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Standard Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques¹

This standard is issued under the fixed designation D4043; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This guide covers an integral part of a series of standards that are being prepared on the in situ determination of hydraulic properties of aquifer systems by single- or multiple-well tests. This guide provides guidance for development of a conceptual model of a field site and selection of an analytical test method for determination of hydraulic properties. This guide does not establish a fixed procedure for determination of hydrologic properties.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *Limitations*—Well techniques have limitations in the determination of hydraulic properties of groundwater flow systems. These limitations are related primarily to the simplifying assumptions that are implicit in each test method. The response of an aquifer system to stress is not unique; therefore, the system must be known sufficiently to select the proper analytical method.

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.*

1.5 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide 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 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.

2. Referenced Documents

2.1 ASTM Standards:²

- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D4044 Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers
- D4104 Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)
- 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
- D4630 Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test
- D5269 Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method
- D5270 Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers
- D5472 Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well
- D5473 Test Method for (Analytical Procedure for) Analyzing the Effects of Partial Penetration of Control Well and Determining the Horizontal and Vertical Hydraulic Conductivity in a Nonleaky Confined Aquifer
- D5716 Test Method for Measuring the Rate of Well Discharge by Circular Orifice Weir

¹ This guide 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 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

D5785 Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)

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

D5850 Test Method for (Analytical Procedure) Determining Transmissivity, Storage Coefficient, and Anisotropy Ratio from a Network of Partially Penetrating Wells

D5881 Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug)

D5912 Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug) (Withdrawn 2013)³

D5920 Test Method (Analytical Procedure) for Tests of Anisotropic Unconfined Aquifers by Neuman Method

3. Terminology

3.1 *Definitions*—For definitions of common terms used in this test method, see Terminology **D653**.

4. Significance and Use

4.1 An aquifer test method is a controlled field experiment made to determine the approximate hydraulic properties of water-bearing material. The hydraulic properties that can be determined are specific to the test method. The hydraulic properties that can be determined are also dependent upon the instrumentation of the field test, the knowledge of the aquifer system at the field site, and conformance of the hydrogeologic conditions at the field site to the assumptions of the test method. Hydraulic conductivity and storage coefficient of the aquifer are the basic properties determined by most test methods. Test methods can be designed also to determine vertical and horizontal anisotropy, aquifer discontinuities, vertical hydraulic conductivity of confining beds, well efficiency, turbulent flow, and specific storage and vertical permeability of confining beds.

5. Procedure

5.1 The procedure for selection of an aquifer test method or methods is primarily based on selection of a test method that is compatible with the hydrogeology of the proposed test site. Secondly, the test method is selected on the basis of the testing conditions specified by the test method, such as the method of stressing or causing water-level changes in the aquifer and the requirements of a test method for observations of water level response in the aquifer. The decision tree in **Table 1** is designed to assist, first, in selecting test methods applicable to specific hydrogeologic site characteristics. Secondly, the decision tree will assist in selecting a test method on the basis of the nature of the stress on the aquifer imposed

by the control well. The decision tree references the sections in this guide where the test methods are cited.

5.2 *Pretest-Selection Procedures*—Aquifer test methods are highly specific to the assumptions of the analytical solution of the test method. Reliability of determination of hydraulic properties depends upon conformance of the hydrologic site characteristics to the assumptions of the test method. A prerequisite for selecting an aquifer test method is knowledge of the hydrogeology of the test site. A conceptual understanding of the hydrogeology of the aquifer system at the prospective test site should be gained in as much detail as practicable from existing literature and data, and a site reconnaissance. In developing a site characterization, incorporate geologic mapping, driller's logs, geophysical logs, records of existing wells, water-level and water-quality data, and results of geophysical surveys. Include information on the thickness, lithology, stratification, depth, attitude, continuity, and extent of the aquifer and confining beds.

5.3 *Select Applicable Aquifer Test Methods*—Select a test method based on conformation of the site hydrogeology to assumptions of the test model and the parameters to be determined. A summary of principal aquifer test methods and their applicability to hydrogeologic site conditions is given in the following paragraphs. The decision tree for aquifer test selection, **Table 1**, provides a graphic display of the hydrogeologic site conditions for each test method and references to the section where each test method is cited.

