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.

Designation: 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*

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

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 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
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

[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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[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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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 *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]

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.

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*, $\bar{H}$, of a set of n hardness measurements $H_1, H_2, \ldots, H_n$ 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:

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

where:

$\bar{H}$ = average of n hardness measurements $H_1, H_2, \ldots, H_n$ made on a reference standard as part of a performance verification, and
H_{STD} = certified average hardness number of the reference standard.

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:

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

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:

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

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.

[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.