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Designation: ~~E3246 – 21~~ E3246 – 22

Standard Test Methods for Differential Indentation Depth Hardness of Metallic Materials[1]

This standard is issued under the fixed designation E3246; 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~~ Scope*

1.1 This test method covers the determination of the Differential Indentation Depth hardness of metallic materials by the Differential Indentation Depth hardness principle. This standard provides the requirements for Differential Indentation Depth hardness testing machines and the procedures for performing Differential Indentation Depth hardness tests.

1.2 This standard includes additional requirements in annexes:

Verification of Differential Indentation Depth Hardness Testing Machines	Annex A1
Guidelines for Determining the Minimum Thickness of a Test Piece	Annex A2

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1.3 This standard includes non-mandatory information in appendixes which relates to the Differential Indentation Depth hardness test.

List of ASTM Standards Giving Hardness Numbers Corresponding to Tensile Strength	Appendix X1
Examples of Procedures for Determining Differential Indentation Depth Hardness Uncertainty	Appendix X2
Examples of Indenters Used in Differential Indentation Depth Machines	Appendix X3

1.4 *Units*—This standard specifies the units of force and length in the International System of Units (SI); that is, force in Newtons (N) and length in micrometers (µm). However, because of continued common usage, values are provided in other units of measure for information.

1.5 The test principles, testing procedures, and verification procedures are essentially identical for all the Differential Indentation Depth hardness testing instruments. The testing instruments may use different test forces and indenter shapes. The type and size of the indenters are matched to the design of the instrument by the manufacturer. Accordingly, the indenters, probes and other instrument components are generally not interchangeable among manufacturers.

1.6 The hardness number reported by these instruments are based on direct correlations to existing hardness scales as determined

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[1] These test methods are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.06 on Indentation Hardness Testing.

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

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by each manufacturer for each instrument and hardness scale. Unless otherwise noted on the instrument or in the operating manual for the instrument, the hardness numbers reported by the instrument are only applicable to non-austenitic steels. See 5.6.1 for additional information.

1.7 *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.*

1.8 *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
~~B19 Specification for Cartridge Brass Sheet, Strip, Plate, Bar, and Disks~~
~~B36/B36M Specification for Brass Plate, Sheet, Strip, And Rolled Bar~~
~~B96/B96M Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels~~
~~B103/B103M Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar~~
~~B121/B121M Specification for Leaded Brass Plate, Sheet, Strip, and Rolled Bar~~
~~B122/B122M Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar~~
~~B130 Specification for Commercial Bronze Strip for Bullet Jackets~~
~~B134/B134M Specification for Brass Wire~~
~~B152/B152M Specification for Copper Sheet, Strip, Plate, and Rolled Bar~~
~~B370 Specification for Copper Sheet and Strip for Building Construction~~
E6 Terminology Relating to Methods of Mechanical Testing
E10 Test Method for Brinell Hardness of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
E110 Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers
E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E384 Test Method for Microindentation Hardness of Materials
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

~~2.2 *American Bearings Manufacturer Association Standard:*~~
~~ABMA 10-1989 Metal Balls[3]~~

2.2 *ISO Standards:*

ISO 18265 Metallic Materials—Conversion of Hardness Values[3]
ISO/IEC 17011 Conformity Assessment—General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies[3]
ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[3]

2.3 *Society of Automotive Engineers (SAE) Standard:*

SAE J417 Hardness Tests and Hardness Number Conversions[4]

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3. Terminology and Equations

3.1 *Definitions:*

3.1.1 *differential indentation depth hardness test, n*—an indentation hardness test using a verified hardness testing machine to force a truncated diamond cone indenter, diamond spheroconical indenter or tungsten carbide ball indenter, under specified conditions, into the surface of the material under test, and to measure the difference in depth of the indentation as the force on the indenter is increased from a specified preliminary test force to a specified total test force and then returned to the preliminary test force.

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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.

~~[3] Available from American Bearing Manufacturers Association (ABMA), 2025 M Street, NW, Suite 800, Washington, DC 20036.~~

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

3.1.2 *differential indentation depth hardness number, n*—a number derived from the net increase in the depth of indentation as the force on an indenter is increased from a specified preliminary test force to a specified total test force and then returned to the preliminary test force.

3.1.3 *differential indentation depth hardness testing machine, n*—a machine capable of performing a Differential Indentation Depth hardness test and displaying the resulting hardness number.

