Designation: ~~D4525 – 08~~ D4525 – 13

Standard Test Method for Permeability of Rocks by Flowing Air[1]

This standard is issued under the fixed designation D4525; 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 determination of the coefficient of specific permeability for the flow of air through rocks. The ~~procedure~~method establishes representative values of the coefficient of permeability of rocks or well-indurated soils.

1.2 This test method is limited to permeability values greater than ~~0.9869 pm~~9.869 × 10-18 m^2 ~~(1.0 picodarcy),~~(0.01 millidarcy), and is limited to rocks free of oil or unctuous matter.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

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

1.4.1 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.

1.5 *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:*[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

D6026 Practice for Using Significant Digits in Geotechnical Data

2.2 *American Petroleum Institute Standard:*[3]

RP-40 Recommended Practice for Core Analysis Procedure

3. Terminology

3.1 *Definitions*—For ~~terminology used~~ definitions of common technical terms in this ~~test method,~~ standard, refer to Terminology D653.

4. Summary of Test Method

4.1 The permeability of a rock sample is measured by flowing dry air through the specimen and measuring the absolute pressure, the flow rate, and absolute pressure differential of the air. Three or more tests are performed on a sample at different mean air pressure values. The permeability values are plotted as a function of the reciprocal mean absolute pressure; those points lying on a straight line are extrapolated to a value corresponding to an infinite mean air pressure to obtain an equivalent permeability value for liquids.

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics.
Current edition approved ~~July 1, 2008~~Nov. 1, 2013. Published ~~July 2008~~December 2013. Originally approved in 1985. Last previous edition approved in ~~2004~~2008 as ~~D4525 – 04.~~D4525 – 08. DOI: ~~10.1520/D4525-08.~~10.1520/D4525-13.

[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] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.org.

*A Summary of Changes section appears at the end of this standard

5. Significance and Use

5.1 This test method is designed to measure the permeability to air of a small sample of rock. By extrapolation, this test method also determines an equivalent of the liquid permeability. This parameter is used to calculate the flow through rock of fluids subjected to a pressure differential.

NOTE 1—~~Notwithstanding the statements on precision and bias contained in this test method, the measures of precision of this test method~~ The quality of the result produced by this standard is dependent on the competence of the personnel performing ~~them,~~it, and ~~on~~ 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. Users of this ~~test method~~ standard are cautioned that compliance with Practice D3740 does not in itself assure reliable ~~testing.~~results. Reliable ~~testing~~results depends on many factors; Practice D3740 provides a means ~~for~~of evaluating some of those factors.

6. Apparatus

6.1 *Permeameter*—The permeameter shall have a specimen holder; a pressure transducer or gauge, or manometers, for measuring the air pressure differential across the ends of the specimen; a means for measuring the flow rate of the air; and a means for providing dry air to the flow stream (see Fig. 1).

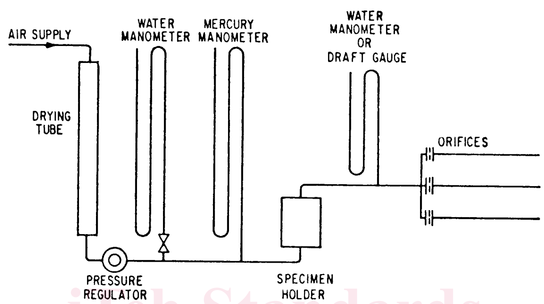

FIG. 1 Air Permeameter (Reproduced from RP-40)

6.1.1 *Specimen Holder*—The specimen holder shall have a diameter of at least ten times the diameter of the largest particle of the specimen. Where suitable, the preferred diameter is 2.54 ~~cm.~~ cm (1 in.). The entrance and exit flow ports shall be sufficiently large to prevent pressure loss at maximum flow rate. The length shall be 1.3 to 1.7 times the diameter.

6.1.2 *Preferred Apparatus*—In the preferred form, the specimen holder shall be an elastomer sleeve and have means for confining the sleeve and compressing it against the specimen so as to prevent bypassing of air under pressure between the sleeve and the specimen. The holder shall also have a means for confining the ends of the sample. In the preferred form, the end confining plugs will have two ports each, one for the flow of air, and the other for a static pressure line to measure pressure at the end faces of the specimen, as in Fig. 2. This type of holder is suitable for many types of flowing fluids and allows the simulation of overburden stress on the specimen.

6.1.3 *Alternative Apparatus*—An elastomer bushing may be used to confine the specimen, as in Fig. 3. This holder is suitable for confining well-indurated specimens of a fine to moderate texture. This holder allows rapid operation; it cannot be used for simulating overburden stress.

6.1.3.1 Alternatively, a rigid bushing may be cast around the specimen (see Fig. 4). The casting material shall be one that will adhere well to both the specimen and the bushing, without penetration of the specimen beyond the superficial pores. Epoxies, polyesters, and sealing wax are suitable for this purpose. This method of mounting samples is particularly well suited for testing less well-indurated specimens. This technique is not applicable for tests requiring the simulation of overburden stress.

6.1.4 The flow rate of the air shall be sensed downstream from the specimen by means of calibrated orifices (Fig. 1), rotameters (Fig. 5), or a bubble meter (Fig. 6).

