

Methods for measurement of

Fluid flow in closed conduits, using tracers —

Part 1: Measurement of water flow —

Section 1.1 General

[ISO title: Measurement of water flow in closed conduits —
Tracer methods — Part I: General]

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- British Gas Corporation
- British Industrial Measuring and Control Apparatus Manufacturers' Association
- British Steel Corporation
- CBMPE (Council of British Manufacturers of Petroleum Equipment)
- Control and Automation Manufacturers' Association (BEAMA)
- Department of Industry (Computers Systems and Electronics)
- Electrical, Electronic, Telecommunications and Plumbing Union
- Electricity Supply Industry in England and Wales*
- Electronic Engineering Association
- Engineering Equipment Users' Association*
- Institute of Measurement and Control
- Institution of Electrical Engineers
- Institution of Gas Engineers
- Oil Companies Materials Association
- Post Office Engineering Union
- Scientific Instrument Manufacturers' Association
- Sira Institute

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Department of Energy (Gas Standards)
- United Kingdom Atomic Energy Authority

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 Executive Board and comes into effect on 31 March 1980

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The following BSI references relate to the work on this standard:
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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 2975-I:1974 “*Measurement of water flow in closed conduits — Tracer methods — Part 1: General*” published by the International Organization for Standardization (ISO).

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

The comma has been used throughout 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”.

With reference to footnote 1) to clause 2, ISO 4006 “*Measurement of fluid flow in closed conduits — Vocabulary and symbols*” was published in 1977.

Cross-reference

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)

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, 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.

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.

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.

¹⁾ In preparation.

- 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:

- it should mix easily with water;
- it should cause only negligible modifications of the rate of flow;
- 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:

- it should be cheap;
- 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

- can, at low concentrations, be analysed accurately;
- 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

- 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 ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$):
 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 ($\text{C}_{28}\text{H}_{31}\text{ClN}_2\text{O}_3$): 2×10^{-4} mg/l
- rhodamine Wt
- lithium chloride (LiCl)
- fluorescein ($\text{C}_{20}\text{H}_{10}\text{O}_5\text{Na}_2$): 5×10^{-3} mg/l

Other tracers have been used, and in particular:

- sodium nitrite (NaNO_2)
- manganese sulphate ($\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$)
- 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.