

Measurement of liquid flow in open channels —

Part 2: Dilution methods —

Part 2C: Methods of measurement using chemical tracers

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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 Policy Committee (PCL/-) to Technical Committee PCL/3, upon which the following bodies were represented:

- Clyde River Purification Board
- Department of the Environment
- Institute of Measurement and Control
- Institution of Water and Environmental Management
- National Rivers Authority
- Water Services Association of England and Wales
- Welsh Office

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

- Institute of Hydrology
- Water Research Centre

This British Standard, having been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 May 1993

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National foreword

This Part of BS 3680 has been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee. It is identical with ISO 9555-3:1992 *Measurement of liquid flow in open channels — Tracer dilution methods for the measurement of steady flow — Part 3 Chemical tracers*, published by the International Organization for Standardization (ISO).

This is one of a series of Parts of BS 3680 on dilution methods, as follows:

- Part 2A, *General*.¹⁾²⁾
- Part 2B:1993, *Methods of measurement using radioactive tracers*.
- Part 2C:1993, *Methods of measurement using chemical tracers*.
- Part 2D:1993, *Methods of measurement using fluorescent tracers*.

These four Parts of BS 3680 supersede BS 3680-2A:1964, BS 3680-2B:1986, and BS 3680-2C:1983, which are withdrawn.

This British Standard calls for the use of substances that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Particular attention is therefore drawn to the possible use of sodium dichromate as a tracer. This practice is deprecated in the United Kingdom because of the toxicity of sodium dichromate.

Cross-references

The Technical Committee has reviewed the provisions of ISO 772:1988 and ISO 9555-1,¹⁾²⁾ to which normative reference is made in the text, 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 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.

¹⁾ In preparation.

²⁾ It is envisaged that, when ISO 9555-1 is published, it will be implemented in the UK as BS 3680-2A.

1 Scope

This part of ISO 9555 deals with the use of chemical tracers in discharge measurements by the dilution method. Apparatus and methods of general application are set out in ISO 9555-1 and are not repeated here, with the exception of those relating specifically to chemical tracers.

Chemical tracers have several advantages as follows.

- a) As with fluorescent tracers, the handling of the tracer follows normal chemical laboratory practice, and no special equipment (e.g. radiation shielding) is required. Care is still required, however, when handling concentrated tracer, to avoid contamination of samples and, with some tracers, for reasons of chemical toxicity.
- b) In general, chemical tracers are widely available commercially, and may be stored indefinitely.
- c) Analysis may be possible using laboratory facilities currently used for water quality determination.
- d) In general, chemical tracers are photochemically stable.

The disadvantages of chemical tracers are as follows:

- a) Their detection limits are relatively high and therefore a larger quantity of tracer is required for each gauging than in the case of radioactive or fluorescent tracers. For practical reasons this may restrict their application to small discharges. However, for certain tracers, reconcentration techniques can permit the measurement of large discharges (of the order of 1 000 m³/s) where conditions of mixing and tracer loss are acceptable.
- b) With the exception of the conductivity method for sodium chloride, the determination ranges of laboratory analysis methods are limited, so dilution of river samples may be necessary before analysis. This limitation means that the constant-rate injection method is preferable for chemical tracers (excepting the conductivity method) since determination of the peak concentrations resulting from a sudden injection would be difficult.
- c) Natural background levels, particularly of conductivity (resulting from dissolved solids in natural waters), may be high and variable, and this necessitates the use of a larger amount of tracer than would be apparent from a consideration of detection limits only.

- d) It is not possible to use a carrier, as in the case of radioactive tracers, and losses by adsorption may be serious in some cases.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 9555. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9555 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols*.

3 Definitions and symbols

3.1 Definitions

Definitions relating to many aspects of flow measurement, including dilution methods, are given in ISO 772. For the purposes of this part of ISO 9555, the following definitions apply.

3.1.1 ion-selective electrode

potentiometric probe, the output potential of which, when measured against a suitable reference electrode, is proportional to the activity of the selected ion in the solution under test

3.1.2 interference

error in the determination of a chemical ion, caused by the sensitivity of the analytical method to the presence of other ions in solution

3.1.3 Beer-Lambert law

a physical law stating that the absorption of light energy by an absorbing medium varies exponentially with the light path length through the medium and with the molar concentration of the medium

3.1.4 colorimetry

chemical analysis method based on the measurement of the absorption of visible light in a given range of wavelengths by substances in solution according to the Beer-Lambert law

3.1.5**atomic absorption flame spectrometry**

chemical analysis method based on the measurement of the absorption of visible light in a given range of wavelengths by a sample atomized in a flame according to the Beer-Lambert law

3.1.6**atomic emission flame spectrometry**

chemical analysis method based on the measurement of light in a given range of wavelengths emitted by a sample atomized in a flame according to the Beer-Lambert law

3.1.7**adsorption**

removal of ions from solution by a solid surface

3.1.8**conductivity method**

technique for determining the concentration of the tracer by means of electrical conductivity

3.2 Symbols

The symbols used in this part of ISO 9555 are defined where they occur in the text.

3.3 Units of measurement

The units of measurement used in this part of ISO 9555 are SI units.

4 Tracers used**4.1 General**

The chemical tracers in common use are as follows:

- a) iodide as sodium iodide, solubility 1 800 kg per m³;
- b) lithium as lithium chloride, solubility 600 kg per m³;
- c) chloride as sodium chloride, solubility 350 kg per m³;
- d) chromium as sodium dichromate, solubility 800 kg per m³.

Bromide and fluoride are satisfactory tracers but are not in common use. Other substances such as manganese sulfate and sodium nitrate have also been used.

The general characteristics of commonly used chemical tracers are given in Annex A.

4.2 Iodide

Sodium iodide and potassium iodide are highly soluble, and solutions of both have been used as tracers; sodium iodide is cheaper per unit mass of iodide. The iodide ion may be determined by catalytic spectrophotometry, or by using an ion-selective electrode. In each case the detection limit is approximately 1 µg/l and a practical working range is 10 µg/l to 100 µg/l. Concentrations in natural fresh waters may reach 2 µg/l but are usually much lower. The catalytic spectrophotometric method is preferred for laboratory analysis (see 5.1.1.1) while the ion-selective electrode method may be applied *in situ* (see 5.1.1.2 and 5.2.1).

4.3 Lithium

Lithium is available as a variety of salts and the chloride is generally used for tracer studies. Lithium chloride is the cheapest chemical form for a given weight of lithium; lithium brine, which may contain up to 83 g of lithium per litre, is more convenient to handle than anhydrous lithium chloride which is deliquescent and dissolves exothermically (see 10.2.1).

Lithium is normally determined either by atomic emission flame spectrometry or atomic absorption flame spectrometry, and the detection limits are typically 0,1 µg/l and 10 mg/l respectively. Concentrations in open-channel flows range from less than 0,1 µg/l in mountain streams to greater than 10 mg/l in mineral processing plant effluents. Sewage effluents, and some rivers receiving these, can contain typically 10 µg/l to 50 µg/l. Destructive analysis uses a few millilitres of sample, but techniques such as flameless atomic absorption spectrometry may be used if only very small sample volumes are available.

4.4 Chloride

The conductivity method owes its popularity to the relative simplicity and low cost of conductivity meters that can be used in the field, and to the properties of the tracer (sodium chloride) which is characterized by a high degree of electrolytic dissociation when dissolved in water, easy availability and low price, and a moderate solubility, with little dependence of solubility on temperature. Furthermore, sodium chloride is relatively harmless to animal and plant life in the concentrations used, and shows little adsorption by vegetation and the materials of the streambed.