INTERNATIONAL STANDARD

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Second edition
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Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full —

Part 6: **Wedge meters**

Mesurage de débit des fluides au moyen d'appareils déprimogènes insérés dans des conduites en charge de section circulaire —

Partie 6: Débitmètres à coin

Reference number
ISO 5167-6:2022(E)

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, Subcommittee SC 2, *Pressure differential devices*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/SS F05, *Measuring instruments*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 5167-6:2019), which has been technically revised.

The main changes are as follows:

— this document is consistent with ISO/IEC Guide 98-3;

— an error in Annex B has been corrected;

— the expansibility uncertainty is given as a relative uncertainty for ease of use with Part 1 (the calculated flow rate uncertainty is unchanged).

A list of all the parts in the ISO 5167 series can be found on the ISO website.

Introduction

ISO 5167, consisting of six parts, covers the geometry and method of use (installation and operating conditions) of orifice plates, nozzles, Venturi tubes, cone and wedge meters when they are inserted in a conduit running full to determine the flow rate of the fluid flow in the conduit. It also gives necessary information for calculating the flow rate and its associated uncertainty.

ISO 5167 (all parts) is applicable only to pressure differential devices in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase, but it is not applicable to the measurement of pulsating flow. Furthermore, each of these devices can only be used within specified limits of pipe size and Reynolds number, *Re*.

ISO 5167 (all parts) 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. However, for wedge meters calibrated in accordance with Clause 7, a wider range of pipe size, β and Reynolds number can be considered.

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 to facilitate the instrument readings are known as secondary devices, and the flow computer that receives these readings and performs the algorithms is known as a tertiary device. ISO 5167 (all parts) covers primary devices; secondary devices (see ISO 2186) and tertiary devices will be mentioned only occasionally.

Aspects of safety are not dealt with in ISO 5167-1 to ISO 5167-6. It is the responsibility of the user to ensure that the system meets applicable safety regulations.

Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full —

Part 6: **Wedge meters**

1 Scope

This document specifies the geometry and method of use (installation and operating conditions) of wedge meters when they are inserted in a conduit running full to determine the flow rate of the fluid flowing in the conduit.

NOTE 1 As the uncertainty of an uncalibrated wedge meter can be too large for a particular application, it could be deemed essential to calibrate the flow meter according to Clause 7.

This document gives requirements for calibration which, if applied, are for use over the calibrated Reynolds number range. Clause 7 could also be useful guidance for calibration of meters of similar design but which fall outside the scope of this document.

It also provides background information for calculating the flow rate and is applicable in conjunction with the requirements given in ISO 5167-1.

This document is applicable only to wedge meters in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. Uncalibrated wedge meters can only be used within specified limits of pipe size, roughness, β (or wedge ratio) and Reynolds number. It is not applicable to the measurement of pulsating flow. It does not cover the use of uncalibrated wedge meters in pipes whose internal diameter is less than 50 mm or more than 600 mm, or where the pipe Reynolds numbers are below 1×10^4.

NOTE 2 A wedge meter has a primary element which consists of a wedge-shaped restriction of a specific geometry. Alternative designs of wedge meters are available; however, at the time of writing there is insufficient data to fully characterize these devices, and therefore these meters are calibrated in accordance with Clause 7.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4006, ISO 5167-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
wedge gap
h
maximum gap between the apex of the wedge element and the pipe wall, in the plane perpendicular to the pipe axis

Note 1 to entry: See Figure 1.

3.2
wedge ratio
ratio of the *wedge gap* (3.1) to the meter inlet diameter, *D*

Note 1 to entry: See ISO 4006:1991, Clause 2, for the meter inlet diameter, *D*.

3.3
wedge throat area
A_t
minimum cross-sectional open area of the wedge meter

4 Principles of the method of measurement and computation

The principle of the method of measurement is based on the installation of the wedge meter into a pipeline in which a fluid is running full. Flow through a wedge meter produces a differential pressure between the upstream and downstream tappings.

The mass flow rate can be determined by the following formulae:

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \varepsilon \frac{\pi}{4} (D\beta)^2 \sqrt{2\Delta p \rho_1} \tag{1}$$

