Designation: D7625 – 22

Standard Test Method for Laboratory Determination of Abrasiveness of Rock Using the CERCHAR Abrasiveness Index Method[1]

This standard is issued under the fixed designation D7625; 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 abrasiveness of rock by the CERCHAR Abrasiveness Index (CAI) method. The test method consists of measuring the wear on the tip of steel stylus with a cone shape and known Rockwell Hardness, caused by scratching against a freshly broken or saw cut rock surface for a prescribed 10 mm distance using one of the two test apparatus.

1.2 This test method is intended for freshly broken rock surfaces; however, saw cut surfaces are covered for when a satisfactory rock surface cannot be obtained.

1.3 The Rockwell Hardness (HR) of the stylus can have a profound effect on the results. The focus of this test method is an HRC value of 55 for every test (**1, 2**).[2] However, there are situations where styli with different Rockwell Hardness can be used. Therefore, this test method includes discussions on stylus with different Rockwell Hardness.

1.3.1 The Rockwell hardness (HR) value is based on the indentation hardness of a material. The Rockwell test, E18, measures the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load). (**3**) There are different scales, denoted by a single letter (A to F), that use different loads or indenters. The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale which in this test method is the scale C, which is for harden-steel.

1.4 Basically, the CERCHAR test is a measurement of the relative different hardness of stylus tip and rock specimen surface. The stylus tip is made of steel having a known Rockwell Hardness. Experiments have shown that CAI varies inversely with stylus hardness. Test results with the same steel type stylus but with different hardness need to be normalized to standard stylus hardness (**2**).

1.5 The scratch distance shall be limited to 10 mm. In general, 85 % of the stylus wear occurs during the first 2 mm of scratch's length. The remaining 15 % of the stylus wear occurs during the last 8 mm of the scratch's length. Therefore, minor variation in the scratch's length from test to test doesn't significantly affect the total stylus wear and the resulting CAI when variation in scratch length is kept between ±0.5 mm in length (**3**).

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

1.6.1 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 analysis methods for engineering design.

1.7 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[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] The bold numbers in parenthesis refer to a list of references at the end of this standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

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

D5079 Practices for Preserving and Transporting Rock Core Samples (Withdrawn 2017)[4]

D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data

E18 Test Methods for Rockwell Hardness of Metallic Materials

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this test method, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abrasiveness, n—in rock,* the wear or loss of material, which the rock produces on contact with another material such as TBM cutter or drill bit.

4. Summary of Test Method

4.1 A steel stylus having a 90 degree conical tip with its axis perpendicular, and in contact with a rock surface, under a total constant force of 70 N, is scratched in a direction parallel to the rock surface over a distance of 10 mm.

4.2 After the test, width of the wear flatness is measured on stylus tip surface in units of 0.1 mm and number of units reported as the CERCHAR Abrasiveness Index, 0.1mm (= 1CAI).

4.3 Five individual CAI tests shall be conducted for each rock specimen to achieve a defined average value (**4**). If there is not an apparent preference, for example, different colors, beddings, foliations, schistosity, large inclusions, weakness planes; on specimen, then a set of three parallel tests in one direction, and two more perpendicular to first set shall be done.

5. Significance and Use

5.1 The CERCHAR test and associated CAI were developed at a time of more demand for application of mechanical excavation machines at the Laboratoire du Center d' Études et Recherches des Charbonnages de France (CERCHAR) (**5**). CAI is used to assess the abrasiveness of rock for mechanical excavation. Rock abrasiveness governs the performance of disc cutters, the rate of its replacement and therefore subsequent tunnel costs. Advances in methods of underground excavation, in particular the use of the tunnel boring machine (TBM), necessitates knowledge of rock abrasiveness. Abrasiveness expresses a behavioral characteristic of rock rather than a fundamental physical or mechanical property.

5.2 CAI tests were originally carried out on natural broken surfaces. In heterogeneous rock types such as conglomerates, coarse grained granite or schistose rock, suitable fresh test surfaces are not achieved by mechanical breakage using a hammer. In these cases CAI values for "smooth" surfaces cut with a diamond saw are acceptable for use but shall be normalized by Eq 2 or Eq 3 before they can be reported (**4**).

5.3 The test velocity for the Original CERCHAR apparatus is approximately 10 mm/s and 1 mm/s for the West CERCHAR apparatus. The CAI values obtained for both testing velocities (**4**) are estimated to be equal.

