Designation: E 103 – 84 (Reapproved 2002)

Standard Test Method for Rapid Indentation Hardness Testing of Metallic Materials[1]

This standard is issued under the fixed designation E 103; 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 procedure for rapid indentation hardness testing of metallic materials as an alternative to Test Method E 10 on standard Brinell hardness. It includes methods for the verification of rapid indentation hardness testing machines, Part B, and the calibration of reference hardness test blocks, Part C.

1.2 The values stated in SI units are to be regarded as standard.

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:*

E 4 Practices for Force Verification of Testing Machines[2]

E 10 Test Method for Brinell Hardness of Metallic Materials[2]

3. Terminology

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 *rapid indentation hardness test*—an indentation hardness test using calibrated machines to force a hard steel or carbide ball, under specified conditions, into the surface of the material under test and to measure the depth of the indentation. The depth measured can be from the surface of the test specimen or from a reference position established by the application of a preliminary test force.

3.1.3 *verification*—checking or testing to assure conformance with the requirements of the method.

4. Significance and Use

4.1 This test method is used when it is desired to make hardness tests very rapidly, as in the inspection of the output of a heat-treating furnace.

4.2 This test method is not to be regarded as a standard Brinell hardness test method.

4.3 Since the test forces and method of display of the depth measurement differ between manufacturers of rapid indentation hardness testing equipment, the test results from equipment from different manufacturers are not comparable.

A. GENERAL DESCRIPTION AND TEST PROCEDURE

5. Apparatus

5.1 *Testing Machine*—Equipment for rapid indentation hardness testing is used essentially to measure hardness by determining the depth of indentation of a penetrator into the specimen. The test force can be applied either as a single total test force whereby the depth is measured usually from the surface of the test specimen or as a preliminary and total test force whereby the depth is measured as the increase from the preliminary to the total test force. The magnitude of the indenting test force or test forces is determined by agreement. The design and construction of the testing machine shall be such that no rotational or lateral movement of the indenter or test specimen occurs while the test force is being applied or removed.

5.2 *Penetrator*:

5.2.1 The standard ball penetrator shall be 10 mm in diameter. Other values of ball penetrator may be used as provided in 7.1.

5.2.2 The balls used shall be free of surface imperfections and conform to the requirements prescribed in 13.1.2.

5.3 *Mechanism for Measuring the Depth of the Indentation*—The depth of the indentation is determined by a measuring device that shall conform to the requirements prescribed in 13.1.3.

5.4 When diameters of indentations are measured to ascertain the accuracy of hardness values of test specimens or of reference hardness test blocks, the measuring microscope shall

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[2] *Annual Book of ASTM Standards*, Vol 03.01.

comply with 3.3 of Test Method E 10 and comparable values as determined from Table 1of Test Method E 10.

6. Test Specimens

6.1 *Finish*—When necessary, the surface on which the indentation is to be made shall be filed, ground, machined, or polished with an abrasive material. The surface in contact with the test support shall be clean, dry, and free of any conditions which may affect the test results.

6.2 *Thickness*—The thickness of the specimen shall be at least ten times the depth of the indentation and such that no bulge or other mark showing the effect of the test force appears on the side of the piece opposite the indentation.

7. Procedure

7.1 *Magnitude of Test Force*—The total test force is usually 3000, 1500, or 500 kgf (29.42, 14.71, or 4.903 kN). The preliminary test force, if used, is usually determined by test requirements. It is desirable that the total test force be of such magnitude that the diameter of the indentation ranges from 25.0 to 60.0 % of the ball diameter (for example, 2.50 to 6.00 mm in the case of the 10-mm diameter penetrator). Table 1 gives the preferred total test force and Brinell hardness number with the 10-mm diameter penetrator. For certain sizes and conditions of test specimens, it may be desirable to use different test forces and penetrators with diameters smaller or larger than 10 mm; in these cases it is recommended that the following relationships be maintained between the diameter of the ball, *D*, measured in kilograms, and the applied test force, *P*, measured in kilograms-force:

Range (Brinell Hardness Number)	P/D^2
96 to 600	30
48 to 300	15
16 to 100	5

7.2 *Spacing of Indentations*—The distance from the center of the indentation to the edge of the specimen, or edge of another indentation, shall be at least two and one-half times the diameter of the indentation.

