SLOVENSKI STANDARD
SIST EN 60534-2-1:2011

01-julij-2011

Nadomešča:

SIST EN 60534-2-1:2001

Regulacijski ventili za industrijske procese - 2-1. del: Kapaciteta pretoka - Enačbe za določanje pretoka tekočin pri postavljenih pogojih (IEC 60534-2-1:2011)

Industrial-process control valves - Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions (IEC 60534-2-1:2011)

Stellventile für die Prozessregelung - Teil 2-1: Durchflusskapazität - Bemessungsgleichungen für Fluide unter Betriebsbedingungen (IEC 60534-2-1:2011)

Vannes de régulation des processus industriels - Partie 2-1: Capacité d'écoulement - Equations de dimensionnement pour l'écoulement des fluides dans les conditions d'installation (CEI 60534-2-1:2011)

Ta slovenski standard je istoveten z: **EN 60534-2-1:2011**

ICS:

23.060.40	Tlačni regulatorji	Pressure regulators
25.040.40	Merjenje in krmiljenje industrijskih postopkov	Industrial process measurement and control

SIST EN 60534-2-1:2011 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60534-2-1

May 2011

ICS 23.060.40; 25.040.40

Supersedes EN 60534-2-1:1998

English version

Industrial-process control valves -
Part 2-1: Flow capacity -
Sizing equations for fluid flow under installed conditions
(IEC 60534-2-1:2011)

Vannes de régulation des processus industriels -
Partie 2-1: Capacité d'écoulement -
Equations de dimensionnement pour l'écoulement des fluides dans les conditions d'installation
(CEI 60534-2-1:2011)

Stellventile für die Prozessregelung -
Teil 2-1: Durchflusskapazität -
Bemessungsgleichungen für Fluide unter Betriebsbedingungen
(IEC 60534-2-1:2011)

This European Standard was approved by CENELEC on 2011-05-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 60534-2-1:2011 E

Foreword

The text of document 65B/783/FDIS, future edition 2 of IEC 60534-2-1, prepared by SC 65B, Devices & process analysis, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60534-2-1 on 2011-05-04.

This European Standard supersedes EN 60534-2-1:1998.

EN 60534-2-1:2011 includes the following significant technical changes with respect to EN 60534-2-1:1998:

— the same fundamental flow model, but changes the equation framework to simplify the use of the standard by introducing the notion of Δp_{sizing};

— changes to the non-turbulent flow corrections and means of computing results;

— multi-stage sizing as an Annex.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-02-04
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2014-05-04

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60534-2-1:2011 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60534-1	2005	Industrial-process control valves - Part 1: Control valve terminology and general considerations	EN 60534-1	2005
IEC 60534-2-3	1997	Industrial-process control valves - Part 2-3: Flow capacity - Test procedures	EN 60534-2-3	1998

IEC 60534-2-1

Edition 2.0 2011-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Industrial-process control valves –
Part 2-1: Flow capacity – Sizing equations for fluid flow under installed conditions

Vannes de régulation des processus industriels –
Partie 2-1: Capacité d'écoulement – Equations de dimensionnement pour l'écoulement des fluides dans les conditions d'installation

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX
XA

ICS 23.060.40; 25.040.40

ISBN 978-2-88912-399-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS CONTROL VALVES –

Part 2-1: Flow capacity – Sizing equations for fluid flow under installed conditions

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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International Standard IEC 60534-2-1 has been prepared by subcommittee 65B: Measurement 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 1998. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- the same fundamental flow model, but changes the equation framework to simplify the use of the standard by introducing the notion of Δp_{sizing};
- changes to the non-turbulent flow corrections and means of computing results;
- multi-stage sizing as an Annex.

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

FDIS	Report on voting
65B/783/FDIS	65B/786/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 the parts of the IEC 60534 series, 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 2-1: Flow capacity – Sizing equations for fluid flow under installed conditions

1 Scope

This part of IEC 60534 includes equations for predicting the flow of compressible and incompressible fluids through control valves.

The equations for incompressible flow are based on standard hydrodynamic equations for Newtonian incompressible fluids. They are not intended for use when non-Newtonian fluids, fluid mixtures, slurries or liquid-solid conveyance systems are encountered. The equations for incompressible flow may be used with caution for non-vaporizing multi-component liquid mixtures. Refer to Clause 6 for additional information.

At very low ratios of pressure differential to absolute inlet pressure ($\Delta p/p_1$), compressible fluids behave similarly to incompressible fluids. Under such conditions, the sizing equations for compressible flow can be traced to the standard hydrodynamic equations for Newtonian incompressible fluids. However, increasing values of $\Delta p/p_1$ result in compressibility effects which require that the basic equations be modified by appropriate correction factors. The equations for compressible fluids are for use with ideal gas or vapor and are not intended for use with multiphase streams such as gas-liquid, vapor-liquid or gas-solid mixtures. Reasonable accuracy can only be maintained when the specific heat ratio, γ, is restricted to the range $1{,}08 < \gamma < 1{,}65$. Refer to Clause 7.2 for more information.

For compressible fluid applications, this standard is valid for valves with $x_T \leq 0{,}84$ (see Table D.2). For valves with $x_T > 0{,}84$ (e.g. some multistage valves), greater inaccuracy of flow prediction can be expected.

