

Australian Standard[®]

**Measurement of water flow in
open channels**

**Part 6.7: Measuring devices,
instruments and equipment—
Ultrasonic (acoustic) velocity
meters**

[ISO title: Liquid flow measurement in open channels— Ultrasonic
(acoustic) velocity meters]

This Australian Standard was prepared by Committee CE/24, Measurement of Water Flow in Open Channels and Closed Conduits. It was approved on behalf of the Council of Standards Australia on 9 January 1992 and published on 16 April 1992.

The following interests are represented on Committee CE/24:

The Association of Consulting Engineers of Australia
Australian Water and Wastewater Association
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
Melbourne Water
Monash University
Snowy Mountains Engineering Corporation
University of New South Wales
University of Queensland
Water Authority of Western Australia
Water Board, Sydney—Illawarra—Blue Mountains
Water Resource Commission, Queensland

Review of Australian Standards. To keep abreast of progress in industry, Australian Standards are subject to periodic review and are kept up to date by the issue of amendments or new editions as necessary. It is important therefore that Standards users ensure that they are in possession of the latest edition, and any amendments thereto.

Full details of all Australian Standards and related publications will be found in the Standards Australia Catalogue of Publications; this information is supplemented each month by the magazine 'The Australian Standard', which subscribing members receive, and which gives details of new publications, new editions and amendments, and of withdrawn Standards.

Suggestions for improvements to Australian Standards, addressed to the head office of Standards Australia, are welcomed. Notification of any inaccuracy or ambiguity found in an Australian Standard should be made without delay in order that the matter may be investigated and appropriate action taken.

Australian Standard[®]

**Measurement of water flow in
open channels**

**Part 6.7: Measuring devices,
instruments and equipment—
Ultrasonic (acoustic) velocity
meters**

First published as AS 3778.6.7—1992.

PUBLISHED BY STANDARDS AUSTRALIA
(STANDARDS ASSOCIATION OF AUSTRALIA)
1 THE CRESCENT, HOMEBUSH, NSW 2140

ISBN 0 7262 7342 2

 **Documents**
Document Sharing Hub

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 6418:1985, *Liquid flow measurement in open channels — Ultrasonic (acoustic) velocity meters*.

Under arrangements made between Standards Australia and the international Standards bodies, ISO and IEC, as well as certain other Standards organizations, users of this Australian Standard are advised of the following:

- (a) Copyright is vested in Standards Australia.
- (b) The number of this Standard is not reproduced on each page; its identity is shown only on the cover and title pages.
- (c) There may be occasional dual language sections, but English is always one of the languages reproduced.
- (d) Where any cross-references to page numbers appear within the text, these relate to page numbering in the International Standard and are to be disregarded.

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*
- Part 6: *Measuring devices*
- 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 (this Standard)*
- 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:

<i>Reference to International Standard or other Publication</i>	<i>Australian Standard</i>
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
6416 Liquid flow measurement in open channels—Measurement of discharge by the ultrasonic (acoustic) method	3778.3.7 Method 3.7: Velocity-area methods—Measurement by ultrasonic (acoustic) method

CONTENTS

	<i>Page</i>
1 SCOPE AND FIELD OF APPLICATION	4
2 REFERENCES	4
3 DEFINITIONS	4
4 UNITS OF MEASUREMENT	4
5 GENERAL	4
6 PRINCIPLE OF OPERATION	4
7 CHARACTERISTICS OF SOUND IN WATER	6
8 INSTRUMENT PERFORMANCE CRITERIA	7
9 SITE SELECTION	8
10 INSTRUMENT INSTALLATION	8
11 OPERATION MANUAL	8
12 CALIBRATION	8
13 UNCERTAINTIES AND SYSTEMATIC ERRORS	8
14 BLOCK DIAGRAMS	9
ANNEXES	
A TYPICAL MINIMUM CLEARANCES WITH RESPECT TO BED AND WATER SURFACE FOR VARIOUS PATH LENGTHS AND OPERATING FREQUENCIES ..	11
B SYSTEMATIC ERRORS INCURRED IF THE ASSUMED DIRECTION OF FLOW IS NOT PARALLEL TO THE CHANNEL AXIS, FOR VARIOUS PATH LENGTHS AND PATH ANGLES	12
C BLOCK DIAGRAMS	13

