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# Measurement of fluid flow in closed conduits — Guidance for the use of electromagnetic flowmeters for conductive liquids

*Mesurage du débit des fluides dans les conduites fermées — Lignes directrices pour l'utilisation des débitmètres électromagnétiques dans les liquides conducteurs*

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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).

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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 5, *Velocity and mass methods*.

This first edition of ISO 20456 cancels and replaces ISO 6817:1992, ISO 9104:1991 and ISO 13359:1998, which has been technically revised.


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# Introduction

Clauses 3 to 7 cover the definitions, symbols and basic theory of electromagnetic flowmeters. This document does not cover insertion type meters, partially filled meters or meters for non-conductive and highly conductive fluids.

Clause 8 covers installation types and practice, the different types of meter construction, transmitters, lay lengths and sizing, in order to achieve the best performance of the electromagnetic flowmeter in the field.

Clauses 9 to 11 cover some methods of calibration, verification, evaluation, and uncertainty analysis, which can be useful for users or independent testing establishments to verify manufacturer's relative performance and to demonstrate suitability of application

The tests specified in this document are not necessarily sufficient for instruments specifically designed for unusually difficult duties. Conversely, a restricted series of tests may be suitable for instruments designed to perform within a limited range of conditions.

This document is for users and manufacturers.

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# Measurement of fluid flow in closed conduits — Guidance for the use of electromagnetic flowmeters for conductive liquids

## 1 Scope

This document applies to industrial electromagnetic flowmeters used for the measurement of flowrate of a conductive liquid in a closed conduit running full. It covers flowmeter types utilizing both alternating current (AC) and pulsed direct current (DC) circuits to drive the field coils and meters running from a mains power supply and those operating from batteries or other sources of power.

This document is not applicable to insertion-type flowmeters or electromagnetic flowmeters designed to work in open channels or pipes running partially full, nor does it apply to the measurement of magnetically permeable slurries or liquid metal applications.

This document does not specify safety requirements in relation to hazardous environmental usage of the flowmeter.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

**3.1**
**electromagnetic flowmeter**
flowmeter which creates a magnetic field perpendicular to the direction of flow, so enabling the flowrate to be deduced from the induced voltage, $U_V$, produced by the motion of a conducting fluid through the magnetic field

Note 1 to entry: The electromagnetic flowmeter consists of a *sensor* (3.2) and a *transmitter* (3.3).

**3.2**
**sensor**
device containing at least the following elements:

— an electrically insulating meter tube through which the conductive fluid to be measured flows;

— one pair of electrodes across which the signal generated in the fluid is measured;

— an electromagnet for producing a magnetic field in the *meter tube* (3.4)

Note 1 to entry: The sensor produces a signal proportional to the flowrate and, in some cases, a *reference signal* (3.9). See 6.2.

Note 2 to entry: For a sensor, the wording primary device or flowtube has previously been used.

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Note 3 to entry: In some cases, further electrodes are used such as grounding electrodes, full pipe detection electrodes (empty pipe detection) (see 3.5).

**3.3**
**transmitter**
equipment which contains the circuitry which drives the field coils and extracts the flow signal

Note 1 to entry: This equipment may be mounted directly onto the *sensor* (3.2) or remotely, connected to the sensor by a cable.

Note 2 to entry: For a transmitter, the wording secondary device, converter or electronic unit has previously been used.

**3.4**
**meter tube**
pipe section of the *sensor* (3.2) through which the liquid flows, at least part of whose inner surface is electrically insulating

**3.5**
**measuring electrodes**
one or more pairs of electrical contacts or capacitor plates by means of which the induced voltage is detected

**3.6**
**lower range value**
lowest value of the measured variable that a device is set to measure

**3.7**
**upper range value**
highest value of the measured variable that a device is set to measure

**3.8**
**span**
difference between the upper and *lower range values* (3.6)

**3.9**
**reference signal**
signal which is proportional to the magnetic flux created in the *sensor* (3.2) and which is compared in the *transmitter* (3.3) with the flow signal

**3.10**
**output signal**
signal from the *transmitter* (3.3) which is a function of the flowrate

**3.11**
**Reynolds number**
dimensionless parameter expressing the ratio between the inertial and the viscous forces

Note 1 to entry: For closed pipe flow through an *electromagnetic flowmeter* (3.1), Reynolds number should be based on the nominal diameter of the meter and corresponding mean velocity through a section of that size.

**3.12**
**accuracy**
closeness of the agreement between the result of a measurement and the (conventional) true value of the measurement

Note 1 to entry: The quantitative expression of accuracy should be in terms of uncertainty (see Annex E).

Note 2 to entry: The use of the term precision for accuracy should be avoided.


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**3.13**
**uncertainty**
<of measurement> range within which the true value of the measured quantity can be expected to lie with a specified value and confidence level

Note 1 to entry: See Clause 11.

**3.14**
**calibration factor**
number, determined by liquid calibration, that enables the *output signal* (3.10) to be related to the volumetric flowrate

**3.15**
**calibration**
operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

**3.16**
**verification**
<in-situ electronic verification> means of verifying that an *electromagnetic flowmeter* (3.1) is operating correctly, normally with a poorer uncertainty than under controlled laboratory conditions

**3.17**
**calibration validation**
number of runs (one or more) at flowrates between zero and the *upper range value* (3.7) in order to verify that the flowmeter does perform in the expected way and within the manufacturer's specification

**3.18**
**measuring window**
period of time during which the voltage representing the flow velocity is measured

**3.19**
**ideal flow conditions**
conditions that exist when a pipe is infinitely long and straight with no internal disturbances

Note 1 to entry: For *electromagnetic flowmeters* (3.1), it may, in addition, also be assumed that the metering liquid has a viscosity and density similar to water. Under these conditions, the flow is axisymmetric and will be fully developed and turbulent at flowrates and pipe sizes most often found in industry.

## 4 Symbols

| Symbol | Quantity | Units (SI) |
|---|---|---|
| $\vec{B}$ | magnetic field strength | Tesla (T) |
| $\overline{B}$ | mean magnetic field strength | Tesla (T) |
| $d$ | inside diameter of meter tube | metres (m)[a] |
| $\vec{E}$ | electric field strength | volt per metre (V/m) |
| $U_c$ | electrochemical voltage | volt (V) |
| $U_t$ | transformer voltage | volt (V) |
| $U_v$ | velocity related voltage | volt (V) |
| $F_{Lorentz}$ | Lorentz force | newton (N) |
| $k_1$ | constant | dimensionless (—) |
| $k_2$ | constant | dimensionless (—) |

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