Designation: A833 – 19

Standard Test Method for Indentation Hardness of Metallic Materials by Comparison Hardness Testers[1]

This standard is issued under the fixed designation A833; 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 indentation hardness of metallic materials using comparison hardness testers.

1.2 This test method applies only to those portable comparison hardness testers that use test bars that have been standardized according to Test Method E10 as a basis for comparison.

1.3 Calibration of test bars, used for comparison to determine hardness numbers, is also covered by this test method.

1.4 The impression force used during comparison hardness testing is normally an impact load applied by striking a hammer on the appropriate areas as outlined in the manufacturer's instructions.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

E10 Test Method for Brinell Hardness of Metallic Materials

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *test bar, n*—that part of the testing apparatus which is used to determine a comparable hardness used in calculation of test part hardness.

3.1.2 *test part, n*—the item for which a hardness test determination is being performed.

4. Significance and Use

4.1 The comparative hardness test is an empirical dynamic indentation hardness test. Comparative hardness tests provide useful information about metallic materials. This information may correlate to tensile strength, wear resistance, ductility, heat treatment condition, or other physical characteristics of metallic materials, and may be useful in quality control and selection of materials.

4.2 Comparative hardness testing at a specific location on a test part may not represent the physical characteristics of the whole test part or end product.

5. Apparatus

5.1 Comparison hardness testers are used principally for testing articles that are too large or unwieldy to be tested in the usual types of testing machines, for testing parts of fixed structures, or for testing under any conditions that require that the indenting force be applied in a direction other than vertical.

5.1.1 Required equipment includes an apparatus that contains the impression ball and a slot or spacing to insert the test bar, a structure to apply the impact (anvil), and an impacting tool, normally a hammer. This apparatus is designed to allow a ball impression to be produced on the standard rod simultaneously with one produced on the piece to be tested. Comparison of the impression diameters together with the hardness of the test bar is used to determine hardness of the test part.

[1] This test method is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.13 on Mechanical and Chemical Testing and Processing Methods of Steel Products and Processes.

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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.

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

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5.1.2 The structure to convey the impact to the test bar, impression ball, and test part is designed with the striking surface for the impacting tool centered directly above the location of the impression ball.

5.1.3 The apparatus may also be designed to include an extension for stabilization.

5.1.4 The Brinell hardness of the test bar used, as determined by Test Method E10 and Test Methods and Definitions A370, shall be within ±10 % of the anticipated Brinell hardness of the test part, and of the same general type of material.

5.1.5 *Impression Ball:*

5.1.5.1 The diameter of the impression ball shall be 10 ± 0.01 mm.

5.1.5.2 The ball shall be made from steel hardened within the range of 60 to 67 HRC and shall be capable of being used in a reasonable number of tests without incurring damage that could affect the results. Use of a tungsten carbide ball may result in fracture or spalling of the ball.

5.1.5.3 The ball shall be inspected regularly according to the equipment manufacturer's recommendations to ensure accuracy.

5.2 *Measuring Microscope*—The divisions of the micrometer scale of the microscope, or other measuring devices used for measuring the impression diameter, shall be such as to permit the direct measuring of the diameter to 0.1 mm and the estimation of the diameter to 0.05 mm.

6. Test Parts

6.1 Test parts by this hardness testing test method vary greatly in form since it is frequently desirable to make the impression upon a test part to be used in the finished product rather than upon a sample test specimen.

6.1.1 *Dimensions*—The thickness of the tested part shall be such that no bulge or other marking showing the effect of the load appears on the side of the piece opposite the impression. In any event, the thickness of the test part shall be at least ten times the depth of the indentation. The minimum width shall be at least two and one half times the diameter of the indentation.

6.1.2 *Finish*—When necessary, the surface on which the impression is to be made shall be filed, ground, machined, or polished with abrasive material so that the edge of the impression shall be defined clearly enough to permit the measurement of the diameter to the specified accuracy. Take care to avoid overheating or cold working the surface. Sufficient metal shall be removed to eliminate decarburized metal.

6.2 *Support*—All test parts shall be adequately supported to prevent any movement or deflection during application of the impact load.

7. Verification of Apparatus and Calibration of Test Bars

7.1 *Verification of Apparatus*—The hardness-testing apparatus (including test bars) shall be verified by performing tests on Brinell blocks that have been standardized according to the requirements of Test Method E10.

7.1.1 Full verification of the apparatus shall be performed prior to use when new, and upon replacement of the impression ball. The full verification shall include testing at least one Brinell test block 3 times. The average of the three measurements shall be within ±5 % of the Brinell value of the test block.

7.1.2 Periodic verifications are recommended at the beginning of each day the comparative tester is used, or during usage as deemed necessary. Periodic verifications should be performed using Brinell test blocks within ±15 % of the expected Brinell hardness of the test parts being tested. One measurement is satisfactory for periodic testing. The result of the periodic test measurement should be within ±5 % of the Brinell value of the test block to be considered to be in compliance with this test method.

7.2 *Calibration of Test Bars*—The Brinell hardness of the test bars shall be determined by the test bar manufacturer using a 10 mm diameter ball and a 3000 kg load according to Test Method E10 on each of the four faces of the test bar at approximately the mid-length of the bar. If the test bar is too soft to permit the use of a 3000 kg load, then a 1500 kg load shall be used. The hardness values obtained shall not vary from each other by more than ±2 %. The ends of the bar shall be permanently marked with the average hardness value, as well as the applied load if the 1500 kg load was used by the manufacturer prior to shipment.