3.1.4 The definitions of Brinell hardness scale, Brinell hardness number, calibration, direct verification, expanded uncertainty, ductility, force, hardness, indentation hardness, indirect verification, load, reference standard, resolution, Rockwell hardness number, standardization, stress, tensile strength, testing machine, and verification are used as defined in Terminology E6.

3.2 *Equations*—The Differential Indentation Depth hardness number is a calculated number, which, by method of calculation, correlates to the hardness in the scale that it is being converted to.

3.2.1 The *average*,H^-, of a set of *n* hardness measurements H_1, H_2, …, H_n is calculated as:

$$\bar{H} = \frac{H_1 + H_2 + \ldots + H_n}{n} \tag{1}$$

3.2.2 The *error*,*E*, in the performance of a Differential Indentation Depth hardness testing machine at each hardness level, relative to a standardized scale, is determined as:

$$E = \bar{H} - H_{\mathrm{STD}} \tag{2}$$

where:

H^- = average of *n* hardness measurements H_1,H_2, …, H_n made on a reference standard as part of a performance verification, and

H_{STD} = certified average hardness number of the reference standard.

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3.2.3 The *range*,*R*, in the performance of a Differential Indentation Depth hardness testing machine at each hardness level, under the particular verification conditions, is estimated by the range of *n* hardness measurements made on a reference standard as part of a performance verification, defined as:

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$$R = H_{\max} - H_{\min} \tag{3}$$

where:

$H_{\max}$ = highest hardness number, and

$H_{\min}$ = lowest hardness number.

3.2.4 The *repeatability*,*r*, in the performance of a Differential Indentation Depth hardness testing machine at each hardness level, under the particular verification conditions, is estimated by the range of *n* hardness measurements made on a reference standard as part of a performance verification divided by the mean of the measurements, defined as:

$$r = \left(\frac{H_{\max} - H_{\min}}{\bar{H}}\right) \times 100 \quad \text{where } r \text{ is in \%} \tag{4}$$

3.2.5 The *relative error*,E_{R}, in the performance of a Differential Indentation Depth hardness testing machine at each hardness level, relative to a standardized reference value, is calculated as an absolute percent relative error determined as:

$$E_{\mathrm{R}} = \left|100 \times \left(\frac{H - H_{\mathrm{STD}}}{H_{\mathrm{STD}}}\right)\right| \tag{5}$$

4. Significance and Use

4.1 The Differential Indentation Depth hardness test is an empirical indentation hardness test that can provide useful information about metallic materials. This information can correlate to tensile strength, wear resistance, ductility, and other physical characteristics of metallic materials, and can be useful in quality control and selection of materials.

4.2 Differential Indentation Depth hardness tests are considered satisfactory for acceptance testing of commercial shipments, and have been used in industry for this purpose.

4.3 Differential Indentation Depth hardness testing at a specific location on a part might not represent the physical characteristics of the whole part or end product. Machines that comply with this Standard are used when machines that comply with the regular hardness standards such as Test Methods E10, E18, E92, and E384 cannot be used. Test results obtained with these machines are comparable BUT NOT EQUIVALENT to those obtained with machines that comply with the above mentioned standards.

4.4 Differential Indentation Depth hardness testing machines covered by this standard do not comply with Test Methods E10, E18, E92, or E110.

5. Principles of Test and Apparatus

5.1 *Differential Indentation Depth Hardness Test Principle*—The general principle of the Differential Indentation Depth hardness test is illustrated in Fig. 1. The test is divided into three steps of force application and removal.

Step 1—The indenter is brought into contact with the test specimen, and the preliminary test force is applied. The baseline depth measurement (baseline depth of indentation) at the point where the preliminary test force, F_0, is achieved is noted as the zero set point for depth measurement.

Step 2—The force on the indenter is increased by the additional test force, F_1, to achieve the total test force, F. The total test force is held for a specified dwell time. The hardness testing machine limits the total test force to the device-specific value.

Step 3—The additional test force is removed, returning to the preliminary test force. At the point where the preliminary test force, F_0, is achieved, the final depth of indentation is measured. The Differential Indentation Depth hardness number is derived from the difference, h, in the final and baseline indentation depths while under the preliminary test force. The preliminary test force is removed and the indenter is removed from the test specimen.