NOTE 1—The quality of the result produced by these practices is dependent upon the competence of the personnel performing it and 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 and sampling. Users of these practices are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Apparatus*—Two types of CERCHAR apparatus (**4**) are in use today (See Fig. 1). Both devices employ a vice to clamp the specimen and a constant force of 70 N acting axially on a stylus tip when place against the test surface. The original apparatus employs a manually operated hand lever to displace the stylus tip on the stationary rock surface held fixed in place by a vice. The West apparatus displaces the vice holding the rock by use of a hand crank and driving screw under a stationary stylus.

6.2 *Stylus*—As mentioned in the Scope, CERCHAR test is a measurement of the relative different hardness between the stylus tip and rock specimen surface. The stylus tip shall be made of steel having a known Rockwell Hardness. The diameter of stylus should be minimum 6 mm and its length shall be minimum 15 mm between the tip and surface of rock.

6.2.1 Experiments have shown that CAI varies inversely with steel hardness. Test results with the same steel type stylus but with different hardness shall be normalized to standard stylus hardness (**2**). The use of stylus hardened to 55 HRC (**3,1**), and conforming to Test Methods E18 is advised.

6.3 *Mass*—The static mass for either test apparatus shall be appropriately sized and configured so that the total force of 70 N, including other components that would contribute additional force to the stylus tip during testing. This force shall act axially on the stylus tip in contact with the specimen surface during the test.

6.4 *Vice*—The vice in Fig. 1(a) shall be of sufficient rigidity, such that the clamped specimen is immobilized during the test. The vice in Fig. 1(b) holds the specimen and moves under the stylus by using the hand crank that advances the driving screw. Small wooden wedges may be used to make sure tightness of fit. Also, the vice shall have precise control of movement in two horizontal planes, with accurate positioning and change of position of the specimen with a secure hold.

[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.

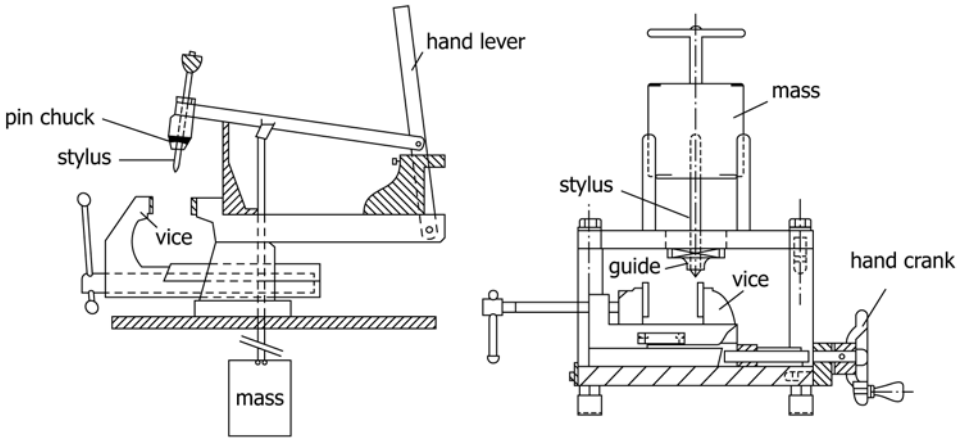

FIG. 1 Illustrations of Two Types of CERCHAR Testing Apparatuses

6.5 *Resting Support*—a mechanism or configuration to hold the mass and stylus in a stationary position above the test surface location while setting up and removing the test specimen. The original CERCHAR apparatus uses a resting support to place the lever arm on and the West CERCHAR apparatus has a set of lock screws to grip onto the static mass.

6.6 *Hand Lever*—The hand lever arm shall be articulated and have sufficient stiffness to displace the stylus over the rock surface allowing unrestrained vertical displacement of the stylus under the total force of 70 N (Fig. 1(a)).

6.7 *Hand Crank*—The hand crank screw-feed attached to the vice and powered manually with a crank displaces the vice holding a specimen under the stationary stylus. The screw-feed thread shall be machined such that displacement of the rock surface occurs at a constant displacement per revolution under the stationary stylus while allowing unrestrained vertical displacement of the stylus under the total force of 70 N (Fig. 1(b)).

6.8 *Microscope*—A toolmaker's microscope equipped with digital micrometer heads, XY stage and LCD (Liquid Crystal Display) readout are recommended. The microscope shall have a minimum magnification of 30×. The XY stage micrometer heads shall have a minimum range of 50 mm graduated to 0.01 mm and readable to 0.001 mm (**5**). Fig. 2 shows one example of this microscope with a stylus tip positioned under it, during flatness measurements. As an alternative, a digital microscope having the same capabilities as the toolmaker's microscope (Fig. 3) could be used for stylus flatness measurements.

