Designation: E110 – 14

Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers[1]

This standard is issued under the fixed designation E110; 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.

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

1. Scope*

1.1 This test method defines the requirements for portable instruments that are intended to be used to measure the Rockwell or Brinell hardness of metallic materials by performing indentation tests on the surface of materials in the field or outside of a test lab, or in cases where the size or weight of the test piece prevents it from being tested on a standard E10 or E18 hardness tester.

1.2 The principles used to measure the Rockwell or Brinell hardness are the same as those defined in the E18 standard test method for Rockwell or E10 standard test method for Brinell.

NOTE 1—Standard test methods E10 and E18 will be referred to in this test method as the standard methods.

1.3 The portable hardness testers covered by this test method are verified only by the indirect verification method. Although the portable hardness testers are designed to employ the same test conditions as those defined in the standard test methods, the forces applied by the portable Rockwell and Brinell testers and the depth measuring systems of the portable Rockwell testers may not meet the tolerance requirements of the standard methods. Portable hardness testers shall use indenters that meet the requirements of the standard test methods.

1.4 This test method does not apply to portable hardness testers that measure hardness by a means or procedure that is different than those defined in E10 or E18 For example, this test method does not apply to the methods defined in ASTM standard Practice A833, Test Methods A956 and A1038 or B647.

1.5 A report section is included to define how to indicate that the test result was obtained by using a portable device that conforms to this document.

1.6 Annex A1 is included that defines the periodic indirect verification and daily verification requirements for these instruments.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A833 Practice for Indentation Hardness of Metallic Materials by Comparison Hardness Testers

A956 Test Method for Leeb Hardness Testing of Steel Products

A1038 Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method

B647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

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

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

2.2 *ISO Standards:*[3]

ISO/IEC 17025 : General requirements for the competence of testing calibration laboratories

ISO/IEC 17011 : Conformity assessment -- General requirements for accreditation bodies accrediting conformity assessment bodies

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

Current edition approved July 1, 2014. Published July 2014. Originally approved in 1955. Last previous edition approved in 2010 as E110– 10. DOI: 10.1520/E0110-14.

[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 International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

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

3. Significance and Use

3.1 Portable hardness testers are used for testing materials that because of their size, location or other requirements such as test point are unable to be tested using traditional fixed instruments.

3.2 Portable hardness testers, by their nature, induce variation that could influence the test results; therefore, hardness measurements made in accordance with this test method are not considered to meet the requirements of E10 or E18. The user should compare the results of the precision and bias studies in E110, E10 and E18 to understand the differences in results expected between portable and fixed instruments.

3.3 Two test parameters that can significantly influence the measurement accuracy when using portable hardness testers are the alignment of the indenter to the test surface and the timing of the test forces. The user is cautioned to do everything possible to keep the centerline of the indenter perpendicular to the test surface and to apply the test forces using the same time cycle as defined in Test Method E10 or Test Methods E18.

3.4 Portable hardness testers are delicate instruments that are subject to damage when they are moved from one test site to another. Therefore, repeating the daily verification process during the testing sequence is recommended to insure that they are working properly.

3.5 Hardness testing at a specific location on a part may not represent the physical characteristics of the whole part or end product.

4. Principles of Test and Apparatus

4.1 The portable hardness tester shall be capable of applying the same test forces, use the same indenter types, and use the same methods for determining and calculating the hardness value as defined in Test Method E10 or Test Methods E18.

4.2 Portable hardness testers are generally provided with various means of holding the indenter in contact with the surface to be tested. For example, the testers may be clamped to the object to be tested, attached to an adjacent fixed object or attached to the surface to be tested by a magnet. For testing inside a cavity the tester may be placed against one wall of the cavity to make a test on the opposite wall.

4.3 Portable hardness testers of the types covered in this method do not employ dead weights to apply the indenting forces. This imposes certain limitations and necessitates certain precautions. All requirements of the standard methods except those modified by the following sections shall apply to the use of portable hardness testers.

4.3.1 Portable testers are not verified by direct verification.

4.3.2 A portable hardness tester does not have to undergo indirect verification each time it is moved.

4.3.3 Some portable Brinell hardness testers do not maintain the force. It is very important to follow manufacturer's instructions on how to operate the portable Brinell hardness tester.

4.4 *Rockwell Hardness Test Principle* (see Test Method E18)—the general principle of the Rockwell indentation hardness test is divided into three steps of force application and removal.

4.4.1 *Step 1*—The indenter is brought into contact with the test piece in a direction perpendicular to the surface, and the preliminary test force is applied. After preliminary test force, the baseline depth of indentation is measured.

4.4.2 *Step 2*—The force on the indenter is increased to additional test force to achieve the total test force.

4.4.3 *Step 3*—The additional test force is removed, returning to the preliminary test force. The final depth of indentation is measured. The preliminary test force is removed and the indenter is removed from the test piece. The Rockwell hardness value is derived in accordance with E18 from the difference in the final and baseline indentation depths while under the preliminary test force.

