Designation: D5089 – 95 (Reapproved 2014)

Standard Test Method for Velocity Measurements of Water in Open Channels with Electromagnetic Current Meters[1]

This standard is issued under the fixed designation D5089; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the use of single-axis or dual-axis electromagnetic current meters for the measurement of water velocities in open channels.

1.2 This test method covers only these components and appurtenances of portable open-channel current-meter systems, which are customarily required when an operator is in attendance.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1129 Terminology Relating to Water

D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water

D3858 Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method

D4409 Test Method for Velocity Measurements of Water in Open Channels with Rotating Element Current Meters

2.2 *ISO Standards:*[3]

ISO 3454 Liquid Flow Measurement in Open Channels—Sounding and Suspension Equipment

ISO 3455 Liquid Flow Measurement in Open Channels—Calibration of Rotating Element Current Meters in Straight Open Tanks

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *boundary layer*—a relatively thin layer of viscous influence adjacent to the probe (or any solid) surface caused by the requirement that the water velocity must be zero at the wall.

3.2.2 *cosine response*—the ability of a meter, placed at an angle to the oncoming flow, to sense the component of velocity parallel to its axis.

3.2.3 *turbulence*—irregular condition of flow in which the various quantities show a random variation with time and space coordinates so that statistically distinct average values can be discerned.

4. Summary of Test Method

4.1 Electromagnetic liquid flow current meters are based on the Faraday principle of electromagnetic induction, which states that voltage is proportional not only to flow speed but also to the magnetic flux density and the distance between electrodes. In the application of the electromagnetic liquid current meter, a conductor (water) moving in a magnetic field (created from within the sensor) generates a voltage that is proportional to the rate of flow of water through the magnetic field. This variable voltage lies in a plane that is perpendicular to both the water velocity vector and the magnetic field vector and is sensed by pairs of electrodes.

5. Significance and Use

5.1 This test method is particularly used for measuring the velocity at a point in an open channel as part of a velocity-area traverse to determine the flowrate of water. To this end it should be used in conjunction with Test Method D3858. A single axis probe with cosine response will suffice for most of these applications.

5.2 This test method is also useful in applications where the velocity itself (rather than a volumetric flowrate) is the desired end product.

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[1] This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.07 on Sediments, Geomorphology, and Open-Channel Flow.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] "Measurement of Liquid Flow in Open Channels," *ISO Standards Handbook 16*, 1983. Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

6. Interferences

6.1 As with any intrusive flow measuring device, electromagnetic current meter sensors may be fouled by pieces of debris of the type that can cling to or wrap around the sensor which could affect measurement accuracy, and sensors may be damaged by heavy debris in very high velocity flow.

6.2 Electromechanical flow sensors can be affected by oil or other materials coating the sensor.

6.3 Electromagnetic flow sensors can be affected by external electrical noise such as that caused by nearby heavy electrical equipment, and by voltage gradients caused by nearby galvanic corrosion, or nearby power lines. Cables and connectors should be properly shielded to reduce noise problems.

6.4 Although electromagnetic velocity meters are in principle capable of measuring substantially lower velocities than rotating element current meters, measurement of near-zero velocities may be hampered by noisy output signals caused by spurious electrical and magnetic noise, by fouling, by zero-drift, and by calibration uncertainties. Where external electrical noise creates uncertainty in sensed velocities, the electromagnetic meter may not be the appropriate velocity instrument for the site.

7. Apparatus

7.1 *Electromagnetic Current Meter:*

7.1.1 The current meter consists of an electromagnet to generate a magnetic field perpendicular to the flow to be measured, electrodes to sense the generated voltage, a housing or supporting structure, and a voltage readout. The sensor can have either one pair of electrodes or two orthogonal pairs of electrodes depending upon whether it is a single-axis or multi-axis instrument.

7.1.2 The current meter must have a self-contained power source for the electromagnet and for any other electrical components. This power source must have sufficient duration for normal field-work requirements. The power cells shall be either rechargeable or readily replaceable by an operator in the field.

7.1.3 The readout may be either in terms of electrical units or directly in velocity. If the former, the manufacturer must supply convenient velocity conversion tables with the instrument. Readouts may be either analog or digital with a readout capability of giving velocity accurate to ±0.01 ft/s (0.305 cm/s).

7.1.4 Optionally the current meter system may include a chart recorder or other type of data recording, storage or transmission device in parallel with the manual readout. One of these options is required only if the current meter is to be used unattended. Specifications for these devices are beyond the scope of this test method.

7.1.5 Optionally the current-meter system may include direction-sensing equipment. Specifications for this equipment are beyond the scope of this test method.

7.1.6 The current meter shall include a means by which the user can check its internal operation. However, it is emphasized that checks of this type do not constitute full calibrations.

7.1.7 All components of the current-meter system shall be made of materials that have corrosion resistance consistent with the intended application. Fabrication material must be selected to preclude galvanic corrosion, which could create electronic interference and degrade accuracy readings of the device.

7.1.8 The manufacturer must inform the user of any limits on ambient temperature, depth, velocity, or other parameters beyond which the instrument should not be used.

7.2 *Suspension:*

7.2.1 The current meter can be suspended in the channel either rigidly, referred to herein as rod mounting, or flexibly, as by cable and weight or other type of mooring. As a minimum, current meters intended for open-channel use shall be equipped with appropriate fittings for either rod mounting or cable suspension; but it is preferable that general purpose current meters be adaptable to both types of suspension. The cable should be adequate to support sounding weights and also be properly electronically shielded to prevent interference with operation of the meter or transmission of signals from meter to readout equipment, or both.

7.2.2 The rating of a current meter may depend upon the geometry of the suspension system in the immediate vicinity of the velocity sensor. Therefore, if the manufacturer does not furnish the suspension system with which the meter was calibrated, he shall provide all specifications necessary for the user to mount the meter in a manner consistent with its calibration.

7.2.3 Although "rod mounting" can describe any rigid suspension, in this context it frequently refers to a rod held vertically against the channel bottom by an operator standing over a small channel (or wading in a larger channel). The connection for rod mounting shall provide, in conjunction with the rod, rigidity and vibration-free performance at the highest velocity claimed for the meter, and shall provide for adjustable sensor position (depth) along the rod. The rod diameter shall be in the range of 0.5 to 1.0 in. (12.7 to 25.4 mm).

7.2.4 Although cable suspension can describe any flexible mooring, in this context it frequently refers to a (nearly) vertical cable which is weighted at its end and which can be winched to place the current sensor at any desired depth. Descriptions of and requirements for suspension equipment appropriate for stream gaging are available in ISO 3454. This test method includes only those elements which directly affect the current-meter performance.

7.2.4.1 The connection between the sensor and cable must permit the sensor to assume its normal operational position. The sensor must be stable with respect to the flow and be able to maintain its proper attitude; this can be accomplished by design of sensor shape, use of fins, or by other means. If detachable fins or other appurtenances are provided, the manufacturer must provide calibrations both with and without this equipment.

7.2.4.2 The weight used in a cable-and-weight suspension should be heavy enough to avoid excessive downstream deflection of the cable, particularly in deep and swift waters. If some deflection is unavoidable, tables for air-line and wet-line