INTERNATIONAL STANDARD

ISO 5167-5

First edition
2016-03-01

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

Part 5: **Cone meters**

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

Partie 5: Cônes de mesure

Reference number
ISO 5167-5:2016(E)

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Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 30, *Measurement of fluid flow in closed conduits*, Subcommittee SC 2, *Pressure differential devices*.

The first edition of ISO 5167-5 is complementary to ISO 5167-1, ISO 5167-2, ISO 5167-3, and ISO 5167-4.

ISO 5167 consists of the following parts, under the general title *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*:

— *Part 1: General principles and requirements*

— *Part 2: Orifice plates*

— *Part 3: Nozzles and Venturi nozzles*

— *Part 4: Venturi tubes*

— *Part 5: Cone meters*

Introduction

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

This International Standard 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.

This International Standard 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 cone meters calibrated in accordance with Clause 7, a wider range of pipe size, β, and Reynolds number may 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 for the measurement are known as "secondary devices". This International Standard covers primary devices; secondary devices[1][5] will be mentioned only occasionally.

This International Standard is divided into the following five parts:

a) ISO 5167-1 gives general terms and definitions, symbols, principles, and requirements as well as methods of measurement and uncertainty that are to be used in conjunction with ISO 5167-1, ISO 5167-2, ISO 5167-3, ISO 5167-4, and ISO 5167-5.

b) ISO 5167-2 specifies requirements for orifice plates, which can be used with corner pressure tappings, D and $D/2$ pressure tappings[1)], and flange pressure tappings.

c) ISO 5167-3 specifies requirements for ISA 1932 nozzles[2)], long radius nozzles, and Venturi nozzles, which differ in shape and in the position of the pressure tappings.

d) ISO 5167-4 specifies requirements for classical Venturi tubes[3)].

e) This part of ISO 5167 specifies requirements for cone meters and includes a section on calibration.

Aspects of safety are not dealt with in ISO 5167 (all parts). It is the responsibility of the user to ensure that the system meets applicable safety regulations.

1) Orifice plates with 'vena contracta' pressure tappings are not considered in ISO 5167 (all parts).

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

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

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

Part 5:
Cone meters

1 Scope

This part of ISO 5167 specifies the geometry and method of use (installation and operating conditions) of cone meters when they are inserted in a conduit running full to determine the flow rate of the fluid flowing in the conduit.

As the uncertainty of an uncalibrated cone meter might be too high for a particular application, it might be deemed essential to calibrate the flow meter in accordance with Clause 7.

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

This part of ISO 5167 is applicable only to cone meters in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. Uncalibrated cone meters can only be used within specified limits of pipe size, roughness, β, and Reynolds number. This part of ISO 5167 is not applicable to the measurement of pulsating flow. It does not cover the use of uncalibrated cone meters in pipes sized less than 50 mm or more than 500 mm, or where the pipe Reynolds numbers are below 8×10^4 or greater than $1,2 \times 10^7$.

A cone meter is a primary device which consists of a cone-shaped restriction held concentrically in the centre of the pipe with the nose of the cone upstream. The design of cone meter defined in this part of ISO 5167 has one or more upstream pressure tappings in the wall, and a downstream pressure tapping positioned in the back face of the cone with the connection to a differential pressure transmitter being a hole through the cone to the support bar, and then up through the support bar.

Alternative designs of cone meters are available; however, at the time of writing, there is insufficient data to fully characterize these devices, and therefore, these meters shall be calibrated in accordance with Clause 7.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 5167-1:2003, *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.