6.1.5 The preferred method of sensing absolute pressure to obtain the pressure differential across the specimen is by means of absolute pressure transducers located at the ends of the specimen. The transducers must operate over a range of 0 to 50 kPa (0 to ~~0.5 atmospheres)~~7.3 psi) with a resolution of 250 Pa ~~(0.0025 atmospheres)~~(36.3 psi) or better. Alternatively, the sensors may be

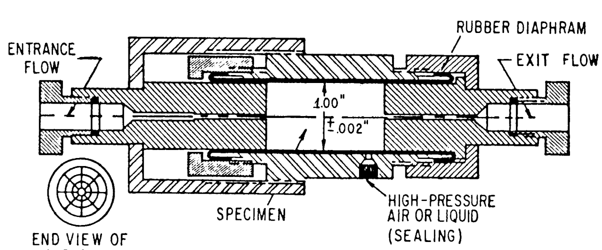

FIG. 2 Hassler Type Specimen Holder

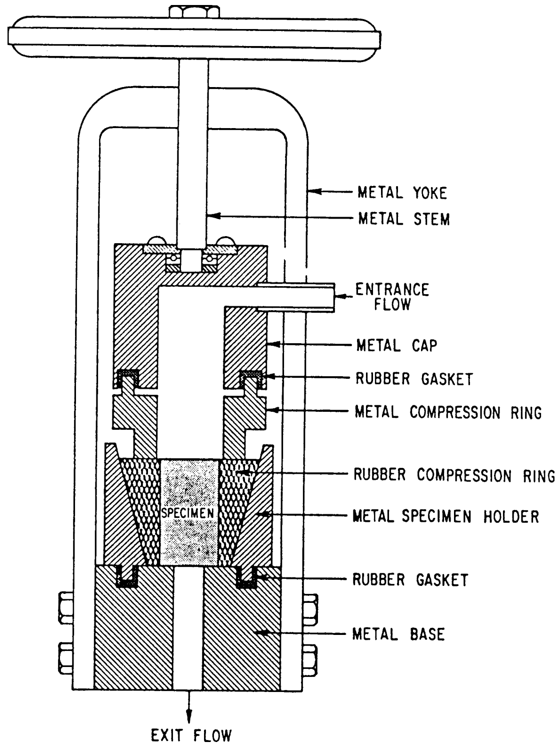

FIG. 3 Fancher-Type Specimen Holder

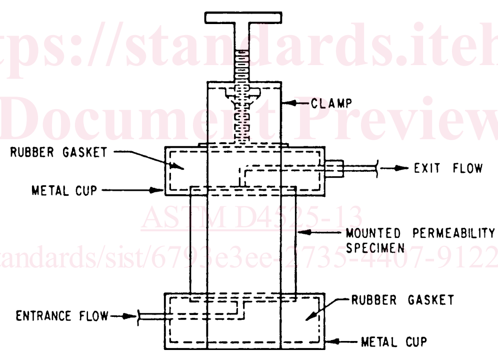

FIG. 4 Compression Cell for Ring-Mounted Specimens

connected to the end faces of the specimen with static lines, or placed in sufficiently large flow lines to cause less than 250 Pa ~~(0.0025 atmospheres)~~(36.3 psi) loss of head at maximum flow rate. Pressure must be sensed between the downstream end of the specimen and the orifice if such a flow sensor is utilized.

6.1.5.1 Manometers may be utilized to measure the pressures of the flowing air. Both ~~a~~ mercury and water ~~manometer~~manometers must be ~~provided,~~provided with a high-pressure cutoff valve to the water manometer as in Fig. 1, to provide the range of differential pressures required. The manometers must be 20 cm (7.9 in.) or more in height.

6.1.5.2 Alternatively, absolute pressure gages with a range of 0 to 50 kPa (0 to ~~0.5 atmospheres)~~7.3 psi) and a resolution of 250 Pa ~~(0.0025 atmospheres)~~(36.3 psi) may be used to measure the pressure of the flowing air.

6.1.6 The dimensions of the column for drying the flowing air shall be a ~~2.54-cm~~ 2.54 cm (1 in.) inside diameter by a ~~30-cm~~ 30 cm (11.8 in.) or more length. The columns shall be filled with silica gel or anhydrous calcium sulfate, with indicator. There shall be a screen of 50 mesh on the downstream end of the filter to prevent particulate matter from reaching the specimen under test.

6.1.7 *Compressed Air Source,* with a regulator and gauge, shall supply air pressure up to 50 kPa ~~(~~(7.3~~½ atmosphere)~~psi) for the flow system.

6.1.7.1 The air shall be clean and free of particles that can plug the pores of the sample.

6.1.7.2 A compressed air supply with a separate regulator and gauge, or a hydraulic pressure source with gauge, shall supply pressure for seating the sleeve when that option for holding the specimen is used. A seating pressure of 700 kPa ~~(7 atmospheres)~~(101.5 psi) or more shall be used for seating. Pressures up to 100 MPa ~~(1000 atmospheres)~~(14503.8 psi) may be required for simulating in situ stress.