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Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes

Mesurage du débit des fluides dans les conduites fermées — Méthode d'exploration du champ des vitesses au moyen de tubes de Pitot doubles

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3966 was prepared by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, Subcommittee SC 5, *Velocity and mass methods*.

This second edition results from the reinstatement of ISO 3966:1977 which was withdrawn in 2003 and with which it is technically identical.

Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes

1 Scope

This International Standard specifies a method for the determination in a closed conduit of the volume rate of flow of a regular flow:

a) of a fluid of substantially constant density or corresponding to a Mach number not exceeding 0,25;

b) with substantially uniform stagnation temperature across the measuring cross-section;

c) running full in the conduit;

d) under steady flow conditions.

In particular, it deals with the technology and maintenance of Pitot static tubes, with the calculation of local velocities from measured differential pressures and with the computation of the flow rate by velocity integration.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2186, *Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements*

ISO 7194, *Measurement of fluid flow in closed conduits — Velocity-area methods of flow measurement in swirling or asymmetric flow conditions in circular ducts by means of current-meters or Pitot static tubes*

3 Symbols and definitions

3.1 Symbols

Symbol	Quantity	Dimensions	SI unit
A	cross-sectional area of the conduit	L^2	m^2
a, a'	distance of the extreme measuring point to the nearest wall	L	m
D	pipe diameter	L	m
d	head diameter	L	m
d'	steam diameter	L	m
d_i	total pressure tapping hole diameter	L	m
H	rectangular conduit height	L	m
h	height of a particular point above the bottom	L	m
k_b	blockage coefficient of a cylindrical stem	—	—
k_g	coefficient depending on the nose shape	—	—
k_t	coefficient of turbulence correction	—	—
L	rectangular conduit width	L	m
l	distance from a particular point to the side-wall	L	m
M	molar mass of fluid	M	kg/mol
m	roughness coefficient	—	—
Ma	Mach number	—	—
p	absolute static pressure of the fluid	$ML^{-1}T^{-2}$	Pa
q_V	volume flow rate	L^3T^{-1}	m^3/s
R_g	molar constant of gas	$ML^2T^{-1}\Theta^{-1}$	J/mol·K
R	pipe radius	L	m
r	measuring circle radius	L	m
Re	Reynolds number	—	—
S	frontal projected area of the stem inside the conduit	L^2	m^2
T	absolute temperature	Θ	K
U	discharge velocity	LT^{-1}	m/s
u	mean velocity along a circumference or a measurement line	LT^{-1}	m/s
v	local velocity of the fluid	LT^{-1}	m/s
X	pipe dimension	L	m
y	distance of a measuring point to the wall	L	m
Z	gas law deviation factor	—	—
α	calibration factor of the Pitot tube	—	—
γ	ratio of the specific heat capacities	—	—
Δp	differential pressure measured by the Pitot tube	$ML^{-1}T^{-2}$	Pa
ε	expansibility factor	—	—
$(1 - \varepsilon)$	compressibility correction factor	—	—
λ	universal coefficient for head loss	—	—
μ	dynamic viscosity of the fluid	$ML^{-1}T^{-1}$	Pa·s
ν_{kv}	kinematic viscosity of the fluid	L^2T^{-1}	m^2/s
ξ	head loss	$ML^{-1}T^{-2}$	Pa
ρ	density of the fluid	ML^{-3}	kg/m^3
φ	Pitot tube inclination	—	—

3.2 Terms and definitions

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

3.2.1
Pitot static tube
"Pitot tube"
a tubular device consisting of a cylindrical head attached perpendicularly to a stem allowing measurement of a differential pressure from which the flow rate of the fluid in which it is inserted can be determined, and which is provided with static pressure tapping holes (drilled all around the circumference of the head at one or more cross-sections) and with a total pressure hole (facing the flow direction at the tip of the axially symmetrical nose of the head)

3.2.2
static pressure tapping
a group of holes for the measurement of fluid static pressure

3.2.3
total pressure tapping
a hole for the measurement of fluid stagnation pressure (the pressure produced by bringing the fluid to rest without change in entropy)

3.2.4
differential pressure
the difference between the pressures at the total and static pressure taps

3.2.5
stationary rake
a set of Pitot tubes, mounted on one or several fixed supports, which explore the whole diameter or measuring section simultaneously

3.2.6
peripheral flow rate
the volume flow rate in the area located between the pipe wall and the contour defined by the velocity measuring points which are the closest to the wall

3.2.7
discharge velocity
the ratio of the volume rate of flow (integral of the axial component of local velocities with respect to the cross-sectional area) to the area of the measuring cross-section

3.2.8
relative velocity
the ratio of the flow velocity at the considered point to a reference velocity measured at the same time and being either the velocity at a particular point (e.g. the centre of a circular conduit) or the discharge velocity in the measuring section

3.2.9
straight length
a conduit section, the axis of which is rectilinear and the surface and cross-section of which are constant

NOTE The shape of this section is usually circular, but it may be rectangular or annular.

3.2.10
irregularity
any element or configuration of a conduit which makes it different from a straight length

NOTE For the purpose of this International Standard, those irregularities which create the most significant disturbances are bends, valves, gates and sudden widening of the section.

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