type	10	20	40	60	80	100
Globe, parabolic plug Flow-to-open	0.12	0.18	0.25	0.32	0.38	0.48
Globe, 4 V-port cage Flow into center	0.42	0.43	0.37	0.29	0.35	0.39
Eccentric rotary plug Flow-to-open	0.12	0.18	0.22	0.30	0.36	0.42
Segment ball Flow into ball face	0.71	0.79	0.86	0.93	0.97	0.99
Full ball Standard port	0.43	0.66	0.85	0.94	0.98	1.0
90 degree butterfly Shaft downstream	0.14	0.14	0.18	0.26	0.33	0.36

Typical values of Valve correction factor for acoustic efficiency, A_η and Strouhal number for peak frequency calculation, St_p

	A_η	St_p
Globe parabolic plug	-4.2	0.19

Globe, cage	-3.8	0.2
Eccentric rotary plug	-3.6	0.3
Segment ball	-3.6	0.3
Butterfly	-4.2	0.3