Designation: ~~D5716/D5716M – 15~~ D5716/D5716M – 20

Standard Test Method for Measuring the Rate of Well Discharge by Circular Orifice Weir[1]

This standard is issued under the fixed designation D5716/D5716M; 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 construction and operation of a circular orifice weir for measuring the discharge from a well. This test method is a part of a series of standards prepared on the in situ determination of hydraulic properties of aquifer systems by single- or multiple-well tests. Selection of a well discharge measurement test method is described in Guide ~~D5737~~D5737M.

1.2 The discharge rate determined by this test method is commonly used for a number of aquifer test methods and to provide information for the evaluation of well and pump performance.

1.3 *Limitations*—This test method is limited to the description of a method common to hydraulic engineering for the purpose of groundwater discharge measurement in temporary or test conditions.

1.4 Much of the information presented in this test method is based on work performed by the Civil Engineering Department of Purdue University during the late 1940s. The essentials of that work have been presented in a pamphlet prepared by Layne-Bowler, Inc.[2] and updated by Layne Western Company, Inc.[3]

1.5 All observed and calculated values shall be conform to the guidelines for significant digits and rounding established in Practice D6026.

1.5.1 The procedures used to specify how data are collected/recorded and calculated in this standard are regarded as the industry standard. In addition they are representative of the significant digits that should generally be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this document to consider significant digits sused analysis methods for engineering design.

1.6 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.7 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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[2] *Measurement of Water Flow Through Pipe Orifice With Free Discharge*, Bulletin 501, Layne-Bowler, Inc., Mission, KS, 1958.

[3] *Measurement of Water Flow Through Pipe Orifice With Free Discharge*, Layne-Western Company, Inc., Mission, KS, 1988.

[4] 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.

***A Summary of Changes section appears at the end of this standard**

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D5737D5737M Guide for Methods for Measuring Well Discharge

D6026 Practice for Using Significant Digits in Geotechnical Data

2.2 *Other Documents:*

GWPD 10 Estimating discharge from a pumping well by use of a circular orifice weir, United States Geological Survey

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *circular orifice weir*—a circular restriction in a pipe that causes back pressure that can be measured in a piezometer tube.

3.2.1.1 *Discussion—*

Also called *orifice tube* and *orifice meter*.

3.3 *Symbols and Dimensions Used in this Standard:*

3.3.1 *A*—orifice plate open area [L^2].

3.3.2 *C*—coefficient of discharge for the orifice [*nd*].

3.3.3 *g*—acceleration due to gravity [LT^{-2}].

3.3.4 *h*—head in manometer [*L*].

3.3.5 *Q*—control well discharge [L^3T^{-1}].

3.3.6 *o*—orifice diameter [*L*].

3.3.7 *d*—pipe inside diameter [*L*].

4. Summary of Test Method

4.1 This test method involves pumping a control well at a constant or variable rate through a circular orifice weir for a given period of time. Discharge is through an orifice weir that allows determination of the discharge rate.

4.2

5. Significance and Use

5.1 This test method provides design information for construction of an orifice weir. It also describes setup, operation, inspection, calculation of discharge, and reporting. The accuracy of a circular weir decreases at low flows. The use of a circular orifice weir requires a constant flow velocity over the period of measurement. The results may be affected by the piezometers distance from the orifice plate. This equipment may not be appropriate for measuring flows on small wells, or wells with limited recharge.

5.2 Aquifer testing has been conducted for the purposes of production and pressure relief well design and water resource assessment. Production wells are used for public and industrial water supplies, hydraulic controls, and groundwater capture. Pressure relief wells are for hydraulic controls. Test wells are for the purpose of water resource assessment.

5.3 Discharge must also be known for certain methods to evaluate well and pump performance.

NOTE 1—Practice D3740 provides evaluation factors for the activities in this standard. The quality of the result produced by this standard is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Construction of a Circular Orifice Weir*—A construction diagram of a circular orifice weir is presented in Fig. 1.[5] The circular orifice is a hole located in the center of a plate attached to a straight horizontal length of discharge pipe. The pipe is at least 1.8 m [6 ft] in length. Approximately 600 mm [24 in.] from the end plate and at least 1.2 m [4 ft] from the other end of the discharge pipe, a piezometer is attached to the discharge pipe so that the head in the discharge pipe can be measured.

