Designation: D 4409 – 95 (Reapproved 2003)

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

This standard is issued under the fixed designation D 4409; 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 describes the design and use of cup-type or vane-type vertical axis current meters and propeller-type horizontal axis current meters for measuring water velocities in open channels.

1.2 This test method is intended primarily for those meters customarily used in open-channel hydraulic (as distinguished from oceanographic) applications with an operator in attendance.

1.3 This test method is intended primarily for current meters that measure one component or filament of flow.

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:*

D 1129 Terminology Relating to Water[2]

D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water[2]

D 3858 Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method[2]

2.2 *ISO Standards:*

ISO 2537 Liquid Flow Measurement in Open Channels—Rotating Element Current Meters[3]

ISO 3454 Liquid Flow Measurement in Open Channels—Direct Depth Sounding and Suspension Equipment[3]

ISO 3455 Liquid Flow Measurement in Open Channels—Calibration of Rotating-Element Current Meters in Straight Open Tanks[3]

3. Terminology

3.1 *Definitions:* For definitions of other terms used in this test method, refer to Terminology D 1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *current meter*—an instrument used to measure the speed or velocity of flowing water at a point.

3.2.2 *Price-type current meters*—generic name for specific vertical axis meters with a rotating element consisting of six conical cups and constructed as described in Refs (**1-3**).[4]

3.2.3 *spin test*— a test performed to check the bearings of a current meter. This test is used primarily with vertical axis current meters.

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

4. Summary of Test Method

4.1 The angular velocity of the rotating element is a function of water speed at the point of immersion. This angular velocity is determined from the meter output and its functional relation to the water speed is determined by calibration.

5. Significance and Use

5.1 This test method describes the design and use of various types of current meters. These current meters are commonly used to measure the velocity at a point in an open channel cross section 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 D 3858.

6. Interferences

6.1 As with any intrusive flow measuring device, rotating element current meters are subject to damage by debris, especially in high velocity flows, and to fouling by floating materials such as aquatic growths and sewage.

6.2 Owing to bearing friction, each rotating element current meter has a limiting low velocity below which it does not

[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] Annual Book of ASTM Standards, Vol 11.01.

[3] Published by International Standards Organization and available from American National Standards Institute, 25 W. 43rd St., 4th floor, New York, NY 10036.

[4] The boldface numbers refer to the list of references at the end of this test method.

function reliably. This velocity is different for each type of meter but, in general, % errors tend to become large as the velocities decrease below 0.1 to 0.2 ft/s (0.03 to 0.06 m/s).

7. Apparatus

7.1 *Current Meters*— Rotating element current meters consist of a rotating element with shaft and bearings, a mechanism for detecting and registering revolutions, and a frame which supports the foregoing elements and provides for suspension of the meter and the insertion of stabilizing fins if needed. Current meters covered by this test method do not customarily incorporate direction-measuring devices.

7.1.1 *Rotor Configuration*—Horizontal-axis meters have propeller-type rotors comprised of two or more blades. Interchangeable elements of different pitch or diameter can be used to cover a wider range of velocities. Vertical-axis meters have a rotating wheel made up of several cup-type or vane-type elements. Rotors employing six conical cups (for example, Price-type meters) are frequently used but other configurations are permissible provided the following requirements are met:

7.1.1.1 The relation between velocity and rotation rate must be stable, that is, there should be no significant uncertainties in the meter's rating curve due to unstable flow separations at the cups or similar hydrodynamic causes.

7.1.1.2 If fractions of revolutions are to be registered, the angular movement of the rotor must be the same during each measured fraction.

7.1.2 *Bearings*:

7.1.2.1 Bearing design shall permit the meter to be used in sediment-laden water, without affecting the accuracy of the meter.

7.1.2.2 If a particular oil is required for bearing lubrication, the supplier shall furnish it with the instrument. Information for obtaining replacement oil shall also be furnished.

7.1.2.3 At the highest velocity claimed for the meter, properly maintained bearings shall function without adversely affecting meter performance for a period of time customarily associated with normal use or for the period of time between recommended recalibrations. If bearing replacement is needed to meet this requirement, such replacement shall be possible in the field.

7.1.2.4 At the lowest velocity claimed for the meter, properly maintained bearings shall function consistently and not contribute to undue deviations in meter response.

7.1.2.5 No breaking-in period for the bearings shall be required after meter delivery.

7.1.3 *Registering Revolutions*—The current meter shall be equipped with a mechanism which detects and signals either single revolutions of the rotor or known fractions or multiples thereof. This detection can be by mechanical-electric contact, by magnetic, optical, or other methods, and shall produce a signal which is audible, visible, or recordable by other means.

7.1.3.1 A mechanical-electric contact device shall not add in any significant manner to the internal friction at the lowest velocity claimed for the meter.

7.1.3.2 The contact device must always actuate the signal at precisely the same position in each revolution (fraction or multiple).

7.1.3.3 If the revolution count is to be made manually by the operator, the audible or visual signals (as distinguished from recorded signals) shall not occur at a frequency greater than 3, and preferably 2.75, cps.

7.1.3.4 A timing device is a necessary adjunct to the meter so that the revolution rate can be determined from the revolution count. In the simplest configuration this system can consist of a manual stopwatch for timing audible or visual signals.

7.1.3.5 If the current meter system has a direct readout in velocity units, the user must be furnished an accuracy statement which includes the readout. Also, the user must be provided with a procedure to check for system malfunctions.

7.1.4 *Frame*—The frame houses the current-meter elements and provides for suspending the meter in the flow. Depending upon the intended use of the meter, the frame can be designed for suspension by rigid rod only, by cable-and-weight only, or it can provide for both types of suspension.

7.1.4.1 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 meter position along the rod. Fixed rod position is necessary for some applications, such as for measuring through ice cover. Rods must be provided with suitable fixtures to accommodate fins as specified in 7.1.4.3.

7.1.4.2 The connection for cable suspension shall permit the meter to swivel in a vertical plane so that it can seek and maintain a horizontal orientation.

7.1.4.3 *Fins*—Meters to be suspended by cable must provide for stabilizing fins to be inserted into the frame. Provision shall be made for balancing the meter-fin unit about its pivot while immersed in water, so that it can operate in a level position at all velocities claimed for the meter.

7.1.5 *Other General Requirements*:

7.1.5.1 The meter design and construction shall be sufficiently sturdy for normal field use and the materials shall be usable in normally encountered fresh and saline waters without undue corrosion or wear.

7.1.5.2 The meter shall offer low resistance to the flow and must be able to maintain a stable position with respect to the flow.

7.1.5.3 Meter parts shall be interchangeable among other meters of the same model and manufacturer. The manufacturer shall state which parts can be replaced without requiring recalibration.

7.1.5.4 Design features which permit minor repairs or parts replacement by the user in the field are encouraged. Any special purpose tools needed for such repairs or replacement shall be furnished with the meter.

7.1.5.5 For high-inertia, vertical-axis meters, spin test durations shall be recommended for effective use of the meters at their lowest claimed velocity. See Refs **(1-3)** for Price-type meters. Users shall be provided with alternative procedures for qualitative indications of internal friction in meters that are not amenable to spin testing.

7.1.5.6 The user shall be provided with the means (detailed dimensions, templates, or forms) to ascertain gradual changes in rotor configuration, where appropriate. See also 10.2.