5.1.1 There are several designs of the Differential Indentation Depth hardness testing machine. Indenters and probes are generally not interchangeable between machines of different design.

5.1.2 For the Differential Indentation Depth hardness test, the preliminary test forces range between 10N and 100N and the total test forces range between 50N and 1000N and are specified by the manufacturers. The preliminary force used is approximately 20 % of the value of the total test force used.

5.1.3 Indenters for the Differential Indentation Depth hardness test include a truncated diamond cone indenter, diamond spheroconical indenter, and tungsten carbide ball indenter of specified diameter.

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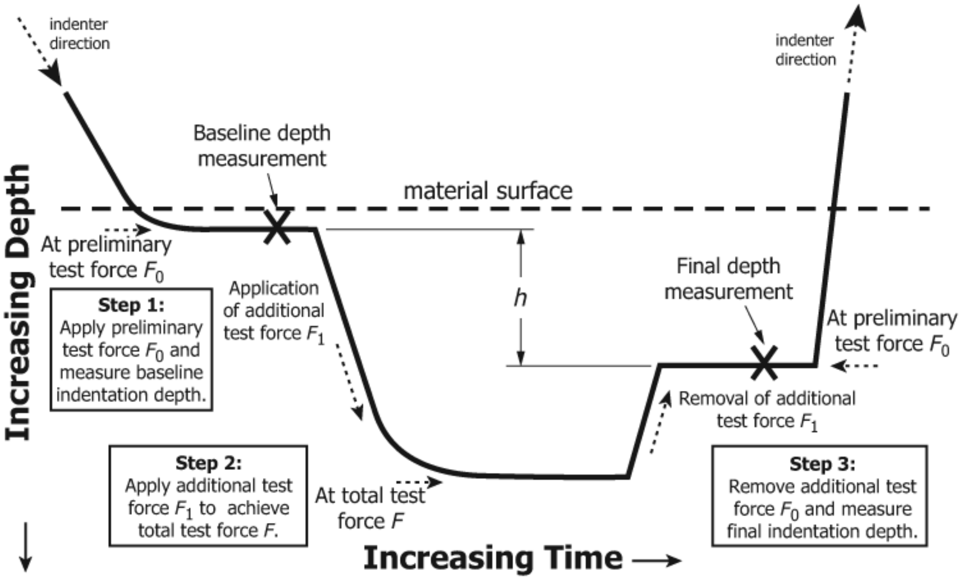

FIG. 1 Differential Indentation Depth Hardness Test Method (Schematic Diagram)

5.2 *Calculation of the Differential Indentation Depth Hardness Number*—During a Differential Indentation Depth hardness test, the force on the indenter is increased from a preliminary test force to a total test force, and then returned to the preliminary test force. The difference in the two indentation depth measurements, while under the preliminary test force, is measured as *h* (see Fig. 1).

5.2.1 The unit measurement for *h* is µm. From the value of *h*, the differential hardness number is derived. The reported hardness number is calculated by the instrument from the differential indentation depth hardness number according to calibration curves specific to the machine as designed by the manufacturer.

5.2.2 The Differential Indentation Depth hardness number is an arbitrary number, which, by method of calculation, results in a higher number for harder material. The Differential Indentation Depth hardness number is converted to a hardness number from commonly used hardness scales.

5.2.3 Differential Indentation Depth hardness numbers shall not be designated by a number alone because it is necessary to indicate which scale is displayed by the instrument.

5.2.3.1 *Examples:*

64 HRC(DID) = Rockwell hardness number of 64 on Rockwell C scale
332 HBW(DID) = Brinell hardness number of 332
72 HRBW(DID) = Rockwell hardness number of 72 on the Rockwell B scale

5.2.4 A reported Differential Indentation Depth hardness number or the average value of Differential Indentation Depth hardness measurements shall be rounded in accordance with Practice E29 with a resolution no greater than the resolution of the hardness number display of the testing machine.

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5.2.4.1 When the Differential Indentation Depth hardness test is used for the acceptance testing of commercial products and materials, the user should take into account the potential measurement differences between hardness testing machines (see Section 10, Precision and Bias).

NOTE 1—Because of the allowable ranges in the tolerances for the range and error of a hardness testing machine, as specified in the verification requirements of Annex A1, it is possible for one hardness testing machine to have a test result that is one or more hardness points different than another hardness testing machine, yet both hardness testing machines can be within verification tolerances (see Table A1.3). Commonly, for acceptance testing, hardness numbers are rounded to whole numbers following Practice E29. Users are encouraged to address rounding practices with regards to acceptance testing within their quality management system, and make any special requirements known during contract review.

