



Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers¹

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 Department of Defense.

1. Scope

1.1 This test method covers determination of the indentation hardness of metallic materials by means of portable hardness testers.

1.2 This test method applies only to those portable hardness testers which apply the same nominal forces and use the same indenters as are used in the methods listed in Section 2.

1.3 *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

E10 Test Method for Brinell Hardness of Metallic Materials²

E18 Test Methods for Rockwell Hardness of Metallic Materials²

E92 Test Method for Vickers Hardness of Metallic Materials²

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, Rockwell Superficial Hardness, Knoop Hardness, and Scleroscope Hardness)

NOTE 1—Test Methods **E10**, **E18**, and **E92** will be referred to in this test method as the “standard methods.”

NOTE 2—The standard methods of making the three hardness tests do not preclude the use of portable hardness testers. However, the machines

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 Jan. 1, 2010. Published February 2010. Originally approved in 1955. Last previous edition approved in 1997 as E110–82 (2002). DOI: 10.1520/E0110-10.

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.

usually used, and considered preferable for these tests, are generally designed so that the magnitude of the indenting force is fixed by dead weights acting on a small piston connected to a hydraulic loading cylinder, or by dead weights acting through a multiple lever system. Portable hardness testers of the types covered in this method do not employ dead weights to fix the indenting forces. This imposes certain limitations and necessitates certain precautions, which are set forth in this test method. All requirements of the standard methods except those modified by the following sections shall apply to the use of portable hardness testers.

3. Apparatus

3.1 Portable 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 which require that the indenting force be applied in a direction other than vertical. In order that they may be portable and also in order that the indenting forces may be applied in any direction, these testers are designed in such a way that dead weights are not used in applying or limiting the indenting force.

3.2 The indenting force may be applied by means of a hydraulic cylinder with a pressure gage to indicate the magnitude of the force. The hydraulic cylinder may also be equipped with a spring-forced relief valve to fix the magnitude of the force. Alternatively the indenting force may be applied by means of a screw through a calibrated spring with a dial gage or other means of measuring the deflection of the spring to indicate the magnitude of the force.

3.3 Portable hardness testers are generally provided with various means of holding the indenter in contact with the surface to be tested. 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. Procedure

4.1 Whatever means is used to hold the tester to the piece being tested, make sure that there is no relative motion between the tester and the piece when the force is applied. This is particularly true for the portable Rockwell type tester. Mount

the tester in such a position that the axis of the indenter is normal to the surface to be tested.

4.2 Application of Force, Portable Brinell Test—Portable Brinell testers generally apply the force by means of a hydraulic cylinder equipped with both a pressure gage and a spring forced relief valve. With this arrangement it is not possible to maintain the force at the point where the relief valve opens for any appreciable time. Therefore bring up the force several times to the point where the pressure is released. It has been determined that for steel, when testing with a 3000-kgf force, three force applications are equivalent to holding the force 15 s as required in the standard method. For other materials and other forces, make comparison tests to determine the number of force applications required to give results equivalent to the standard method. Bring the force up gradually each time without jerking.

4.3 Application of Force, Portable Rockwell Type Test—Portable Rockwell type testers generally apply the force through a calibrated spring by means of a screw and are generally equipped with two indicators, one a dial gage that measures deflection of the spring to indicate the force, and the other a dial gage or micrometer screw to indicate the depth of penetration. Apply the preliminary test force as shown by the force indicator. Set the index on the depth indicator to the proper point. Then apply the total test force. Turn the loading screw in the opposite direction until the preliminary test force is again indicated on the force dial. Then read the hardness on the depth indicator as the difference between the readings at the minor force before and after application of the major force. Bring the force up gradually without jerking. Exercise care not to exceed either the preliminary or the total test forces. Complete the removal of the total test force within 2 s after it has been completely applied.

4.4 Application of Force, Vickers Type Tester—Portable Vickers type testers generally apply the force by means of a hydraulic cylinder equipped with a pressure gage. Bring the indenter just in contact with the test surface and check the zero reading of the pressure gage. Then bring the force up to the required value as shown on the pressure gage. Bring the force up gradually without jerking and take care that the required force is not overrun. Maintain the full force for at least 15 s, unless otherwise specified, and then release.

5. Calibration of Apparatus

5.1 Portable hardness testers shall be used only with applied forces at which the force measuring device has been calibrated.

5.2 Portable hardness testers shall also be checked for error periodically by the comparison method or by test blocks as described in the standard methods.

6. Precision and Bias

6.1 A precision and bias study was conducted in late 2007/early 2008 in accordance with Practice E691 to determine the precision of Rockwell and Brinell test results obtained with portable hardness testers. Because of the difference in the equipment used, the Rockwell and Brinell testing were treated

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

as two separate studies. The full results are filed under ASTM Research Report RR:E28-1043.³

6.2 Seven laboratories were used for each study. Three of the laboratories were manufacturers of portable hardness testers 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 users' facilities. In some cases the testing was done by calibration agency personal.

6.3 Separate studies were done for Rockwell and Brinell portable hardness testers.

6.3.1 For the Rockwell scale testing, four different types of portable hardness testers were used that were produced by three manufacturers. Some testers were new and some were older and well used.

6.3.2 The Brinell tests were all performed on testers from one manufacturer since it is by far the most commonly used by industry. The seven portable hardness testers used for the Brinell testing ranged from new to 30 years old. Five different measuring systems were used to determine the size of the Brinell indent. Two were computer-controlled systems and the others were manual hand-held scopes with 20X magnification from three different manufacturers.

6.4 The E110-82(2002) version of the standard was current at the time of the study. Since the standard did not clearly specify that an indirect verification of the testers was required, no attempt was made to qualify them by verifying their overall performance on test blocks before using them in the study. All of the portable hardness testers used for the testing were considered to be in good working order and typical of those used for everyday testing.

6.5 The hardness tests were made on standardized test blocks calibrated according to E18-07 or E10-07. The Rockwell HRC and HRBW and the Brinell HBW 10/3000 scales were used. For 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.

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

6.6.1 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

³ 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

of less than the r_{PB} value for that material is an indication that the results may be equivalent.

6.6.2 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 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.

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

6.6.4 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.

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

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

7. Keywords

7.1 metallic; portable hardness tester

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT/).