EMPIR Call 2018 – Health, SI Broader Scope, Normative and Research Potential

Selected Research Topic number: **SRT-s19**
Version: 1.0

Title: Comprehensive traceability for force metrology services

Abstract

Force measurement related to material testing is very important in a wide range of applications in the automotive, aerospace, off-shore energy, healthcare and construction industries as well as research. Dynamic force traceability is a key element in fatigue testing of materials and structures directly impacting on the improvement of mechanical systems in internal combustion engines, drivetrains, brake systems, and orthopaedic implantable devices etc. Currently, only static calibration services are available and no metrological services or traceability for continuous and dynamic forces exist. Methods and suitable transfer standards should be developed and investigated to extend the force traceability chain from static to continuous and dynamic forces considering parasitical influences from the alignment of the apparatus and the environment. This is important to ensure that the units of force are realised and disseminated with increasingly smaller uncertainties.

Keywords

Force traceability chain, force measurement (static, continuous and dynamic), multi-component force measurement, temperature influences, digital twins, material testing machines, metrological services

Background to the Metrological Challenges

The force calibration of material testing machines is currently performed according to the ISO 7500-1 standard, which only considers the static axial calibration of the equipment. In the case of continuous or dynamic force application, which is required in many fields of material testing, there is the need for a suitable calibration procedure, since there are presently no European standards or recommendations available for such measurements. In addition there are no CMC values available for non-static forces [1]. Therefore, the traceability chain in all applications with continuous and dynamic forces is an unsolved problem for the users of metrology services.

Parasitical influences caused by the alignment of the gripping apparatus (e.g. bending strain) and temperature effects under non-static conditions would need to be considered. Moreover, in spring loaded testing equipment not only the traceability of the vertical force but also the transversal forces are very important and that would require further developments and investigations.

For multi-component force measurement and for dynamic forces there are is a complete luck of calibration standards and existing ISO and ASTM standards only provide verification procedures. The evaluation of the measurement uncertainty is totally unknown. The users of metrology need methods which are traceable to national standards and which consider the different effects.

The focus of the former EMRP project SIB63 Force “Force traceability within the meganewton range” was mainly on the measurement of large forces and that was considerably improved. However, not all different types of material testing machines could be considered. In the former EMRP project “Traceable Dynamic Measurement of Mechanical Quantities” (Dynamic, IND09) mainly the traceability to the NMIs was improved. But the problem of the application of dynamic force measurement in many different material testing machines was left as an open question.

The focus of any proposal against this SRT should be the improvement of force measurement in many material testing machines by considering in addition to static, continuous and dynamic forces as well as the effects of multi-component force measurement for alignment influence, values of bending strain, associated percent bending, gripping and apparatus and the influences of temperature, which are also addressed in the “Force” and “Dynamic” roadmaps of the EURAMET TC Mass and related quantities.

EURAMET MSU, Hampton Road, Teddington, Middlesex, TW11 0LW, UK
Phone: +44 20 8943 6666 Email: msu@npl.co.uk
msu.euramet.org

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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 traceable measurement and characterisation of force to enable extension from static to continuous and dynamic force application.

The specific objectives are

1. To review all types of mechanical and materials testing machine standards and force calibration methods and their traceability chain to national standards and to define and develop new extended calibration methods and innovative force transfer standards considering the static force calibration method as well as the influence of continuous and dynamic force application.
2. To develop advanced models that accurately describe the influences in force measuring devices including the development of digital twins of force measuring devices according to the future requirements for digitisation and industry 4.0.
3. To develop a force traceability chain for metrological services by implementing new improved methods to consider static, continuous and dynamic force calibrations in the frequency range from 0 Hz to 1000 Hz.
4. To develop new recommendations and standards for force calibration of testing machines under consideration of static, continuous and dynamic force applications and parasitical influences from multi-component forces and temperature effects and to develop a strategy for offering calibration services from the established facilities to their own and neighbouring countries.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g. National Metrology Institutes, National Accreditation Bodies), standards developing organisations (e.g. ISO, ASTM) and end users (e.g. testing machine manufacturers, test houses).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

In particular, proposers should outline the achievements of the EMRP projects SIB63 and IND09 and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.8 M€, and has defined an upper limit of 2.1 M€ for this project.

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

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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the Testing, Inspection & Certification (TIC) sector.

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 EMPIR 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.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] BIPM, Calibration and Measurement Capabilities – CMCs, https://kcdb.bipm.org/appendixc