SLOVENSKI STANDARD
SIST ISO 2975-1:1997

01-september-1997

Measurement of water flow in closed conduits - Tracer methods - Part I: General

Measurement of water flow in closed conduits -- Tracer methods -- Part 1: General

Mesure de débit de l'eau dans les conduites fermées -- Méthodes par traceurs -- Partie 1: Généralités

Ta slovenski standard je istoveten z: ISO 2975-1:1974

ICS:

17.120.10 Pretok v zaprtih vodih Flow in closed conduits

SIST ISO 2975-1:1997 **en**

INTERNATIONAL STANDARD ISO 2975/I

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

Measurement of water flow in closed conduits — Tracer methods — Part I : General

Mesure de débit de l'eau dans les conduites fermées — Méthodes par traceurs — Partie I : Généralités

First edition — 1974-05-01

UDC 681.121.84

Ref. No. ISO 2975/I-1974 (E)

Descriptors : liquid flow, water flow, pipe flow, flow measurement, isotopic labelling.

Price based on 11 pages

ISO 2975/I-1974 (E)

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 2975/I was drawn up by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, and circulated to the Member Bodies in October 1972.

It has been approved by the Member Bodies of the following countries :

Australia	Japan	Thailand
Belgium	Netherlands	United Kingdom
Czechoslovakia	New Zealand	U.S.A.
France	South Africa, Rep. of	U.S.S.R.
Germany	Spain	
Hungary	Switzerland	

No Member Body expressed disapproval of the document.

Printed in Switzerland

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Measurement of water flow in closed conduits – Tracer methods – Part I : General

0 INTRODUCTION

This International Standard is the first of a series of standards covering tracer methods of water flow measurement in closed conduits. The complete series of standards will be as follows :

– Part I : *General.*

– Part II : *Constant rate injection method using non-radioactive tracers.*

– Part III : *Constant rate injection method using radioactive tracers.*

– Part IV : *Integration (sudden injection) method using non-radioactive tracers.*

– Part V : *Integration (sudden injection) method using radioactive tracers.*

– Part VI : *Transit time method using non-radioactive tracers.*

– Part VII : *Transit time method using radioactive tracers.*

1 SCOPE AND FIELD OF APPLICATION

This International Standard deals with the measurement of water flow in closed conduits by using tracer methods; the flow of other liquids and of gases will be dealt with in subsequent International Standards.

These methods apply to flow measurement in conduits into which a solution can be injected and those cases where effective mixing of this solution with the water flowing in the conduit can be achieved, this last condition being fundamental.

Three fundamental procedures are used :

Two procedures, known as the constant rate injection method and the integration (sudden injection) method, are based on the dilution principle : a tracer solution is injected into the conduit and the dilution (ratio) of this tracer in the water flowing in the conduit is determined, this dilution being proportional to the rate of flow.

The third is a method of measurement of the mean transit time (formerly called Allen velocity method) : the tracer is injected into the conduit and the time taken by the tracer to travel a specified length between two cross-sections in each of which it is detected, is measured.

In these three methods, the advantages and disadvantages of which are considered in clause 4, the distance between injection and measuring sections should be great enough to achieve adequate mixing of the tracer with the water flowing in the conduit; the problem of an adequate mixing distance is considered in clause 6.

A large number of different tracers may be used, such as radioactive or non-radioactive, mineral or organic materials. The choice of tracer depends on the circumstances of the measurement (clause 5). The error in measurements using tracers can be less than 1 % under good conditions (clause 7).

2 VOCABULARY AND SYMBOLS

The vocabulary and symbols used in this International Standard will be defined in ISO ..., *Glossary of terms and symbols relative to the measurement of fluid flow in closed conduits.*[1)]

3 UNITS

The basic units in this International Standard are SI units.

4 CHOICE OF METHOD

4.1 Comparison between dilution methods and methods based on transit time measurement

4.1.1 *Advantage of the dilution methods*

It is not necessary to know the geometrical characteristics of the conduit.

1) In preparation.

4.1.2 *Advantages of methods based on transit time measurement*

It is necessary only to determine the concentration-time distribution at two measuring cross-sections separated by a known volume of pipe. It is not necessary to know volumes, masses, rates of flow or characteristics of the injected solutions.

4.2 Comparison between the two dilution methods (constant rate injection and integration (sudden injection) procedure)

4.2.1 *Advantages of the constant rate injection method*

— If the rate of flow of the injection is known to be of the required accuracy and constancy it is not necessary to measure any period of injection.

— It is simple to check good mixing by using only one instrument when samples can be taken at different locations in the plane of the points of measurement. However, several instruments in parallel should be used when the same verification is required in the integration method.

— It is simpler to determine random errors.

— It is not necessary to know the volume of injected solution.

4.2.2 *Advantages of the integration method*

— This method requires a smaller mass of tracer and less time than the constant rate injection method.

— Method of injection does not matter and the apparatus is simple.

— With the same quantity of tracer it is possible to make the measurement over a greater length of pipe.

