AS 3778.6.7—1992

ISO 6418:1985

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]

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

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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*

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:

Reference to International Standard or other Publication ISO		*Australian Standard* 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 method — Measurement by ultrasonic (acoustic) method

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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

$$t_{AB} = \frac{L}{c - v_p} \qquad \text{... (1)}$$

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

$$t_{BA} = \frac{L}{c + v_p} \qquad \text{... (2)}$$

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

$$v_p = \frac{L}{2}\left(\frac{1}{t_{BA}} - \frac{1}{t_{AB}}\right) \qquad \text{... (3)}$$

As

$$v_p = v_L \cos \alpha \qquad \text{. . . . (4)}$$

then

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

where

c is the velocity of sound in still water;

L is the length of the acoustic path AB;