



Standard Test Method for Determination of the In-Situ Stress in Rock Using the Hydraulic Fracturing Method¹

This standard is issued under the fixed designation D 4645; 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 in-situ state of stress in rock by hydraulic fracturing.

NOTE 1—Hydraulic fracturing for stress determination is also referred to as hydrofracturing, and sometimes as minifrac. Hydraulic fracturing and hydrofracturing may also refer to fracturing of the rock by fluid pressure for the purpose of altering rock properties, such as permeability and porosity.

1.2 Hydraulic fracturing is the widely accepted field method available for in situ stress measurements at depths greater than 50 m. It can be used in drill holes of any diameter.

1.3 Hydraulic fracturing can also be used in short holes for which other stress measuring methods, such as overcoring, are also available. The advantage of hydraulic fracturing is that it yields stresses averaged over a few square metres (the size of the induced hydraulic fracture) rather than over grain size areas, as in the case of overcoring techniques.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.4.1 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.

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

1.6 *This standard does not purport to address all of the safety problems, 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

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.

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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.

D 653 Terminology Relating to Soil, Rock and Contained Fluids

D 2113 Practice for Diamond Core Drilling for Site Investigation

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 5079 Practices for Preserving and Transporting Rock Core Sample

D 6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 For terminology used in this test method, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *breakdown pressure*—the pressure required to induce a hydraulic fracture in a previously intact test interval.

3.2.2 *in-situ stress*—rock stress measured in situ (as opposed to by remote sensing).

3.2.3 *secondary breakdown (or fracture reopening, or re-frac) pressure*—the pressure required to reopen a closed, previously induced hydrofracture after the test interval pressure has been allowed to return to its initial condition.

3.2.4 *shut-in pressure (or ISIP (instantaneous shut-in pressure))*—the pressure reached when the induced hydrofracture closes back after pumping is stopped.

3.2.5 *vertical and horizontal principal stresses*—the three principal stresses in situ are generally assumed to act one in the vertical direction and the other two in the horizontal plane.

4. Summary of Test Method

4.1 A section of the borehole is isolated by pressurizing two inflatable rubber packers. The fluid pressure in the sealed-off interval between the two packers is raised by pumping fluid into it at a controlled rate until a fracture occurs in the borehole wall. Pumping is stopped and the pressure in the interval is allowed to stabilize. The pressure is then reduced to the pore pressure level of the rock formation, and the pressurization process is repeated several times maintaining the same flow rate. Additional pressure cycles can be conducted at different flow rates. The magnitudes of the principal stresses are calculated from the various pressure readings. The orientation

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