5 CHOICE OF TRACER

5.1 General

A large number of different tracers may be used, such as radioactive or non-radioactive, mineral or organic, but it is necessary for any tracer to comply with the following requirements :

a) it should mix easily with water;

b) it should cause only negligible modifications of the rate of flow;

c) it should be detectable at a concentration lower than the highest permissible concentration while taking account of toxicity, corrosion, etc.

It is also preferable for the tracer to comply with the following requirements :

d) it should be cheap;

e) it should only be present in the water flowing in the conduit at a negligible or constant concentration.

In addition, for dilution methods, it is important that the tracer

f) can, at low concentrations, be analysed accurately;

g) should not react with the water flowing in the conduit or with any other substance with which it may come into contact in such a way as to affect the measurement.

Furthermore, for transit time methods, it is absolutely necessary that the tracer be such that

h) its concentration in the measuring cross-sections can be determined at any moment.

The following substances are given as examples, together with final minimum concentrations at which they can be detected at the required levels after dilution in water :

5.1.1 *Non-radioactive tracers*

— sodium dichromate ($Na_2Cr_2O_7{\cdot}2H_2O$) :
2×10^{-1} mg/l with direct analysis
2×10^{-3} mg/l after reconcentration

— sodium chloride (NaCl) : 1 to 10 mg/l depending on original conductivity

— rhodamine B ($C_{28}H_{31}ClN_2O_3$) : 2×10^{-4} mg/l

— rhodamine Wt

— lithium chloride (LiCl)

— fluorescein ($C_{20}H_{10}O_5Na_2$) : 5×10^{-3} mg/l

Other tracers have been used, and in particular :

— sodium nitrite ($NaNO_2$)

— manganese sulphate ($MnSO_4{\cdot}4H_2O$)

— sulfo-rhodamine G

5.1.2 *Radioactive tracers*

Dilution and transit time methods :

— bromine 82 (half-life 36 h, γ energies of 0,55 to 1,48 MeV)

— sodium 24 (half-life 15 h, γ energies of 1,37 to 2,75 MeV)

Other isotopes such as :

— gold 198 (half-life 2,7 days, γ energies of 0,41 to 1,09 MeV)

— iodine 131 (half-life 8,04 days, γ energies of 0,25 to 0,81 MeV)

— chromium 51 (half-life 27,8 days, γ energy of 0,32 MeV)

may be used if preliminary measurements confirm that no adsorption of tracer occurs on the walls of the conduit or on the walls of sampling and counting containers.

Tritium (half-life 12,26 years, β energy of 0,018 MeV) may also be used.

In addition, for transit time methods, because the effect of wall adsorption on the measurement is not as great as in the dilution methods, other isotopes may be used, in particular, isotopes obtained from radioactive cows, such as :

— 137 caesium—137 m barium (half-life 2,6 min, γ energy of 0,66 MeV)

— 113 tin—113 m indium (half-life 104 min, γ energy of 0,39 MeV)

5.2 Advantages or disadvantages of the different tracers

5.2.1 *Comparison between radioactive and non-radioactive tracers*

5.2.1.1 Advantages of radioactive tracers

— These can be detected by means of probes located outside the conduit (for tracers emitting γ radiation).

— The measurements are less affected by turbidity of the water than are those made with non-radioactive tracers.

— If the basic substance of tracers with a short half-life is inoffensive, any contamination danger disappears very quickly and there is no permanent pollution.

— The cost of the tracer is not proportional to the rate of flow to be measured, and this makes its use attractive in the case of large rates of flow.

5.2.1.2 Particular advantages of radio-element generators

— A practically inexhaustible quantity of radioactive tracer of short half-life is availabe at the measuring place from a small quantity of "mother" substance of long half-life at a very low cost.

— It is possible to make repeated measurements in recirculating systems when the "daughter" substance has a sufficiently short half-life.

5.2.1.3 Advantages of non-radioactive tracers

— It is not necessary for the operators to be specially trained and classified.

— Substances generally remain stable with time; delays and distances between the supply and the use of the substance do not matter.

— Transport and injection of the substance do not require particular safety procedures; containers can be light.

— Administrative authorizations are not necessary for each measurement.

5.2.2 *Comparison of various non-radioactive tracers in general use*

5.2.2.1 Advantages of dichromate

— Small concentrations can be analyzed by colorimetric procedures which do not require specialised operators; it can easily be reconcentrated.

— It is not present in natural waters.

— It is very stable when in crystalline form and relatively stable when in solution in pure waters, even in sunshine.

— It is very soluble in water (more than 600 g/l).

— It is relatively cheap.

5.2.2.2 Disadvantages of dichromate

— Instability in certain reducing conditions.

— Need of a reagent.

— Toxic in concentrated solutions.

5.2.2.3 Advantages of rhodamines

— They can be analyzed in smaller concentrations than can dichromate.

— Their concentration can be recorded during measurements as they do not need any reagent for the analysis.

— They are not present in natural waters.

— They are not significantly toxic and do not affect animal life.

5.2.2.4 Disadvantages of rhodamines

— Not very soluble.

— Rather expensive.