ASME MFC-5.1–2011
(Revision and Partition of ANSI/ASME MFC-5M–1985)

REAFFIRMED 2024

Measurement of Liquid Flow in Closed Conduits Using Transit-Time Ultrasonic Flowmeters

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Three Park Avenue • New York, NY • 10016 USA

Date of Issuance: June 17, 2011

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FOREWORD

The need for a standard describing measurement of liquid measurement of liquid flows by means of transit-time ultrasonic flowmeters has been recognized for many years. The ASME Standards Committee MFC, Measurement of Fluid Flow in Closed Conduits, developed a standard, ANSI/ASME MFC-5M–1985 to address this need. Subsequently, it was decided to revise and partition ANSI/ASME MFC-5M into three standards to assist the readers in understanding the three technologies: transit time, cross-correlation, and scattering (Doppler).

This Standard applies to ultrasonic flowmeters that base their operation on the measurement of transit time of acoustic signals. This Standard concerns the volume flow-rate measurement of a single-phase liquid with steady flow or flow varying only slowly with time in a completely filled closed conduit.

The next standard planned in this series, Measurement of Liquids Using Cross-Correlation Ultrasonic Flowmeters (ASME MFC-5.2M), will apply to ultrasonic flowmeters that base their operation on the cross-correlation of modulated acoustic signals. It will be concerned with the volume flow-rate measurement of a single-phase or multiphase liquid with steady flow or flow varying only slowly with time in a completely filled closed conduit.

The last standard planned for this series, Measurement of Liquids Using Scattering (Doppler) Ultrasonic Flowmeters (ASME MFC-5.3M), will apply to ultrasonic flowmeters that base their operation on the scattering (Doppler) of acoustic signals. It will be concerned with the volume flow-rate measurement of two-phase liquid with steady flow or flow varying only slowly with time in a completely filled closed conduit.

Suggestions for improvement of this Standard are welcome. They should be sent to The American Society of Mechanical Engineers; Attn: Secretary, MFC Standards Committee; Three Park Avenue; New York, NY 10016-5990.

This Standard was approved as an American National Standard on January 28, 2011.

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Measurement of Fluid Flow in Closed Conduits

(The following is the roster of the Committee at the time of approval of this Standard.)

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The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

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The request for interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
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Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

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MEASUREMENT OF LIQUID FLOW IN CLOSED CONDUITS USING TRANSIT-TIME ULTRASONIC FLOWMETERS

1 GENERAL

1.1 Scope

This Standard applies to ultrasonic flowmeters that base their operation on the measurement of transit time of acoustic signals. This Standard concerns the volume flow-rate measurement of a single-phase liquid with steady flow or flow varying only slowly with time in a completely filled closed conduit.

1.2 Purpose

This Standard provides

(a) a description of the operating principles employed by the transit-time ultrasonic flowmeters

(b) a guideline to expected performance characteristics of transit-time ultrasonic flowmeters

(c) a description of calibration, verification, and diagnostic procedures

(d) a description of potential uncertainty sources and their reduction

(e) a common set of terminology, symbols, definitions, and specifications

1.3 Terminology and Symbols

(a) Paragraph 1.3.1 lists definitions from ASME MFC-1M used in this Standard.

(b) Paragraph 1.3.2 lists definitions specific to this Standard.

(c) Table 1-1 lists symbols used in this Standard.

(d) Table 1-2 lists subscripts used in this Standard.

1.3.1 Definitions From ASME MFC-1M

accuracy: closeness of agreement between a measured quantity value and a true quantity value of a measurand.

NOTES:

(1) The concept "measurement accuracy" is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it provides a smaller measurement error.

(2) The term "measurement accuracy" is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand. "Measurement accuracy" should not be mistaken for "measurement precision."

acoustic path: path that the acoustic signals follow as they propagate through the measurement section. There may be one (single path) or more (multipath) acoustic paths in the measurement section. Common transit-time path types are axial, diametrical, and chordal.

axial flow velocity: component of liquid flow velocity, V_{ax}, at a point in the measurement section that is parallel to the measurement section's axis.

calibration: experimental determination of the relationship between the quantity being measured and the device that measures it, usually by comparison with a traceable reference standard; also including the act of adjusting the output of a device to bring it to a desired value, within a specified tolerance, for a particular value of the input.

NOTE: This document is written with calibration defined as the determination of difference from a reference and the adjustment to align within a specified tolerance. This is common U.S. usage.

It is understood that in other parts of the world some countries and groups define calibration as only the determination of difference from a reference. A second term used is calibration adjustment, which is to align within a specified tolerance.

cross-flow velocity: component of liquid flow velocity at a point in the measurement section that is perpendicular to the measurement section's axis.

measurement section: section of conduit in which the volumetric flow rate is sensed by the acoustic signals. The measurement section is bounded at both ends by planes perpendicular to the axis of the section and located at the extreme upstream and downstream transducer positions. The measurement section is usually circular in cross section; however, it may be square, rectangular, elliptical, or some other shape.

nonrefractive system: an ultrasonic flowmeter system in which the acoustic path crosses the transducer/process liquid interfaces at a right angle to the boundary surface.

refractive system: an ultrasonic flowmeter in which the acoustic path crosses the conduit boundary/process liquid interfaces at other than a right angle.

transit time, t: time required for an acoustic signal to traverse an acoustic path.

uncertainty: parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.

NOTES:

(1) Measurement uncertainty is often comprised of many components: Some of these may be evaluated by Type A evaluation