© Copyright — STANDARDS AUSTRALIA

Users of Standards are reminded that copyright subsists in all Standards Australia publications and software. Except where the Copyright Act allows and except where provided for below no publications or software produced by Standards Australia may be reproduced, stored in a retrieval system in any form or transmitted by any means without prior permission in writing from Standards Australia. Permission may be conditional on an appropriate royalty payment. Requests for permission and information on commercial software royalties should be directed to the head office of Standards Australia.

Standards Australia will permit up to 10 percent of the technical content pages of a Standard to be copied for use exclusively in-house by purchasers of the Standard without payment of a royalty or advice to Standards Australia.

Standards Australia will also permit the inclusion of its copyright material in computer software programs for no royalty payment provided such programs are used exclusively in-house by the creators of the programs.

Care should be taken to ensure that material used is from the current edition of the Standard and that it is updated whenever the Standard is amended or revised. The number and date of the Standard should therefore be clearly identified.

The use of material in print form or in computer software programs to be used commercially, with or without payment, or in commercial contracts is subject to the payment of a royalty. This policy may be varied by Standards Australia at any time.

Measurement of water flow in open channels—

Part 6.7:

Measuring devices, instruments and equipment— Ultrasonic (acoustic) velocity meters

1 Scope and field of application

This International Standard describes the general design, operation, performance and application of ultrasonic (acoustic) velocity meters for measurement of flow in open channels.

While it is recognized that, theoretically, such meters might operate at any frequency, practical considerations tend to limit applications to frequencies above the acoustic range, that is, greater than 15 kHz. However, the term "acoustic" has been applied in practice, in many countries, to meters of this type irrespective of frequency and the term is retained in this International Standard for that reason.

2 References

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

ISO 6416, *Liquid flow measurement in open channels—Measurement of discharge by the ultrasonic (acoustic) method*.

3 Definitions

For the purpose 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 those of the International System of Units (SI). Degrees or radians are used in measurement of plane angles.

5 General

The ultrasonic (acoustic) velocity meter is a device which utilizes acoustic transmission to measure the average velocity along a line between one or more opposing sets of transducers. This device provides continuous measurement of velocity and is useful particularly in circumstances in which regulated flows, navigation of tidal influences, for example, render velocity measurements by traditional methods either difficult, less accurate or impossible.

6 Principle of operation

Several ultrasonic (acoustic) velocity meter systems have been developed using variations of the same basic theory. Common to each is the measurement of water velocity by determination of the travel times of sound pulses moving in both directions along a path diagonal to the flow. The water velocity measured by the system is the average component of the velocity along the acoustic path (see figure 1). The primary methods used are the total travel time method, the sing-around method, the difference frequency method and the differential travel time method.

6.1 Travel time method

The velocity of a sound pulse in moving water is the algebraic sum of the acoustic propagation rate and the component of water velocity along the acoustic path (see figure 1). The travel time of an acoustic pulse, originating from a transducer at point A and travelling in opposition to the flow of water along the path AB, can be expressed as

$$t_{AB} = \frac{L}{c - v_p} \quad \dots (1)$$

Similarly, the travel time for a pulse travelling with the current from B to A is

$$t_{BA} = \frac{L}{c + v_p} \quad \dots (2)$$

Equations (1) and (2) can be combined and solved for v_p :

$$v_p = \frac{L}{2} \left(\frac{1}{t_{BA}} - \frac{1}{t_{AB}} \right) \quad \dots (3)$$

As

$$v_p = v_L \cos \alpha \quad \dots (4)$$

then

$$v_L = \frac{L}{2 \cos \alpha} \left(\frac{1}{t_{BA}} - \frac{1}{t_{AB}} \right) \quad \dots (5)$$

where

c is the velocity of sound in still water;

L is the length of the acoustic path AB;