4.5 *Brinell Hardness Test Principle–(see Test Method E10)*—the general principle of the Brinell indentation hardness test consists of two steps.

4.5.1 *Step 1*—The indenter is brought into contact with the test piece in a direction perpendicular to the surface, and the test force is applied. The test force is then removed.

4.5.2 *Step 2*—The diameter of the indentation is measured. The Brinell hardness value is derived from the mean of the diameter measurements.

5. Test Piece

5.1 Accurate hardness test results are dependent on proper preparation of the test piece. All requirements for test pieces upon which the indentation will be made shall conform to the applicable standard methods.

6. Test Procedures

6.1 A daily verification (see A1.1.3 and Table A1.1) of the testing machine shall be performed in accordance with the applicable standard methods. It is recommended that daily verification should be performed just prior to making the hardness tests at the test worksite where the hardness tests are to be made. The daily verification should be performed with the testing machine oriented in the position that it will be used. Repeating the daily verification between multiple tests in a sequence and after a test sequence is completed is recommended. The purpose of performing the daily verification at the test site is to ensure that environmental conditions (temperature), position or damage during travel and usage have not affected the ability of the test equipment to perform properly.

6.2 Relative motion between the tester and the test piece will affect the results of the test; therefore the tester shall be held and supported such that relative motion is minimized. This is particularly true for the portable Rockwell hardness tester. Mount the tester in such a position that the axis of the indenter is normal to the surface to be tested.

6.3 Adhere to manufacturer's instructions manual for the proper operating procedures and testing precautions.

6.4 The test procedure defined by the applicable standard method shall be used.

7. Conversion to Other Hardness Scales or Tensile Strength Values

7.1 There is no general method of accurately converting the hardness numbers on one scale to hardness numbers on another scale or to tensile strength values. Conversions between hardness scales are approximations and therefore, should be avoided except for special cases where a reliable basis for the approximate conversion has been obtained by comparison tests. The measured values (Rockwell or Brinell) must be reported as required in Section 8 along with any converted values, clearly marked as converted values.

NOTE 2—The Standard Hardness Conversion Tables for Metals, E140, give approximate conversion values for specific materials and reporting requirements for converted values.

8. Report

8.1 The report shall meet the requirements of the standard method with the following additions.

8.2 Reports shall reference this standard.

8.3 The measured hardness number shall be reported in accordance with the standard methods and appended with a /P to indicate that it was determined by a portable hardness tester.

Rockwell hardness examples:

40 HRC/P = Rockwell hardness number of 40 on Rockwell C scale.

72 HRBW/P = Rockwell hardness number of 72 on the Rockwell B scale using a tungsten carbide ball indenter.

Brinell hardness examples:

220 HBW/P 10/3000 = Brinell hardness of 220 determined with a ball of 10 mm diameter and with a test force of 3000 kgf (29.42 kN) applied for 10 s to 15 s.

350 HBW/P 5/750 = Brinell hardness of 350 determined with a ball of 5 mm diameter and with a test force of 750 kgf (7.355 kN) applied for 10 s to 15 s.

600 HBW/P 2.5/62.5/20 = Brinell hardness of 600 determined with a ball of 2.5 mm diameter and with a test force of 62.5 kgf (612.9 N) applied for 20 s.

9. Precision and Bias

9.1 A precision and bias study was conducted in 2008 in accordance with ASTM Practice E691 to determine the precision of Rockwell and Brinell test results obtained with portable instruments. Because of the difference in the equipment used, the Rockwell and Brinell testing were treated as two separate studies. The full results are filed under ASTM Research Report RR: RR:E28-1043[4]

9.2 Seven laboratories were used for each study. Three of the laboratories were manufactures of instruments and four were users of the equipment. The testing for five of the laboratories was done at the November 2008 ASTM meeting in Tampa Florida. The remainders were done at the user's facility. In some cases the testing was done by calibration agency personal.

TABLE 1 Results of the Rockwell Hardness Precision and Bias Study

Materials	Average Hardness	Sr	SR	r_{PB}	R_{PB}
HRC 63.53	63.59	0.29	0.80	0.82	2.25
HRC 45.91	45.38	0.20	0.51	0.56	1.44
HRC 24.92	25.00	0.33	0.63	0.92	1.76
HRBW 93.27	93.80	0.34	1.18	0.96	3.29
HRBW 60.60	61.48	0.45	1.33	1.27	3.73
HRBW 41.78	42.65	0.74	1.42	2.07	3.97

9.3 Separate studies were done for Rockwell and Brinell testing machines.

9.3.1 For the Rockwell scale testing, four different types of instruments of various ages were used that were produced by three manufacturers.

9.3.2 The Brinell tests were all performed on one manufacturer's instrument since it is by far the most common used by industry. The seven instruments used to do the test ranged from a new unit to one that was 30 years old. There were five different measuring systems used to determine the size of the Brinell indent. Two were computer controlled systems and the others were manual scopes with 20X magnification from three different manufacturers.

