Designation: ~~D4050 – 14~~ D4050 – 20

Standard Test Method for (Field Procedure) for Withdrawal and Injection Well Testing for Determining Hydraulic Properties of Aquifer Systems[1]

This standard is issued under the fixed designation D4050; 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 the field procedure for selecting well locations, controlling change (discharge or injection) rates, and measuring water levels used to analyze the hydraulic properties of an aquifer or aquifers and adjacent confining beds.

1.2 This test method is used in conjunction with an analytical procedure such as Test Methods ~~D4105~~D4105/D4105M or D4106 to evaluate the data and determine aquifer properties.

1.3 The appropriate field and analytical procedures are selected as described in Guide D4043.

1.4 *Limitations*—~~Limitations—The~~The limitations of this test method are primarily related to the correspondence between the field situation determined by this test method and the simplifying assumptions of the analytical Test Methods ~~D4105~~D4105/D4105M or ~~D4106~~D4106 and D4043~~D4043.~~ .

1.5 *Units*—The values stated in SI units are to be regarded as standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

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

1.6.1 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should 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 standard to consider significant digits used in analytical methods for engineering design.

1.7 This test method offers a set of instructions for performing one or more operations. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this standard 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 projects 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.

1.8 *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.*

1.9 *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

---

[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 ~~June 1, 2014~~Jan. 1, 2020. Published ~~July 2014~~January 2020. Originally approved in 1991. Last previous edition approved in ~~2008~~2014 as ~~D4050 – 96 (2008).~~D4050 – 14. DOI: ~~10.1520/D4050-14.~~10.1520/D4050-20.

[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**

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedures)
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
~~D4044~~D4044/D4044M Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers
~~D4105~~D4105/D4105M 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—*~~*Definitions:* ~~For definitions of common technical terms in this test method, refer to Terminology D653.~~
3.1.1 For definitions of common technical terms in this standard, refer to Terminology D653.

4. Summary of Test Method

4.1 This test method describes the field practices in conducting aquifer performance tests by either withdrawal or injection through a well point. These methods involve changing the control well water level by either the withdrawal of water from or injection of water to an aquifer and measurement of the water-level response in the aquifer. The analysis of the data from this field practice is described in standards such as Test Methods ~~D4105~~D4105/D4105M and D4106.

NOTE 1—The injection or withdrawal of water into an aquifer may be regulated or require regulatory approvals. Withdrawal of contaminated waters may require that the removed water be ~~properly~~ treated prior to discharge.

5. Significance and Use

5.1 Withdrawal or injection well test field procedures are used with appropriate analytical procedures in appropriate hydrogeological sites to determine transmissivity and storage coefficient of aquifers and hydraulic conductivity of confining beds.

5.2 Practice D3740 provides evaluation factors for the activities in this test method.

NOTE 2—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.

5.3 This test method may be limited due to the correspondence between the field situation determined by this test method and the simplifying assumptions of the analytical Test Methods ~~D4106~~D4105/D4105M or ~~D4106~~D4106 and D4043~~D4043.~~.

6. Apparatus

6.1 Various types of equipment can be used to withdraw or inject water into the control well, measure withdrawal and injection rates, and measure water levels. The test procedure may be conducted with different types of equipment to achieve similar results. The objectives to be achieved by the use of the equipment are given in this section and in Sections 7 and 8. The selection of equipment and measuring apparatus will be evaluated to ~~ensure~~ make sure that sufficient accuracy and sensitivity will be provided for the later evaluation of data by ~~D4105~~D4105/D4105M and D4106~~D4106.~~.

6.2 *Control Well*—Discharge or injection well test methods require that water be withdrawn from or injected into a single well. This well, known as the control well, must be drilled and completed such that it transmits water to or from the aquifer (usually the entire thickness of the aquifer) at rates such that a measurable water level change will occur at observation wells. The control well ~~should~~must be as efficient as possible, to reduce the head loss between the aquifer and the well. Well development should be as complete as possible to eliminate additional production of sand or silt and consequent changes in well efficiency and pumping water levels during the test. The cuttings from the control well (if available) should be described and recorded according to Practice D2488. The analytical method selected for analysis of the data may specify certain dimensions of the control well such as screen length and depth of screen placement. Specific requirements for control wells ~~may be~~ are given in standards for specific analytical methods (see, for example, Test Methods ~~D4105~~D4105/D4105M and D4106).

6.3 *Observation Wells or Piezometers*—Numbers of observation wells and their distance from the control well and their screened interval may be dependent upon the test method to be employed. Refer to the analytical test method to be used for specifications of observation wells (see, for example, Test Methods ~~D4105~~D4105/D4105M and D4106).