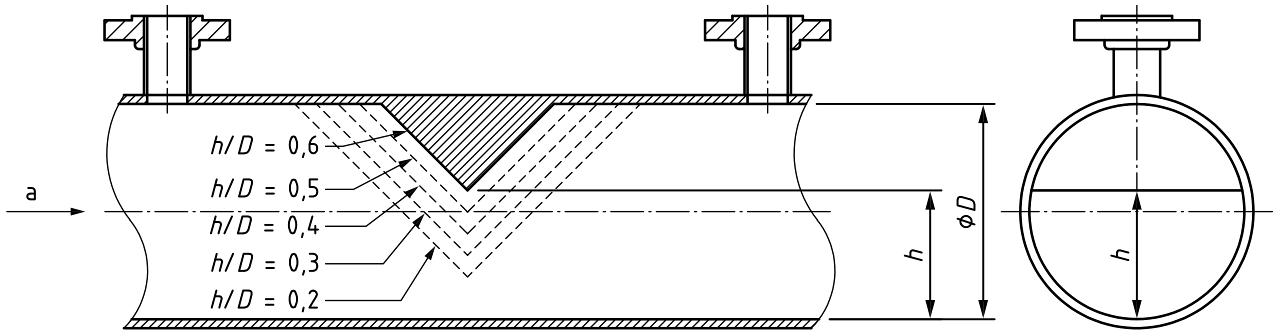
and

$$\beta = \sqrt{\frac{4A_t}{\pi D^2}} \tag{2}$$

A larger β corresponds to a larger wedge gap height, *h* (see Figure 1), and therefore a larger wedge throat area, A_t. The value of β can be calculated using Formula (3):

$$\beta = \sqrt{\frac{1}{\pi}\left[\arccos\left(1-\frac{2h}{D}\right) - 2\left(1-\frac{2h}{D}\right) \times \sqrt{\frac{h}{D}-\left(\frac{h}{D}\right)^2}\right]} \tag{3}$$

NOTE For example, h/D = 0,5 does not correspond to β = 0,5, but to $\beta = \sqrt{0,5} \approx 0,707$. β = 0,5 corresponds to $h/D \approx 0,298$.



a Direction of flow.

Figure 1 — Wedge meter showing different values of wedge ratio

The uncertainty limits can be calculated using the procedure given in ISO 5167-1:2022, Clause 8.

Similarly, the value of the volume flow rate can be calculated since

$$q_V = \frac{q_m}{\rho} \tag{4}$$

where ρ is the fluid density at the temperature and pressure for which the volume is stated.

Computation of the flow rate, which is a purely arithmetic process, is performed by replacing the different items on the right-hand side of Formula (1) by their numerical values. Formula (5) (or the computed values in Table A.1) gives wedge meter expansibility factors, ε. The values in Table A.1 are not intended for precise interpolation. Extrapolation is not permitted. However, for a meter calibrated according to Clause 7, the discharge coefficient, C, is generally related to the Reynolds number, Re, which is itself related to q_m, and has to be obtained by iteration (see ISO 5167-1:2022, Annex A, for guidance regarding the choice of iteration procedure and initial estimates).

The wedge gap, h, and the pipe diameter, D, mentioned in Formula (3) are the values of the lengths at working conditions. Measurements taken at any other conditions should be corrected for any possible expansion or contraction of the primary device and the pipe due to the values of the temperature and pressure of the fluid during the measurement.

As the wedge meter flow rate calculation is particularly sensitive to the pipe diameter and wedge gap values used, the user shall ensure that these are correctly entered into the flow computation calculations. The measured internal diameter shall be used rather than a nominal value.

It is necessary to know the density and the viscosity of the fluid at working conditions. In the case of a compressible fluid, it is also necessary to know the isentropic exponent of the fluid at working conditions.

5 Wedge meters

5.1 Field of application

Uncalibrated wedge meters can be used in pipes with diameters between 50 mm and 600 mm and with $0{,}377 \le \beta \le 0{,}791$ (wedge ratio $0{,}2 \le h/D \le 0{,}6$). Wedge meters with $\beta > 0{,}791$ ($h/D > 0{,}6$) or $\beta < 0{,}377$ ($h/D < 0{,}2$) are not normally manufactured.

There are limits to the roughness which are addressed in 5.2.3, 5.2.7, and 6.3.2. There are limits to the Reynolds number which are addressed in 5.5.2.

