



Designation: D 4406 – 93 (Reapproved 1998)

Standard Test Method for Creep of Cylindrical Rock Core Specimens in Triaxial Compression¹

This standard is issued under the fixed designation D 4406; 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 creep behavior of intact cylindrical rock core specimens¹ in triaxial compression. It specifies the apparatus, instrumentation, and procedures for determining the strain as a function of time under sustained load.

1.2 *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.* For specific precautionary statements, see Section 6.

2. Referenced Documents

2.1 ASTM Standards:

- D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock²
- D 4341 Test Method for Creep of Cylindrical Hard Rock Core Specimens in Uniaxial Compression²
- D 4543 Practice for Preparing Rock Core Specimens and Determining Dimensional and Shape Tolerances²
- E 4 Practices for Load Verification of Testing Machines³
- E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process⁴

3. Summary of Test Method

3.1 A rock core sample is cut to length, and the ends are machined flat. The specimen is placed in a triaxial loading chamber, subjected to confining pressure, and, if required, heated to the desired test temperature. Axial load is rapidly applied to the specimen and sustained. Deformation is moni-

tored as a function of elapsed time. Sample deformation is monitored periodically.

4. Significance and Use

4.1 There are many underground structures that are created for permanent or long-term use. Often these structures are subjected to an approximately constant load. Creep tests provide quantitative parameters for stability analysis of these structures.

4.2 The deformation and strength properties of rock cores measured in the laboratory usually do not accurately reflect large-scale in situ properties, because the latter are strongly influenced by joints, faults, inhomogeneities, weakness planes, and other factors. Therefore, laboratory values for intact specimens must be employed with proper judgment in engineering applications.

5. Apparatus

5.1 *Loading Device*—The loading device shall be of sufficient capacity to apply load at a rate conforming to the requirements specified in 9.6 and shall be able to maintain the specified load within 2 %. It shall be verified at suitable time intervals in accordance with the procedures given in Practices E 4 and comply with the requirements prescribed in this test method.

NOTE 1—By definition, creep is the time-dependent deformation under constant stress. The loading device is specified to maintain constant axial load and therefore, constant engineering stress. The true stress, however, decreases as the specimen deforms and the cross-sectional area increases. Because of the associated experimental ease, constant load testing is recommended. However, the procedure permits constant true-stress testing, provided that the applied load is increased with specimen deformation so that true stress is constant within 2 %.

5.2 *Triaxial Apparatus*—The triaxial apparatus shall consist of a chamber in which the test specimen may be subjected to a constant lateral fluid pressure and the required axial load. The apparatus shall have safety valves, suitable entry ports for filling the chamber, and associated hoses, gages, and valves as needed. Fig. 1 shows a typical test apparatus and associated equipment.

¹ This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

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² *Annual Book of ASTM Standards*, Vol 04.08.

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.

