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

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



Stellventile für die Prozeßregelung -- Teil 2-1: Durchflußleistung - Bemessungsgleichungen für Fluide unter Einbaubedingungen



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

**Ta slovenski standard je istoveten z:** **EN 60534-2-1:1998**

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**ICS:**

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

**SIST EN 60534-2-1:2001** **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 60534-2-1

October 1998

ICS 23.060.40; 25.040.40

Supersedes EN 60534-2-1:1993 & EN 60534-2-2:1993

Descriptors: Industrial-process, control valves, installed conditions, flow capacity, sizing equations

English version

## Industrial-process control valves
## Part 2-1: Flow capacity - Sizing equations for fluid flow under installed conditions
## (IEC 60534-2-1:1998)

Vannes de régulation des processus industriels
Partie 2-1: Capacité d'écoulement
Equations de dimensionnement des vannes de régulation pour l'écoulement des fluides dans les conditions d'installation
(CEI 60534-2-1:1998)

Stellventile für die Prozeßregelung
Teil 2-1: Durchflußleistung
Bemessungsgleichungen für Fluide unter Einbaubedingungen
(IEC 60534-2-1:1998)



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

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of document 65B/347/FDIS, future edition 1 of IEC 60534-2-1, prepared by SC 65B, Devices, of IEC TC 65, Industrial-process measurement and control, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60534-2-1 on 1998-10-01.

This European Standard supersedes EN 60534-2-1:1993 and EN 60534-2-2:1993.

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) | 1999-07-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2001-07-01 |

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A, B, C, D and E are informative.
Annex ZA has been added by CENELEC.

## Endorsement notice



The text of the International Standard IEC 60534-2-1:1998 was approved by CENELEC as a European Standard without any modification.

## **Annex ZA** (normative)

### Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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 | 1987 | Industrial-process control valves<br>Part 1: Control valve terminology and general considerations | EN 60534-1 | 1993 |
| IEC 60534-2-3 | 1997 | Part 2-3: Flow capacity - Test procedures | EN 60534-2-3 | 1998 |

IEC 60534-2-1

Edition 1.0 1998-09

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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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: Devices, of IEC technical committee 65: Industrial-process measurement and control.

IEC 60534-2-1 cancels and replaces the first edition of both IEC 60534-2, published in 1978, and IEC 60534-2-2, published in 1980, which covered incompressible and compressible fluid flow, respectively.

IEC 60534-2-1 covers sizing equations for both incompressible and compressible fluid flow.

This bilingual version, published in 1999-03, corresponds to the English version.

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

| FDIS | Report on voting |
|---|---|
| 65B/347/FDIS | 65B/357/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.

Annexes A, B, C, D and E are for information only.

The contents of the corrigendum of February 2000 have been included in this copy.

# 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.

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 gas or vapour and are not intended for use with multiphase streams such as gas-liquid, vapour-liquid or gas-solid mixtures.



For compressible fluid applications, this part of IEC 60534 is valid for valves with $x_T \leq 0,84$ (see table 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 $K_v/d^2 < 0,04$ ($C_v/d^2 < 0,047$).

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60534. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60534 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60534-1:1987, *Industrial-process control valves – Part 1: Control valve terminology and general considerations*

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

## 3 Definitions

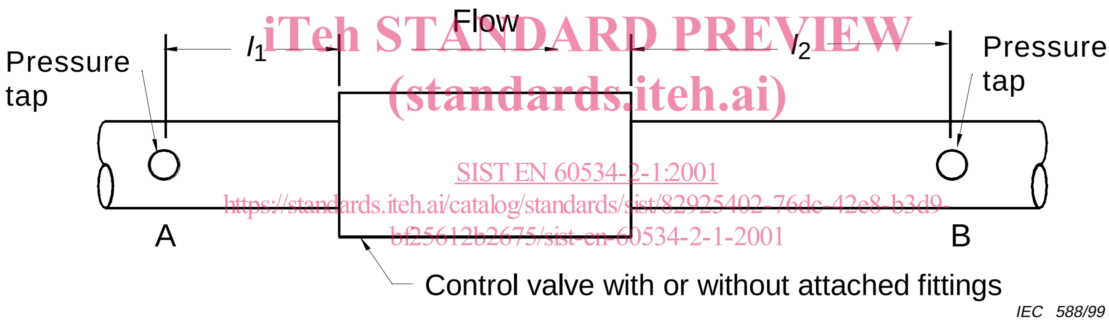
For the purpose of this part of IEC 60534, definitions given in IEC 60534-1 apply with the addition of the following:

