

Industrial-process control valves —

Part 2-5: Flow capacity — Sizing equations for fluid flow through multistage control valves with interstage recovery

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British Standard

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National foreword

This British Standard is the official English language version of EN 60534-2-5:2003. It is identical with IEC 60534-2-5:2003.

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Summary of pages

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**Industrial-process control valves
Part 2-5: Flow capacity –
Sizing equations for fluid flow
through multistage control valves
with interstage recovery
(IEC 60534-2-5:2003)**

Vannes de régulation des processus industriels
Partie 2-5: Capacité d'écoulement –
Equations de dimensionnement
pour l'écoulement des fluides
dans les vannes de régulation
multi-étagées avec récupération
entre étages
(CEI 60534-2-5:2003)

Stellventile für die Prozessregelung
Teil 2-5: Durchflusskapazität –
Bemessungsgleichungen für Fluide
durch Mehrstufenregelventile
mit Druckrückgewinn
zwischen den Stufen
(IEC 60534-2-5:2003)

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CENELEC

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Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 65B/488/FDIS, future edition 1 of IEC 60534-2-5, 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 60534-2-5 on 2003-10-01.

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) 2004-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2006-10-01

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 and B are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60534-2-5:2003 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This part of IEC 60534 includes equations for predicting flow which are the same as IEC 60534-2-1. The differences in this multistage standard are:

- a) the equation for the calculation of expansion factor Y (equation 18);
- b) the non-inclusion of the section on sizing for laminar flow;
- c) the inclusion of stage interaction factor k (8.8) and reheat factor r (8.9);
- d) the addition of Tables for multistage valves for values of F_L and x_T .

The test data used to validate the method for numbers of stages from one to five was obtained from sizing tests carried out in accordance with IEC 60534-2-3 using air as the test medium at pressures varying from 5×10^5 Pa to $13,5 \times 10^5$ Pa and at temperatures of approximately 300 K. Some data was obtained under plant conditions using steam at pressures varying from 12×10^5 Pa to 110×10^5 Pa and temperatures from 460 K to 750 K.

The method is applicable to any number of stages but has only been validated up to five stages.

If valve specific coefficients (such as K_v or C_v , F_L , and x_T) cannot be determined by appropriate test procedures in IEC 60534-2-3, values supplied by the manufacturer should then be used.

INDUSTRIAL-PROCESS CONTROL VALVES –

Part 2-5: Flow capacity – Sizing equations for fluid flow through multistage control valves with interstage recovery

1 Scope

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

This standard is applicable only to those designs of multistage multipath control valves and multistage single path control valves.

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

IEC 60534-2-1:1998, *Industrial-process control valves – Part 2-1: Flow capacity – Sizing equations for fluid flow under installed conditions*

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 **multistage control valves**

a globe control valve where the trim has several stages which are separated by a gap (see Figures 1 and 2). The geometrical contour of the apertures in all stages must be similar. The ratio of the second stage flow coefficient C to the first stage flow coefficient C must not exceed 1,80. The ratio of the flow coefficient C of the other stages to their previous stage must not exceed 1,55 and must be uniform within a tolerance of $\pm 9\%$. Normally for incompressible fluids the flow coefficients of the stages are approximately equal, a slightly smaller flow coefficient C being allocated to a particular stage only if it is required to take a higher pressure drop.

3.2 **gap** the distance between adjacent stages

3.3 **multistage multipath control valves**

a globe control valve where the trim has multiple flow passages having several stages which are separated by a gap (see Figure 1). The gap should conform to the values calculated from the following equation with a tolerance of $+15\%$ and -10% (see Figures 1 and 2).

$$\text{gap} = \text{total hole area of adjacent upstream stage at rated travel} \times \frac{1}{l} \times \frac{1,589}{\sqrt{D_s}}$$

where

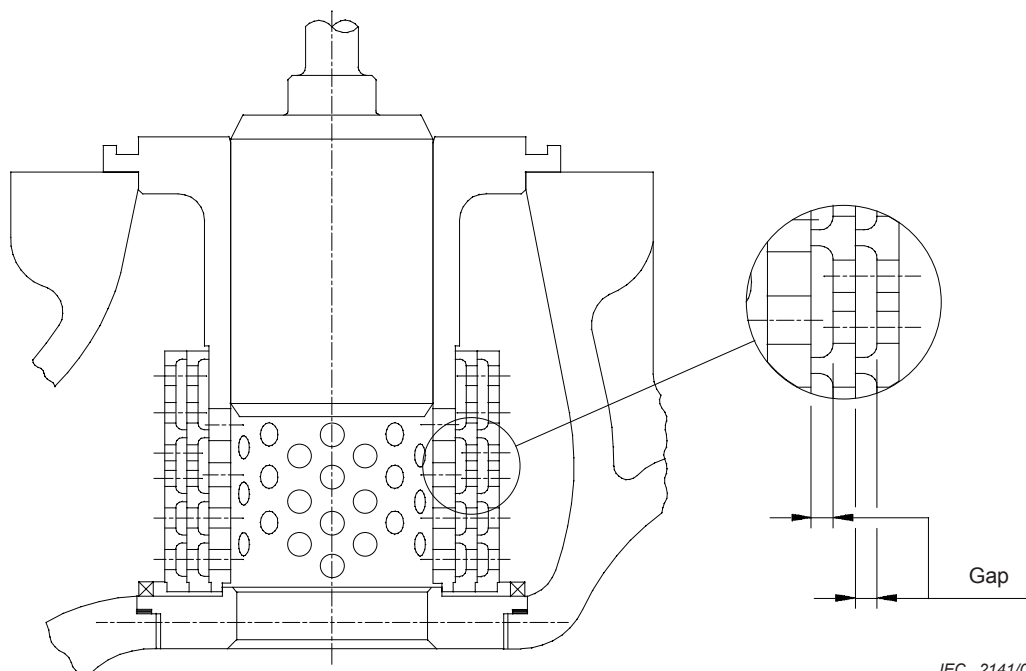
the total hole area is in mm^2 ;

l is the travel, in mm;