6.4 *Control Well Pump*—A pump capable of withdrawal or injection of a constant or predetermined variable rate of water to or from the control well. The pump and motor ~~should~~must be adequately sized for the designed pumping rate and lift. The pump or motor must be equipped with a control mechanism to adjust discharge rate. In the case of diesel-, gasoline-, or natural-gas-fueled

engines, throttle settings ~~should~~ need to allow for small adjustments in pumping rates. Pumps equipped with electric motors are usually controlled by adjusting back pressure on the pump through a gate valve in the discharge line. Take care to select a discharge rate small enough such that the rate can be maintained throughout the test without fully opening the gate valve. If neither method of control is practical, split the discharge and route part of the discharge back to the well through a separate discharge line. If water is withdrawn, the discharge should be at a distance sufficiently away from the area to prevent recharging back into the aquifer being tested.

6.5 Many aquifer tests are made at "sites of opportunity," that is, using existing production or monitoring wells as the control well and using other existing wells for observation of water level. In such ~~cases~~ cases, evaluate the locations and screened intervals of the wells ~~should be compatible~~ for compatibility with the requirements of the method of test analysis.

6.6 *Water-Level Measurement Equipment*—Manual measurements can be made with a steel tape or electric tape, with a mechanical recorder linked to a float, or combination of pressure transducer and electronic data logger. The accuracy of the water level measurement ~~should~~must be adequate to satisfy the requirements of ~~D4105~~D4105/D4105M and D4106~~D4106.~~. Generally a water level accuracy of 0.254 cm should be adequate.

6.6.1 *Mechanical Recorders*—Mechanical recorders employ a float in the well to produce a graphic record of water level changes. Early in the test, it may be difficult to distinguish small increments of time on the recorder chart, therefore the recorder readings should be supplemented with additional early time measurements or by marking the trace of an automatic water-level recorder chart and recording the time by the mark. Check the mechanical recorder periodically throughout the test using the steel tape.

6.6.2 *Pressure Transducers and Electronic Data Loggers*—A combination of a pressure transducer and electronic data logger can provide rapid measurements of water-level change, and can be programmed to sample at a higher frequency early in the test and a reduced frequency late in the test. Select the pressure transducer to measure pressure changes equivalent to the range of expected water level changes. Check the transducer in the field by raising and lowering the transducer a measured distance in the well. Also check the transducer readings periodically with a steel tape.

NOTE 3—Pressure transducers have ratings that are depth specific and should be selected to measure the expected range of water levels.

6.6.3 Equipment used for measuring flows and water levels ~~should~~must have calibration records, or be calibrated for the test.

6.7 *Sand Content Measurement Device*—Apparatus to measure the sand content in discharged water. Cone Types (for example, Imhoff) can be used for higher concentrations of sand in the discharge water and centrifugal sand separators (for example, Rossum) can be used for lower levels and are commercially available and commonly used.

6.8 *Barometric Pressure*—~~Barometric pressures should be determined and routinely logged,~~ Determine the barometric pressures and routinely log the data, particularly if the test is of a long duration, such as over several days between the initial and ~~final~~end readings.

7. Conditioning

7.1 *Pre-Test Procedures:*

7.1.1 *Selecting Aquifer-Test Method*—Develop a conceptual model of the site hydrogeology and select the appropriate aquifer test method according to Guide D4043. Observe the requirements of the selected test method with regard to specifications for the control well and observations wells.

7.1.2 *Field Reconnaissance*—Make a field reconnaissance of the site before conducting the test to include as much detail as possible on depth, continuity, extent, and preliminary estimates of the hydrologic properties of the aquifers and confining beds. Note the location of existing wells and water-holding or conveying structures that might interfere with the test. The control well should be equipped with a pipeline or conveyance structure adequate to transmit the water away from the test site, so that recharge is not induced near the site. Make arrangements ~~to ensure~~ and make sure that nearby wells are turned off well before the test, and automatic pump controls are disabled throughout the anticipated test period. Alternately, it may be necessary to pump some wells throughout the test. If so, they ~~should~~must be pumped at a constant rate, and not started and stopped for a duration equal to that of the test before nor should they be started and stopped during the test.

7.1.3 *Testing of Control Well*—Conduct a short term preliminary test of the control well to estimate hydraulic properties of the aquifer, estimate the duration of the test and establish a pumping rate for the field procedure.

7.1.4 *Testing Observation Wells*—Test the observation wells or piezometers prior to the aquifer test to ~~ensure~~ make sure that they are hydraulically connected to the aquifer. Accomplish this by adding or withdrawing a known volume of water (slug) and measure the water-level response in the well. The resultant response ~~should~~ needs to be rapid enough to ~~ensure~~ make sure that the water level in the piezometer will reflect the water level in the aquifer during the test. Redevelop piezometers with unusually sluggish response. Information on performing a slug test can be found in ~~D4044.~~Test Method D4044/D4044M.

7.1.5 *Measuring Pre-Testing Water-Level Trends*—Measure and record water levels in ~~all~~the observation wells prior to start of pumping for a period long enough to establish the static pre-test water level trend. This period is at least equal to the length of the test. The trend in ~~all~~the observation wells should be similar. A well with an unusual trend may reflect effects of local disturbances in the hydrologic system, or may be inadequately developed.