Reasonable accuracy can only be maintained for control valves if:

$$\frac{C}{N_{18} d^2} < 0{,}047$$

Note that while the equation structure utilized in this document departs radically from previous versions of the standard, the basic technology is relatively unchanged. The revised equation format was adopted to simplify presentation of the various equations and improve readability of the document.

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*

3 Terms and definitions

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

3.1
valve style modifier
the ratio of the hydraulic diameter of a single flow passage to the diameter of a circular orifice, the area of which is equivalent to the sum of areas of all identical flow passages at a given travel. It should be stated by the manufacturer as a function of travel (see Annex A).

3.2
standard volumetric flowrates
compressible fluid volumetric flow rates in cubic metres per hour, identified by the symbol Q_S, refer to either

a) *Standard* conditions, which is an absolute pressure of 1 013,25 mbar and a temperature of 288,6 K, or

b) *Normal* conditions, which is an absolute pressure of 1 013,25 mbar and a temperature of 273 K.

Numerical constants for the flow equations are provided for both conventions (see Table 1).

4 Symbols

Symbol	Description	Unit
C	Flow coefficient (K_v, C_v)	Various (see IEC 60534-1) (see Note 4)
d	Nominal valve size	mm
D	Internal diameter of the piping	mm
D_1	Internal diameter of upstream piping	mm
D_2	Internal diameter of downstream piping	mm
D_o	Orifice diameter	mm
F_d	Valve style modifier (see Annex A)	Dimensionless (see Note 4)
F_F	Liquid critical pressure ratio factor	Dimensionless
F_L	Liquid pressure recovery factor of a control valve without attached fittings	Dimensionless (see Note 4)
F_{LP}	Combined liquid pressure recovery factor and piping geometry factor of a control valve with attached fittings	Dimensionless
F_P	Piping geometry factor	Dimensionless
F_R	Reynolds number factor	Dimensionless
F_γ	Specific heat ratio factor	Dimensionless
M	Molecular mass of flowing fluid	kg/kmol
N	Numerical constants (see Table 1)	Various (see Note 1)
p_1	Inlet absolute static pressure measured at point A (see Figure 1)	kPa or bar (see Note 2)
p_2	Outlet absolute static pressure measured at point B (see Figure 1)	kPa or bar
p_c	Absolute thermodynamic critical pressure	kPa or bar
p_r	Reduced pressure (p_1/p_c)	Dimensionless
p_v	Absolute vapour pressure of the liquid at inlet temperature	kPa or bar
Δp_{actual}	Differential pressure between upstream and downstream pressure taps ($P_1 - P_2$)	kPa or bar
Δp_{choked}	Computed value of limiting pressure differential for incompressible flow	kPa or bar
Δp_{sizing}	Value of pressure differential used in computing flow or required flow coefficient for incompressible flows	kPa or bar
Q	Actual volumetric flow rate	m^3/h
Q_S	Standard volumetric flow rate (see definition 3.2)	m^3/h
Re_v	Valve Reynolds number	Dimensionless
T_1	Inlet absolute temperature	K
T_c	Absolute thermodynamic critical temperature	K
T_r	Reduced temperature (T_1/T_c)	Dimensionless
t_s	Absolute reference temperature for standard cubic metre	K
W	Mass flow rate	kg/h
x	Ratio of actual pressure differential to inlet absolute pressure ($\Delta P/P_1$)	Dimensionless
x_{choked}	Choked pressure drop ratio for compressible flow	Dimensionless
x_{sizing}	Value of pressure drop ratio used in computing flow or required flow coefficient for compressible flows	Dimensionless

Symbol	Description	Unit
x_T	Pressure differential ratio factor of a control valve without attached fittings at choked flow	Dimensionless (see Note 4)
x_{TP}	Pressure differential ratio factor of a control valve with attached fittings at choked flow	Dimensionless
Y	Expansion factor	Dimensionless
Z_1	Compressibility factor at inlet conditions	Dimensionless
ν	Kinematic viscosity	m^2/s (see Note 3)
ρ_1	Density of fluid at p_1 and T_1	kg/m^3
ρ_1/ρ_o	Relative density (ρ_1/ρ_o = 1,0 for water at 15 °C)	Dimensionless
γ	Specific heat ratio	Dimensionless
ζ	Velocity head loss coefficient of a reducer, expander or other fitting attached to a control valve or valve trim	Dimensionless
ζ_1	Upstream velocity head loss coefficient of fitting	Dimensionless
ζ_2	Downstream velocity head loss coefficient of fitting	Dimensionless
ζ_{B1}	Inlet Bernoulli coefficient	Dimensionless
ζ_{B2}	Outlet Bernoulli coefficient	Dimensionless

NOTE 1 To determine the units for the numerical constants, dimensional analysis may be performed on the appropriate equations using the units given in Table 1.

NOTE 2 1 bar = 10^2 kPa = 10^5 Pa

NOTE 3 1 centistoke = 10^{-6} m^2/s

NOTE 4 These values are travel-related and should be stated by the manufacturer.

5 Installation

In many industrial applications, reducers or other fittings are attached to the control valves. The effect of these types of fittings on the nominal flow coefficient of the control valve can be significant. A correction factor is introduced to account for this effect. Additional factors are introduced to take account of the fluid property characteristics that influence the flow capacity of a control valve.

In sizing control valves, using the relationships presented herein, the flow coefficients calculated are assumed to include all head losses between points A and B, as shown in Figure 1.