SLOVENSKI STANDARD
SIST EN ISO 5167-1:1997

01-april-1997

Merjenje pretoka fluida na osnovi razlike tlakov - 1. del: Zaslonke, šobe in Venturijeve cevi, vstavljene v polno zapolnjen vod s krožnim prerezom

Measurement of fluid flow by means of pressure differential devices - Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full (ISO 5167-1:1991)

Durchflußmessung von Fluiden mit Drosselgeräten - Teil 1: Blenden, Düsen und Venturirohre in voll durchströmten Leitungen mit Kreisquerschnitt (ISO 5167-1:1991)

Mesure de débit des fluides au moyen d'appareils déprimogenes - Partie 1: Diaphragmes, tuyeres et tubes de Venturi insérés dans des conduites en charge de section circulaire (ISO 5167-1:1991)

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ICS:

17.120.10 Pretok v zaprtih vodih Flow in closed conduits

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English version

Measurement of fluid flow by means of pressure differential devices - Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full (ISO 5167-1:1991)

Mesure de débit des fluides au moyen d'appareil déprimogènes - Partie 1: Diaphragmes, tuyères et tubes de Venturi insérés dans des conduites en charge de section circulaire (ISO 5167-1:1991)

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CEN

European Committee for Standardization
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Foreword

This European Standard was taken over by CEN from the work of ISO/TC 30 "Measurementof fluid flow in closed conduits" of the International Standards Organization (ISO).

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 1996 , and conflicting national standards shall be withdrawn at the latest by March 1996.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Endorsement notice

The text of the International Standard ISO 5167-1:1991 was approved by CEN as a European Standard without any modification.

NOTE: Normative references to International publications are listed in annex ZA (normative).

Annex ZA (normative)
Normative references to international publications with their relevant 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).

Publication	Year	Title	EN	Year
ISO 4006	1991	Measurement of fluid flow in closed conduits - Vocabulary and symbols	EN 24006	1993

INTERNATIONAL STANDARD

ISO 5167-1

First edition
1991-12-15

Measurement of fluid flow by means of pressure differential devices —

Part 1:
Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full

Mesure de débit des fluides au moyen d'appareils déprimogènes —

Partie 1: Diaphragmes, tuyères et tubes de Venturi insérés dans des conduites en charge de section circulaire

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Contents

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Annexes

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 5167-1 was prepared by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, Sub-Committee SC 2, *Pressure differential devices*.

This first edition of ISO 5167-1 cancels and replaces ISO 5167:1980, of which it constitutes a technical revision.

ISO 5167 consists of the following parts, under the general title *Measurement of fluid flow by means of pressure differential devices*:

— *Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full*

— *Part 2: Diaphragms or nozzles installed at the inlet of a conduit*

Annexes A, B, C, D and E of this part of ISO 5167 are for information only.

Measurement of fluid flow by means of pressure differential devices —

Part 1:
Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full

1 Scope

This part of ISO 5167 specifies the geometry and method of use (installation and operating conditions) of orifice plates, nozzles and Venturi tubes when they are inserted in a conduit running full to determine the flow-rate of the fluid flowing in the conduit. It also gives necessary information for calculating the flow-rate and its associated uncertainty.

It applies only to pressure differential devices in which the flow remains subsonic throughout the measuring section and is steady or varies only slowly with time and where the fluid can be considered as single-phase. In addition, each of these devices can only be used within specified limits of pipe size and Reynolds number. Thus this part of ISO 5167 cannot be used for pipe sizes less than 50 mm or more than 1 200 mm or for pipe Reynolds numbers below 3 150.

It deals with devices for which direct calibration experiments have been made, sufficient in number, spread and quality to enable coherent systems of application to be based on their results and coefficients to be given with certain predictable limits of uncertainty.

The devices introduced into the pipe are called "primary devices". The term primary device also includes the pressure tappings. All other instruments or devices required for the measurement are known as "secondary devices". This part of ISO 5167 covers primary devices; secondary devices[1] will be mentioned only occasionally.

1) See ISO 2186:1973, *Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements.*

The different primary devices dealt with in this part of ISO 5167 are as follows:

a) orifice plates, which can be used with corner pressure tappings, D and $D/2$ pressure tappings[2], and flange pressure tappings;

b) ISA 1932 nozzles[3], and long radius nozzles, which differ in shape and in the position of the pressure tappings;

c) classical Venturi tubes[4], and Venturi nozzles, which differ in shape and in the position of the pressure tappings.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5167. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5167 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 468:1982, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 4006:1991, *Measurement of fluid flow in closed conduits — Vocabulary and symbols.*

ISO 5168:—[5], *Measurement of fluid flow — Evaluation of uncertainties.*

3 Definitions

For the purposes of this part of ISO 5167, the definitions given in ISO 4006 apply.