5.3 *Differential Indentation Depth Testing Machine*—The Differential Indentation Depth testing machine shall make hardness determinations by applying the test forces and measuring the depth of indentation in accordance with the Differential Indentation Depth hardness test principle.

5.3.1 See the Equipment Manufacturer's Instruction Manual for a description of the machine's characteristics, limitations, and respective operating procedures.

5.3.2 The Differential Indentation Depth testing machine shall automatically convert the depth measurements to a hardness number and indicate the hardness number and scale by an electronic device or by a mechanical indicator.

5.4 *Indenters*—The standard Differential Indentation Depth indenters are diamond spheroconical indenters, truncated diamond cone indenters or tungsten carbide balls. Indenter characteristics are specified by the manufacturers.

5.4.1 Dust, dirt, or other foreign materials shall not be allowed to accumulate on the indenter, as this will affect the test results.

5.5 *Specimen Support*—A specimen support shall be used when necessary for supporting the specimen to be tested. It is necessary to support the specimen when the specimen stiffness is such that the specimen will flex under the test loads.

5.5.1 Flat pieces should be tested on a flat support that has a smooth, flat bearing surface whose plane is perpendicular to the axis of the indenter.

5.5.2 Small diameter cylindrical pieces shall be tested with a hard V-grooved support with the axis of the V-groove directly under the indenter, or on hard, parallel, twin cylinders properly positioned and clamped in their base. These types of specimen supports shall support the specimen with the apex of the cylinder directly under the indenter.

5.5.3 Special supports or fixtures, including clamping fixtures, may be used for testing pieces or parts that cannot be supported by standard supports.

NOTE 2—Not all reference standards will have parallel surfaces that are supported by standard supports. Reference standards with non-parallel or non-flat surfaces are examples of reference standards that can require a special support or fixture.

5.6 *Verification*—Differential Indentation Depth hardness testing machines shall be verified periodically in accordance with Annex A1.

5.6.1 Because the reported values are correlations to existing hardness scales, the user should verify the accuracy of the reported hardness number on the specific material to be tested. Verification should be performed according to A1.4.

5.7 *Reference Standards*—Reference standards meeting the requirements of Test Methods E10, E18, or E92, or combinations thereof shall be used to verify the testing machine.

NOTE 3—Reference standards certified to revision Test Methods E18-07 or later meet the requirements of this standard.

NOTE 4—Appropriate reference standards are not available for all geometric shapes, or materials, or both.

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6. Test Piece

6.1 For best results, both surfaces of the test piece should be smooth, even and free from oxide scale, foreign matter, and lubricants. An exception is made for certain materials such as reactive metals that might adhere to the indenter. In such situations, a suitable lubricant such as kerosene may be used. The use of a lubricant shall be defined on the test report.

6.2 Preparation shall be carried out in such a way that any alteration of the surface hardness of the test surface (for example, due to heat or cold-working) is minimized.

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6.3 The thickness of the test piece or of the layer under test should be as defined in tables in Annex A2. These tables were determined from studies conducted by the manufacturers and have proven to give reliable results. For all other materials, the thickness of the test piece should exceed 10 times the depth of indentation. In general, no deformation should be visible on the back of the test piece after the test, although not all such marking is indicative of a bad test.

6.3.1 Special consideration should be made when testing parts that exhibit hardness gradients; for example, parts that were case-hardened by processes such as carburizing, carbonitriding, nitriding, induction, etc. The minimum thickness guidelines given in Annex A2 only apply to materials of uniform hardness, and should not be used to determine the appropriate use for measuring parts with hardness gradients. The selection of an appropriate instrument for parts with hardness gradients should be made by special agreement.

6.4 When testing on convex cylindrical and spherical surfaces, the result might not accurately indicate the true hardness; therefore, the corrections given for the instrument by the manufacturer shall be applied.

6.4.1 Concave surfaces may be able to be tested with the Differential Indentation Depth method if the machine manufacturer specifies suitability of the specific Differential Depth hardness testing machine to test conditions. Do not test on concave surfaces if the manufacturer does not specify suitability of the Differential Indentation Depth hardness testing machine for testing on concave surfaces.