D_s is the outside diameter of adjacent upstream stage, in mm;

minimum gap limit = 4 mm;

maximum gap limit = 44 mm.



NOTE This is one example of a multistage trim.

Figure 1 – Multistage multipath trim

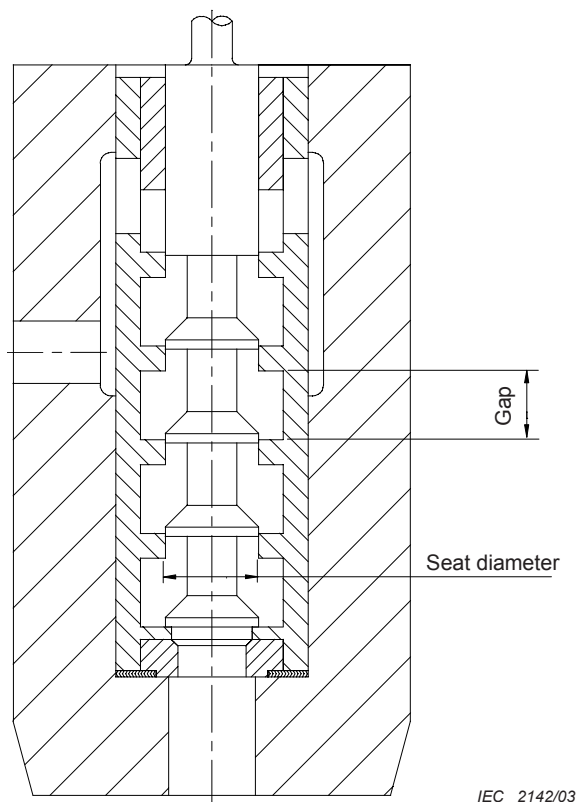
3.4

multistage single path control valves

a globe control valve where the trim has one flow passage having several stages which are separated by a gap (see Figure 2). The gap should be within the following minimum and maximum limits:

minimum gap = 0,60 times the seat diameter of the previous stage;

maximum gap = 1,10 times the seat diameter of the previous stage.



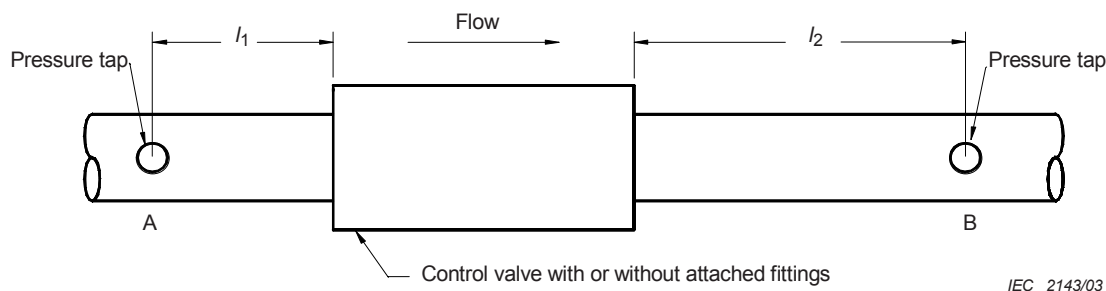
NOTE This is one example of a multistage trim.

Figure 2 – Multistage single path trim

4 Installation

In applications for single stage valves, the influence of reducers and other fittings may be significant. For multistage valves with $C_v/d^2 \leq 0,01$ ($K_v/d^2 \leq 0,0086$) they have virtually no effect.

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 3.



Key

l_1 = two nominal pipe diameters

l_2 = six nominal pipe diameters

Figure 3 – Reference pipe section for sizing

5 Symbols

Symbol	Description	Unit
C	Flow coefficient (K_v , C_v)	Various (see IEC 60534-1) (see Note 3)
C_i	Assumed flow coefficient for iterative purposes	Various (see IEC 60534-1) (see Note 3)
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_F	Liquid critical pressure ratio factor	1
F_L	Liquid pressure recovery factor of a control valve without attached fittings	1 (see Note 3)
F_{LP}	Combined liquid pressure recovery factor and piping geometry factor of a control valve with attached fittings	1 (see Note 3)
F_P	Piping geometry factor	1
F_γ	Specific heat ratio factor	1
k	Stage interaction factor	1
M	Molecular mass of flowing fluid	kg/kmol
N	Numerical constants (see Table 1)	Various (see Note 1)
n	Number of stages	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
Δp	Differential pressure between upstream and downstream pressure taps ($p_1 - p_2$)	kPa or bar
Q	Volumetric flow rate (see Note 4)	m ³ /h
r	Reheat factor	1