7.3 *Application of the Test Force(s)*—Apply the test force(s) to the test specimen without shock or vibration.

7.4 *Alignment*—The angle between the load line and the normal to the specimen shall not exceed 2°.

8. Determination of Hardness Limits

8.1 In order to establish the limit(s) of acceptable hardness for a given part or piece, test specimens representing the extreme(s) of acceptability shall be tested in the rapid indentation hardness tester that is to be used. The results obtained shall be considered the limits of acceptability.

9. Report

9.1 Report the following information:

TABLE 1 Preferred Total Test Forces for 10-mm Ball

Total Test Force, kgf (kN)	Recommended Range, Brinell Hardness Number
3000 (29.42)	96 to 600
1500 (14.71)	48 to 300
500 (4.903)	16 to 100

9.1.1 The test force (or test forces when preliminary and total test forces are applied) in kilogram-force,

9.1.2 The diameter of the ball penetrator and whether steel or carbide balls are being used, and

9.1.3 The depth of penetration in millimetres, or either a converted Brinell hardness number or other hardness number established by the manufacturer. In the last two cases, the hardness relationship shall be reported or referenced.

10. Precision and Bias

10.1 *Precision*—Since the test results are not comparable between equipment from different manufacturers, an interlaboratory comparison test program is not appropriate. Therefore, a precision statement cannot be determined for this test method.

10.2 *Bias*—There is no basis for defining the bias for this test method.

B. VERIFICATION OF RAPID INDENTATION HARDNESS TESTING MACHINES

11. Scope

11.1 Part B covers two procedures for the verification of rapid indentation hardness testing machines. These are as follows:

11.1.1 Separate verification of test force application, penetrator, and depth-measuring device.

11.1.2 Verification by reference test block method.

11.2 New or rebuilt machines shall be checked by the separate verification method.

11.3 Machines in use in production testing may be checked by either method.

12. General Requirements

12.1 Before a rapid indentation hardness testing machine is verified, examine the machine to ensure the following:

12.1.1 Set up the machine properly.

12.1.2 Mount the ball holder, with a new ball, in the plunger.

12.1.3 Apply and remove the test force without shock or vibration and in such a manner that the readings are not affected.

13. Verification

13.1 *Separate Verification of Test Force Application, Penetrator, and Depth-Measuring Device*:

13.1.1 *Test Force Application*—Rapid indentation hardness testing machines shall be verified at the applied preliminary test force, when applicable, and at the applied total test force. Check the applied test force(s) periodically with a proving ring, or by an elastic calibration device in the manner described in Practices E 4. The difference between the nominal test force and the measured test force, or forces, shall not exceed ±2 % of the nominal test force or forces.

13.1.2 *Penetrator*:

13.1.2.1 The diameter of the standard ball shall be 10 mm with a deviation from this value of not more than 0.005 mm in any diameter. Other sizes of ball may be used as provided in 7.1.

13.1.2.2 A steel ball with a hardness not less than 850 HV 10 may be used to test materials with a hardness not greater

than 450 HB, whereas a carbide ball may be used on materials with a hardness not greater than 630 HB. Polish the ball free of defects.

13.1.2.3 The maximum value of the mean of the two diagonals of an indentation made by the Vickers indenter on a steel ball shall not exceed the appropriate value listed in Table 2.

13.1.2.4 The ball shall not show a permanent change in diameter greater than 0.005 mm when pressed with the test force against a test specimen.