6.5 When testing small diameter specimens, the accuracy of the test will be seriously affected by alignment between the indenter and the test piece, by surface finish, and, if the specimen is cylindrical, by the straightness of the cylinder.

7. Test Procedure

7.1 Perform a daily verification of the Differential Indentation Depth hardness testing machine in accordance with A1.4 prior to making hardness tests. Hardness measurements shall be made only on the calibrated surface of the reference standard.

7.2 Differential Indentation Depth hardness tests should be carried out at ambient temperature within the limits of 10 °C to 35 °C (50 °F to 95 °F). Users of the Differential Indentation Depth hardness test are cautioned that the temperature of the test material and the temperature of the hardness tester can affect test results. Consequently, users should ensure that the test temperature does not adversely affect the hardness measurement.

7.3 Support the test piece rigidly so that displacement of the test surface is minimized (see 5.5).

7.4 *Test Cycle*—Use the manufacturer's procedure to control the test cycle. The test cycle to be used with the hardness testing machine should match, as closely as possible, the test cycle used for the indirect verification of the hardness testing machine.

NOTE 5—Varying the values of the testing cycle parameters can produce different hardness results.

7.5 *Test Procedure*—There are many designs of Differential Indentation Depth hardness testing machines, requiring various levels of operator control. Some hardness testing machines can perform the Differential Indentation Depth hardness test procedure automatically with almost no operator influence, while other machines require the operator to control most of the test procedure.

7.5.1 Bring the indenter into contact with the test surface in a direction perpendicular to the surface and, if possible, at a velocity within the maximum contact velocity as recommended by the instrument manufacturer.

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7.5.2 Apply the preliminary test force, F_0.

7.5.3 Maintain the preliminary force for the preliminary force dwell time specified by the manufacturer, then measure the depth of penetration. This is the baseline depth measurement.

7.5.4 Increase the force by the value of the additional test force, F_1, needed to obtain the required total test force, F. The additional force, F_1, shall be applied in a controlled manner.

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7.5.5 Maintain the total force, F, for the total force dwell time specified by the manufacturer.

7.5.6 Remove the additional test force, F_1, and allow the instrument to cycle through the preliminary test force, F_0, then measure the depth of penetration. This is the final depth measurement.

7.5.7 The testing machine shall calculate the difference between the final and baseline depth measurements and indicate the resulting hardness number. The hardness number is derived from the differential increase in depth of indentation.

7.6 Throughout the test, protect the apparatus from shock or vibration that could affect the hardness measurement result.

7.7 After each removal and replacement of the indenter, the operation of the machine should be checked in accordance with the daily verification method specified in Annex A1.

7.8 Maintain a distance of at least three times the diameter, d, of the indentation (see Fig. 2) between the centers of two adjacent indentations.

7.8.1 The distance from the center of any indentation to an edge of the test piece shall be at least two and a half times the diameter of the indentation (see Fig. 2).

NOTE 6—*Indentation Spacing*—The hardness of the material immediately surrounding a previously made indentation will usually increase due to the induced residual stress and work-hardening caused by the indentation process. If a new indentation is made in this affected material, the measured hardness number will likely be higher than the true hardness of the material as a whole. Also, if an indentation is made too close to the edge of the material or very close to a previously made indentation, there might be insufficient material to constrain the deformation zone surrounding the indentation. This

