IEC 60534-8-2

Edition 2.0 2011-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Industrial-process control valves –
Part 8-2: Noise considerations – Laboratory measurement of noise generated by hydrodynamic flow through control valves**

**Vannes de régulation des processus industriels –
Partie 8-2: Considérations sur le bruit – Mesure en laboratoire du bruit créé par un écoulement hydrodynamique dans une vanne de régulation**

IEC 60534-8-2:2011

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FOREWORD

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International Standard IEC 60534-8-2 has been prepared by subcommittee 65B: Measurements and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 1991 and constitutes a technical revision that includes internal noise measurement.

The text of this standard is based on the following documents:

FDIS	Report on voting
65B/801/FDIS	65B/808/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above Table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60534 series, published under the general title *Industrial-process control valves*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INDUSTRIAL-PROCESS CONTROL VALVES –

Part 8-2: Noise considerations – Laboratory measurement of noise generated by hydrodynamic flow through control valves

1 Scope

This part of IEC 60534-8 includes the method for measuring the sound pressure level due to liquid flow through a control valve and the method for determining the characteristic increase of noise due to the onset of cavitation. It also defines the equipment, methods and procedures for the laboratory measurement of the airborne sound needed to determine these characteristics.

Two methods are provided for testing the noise generating characteristics of control valves.

The first is a uniform method of measuring the radiated noise from the valve and the associated test piping including fixed flow restrictions through which the test fluid (water) is passing (see Note 1). The noise criteria are expressed by determining the sound pressure level of the valve under consideration.

The second is a procedure for measuring the sound pressure levels within pipe systems upstream and downstream of the valve under fixed operating conditions. Since inaccuracies due to the pipe transmission are eliminated, this method shall be preferred for evaluation of the acoustical characteristic of valves.

The noise characteristics to be determined are useful:

a) to determine acoustical characteristics of valves and valve assemblies and the characteristic pressure ratio factor x_{Fz} of a control valve;
b) to predict valve noise for given process conditions;
c) to compare the performance of different valves and various measuring results;
d) to plan measures for increasing service life and noise abatement;
e) to determine possible adverse effects on ultra-sonic flow meter measurements;
f) to enable proper sizing of sound absorbers.

NOTE 1 Test fluids other than water or valves without downstream piping are not within the scope of this section of IEC 60534-8.

NOTE 2 The factor x_{Fz} is used in a noise prediction method which is covered in IEC 60534-8-4.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60534-1:2005, *Industrial-process control valves – Part 1: Control valve terminology and general considerations*

IEC 60534-2-3:1997, *Industrial-process control valves – Part 2-3: Flow capacity – Test procedures*

IEC 60534-8-4, *Industrial-process control valves – Part 8-4: Noise considerations – Prediction of noise generated by hydrodynamic flow*

IEC 61672-1:2002, *Sound level meters – Part 1: Specifications*

ISO 3744:1994, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods in an essentially free field conditions over a reflecting plane*

ISO 3745:2003, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for anechoic and hemi-anechoic rooms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60534-1, as well as the following, apply.

3.1
test specimen
valve or combination of valve, reducer, expander, or other fittings for which test data are required. All parts/accessories necessary to operate the specimen properly shall be included

4 Symbols

Symbol	Description	Unit
C	Flow coefficient (C_v, K_v)	Various (see IEC 60534-1)
F_L	Pressure recovery factor of a control valve without attached fittings at choked flow	Dimensionless
F_{LP}	Pressure recovery factor of a control valve with attached fittings at choked flow	Dimensionless
F_p	Piping geometry factor	Dimensionless
L_{pi}	Internal sound pressure level at pipe wall	dB(ref P_o)
$\dot{m}$	Mass flow rate	kg/s
p_1	Inlet absolute static pressure	kPa or bar
p_2	Outlet absolute static pressure	kPa or bar
Δp	Differential pressure between upstream and downstream pressure taps ($p_1 - p_2$)	kPa or bar
Q	Volumetric flow rate	m^3/h
T_1	Inlet temperature	K
T_2	Outlet temperature	K
u	Mean (average fluid velocity)	m/s
x_F	Ratio of pressure differential to difference of the inlet pressure p_1 and the vapour pressure p_v ($\Delta p/(p_1-p_v)$)	Dimensionless
x_{Fz}	Value of x_F where cavitation noise becomes dominant over non-cavitating noise.	Dimensionless

5 General test criteria

5.1 General

Hydrodynamic noise may be measured externally as it radiates from the pipewall or internally as it propagates through the fluid. Both of these measurements can be made in either a closed loop or an open loop system and are shown in Figures 1a and 1b.

The following information is common to all test configurations.