6.1.1 *Orifice Plate*—The orifice is a round hole with clean, square edges in the center of a circular steel plate. The plate must be a minimum of 1.6 mm [1⁄16 in.] thick around the circumference of the hole. The remaining thickness of the orifice should be chamfered to 45° and with the chamfered edge down stream.

[5] Driscoll, F. G., *Ground Water and Wells*, Johnson Division, St. Paul, MN, 1986, pp. 537–541.

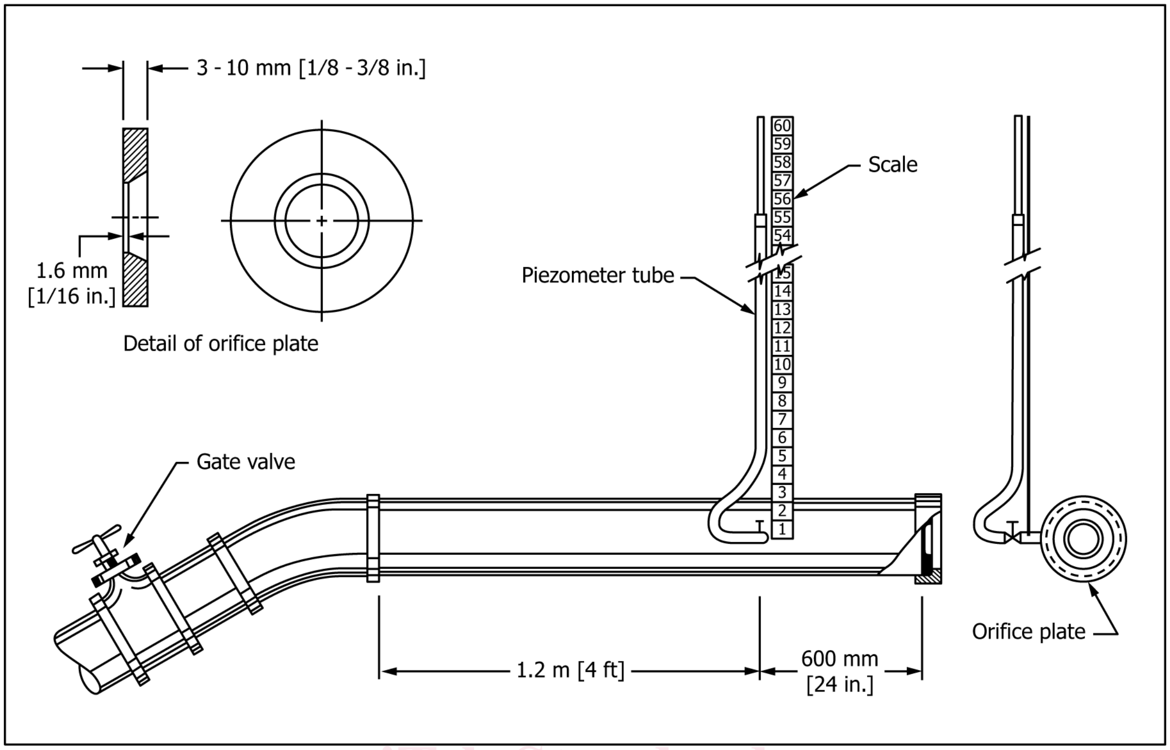

FIG. 1 Construction of a Circular Orifice Weir[5]

6.1.2 *Discharge Pipe*—The discharge pipe must be straight and level for a distance of at least 1.8 m [6 ft] before the water reaches the orifice plate. This approach channel should be longer if possible. The end of the pipe must be cut squarely so the plate will be vertical. The bore of the pipe should be smooth and free of any obstruction that might cause abnormal turbulence.