3.1
beta edge
maximum circumference of the cone

4 Principles of the method of measurement and computation

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

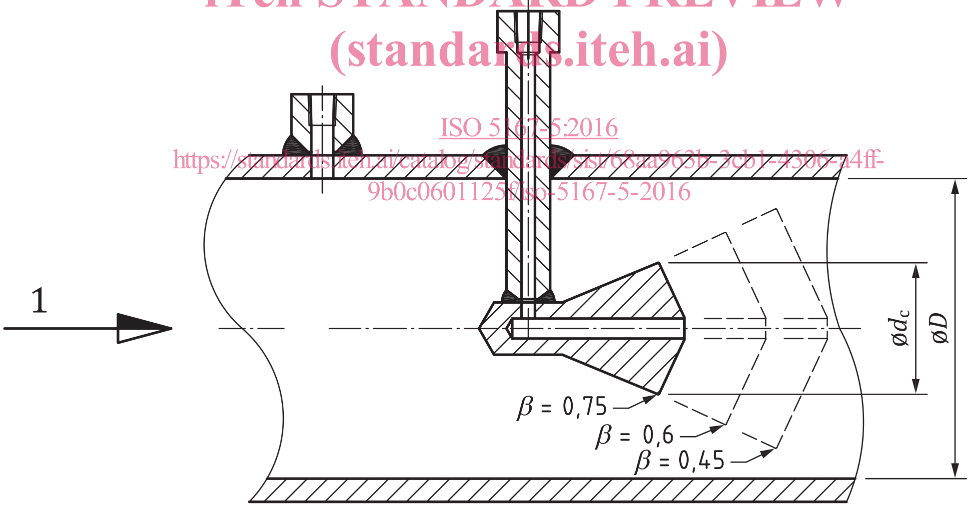
The mass flow rate can be determined by Formulae (1) and (2):

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

and

$$\beta = \sqrt{1 - \frac{d_c^2}{D^2}} \qquad (2)$$

where d_c is the diameter of the cone in the plane of the beta edge. This assumes that the diameter of the pipe at the upstream tapping, D_{TAP}, is equal to the diameter of the pipe at the beta edge, D. Figure 1 shows that as the cone diameter increases, β decreases.



Key

1 flow

Figure 1 — Cone meter showing different values of β

The uncertainty limits can be calculated using the procedure given in ISO 5167-1:2003, Clause 8, except that Formula (3) should be used instead of ISO 5167-1:2003, Formula (3)

$$\frac{\delta q_m}{q_m}=\left[\left(\frac{\delta C}{C}\right)^2+\left(\frac{\delta \varepsilon}{\varepsilon}\right)^2+\left(\frac{2(1+\beta^2+\beta^4)}{\beta^2(1+\beta^2)}\right)^2\left(\frac{\delta D}{D}\right)^2+\left(\frac{2}{\beta^2(1+\beta^2)}\right)^2\left(\frac{\delta d_c}{d_c}\right)^2+\frac{1}{4}\left(\frac{\delta \Delta p}{\Delta p}\right)^2+\frac{1}{4}\left(\frac{\delta \rho_1}{\rho_1}\right)^2\right]^{1/2}$$

(3)

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) in 5.6 (or the computed values in Table A.1) gives cone meter expansibility factors (ε). The values in Table A.1 are not intended for precise interpolation. Extrapolation is not permitted. However, the coefficient of discharge, C, is generally dependent on the Reynolds number, Re, which is itself dependent on q_m, and has to be obtained by iteration (see ISO 5167-1:2003, Annex A for guidance regarding the choice of iteration procedure and initial estimates).

The diameters, d_c and D, mentioned in Formulae (1) and (2) are the values of the diameters 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 cone meter flow rate calculation is particularly sensitive to the pipe and cone diameter values used, the user shall ensure that these are correctly entered into the flow computation calculations. For example, care shall be taken to use the measured internal diameter 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.

NOTE The turndown of all differential pressure flow meters is dependent upon the differential pressure range. Typically, a 10:1 turndown in flow rate (equivalent to 100:1 turndown in differential pressure) can be achieved.

