Designation: E 103 – 12

Standard Practice 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 (′) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a procedure for rapid indentation hardness testing of metallic materials.

1.2 This practice includes additional requirements in Annex A1 for the direct, indirect, and daily verification of rapid indentation hardness testing machines.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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]

E4 Practices for Force Verification of Testing Machines

E10 Test Method for Brinell Hardness of Metallic Materials

E74 Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines

2.2 *ISO Standards:*[3]

ISO 17025 General requirements for the competence of testing and calibration laboratories

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

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 tungsten 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. The depth measurement is usually correlated to another scale or Brinell hardness number.

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

4. Significance and Use

4.1 This practice is used when it is desired to make Brinell type hardness tests very rapidly on a high volume of samples, as in the inspection of the output of a heat-treating furnace.

4.2 This practice requires the measurement of indentation depth and eliminates the need to measure the diameter of the indent optically as required in a Brinell hardness test.

4.3 This practice is not a standard Brinell hardness test method and does not meet the requirements of Test Method E10.

4.4 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.

5. Apparatus

5.1 *Testing Machine*—Equipment for rapid indentation hardness testing usually consists of a testing machine, which supports the test specimen and applies an indenting force(s) to

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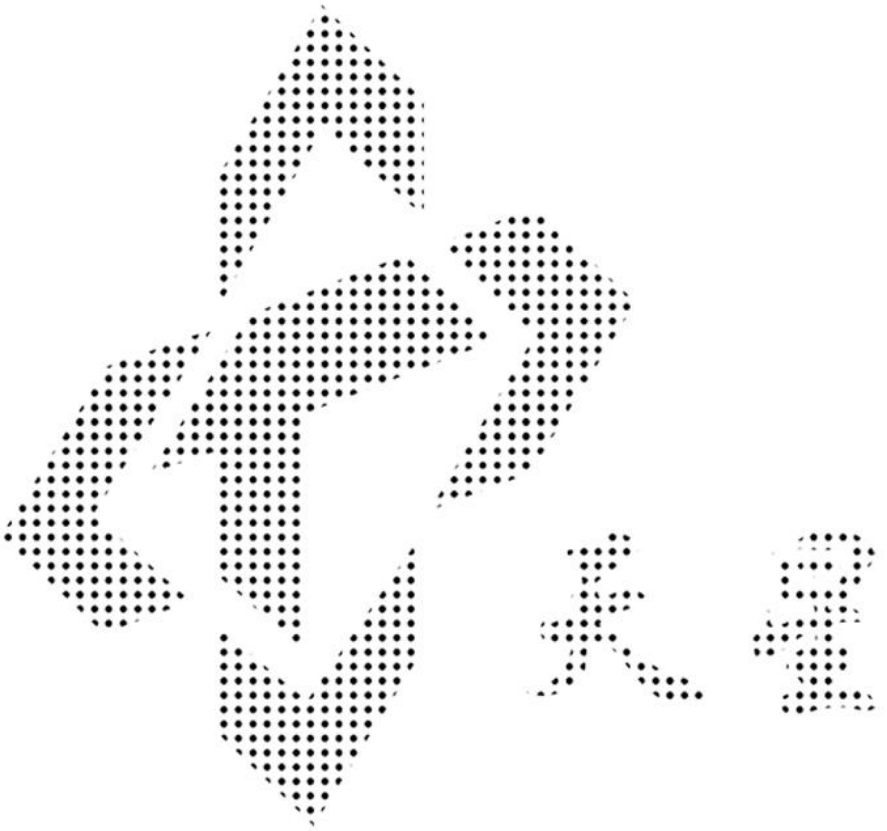
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[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 ball in contact with the specimen, and a system for measuring and displaying an indication of the depth of the indentation. 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.

5.1.1 The testing machine shall meet the requirements of Annex A1.

5.1.2 The testing machine shall ensure that the force to the indenter is applied smoothly and without impact forces that affect the measurement result. Precautions shall be taken to prevent a momentary high test force caused by the inertia of the system, hydraulic system overshoot, etc.

5.1.3 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.

5.1.4 An anvil, or specimen support, should be used that is suitable for the specimen to be tested. The seating and supporting surfaces of all anvils should be clean and free of foreign material.

5.1.5 The indenters used for rapid indentation testing shall be tungsten carbide balls that meet the requirements defined in Test Method E10, Annex A3.

5.1.6 The mechanism for measuring the depth of the indentation shall conform to the requirements prescribed in A1.3.3. The method for determining the depth of the indentation is determined by the manufacturer of the tester.

5.1.7 A display or output relative to the indentation depth shall be provided. The display may indicate the full or partial depth or the depth may be converted to another relevant scale. In this case, conversion to a related Brinell hardness number is recommended. When used, the method of conversion from depth to another scale or Brinell hardness numbers is determined by the manufacturer of the tester.

5.1.8 Refer to the Equipment Manufacturer's Instruction Manual for a description of the machine's characteristics, limitations, and respective operating procedures.