5.2 Pressure regulating devices

The upstream and/or downstream regulating devices are used to regulate the test pressures. Caution should be taken to avoid a pressure differential which will create significant noise, i.e. cavitation. If such pressure drops are unavoidable, the use of silencers, see 5.6, is recommended as shown in Figure 1. Flow meters should be installed in accordance with the manufacturer's instructions.

5.3 Test specimen insulation

The test specimen shall not be provided with any insulation other than that attached by the manufacturer as part of the normal production for the test specimen.

5.4 Test section piping

There is no limitation concerning the maximum length of upstream and downstream piping connected to the test specimen. Uninsulated pipe shall be used. The exposed downstream or upstream pipe within the acoustic environment shall be of a straight one-piece construction, i.e. no flanges, circumferential joints or other pipewall reinforcements. The exposed length of the downstream pipe shall be as specified in Figure 2a or Figure 2b. The corresponding length of the upstream pipe shall be at least 1 m.

A mismatch between the inlet and outlet diameters of the test specimen with the inside diameter of the adjacent piping should be minimized as far as is practical. The distance of the pipe axis from the floor shall be approximately 1 m.

Other pipe wall thicknesses, pipe materials and insulated piping may be used but shall be reported in the test data as (an) optional test(s).

5.5 Pressure taps

Pressure taps shall be provided for the measurement of pressures and shall conform to IEC 60534-2-3.

5.6 Acoustic environment

The test environment shall be controlled in such a way that background, reflected, and other extraneous noise be at least 10 dB lower than that radiated by the test section. Depending on the test system and the acoustic environment, upstream and downstream silencers may be necessary. General considerations for the acoustic environment can be found in ISO 3744 and ISO 3745. No sound pressure level correction shall be made for the presence of extraneous noise.

5.7 Instrumentation

The instrumentation for sound pressure level measurement shall conform to IEC 61672-1 Class 1 or Class 2. Sound level meter characteristics shall conform to IEC 61272-1 Table 2 (A-weighting). Sound level meter calibration and sensitivity test results shall be corrected to sea level conditions.

Additional instrumentation such as electronic recording devices and computers shall not cause errors in the measured data of more than ± 1 dB.

6 External sound pressure measurement

6.1 General

Alternative test arrangements are shown in Figures 2a and 2b.

The test system according to Figure 2a includes the control valve as a noise radiating device.

The test system according to Figure 2b does not include the valve, however, it does provide a uniform sound field radiating from the pipe.

6.2 Instrumentation for noise measurement

The sound level sensor shall be located level with the centreline of the pipe 1 m from the nearest pipe surface. Downstream distance shall be six nominal pipe diameters, but not less than 1 m, from the test specimen outlet (see Figures 2a and 2b). Orientation of the microphone with respect to the piping shall be in accordance with the requirements of the microphone manufacturer.

6.3 Test data accuracy

Accuracy of flow rate, pressure and temperature measurements shall conform to IEC 60534-2-3.

6.4 Test data

The following data and description of the test specimen and equipment facility shall be recorded:

		Units
1	Absolute upstream pressure, p_1	kPa or bar
2	Differential pressure, Δp	kPa or bar
3	Differential pressure corresponding to characteristic pressure ratio, Δp_k	kPa or bar
4	Absolute vapour pressure, p_v	kPa or bar
5	Density of test fluid, ρ	kg/m^3
6	Upstream fluid temperature, T_1	K
7	Characteristic pressure ratio, x_{Fz} for orifice plate	Dimensionless
8	Flow rate, Q	m^3/h
9	Rated travel	mm or degrees
10	Relative travel, h	Dimensionless
11	Flow coefficient at test travels (A_v, K_v, C_v)	Various (see IEC 60534-1)
12	Relative flow coefficient at test travel, ϕ	Dimensionless
13	Characteristic pressure ratio, $x_{Fz,\phi}$ (see note)	Dimensionless
14	Sound pressure level for each measuring point L_p	dB or dB(A) (as required)
15	Peak frequency	Hz
16	Instruments used	
17	Sound level sensor position	

18	Description of test specimen including nominal size of valve, direction of flow, etc.
19	Description of test facility including: a) piping and instrumentation (schematic) b) nominal pipe size and wall thickness c) environmental chamber (if appropriate) d) dimensional sketch of test facility
20	Any deviation from this part of IEC 60534-8

NOTE See Clause 8 for values of ϕ at which test data are to be taken.

7 Internal sound pressure measurement

7.1 Test system

The principal arrangement of a test stand for measuring internal sound pressure is shown in Figure 1a.

The measuring arrangement and the equipment for measuring the parameters Q, T_1, p_1 and T_2, p_2 shall meet the requirements of IEC 60534-2-3.

The upstream silencer 4b and downstream silencer 9b shall be designed to avoid any increase of the measured noise due to sound power generated by the upstream pressure regulating valve 3 and downstream pressure regulating valve 9 and to prevent any acoustic reflections of the noise created by the measured device 6. The latter is fulfilled when the attenuation of the silencer reaches 15 dB in the considered frequency range.