5.3.1 *Extensive, Isotropic, Homogeneous, Confined, Nonleaky Aquifer:*

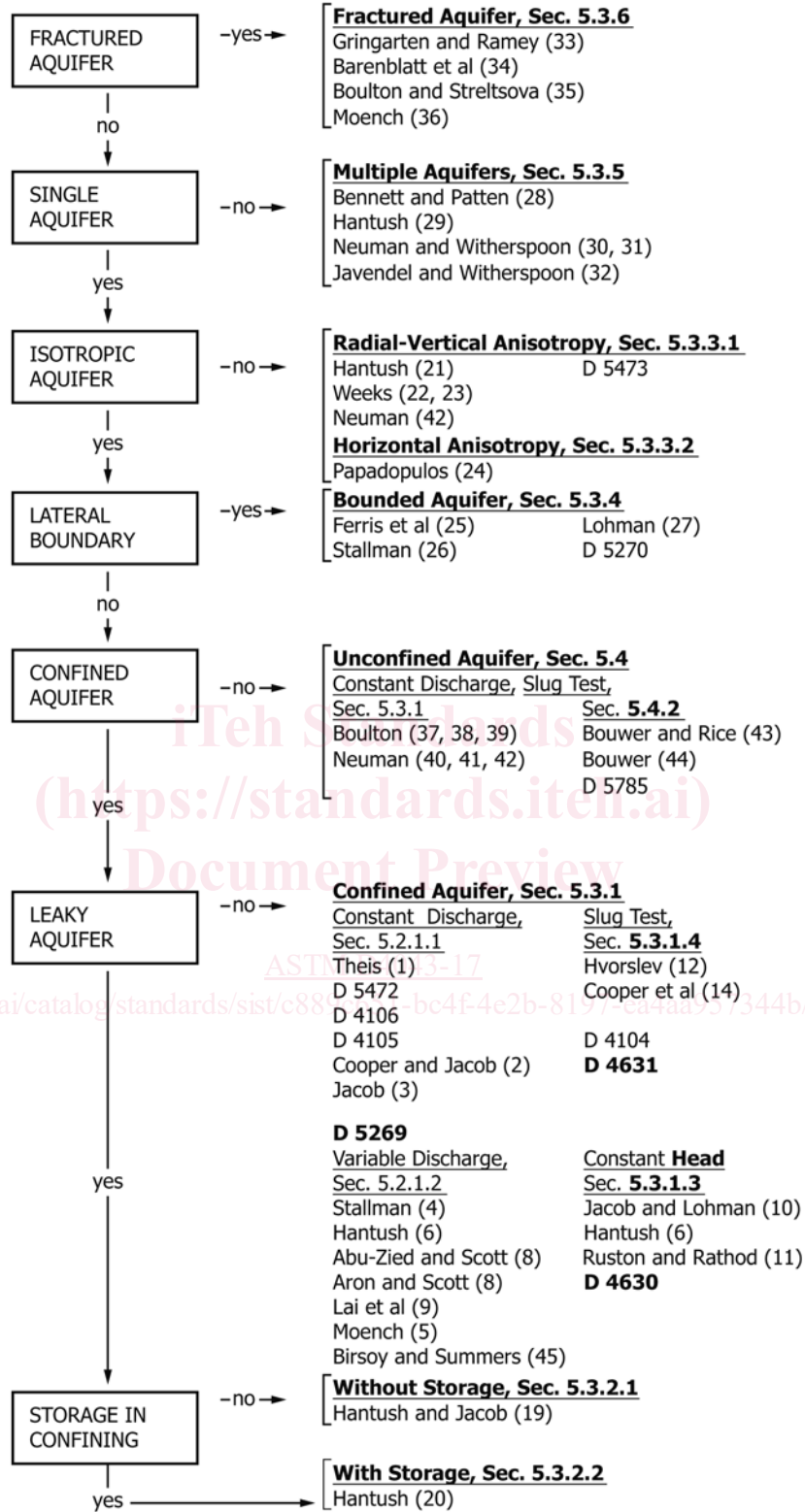
5.3.1.1 *Constant Discharge*—Test method in which the discharge or injection rate in the control well is constant are given by the nonequilibrium method of Theis (**1**)⁴ for the drawdown and recovery phases. The Theis test method is the most widely referenced and applied aquifer test method and is the basis for the solution to other more complicated boundary condition problems. The Theis test method for the pumping or injection phase is given in Test Method **D4106**. Cooper and Jacob (**2**) and Jacob (**3**) recognized that for large values of time and small values of distance from the control well, the Theis solution yields a straight line on semilogarithmic plots of various combinations of drawdown and distance from the control well. The solution of the Theis equation can therefore be simplified by the use of semilogarithmic plots. The modified Theis nonequilibrium test method is given in Test Method **D4105**. A test method for estimating transmissivity from specific capacity by the Theis method is given in Test Method **D5472**. Test Method **D5716** provides a means of means of measuring discharge from high capacity wells. Test Method **D5269** provides a method of determining transmissivity in a non-leaky aquifer.

5.3.1.2 *Variable Discharge*—Test methods for a variably discharging control well have been presented by Stallman (**4**) and Moench (**5**) and Birsoy and Summers (**6**). These test methods simulate pumpage as a sequence of constant-rate stepped changes in discharge. The test methods utilize the

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ The boldface numbers in parentheses refer to the list of references at the end of this guide.

TABLE 1 Decision Tree for Selection of Aquifer Test Method



principle of superposition in constructing type curves by summing the effects of successive changes in discharge. The type curves may be derived for control wells discharging from

extensive, leaky, and nonleaky confined aquifers or situations where the response to a unit stress is known. Hantush (7) developed drawdown functions for three types of decreases in