6.1.3 *Piezometer*—The discharge pipe wall is tapped midway between the top and bottom with a 3 mm [1⁄8-in.] or 6 mm [1⁄4-in.] hole exactly 600 mm [24 in.] from the orifice plate. The manometer should be a distance of at least ten discharge pipe diameters from the gate valve used to control pipe flow. Any burrs inside the pipe resulting from the drilling or tapping of the hole should be filed off. A nipple is screwed into the tapped hole. The nipple must not protrude inside the discharge pipe. A clear plastic tube 1.2 to 1.5 m [4 or 5 ft] long is connected at one end to the nipple. A scale is fastened to a support so that the vertical distance from the center of the discharge pipe up to the water level in the manometer can be measured. Alternately, a u-tube manometer or pressure transducer may be used. During a test the manometer must be free of air bubbles.

6.2 The diameter of the orifice should be less than 80 % of the inside diameter of the approach channel pipe.

7. Procedure

7.1 Set up the apparatus as shown in Fig. 1 and Fig. 2. The apparatus should be set up so that the orifice pipe is horizontal and the discharge is unimpeded. Use a combination of pipe and orifice diameter so that the anticipated head will be at least three times the diameter of the orifice. The orifice plate must be vertical and centered in the discharge pipe.

7.2 Equipment should be inspected to minimize the potential of wear, damage or misuse causing increased head loss that will bias results.

7.3 Initiate flow through the discharge pipe. Check that the manometer is free of air bubbles. Record the manometer level. Using Table 1 and Table 2 for the appropriate pipe and orifice size, read the discharge.

8. Calculation

8.1 Calculate the flow through the orifice using the basic equation:

$$Q = AVC \quad (1)$$

where:

Q = the flow per unit time,
A = the area of the orifice,
V = the velocity of flow through the orifice, and
C = the coefficient of discharge for the orifice.

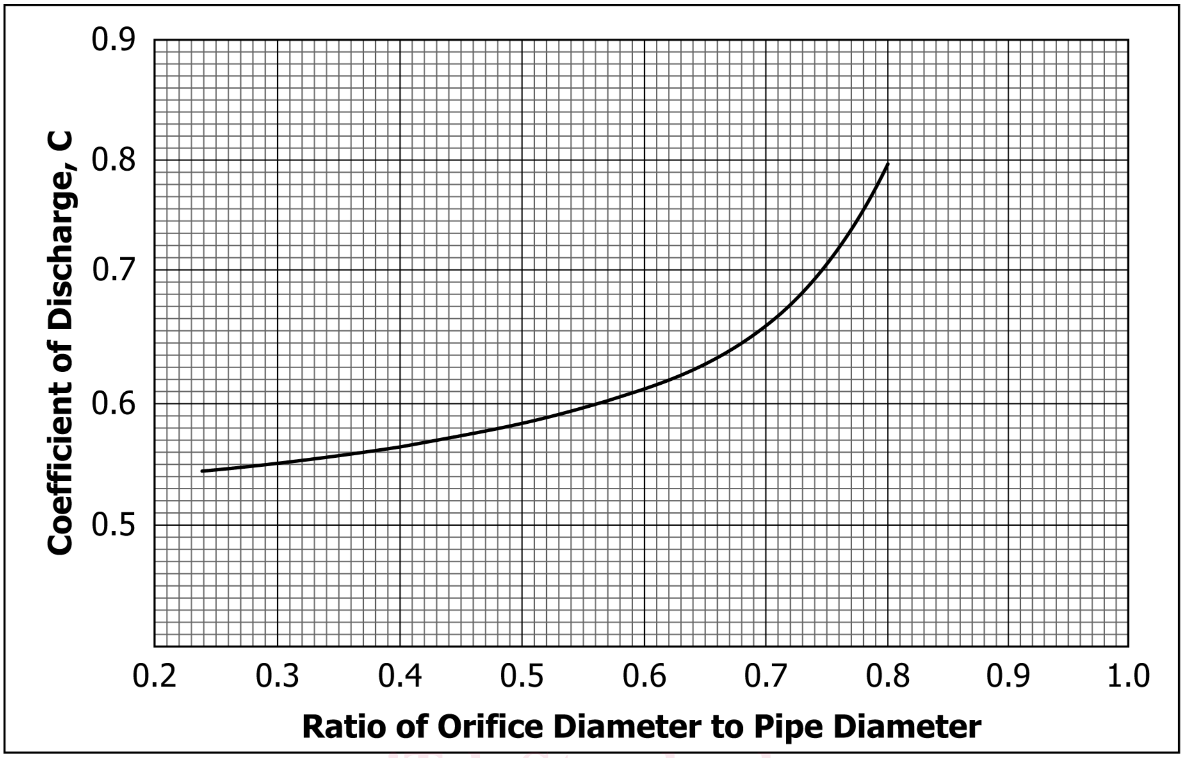

FIG. 2 The Coefficient of Discharge, *C*, in the Orifice-Weir Equation[3]