The following definitions are given only for terms used in some special sense or for terms the meaning of which it seems useful to emphasize.

3.1 Pressure measurement

3.1.1 wall pressure tapping: Annular or circular hole drilled in the wall of a conduit in such a way that the edge of the hole is flush with the internal surface of the conduit.

The hole is usually circular but in certain cases may be an annular slot.

3.1.2 static pressure of a fluid flowing through a straight pipeline, p: Pressure which can be measured by connecting a pressure gauge to a wall pressure tapping. Only the value of the absolute static pressure is considered in this part of ISO 5167.

3.1.3 differential pressure, Δp: Difference between the (static) pressures measured at the wall pressure tappings, one of which is on the upstream side and the other of which is on the downstream side of a primary device (or in the throat for a Venturi tube) inserted in a straight pipe through which flow occurs, when any difference in height between the upstream and downstream tappings has been taken into account.

In this part of ISO 5167 the term "differential pressure" is used only if the pressure tappings are in the positions specified for each standard primary device.

3.1.4 pressure ratio, τ: Ratio of the absolute (static) pressure at the downstream pressure tapping to the absolute (static) pressure at the upstream pressure tapping.

2) Orifice plates with *vena contracta* pressure tappings are not considered in this part of ISO 5167.

3) ISA is the abbreviation for the International Federation of the National Standardizing Associations, which was succeeded by ISO in 1946.

4) In the USA the classical Venturi tube is sometimes called the Herschel Venturi tube.

5) To be published. (Revision of ISO 5168:1978)

3.2 Primary devices

3.2.1 orifice; throat: Opening of minimum cross-sectional area of a primary device.

Standard primary device orifices are circular and coaxial with the pipeline.

3.2.2 orifice plate: Thin plate in which a circular aperture has been machined.

Standard orifice plates are described as "thin plate" and "with sharp square edge", because the thickness of the plate is small compared with the diameter of the measuring section and because the upstream edge of the orifice is sharp and square.

3.2.3 nozzle: Device which consists of a convergent inlet connected to a cylindrical section generally called the "throat".

3.2.4 Venturi tube: Device which consists of a convergent inlet connected to a cylindrical part called the "throat" and an expanding section called the "divergent" which is conical.

If the convergent inlet is a standardized ISA 1932 nozzle, the device is called a "Venturi nozzle". If the convergent inlet is conical, the device is called a "classical Venturi tube".

3.2.5 diameter ratio of a primary device used in a given pipe, β: Ratio of the diameter of the orifice (or throat) of the primary device to the internal diameter of the measuring pipe upstream of the primary device.

However, when the primary device has a cylindrical section upstream, having the same diameter as that of the pipe (as in the case of the classical Venturi tube), the diameter ratio is the quotient of the throat diameter and the diameter of this cylindrical section at the plane of the upstream pressure tappings.

3.3 Flow

3.3.1 rate of flow of fluid passing through a primary device, q: Mass or volume of fluid passing through the orifice (or throat) per unit time; in all cases it is necessary to state explicitly whether the mass rate of flow q_m, expressed in mass per unit time, or the volume rate of flow q_V, expressed in volume per unit time, is being used.

3.3.2 Reynolds number, Re: Dimensionless parameter expressing the ratio between the inertia and viscous forces.

The Reynolds number used in this part of ISO 5167 is referred to

— either the upstream condition of the fluid and the upstream diameter of the pipe, i.e.

$$Re_D = \frac{U_1 D}{\nu_1} = \frac{4 q_m}{\pi \mu_1 D}$$

— or the orifice or throat diameter of the primary device, i.e.

$$Re_d = \frac{Re_D}{\beta}$$

3.3.3 Isentropic exponent, κ: Ratio of the relative variation in pressure to the corresponding relative variation in density under elementary reversible adiabatic (isentropic) transformation conditions.

The isentropic exponent κ appears in the different formulae for the expansibility [expansion] factor ε and varies with the nature of the gas and with its temperature and pressure.

There are many gases and vapours for which no values for κ have been published so far. In such a case, for the purposes of this part of ISO 5167, the ratio of the specific heat capacities of ideal gases can be used in place of the isentropic exponent.

3.3.4 discharge coefficient, C: Coefficient, defined for an incompressible fluid flow, which relates the actual flow-rate to the theoretical flow-rate through a device. It is given by the formula

$$C = \frac{q_m \sqrt{1 - \beta^4}}{\frac{\pi}{4} d^2 \sqrt{2 \Delta p \varrho_1}}$$

Calibration of standard primary devices by means of incompressible fluids (liquids) shows that the discharge coefficient is dependent only on the Reynolds number for a given primary device in a given installation.

