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Measurement of fluid flow in closed conduits — Thermal mass flowmeters

Mesure de débit des fluides dans les conduites fermées — Débitmètres massiques par effet thermique

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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 of 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 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 5, *Velocity and mass methods*.

This second edition cancels and replaces the first edition (ISO 14511:2001), of which it constitutes a minor revision.

The changes compared to the previous edition are as follows:

— the sentence *"The measurand temperature difference between the two sensors is proportional to the mass flow rate"* has been removed from 5.1;

— the references to the VIM and GUM Guides have been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document has been prepared to guide those concerned with the specification, testing, inspection, installation, operation and calibration of thermal mass gas flowmeters.

A list of standards related to this document is given in the Bibliography.

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Measurement of fluid flow in closed conduits — Thermal mass flowmeters

1 Scope

This document gives guidelines for the specification, testing, inspection, installation, operation and calibration of thermal mass gas flowmeters for the metering of gases and gas mixtures. It is not applicable to measuring liquid mass flowrates using thermal mass flowmeters.

This document is not applicable to hot wire and other hot film anemometers, also used in making point velocity measurements.

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/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

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

ISO 7066-2, *Assessment of uncertainty in the calibration and use of flow measurement devices — Part 2: Non-linear calibration relationships*

IEC 61000-4, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4006 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 http://www.electropedia.org/

3.1 General terms

3.1.1
flowrate
quotient of the quantity of fluid passing through the cross-section of a conduit and the time taken for this quantity to pass through this section

Note 1 to entry: In this International Standard, the term “flowrate” is used as a synonym for mass flowrate, unless otherwise stated.

3.1.2
mass flowrate
flowrate in which the quantity of fluid is expressed as a mass

Note 1 to entry: The term “flowrate” is used as a synonym for mass flowrate in this International Standard, unless otherwise stated.

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3.1.3
uncertainty of measurement
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that can reasonably be attributed to the measurand

Note 1 to entry: To explain the closeness of agreement between the result of a measurement and a true value of the measurand the expression “accuracy of measurement” is used.

Note 2 to entry: Accuracy is a qualitative concept.

3.1.4
repeatability
<measuring instrument> ability of a measuring instrument to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement

Note 1 to entry: These conditions include:

— minimized variations resulting from the observer;

— the same measurement procedure;

— the same observer;

— the same measuring equipment, used under the same conditions;

— the same location;

— repeated measurements within a short period of time.

3.1.5
flow profile
graphic representation of the velocity distribution

Note 1 to entry: The point flow velocity across the cross-section of a conduit is not constant. It varies as a consequence of upstream and downstream disturbances and with the Reynolds number of the flow stream. For a fully developed flow, the point flow velocity varies from 0 m/s at the pipe wall to a maximum value at the conduit centre. The flow profile describes the variation of the flow velocity across the conduit cross-section and may be expressed mathematically or graphically.

3.2 Specific terms

3.2.1
sensor
element of a measuring instrument or measuring chain that is directly affected by the measurand

3.2.2
laminar flow element
element inserted into the gas stream to establish a constant ratio between the main flow stream and the bypass flow through the sensor

3.2.3
thermal mass flowmeter
TMF meter
flow-measuring device which uses heat transfer to measure and indicate mass flowrate

Note 1 to entry: The term thermal mass flowmeter also applies to the measuring portion of a thermal mass flow controller and not the control function.

3.2.4
capillary thermal mass flowmeter
CTMF meter
TMF meter normally consisting of a laminar flow element, bypass tube (capillary), temperature sensors (some designs include a separate heater) with supporting electronics and housing

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3.2.5
insertion and/or in-line thermal mass flowmeter
ITMF meter
TMF meter normally consisting of one or two temperature sensing sensors (some designs have a separate heater) with supporting structure, electronics and housing, of which the sensors are exposed to the full gas stream

3.2.5.1
insertion-ITMF meter
ITMF meter with the sensors mounted on a probe, inserted through the process conduit wall, into the gas stream

3.2.5.2
in-line ITMF meter
ITMF meter with the sensors mounted in a flow body which serves as an integral part of the conduit

3.2.6
mass flow controller
flow controlling device that comprises a TMF meter, a valve and controlling electronics

Note 1 to entry: The output of the TMF meter is compared against an adjustable setpoint and the valve is correspondingly opened or closed to maintain the measured flowrate at the setpoint value.

