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Standard Test Method for Hardness Testing of Cemented Carbides[1]

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1. Scope

1.1 This test method covers the hardness testing of cemented carbides by use of the Rockwell hardness tester with the Rockwell A scale (diamond indenter and 588.4 N (60 kgf) load) in the range of Rockwell A80 and above. Also covered are the procedures for the testing and selection of diamond indenters, the management and traceability of the four levels of standard test blocks, the acquisition of secondary standard test blocks, and the making and calibration of working standard test blocks.

1.2 The Rockwell hardness tester is a convenient and reliable means of measuring the hardness of cemented carbides. A hardness value is obtained easily, but it is subject to considerable error unless certain precautions are observed.

1.3 Test Methods E 18 shall be followed except where otherwise indicated in this test method.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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:*

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]

2.2 *ISO Standard:*

3738-2 Hardmetals—Rockwell hardness test (Scale A)—Part 2, Preparation and calibration of standard test blocks[4]

3. Significance and Use

3.1 Rockwell hardness is one of the more important properties used to evaluate cemented carbides. For compositional groups of cemented carbides, hardness is an indication of wear resistance and toughness. Lower hardness grades usually indicate less wear resistance but greater toughness. For a specific grade of cemented carbide, hardness is an indication of the metallurgical quality of the material. In no case is hardness the only property to be considered in evaluating cemented carbides.

4. Apparatus

4.1 *Scale*—All hardness tests shall be made on the regular (as opposed to superficial) Rockwell tester, using a 588.4 N (60 kgf) load (Rockwell A scale).

4.2 *Effect of Vibration*—The Rockwell hardness tester should be located in a vibration-free area in order to avoid erroneous results. If this is not possible, the tester shall be mounted so as to minimize vibrations, since vibrations tend to cause erratic readings.

4.3 *Indenter*—The standard indenter shall be selected, in accordance with the Annex to this test method, from diamond cone indenters specified for Rockwell A scale use and in conformance with Test Methods E 18.

4.3.1 The indenter, and an indentation made with it, in hardened steel or cemented carbide should be examined optically at approximately 50-diameter magnification for defects, conformance to shape, and mounting of the diamond. Examination should be made when selecting an indenter, occasionally during use, and whenever some event may be suspected of having damaged the diamond or its mounting.

4.4 *Anvils*—Select an anvil suitable for the specimen to be tested. The shoulder of the screw and the mating surface of the anvil should be clean. Seat the anvil securely. For the best accuracy, flat test pieces should be tested on a flat anvil of approximately 6-mm (¼-in.) diameter. The bearing surface of this anvil, with a Rockwell C hardness of at least 60, shall be polished smooth and be free of pits and heavy scratches. The test piece should be supported suitably, with the test surface perpendicular to the line of travel of the indenter. Dust, dirt, grease, or scale should not be allowed to accumulate on any part of the apparatus, as this will affect the results.

4.5 *Test Blocks*—Secondary standard test blocks or working standard test blocks that have been prepared and calibrated in

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[2] *Annual Book of ASTM Standards*, Vol 03.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th floor, New York, NY 10036.

accordance with the Annex to this test method shall be used.

5. Test Specimens

5.1 *Size of Specimens*—A minimum thickness of 1.6 mm (1⁄16 in.) is recommended. With thinner specimens, breakage may occur, resulting in damage to the anvil, the indenter, or both. Specimens that have enough overhang to cause imbalance shall be supported properly. The 6-mm (¼-in.) anvil will support flat test specimens up to approximately 113 g (¼ lb) and will also support the standard test blocks recommended previously.

5.2 *Preparation of Test Specimens*—The finish of the test surface is of major importance. The surface to be tested should be prepared to obtain a roughness of Ra ≤0.2 µm (8 µin.) A coarser finish will provide a wider range of readings. Preparation shall be conducted in such a way that alteration of the surface due to heat or cold-working is minimized. A 220-grit medium hardness resinoid bond diamond wheel, downfed 0.01 mm (0.0005 in.) per pass with abundant flow of coolant, should provide the desired surface. The thickness of the layer removed from an as-sintered surface to be tested shall be not less than 0.2 mm (0.008 in.).