5.2 General shape

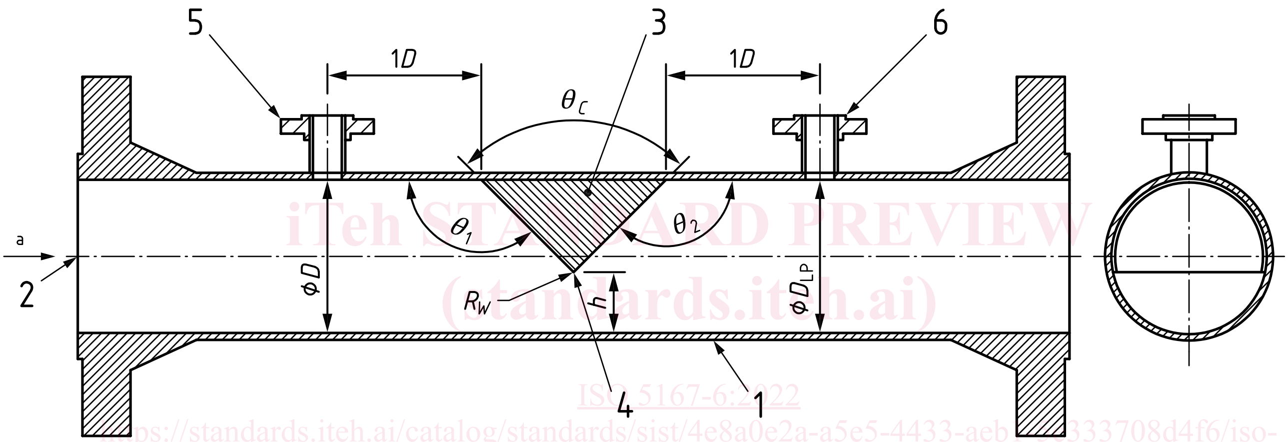
5.2.1 The wedge meter as shown in Figure 2 comprises (listed in the direction of flow) an entrance cylinder, an upstream pressure tapping, a pipe section including the wedge element, a downstream pressure tapping, and an exit cylinder. The form of the pressure tappings is described in 5.4.

5.2.2 The diameter *D* shall be measured at the plane of the upstream tapping. The number of measurements shall be a minimum of four equally spaced around the pipe internal circumference. The arithmetic mean value of these measurements shall be taken as the value of *D* in the calculations.

The minimum entrance cylinder length shall be 0,5*D*. The minimum exit cylinder length shall be 0,5*D*.

Diameters shall also be measured in planes other than the plane of the upstream pressure tapping.

No diameter along the wedge meter shall differ by more than 0,4 % from the value of the mean diameter. This requirement is satisfied when the difference in the length of any of the measured diameters complies with the said requirement with respect to the mean of the measured diameters.



Key

1 meter body

2 meter body centreline

3 wedge element

4 wedge apex

5 high pressure tapping

6 low pressure tapping

a Direction of flow.

Figure 2 — Geometric profile of wedge meter

5.2.3 The internal surface of the pipe section between the planes of the upstream and downstream tappings shall be clean and smooth, and the roughness criterion, *Ra*, should be as small as possible and shall be less than $10^{-3}D$.

5.2.4 The wedge plane angle, θ_c, shall be 90° ± 2° at all points of intersection along the span of the wedge apex. The span of the wedge apex shall be perpendicular to the centreline of the tappings and also to the centreline of the wedge meter.

5.2.5 The radius of curvature of the wedge apex, R_w, as shown in Figure 3, shall be less than or equal to 1 mm along the span of the wedge apex.

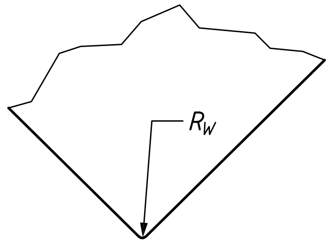


Figure 3 — Radius of curvature, R_w, at the wedge apex

5.2.6 The upstream external angle, θ_1, and downstream external angle, θ_2, of the wedge shall be measured and shall both be equal to 135° ± 2°.

5.2.7 The wedge surface shall be clean and smooth, and the roughness criterion, *Ra*, shall be as small as possible and shall always be less than $10^{-3}D$.

5.2.8 Where the wedge is attached to the meter body by welding, the manufacturer should take care to minimize the size of the weld beads within the limits required for structural integrity.

5.2.9 Where the wedge is attached to the meter body by welding, the manufacturer shall ensure there is no intrusion of the weld into the design throat area.

5.3 Material and manufacture

5.3.1 The wedge meter may be manufactured from any material and using any construction technique, provided that the wedge meter is in accordance with the foregoing description and will remain so during use.

5.3.2 Hollow wedge element designs shall include a pressure equalization system to ensure the structural stability of the wedge under rapid pressure changes.

5.4 Pressure tappings

5.4.1 The upstream tapping shall be made either in the form of a pipe wall pressure tapping or a large bore branch tapping. It is recommended that the tappings be as small as compatible with the fluid (for example, with its viscosity and contaminants).

The large bore tapping design may be considered to be more applicable for slurry, corrosive fluids, or fluids which require diaphragm seals.

5.4.2 The centreline of the tappings shall be perpendicular to and pass through the centreline of the meter body (see Figure 2). The centreline of the tappings shall also be perpendicular to the line of the wedge apex ±2°. The tappings shall be located on the same side of the meter body as the wedge element.

5.4.3 The centreline of the tappings shall be located $1D \pm 0{,}02D$ from the nearest point of the wedge element.

5.4.4 The diameter of pipe wall pressure tappings shall be between 4 mm and 10 mm.