3.2.7
transmitter
associated electronics providing the heater with electrical power and transforming the signals from the temperature sensors to give output(s) of the measured parameters

Note 1 to entry: The transmitter can be integrally mounted to a TMF meter. However, for some applications the transmitter can be remotely installed away from the flow sensor.

3.2.8
retractor mechanism
<insertion-ITMF meters> mechanical arrangement including an isolation valve that allows the positioning and/or extraction of the flow sensor within the conduit

3.2.9
rangeability
statement of the minimum and maximum limits of which an individual sensor can measure and indicate

EXAMPLE For a maximum flowrate = 1 000 kg/h and a minimum flowrate = 10 kg/h, the rangeability = 10 kg/h to 1 000 kg/h.

3.2.9.1
turndown
numerical ratio of the maximum to minimum limits of which an individual sensor can measure

EXAMPLE For a maximum flowrate = 1 000 kg/h and a minimum flowrate = 10 kg/h, the turndown ratio = 1 000/10 = 100:1.

Note 1 to entry: In practice, the terms rangeability and turndown are used interchangeably and can be associated with an uncertainty statement.

3.2.10
***k*-factor**
numerical factor unique to each TMF meter which is associated with the mass flowrate derived during the calibration and when programmed into the transmitter ensures that the meter performs to its stated specification

Note 1 to entry: When a surrogate gas has been used for calibration purposes, the manufacturer's gas factor list or database has been applied for conversion to the desired gas under process conditions.

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3.2.11
normalized volume flowrate, (GB)
standardized volume flowrate, (US)
flowrate for which the quantity of fluid is expressed in terms of volume, with the fluid density calculated at a known and fixed pressure and temperature condition

Note 1 to entry: The values used to define these reference conditions (also known as "standard reference conditions") are industry and country specific and therefore shall always be specified when these units are used. Typical reference conditions are 0 °C and 101,325 kPa.

Note 2 to entry: Normalized volumetric units or volumetric units specified to standard reference conditions, such as "Nm^3/h", are commonly used with CTMF and ITMF meters, however this practice is not recommended as they are neither SI units nor symbols and their use without knowledge of the reference conditions will lead to significant errors. In this International Standard, volumetric units specified to standard reference conditions are followed by the expression "(normalized)", e.g. m^3/h (normalized).

3.2.12
normalized velocity, (GB)
standardized velocity, (US)
flowrate for which the quantity of fluid is expressed in terms of the speed of flow, with the fluid density calculated at a known and fixed pressure and temperature condition

Note 1 to entry: The values used to define these reference conditions (also known as "standard reference conditions") are industry and country specific and therefore shall always be specified when these units are used. Typical reference conditions are 0 °C and 101,325 kPa.

Note 2 to entry: Normalized volumetric units or volumetric units specified to standard reference conditions, such as "Nm/s", are commonly used with CTMF and ITMF meters, however this practice is not recommended as they are neither SI units or symbols and their use without knowledge of the reference conditions will lead to significant errors. In this International Standard, volumetric units specified to standard reference conditions are followed by the expression "(normalized)", e.g. m/s (normalized).

4 Selection of thermal mass flowmeters

TMF meters fall into two basic design categories:

a) capillary TMF meters (CTMF meters);

b) full bore TMF meters, consisting of the following two types (ITMF meter):

   1) insertion type;

   2) in-line type.

The choice of appropriate design for a particular application is primarily dependent on:

— the required flowrate and range;

— the cleanliness of the gas;

— the conduit dimensions.

The two basic types of TMF meters have a number of overlapping characteristics for flowrate and conduit dimensions as shown in Table 1. Other factors may influence the final choice of the meter depending on the application. Table 1 is a guideline only and the manufacturer's specifications should be consulted for the absolute limits.

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