9.4 Since the E110-82(2002) standard, which was current at the time of the study, did not clearly specify indirect verification results required of the instruments to meet the standard, no attempt was made to qualify them by verifying their overall performance on test blocks before using them in the study. All of the instruments used for the testing were considered to be in good working order and typical of those used for every day testing.

9.5 Standardized test blocks used were calibrated according to ASTM Test Methods E18 or Test Method E10 The Rockwell HRC and HRBW and the Brinell HBW 10/3000 scales were used. In each scale three test blocks were used, one each in the high, medium, and low hardness ranges. Three tests were performed on each test block in specific locations.

NOTE 3—Practice E691 requires a minimum of four (4) test blocks to be used for each study. Since the Brinell study only used three blocks, the Brinell part of this study will have to be redone. Until then the Brinell part is considered to be provisional.

9.6 A summary of the test data is shown in Table 1 and Table 2.

9.6.1 The value of r_{PB} indicates the typical amount of variation that can be expected between test results obtained for the same material by the same operator using the same hardness tester on the same day. When comparing two test results made under these conditions, a measurement difference of less than the r_{PB} value for that material is an indication that the results may be equivalent.

9.6.2 The value of R_{PB} indicates the typical amount of variation that can be expected between test results obtained for the same material by different operators using the different hardness tester on different days. When comparing two test

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: RR:E28-1043.

TABLE 2 Results of the Brinell Hardness Precision and Bias Study

Materials	Average Hardness	Sr	SR	r_{PB}	R_{PB}
HBW 201	206.10	1.11	5.05	3.12	14.14
HBW 315	316.81	1.69	5.17	4.73	14.48
HBW 543	556.00	4.08	14.06	11.43	39.37

results made under these conditions, a measurement difference of less than the R_{PB} value for that material is an indication that the results may be equivalent.

9.6.3 Any judgments based on the results would have an approximate 95% probability of being correct.

9.6.4 Although the precision values given in Table 1 and Table 2 provide guidance on interpreting differences in measurement results, a complete evaluation of measurement uncertainty will provide a more definitive interpretation of the results for the specific testing conditions.

9.7 The data generally indicated the precision expected when using a portable hardness tester.

9.8 There are no recognized standards by which to estimate the bias of this test method.

10. Keywords

10.1 Brinell; hardness; portable; Rockwell

ANNEX

A1. VERIFICATION OF PORTABLE ROCKWELL AND BRINELL HARDNESS TESTING MACHINES

A1.1 Verification of Apparatus

A1.1.1 Annex A1 specifies two types of procedures for verifying portable hardness test machines: indirect verification and daily verification. The portable hardness tester shall be verified at specific instances and at periodic intervals in accordance with Table A1.1. Portable testers are not verified by direct verification.

A1.1.2 The procedures to be used for the indirect verification shall be the applicable procedures specified by the standard methods. The repeatability *R* and the error *E*, as defined in the standard methods, shall be within the tolerances given in E18 for Rockwell hardness testers or E10 for Brinell hardness testers.

A1.1.3 The procedures to be used for the daily verification shall be the applicable procedures specified by the standard methods. The repeatability *R* and the error *E*, as defined in the standard methods, shall be within the tolerances given in E18 for Rockwell hardness testers or E10 for Brinell hardness testers.

A1.1.4 The test blocks used for the indirect and daily verifications shall meet the requirements of the standard methods.

A1.1.5 The indenters used for the indirect and daily verifications shall meet the requirements of the standard methods.

A1.1.6 If the results of the daily verification or indirect verification do not fall within the tolerances given in E18 for Rockwell hardness testers or E10 for Brinell hardness testers, the verification procedures may be repeated. If it fails a second time, the hardness tester shall not be used until it undergoes adjustment or repair, and passes an indirect verification.

NOTE A1.1—It is recommended that the calibration agency that is used to conduct the indirect verifications of portable hardness testers be accredited to the requirements of ISO/IEC 17025 (or an equivalent) by a recognized accrediting body that operates to the requirements of ISO/IEC 17011.

A1.2 Verification Report

A1.2.1 A verification report is required for an indirect verification. A verification report is not required for a daily verification. The verification report shall be in accordance with the requirements of the standard methods.

TABLE A1.1 Verification Schedule for a Portable Hardness Tester

Verification Procedure		Schedule
Indirect verification		As specified by the standard methods, and when circumstances occur that may affect the performance of the tester. An exception to the requirements of the standard methods is that a portable hardness tester does not have to undergo indirect verification each time it is moved.
Daily verification	Required:	each day that hardness tests are to be made.
	Recommended:	just prior to making the hardness tests at the test worksite where the hardness tests are to be made. between multiple tests in a sequence and after a test sequence is completed. whenever the indenter is changed. whenever the scale is changed. whenever the instrument is subject to shock or rough handling that may affect its performance.

SUMMARY OF CHANGES

Committee E28 has identified the location of selected changes to this standard since the last issue (E110–10) that may impact the use of this standard. (Approved July 1, 2014.)

(1) The text and structure of the whole test method has been revised.