



Designation: D5855/D5855M – 20

Standard Practice for (Analytical Procedure) Determining Transmissivity and Storage Coefficient of Confined Nonleaky or Leaky Aquifer by Constant Drawdown Method in Flowing Well¹

This standard is issued under the fixed designation D5855/D5855M; 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 practice covers an analytical solution for determining transmissivity and storage coefficient of a leaky or nonleaky confined aquifer. It is used to analyze data on the flow rate from a control well while a constant head is maintained in the well.

1.2 This analytical procedure is used in conjunction with the field procedure in Practice [D5786](#).

1.3 *Limitations*—The limitations of this technique for the determination of hydraulic properties of aquifers are primarily related to the correspondence between field situation and the simplifying assumption of the solution.

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values 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 nonconformance with the standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this practice.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice [D6026](#).

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of the practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without the consideration of a project's many unique aspects. The word "Standard" in*

the title of this document means only that the document has been approved through the ASTM consensus process.

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, health, and 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:²

[D653](#) Terminology Relating to Soil, Rock, and Contained Fluids

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

[D4043](#) Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques

[D5786](#) Practice for (Field Procedure) for Constant Drawdown Tests in Flowing Wells for Determining Hydraulic Properties of Aquifer Systems

[D6026](#) Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 Definitions:

3.1.1 For definitions of common technical terms used in this practice, refer to Terminology [D653](#).

3.2 Symbols and Dimensions:

3.2.1 T —transmissivity [$L^2 T^{-1}$].

¹ This practice 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.

Current edition approved May 15, 2020. Published May 2020. Originally approved in 1995. Last previous edition approved in 2015 as D5855 – 15. DOI: 10.1520/D5855_D5855M-20.

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.

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



3.2.2 K_1 —modified Bessel function of the second kind, first order $[nd]$.

3.2.3 K_2 —modified Bessel function of the second kind, zero order $[nd]$.

3.2.4 J_0 —Bessel function of the first kind, zero order $[nd]$.

3.2.5 Y_0 —Bessel function of the second kind, zero order $[nd]$.

3.2.6 $W(u)$ — w (well) function of u $[nd]$.

3.2.7 u —variable of integration $[nd]$.

3.2.8 t —elapsed time test $[T]$.

3.2.9 Q —discharge rate $[L^3 T^{-1}]$.

3.2.10 s_w —constant drawdown in control well $[L]$.

3.2.11 S —storage coefficient $[nd]$.

3.2.12 r_w —radius of control well.

4. Summary of Practice

4.1 This practice describes the analytical procedure for analyzing data collected during a constant drawdown aquifer test. This practice is usually performed on a flowing well. After the well has been shut-in for a period of time, the well is opened and the discharge rate is measured over a period of time after allowing the well to flow. The water level in the control well while the well is flowing is the elevation of the opening of the control well through which the water is allowed to flow. Data are analyzed by plotting the discharge rate versus time.

NOTE 1—This practice involves the withdrawal of water from a control well that is fully screened through the confined aquifer. The withdrawal rate is varied to cause the water level within the well to remain constant. The field procedure involved in conducting a constant drawdown test is given in Practice D5786. Methods used to develop a conceptual model of the site and for initially selecting an analytical procedure are described in Guide D4043.

4.2 *Leaky Aquifer Solution*—The solution is given by Hantush.³ Transmissivity is calculated as follows:

NOTE 2—These are Eq (93) through (97) of Lohman.⁴

$$T = \frac{Q}{2\pi s_w G(\alpha, r_w/B)} [L^2 T^{-1}] \quad (1)$$

where:

$$\alpha = \frac{Tt}{Sr_w^2} [nd] \quad (2)$$

$$r_w/B = r_w [T/(K'/b')]^{-0.5} [L^2] \quad (3)$$

and:

$$G\left[\frac{r_w}{B}\right] = \left[\frac{r_w}{B}\right] \left[\frac{K_1(r_w/b)}{K_0(r_w/b)}\right] + \frac{r}{\pi^2} \exp\left[-\alpha \left(\frac{r_w}{B}\right)^2\right]. \quad (4)$$

$$\int_0^\infty \frac{u \exp(-\alpha u^2)}{J_0^2(u) + Y_0^2(u)} \cdot \frac{du}{u^2 + (r_w/B)^2} [nd]$$

4.2.1 Storage coefficient is given by:

$$S = \frac{Tt}{r_w^2 \alpha} [nd] \quad (5)$$

4.3 *Non-Leaky Aquifer:*

4.3.1 *Log-Log*—The solution is given by Lohman.⁴

NOTE 3—These equations are Eq (66) through (69) of Lohman.⁴

4.3.1.1 Transmissivity is calculated as follows:

$$T = \frac{Q}{2\pi G(\alpha) s_w} [L^2 T^{-1}] \quad (6)$$

where:

$$\alpha = \frac{Tt}{Sr_w^2} [nd] \quad (7)$$

and:

$$G(\alpha) = \frac{4\alpha}{\pi} \int_0^\infty x e^{-\alpha x^2} \left[\frac{\pi}{2} + \tan^{-1} \left(\frac{Y_0(x)}{J_0(x)} \right) \right] dx [nd] \quad (8)$$

4.3.1.2 Storage coefficient is given by:

$$S = \frac{Tt}{\alpha r_w^2} [nd] \quad (9)$$

4.3.2 *Semi-Log*—The solution is given by Jacob and Lohman.⁵

NOTE 4—Jacob and Lohman⁵ showed that for all but extremely small values of t , the function of $G(\alpha)$ shown above can be approximated very closely by $2/W(u)$. For sufficiently small values of u , $W(u)$ are further approximated by $2.30 \log_{10} 2.25Tt/r_w^2 S$. The use of this semi-logarithmic method will produce values of transmissivity that are slightly elevated. Examples of this error are shown below:

u	$W(u)$	Estimated Error, %
0.25000	1.044283	25
0.00625	4.504198	10
0.000833	6.513694	5
1.25E-05	10.71258	2

4.3.2.1 Transmissivity is calculated as follows:

NOTE 5—These equations are Eqs (71) and (73) of Lohman.⁴

$$T = \frac{2.30}{4\pi \Delta(s_w/Q)/\Delta \log_{10}(t/r_w^2)} [L^2 T^{-1}] \quad (10)$$

by extrapolating the straight line to $s_w/Q = 0$ (the point of zero drawdown), storage coefficient is given by:

$$S = 2.25 \frac{Tt}{r_w^2} [nd] \quad (11)$$

NOTE 6—In (Eq 10) and (Eq 11), Q is in cubic feet per day, t is in days.

5. Significance and Use

5.1 *Assumptions—Leaky Aquifer:*

5.1.1 Drawdown (s_w) in the control well is constant,

5.1.2 Well is infinitesimal diameter and fully penetrates aquifer,

5.1.3 The aquifer is homogeneous, isotropic, and areally extensive, and

5.1.4 The control well is 100 % efficient.

³ Hantush, M. S., "Nonsteady Flow to Flowing Wells in Leaky Aquifer," *Journal of Geophysical Research*, Vol 64, No. 8, 1959, pp. 1043–1052.

⁴ Lohman, S. W., "Ground-Water Hydraulics," *Professional Paper 708*, U.S. Geological Survey, 1972.

⁵ Jacob, C. E., and Lohman, S. W., "Nonsteady Flow to a Well of Constant Drawdown in an Extensive Aquifer," *American Geophysical Union Transactions*, Vol 33, No. 4, 1952, pp. 552–569.

