AS 3778.5.2—1991

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Australian Standard®

Measurement of water flow in open channels

Part 5: Dilution methods

Methods 5.2: Integration method for the measurement of steady flow

[ISO title: Liquid flow measurement in open channels—Dilution methods for the measurement of steady flow—Part 2: Integration method]

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Department of Water Resources, N.S.W

Engineering and Water Supply Department of South Australia

Forestry Commission, N.S.W.

Institute of Instrumentation and Control

Monash University

Snowy Mountains Engineering Corporation

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Water Authority of Western Australia

Water Board, Sydney—Illawarra—Blue Mountains

Water Resources Commission, Queensland

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PREFACE

This Standard was prepared by the Standards Australia Committee on Measurement of Water Flow in Open Channels and Closed Conduits. It is identical with and has been reproduced from ISO 555-2:1973, *Liquid flow measurement in open channels—Dilution methods for the measurement of steady flow,* Part 2: *Integration method.*

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This Standard is one of a series which deals with methods of measurement of water flow in open channels. The series when complete will consist of the following parts:

Part 1:	*Vocabulary and symbols*
Part 2.1:	*General—Guidelines for the selection of methods of measurement*
Part 2.2:	*General—Establishment and operation of a gauging station*
Part 2.3:	*General—Determination of the stage-discharge relation*
Part 2.4:	*General—Estimation of uncertainty of a flow-rate measurement*
Part 2.5:	*General—Guidelines for the selection of flow gauging structures*
Part 3:	*Velocity-area methods*
Method 3.1:	*Measurement by current-meters and floats*
Method 3.2:	*Measurement by moving-boat method*
Method 3.3:	*Measurement by slope-area method*
Method 3.4:	*Collection and processing of data for determination of errors in measurement*
Method 3.5:	*Investigation of total error*
Method 3.6:	*Measurement of flow in tidal channels*
Method 3.7:	*Measurement by ultrasonic (acoustic) method*
Method 3.8:	*Electromagnetic method using a full-channel-width coil*
Part 4:	*Measurement using flow gauging structures*
Method 4.1:	*Thin-plate weirs*
Method 4.2:	*Rectangular broad-crested weirs*
Method 4.3:	*Round-nose horizontal broad-crested weirs*
Method 4.4:	*V-shaped broad-crested weirs*
Method 4.5:	*Triangular profile weirs*
Method 4.6:	*Flat-V weirs*
Method 4.7:	*Rectangular, trapezoidal and U-shaped flumes*
Method 4.8:	*Trapezoidal profile weirs*
Method 4.9:	*Parshall and Saniiri flumes*
Method 4.10:	*End-depth method for estimation of flow in rectangular channels with a free overfall*
Method 4.11:	*End-depth method for estimation of flow in non-rectangular channels with a free overfall (approximate method)*
Part 5:	*Dilution methods*
Method 5.1:	*Constant-rate injection method for the measurement of steady flow*
Method 5.2:	*Integration method for the measurement of steady flow* (this Standard)
Part 6.1:	*Measuring devices, instruments and equipment—Rotating element current-meters*
Part 6.2:	*Measuring devices, instruments and equipment—Direct depth sounding and suspension equipment*
Part 6.3:	*Measuring devices, instruments and equipment—Calibration of rotating element current-meters in straight open tanks*
Part 6.4:	*Measuring devices, instruments and equipment—Echo sounders for water depth measurements*
Part 6.5:	*Measuring devices, instruments and equipment—Water level measuring devices*
Part 6.6:	*Measuring devices, instruments and equipment—Cableway system for stream gauging*
Part 6.7:	*Measuring devices, instruments and equipment—Ultrasonic (acoustic) velocity meters*
Part 6.8:	*Measuring devices, instruments and equipment—Position fixing equipment for hydrometric boats*

For the purposes of this Australian Standard, the ISO text should be modified as follows:

(i) Wherever the words 'International Standard' appear, referring to this Standard, they should be read as 'Australian Standard'.

(ii) Wherever the word 'fluid' appears, it should be read as 'water'.