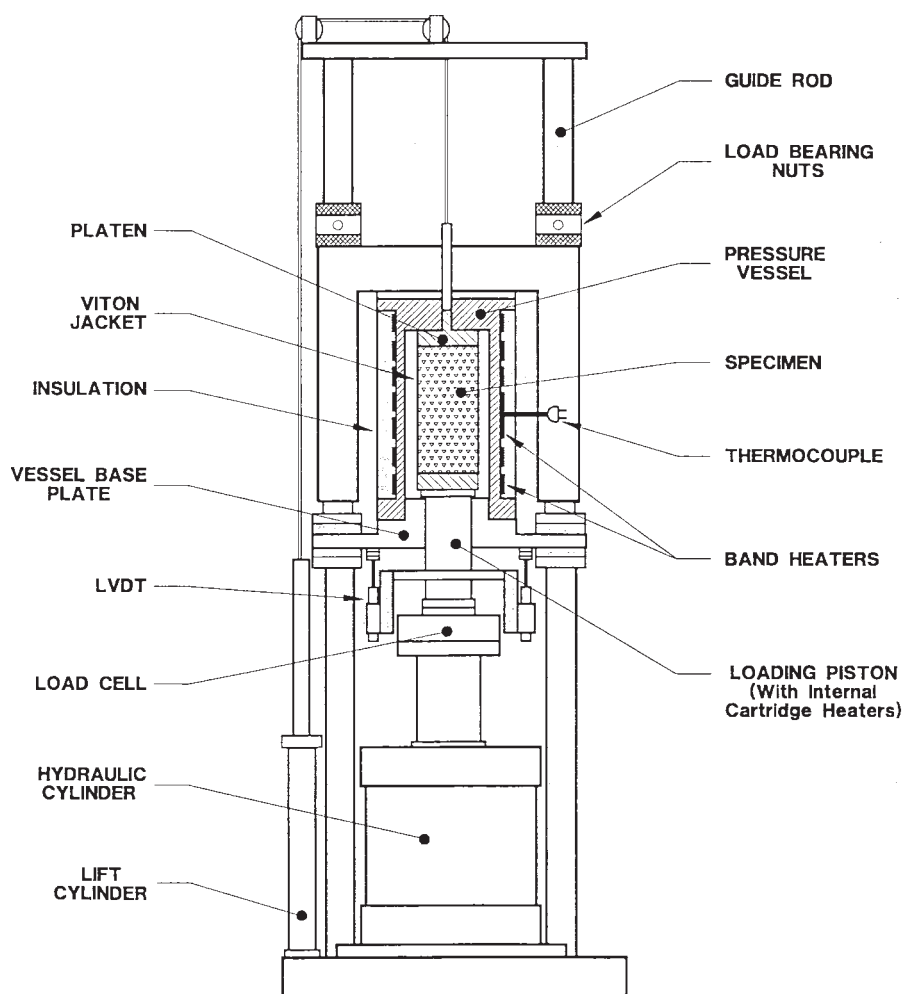


FIG. 1 Test Apparatus

5.3 Flexible Membrane—This membrane encloses the rock specimen and extends over the platens to prevent penetration by the confining fluid. A sleeve of natural or synthetic rubber or plastic is satisfactory for room temperature tests; however, metal or high-temperature rubber jackets⁵ are usually required for elevated temperature tests. The membrane shall be inert relative to the confining fluid and shall cover small pores in the sample without rupturing when confining pressure is applied. Plastic or silicone rubber coatings may be applied directly to the sample, provided these materials do not penetrate and strengthen the specimen. Care must be taken to form an effective seal where the platen and specimen meet. Membranes formed by coatings shall be subject to the same performance requirements as elastic sleeve membranes.

5.4 Pressure-Maintaining Device—A hydraulic pump, pressure intensifier, or other system of sufficient capacity to maintain constant the desired lateral pressure. The pressurization system shall be capable of maintaining the confining pressure constant to within $\pm 1\%$ throughout the test. The confining pressure shall be measured with a hydraulic pressure

gage or electronic transducer having an accuracy of at least $\pm 1\%$ of the confining pressure, including errors due to readout equipment, and a resolution of at least 0.5% of the confining pressure.

5.5 Confining-Pressure Fluids—For room temperature tests, hydraulic fluids compatible with the pressure-maintaining device should be used. For elevated temperature tests the fluid must remain stable at the temperature and pressure levels designated for the test.

5.6 Elevated-Temperature Enclosure—The elevated temperature enclosure may be either an internal system that fits in the triaxial apparatus, an external system enclosing the entire triaxial apparatus, or an external system encompassing the complete test apparatus. For high temperatures, a system of heaters, insulation, and temperature measuring devices are normally required to maintain the specified temperature. Temperature shall be measured at three locations, with one sensor near the top, one at midheight, and one near the bottom of the specimen. The average specimen temperature based on the midheight sensor shall be maintained to within $\pm 1^\circ\text{C}$ of the

⁵ For example, viton.