

LAB 25

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Traceability of Hardness Measurements

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Changes since last edition

References to ISO/IEC 17025 updated. Uncertainty definition revised to align with GUM definition.

1. Introduction

- 1.1 Laboratories that have been assessed by UKAS as meeting the requirements of ISO/IEC 17025 *General requirements for the Competence of Testing and Calibration Laboratories* may be granted UKAS Accreditation. Several guidance publications on the application of these requirements, providing extra information, detail and limitations are listed in the publications section of the UKAS website.
- 1.2 In general, calibration and verification of hardness testing equipment needs to be traceable to national standards. When using external calibration sources, a valid certificate should be obtained from a calibration laboratory that demonstrates competence, measurement capability and traceability. A calibration certificate bearing the UKAS accreditation mark (or identity of the national standards laboratory or mark of an accreditation body with which UKAS has a recognition agreement) for the relevant calibration/verification will be sufficient evidence.
- 1.3 This publication provides guidance for laboratories needing to meet the requirements as applied to hardness testing. By following this guidance, laboratories will be able to demonstrate that they meet these requirements. Alternative methods may be used provided they are shown to give an equivalent outcome.

2. Direct Machine Verification

- 2.1 All hardness machines should be directly verified as evidenced by a calibration certificate (see 1.2 above). The certificate should report all the measured values and the estimated uncertainty of the measured values. The direct verification shall be performed using the customer's indenters.
- 2.2 Intervals between direct verifications
- Calibration machines should be directly verified at intervals no greater than twelve months
 - Testing machines should be directly verified at first installation.
 - Testing machines should be directly verified following failure of an indirect verification.
 - Testing machines should be directly verified after dismantling and reassembling if the force, measuring system or test cycle are affected.
 - Testing machines should be directly verified if moved from the location where the previous direct verification was performed unless the relocation of the machine has been performed in accordance with section 2.2f.
 - Prior to relocation the machine is prepared for the move by a qualified service and calibration engineer. After relocation the machine is setup and indirectly verified. The indirect certificate should have a comment stating that the machine was moved by a competent person.

3. Indirect Machine Verification

- 3.1 All hardness machines should be indirectly verified as evidenced by a calibration certificate (see 1.2 above). The certificate should report all the measured hardness values and the estimated uncertainty of the measured hardness values. The certificate shall clearly identify the hardness machine, the indenter(s) and the standard hardness block(s) used in the verification. The indirect verification shall be performed using the customer's indenters.
- 3.2. Intervals between indirect verifications
- Calibration and testing machines should be indirectly verified following a direct verification.
 - Calibration and testing machines should be indirectly verified at intervals no greater than twelve months.

4. Traceability of Reference Hardness Blocks

- 4.1 All primary hardness reference blocks used for the verification of hardness calibration machines should be calibrated as evidenced by a valid calibration certificate. The certificate should report all the measured values and the estimated uncertainty of the measured values.
- 4.2 Certification of primary hardness reference blocks shall be obtained from:
- Istituto Nazionale di Ricerca Metrologica** (INRIM), Italy
 - or **Physikalisch-Technische Bundesanstalt** (PTB), Germany
 - or a **National Measuring Institute** that demonstrates that they have met the requirements of the monitoring system for the relevant hardness measurements.
 - or **National Institute of Standards and Technology** (NIST), USA in the case of ASTM Standards.
- 4.3 Reference hardness blocks used for the verification of hardness testing machines should be calibrated as evidenced by a valid calibration certificate obtained from an ISO/IEC17025 accredited calibration laboratory (see 1.2 above). The certificate should report all the measured values and the estimated uncertainty of the measured values.

- 4.4 Reference hardness blocks used for regular checks should be calibrated as evidenced by a valid calibration certificate obtained from an ISO/IEC 17025 accredited calibration laboratory (see 1.2 above). The reference hardness blocks should be suitably protected, maintained in a satisfactory condition in accordance with the requirements of the relevant standard specification and used solely for this purpose.
- 4.5 Reference hardness blocks for Vickers, Knoop and Brinell Testing should contain a reference indentation. This should be used to carry out indirect verification and regular monitoring of the optical measuring equipment.

5. Traceability of Diamond Hardness Indenters

- 5.1 All diamond indenters for Vickers, Knoop, Rockwell and Rockwell Superficial shall be verified as evidenced by a valid calibration certificate (see 1.2 above). The certificate should report all the measured values and the estimated uncertainty of the measured values.

6. Traceability of Ball Indenters

- 6.1 All ball indenters for Rockwell and Brinell shall be verified as evidenced by a valid calibration certificate (see 1.2 above). The certificate should report all the measured values and the estimated uncertainty of the measured values.
- 6.2 The relevant standards specify sampling requirements and limits for ball diameter; roundness; surface finish; hardness; and, in the case of tungsten carbide, chemical composition and density.
- 6.3 Indenter balls should be obtained from a bonded batch and evidenced by a valid certificate confirming compliance with the relevant standard specifications.
- 6.4 All calibration certificates should contain actual measured values together with the estimated uncertainty of that measurement.

7. Indentation Measuring Equipment

- 7.1 The indirect verification of integral indentation measuring equipment is normally carried out by a UKAS accredited calibration laboratory as part of the indirect verification of a hardness machine. Auxiliary measuring equipment such as hand microscopes, scanning systems and profile projectors shall be indirectly verified at intervals no greater than twelve months and whenever the equipment becomes damaged or is repaired. The verification shall be evidenced by a valid calibration certificate (see 1.2 above).
- 7.2 To account for lighting, numerical aperture of the lens and operator discrimination, readings should be obtained from the reference indentations of the reference hardness blocks used for the indirect verification (reference reading blocks may also be used).
- 7.3 If auxiliary measuring devices fail indirect verification the device should be directly verified.
- 7.4 Integral and auxiliary measuring devices used for the measurement of Brinell indentations can be classified into two distinct types:
- 1: Devices include microscopes having moveable measuring lines with some type of indicator or computerised measuring system, or an image analysis system.
 - 2: Hand held microscopes with fixed measuring lines.