6.9 *Grinder*—An apparatus that uses an abrasive stone wheel that is rotated and when place in contact with softer material removes material from that surface without appreciable wear to the stone wheel, or other suitable metal work apparatus, capable of shaping metal pen stock or sharpening the end of the stylus according to desired geometry. Cooling of the surface being ground by some type of fluid is advised in order not to heat up the metal excessively and change the original Rockwell hardness of the metal being used for the stylus.

FIG. 2 Toolmaker's Microscope

6.10 *Rock Saw*—A cutting device equipped with a segmented circular diamond saw blade, with a moveable platform for holding and feeding the sample, perpendicular to the rock core or block, into the cutting surface of the blade. The moveable platform may be a manual or automatic feed. The apparatus is also equipped to apply appropriate cooling and cutting agents (if needed) at the cutting surface to cool the blade and wash away cuttings.

6.11 *Miscellaneous*—Machinist's blue dye, wood shims, timer, digital or film camera.

7. Sampling and Test Specimens

7.1 The samples shall be selected by visual observation to include a range of specimens based on rock type, mineral constituents, grain sizes and shape, partings, and defects such as pores and fissures.

FIG. 3 Digital Microscope

7.2 The specimen shall be selected from the core sample or pieces of in situ rock representative of the type of rocks to be drilled or bored. This can be achieved on a large scale by viewing rock types encountered at the project and on a smaller scale by visual observations of mineral constituents, grain sizes and shape, partings, and defects such as pores and fissures. Core or irregular shape specimens prepared out of available samples with a typical diameter or length of approximately 50 mm are recommended.

7.3 The moisture conditions of the specimen at the time of test can have a significant effect upon the indicated strength of the rock. The field moisture condition for the specimen shall be preserved until the time of test in accordance with Practices D5079. This may be problematic when saw cut or drilled rock surfaces that need a water coolant are used instead of natural rock surfaces.

7.4 Specimens displaying apparent anisotropic features such as bedding or schistosity shall be prepared so that the orientation of the CAI test surface relative to anisotropic features can be described precisely.

7.5 Specimen test surface shall be either fresh flat natural surface or saw cut one. For saw cut surface, specimen surfaces shall be prepared by cutting the rock sample with cooling agent such as water-/air-cooled diamond saw blade to expose fresh specimen surfaces provided the resulting surfaces are reasonably planar.

7.6 The specimen's test surface shall have sufficient length that edge chipping within the 10 mm test path does not occur as the stylus approaches the specimen outer dimension.

7.7 Specimens with either natural or saw cut test surfaces shall be trimmed to fit in the CERCHAR test machine by cutting the rock sample with a cooling agent such as water-/air-cooled diamond saw blade.

7.8 Before and after photographs shall be taken of tested surfaces.

8. Preparation of Apparatus

8.1 The stylus shall be in good condition and verified under a microscope before use. The tip shall exhibit a width of wear of less than 0.05 mm and a conical angle of 90° to a minimum length of 1 mm as verified with the regular/digital microscopes rotating cross-line reticle.

8.2 If the stylus is not in good condition or previously used, then prior to testing, stylus tip shall be sharpened to the prescribed shape and condition described in 6.2. Special care shall be taken when re-sharpening used styli. High temperatures induced from sharpening too quickly can influence the styli hardness. Therefore application of a water coolant during re-sharpening process is recommended.

8.3 Regularly re-examining of stylus hardness is advised; Rockwell Hardness of stylus shall be 55 HRC.

8.4 Rockwell Hardness of stylus shall be verified in accordance with Test Methods E18.

8.5 Prior to testing, coating of each stylus tip with machinist's blue dye makes the wear flat area of the tip more visible under the microscope, and also helps to differentiate ready for test styli from used ones.

9. Procedure

9.1 Orient and securely clamp the test specimen in the vice such that the test surface is horizontal and parallel to the direction of displacement with the stylus. If necessary, use wood or other suitable materials between the vice and specimen surface to assist in clamping and orienting the specimen.

9.2 The stylus and associated components are lowered with care to bear on the specimen test surface so that the stylus tip is not damaged before testing. Adjust the position of the specimen in the apparatus so that the stylus will be able to scratch for 10 mm in the intended direction.

9.3 The static mass and associated components are positioned and checked for functionality ensuring there are no frictional impediments to the specified 70 N total force.

9.4 Two scratching velocities are used depending on which device is available. A scratching distance of 10 mm is used for both devices.

9.4.1 The articulated hand lever of original CERCHAR apparatus is pulled over 10 mm of the test surface within