7.2 Instrumentation for noise measurement

The sound level sensors exposed to the fluid shall be suitable for the given operating conditions. For the measurement of pressures which deviate considerably from the normal air pressure, dynamic pressure sensors are recommended. The dynamic range of the pressure sensor arrangement (range between background noise and over modulation) should amount to at least 80 dB. The frequency range should comprise 40 (63 Hz octave band or 50 Hz 1/3 octave band centre frequency) and 22 400 Hz (16 000 Hz octave band or 20 000 Hz 1/3 octave band centre frequency) with an amplitude deviation of ± 1 dB. Before and after each measuring procedure, the measuring system has to be tested by means of an acoustical calibrator.

NOTE Certain low noise trims have peak frequencies exceeding 16 000 Hz. Verification that the peak frequency is within the measuring range of the sound level meter before processing the measured data is recommended. The peak frequency is that frequency at which the sound pressure level decays by at least 4 dB per octave above and below this frequency.

Additional instrumentation such as electronic recording devices and computers shall not cause errors in the measured data of more than ± 1 dB.

7.3 Test fluid

Water is the only fluid to be used in the test procedure, because other incompressible fluids behave differently and do not allow a comparison of test data. The water shall be sufficiently free from suspended particles, air, or other gases so as to ensure that the test results are not affected.

The mean (average) fluid velocity u through the measuring area shall be limited by selecting a suitable nominal pipe diameter in such a way that the noise level caused by disturbances in the boundary layer is at least 5 dB lower than the measured internal sound pressure level.

7.4 Background noise

Background noise or noise induced by the measuring system, or by the test stand itself, shall be at least 5 dB lower than the measured internal sound pressure level in the octave band range between 63 Hz and 16 000 Hz.

7.5 Sound level sensor position

The sound level sensor positions shall be located within the measuring area. The tap for mounting the sound level sensors shall be situated at the lower part of the pipe for liquids. The tap shall be even with the inner pipe wall to avoid secondary noise generation (see Figure 7).

7.6 Test data accuracy

Accuracy of flow rate, pressure, travel, and temperature measurements shall conform to IEC 60534-2-3.

7.7 Test data

For the determination of the acoustical characteristics, the pressure ratios x_F at the test specimen have to be widely varied. A range of $x_F > 0,1$ is recommended. The following data shall be recorded:

1)	Absolute upstream pressure	kPa or bar
2)	Pressure differential and/or downstream pressure	kPa or bar
3)	Upstream fluid temperature	K
4)	Downstream fluid temperature	K
5)	Flow rate	m^3/h (see note), kg/s
6)	Relative travel	Dimensionless
7)	Acoustic data: The unweighted sound pressure levels L_{pi}, measured at 1/3 octave bands, in the octave band range 63 Hz to 16 000 Hz	dB
8)	Description of the test specimen, including at least the following	
	a) Nominal size of valve	
	a) Description of fittings	
	b) Description of flow direction	
	c) Rated flow coefficient C (K_v or C_v)	Various (see IEC 60534-1)
	d) Rated travel/opening angle	mm/°
9)	Description of the test facility including:	
	a) Piping and instrumentation schematic	
	b) Nominal pipe size and wall thickness	
	c) Pipe material	
	d) Dimensional sketch of test facility	
10)	Description of test fluid, including one of the following:	
	a) Absolute vapour pressure	kPa or bar
	b) Density	kg/m^3
11)	Description of instruments	
12)	Flow coefficient C (K_v or C_v) at the test travel	Various (see IEC 60534-1)
13)	Pressure recovery factor of a control valve without attached fittings at choked flow, F_L	Dimensionless
14)	Pressure recovery factor of a control valve with attached fittings at choked flow, F_{LP}	Dimensionless
15)	Piping geometry factor, F_p	Dimensionless
16)	Any deviation from this standard	

7.8 Accuracy

The overall accuracy of this method is limited to ± 3 dB.

7.9 Data evaluation

The data shall be evaluated in accordance with the IEC 60534-8-4.

The x_{Fz} factor can be determined alternatively based on the procedure as described in Clause 8 by using the internal sound pressure level L_{pi} instead of the external sound pressure level.

