



## Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems<sup>1</sup>

This standard is issued under the fixed designation D 4050; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method describes the field procedure for selecting well locations, controlling 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 D 4105 or D 4106 to determine aquifer properties.

1.3 The appropriate field and analytical procedures are selected as described in Guide D 4043.

1.4 The values stated in SI units are to be regarded as standard.

1.5 *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:

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>2</sup>
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>2</sup>
- D 4043 Guide for Selection of Aquifer-Test Method in Determining Hydraulic Properties by Well Techniques<sup>2</sup>
- D 4105 Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method<sup>2</sup>
- D 4106 Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method<sup>2</sup>
- D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)<sup>2</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *aquifer, confined*—an aquifer bounded above and below by confining beds and in which the static head is above the top of the aquifer.

3.1.2 *confining bed*—a hydrogeologic unit of less permeable material bounding one or more aquifers.

3.1.3 *control well*—well by which the head and flow in the aquifer is changed, for example, by pumping, injection, or change of head.

3.1.4 *hydraulic conductivity (field aquifer tests)*—the volume of water at the existing kinematic viscosity that will move in a unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

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

3.1.6 *piezometer*—a device used to measure hydraulic head at a point in the subsurface.

3.1.7 *specific storage*—the volume of water released from or taken into storage per unit volume of the porous medium per unit change in head.

3.1.8 *storage coefficient*—the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. For a confined aquifer, the storage coefficient is equal to the product of the specific storage and aquifer thickness. For an unconfined aquifer, the storage coefficient is approximately equal to the specific yield.

3.1.9 *transmissivity*—the volume of water at the existing kinematic viscosity that will move in a unit time under a unit hydraulic gradient through a unit width of the aquifer.

3.1.10 For definitions of other terms used in this test method, see Terminology D 653.

### 4. Summary of Test Method

4.1 This test method describes the field practices in conducting withdrawal and injection well tests. These methods involve withdrawal of water from or injection of water to an aquifer through a control well 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 D 4105 and D 4106.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.08.

## 5. Significance and Use

5.1 Withdrawal and 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.

## 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.

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 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 should be described and recorded according to Practice D 2488. 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 given in standards for specific analytical methods (see, for example, Test Methods D 4105 and D 4106).

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 D 4105 and D 4106).

6.4 *Control Well Pump*—A pump capable of withdrawal of a constant or predetermined variable rate of water from the control well. The pump and motor should 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 allow for small adjustments in pumping rates. Pumps equipped with electric motors are usually controlled by adjusting backpressure 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.

6.5 Many aquifer tests are made at “sites of opportunity,” that is, using existing production wells as the control well and using other existing wells for observation of water level. In such cases the locations and screened intervals of the wells

should be compatible 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 as described in Test Method D 4750, with a mechanical recorder linked to a float, or combination of pressure transducer and electronic data logger.

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 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 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.

## 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 D 4043. 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 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 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 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 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