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Measurement of water flow in closed conduits — Tracer methods — Part II : Constant rate injection method using non-radioactive tracers

*Mesure de débit de l'eau dans les conduites fermées — Méthodes par traceurs —
Partie II : Méthode d'injection à débit constant, utilisant des traceurs non radio-actifs*

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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.

International Standard ISO 2975/II was drawn up by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, and circulated to the Member Bodies in May 1974.

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

Australia	Ireland	Thailand
Belgium	Mexico	Turkey
Bulgaria	Netherlands	United Kingdom
Czechoslovakia	Romania	U.S.A.
France	Spain	U.S.S.R.
Germany	Switzerland	Yugoslavia

No Member Body expressed disapproval of the document.

Measurement of water flow in closed conduits — Tracer methods — Part II : Constant rate injection method using non-radioactive tracers

0 INTRODUCTION

This International Standard is the second 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 specifies the constant rate injection method using non-radioactive tracers for the measurement of water flow rate in closed conduits.

2 PRINCIPLE

Flow rate measurement by a constant rate injection method is based on a comparison between the concentration C_1 of a tracer, continuously introduced with a known volume rate of flow q , and the concentration of samples C_2 taken at some place beyond the mixing distance. The mixing distance is defined as the shortest distance at which the variation in concentration of the tracer over the cross-section is less than some pre-determined value (for example : 0,5 %). (See clause 6 of part I.)

The tracer rate at the injection point is equal to the rate at which it passes the sampling point :

$$q C_1 + Q C_0 = (Q + q) C_2$$

where C_0 is the initial concentration in the stream which is flowing at the rate Q .

Hence :

$$Q = q \left(\frac{C_1 - C_2}{C_2 - C_0} \right)$$

Generally C_1 is much greater than C_2 which leads to a simplification of equation (1) as follows :

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

When C_2 is much greater than C_0 , the equation can be reduced still further to

$$Q = q \left(\frac{C_1}{C_2} \right)$$

Flow rate Q can thus be determined by comparing the concentration of the injected solution with the concentration of samples removed from the conduit.

In order to increase the accuracy it is recommended that the standard solution be prepared to a given dilution ratio N_{st} which shall be approximately equivalent to the dilution ratio N which is expected in the sample taken from the measuring cross-section.

The standard solutions and the samples taken from the measuring cross-section shall be compared using identical methods, and the following formula is applicable :

$$m = \frac{N}{N_{st}}$$

The flow rate to be determined can be found from the formula

$$Q = q m \bar{N}_{st}$$

3 REQUIRED CONDITIONS

3.1 Tracer

For the constant rate injection method the tracer shall meet the general requirements defined in 5.1 of part I. A list of generally used tracers is given in 5.1.1 of part I and their advantages with respect to the radioactive tracers are stated in 5.2.1.3 and with respect to other non-radioactive tracers in 5.2.2 of part I.

In practice, to obtain a concentration level of duration Δt at cross-section S, a calculation is made of the minimum required period of injection by adding to the value of Δt the time $t_2 = AB$ taken by the instantaneously injected tracer to pass through S.

$$t_2 = \frac{6}{U} \sqrt{\frac{DX}{2}}$$

It is possible, when no preliminary injection is made, to check the appearance of the concentration level, and therefore the minimum injection time, by taking samples and analysing them during the measurement, with the apparatus used for the measurement. This procedure enables the concentration variation to be determined as a function of time.

