

Measurement of fluid flow in closed conduits —

Part 2: Velocity area methods —

Section 2.2 Method of measurement of velocity at one point of a conduit of circular cross section

[ISO title: Determination of flowrate of fluids in closed conduits
of circular cross-section — Method of velocity measurement at
one point of the cross-section]

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Industrial-process Measurement and Control Standards Committee (PCL/-) to Technical Committee PCL/2 upon which the following bodies were represented:

- British Compressed Air Society
- British Gas Corporation
- British Industrial Measuring and Control Apparatus Manufacturers' Association (BEAMA)
- Department of Energy (Gas Standards)
- Department of Industry (National Engineering Laboratory)
- Department of Trade (Consumer Safety Unit, CS Division)
- Department of Trade (National Weights and Measures Laboratory)
- Electricity Supply Industry in England and Wales
- Energy Industries Council
- Institute of Measurement and Control
- Institute of Petroleum
- Institute of Trading Standards Administration
- Institution of Gas Engineers
- National Water Council
- Society of Chemical Industry
- United Kingdom Atomic Energy Authority
- Coopted member

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Fan Manufacturers' Association
- Hevac Association
- National Coal Board
- Scientific Instrument Manufacturers' Association (BEAMA)

This British Standard, having been prepared under the direction of the Industrial-process Measurement and Control Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 August 1983

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National foreword

This British Standard has been prepared under the direction of the Industrial-process Measurement and Control Standards Committee and is identical with ISO 7145:1982 “*Determination of flowrate of fluids in closed conduits of circular cross-section — Method of velocity measurement at one point of the cross-section*”, published by the International Organization for Standardization (ISO).

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words “International Standard” appear, referring to this standard, they should be read as “British Standard”.

Cross-references

International standard	Corresponding British Standard
ISO 4006:1977	BS 5875:1980 <i>Glossary of terms and symbols for measurement of fluid flow in closed conduits</i> (Identical)
ISO 5168:1978	BS 5844:1980 <i>Methods of measurement of fluid flow: estimation of uncertainty of a flowrate measurement</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 3354 and ISO 3966, to which reference is made in the text and for which there are no corresponding British Standards, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope and field of application

1.1 Scope

This International Standard specifies a method for the determination of the volume rate of flow of a single phase fluid of a substantially constant density (Mach number $\leq 0,25$) under steady fully developed flow conditions in a closed conduit of circular cross-section running full by measurement of the flow velocity in a single point.

The method provides for the possibility of placing the primary velocity measuring device either at the point where it is assumed the mean axial velocity prevails, i.e. at a distance of $0,242 R$ from the wall of the conduit (R being the radius of the conduit), or on the axis of the conduit.

If there are doubts about the symmetry of the flow it is advisable to use at least two measuring points located symmetrically on one circumference at the distance from the wall specified above.

1.2 Field of application

The method specified in this International Standard does not apply unless the following conditions have been fulfilled:

a) The conduit shall have a straight length sufficiently long so that, in the measuring section, a distribution of velocities corresponding to fully developed turbulent flow can be observed (see 2.3.5).

Hydraulic resistance coefficient λ of the conduit should not exceed 0,06.

b) The flow must be turbulent and the Reynolds number, Re_D , should exceed or be equal to the following values:

λ	$\geq 0,03$	0,025	0,02	0,01
Re_D	10^4	3×10^4	10^5	10^6

When the velocity is measured on the conduit axis, the flow should be in fully rough turbulent regime (see 2.3.6). The Reynolds number, Re_D , should then exceed or be equal to:

λ	0,06	0,05	0,04	0,03	0,025	0,02	0,01
Re_D	3×10^4	5×10^4	10^5	3×10^5	5×10^5	10^6	5×10^7

c) The experimental data on which this International Standard is based principally relate to conduits of diameter equal to or greater than 300 mm, but there is every reason to believe that the method can be applied to conduits of smaller diameter.

d) In any point of the measuring cross-section, the angle between the direction of local velocity and the axis should not exceed 5° .

This condition can be verified either with the probe used for the measurements, if the design permits this, or with a different type of probe. It can be assumed that if the condition required is verified for a given flow q , then this condition is also met within the range $q/3$ to $3q$.

1.3 Accuracy of the method

As a guide, it can be considered that determination of flow from velocity measurement at a single point, carried out in accordance with the requirements of this International Standard, will lead to an uncertainty (at a confidence level of 95 %) not exceeding ± 3 %. However, the uncertainty on the flow shall be calculated for each individual application of this International Standard depending on the type of primary device, on the method of use and if necessary, on the method of calibration as well as on the measuring conditions.

2 Symbols and definitions

2.1 References

The vocabulary and symbols used in this International Standard are defined in the following International Standards:

ISO 3354, *Measurement of clean water flow in closed conduits — Velocity-area method using current-meters.*

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity-area method using pitot-static tubes.*

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

ISO 5168, *Measurement of fluid flow — Estimation of uncertainty of a flow-rate measurement.*

The definitions appearing in 2.3 are given only for terms used in a special sense for which it would seem useful to repeat the definition of meaning.

2.2 Symbols

Symbol	Quantity	Dimensions ^a	SI units
A	Area of the cross-section of the conduit	L^2	m^2
a	Height of any high spot or protrusion on the external wall of the conduit	L	m
D	Diameter of the conduit	L	m
d	Diameter of the active part of the primary device	L	m
e	Uncertainty, as an absolute value	b	b
E	Uncertainty, as a relative value	—	—
k	Uniform equivalent roughness	L	m
P	External perimeter of the conduit	L	m
q_V	Volume flow rate	L^3T^{-1}	m^3/s
R	Radius of the conduit	L	m
Re_D	Reynolds number, $Re_D = \frac{UD}{\nu}$	—	—
s	Standard deviation	b	b
U	Mean axial velocity	LT^{-1}	m/s
u^*	Friction velocity, $u^* = U \sqrt{\frac{\lambda}{8}}$	LT^{-1}	m/s
ν	Local fluid velocity	LT^{-1}	m/s
ν_0	Local velocity at centre of conduit	LT^{-1}	m/s
ν^*	Local non dimensional velocity, $\nu^* = \frac{\nu}{U}$	—	—
y	Distance from one measurement point to the wall	L	m
y^*	Non dimensional distance from one measurement point to the wall, $y^* = \frac{y}{R}$	—	—
λ	Universal coefficient of head loss as defined by the formula $\Delta p = \lambda \frac{L}{D} \times \frac{1}{2} \rho U^2$ where Δp is the pressure drop on the tube length L and ρ is the fluid density	—	—
ν	Kinematic viscosity of the fluid	L^2T^{-1}	m^2/s

^a L = length, T = time
^b The dimensions and units are those of the quantity to which the symbol refers, and which will be indicated by an index.