

International Standard



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Liquid flow measurement in open channels — Ultrasonic (acoustic) velocity meters

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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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6418 was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*.

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Liquid flow measurement in open channels — 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 or 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

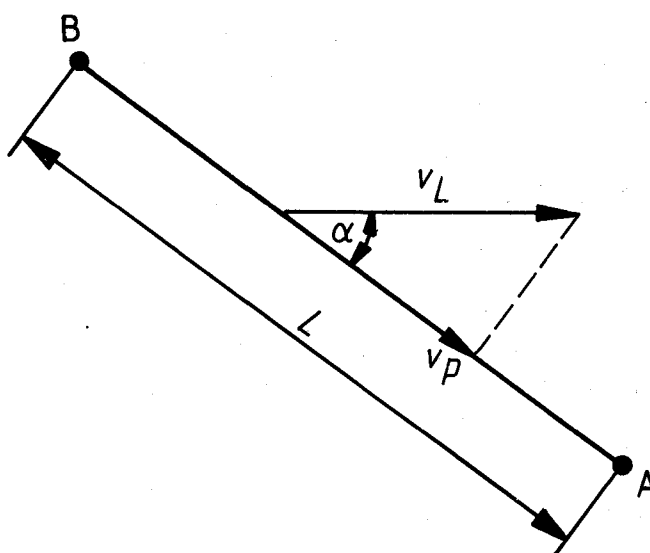


Figure 1 — The direction of acoustic path relative to flow velocity

t_{AB} is the travel time from A to B;

t_{BA} is the travel time from B to A;

v_p is the component of the measured average water velocity along the acoustic path;

v_L is the average water velocity at the elevation of the acoustic path parallel to the axis of the channel;

α is the angle between the mean direction of flow and the acoustic path.

In this type of system, corrections for changes in the propagation rate of sound are automatically compensated for by the treatment of the data.

Travel times are measured sequentially for pulses originating at A and travelling against the current, and then for pulses originating at B and travelling with the current. Accuracy of a system of this type depends on the precision with which the individual travel times can be measured. Errors in indicated velocities are a linear function of timing errors in either direction.

6.2 Sing-around method

The sing-around method, sometimes referred to as the pulse-repetition frequency system, is being used by several developers. Cumulative measurements of travel times are made by using the received pulse at the far end of an acoustic path to trigger a second transmittal pulse at the originating transducer. Arrival of the second pulse triggers the next transmission, and the system is allowed to continue operation in this repetitive pattern. Transit time of the acoustic wave is resolved either by measuring the total time for a fixed number of cycles or by reducing the cycling rate to a continuous pulse-repetition frequency. Where a single pair of transducers is employed, such

systems usually measure transit times for a given period in one direction along the acoustic path and then in the other direction. Sometimes, two pairs of transducers are used, tuned to different frequencies and operating simultaneously.

The quotients $1/t_{BA}$ and $1/t_{AB}$ in equation (5) are the pulse-repetition frequencies for acoustic transmission in each direction that are measured.

6.3 Difference frequency method

A train of ultrasonic pulses is transmitted by each transducer in turn. The transducers at both banks act as receivers detecting the pulses emitted by the opposite transducers. Each receiving transducer controls the frequency of the oscillator which generates the pulse train for the opposite transmitting transducer. The period of each of the frequencies f_1 and f_2 is adjusted to be a function of the transit time of the pulse (see figure 5). The oscillator controlled by the pulses travelling with the flow will have a higher frequency than that controlled by the pulses travelling against the flow. The two frequencies are then compared by the signal processing equipment and a frequency difference derived for a specified period of time, this period being chosen as a function of the cross-sectional area of the flow. By careful choice of the counting time, the pulse count is a direct reading of discharge in desired units.

6.4 Differential travel time method

The differential travel time method differs from the other methods previously considered in that the difference in the time of arrival of acoustic pulses, triggered simultaneously at each end of the path, is directly measured. When two transducers transmit signals simultaneously towards each other, the flow of water in the path will increase the speed of one signal and decrease the other. The signal transmitted in the downstream