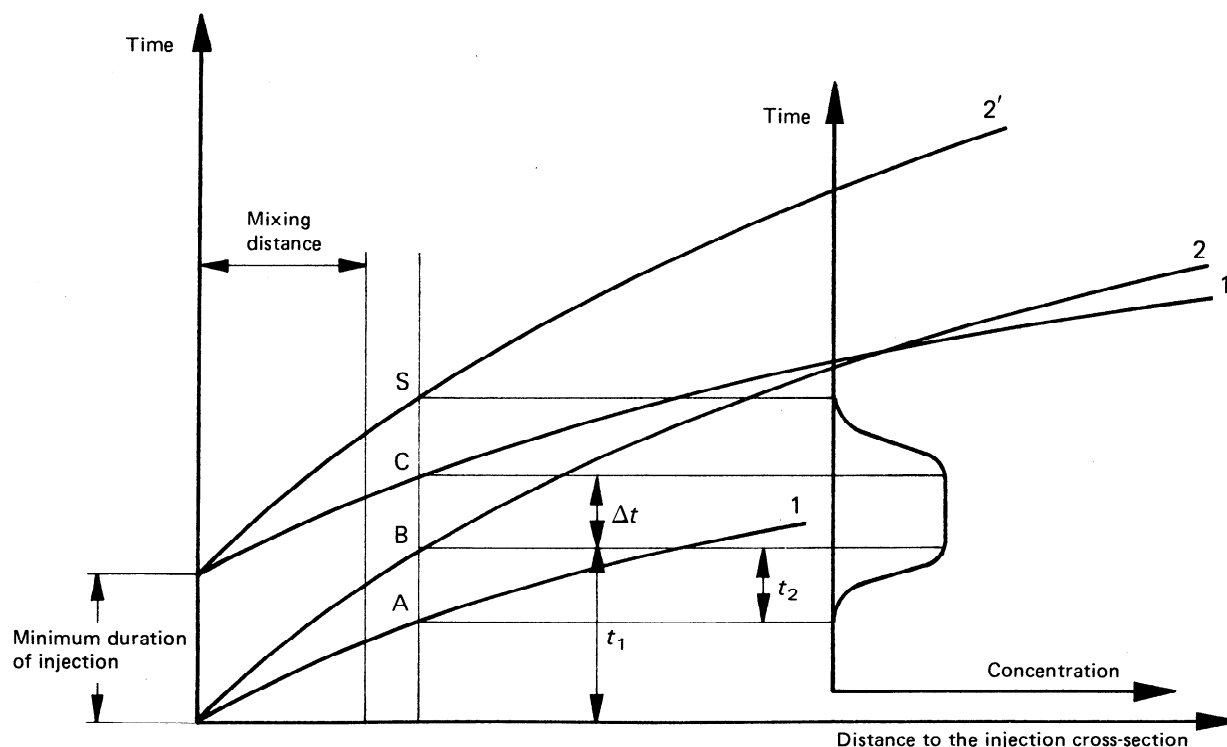


FIGURE – Determination of the duration of injection

4 CHOICE OF MEASURING LENGTH

4.1 Mixing distance

The mixing distance is defined in 6.1 of part I and may be calculated theoretically according to 6.2.1 of part I. Figure 3 of part I indicates the measured variation of the actual mixing distance according to the required accuracy in the case of a central injection, and in the case of three other injection methods. Methods for reducing the mixing distance are described in 6.3 of part I.

4.2 Experimental checking

It is seldom possible in conduits to check experimentally the homogeneity of the mixture and the duration of the tracer passage resulting from an instantaneous injection in a large number of cross-sections.

In practice, therefore, the experimentation consists of

- a) determining the minimum period of injection in the measuring length chosen by a preliminary test (see 3.2);
- b) checking, where possible, at the time of the measurement, that the mixture is homogeneous, by taking samples from at least two points of the measuring cross-section. In the case of high accuracy measurements (for example 0,2 %), it is necessary to check the homogeneity of the mixture, prior to the measurement itself, when a doubt exists on the quality of this mixture;
- c) studying, whenever possible by taking samples from another cross-section further downstream, whether there are any systematic differences between the mean concentrations at the two measuring cross-sections. In particular, this method permits verification that the injected tracer is not absorbed in the measuring length either by entrained products in the liquid or by the conduit walls.¹⁾

4.3 Losses and additions

The losses and additions of the same liquid as that in the measuring length do not affect the results provided certain conditions are met as described in 6.5.1 of part I.

5 PROCEDURE

5.1 Preparation of the concentrated solution

It is essential for the injected solution to be homogeneous. The homogeneity of the solution can be obtained by vigorous mixing, by means of a mechanical stirrer or a closed circuit pump. It is advisable to prepare the injection solution in a separate container from the supply container with water filtered using an appropriate procedure.

However, if mixing is carried out in the supply container, the latter shall have sufficient capacity so that it is not necessary to add liquid or tracer during the injection. The solution shall be taken at a certain level above the bottom of the container, and every precaution shall be taken so that undissolved particles of the tracer are not carried in the solution injected. In the case of an injection of long duration, provision shall be made as required to avoid a variation of the solution concentration with time (for example by evaporation under the influence of ambient temperature).

5.2 Injection of the concentrated solution

The concentrated solution shall be injected into the conduit at a constant rate and for a sufficient duration to ensure a satisfactory period of constant concentration at the measuring cross-section (see 3.2 and 4.2). Several devices may be used for the injection of the concentrated solution. For all devices it must be possible to check the following :

- that the injection system is always free from leaks;
- that the injection rate is constant over the whole injection duration. To this end, any entrained impurities which may be contained in the solution shall be eliminated as they could partly or totally block the injection circuits.

One of the possible devices is a positive displacement pump driven by a constant speed motor.

5.3 Measurement of injection flow rate

The accuracy with which the injection rate can be measured depends on the measuring instruments used. The accuracy of the device shall be taken into account in the estimation of the total error on flow measurement.

Various measuring devices can be used provided they comply with one of the following requirements :

- a) they satisfy a principle based on the measurement of the basic quantities of mass, length, time, directly involved in the definition of the quantity of flow;
- b) they are calibrated in the conditions of use by measuring basic quantities involved in the flow rate definition (for example calibrated capacity method – weighing method, etc.);
- c) they are installed and used in conformity with the requirements of a Standard making it possible to calculate the accuracy obtained.

In the case of high accuracy measurements (for example 0,2 %), it is necessary to measure the injection rate in accordance with items a) or b).

1) See 5.1 of part I.