TABLE 1 Flow Rates through Circular Orifice Weirs[5] (SI)

NOTE 1—Flow rates indicated below the line are more exact than those above the line because the head developed in the piezometer tube for particular pipe and orifice diameters is large enough to ensure the accuracy of results obtained from Eq 5.

Head of Water mm	100 mm Pipe		150 mm Pipe		200 mm Pipe			250 mm Pipe			300 mm Pipe		400 mm Pipe		
	64 mm Orifice Lpm	76 mm Orifice Lpm	76 mm Orifice Lpm	102 mm Orifice Lpm	102 mm Orifice Lpm	127 mm Orifice Lpm	150 mm Orifice Lpm	150 mm Orifice Lpm	178 mm Orifice Lpm	200 mm Orifice Lpm	150 mm Orifice Lpm	200 mm Orifice Lpm	200 mm Orifice Lpm	250 mm Orifice Lpm	300 mm Orifice Lpm
127	210	340	290	550	500	830	1340	1170	1740	2570	1170	2200	2010	3330	5380
150	230	370	310	600	550	910	1480	1290	1890	2800	1230	2420	2200	3630	5900
175	250	400	330	650	590	980	1590	1400	2040	3140	1330	2610	2350	3940	6360
200	260	420	360	690	630	1040	1700	1490	2200	3330	1420	2760	2540	4200	6810
230	280	450	380	730	670	1120	1780	1590	2310	3560	1510	2950	2690	4470	7230
250	290	480	400	770	700	1170	1890	1670	2420	3750	1590	3100	2840	4690	7610
300	320	520	430	840	770	1290	2080	1820	2650	4090	1740	3410	3100	5150	8330
350	350	560	475	910	830	1380	2250	1970	2880	4430	1890	3670	3330	5570	9010
400	370	600	500	980	890	1480	2400	2100	3070	4730	2010	3940	3560	5940	9620
450	390	640	530	1030	950	1570	2560	2230	3260	5040	2120	4160	3780	6320	10180
500	420	670	570	1090	1000	1670	2690	2350	3450	5300	2230	4390	3980	6660	10750
560	440	700	600	1140	1040	1740	2820	2460	3600	5570	2350	4620	4200	6970	11280
635	460	750	640	1220	1120	1860	3010	2610	3860	5900	2500	4920	4470	7420	12040
760	510	820	690	1340	1230	2040	3290	2880	4240	6730	2760	5380	4880	8140	13170
890	550	890	750	1440	1340	2200	3560	3100	4580	7000	2990	5790	5300	8780	14230
1020	590	950	800	1530	1400	2350	3780	3330	4880	7500	3180	6210	5640	9390	15220
1140	620	1010	840	1630	1500	2500	4010	3520	5190	7680	3370	6590	5980	9960	16130
1270	660	1060	890	1720	1570	2610	4240	3710	5450	8110	3560	6930	6320	10520	17000
1525	720	1770	980	1890	1720	2880	4660	4090	5980	8860	3900	7610	6930	11500	18620
1780	780	1320	1060	1990	1850	3070	4850	4320	6470	9580	4200	8210	7460	12420	20100

The velocity of the water at the orifice consists of its velocity in the approach channel plus the additional velocity head created by the pressure drop that occurs between the connection for the manometer and the orifice. Because the water discharges at atmospheric pressure, the pressure head indicated by the manometer can be converted to the velocity if friction in the pipe is neglected.

8.2 Relate the velocity to the head in the manometer by the equation:

$$V = \sqrt{2gh} \tag{2}$$