5.3 The surfaces of the test specimen shall be flat and parallel within one part per hundred parts in general practice, but within one part per thousand parts when critical comparisons are being made. The surface in contact with the anvil shall be free of any irregularity (for example, a previous hardness indentation). Taper that results in the test surface not being normal to the axis of the indenter, or irregularity that causes instability during the test, will result in error.

5.4 When determining the hardness of a test specimen with a curved surface, the radius of curvature shall not be less than 15 mm (9⁄16 in.). If less, then a flat surface at least 3-mm (⅛-in.) wide shall be prepared on which to conduct the test, and there shall be an opposite flat surface such that the specimen conforms to the requirements of 5.2 and 5.3. If the test surface is curved or the opposite surface must be supported in a V-anvil, the repeatability and reproducibility limits of 8.2 and 8.3 may not apply.

5.5 *Preparation of Mounted Carbides*—Remove mounted carbides from the steel body by heating or some other convenient method. All braze metal or other bond material shall be removed from both the test surface and the opposite face. The specimen should then be prepared as described in 5.1 through 5.4.

6. Procedure

6.1 Procedures that are not described in this test method shall conform to those of Test Methods E 18.

6.2 Disregard the first two readings after an indenter has been newly mounted.

6.3 Limit the speed of applying the major load so that the movement of the weights is completed in 4 to 6 s, with no test piece on the testing equipment and with the machine set to apply a major load of 60 Kg. Verification should be by direct observation of the weight motion, if visible.

6.4 Do not permit the time of maintaining the major load after the motion of the needle or the changing of the digital readout has ceased to exceed 2 s. Removal of the major load should be gradual by operating lever in manual machines or by motor in automatic machines, and should not exceed two additional seconds. On manual machines, abrupt actuation of the major load trip lever may affect the hardness value obtained. Abrupt actuation of the major load removal lever will significantly affect the hardness value obtained.

6.5 The Rockwell A hardness value is read after the major load has been removed and while the minor load is still applied.

6.6 The distance between the centers of any two adjacent indentations, and the distance between the center of any indentation and the edge of a test specimen, shall be at least 1.5 mm (0.06 in.).

6.7 Hardness should be read or estimated to the nearest 0.1 HRA. Calculations should be carried to two decimal places.

6.8 Make two trial determinations of the hardness of the test specimen. This action also reassures that the indenter is seated properly.

6.8.1 Select the standard test block having a value closest to the trial hardness of the test specimen. Determine the Rockwell A hardness at three points on the block.

6.8.2 If the arithmetic mean of the three determinations differs from the certified hardness value of the standard test block by more than± 0.5 HRA, check the diamond indenter and the testing equipment, and eliminate the cause of the error. Repeat the determinations.

6.8.3 If the arithmetic mean of the three determinations differs from the certified hardness value of the standard test block by ±0.5 HRA or less, record the difference, giving due regard to the algebraic sign. This difference will be used to correct the arithmetic mean of the hardness of the test specimens.

6.8.4 Determine the Rockwell A hardness of the test specimen, with determinations at three or more locations chosen at random, or as dictated by the purpose of the test.

6.8.5 Calculate the arithmetic mean of the hardness determinations. Apply the correction determined as in 6.8.3, giving due regard to the algebraic sign.

6.8.6 Report the corrected arithmetic mean of the hardness determinations, rounded in accordance with Practice E 29[5] to the nearest 0.1 HRA.

7. Report

7.1 Report the following information:

7.1.1 All details necessary for identification of the test specimen,

7.1.2 The corrected mean hardness,

7.1.3 The range of hardness determinations,

7.1.4 The number of hardness determinations,

7.1.5 The smallest division of readout or graduation of the hardness test machine and whether it is digital or analog,

7.1.6 The identification and original source of calibration for the standard test blocks used,

[5] When the second decimal place is less than 0.05, leave the first decimal place unchanged. When the second decimal place is more than 0.05, increase the first decimal place by 0.1. When the second decimal place is exactly 5 and the first decimal place is odd, increase the first decimal by 0.1. If the first decimal place is even, leave it unchanged.