

INTERNATIONAL STANDARD



2975 / II

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

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*

First edition — 1975-08-15

UDC 681.121.84

Ref. No. ISO 2975/II-1975 (E)

Descriptors: flow measurement, pipe flow, water flow, tracer method, non-radioactive tracers, testing conditions, colorimetric analysis, fluorimetric analysis, conductimetric analysis, error analysis.



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FOREWORD

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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
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No Member Body expressed disapproval of the document.

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Printed in Switzerland

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.

3.2 Duration of injection

The duration of injection shall be such that stable concentration conditions are established at all points of the measuring cross-section over a sufficient period of time.

Constant concentration shall be obtained for a period of at least several minutes.

A suitable duration of injection may be determined by a preliminary investigation involving the instantaneous injection of a dye such as fluorescein or a radioactive tracer. Curves 1 and 2 of the figure may be plotted for a given flow rate from the observation of the moment when the tracer (dye or activity) appears and disappears in each cross-section.

If it is required to achieve steady conditions for a period of time Δt in a selected measuring cross-section S, it is sufficient to add this period of time Δt to the time t_1 corresponding to the disappearance of the tracer at this point (i.e. on curve 2) and to plot through the resulting point C a curve 1' parallel to curve 1 characteristic of the appearance of the dye (or activity). The ordinate at the origin of this curve gives the duration of the injection to obtain a concentration level of duration Δt at cross-section S.

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.

The time interval t_1 between the beginning of the injection and the establishment of stable conditions can be read from curve 2 (ordinate of point B) and is directly obtained by measuring the time interval between the instantaneous injection and the tracer disappearance in cross-section S.

In the case of central injection, straight measuring length and turbulent flow, time $t_2 = AB$ may be estimated from the relationship

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

where

U is the mean velocity of the flow;

X is the distance to the injection point;

D is the conduit diameter.

The fraction of maximum concentration remaining after time t_2 as given by this formula is 0,3 %.

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.

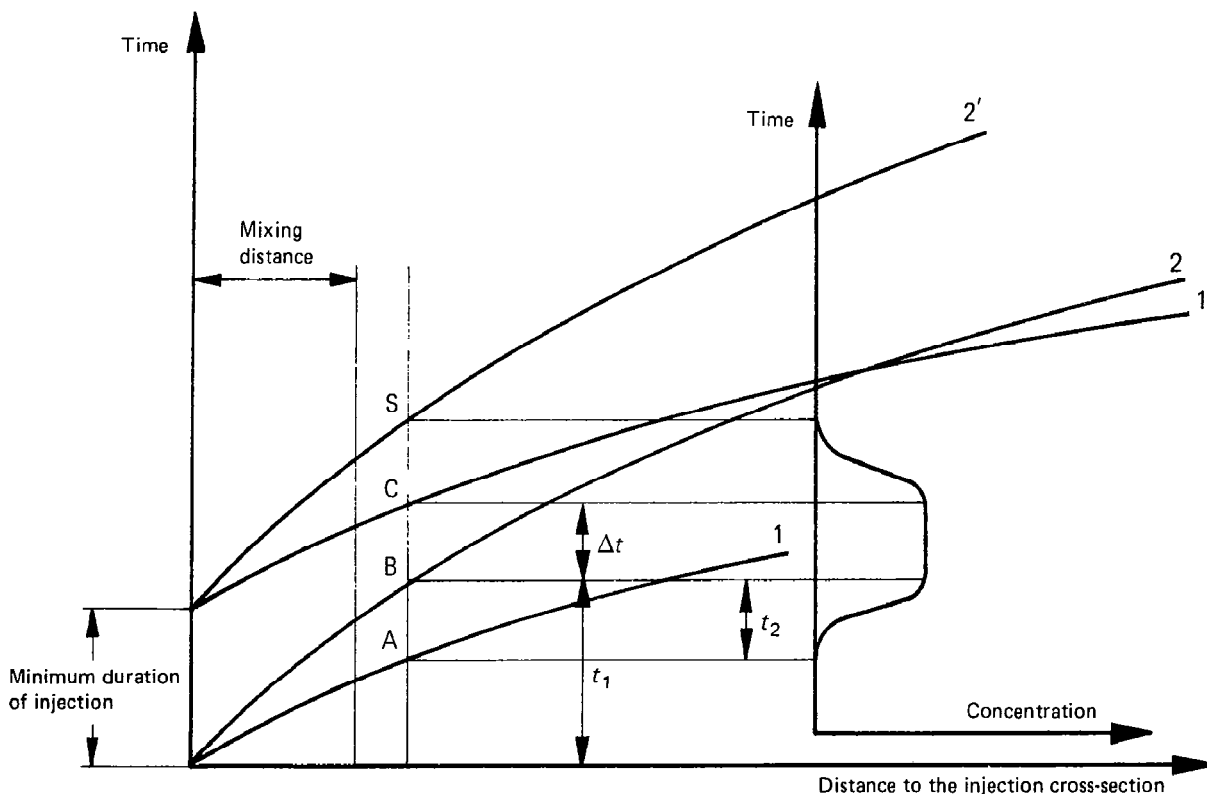


FIGURE – Determination of the duration of injection