**3.1**
**valve style modifier $F_d$**
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

## 4 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.






$l_1$ = two nominal pipe diameters

$l_2$ = six nominal pipe diameters

**Figure 1 – Reference pipe section for sizing**

## 5 Symbols

| Symbol | Description | Unit |
|---|---|---|
| $C$ | Flow coefficient ($K_v$, $C_v$) | Various (see IEC 60534-1) (see note 4) |
| $C_i$ | Assumed flow coefficient for iterative purposes | 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) | 1 (see note 4) |
| $F_F$ | Liquid critical pressure ratio factor | 1 |
| $F_L$ | Liquid pressure recovery factor of a control valve without attached fittings | 1 (see note 4) |
| $F_{LP}$ | Combined liquid pressure recovery factor and piping geometry factor of a control valve with attached fittings | 1 (see note 4) |
| $F_P$ | Piping geometry factor | 1 |
| $F_R$ | Reynolds number factor | 1 |
| $F_\gamma$ | Specific heat ratio factor | 1 |
| $M$ | 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 ($p_1/p_c$) | 1 |
| $p_v$ | Absolute vapour pressure of the liquid at inlet temperature | kPa or bar |
| $\Delta p$ | Differential pressure between upstream and downstream pressure taps ($p_1 - p_2$) | kPa or bar |
| $Q$ | Volumetric flow rate (see note 5) | $m^3/h$ |
| $Re_v$ | Valve Reynolds number | 1 |
| $T_1$ | Inlet absolute temperature | K |
| $T_c$ | Absolute thermodynamic critical temperature | K |
| $T_r$ | Reduced temperature ($T_1/T_c$) | 1 |
| $t_s$ | Absolute reference temperature for standard cubic metre | K |
| $W$ | Mass flow rate | kg/h |
| $x$ | Ratio of pressure differential to inlet absolute pressure ($\Delta p/p_1$) | 1 |
| $x_T$ | Pressure differential ratio factor of a control valve without attached fittings at choked flow | 1 (see note 4) |
| $x_{TP}$ | Pressure differential ratio factor of a control valve with attached fittings at choked flow | 1 (see note 4) |

| Symbol | Description | Unit |
|---|---|---|
| $Y$ | Expansion factor | 1 |
| $Z$ | Compressibility factor | 1 |
| $\nu$ | Kinematic viscosity | m²/s (see note 3) |
| $\rho_1$ | Density of fluid at $p_1$ and $T_1$ | kg/m³ |
| $\rho_1/\rho_o$ | Relative density ($\rho_1/\rho_o$ = 1,0 for water at 15 °C) | 1 |
| $\gamma$ | Specific heat ratio | 1 |
| $\zeta$ | Velocity head loss coefficient of a reducer, expander or other fitting attached to a control valve or valve trim | 1 |
| $\zeta_1$ | Upstream velocity head loss coefficient of fitting | 1 |
| $\zeta_2$ | Downstream velocity head loss coefficient of fitting | 1 |
| $\zeta_{B1}$ | Inlet Bernoulli coefficient | 1 |
| $\zeta_{B2}$ | Outlet Bernoulli coefficient | 1 |

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 = $10^{-6}$ m²/s

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

NOTE 5 – Volumetric flow rates in cubic metres per hour, identified by the symbol $Q$, refer to standard conditions. The standard cubic metre is taken at 1 013,25 mbar and either 273 K or 288 K (see table 1).



## 6 Sizing equations for incompressible fluids

The equations listed below identify the relationships between flow rates, flow coefficients, related installation factors, and pertinent service conditions for control valves handling incompressible fluids. Flow coefficients may be calculated using the appropriate equation selected from the ones given below. A sizing flow chart for incompressible fluids is given in annex B.

### 6.1 Turbulent flow

The equations for the flow rate of a Newtonian liquid through a control valve when operating under non-choked flow conditions are derived from the basic formula as given in IEC 60534-1.

#### 6.1.1 Non-choked turbulent flow

##### 6.1.1.1 Non-choked turbulent flow without attached fittings

$$\left[\text{Applicable if } \Delta p < F_L^{\,2}\left(p_1 - F_F \times p_v\right)\right]$$

The flow coefficient shall be determined by

$$C = \frac{Q}{N_1}\sqrt{\frac{\rho_1/\rho_o}{\Delta p}} \qquad (1)$$

NOTE 1 – The numerical constant $N_1$ depends on the units used in the general sizing equation and the type of flow coefficient: $K_v$ or $C_v$.

NOTE 2 – An example of sizing a valve with non-choked turbulent flow without attached fittings is given in annex D.

#### 6.1.1.2 Non-choked turbulent flow with attached fittings

$$\left\{ \text{Applicable if } \Delta p < \left[ \left( F_{LP} / F_P \right)^2 \left( p_1 - F_F \times p_v \right) \right] \right\}$$

The flow coefficient shall be determined as follows:

$$C = \frac{Q}{N_1 F_P} \sqrt{\frac{\rho_1 / \rho_o}{\Delta p}} \qquad (2)$$

NOTE – Refer to 8.1 for the piping geometry factor $F_P$.

### 6.1.2 Choked turbulent flow

The maximum rate at which flow will pass through a control valve at choked flow conditions shall be calculated from the following equations.

#### 6.1.2.1 Choked turbulent flow without attached fittings

$$\left[ \text{Applicable if } \Delta p \geq F_L^{\ 2} \left( p_1 - F_F \times p_v \right) \right]$$

The flow coefficient shall be determined as follows:

$$C = \frac{Q}{N_1 F_L} \sqrt{\frac{\rho_1 / \rho_o}{p_1 - F_F \times p_v}} \qquad (3)$$



NOTE – An example of sizing a valve with choked flow without attached fittings is given in annex D.



#### 6.1.2.2 Choked turbulent flow with attached fittings

$$\left[ \text{Applicable if } \Delta p \geq \left( F_{LP} / F_P \right)^2 \left( p_1 - F_F \times p_v \right) \right]$$



The following equation shall be used to calculate the flow coefficient:

$$C = \frac{Q}{N_1 F_{LP}} \sqrt{\frac{\rho_1 / \rho_o}{p_1 - F_F \times p_v}} \qquad (4)$$

### 6.2 Non-turbulent (laminar and transitional) flow

The equations for the flow rate of a Newtonian liquid through a control valve when operating under non-turbulent flow conditions are derived from the basic formula as given in IEC 60534-1. This equation is applicable if $Re_v$ < 10 000 (see equation (28)).

### 6.2.1 Non-turbulent flow without attached fittings

The flow coefficient shall be calculated as follows:

$$C = \frac{Q}{N_1 F_R} \sqrt{\frac{\rho_1 / \rho_o}{\Delta p}} \qquad (5)$$