European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-r04**
Version: 1.0

Title: Traceability for indentation measurements in Brinell-Vickers-Knoop hardness

Abstract

In order to remain competitive European manufacturers need to produce higher quality products. This requires further developments in field of material science and an improved understanding of a materials' mechanical properties such as hardness. There are many types of indentation measurement systems used to measure hardness however measurement is dependent on imaging and processing instruments, operators and software used. As a result, there is a significant inconsistency between the NMIs, NMI level systems and the testing laboratories due to lack of well-defined indentation measurement methodology. This proposed project aims to overcome this problem via investigating parameters affecting indentation measurements for different instruments, methods, operators, and software and constitute a methodology for consistent and traceable hardness measurements for inter-NMIs and NMI-calibration and testing laboratories level.

Keywords

Hardness, Brinell, Vickers, Knoop, indentation, traceability chain, indenter, reference material

Background to the Metrological Challenges

Consumers demand higher quality products. A deeper knowledge of a material's mechanical properties at various stages from research and development at universities and institutions to design and production at manufactures can facilitate improved product design. It is therefore important to establish accurate and reliable reference standards and traceability chains at national metrology institutes (NMIs). Brinell, Vickers and Knoop Hardness methods are three of the most important hardness scales used for testing metallic materials. However, currently there is no complete traceability chain for indentation measurements of Brinell, Vickers and Knoop hardness scales which results in inconsistent measurements at different NMIs and hence for end users.

There are many types of indentation measurement systems however some are more sophisticated at the NMI level than those used in calibration and testing laboratories. The indentation size measurement is completely dependent on the image magnification and processing instrument, operator, and software (if any). There is a significant inconsistency between the NMIs and testing laboratories due to a lack of well-defined methodology and specifications. This was reinforced in the CIPM Brinell Key Comparison, CCM.H-K2, in 2005.

More consistent and reliable indentation measurements between NMIs according to the relevant hardness standards are needed and deviations between NMIs resulted by the usage of different systems, measurement principles and operators need to be overcome. Better defined reference standards are required to ensure that traceable indentation measurements can be performed in every country. Compared to the systems used in NMIs, the variety and the differences between the testing and calibration machines is much bigger and this causes interruption of traceability from the NMI level to the user level to a greater extent. Consistent, unified, reliable, and traceable hardness measurements from the NMI level to testing laboratories is needed. To cope with the operator effect and to adopt updated technology, automated indentation measurements from the determination of border of indentation to measurements of the number of indentations on the surfaces including the calibration of indentation measurements system by itself also need to be investigated. In addition, to minimize possible systematic effects introduced by automatic software in the measurements result, algorithms for measuring the indentation dimension as the optical parameters of the images vary are needed.

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Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of metrology capability in traceable indentation measurements in Brinell-Vickers-Knoop hardness methods.

The specific objectives are

1. To determine the parameters affecting Brinell, Vickers and Knoop indentation measurements and develop 3 methods, one each for Brinell, Vickers and Knoop indentation measurements, suitable for use by European NMIs/DIs. Each method should include technical specifications for the associated measurement instrument used and must align with existing relevant ISO hardness standards.
2. To develop traceable and validated methods for indentation measurements that are suitable for use with the majority of devices used by both NMIs and users of calibration and testing instruments. The methods should use at least 3 traceable reference materials, one each for Brinell, Vickers and Knoop indentation measurements that are applicable for use by both NMIs/DIs and users of calibration and testing instruments
3. To develop recommendations for ensuring the consistency in indentation measurement systems for the next generation of testing machines. This should include technical specifications and the most important parameters affecting Brinell, Vickers and Knoop indentation measurements.
4. To develop algorithms and the associated software necessary for automated indentation and uncertainty measurements. This should include the (i) determination of the indentation edge, (ii) determination of indentation dimensions during varied image optical parameters, (iii) determination of the number of indentations present on the block surface, and (iv) self-calibration of the indentation measurement system.
5. To facilitate the take up and long term operation of the capabilities, technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs/DIs, calibration and testing laboratories), standards developing organisations (ISO), and end users (e.g. industry, regulators, manufacturers). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs e.g. EURAMET TCs or EMNs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities will have on the industrial competitiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.5 M€ and has defined an upper limit of 0.9 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the ‘end user’ community, describing how the project partners will engage with relevant communities during the project to facilitate

knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the 'end user' community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health or protection of the environment,
- Transfer knowledge to the testing and calibration sector and the metrology community.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects (JRPs)"

You should also detail how your approach to realising the objectives will further the aim of the Partnership to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.