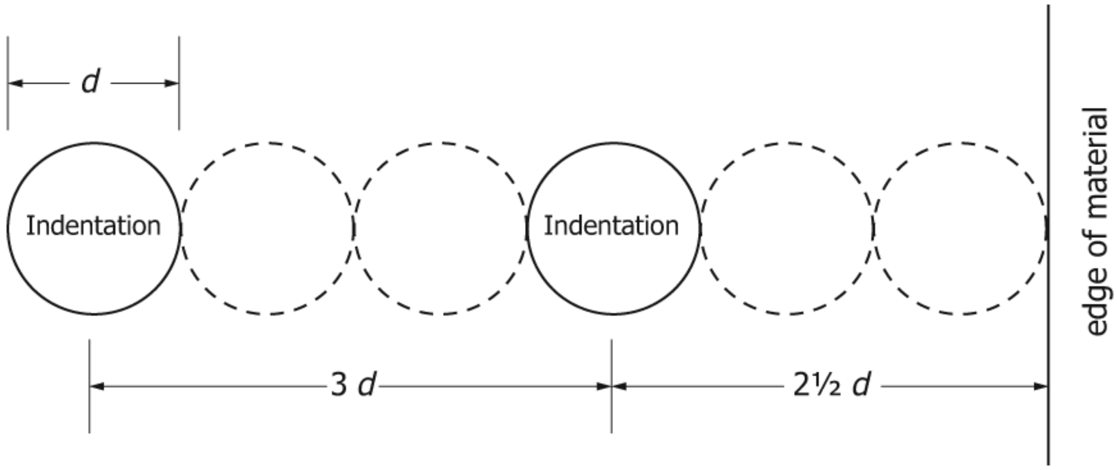

FIG. 2 Schematic of Minimum Indentation Spacing

can result in an apparent lowering of the hardness number. Both of these circumstances can be avoided by allowing appropriate spacing between indentations and from the edge of the material.

7.9 *Number of Measurements*—One measurement shall constitute a test.

NOTE 7—While one measurement constitutes a test, the average of multiple measurements can provide the user with a more accurate indication of the hardness of the test location.

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8. Conversion to Other Hardness Scales or Tensile Strength Values

8.1 The design of the Differential Indentation Depth hardness testing machine is such that the hardness number is directly calculated from the measured differential indentation depth for one or more hardness scales. These direct calculations are based upon empirical comparison tests conducted by the manufacturer and verified by indirect verification using reference standards that were measured according to Test Methods E10, E18, or E92, or combinations thereof.

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8.2 There is no general method of accurately converting the Differential Indentation Depth hardness numbers on one scale to Differential Indentation Depth hardness numbers on another scale, or to other types of hardness numbers, or to tensile strength values. Such conversions are, at best, approximations and, therefore, should be avoided except for special cases where a reliable basis for the approximate conversion has been obtained by comparison tests.

NOTE 8—The Standard Hardness Conversion Tables for Metals, E140, give approximate conversion values for specific materials such as steel, austenitic stainless steel, nickel and high-nickel alloys, cartridge brass, copper alloys, and alloyed white cast irons. The Rockwell hardness data in the conversion tables of E140 was determined using steel ball indenters.

NOTE 9—ASTM standards giving approximate hardness-tensile strength relationships are listed in Appendix X1.

NOTE 10—Other international standards for conversion, for example, ISO 18265 or SAE J417, can provide conversion values that differ from other conversion standards.

9. Report

9.1 The test report shall include the following information:

9.1.1 The hardness number. All reports of hardness numbers shall indicate the scale used. The reported number shall be rounded in accordance with Practice E29 (see 5.2.4).

9.1.1.1 When hardness numbers obtained by Differential Indentation Depth measurement are reported, the test method shall be noted in parenthesis after the number and hardness scale, for example 35 HRC(DID), where HRC(DID) is for Hardness Differential Indentation Depth Rockwell C, HV(DID) is for Hardness Differential Indentation Depth Vickers, and HBW(DID) is for Hardness Differential Indentation Depth Brinell.

TABLE 1 Hardness (HRC)

Material Tested	Average	Repeatability Standard Deviation	Preliminary Repeatability Limit
	$\bar{x}$	s_r	r_L
Rockwell reference standard	44.71	0.60	1.67

9.1.2 The ambient temperature at the time of test, if outside the limits of 10 °C to 35 °C (50 °F to 95 °F), unless it has been shown not to affect the measurement result.

9.1.3 Identification of the equipment used to obtain the hardness number.

9.1.4 Identification of the equipment operator.

9.1.5 The test date.

10. Precision and Bias

10.1 The precision of this test method is based on an intralaboratory study of ASTM E3246 – Standard Test Method for Differential Indentation Depth Hardness of Metallic Materials, conducted in 2018. A single laboratory participated in this study, testing a single standardized Rockwell reference standard. Every "test result" represents an individual measurement. The laboratory reported 50 replicate test results. Except for the use of only one laboratory, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM RR:E28-2000.[5]

10.1.1 *Repeatability limit, rL*—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.

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10.1.1.2 Repeatability limits are listed in Table 1.

10.1.2 *Reproducibility limit, 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 cannot be calculated from a single laboratory's results.

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 statement X1.1 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities that are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

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[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E28-2000. Contact ASTM Customer Service at service@astm.org.

