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# Measurement of Fluid Flow by Means of Thermal Dispersion Mass Flowmeters

AN AMERICAN NATIONAL STANDARD



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# FOREWORD

Thermal dispersion mass flowmeters comprise a family of instruments for the measurement of the total mass flow rate of a fluid, primarily gases, flowing through closed conduits.

The operation of thermal dispersion mass flowmeters is attributed to L.V. King who, in 1914 [1], published his famous King's Law revealing how a heated wire immersed in a fluid flow measures the mass velocity at a point in the flow. King called his instrument a "hot-wire anemometer." However, it was not until the 1960s and 1970s that industrial-grade thermal dispersion mass flowmeters finally emerged.

This Standard covers the thermal dispersion type of thermal mass flowmeter. A companion standard, ASME MFC 21.1, Measurement of Fluid Flow by Means of Capillary Tube Thermal Mass Flowmeters and Controllers, covers the other most commonly used type of thermal mass flowmeter. Both types measure fluid mass flow rate by means of the heat convected from a heated surface to the flowing fluid. In the case of the thermal dispersion, or immersible, type of flowmeter, the heat is transferred to the boundary layer of the fluid flowing over the heated surface. In the case of the capillary tube type of flowmeter the heat is transferred to the bulk of the fluid flowing through a small heated capillary tube. The principles of operation of the two types are both thermal in nature, but are so substantially different that two separate standards are required. Additionally, their applications are much different. Thermal dispersion flowmeters are commonly used for general industrial gas-flow applications in pipes and ducts, whereas capillary tube flowmeters are primarily used for smaller flows of clean gases in tubes.

Suggestions for improvement of this Standard will be welcomed. 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 June 24, 2010.

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# Measurement of Fluid Flow in Closed Conduits

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|---|---|
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# MEASUREMENT OF FLUID FLOW BY MEANS OF THERMAL DISPERSION MASS FLOWMETERS

## 1 SCOPE

This Standard establishes common terminology and gives guidelines for the quality, description, principle of operation, selection, installation, and flow calibration of thermal dispersion flowmeters for the measurement of the mass flow rate, and to a lesser extent, the volumetric flow rate, of the flow of a fluid in a closed conduit. Multivariable versions additionally measure fluid temperature. Thermal dispersion mass flowmeters are applicable to the flow of single-phase pure gases and gas mixtures of known composition and, less commonly, to single-phase liquids of known composition. Companion standard ASME MFC-21.1 covers capillary tube type thermal mass flowmeters and controllers.

## 2 TERMINOLOGY AND SYMBOLS

*(a)* Paragraph 2.1 lists definitions from ASME MFC-1M used in ASME MFC-21.2.

*(b)* Paragraph 2.2 lists definitions specific to this Standard.

*(c)* Paragraph 2.3 lists symbols (see Table 2.3-1) used in this Standard (see notes and superscripts).

*(d)* Paragraph 2.4 lists abbreviations (see Table 2.4-1) used in this Standard.

### 2.1 Definitions Copied From ASME MFC-1M

*accuracy:* the degree of freedom from error; the degree of conformity of the indicated value to the true value of the measured quantity.

*calibration:* the experimental determination of the relationship between the quantity being measured and the device that measures it, usually by comparison with a standard. Also, 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.

*cavitation:* the implosion of vapor bubbles formed after flashing when the local pressure rises above the vapor pressure of a liquid. (See also *flashing*.)

*flashing:* the formation of vapor bubbles in a liquid when the local pressure falls to or below the vapor pressure of the liquid, often due to local lowering of pressure because of an increase in the liquid velocity. (See also *cavitation*.)

*flow profile:* graphic representation of the velocity distribution.

*fully developed velocity distribution:* a velocity distribution, in a straight length of pipe, that has zero radial and azimuthal fluid velocity components and an axisymmetric axial velocity profile that is independent of axial position along the pipe.

*rangeability (turndown):* flowmeter rangeability is the ratio of the maximum to minimum flow rates or Reynolds number in the range over which the meter meets a specified uncertainty (accuracy).

*repeatability (qualitative):* the closeness of agreement among a series of results obtained with the same method on identical test material, under the same conditions (same operator, same apparatus, same laboratory, and short intervals of time). [See also *repeatability (quantitative).*]

*repeatability (quantitative):* the value below which the absolute difference between any two single test results obtained under same conditions may be expected to lie with a specified probability. In the absence of other indications, the probability is 95%. [See also *repeatability (qualitative).*]

*reproducibility (quantitative):* the closeness of agreement between results obtained when the conditions of measurement differ; for example, with respect to different test apparatus, operators, facilities, time intervals, etc.

*swirling flow:* flow that has axial and circumferential velocity components.

*transmitter (secondary device):* electronic system providing the drive and transforming the signals from the flow sensor to give output(s) of measured and inferred parameters; it also provides corrections derived from parameters such as temperature.

*uncertainty interval, u:* an estimate of the error band, centered about the measurement, within which the true value must fall with a specified probability.

### 2.2 Definitions Specific to This Document

*base conditions:* the conditions of temperature and pressure to which measured volumes are to be corrected (same as *Reference* or *Standard Conditions*).