6. Test Specimens

6.1 Rapid indentation hardness tests can be made on any test specimen that can be tested using the E10 Brinell Test Method.

6.2 *Finish*—When necessary, the surface on which the indentation is to be made shall be filed, ground, machined, or polished with an abrasive material to allow accurate depth measurements and to remove any surface conditions (such as decarburization) that may affect the hardness of the sample. Preparation shall be carried out in such a way that any alteration of the hardness of the test surface (for example, due to overheating or cold-working) is minimized. The surface in contact with the test support anvil, when used, should be clean and free of any conditions which may affect the test results.

6.3 *Thickness*—The thickness of the test 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. See Test Method E10, Table 4 for more information about minimum thickness.

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 determined by the manufacturer of the tester. The total test force and ball indenter size used should be the same as the Brinell scale test that is being replaced by the rapid indentation test. When selecting the total test force and ball size to use, refer to Test Method E10, Section 7 for Brinell hardness testing.

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)*—Bring the indenter into contact with the test surface in a direction perpendicular to the surface without shock, vibration or overshoot. The angle between the indenter force-line and the surface of the specimen should be perpendicular. Apply the test force(s) according to the manufacture's instructions.

7.4 *Depth measurement of the indent*—Measure the depth of the indentation according to the manufacturer's instructions. When this practice is used to monitor the hardness of production parts it is recommended that the displayed depth indication as defined in 5.1.7 be recorded. All recorded data shall reference this practice.

8. Determination of Hardness Limits

8.1 Rapid indentation hardness tests are normally used to test specimens in limited Brinell hardness ranges. In order to establish the limit(s) of acceptable hardness for a given part or piece, test specimens representing the extreme(s) of acceptability should be tested in the rapid indentation hardness tester that is to be used. The results obtained may be considered the limits of application of the rapid indentation test.

9. Report

9.1 When a report is desired, it is recommended that the following information be reported:

9.1.1 The total test force,

9.1.2 The diameter of the ball indenter,

9.1.3 The displayed value as defined in 5.1.7, and

9.1.4 Reference to this practice.

10. Keywords

10.1 hardness; mechanical test; metals; rapid indentation

ANNEX

A1. VERIFICATION OF RAPID INDENTATION HARDNESS TESTING MACHINES

A1.1 Scope

A1.1.1 Annex A1 specifies three types of procedures for verifying rapid indentation hardness testing machines: direct verification, indirect verification, and daily verification.

A1.1.2 Direct verification is a process for verifying that critical components of the hardness testing machine are within allowable tolerances by directly measuring the test forces and the indentation depth measuring system.

A1.1.3 Indirect verification is a process for periodically verifying the performance of the testing machine by means of standardized test blocks or samples of known hardness.

A1.1.4 The daily verification is a process for monitoring the performance of the testing machine between indirect verifications by means of standardized test blocks or samples of known hardness.

NOTE A1.1—It may be necessary to refer to the tester manufacturer's manual to perform some of the verifications defined in this annex.

A1.2 General Requirements

A1.2.1 The testing machine shall be verified at specific instances and at periodic intervals as specified in Table A1.1, and when circumstances occur that may affect the performance of the testing machine.

A1.2.2 The temperature at the verification site shall be measured with an instrument having an accuracy of at least 2.0 °C or 3.6 °F. It is recommended that the temperature be monitored throughout the verification period, and significant temperature variations be recorded and reported. The temperature at the verification site does not need to be measured for a daily verification.

A1.2.3 All instruments used to make measurements required by this annex shall be calibrated, traceable to national standards when a system of traceability exists.

A1.2.4 Indirect verification of the testing machine shall be performed at the location where it will be used.

A1.2.5 Direct verification of newly manufactured or rebuilt testing machines may be performed at the place of manufacture, rebuild, repair or the location of use.

NOTE A1.2—It is recommended that the calibration agency that is used to conduct the verifications of rapid indentation hardness testing machines be accredited to the requirements of ISO 17025 (or an equivalent) by an accrediting body recognized by the International Laboratory Accreditation Cooperation (ILAC) as operating to the requirements of ISO/IEC 17011.

A1.3 Direct Verification

A1.3.1 A direct verification of the testing machine shall be performed at specific instances in accordance with Table A1.1. The test forces, indentation depth measuring system, and indenter shall be verified as follows.

A1.3.2 *Verification of the Test Forces*

The test forces used shall be measured by means of a Class A elastic force measuring instrument having an accuracy of at least 0.25 %, as described in Practice E74.

A1.3.2.1 Make three measurements of each force. The forces shall be measured as they are applied during testing; however, longer dwell times are allowed when necessary to enable the measuring device to obtain accurate measurements.

A1.3.2.2 Each test force used shall be accurate to within 2 % of the nominal value.

A1.3.3 Verification of the Indentation Depth Measuring System—The measuring system used to determine the depth of the indentation shall be verified over the working range by comparison with a reference scale, gage blocks or other devices accurate to at least 0.005 mm.