The numerical value of C is the same for different installations whenever such installations are geometrically similar and the flows are characterized by identical Reynolds numbers.

The equations for the numerical values of C given in this part of ISO 5167 are based on data determined experimentally.

NOTE 1 The quantity $1/\sqrt{1-\beta^4}$ is called the "velocity of approach factor" and the product

$$C\frac{1}{\sqrt{1-\beta^4}}$$

is called the "flow coefficient".

3.3.5 expansibility [expansion] factor, ε: Coefficient used to take into account the compressibility of the fluid. It is given by the formula

$$\varepsilon = \frac{q_m\sqrt{1-\beta^4}}{\frac{\pi}{4}d^2C\sqrt{2\Delta p \varrho_1}}$$

Calibration of a given primary device by means of a compressible fluid (gas), shows that the ratio

$$\frac{q_m\sqrt{1-\beta^4}}{\frac{\pi}{4}d^2\sqrt{2\Delta p \varrho_1}}$$

is dependent on the value of the Reynolds number as well as on the values of the pressure ratio and the isentropic exponent of the gas.

The method adopted for representing these variations consists of multiplying the discharge coefficient C of the primary device considered, as determined by direct calibration carried out with liquids for the same value of the Reynolds number, by the expansibility [expansion] factor ε.

ε is equal to unity when the fluid is incompressible and is less than unity when the fluid is compressible.

This method is possible because experiments show that ε is practically independent of the Reynolds number and, for a given diameter ratio of a given primary device, ε only depends on the differential pressure, static pressure and the isentropic exponent.

The numerical values of ε for orifice plates given in this part of ISO 5167 are based on data determined experimentally. For nozzles and Venturi tubes they are based on the thermodynamic general energy equation.

3.3.6 arithmetical mean deviation of the (roughness) profile, R_a: Arithmetic mean deviation from the mean line of the profile being measured. The mean line is such that the sum of the squares of the distances between the effective surface and the mean line is a minimum. In practice R_a can be measured with standard equipment for machined surfaces but can only be estimated for rougher surfaces of pipes. (See also ISO 468.)

For pipes, the uniform equivalent roughness k is used. This value can be determined experimentally (see 8.3.1) or taken from tables (see annex E).

4 Symbols and subscripts

4.1 Symbols

Symbol	Quantity	Dimension[1]	SI unit
C	Coefficient of discharge	dimensionless	—
d	Diameter of orifice (or throat) of primary device at working conditions	L	m
D	Upstream internal pipe diameter (or upstream diameter of a classical Venturi tube) at working conditions	L	m
e	Relative uncertainty	dimensionless	—
k	Uniform equivalent roughness	L	m
l	Pressure tapping spacing	L	m
L	Relative pressure tapping spacing $L = \frac{l}{D}$	dimensionless	—
p	Absolute static pressure of the fluid	$ML^{-1}T^{-2}$	Pa
q_m	Mass rate of flow	MT^{-1}	kg/s
q_V	Volume rate of flow	L^3T^{-1}	m^3/s
R	Radius	L	m
R_a	Arithmetical mean deviation of the (roughness) profile	L	m
Re	Reynolds number	dimensionless	—
Re_D	Reynolds number referred to D	dimensionless	—
Re_d	Reynolds number referred to d	dimensionless	—
t	Temperature of the fluid	Θ	°C
U	Mean axial velocity of the fluid in the pipe	LT^{-1}	m/s
β	Diameter ratio $\beta = \frac{d}{D}$	dimensionless	—
γ	Ratio of specific heat capacities[2]	dimensionless	—
δ	Absolute uncertainty	[3]	[3]
Δp	Differential pressure	$ML^{-1}T^{-2}$	Pa
$\Delta \varpi$	Pressure loss	$ML^{-1}T^{-2}$	Pa
ε	Expansibility [expansion] factor	dimensionless	—
κ	Isentropic exponent[2]	dimensionless	—
μ	Dynamic viscosity of the fluid	$ML^{-1}T^{-2}$	Pa·s
ν	Kinematic viscosity of the fluid $\nu = \frac{\mu}{\varrho}$	L^2T^{-1}	m^2/s
ξ	Relative pressure loss	dimensionless	—
ϱ	Density of the fluid	ML^{-3}	kg/m^3
τ	Pressure ratio $\tau = \frac{p_2}{p_1}$	dimensionless	—
φ	Total angle of the divergent section	dimensionless	rad

1) M = mass, L = length, T = time, Θ = temperature.

2) γ is the ratio of the specific heat capacity at constant pressure to the specific heat capacity at constant volume. For ideal gases, the ratio of the specific heat capacities and the isentropic exponent have the same value (see 3.3.3). These values depend on the nature of the gas.

3) The dimensions and units are those of the corresponding quantity.