Note: When working to ASTM E10 hand held microscopes with fixed measuring lines shall not be used for measuring indentations made with 2,5 mm or 1 mm ball indenters.

Note: When working to ISO 6506 hand held microscopes with fixed measuring lines shall not be used for measuring indentations < 4 mm using a x 20 magnification or < 2 mm using a x 40 magnification.

8. Regular Monitoring by In-house Checks

- 8.1 Laboratories holding accreditation for hardness testing should carry out regular in-house checks using reference hardness blocks, which meet the requirements of Section 4.
- 8.2 In-house checks should be made at intervals specified by the testing standard. If no period is specified, checks should be made before use on each day the machine is used. The checks should be made under conditions of load and hardness comparable to those to be used in the subsequent hardness test measurements. Permanent records should be made of each check. A machine should be deemed satisfactory if all hardness readings fall within the tolerance values for monitoring hardness machines as stated in the relevant standard specification. If not, an indirect verification should be performed.
- 8.3 Measuring devices including microscopes and scanning systems should be checked before the hardness check in paragraph 7.1 or as required by the relevant standard specification, by measuring a reference indentation on a reference block where the reference indentation is of a similar size to the indentations on the work being tested. Permanent records should be made of each check.

9. Portable Hardness Testers and Comparators

- 9.1 In cases where it is possible to establish traceability and to directly and indirectly verify portable hardness testers, then this should be carried out in line with the relevant standards.
- 9.2 Where portable hardness testers are Directly and Indirectly verified each removable part (Loadcell, measuring system etc.) shall have a serial number which shall be referenced on the calibration certificate.
- 9.3 In cases where no route exists to establish the traceability of verification of portable hardness testing machines, accreditation is limited to comparative testing.
- 9.4 Portable hardness testing comparators should be serviced at intervals no greater than twelve-months and be evidenced by a service report.
- 9.5 Laboratories holding accreditation for comparative portable hardness testing should carry out regular in-house checks using suitable reference hardness blocks or samples. These checks should include as a minimum:
- a) a check before use on each day the portable hardness comparator is used;
 - b) checks when different surface configurations are tested;
 - c) checks before use whenever the orientation at which the comparator is used is changed (e.g. from vertically upwards to horizontally);
 - d) checks when a series of tests is to be carried out in the same orientation; these checks should be made at intervals that are sufficiently short to ensure that the portable hardness testing comparator is producing consistent comparative hardness values.
- 9.6 For portable Brinell, Rockwell, superficial Rockwell or Vickers hardness comparators, reference hardness blocks with a valid certificate of calibration should be used where possible.

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- 9.7 Test reports issued by laboratories accredited for comparative portable hardness testing should clearly state that the hardness tests results are comparative.
- 9.8 Hardness readings reported as a conversion to another hardness scale shall not be reported as accredited.

10. Bias and Uncertainty

- 10.1 When a hardness machine is directly verified the associated bias can be calculated from the direct verification measurements.
- 10.2 Direct and indirect verification certificates for hardness machines should contain an estimate of the uncertainty of measurement for each measurement made. Hardness testing laboratories should also report an estimate of the uncertainty of measurement for hardness values obtained during a test.
- 10.3 The estimate for the uncertainty of measurement should be calculated in accordance with the informative annex given in the relative hardness standard or calculated in accordance with the Euramet document cg-16 version 2.0 "Guidelines on the Estimation of Uncertainty in Hardness Measurements" (Previously EA-10/16).
- 10.4 Indenter certificates should contain sufficient information to calculate the estimated uncertainty of measurement and bias values for the hardness machine in which it is to be used.

11. Bibliography

- 11.1 International Standards Organisation (ISO), *Guide to the Expression of Uncertainty in Measurement (GUM)*.
- 11.2 European Association of National Metrology Institutes (EURAMET) cg-16, *Guidelines on the Estimation of Uncertainty in Hardness Measurements*.
- 11.3 United Kingdom Accreditation Service (UKAS), M3003, *The Expression of Uncertainty and Confidence in Measurement*.

12. Glossary of Terms

Bias	The difference between the true value and the measured or calculated value.
Calibration	Specific types of measurement performed on measuring instruments to establish the relationship between the indicated values and known values of a measured quantity. <i>Note: The term 'calibration' as defined internationally does not include adjustment of the instrument.</i>
Direct verification	Calibration of the force and measuring system and verification of the time cycle and indenter.
Indirect verification	The verification of a machine using reference hardness blocks.
Repeatability	A measure of a hardness machine's ability to display the same result when repeated measurements are made under the same conditions.
Resolution	The value of the smallest scale or digital interval displayed by the machine display.
Scale	A hardness scale as defined by force, and indenter type.
Primary standardising machine	A national hardness machine which is directly verified and is used to calibrate primary reference blocks.
Calibration machine	A hardness machine which is directly and indirectly verified annually and is used to calibrate reference blocks and indenters.
Testing machine	A hardness machine which is directly verified on installation and indirectly verified annually and is used to carry out hardness testing.
Primary reference hardness block	A hardness block calibrated using a primary standardising machine.
Reference hardness block	A hardness block calibrated using a calibration machine.
Uncertainty	Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.