# SLOVENSKI STANDARD
# SIST ISO 7145:1996

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**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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Détermination du débit des fluides dans les conduites fermées de section circulaire -- Méthode par mesure de la vitesse en un seul point



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**SIST ISO 7145:1996** **en**

# International Standard 7145

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

## Determination of flowrate of fluids in closed conduits of circular cross-section — Method of velocity measurement at one point of the cross-section

*Détermination du débit des fluides dans les conduites fermées de section circulaire — Méthode par mesure de la vitesse en un seul point*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 7145 was developed by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, and was circulated to the member bodies in April 1981.



It has been approved by the member bodies of the following countries :



| | | |
|---|---|---|
| Australia | Italy | Portugal |
| Belgium | Japan | Romania |
| Czechoslovakia | Korea, Dem. P. Rep. of | South Africa, Rep. of |
| Egypt, Arab Rep. of | Korea, Rep. of | United Kingdom |
| France | Netherlands | USSR |
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

Germany, F. R.
USA



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# Determination of flowrate of fluids in closed conduits of circular cross-section — Method of velocity measurement at one point of the cross-section

## 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 ⩽ 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 $\lambda$ 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 :

| $\lambda$ | > 0,03 | 0,025 | 0,02 | 0,01 |
|---|---|---|---|---|
| $Re_D$ | $10^4$ | $3 \times 10^4$ | $10^5$ | $10^6$ |

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 :

| $\lambda$ | 0,06 | 0,05 | 0,04 | 0,03 | 0,025 | 0,02 | 0,01 |
|---|---|---|---|---|---|---|---|
| $Re_D$ | $3 \times 10^4$ | $5 \times 10^4$ | $10^5$ | $3 \times 10^5$ | $5 \times 10^5$ | $10^6$ | $5 \times 10^7$ |

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[1)] | 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 | 2) | 2) |
| $E$ | 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 | 2) | 2) |
| $U$ | Mean axial velocity | $LT^{-1}$ | m/s |
| $u^*$ | Friction velocity, $u^* = U\sqrt{\frac{\lambda}{8}}$ | $LT^{-1}$ | m/s |
| $v$ | Local fluid velocity | $LT^{-1}$ | m/s |
| $v_0$ | Local velocity at centre of conduit | $LT^{-1}$ | m/s |
| $v^*$ | Local non dimensional velocity, $v^* = \frac{v}{U}$ | — | — |
| $y$ | Distance from one measurement point to the wall | L | m |
| $y^*$ | Non dimensional distance from one measurement point to the wall, $y^* = \frac{y}{R}$ | — | — |
| $\lambda$ | Universal coefficient of head loss as defined by the formula $\Delta p = \lambda \frac{L}{D} \times \frac{1}{2} \varrho U^2$ where $\Delta p$ is the pressure drop on the tube length $L$ and $\varrho$ is the fluid density | — | — |
| $\nu$ | Kinematic viscosity of the fluid | $L^2T^{-1}$ | $m^2/s$ |

1) L = length, T = time

2) The dimensions and units are those of the quantity to which the symbol refers, and which will be indicated by an index.

### 2.3 Definitions

**2.3.1 primary velocity measuring device :** Any device that changes a local flow velocity into a physical quantity suitable for measurement (for example, differential pressure, frequency of an electric signal, etc.).

NOTE — Throughout the rest of this document, the expression "primary device" is used instead of "primary velocity measurement device".

**2.3.2 measuring point :** Any point where the local velocity of the flow is measured.

**2.3.3 mean axial velocity :** Ratio of the volumetric flowrate and the area of the measuring section

$$U = \frac{q_V}{A}$$

**2.3.4 point of mean axial velocity :** In a cross-section of the conduit this is a point where the local velocity of the flow is equal to the mean axial velocity.



**2.3.5 fully developed flow :** The flow in which the distribution of velocities does not change from one cross-section to another. It is generally obtained at the outlet of a straight length of conduit of sufficient length (see 4.1).



**2.3.6 fully rough turbulent flow :** In a conduit of given relative roughness, this occurs when the hydraulic resistance coefficient is independant of the Reynolds number and may be assumed to be present when

$$Re_D > 500 \times 10^{\frac{1}{2\sqrt{\lambda}}}$$

or

$$Re_D > 1\,850 \frac{D}{k}$$

## 3 Principle

### 3.1 General

The principle of the determination of flow by measurement of the local velocity at a single point is based on the existence of laws applicable to all conduits, provided that all parameters remain within the limits indicated in 1.2, which relate the value of the local velocity at a given point in the cross-section to the value of the mean axial velocity in this section.

Two variants on this method, which differ in the position of the measuring point, are described in 3.2 and 3.3. It should however be emphasized that these two methods are not equivalent as the second one requires previous calibrations.

### 3.2 Measurement at the point of mean axial velocity

From a large number of experimental results it has been possible to establish that under turbulent conditions and within the limits indicated in 1.2 the position of the circle centred on the pipe axis at which the local velocity is equal to the mean axial velocity remains fixed as the flowrate changes, and is the same for any pipe. This circle is at a distance from the wall $y_1 = (0{,}242 \pm 0{,}013)\,R$, $R$ being the radius of the cross-section.

The principle of the method therefore consists of :

a) Selecting a measurement cross-section (see 4.1).

b) Measuring the dimensions of this cross-section in order to obtain its area $A$ (see 4.2).

c) Selecting, at the above-mentioned distance $y_1$ from the wall, the point of measurement of velocity (see 4.4.1).

d) Measuring the local velocity $v_1$ of the flow, according to the special conditions required by the primary device used (see 4.3).

e) Calculating the volume rate of flow equal to the product of the cross-sectional area and the measured velocity ($v_1$) taken as being the mean axial velocity ($U$) :

$$q_V = A \times U = A \times v_1$$

f) Determining the uncertainty associated with this flow measurement (see clause 5).

### 3.3 Measurement on the axis of the conduit

If the above method cannot be applied, the local velocity of the flow can be measured at the centre of the measurement cross-section on the axis of the conduit. However, it is then necessary to carry out calibrations by previous determination of the ratio $U/v_0$ of the mean axial velocity at the velocity at the centre. This ratio remains approximately constant for a given pipe in fully rough turbulent conditions.

The principle of the method therefore consists of :

a) Selecting a measurement cross-section (see 4.1).

b) Measuring the dimensions of this cross-section in order to obtain its area $A$ (see 4.2).

c) Measuring the local velocity of flow at the centre of the cross-section $v_0$, in accordance with the special conditions required by the primary device used (see 4.3).

d) Calculating the mean axial velocity $U$ by multiplying the velocity measured at centre $v_0$ by the previously determined calibration coefficient (see 4.4.2).

e) Calculating the volume rate of flow equal to the product of the cross-sectional area and the mean axial velocity :

$$q_V = A \times U = A \times v_0 \times \left(\frac{U}{v_0}\right)$$

f) Determining the uncertainty associated with this flow measurement (see section 5).