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

Part 3:
Nozzles and Venturi nozzles

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

Partie 3: Tuyères et Venturi-tuyères

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

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

This first edition of ISO 5167-3, together with the second edition of ISO 5167-1 and the first editions of ISO 5167-2 and ISO 5167-4, cancels and replaces the first edition of ISO 5167-1:1991, which has been technically revised, and ISO 5167-1:1991/Amd.1:1998.

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*

Introduction

ISO 5167, consisting of four parts, covers 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 flowrate of the fluid flowing in the conduit. It also gives necessary information for calculating the flowrate 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 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.

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.

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”. ISO 5167 (all parts) covers primary devices; secondary devices[1)] will be mentioned only occasionally.

ISO 5167 consists of the following four 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 5167-2, ISO 5167-3 and ISO 5167-4.

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

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

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

Aspects of safety are not dealt with in Parts 1 to 4 of ISO 5167. It is the responsibility of the user to ensure that the system meets applicable safety regulations.

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

2) Orifice plates with “vena contracta” pressure tappings are not considered in 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.

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

Part 3:
Nozzles and Venturi nozzles

1 Scope

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

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

This part of ISO 5167 is applicable to nozzles and Venturi nozzles in which the flow remains subsonic throughout the measuring section and where the fluid can be considered as single-phase. In addition, each of the devices can only be used within specified limits of pipe size and Reynolds number. It is not applicable to the measurement of pulsating flow. It does not cover the use of nozzles and Venturi nozzles in pipe sizes less than 50 mm or more than 630 mm, or where the pipe Reynolds numbers are below 10 000.

This part of ISO 5167 deals with

a) two types of standard nozzles:

   1) the ISA[5] 1932 nozzle;

   2) the long radius nozzle[6];

b) the Venturi nozzle.

The two types of standard nozzle are fundamentally different and are described separately in this part of ISO 5167. The Venturi nozzle has the same upstream face as the ISA 1932 nozzle, but has a divergent section and, therefore, a different location for the downstream pressure tappings, and is described separately. This design has a lower pressure loss than a similar nozzle. For both of these nozzles and for the Venturi nozzle 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.

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

6) The long radius nozzle differs from the ISA 1932 nozzle in shape and in the position of the pressure tappings.

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.

ISO 4006:1991, *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 and ISO 5167-1 apply.

4 Principles of the method of measurement and computation

The principle of the method of measurement is based on the installation of a nozzle or a Venturi nozzle into a pipeline in which a fluid is running full. The installation of the primary device causes a static pressure difference between the upstream side and the throat. The flowrate can be determined from the measured value of this pressure difference and from the knowledge of the characteristics of the flowing fluid as well as the circumstances under which the device is being used. It is assumed that the device is geometrically similar to one on which calibration has been carried out and that the conditions of use are the same, i.e. that it is in accordance with this part of ISO 5167.

The mass flowrate can be determined by Equation (1):

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

The uncertainty limits can be calculated using the procedure given in Clause 8 of ISO 5167-1:2003.

Similarly, the value of the volume flowrate can be calculated since

$$q_V = \frac{q_m}{\rho} \tag{2}$$

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

Computation of the flowrate, which is a purely arithmetic process, is performed by replacing the different items on the right-hand side of Equation (1) by their numerical values. Tables A.1 to A.4 are given for convenience. Tables A.1 to A.3 give the values of C as a function of β. Table A.4 gives expansibility (expansion) factors ε. They are not intended for precise interpolation. Extrapolation is not permitted.

The coefficient of discharge C may be dependent on Re_D, which is itself dependent on q_m and has to be obtained by iteration. (See ISO 5167-1 for guidance regarding the choice of the iteration procedure and initial estimates.)

The diameters d and D mentioned in Equation (1) 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.