



Standard Test Methods for Rockwell Hardness of Metallic Materials^{1,2}

This standard is issued under the fixed designation E18; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods cover the determination of the Rockwell hardness and the Rockwell superficial hardness of metallic materials by the Rockwell indentation hardness principle. This standard provides the requirements for Rockwell hardness machines and the procedures for performing Rockwell hardness tests.

1.2 This test method includes requirements for the use of portable Rockwell hardness testing machines that measure Rockwell hardness by the Rockwell hardness test principle and can meet all the requirements of this test method, including the direct and indirect verifications of the testing machine. Portable Rockwell hardness testing machines that cannot meet the direct verification requirements and can only be verified by indirect verification requirements are covered in Test Method E110.

1.3 This standard includes additional requirements in the following annexes:

Verification of Rockwell Hardness Testing Machines	Annex A1
Rockwell Hardness Standardizing Machines	Annex A2
Standardization of Rockwell Indenters	Annex A3
Standardization of Rockwell Hardness Test Blocks	Annex A4
Guidelines for Determining the Minimum Thickness of a Test Piece	Annex A5
Hardness Value Corrections When Testing on Convex Cylindrical Surfaces	Annex A6

1.4 This standard includes nonmandatory information in the following appendixes that relates to the Rockwell hardness test.

List of ASTM Standards Giving Hardness Values Corresponding to Tensile Strength	Appendix X1
Examples of Procedures for Determining Rockwell Hardness Uncertainty	Appendix X2

1.5 *Units*—At the time the Rockwell hardness test was developed, the force levels were specified in units of

kilograms-force (kgf) and the indenter ball diameters were specified in units of inches (in.). 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 millimeters (mm). However, because of the historical precedent and continued common usage, force values in kgf units and ball diameters in inch units are provided for information and much of the discussion in this standard refers to these units.

1.6 The test principles, testing procedures, and verification procedures are essentially identical for both the Rockwell and Rockwell superficial hardness tests. The significant differences between the two tests are that the test forces are smaller for the Rockwell superficial test than for the Rockwell test. The same type and size indenters may be used for either test, depending on the scale being employed. Accordingly, throughout this standard, the term Rockwell will imply both Rockwell and Rockwell superficial unless stated otherwise.

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:³

- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A623 Specification for Tin Mill Products, General Requirements
- A623M Specification for Tin Mill Products, General Requirements [Metric]

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

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² In this test method, the term Rockwell refers to an internationally recognized type of indentation hardness test as defined in Section 3, and not to the hardness testing equipment of a particular manufacturer.

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.

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

- A883 Test Method for Ferrimagnetic Resonance Linewidth and Gyromagnetic Ratio of Nonmetallic Magnetic Materials
- A956/A956M Test Method for Leeb Hardness Testing of Steel Products
- A1038 Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method
- 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
- B647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E74 Practices for Calibration and Verification for Force-Measuring Instruments
- 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
- 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 Balls⁴

2.3 *ISO Standards:*

ISO 6508-1 Metallic Materials—Rockwell Hardness Test—Part 1: Test Method (scales A, B, C, D, E, F, G, H, K, N, T)⁵

ISO/IEC 17011 Conformity Assessment—General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies⁵

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories⁵

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

SAE J417 Hardness Tests and Hardness Number Conversions⁶

3. Terminology and Equations

3.1 Definitions:

3.1.1 *calibration*—determination of the values of the significant parameters by comparison with values indicated by a reference instrument or by a set of reference standards.

3.1.2 *standardization*—to bring in conformance to a known standard through verification or calibration.

3.1.3 *verification*—checking or testing to assure conformance with the specification.

3.1.4 *Rockwell hardness test*—an indentation hardness test using a verified machine to force a diamond spheroconical indenter or tungsten carbide (or steel) 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.

3.1.5 *Rockwell superficial hardness test*—same as the Rockwell hardness test except that smaller preliminary and total test forces are used with a shorter depth scale.

3.1.6 *Rockwell hardness number*—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.

3.1.7 *Rockwell hardness machine*—a machine capable of performing a Rockwell hardness test and/or a Rockwell superficial hardness test and displaying the resulting Rockwell hardness number.

3.1.7.1 *Rockwell hardness testing machine*—a Rockwell hardness machine used for general testing purposes.

3.1.7.2 *Rockwell hardness standardizing machine*—a Rockwell hardness machine used for the standardization of Rockwell hardness indenters, and for the standardization of Rockwell hardness test blocks. The standardizing machine differs from a regular Rockwell hardness testing machine by having tighter tolerances on certain parameters.

3.1.7.3 *portable Rockwell hardness testing machine*—a Rockwell hardness testing machine that is designed to be transported, carried, set up, and operated by the users, and that measures Rockwell hardness by the Rockwell indentation hardness test principle.