8. Procedure

8.1 Assemble the test bar into the apparatus making sure a minimum distance of no less than 5 mm will exist between diameter of the impression to be made and any other indentations on the face. Minimum distance of the indentation diameter from the edge of the test part shall be 12.5 mm. If the apparatus is equipped with a presetting bar stop, ensure the fixture is properly in place. Place the apparatus on the surface of the component to be tested and apply the impact load using a 1 to 2¼ kg hammer. It is essential to apply a well guided, short blow in order to avoid a rebound and thus a double blow that may produce an erroneous result by damaging the sharp edge of the ball impression.

NOTE 1—A hammer weight of 2 to 5 lb may be used instead of the kilogram rating.

8.2 *Impression Diameter*—In order to achieve the published precision level (see Section 10), impression diameters on test part should fall between 3.0 and 4.0 mm. If a larger impression is produced, the test bar may give way laterally and the test result may be in error.

8.3 *Measurements*—Each impression shall be measured twice with the measurements taken at right angles to each other. The two diameters, determined with equipment in accordance with 5.2, shall be within 0.05 mm of each other. If the two measured diameters are not within 0.05 mm of each other, then the test impression is deemed to be invalid and a retest must be performed. The mean value of the two diameter measurements (taken at right angles) is then used as the basis for subsequent calculation as discussed in 8.4.

8.4 *Determination of Test Part Hardness*—Employing the calculation device or mathematical equation supplied by the manufacturer for the apparatus, determine the hardness of the test part by using both (test bar and test part) impression

TABLE 1 Hardness [HBC]

NOTE 1—Based on individual test determinations.
Five labs reported 12 replicates; three labs reported 11 replicates.

Material	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	S_r	S_R	r	R
Hardness Test Block Plate	197.6	11.0	12.9	30.8	36.2

[A] The average of the laboratories' calculated averages.

TABLE 2 Average Hardness [HBC]
(See Supplementary Requirement S1)

NOTE 1—Based on the average of three individual test determinations.
Five labs reported four replicates; three labs reported three replicates.

Material	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	S_r	S_R	r	R
Hardness Test Block Plate	197.4	6.8	9.6	19.1	26.9

[A] The average of the laboratories' calculated averages.

diameters and the hardness of the test bar in accordance with the equipment manufacturer's instructions. Annex A1 gives details of typical formulae used in calculating the comparison hardness.

8.4.1 See Supplementary Requirement S1 for the use of averaging to achieve greater repeatability.

9. Test Report

9.1 The test report shall include the following information:

9.1.1 Indentation hardness number of the test part as calculated in 8.4 followed by the designation HBC and the Brinell hardness number of the test bar,

9.1.1.1 The result shall be written as shown in the following example:

232HBC/240 where 232 is the hardness determined as defined in 8.4 and 240 is the Brinell hardness of the test bar.

9.1.2 Identification of the manufacturer's equipment, and

9.1.3 Diameters of the impressions in the test part and test bar.

10. Precision and Bias[3]

10.1 The precision of this test method is based on an interlaboratory study of A833, Standard Test Method for Indentation Hardness of Metallic Materials by Comparison Hardness Testers, conducted in 2015. Eight laboratories tested a single reference hardness block. Test results were reported as both individual determinations (12 from each participant) and as the calculated average of three determinations (four from each participant). Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:A01-1005.

10.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

10.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

10.1.1.2 Repeatability limits are listed in Tables 1 and 2.

10.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

10.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

10.1.2.2 Reproducibility limits are listed in Tables 1 and 2.

10.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

10.1.4 Any judgment in accordance with statements 10.1.1 and 10.1.2 would have an approximate 95 % probability of being correct.

10.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

10.3 The precision statement was determined through statistical examination of 93 individual test determinations, from eight laboratories, on a single test block.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:A01-1005. Contact ASTM Customer Service at service@astm.org.

NOTE 2—Various configurations of testers are available to perform a hardness test in accordance with this test method. All data contained in this Interlaboratory Study report was obtained with one particular type as defined in the Research Report. Use of differing equipment could affect precision.

11. Keywords

11.1 Brinell hardness; comparative hardness; comparative hardness testers; metallic

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement(s) shall apply only when individually specified.

S1. Averaging of Hardness Values

S1.1 If greater precision is required, it is permissible to report the hardness as an arithmetic average of three individual hardness determinations. See Table 2 in Section 10 on Precision and Bias. The three individual readings shall be obtained in an area not greater than 1 in^2.

ANNEX

A1. ANALYTICAL HARDNESS DETERMINATION

A1.1 As an example, the hardness of the test part may be determined from the following equation, based on the use of a 10 mm diameter ball. However the manufacturer of the actual apparatus used may use another formula for obtaining the comparison hardness value as stated in 8.4.

$$B_1 = B_2\left(10 - \sqrt{100 - D_1^2}\right)/\left(10 - \sqrt{100 - D_2^2}\right)$$

where:

B_1 = comparison hardness of the test part,
B_2 = Brinell hardness of the test bar,
D_1^2 = diameter of impression in the test bar,
D_2^2 = diameter of impression in the test part.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A833 – 17) that may impact the use of this standard. (Approved Nov. 1, 2019.)

(1) Deleted former subsection 8.3.1.