13.1.3 *Depth-Measurement Device*—The depth-measurement device shall be verified over the working range by the use of an accurate reference scale, or other means, and shall correctly indicate the depth of penetration to any accuracy of ±0.005 mm.

13.2 *Verification by Reference Test Block Method*:

13.2.1 A rapid indentation hardness testing machine may be checked by making a series of indentations on reference Brinell hardness test blocks which are commercially available or by utilizing parts or samples of known hardness.

13.2.2 The machine shall be verified under the same conditions as in testing, that is, using the same test force(s) and the same penetrator and time of application of the test force(s).

13.2.3 Verification by the reference test block method shall be established by measurement of the indentation diameter. The rapid indentation hardness testing machine shall be considered verified if the mean diameter of the indentation differs by no more than the equivalent of 2 % of the mean diameter of the calibration indentation of the reference hardness test block.

13.2.4 It is recommended that the depth-measurement readout on a reference test block be compared with the depth-measurement values for the reference test block. These will either be included on the calibration certificate or can be determined from the correlation information furnished by the supplier.

C. CALIBRATION OF REFERENCE HARDNESS TEST BLOCKS

14. Scope

14.1 Part C covers the calibration of reference hardness test blocks for the verification of rapid indentation hardness testing machines as described in Part B.

15. Manufacture

15.1 Each reference hardness test block to be calibrated shall be not less than ⅝ in. (16 mm) in thickness for use with 10-mm balls, ½ in. (12 mm) for use with 5-mm balls and ¼ in. (6 mm) for use with smaller balls.

TABLE 2 Maximum Mean Diagonal of Vickers Hardness Indentation of Brinell Hardness Balls

Ball Diameter, mm	Maximum Mean Diagonal with Vickers Indenter under 10 kgf (98.07 N)$_1$ mm
10	0.146
5	0.145
2.5	0.143
2	0.142
1	0.139

15.2 Each block shall be prepared and heat treated to give the necessary homogeneity and stability of structure.

15.3 Each block, if made of steel, shall be demagnetized by the manufacturer and maintained demagnetized by the user.

15.4 The supporting surface of the test block shall have a ground finish.

15.5 The test surface shall be free of scratches that would interfere with measurement of the diameter of the indentation.

15.5.1 The mean surface roughness height rating shall not exceed 12-µin. (0.0003-mm) center line average for the standard 10-mm ball. For smaller balls a mean surface roughness height rating of 6 µin. (0.00015 mm) is recommended.

15.6 To ensure that no material is subsequently removed from the test surface of the reference hardness test block, either the manufacturer's mark shall be etched on the test surface or the thickness at the time of calibration shall be stamped or engraved on the block. In the latter case, the thickness shall be indicated to an accuracy of ±0.005 in. (0.01 mm).

16. Standardizing Procedure

16.1 Calibrate the reference blocks by using a Brinnell hardness testing machine verified in accordance with the requirements of Test Method E 10.

17. Penetrator

17.1 A new ball conforming to the requirements of 13.1.2 shall be used for calibrating reference hardness test blocks.

18. Number of Indentations

18.1 At least five randomly distributed indentations shall be made on each test surface of the block.

19. Uniformity of Hardness

19.1 If d_1, d_2, ... d_n are the mean values of the measured diameters as determined by one observer and arranged in increasing order of magnitude, the range of the hardness readings on the block is defined as ($d_n - d_1$).

19.2 Unless the range of the mean diameters of each of the five indentations is within 2 % of the mean value for the five readings, the block cannot be regarded as sufficiently uniform for standardization purposes.

20. Marking

20.1 Mark each block with the following:

20.1.1 Arithmetic mean of the hardness values determined by the standardization test.

20.1.2 Name or mark of the manufacturer.

20.1.3 Serial number of the block.

20.1.4 Thickness of the block or the manufacturer's mark on the test surface.

20.2 The manufacturer may include the arithmetic mean of the depth measurements values corresponding to the five readings.

21. Keywords

21.1 indentation hardness; metallic