3.1.7.4 *movable Rockwell hardness testing machine*—a Rockwell hardness testing machine that is designed to be

⁴ Available from American Bearing Manufacturers Association (ABMA), 2025 M Street, NW, Suite 800, Washington, DC 20036.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁶ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

moved to different locations on a moveable frame, table or similar support that is integral to the testing machine (for example, securely fixed to a rolling table), or a Rockwell hardness testing machine that is designed to move into testing position prior to a test, (for example, securely fixed to a moving support arm), and has been previously verified to ensure that such a move will not affect the hardness result.

3.2 Equations:

3.2.1 The average \bar{H} of a set of n hardness measurements H_1, H_2, \dots, H_n is calculated as:

$$\bar{H} = \frac{H_1 + H_2 + \dots + H_n}{n} \quad (1)$$

3.2.2 The error E in the performance of a Rockwell hardness machine at each hardness level, relative to a standardized scale, is determined as:

$$E = \bar{H} - H_{STD} \quad (2)$$

where:

\bar{H} = average of n hardness measurements H_1, H_2, \dots, H_n made on a standardized test block as part of a performance verification, and

H_{STD} = certified average hardness value of the standardized test block.

3.2.3 The repeatability R in the performance of a Rockwell hardness machine at each hardness level, under the particular verification conditions, is estimated by the range of n hardness measurements made on a standardized test block as part of a performance verification, defined as:

$$R = H_{max} - H_{min} \quad (3)$$

where:

H_{max} = highest hardness value, and

H_{min} = lowest hardness value.

4. Significance and Use

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

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

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

4.4 Adherence to this standard test method provides traceability to national Rockwell hardness standards except as stated otherwise.

5. Principles of Test and Apparatus

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

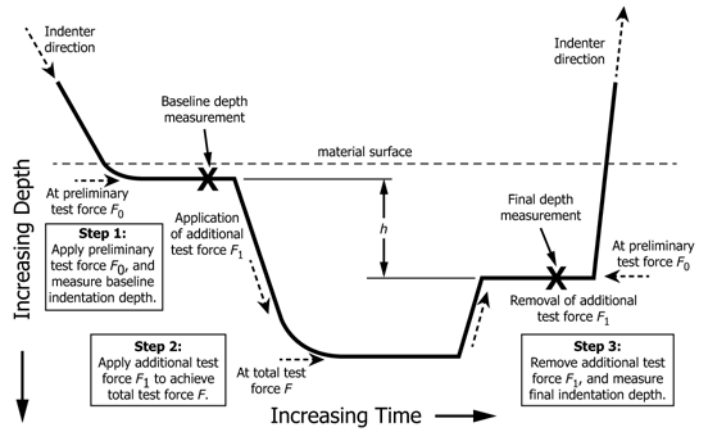


FIG. 1 Rockwell Hardness Test Method (Schematic Diagram)

Step 1—The indenter is brought into contact with the test specimen, and the preliminary test force F_0 is applied. After holding the preliminary test force for a specified dwell time, the baseline depth of indentation is measured.

Step 2—The force on the indenter is increased at a controlled rate 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.

Step 3—The additional test force is removed, returning to the preliminary test force. After holding the preliminary test force for a specified dwell time, the final depth of indentation is measured. The Rockwell hardness value 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 two general classifications of the Rockwell test: the Rockwell hardness test and the Rockwell superficial hardness test. The significant difference between the two test classifications is in the test forces that are used. For the Rockwell hardness test, the preliminary test force is 10 kgf (98 N) and the total test forces are 60 kgf (589 N), 100 kgf (981 N), and 150 kgf (1471 N). For the Rockwell superficial hardness test, the preliminary test force is 3 kgf (29 N) and the total test forces are 15 kgf (147 N), 30 kgf (294 N), and 45 kgf (441 N).

5.1.2 Indenters for the Rockwell hardness test include a diamond spheroconical indenter and tungsten carbide ball indenters of specified diameters.

5.1.2.1 Steel indenter balls may be used only for testing thin sheet tin mill products specified in Specifications A623 and A623M using the HR15T and HR30T scales with a diamond spot anvil. Testing of this product may give significantly differing results using a tungsten carbide ball as compared to historical test data using a steel ball.

NOTE 1—Previous editions of this standard have stated that the steel ball was the standard type of Rockwell indenter ball. The tungsten carbide ball is considered the standard type of Rockwell indenter ball. The use of tungsten carbide balls provide an improvement to the Rockwell hardness test because of the tendency of steel balls to flatten with use, which results in an erroneously elevated hardness value. The user is cautioned that Rockwell hardness tests comparing the use of steel and tungsten carbide balls have been shown to give different results. For example, depending on the material tested and its hardness level, Rockwell B scale tests using a tungsten carbide ball indenter have given results approximately one