Designation: D5269 – 15

Standard Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method[1]

This standard is issued under the fixed designation D5269; 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 an analytical procedure for determining the transmissivity of a confined aquifer. This test method is used to analyze data from the recovery of water levels following pumping or injection of water to or from a control well at a constant rate.

1.2 The analytical procedure given in this test method, along with several others, is used in conjunction with the field procedure in Test Method D4050. Guide D4043 provides information for determining hydraulic properties.

1.3 *Limitations*—The valid use of the Theis recovery method is limited to determination of transmissivities for aquifers in hydrogeologic settings reasonably corresponding to the assumptions of the Theis theory (see 5.2).

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 test method.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026. All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless otherwise superseded by this standard.

1.6 *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]

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

D4050 Test Method for (Field Procedure) for Withdrawal and Injection Well Testing for Determining Hydraulic Properties of Aquifer Systems

D4105 Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method

D4106 Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common Terminology terms used within this guide refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *observation well*—a well open to all or part of an aquifer.

3.3 *Symbols and Dimensions:*

3.3.1 b [L]—aquifer thickness.

3.3.2 K [LT^{-1}]—hydraulic conductivity.

[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.

Current edition approved April 15, 2015. Published May 2015. Originally approved in 1992. Last previous edition approved in 2008 as D5269 – 96 (2008). DOI: 10.1520/D5269-15.

[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.

3.3.2.1 *Discussion*—The use of the symbol K for the term hydraulic conductivity is the predominant usage in groundwater literature by hydrogeologists, whereas the symbol k is commonly used for this term in rock mechanics and soil science.

3.3.3 K_r—hydraulic conductivity in the plane of the aquifer, radially from the control well.

3.3.4 K_z—hydraulic conductivity in the vertical direction.

3.3.5 *ln*—natural logarithm.

3.3.6 $\log_{10}$—logarithm to the base 10.

3.3.7 Q [L^3T^{-1}]—discharge.

3.3.8 r [L]—radial distance from control well.

3.3.9 r_c [L]—equivalent inside radius of control well.

3.3.10 S [nd]—storage coefficient.

3.3.11 s [L]—drawdown.

3.3.12 s_c [L]—drawdown corrected for the effects of reduction in saturated thickness.

3.3.13 S_y [nd]—specific yield.

3.3.14 s' *[L]*—residual drawdown.

3.3.15 $\Delta s'$ [L]—change in residual drawdown over one log cycle of t/t'.

3.3.16 T [L^2T^{-1}]—transmissivity.

3.3.17 t [T]—time since pumping or injection began.

3.3.18 t' [T]—time since pumping or injection stopped.

3.3.19 u—dimensionless parameter, equal to $r^2S/4Tt$.

3.3.20 u'—dimensionless parameter, equal to $r^2S/4Tt'$.

4. Summary of Test Method

4.1 This test method describes an analytical procedure for determining transmissivity using data collected during the recovery phase of a withdrawal or injection well test. The field test (see Test Method D4050) requires pumping or injecting a control well that is open to the entire thickness of a confined aquifer at a constant rate for a specified period. The water-levels in the control well, observation wells, or piezometers are measured after pumping is stopped and used to calculate the transmissivity of the aquifer using the procedures in this test method. Alternatively, this test method can be performed by injecting water into the control well at a constant rate. With some modification, this test method can also be used to analyze the residual drawdown following a step test. This test method is used by plotting residual drawdown against either a function of time or a function of time and discharge and determining the slope of a straight line fitted to the points. The solution calculations are shown in Section 8.

5. Significance and Use

5.1 This test method is useful for analyzing data on the recovery of water levels following pumping or injection of water to or from a control well at a constant rate. The analytical procedure given in this test method along with several others is used in conjunction with the field procedure in Test Method D4050.

5.2 *Assumptions:*

5.2.1 The well discharges at a constant rate, Q, or at steps of constant rate Q_1, Q_2 ... Q_n.

5.2.2 Well is of infinitesimal diameter and is open through the full thickness of the aquifer.

5.2.3 The nonleaky aquifer is homogeneous, isotropic, and extensive in area.

5.2.4 Discharge from the well is derived exclusively from storage in the aquifer.

5.2.5 The geometry of the assumed aquifer and well are shown in Fig. 1.

5.3 *Implications of Assumptions:*

5.3.1 Implicit in the assumptions are the conditions of radial flow. Vertical flow components are induced by a control well that partially penetrates the aquifer, that is, not open to the aquifer through the full thickness of the aquifer. If vertical flow components are significant, the nearest partially penetrating observation well should be located at a distance, r, beyond which vertical flow components are negligible. See 5.3.1 of Test Method D4106 for assistance in determining the minimum distance to partially penetrating observation wells and piezometers.

5.3.2 The Theis method assumes the control well is of infinitesimal diameter. The storage in the control well may adversely affect drawdown measurements obtained in the early part of the test. See 5.3.2 of Test Method D4106 for assistance in determining the duration of the effects of well-bore storage on drawdown.

5.3.3 *Application of Theis Recovery Method for Unconfined Aquifers:*

5.3.3.1 Although the assumptions are applicable to artesian or confined conditions, the Theis solution may be applied to unconfined aquifers if (*A*) drawdown is small compared with the saturated thickness of the aquifer or if the drawdown is corrected for reduction in thickness of the aquifer and (*B*) the effects of delayed gravity yield are small. See 5.3.3 of Test

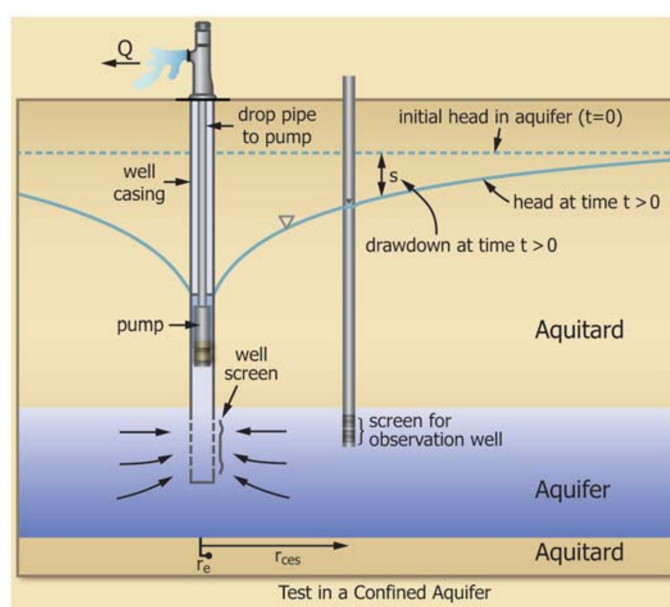

FIG. 1 Cross Section Through a Discharging Well in a Nonleaky Aquifer