
INTERNATIONAL STANDARD



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Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Constant-rate injection method

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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.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, International Standard ISO 555 replaces ISO Recommendation R 555-1966, drawn up by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*.

The Member Bodies of the following countries approved the Recommendation :

Belgium	Hungary	Portugal
Chile	India	Romania
Colombia	Israel	Switzerland
Czechoslovakia	Italy	United Kingdom
France	Korea, Rep. of	U.S.A.
Germany	Netherlands	U.S.S.R.
Greece	New Zealand	

The Member Body of the following country expressed disapproval of the Recommendation on technical grounds :

Japan *

- Subsequently, this Member Body approved the Recommendation.

CONTENTS

	Page
1 Scope and field of application	1
2 References	1
3 Terminology	1
4 Units of measurement	1
5 Principle of the constant-rate injection method	1
6 Required characteristics of injected solutions	2
7 Choice of the measuring-reach	2
8 Procedure	5
9 Principal chemical substances and methods of analysis in present-day use	9
10 Errors in flow measurements	12

Annexes

A Example of the calculation of flow rate and estimation of tolerances in the case of volumetric chemical analysis	13
B Example of the calculation of flow rate and estimation of tolerances in the case of conductivimetric analysis	15

Liquid flow measurement in open channels – Dilution methods for measurement of steady flow – Constant-rate injection method

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies methods for the measurement of flow in channels under steady flow conditions by the dilution method using constant-rate injection. The method is applicable to the measurement of the flow in channels where the degree of turbulence is sufficiently high to ensure efficient mixing of the injected solution throughout the whole flow. This is generally the case in hill streams and torrents.

The apparatus and the chemicals to be used, the specifications of the techniques of injection and sampling, and also the methods of analysis, are detailed.

2 REFERENCES

ISO/R 541, *Measurement of fluid flow by means of orifice plates and nozzles*.

ISO 772, *Liquid flow measurement in open channels – Vocabulary and symbols*.

ISO 2638, *Liquid flow measurement in open channels – Dilution methods for measurement of steady flow – Integration (sudden injection) method*.¹⁾

3 TERMINOLOGY

For the purposes of this International Standard, the definitions given in ISO 772 apply.

4 UNITS OF MEASUREMENT

The units of measurement used in this International Standard are metres (or feet) and seconds.

5 PRINCIPLE OF THE CONSTANT-RATE INJECTION METHOD

A solution of a suitably selected salt is injected at a constant rate, at a cross-section, at entry of the measuring-reach of the channel in which the rate of flow is constant over the period of test.

In a downstream cross-section of this reach, far enough from the first for the injected solution to be uniformly diluted throughout this cross-section, samples are taken at regular intervals of time. Provided that the concentration of the added chemical has attained a steady value, the rate of flow Q in the channel may be calculated from the equation :

$$Q = qN$$

where

q is the rate of injection of the chemical salt solution;

N is the ratio of the concentration of the salt in the injected solution to that at the downstream cross-section of the channel; however, if traces of the chemical salt are already present in the stream prior to the injection, N is defined by the equation given at the end of 5.1.

The ratio N , which is called the dilution ratio, may be determined by one of the following methods.

1) At present at the stage of draft.

5.1 Method of direct measurement of concentration

The concentration of the salt is determined :

- upstream of the point of injection where the water is in its natural state (concentration C_0). See, however, 8.4 a);
- in the injected solution (concentration C_1);
- in samples obtained from the downstream section (where the concentration of the chemical has attained a steady value C_2).

Equating the mass of the salt passing the injection section ($C_0Q + C_1q$) and that passing the sampling section $C_2(Q + q)$ gives :

$$Q = \frac{C_1 - C_2}{C_2 - C_0} q$$

and if C_2 is small compared with C_1

$$\frac{Q}{q} = N \approx \frac{C_1}{C_2 - C_0}$$

5.2 Method of comparative dilutions

A set of standard solutions is made by diluting samples from the injected solution with different amounts of water from the natural stream, taken from a point upstream of the injection station. These known dilution ratios $N_1, N_2 \dots$ shall be approximately the same as those expected of the samples from the downstream section.

The standard solutions and the samples taken downstream are compared by a similar technique to establish the dilution ratio N of the unknown samples.

6 REQUIRED CHARACTERISTICS OF INJECTED SOLUTIONS

The chemical substance to be used for the injected solution shall comply with the following requirements :

- it shall not give any reaction with the natural water of the river concerned or with any matter (organic matter in particular) which this may contain in solution or suspension, or with the material which forms the river bed;
- it shall be stable to light;
- it shall not be toxic to fish in the dilutions used;
- it shall be capable of being accurately determined at the concentration level of the diluted sample;
- it shall be used only when the concentration of the chemical in solution in the natural water is relatively low.

The following substances, which may not be suitable for all waters, are given as examples, together with final minimum concentrations at which they can be used after dilution :

- sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) : 0,2 mg/l
- sodium chloride (NaCl) $\leftarrow$ 2 mg/l

Other salts have been used, in particular :

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

A chemical substance such as fluorescein ($\text{C}_{20}\text{H}_{12}\text{O}_5$) having sufficient colouring power to allow the passage of the cloud in the river to be checked visually is useful, particularly in preliminary tests to check the delay period before sampling (see 7.2.1).

7 CHOICE OF THE MEASURING-REACH

7.1 General considerations for selection of site

There shall be no loss or gain of water in the measuring-reach (for example, for a tributary joining or a distributary leaving the main flow, or overflow from or to the banks of the stream), and its length shall be such that, allowing for the natural mixing action of the stream, the solution injected at its beginning is uniformly diluted throughout the sampling cross-section.

The distance between the injection and sampling cross-sections shall be as short as practicable and the dead-water zones shall be as small as possible, to reduce the duration of injection and the quantity of salt injected.

For rivers, this condition is easier to satisfy in relatively narrow channels; mixing is also improved by disturbances such as bends, narrows, shelves, falls, etc. In particular, very wide channels shall be avoided, and reaches in which the stream divides into a number of branches shall not be used.

Great care is required to make a satisfactory choice of a reach suitable for the measurement of discharge by the dilution method using constant-rate injection. This choice is facilitated by carrying out the preliminary tests described in 7.2.

7.2 Preliminary tests

It is essential to the success of the method that the injected material have a constant concentration over the whole of the cross-section at the downstream sampling station during the whole of the sampling period.

Before selecting the measuring-reach, it is advisable to make preliminary tests to ensure that efficient mixing in the river will be achieved, to choose the injection and sampling cross-sections and, once these have been chosen, to determine the duration of the injection period.