8 Determination of the characteristic pressure ratio x_{Fz}

8.1 General

The pressure ratio x_F is given as follows:

$$x_F = \frac{\Delta p}{p_1 - p_v}$$

When x_F is increased sufficiently, there is a transition from non-cavitating to cavitating flow. The pressure differential where the sound pressure level begins to increase due to cavitation during this transition is Δp_k. The corresponding ratio is the characteristic pressure ratio x_{Fz} and is defined as follows:

$$x_{Fz} = \frac{\Delta p_k}{p_1 - p_v} \bullet \left(\frac{p_1}{6 x 10^2} \right)^{0,125}$$

According to IEC 60534-8-4, x_{Fz} is related to the reference inlet pressure p_1= 6 bar (600 kPa). If other inlet pressures are used, they shall be corrected with the second term in the equation above (p_1 in kPa). Generally, x_{Fz} varies with travel and shall be measured at relative flow coefficients of 0,25, 0,50, 0,75 and 1,00 or the highest one achievable. When necessary, additional measurements with other relative flow coefficients should be included. With these values of x_{Fz}, linear interpolation may be used to obtain x_{Fz} values for other relative flow coefficients. The value of x_{Fz} at a relative flow coefficient ϕ is denoted as $x_{Fz,\phi}$. See Figure 3 for a typical curve of x_{Fz}.

8.2 Test procedures

8.2.1 Test fluid

Water is the only fluid to be used in the test procedure, because other incompressible fluids behave differently and do not allow a comparison of test data. The water shall be sufficiently free from suspended particles, air, or other gases so as to ensure that the test results are not affected. To accomplish this, the suitability of the water shall be tested first by using a special orifice plate, which is to be considered the reference test orifice plate (Figure 4). This orifice plate shall be installed in a DN 50 pipe (either permanently in a bypass or by changing the test section piping). The characteristic pressure ratio x_{Fz} for the orifice plate shall be determined at an absolute upstream pressure between 300 kPa and 400 kPa (3 bar and 4 bar). The value of x_{Fz} shall be not less than 0,35. Water within a temperature range of 5 °C to 40 °C shall be the basic fluid used in this test procedure. During the test, the temperature shall remain constant within ± 3 °C.

Other orifice plates may be used as an alternative provided the upstream pressure is as stated above. The dimensions shown in Figure 4 shall remain the same, except that the diameters shall be changed to maintain the same opening ratio of 0,25.

8.2.2 Test conditions for determination of x_{Fz}

The determination of x_{Fz} depends on many parameters. A detailed explanation is beyond the scope of this section of IEC 60534-8. To make the test results comparable, the following test conditions shall be maintained:

a) Either closed or open test loops may be used in accordance with Figure 1a and 1b, provided all requirements of this standard are met.

b) Absolute upstream pressure p_1 shall be in the range of 500 kPa to 700 kPa (5 bar to 7 bar). The selected test pressure shall be kept constant within ± 5 %.

NOTE Caution should be exercised not to exceed the rated service conditions of the valve.

c) To avoid incorrect results due to "cavitation hysteresis", the characteristic pressure ratio x_{Fz} shall be determined by decreasing the pressure ratio x_F in such a way that there is a transition from cavitating to non-cavitating flow.

d) Water within a temperature range of 5 °C to 40 °C shall be the basic fluid used in this test procedure. During the test, the temperature shall remain constant within ± 3 °C.

8.3 Determination of x_{Fz}

8.3.1 Peak frequency method

The determination of x_{Fz} by this method requires the measurement of the sound pressure level (L_p) at the peak frequency. The procedure is as follows (refer to Figure 5):

a) select a travel corresponding to one of the relative flow coefficients given in Clause 8;

b) decrease the pressure ratio x_F in such a way that there is a transition from cavitating to non-cavitating flow and measure L_p as a function of frequency for each value of x_F used;

c) from the data obtained in b), determine the approximate frequency which gives the maximum L_p response. This is the peak frequency;

d) using a sound level meter with an octave band filter that includes the peak frequency, measure the L_p as x_F is decreased. The range of x_F shall be sufficient to establish the curves in both the cavitating and non-cavitating regions;

e) in both the cavitating and non-cavitating regions, fit a straight line through the data points. The intersection of the straight lines shall determine the value of x_{Fz}. See point A in Figure 5;

f) repeat the procedure for the other relative flow coefficients given in Clause 8.

8.3.2 A-weighted method

This method of determining x_{Fz} requires the measurement of the overall sound pressure level (L_{pA}) using the A-weighted method. The procedure is as follows (refer to Figure 6):

a) at a given travel (corresponding to one of the relative flow coefficients given in Clause 8), the L_{pA} versus x_F curve as shown by the dashed line shall be determined. Decrease the pressure ratio x_F in such a way that there is a transition from cavitating to non-cavitating flow and measure L_{pA} for each value of x_F used;

b) from the above curve, x_{F3} and x_{F6}, which are the approximate values at which the L_{pA} curve changes slope, shall be determined;

c) the ranges Δx_{FI} and Δx_{FII} shall each be divided into three equal parts (designated as "a" and "b", respectively);

d) at each of the values x_{F6} through x_{F1}, the A-weighted overall sound pressure level shall be measured. This procedure shall be repeated twice so that there are three series of measurements;

e) for each value of x_F, the arithmetic average, $\overline{L_{pA}}$, of the three L_{pA} values shall be calculated and the points plotted;