10.2 *Bias*—Reference material tested: Certified Rockwell reference standard, SN 15R2117 from Westport, mean hardness 44.30 HRC, expanded uncertainty 0.40 HRC, standard base uncertainty 0.197. The mean reported test measurement was 44.7. The maximum reported test measurement was 45.9. The minimum reported test measurement was 43.6. The standard deviation of the reported test measurements was 0.59.

10.3 The precision statement was determined through statistical examination of 50 individual test results, from a single laboratory, on a single certified Rockwell reference standard.

10.4 This is a preliminary precision and bias statement in accordance with section A21.5.1 of the ASTM Form and Style Manual. A full precision and bias statement will be generated within 5 years of first approval of this standard as required.

11. Keywords

11.1 hardness; indentation depth; mechanical test; metals; portable

ANNEXES

(Mandatory Information)

A1. VERIFICATION OF DIFFERENTIAL INDENTATION DEPTH HARDNESS TESTING MACHINES

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ASTM E3246-22
https://standards.iteh.ai/catalog/standards/sist/6681d188-b4d8-464e-85ad-ce91cb552c9e/astm-e3246-22

A1.1 Scope

A1.1.1 Annex A1 specifies two types of procedures for verifying Differential Indentation Depth hardness testing machines: *indirect verification*, and *daily verification*.

A1.1.2 Indirect verification is a process for periodically verifying the performance of the testing machine by means of reference standards and indenters.

A1.1.3 The daily verification is a process for monitoring the performance of the testing machine between indirect verifications by means of reference standards.

A1.1.4 Adherence to this standard and annex provides metrological traceability to the SI, except as stated otherwise.

A1.2 General Requirements

A1.2.1 The testing machine shall be verified at specific instances and at periodic intervals as specified in Table A1.1, and when circumstances occur that might affect the performance of the testing machine.

A1.2.2 The temperature at the verification site shall be measured with an instrument having an accuracy of at least ±2.0 °C (±3.6 °F). It is recommended that the temperature be monitored throughout the verification period, and significant temperature variations be recorded and reported. Temperature measurement may not be measured at the verification site for a daily verification or when qualifying additional user's indenters in accordance with A1.3.9.

TABLE A1.1 Verification Schedule for a Differential Indentation Depth Hardness Testing Machine

Verification Procedure	Schedule
Indirect verification	Recommended every 12 months, or more often if needed. Shall be no longer than every 18 months. To qualify an indenter that was not verified in the last indirect verification, only a partial indirect verification is performed, (see A1.4).
Daily verification	Required each day that hardness tests are to be made. Recommended whenever the indenter is changed.

A1.2.3 All instruments used to make measurements required by this Annex shall be calibrated metrologically traceable to the SI when a system of traceability exists, except as noted otherwise.

A1.2.4 Indirect verification of the testing machine shall be performed at the place of manufacture, rebuild or repair, or at the location where it will be used.

NOTE A1.1—It is recommended that the calibration agency that is used to conduct the verifications of Differential Indentation Depth hardness testing machines be accredited to the requirements of ISO 17025 (or an equivalent) by an accrediting body recognized by the International Laboratory Accreditation Cooperation (ILAC) as operating to the requirements of ISO/IEC 17011.

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A1.3 Indirect Verification

ASTM E3246-22

A1.3.1 An indirect verification of the testing machine shall be performed, at a minimum, in accordance with the schedule given in Table A1.1. The frequency of indirect verifications should be based on the usage of the testing machine.

A1.3.2 The testing machine shall be verified for each hardness scale where a direct calculation of hardness number from the measured indentation depth is performed.

NOTE A1.2—The manufacturer of the device provides the information of what scales are calculated directly from the indentation depth. Consult with the manufacturer of the device if this information is not found in the operating instructions or other documentation.

A1.3.3 Reference standards meeting the requirements of Test Methods E10, E18, or E92, or combinations thereof where appropriate as in accordance with A1.3.2 shall be used in the appropriate hardness ranges for each scale to be verified. These ranges are given in Table A1.2 and Table A1.3. Hardness measurements shall be made only on the calibrated surface of the reference standard.

A1.3.4 The testing cycle to be used for the indirect verification shall be the same as is typically used by the user.

A1.3.5 Prior to performing the indirect verification, ensure that the testing machine is working freely, and that the indenter and support are seated adequately. Make at least two hardness measurements on a suitable test piece to seat the indenter and support. The results of these measurements need not be recorded.