(iii) Substitute a full point (.) for a comma (,) as a decimal marker.

(iv) The references to other publications should be replaced by references to Australian Standards as follows:

Reference to International Standard		*Australian Standard*	
ISO		AS	
		3778	Measurement of water flow in open channels
772	Liquid flow measurement in open channels—Vocabulary and symbols	3778.1	Part 1: Vocabulary and symbols
1100	Liquid flow measurement in open channels		
1100-1	Part 1: Establishment and operation of a gauging station	3778.2.2	Part 2.2: General—Establishment and operation of a gauging station
1100-2	Part 2: Determination of the stage-discharge relation	3778.2.3	Part 2.3: General-Determination of the stage-discharge relation
555	Liquid flow measurement in open channels—Dilution methods for measurement of steady flow		
555-1	Part 1: Constant rate injection method	3778.5.1	Part 5: Dilution methods Method 5.1: Constant-rate injection method for the measurement of steady flow
555-3	Part 3: Constant rate injection method and integration method using radioactive tracers	—	

Measurement of water flow in open channels

Part 5: Dilution methods

Method 5.2: Integration method for the measurement of steady flow

0 Introduction

The flow in open channels such as rivers and sewers can be determined by the dilution method, often by simply emptying a known amount of tracer into the channel. The method described in this part of ISO 555 forms an alternative to the constant-rate injection method specified in ISO 555-1 and all the requirements regarding the tracers, the channel and the type of flow are similar for both methods. The method was formerly known as the “sudden injection” method, but this term is being replaced here because it can lead to misunderstandings.[1)]

Open channels may be used to convey various liquids including organic liquors and slurries. This part of ISO 555 therefore deals with the general case, although it is realized that most dilution gauging is carried out in aqueous flows.

1 Scope

This part of ISO 555 gives the principles of the integration method and describes several sampling procedures that may be used to establish that the tracer mixing is satisfactory at the cross-section where the measurement of flow is required. It deals with the choice of tracer and gives a brief outline of the channel characteristics necessary for the application of the method. The procedures that maybe required to inject the tracer, to determine the quantity injected and to measure the concentrations of tracer in the injection solution and in the samples are given. The complexity of these procedures can vary considerably, depending on the objectives. When only a rough estimate of discharge is required in a remote area or during spate flow conditions, the experimental and analytical techniques can be far less rigorous than those required when calibration of a gauging structure is required. Sample analysis is not dealt with in detail but a numerical example is given to illustrate the calculation of flow and the estimation of uncertainties.

2 Field of application

For a given discharge, the integration method requires less tracer than the constant-rate injection method. It is, therefore, particularly applicable for high discharges or where tracer economy is important because of considerations of cost. Discharges of several thousand cubic metres per second have been determined using the integration method. In the case of smaller flows, the method may be preferred on sites where access is difficult or when facilities are sparse, because the field operations can be very simple. Should any doubt exist as to the steadiness of the flow, the constant-rate injection method should be used, since the integration method may provide no information on the variation of flow with time and, consequently, errors in the computed flow would occur. In narrow channels such as sewers where the tracer concentrations may rise and fall too rapidly for samples to be taken in such a way as to represent accurately the passage of tracer, the constant-rate injection method shall be used (see ISO 555-1).

The method can only be applied when the mixing processes within the channel, whether caused by natural turbulence or otherwise, are sufficient for the tracer to be thoroughly mixed across the entire section of the channel at the sampling station and when all the tracer injected passes through the sampling cross-section. Dilution gauging is particularly suitable for turbulent rivers where other methods are difficult to apply, e.g. rock-strewn shallow rivers with steep slopes. The method may be used to calibrate other methods because dilution gauging involves absolute determinations of volumes and times and determinations of relative values of concentrations only. When calibrating other methods, the accuracy and cost of dilution gauging should be compatible with the device or structure under examination and for guidance on the correlation to be expected between results reference should be made to the relevant International Standards dealing with the other methods.

1) The method is valid for an injection over an extended period of time and can therefore be applied to some advantage where accidental spills of soluble chemicals occur or where a constant-rate injection has been prematurely stopped.