5 Cone meters

5.1 Field of application

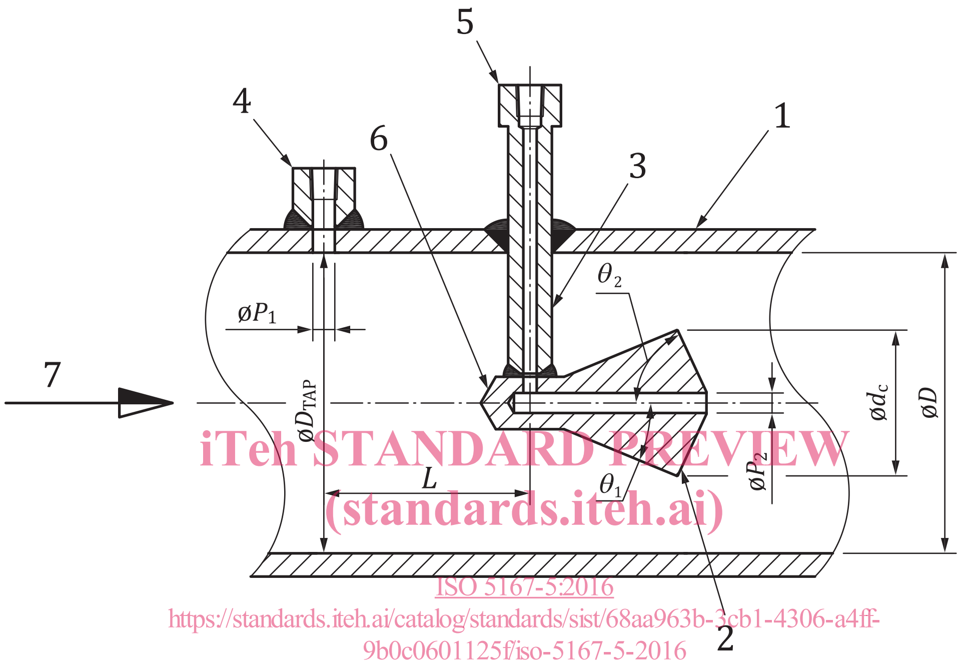
Uncalibrated cone meters can be used in pipes with diameters between 50 mm and 500 mm and with $0{,}45 \le \beta \le 0{,}75$. Cone meters with $\beta > 0{,}75$ shall be calibrated. Cone meters with values of $\beta < 0{,}45$ are not normally manufactured.

There are limits to the roughness and Reynolds number which shall be addressed.

5.2 General shape

5.2.1 Figure 2 shows a section through the centreline of a cone meter. Figure 4 shows other sections through the meter to aid in the metrology of the cone meter. The letters used in the text refer to those shown in Figure 2 and Figure 4.

The cone meter is made up of a pipe section of diameter, D, which houses the cone assembly with cone diameter, d_c, the support structure for the cone, and the tappings for differential pressure measurement. The cone assembly is installed such that the cone centreline is concentric to the centreline of the pipe section, as per 5.2.13.



Key

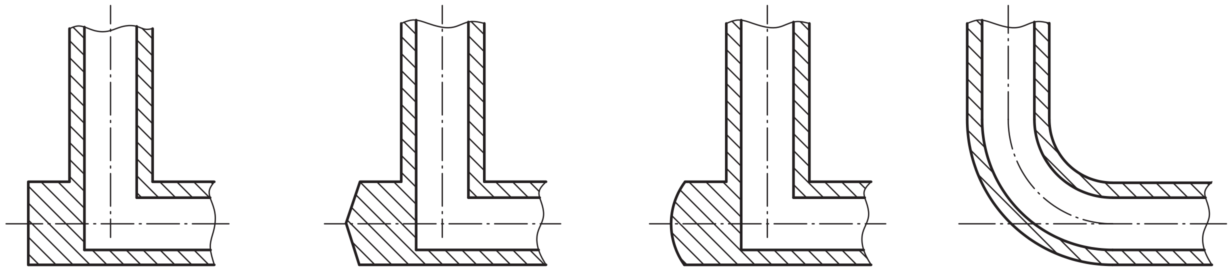
1 flow
2 body pipe
3 cone element
4 support strut
5 high pressure tapping
6 low pressure tapping
7 cone nose

NOTE 50 mm ≤ L ≤ 2D, as defined in 5.4.7.

Figure 2 — Geometric profile of cone meter

5.2.2 The design of the nose of the cone (for examples, see Figure 3) can be constructed as a machined component or from an elbow. The nose shall be downstream of the plane of the centreline of the upstream tapping(s). It is recommended that the nose be as short as practicable.

These designs shown in Figure 3 should not be considered exclusive.



a) Flat b) Pointed c) Curved d) Elbow

Figure 3 — Examples of different cone nose designs

5.2.3 The pipe diameter, *D*, shall be measured at plane A of Figure 4. 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.

5.2.4 The pipe diameter shall also be measured at plane C of Figure 4 (shown as D_{TAP} in Figure 2). The number of measurements at this plane shall be at least equal to the number of pressure tappings (with a minimum of four).

5.2.5 No diameter at any point between plane C and 1*D* downstream of plane A from Figure 4 shall differ from the pipe diameter, *D*, by more than 1,0 %.