Designation: D5126 – 16$^{\varepsilon 1}$

Standard Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in Vadose Zone[1]

This standard is issued under the fixed designation D5126; 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.

ε[1] NOTE—The designation was editorially corrected to match the units of measurement statement in October 2016.

1. Scope*

1.1 This guide covers a review of the test methods for determining hydraulic conductivity in unsaturated soils and sediments. Test methods for determining both field-saturated and unsaturated hydraulic conductivity are described.

1.2 Measurement of hydraulic conductivity in the field is used for estimating the rate of water movement through clay liners to determine if they are a barrier to water flux, for characterizing water movement below waste disposal sites to predict contaminant movement, and to measure infiltration and drainage in soils and sediment for a variety of applications. Test methods are needed for measuring hydraulic conductivity ranging from 1×10^{-2} to 1×10^{-8} cm/s, for both surface and subsurface layers, and for both field-saturated and unsaturated flow.

1.3 For these field test methods a distinction is made between "saturated" (K_s) and "field-saturated" (K_{fs}) hydraulic conductivity. True saturated conditions seldom occur in the vadose zone except where impermeable layers result in the presence of perched water tables. During infiltration events or in the event of a leak from a lined pond, a "field-saturated" condition develops. True saturation does not occur due to entrapped air (**1**).[2] The entrapped air prevents water from moving in air-filled pores that, in turn, may reduce the hydraulic conductivity measured in the field by as much as a factor of two compared to conditions when trapped air is not present (**2**). Field test methods should simulate the "field-saturated" condition.

1.4 Field test methods commonly used to determine field-saturated hydraulic conductivity include various double-ring infiltrometer test methods, air-entry permeameter test methods, and borehole permeameter tests. Many empirical test methods are used for calculating hydraulic conductivity from data obtained with each test method. A general description of each test method and special characteristics affecting applicability is provided.

1.5 Field test methods used to determine unsaturated hydraulic conductivity in the field include direct measurement techniques and various estimation methods. Direct measurement techniques for determining unsaturated hydraulic conductivity include the instantaneous profile (IP) test method and the gypsum crust method. Estimation techniques have been developed using borehole permeameter data and using data obtained from desorption curves (a curve relating water content to matric potential).

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

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

1.7.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.9 *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*

[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.

Current edition approved July 1, 2016. Published July 2016. Originally approved in 1990. Last previous edition approved in 2010 as D5126–90(2010)$^{\varepsilon 1}$. DOI: 10.1520/D5126-16E01.

[2] The boldface numbers in parentheses refer to a list of references at the end of the text.

*A Summary of Changes section appears at the end of this standard *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:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2434 Test Method for Permeability of Granular Soils (Constant Head) (Withdrawn 2015)[4]

D3385 Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer

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

D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D653.

3.2 Descriptions of other related terms can be found in Ref (**3**).

4. Summary of Guide

4.1 *Test Methods for Measuring Saturated Hydraulic Conductivity Above the Water Table*—There are several test methods available for determining the field saturated hydraulic conductivity of unsaturated materials above the water table. Most of these methods involve measurement of the infiltration rate of water into the soil from an infiltrometer or permeameter device. Infiltrometers typically measure conductivity at the soil surface, whereas permeameters may be used to determine conductivity at different depths within the soil profile. A representative list of the most commonly used equipment includes the following: infiltrometers (single and double-ring infiltrometers), double-tube method, air-entry permeameter, and borehole permeameter methods (constant and multiple head methods).

4.1.1 *Infiltrometer Test Method:*

4.1.1.1 Infiltrometer test methods measure the rate of infiltration at the soil surface (see Test Method D2434) that is influenced both by saturated hydraulic conductivity as well as capillary effects of soil (**4**). Capillary effect refers to the ability of dry soil to pull or wick water away from a zone of saturation faster than would occur if soil were uniformly saturated. The magnitude of the capillary effect is determined by initial moisture content at the time of testing, the pore size, soil physical characteristics (texture, structure), and a number of other factors. By waiting until steady-state infiltration is reached, the capillary effects are minimized.

4.1.1.2 Most infiltrometers generally employ the use of a metal cylinder placed at shallow depths into the soil, and include the single-ring infiltrometer, the double-ring infiltrometer, and the infiltration gradient method. Various adaptations to the design and implementation of these methods have been employed to determine the field-saturated hydraulic conductivity of material within the unsaturated zone (**5**). The principles of operation of these methods are similar in that the steady volumetric flux of water infiltrating into the soil enclosed within the infiltrometer ring is measured. Saturated hydraulic conductivity is derived directly from solution of Darcy's Equation for saturated flow. Primary assumptions are that the volume of soil being tested is field saturated and that the saturated hydraulic conductivity is a function of the flow rate and the applied hydraulic gradient across the soil volume.

4.1.1.3 Additional assumptions common to infiltrometer tests are as follows:

(a) The movement of water into the soil profile is one-dimensional downward.

(b) Equipment compliance effects are minimal and may be disregarded or easily accounted for.

(c) The pressure of soil gas does not offer any impedance to the downward movement of the wetting front.

(d) The wetting front is distinct and easily determined.

(e) Dispersion of clays in the surface layer of finer soils is insignificant.

(f) The soil is non-swelling, or the effects of swelling can easily be accounted for.

4.1.2 *Single-Ring Infiltrometer:*

4.1.2.1 The single-ring infiltrometer typically consists of a cylindrical ring 30 cm or larger in diameter that is driven several centimetres into the soil. Water is ponded within the ring above the soil surface. The upper surface of the ring is often covered to prevent evaporation. The volumetric rate of water added to the ring sufficient to maintain a constant head within the ring is measured. Alternatively, if the head of water within the ring is relatively large, a falling head type test may be used wherein the flow rate, as measured by the rate of decline of the water level within the ring, and the head for the later portion of the test are used in the calculations. Infiltration is terminated after the flow rate has approximately stabilized. The infiltrometer is removed immediately after termination of infiltration, and the depth to the wetting front is determined either visually, with a penetrometer-type probe, or by moisture content determination for soil samples (see Test Method D4643).

4.1.2.2 A special type of single-ring infiltrometer is the ponded infiltration basin. This type of test is conducted by ponding water within a generally rectangular basin that may be as large as several metres on a side. The flow rate to maintain a constant head of water within the pond is measured. If the depth of ponding is negligible compared to the depth of the wetting front, the steady state flux of water across the soil surface within the basin is presumed to be equal to the saturated hydraulic conductivity of the soil.

[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.