A1.3.3.1 The depth-measurement system shall correctly indicate the depth of penetration to an accuracy of 60.005 mm.

A1.3.4 Verification of the indenter—The tungsten carbide ball shall be in compliance with Test Method E10, Annex A3.

A1.4 Indirect Verification

A1.4.1 An indirect verification of the testing machine shall be performed in accordance with the schedule given in Table A1.1. Indirect verifications may be required more frequently than stated in Table A1.1 and should be based on the usage of the testing machine.

A1.4.2 The testing machine shall be verified for each total test force/ball size combination that will be used prior to the next indirect verification.

A1.4.3 A rapid indentation hardness testing machine shall be indirectly verified by making at least three indentations on reference Brinell hardness test blocks that comply with Test

TABLE A1.1 Verification Schedule for a Rapid Indentation Hardness Testing Machine

Verification Procedure	Schedule
Direct verification	When a testing machine is new, or when adjustments, modifications or repairs are made that could affect the application of the test forces or the depth measuring system. When a testing machine fails an indirect verification.
Indirect verification	Recommended every 12 months, or more often if needed Shall be no longer than every 18 months. When a test machine is installed Following a direct verification.
Daily verification	Required each day that hardness tests are made. Recommended whenever the indenter or test force is changed

Method E10, Annex A4 or by utilizing parts or samples of known hardness previously tested by the E10 method to produce calibration indentations. Two blocks or parts shall be used that span the softest and hardest samples to be tested (see Section 8).

A1.4.4 The machine shall be verified under the same conditions as in testing using the same test force(s) and the same ball indenter and time of application of the test force(s).

A1.4.5 The rapid indentation hardness testing machine shall be considered verified if the mean diameter of each indentation differs by no more than the equivalent of 2 % of the mean diameter of the calibration indentations of the reference hardness test block.

A1.4.6 The displayed indentation depth, as defined in 5.1.7, shall comply with the manufacturer's specifications for accuracy. When the rapid indentation tester displays the Brinell hardness of the sample, the error between the displayed value and the certified hardness of the test blocks or parts shall not differ by more than 3% for each test made.

A1.5 Daily Verification

A1.5.1 The daily verification is intended as a tool for the user to monitor the performance of the testing machine between indirect verifications. At a minimum, the daily verification shall be performed in accordance with the schedule given in Table A1.1 for each total test force/ball size combination that will be used.

A1.5.2 The procedure for a daily verification is the same as an indirect verification except that only one test block or part is required to be tested and a minimum of one test is required. The error tolerances defined in A1.4.5 and A1.4.6 shall apply. It is recommended that the block or part tested have a hardness in the middle of the range of hardness levels to be tested.

A1.6 Verification Report

A1.6.1 A verification report is required for direct and indirect verifications. A verification report is not required for a daily verification.

A1.6.2 The verification report shall be produced by the person performing the verification and include at minimum the following information.

A1.6.3 *Direct Verification*:

A1.6.3.1 Reference to this practice.

A1.6.3.2 Identification of the rapid indentation hardness testing machine, including the serial number, and model number.

A1.6.3.3 Identification of all devices (elastic proving devices, etc.) used for the verification, including serial numbers, and identification of standards to which traceability is made.

A1.6.3.4 Test temperature at the time of verification reported to a resolution of at least 1°C.

A1.6.3.5 The individual measurement values and calculated results used to determine whether the testing machine meets the requirements of the verification performed. It is recommended that the uncertainty in the calculated results used to determine whether the testing machine meets the requirements of the verification performed also be reported.

A1.6.3.6 Description of adjustments or maintenance done to the testing machine, when applicable.

A1.6.3.7 Date of verification and reference to the verifying agency or department.

A1.6.3.8 Signature of the person performing the verification.

A1.6.4 *Indirect Verification*:

A1.6.4.1 Reference to this ASTM practice.

A1.6.4.2 Identification of the hardness testing machine, including the serial number and model number.

A1.6.4.3 Identification of all devices (test blocks, etc.) used for the verification, including serial numbers, andidentification of standards to which traceability is made.

A1.6.4.4 Test temperature at the time of verification reported to a resolution of 1 °C.

A1.6.4.5 The test force(s) ball size combinations verified.

A1.6.4.6 The individual test values and calculated results used to determine whether the testing machine meets the requirements of the verification performed. It is recommended that the uncertainty in the calculated results used to determine whether the testing machine meets the requirements of the verification performed also be reported.

A1.6.4.7 Description of maintenance done to the testing machine, when applicable.

A1.6.4.8 Date of verification and reference to the verifying agency or department.

A1.6.4.9 Signature of the person performing the verification.

A1.6.5 *Daily Verification*:

A1.6.5.1 No verification report is required for the daily verifications; however, it is recommended that records be kept of the daily verification results, including the verification date, measurement results, certified value of the test block, test block identification, and the name of the person that performed the verification, etc. These records can be used to evaluate the performance of the hardness machine over time.