EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-i26**
Version: 1.0

Title: Metrology for dynamic pressure and temperature measurements

Abstract

Dynamic measurements are a key requirement for modern process control in several demanding applications, such as automotives, marine and turbine engines, engine power plants, manufacturing and safety testing. Research is needed to improve the accuracy and reliability of pressure and temperature measurements in dynamic conditions. These applications cover a wide pressure, signal frequency, and temperature range. Establishing SI traceability for these measurements through development of dynamic measurement standards and methods, and characterised sensor technologies will significantly improve the quality of measurements and thus support the innovation potential and competitiveness of European industry. Proposals addressing this SRT should focus on metrology research necessary to improve the accuracy and reliability of dynamic measurements of pressure and temperature in demanding industrial applications through development of traceable measurement standards, calibration techniques, and sensors.

Keywords

Dynamic pressure, dynamic temperature, calibration, dynamic pressure sensor, dynamic temperature sensor, process control, automotive industry, maritime industry, engine power plants, manufacturing industry

Background to the Metrological Challenges

Dynamic measurements of pressure and temperature are widely performed in industry, e.g. for optimising combustion engine performance, and as part of modern manufacturing, process control and safety testing, including research and development activities in these areas. The accuracy and reliability of these measurements have a direct impact on both product quality and/or price competitiveness through energy and material efficiency. Currently, the lack of traceable calibration and measurement methods, and suitable sensors, are the main obstacles for progress.

The ongoing energy revolution, i.e. the transition from fossil fuels to renewable energy sources, such as wind and solar energy and bio-based fuels, sets new and more demanding requirements for combustion engines used in transportation and for back-up power generation. Engines need to be more flexible depending on load demand and fuel supply. In addition, their efficiency needs to be further improved and emissions reduced. This, in turn, means that combustion control needs to be improved and sensors need to cope with even more demanding conditions. Precise control of the combustion process inside an engine requires dynamic pressure and temperature measurements at an accuracy level of 1 %, which cannot be achieved with current calibration and measurement technologies.

The wide needs for further developments have been recognised in the ongoing EMPIR project 17IND07 DynPT "*Development of measurement and calibration techniques for dynamic pressures and temperatures*". Reported measurement uncertainties are from 1.5 % up to 3 % depending on the measurement range, which is not sufficient to fulfil the needs of industry. Recent findings in the DynPT project indicate that operating conditions, e.g. temperature and measuring media, have a significant influence on the sensor response. In order to reach the 1 % accuracy target, calibration methods need to be developed further to better match the actual process conditions.

The calibration chain from the primary realisation to industry level measurements is incomplete due to the lack of traceable and validated secondary calibration methods. Consequently, industry still performs calibrations at static conditions, which can result in errors up to 10 %, when sensors are used at dynamically changing conditions. Robust and cost-effective secondary standards and calibration techniques need to be developed to enable practical calibrations at the industry level.

Current dynamic pressure sensors tend to degrade and break down when used in harsh conditions, such as inside a combustion engine, which compromises the validity of results, with implications on product quality and cost effectiveness. In addition, the sensor response is sensitive to temperature, which can lead to measurement errors of more than 1 % at elevated temperatures. To reach the accuracy target of 1 %, in addition to calibrating sensors at representative conditions, sensor technologies need to be developed further to improve reliability and to minimize the influence of process conditions on sensor response.

Traceability of dynamic pressure and temperature measurements in industry is non-existent, partly because validated and documented calibration and measurement methods that fulfil the end-user needs are not available. The implementation of traceability from the primary realisation to measurements at process conditions needs to be validated through demonstration in actual process conditions to verify that the developed measurement techniques and technologies fulfil the requirements of the targeted applications. Furthermore, written standards are not available. Close communication with industry through, e.g. workshops, is needed for disseminating the best practices to industry.

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 metrology research necessary to improve the accuracy and reliability of dynamic measurements of pressure and temperature in demanding industrial applications through development of traceable measurement standards, calibration techniques, and sensors.

The specific objectives are

1. To develop primary measurement standards and calibration methods for dynamic pressure and temperature at application-specific operating conditions, to establish traceability and measurement uncertainties at 1 % across ranges up to 400 MPa and 3000 °C.
2. To develop practical and cost-effective secondary measurement standards and calibration methods for dynamic pressure and temperature, including in-field techniques, to establish traceability at the point of use at the industry level.
3. To develop new measurement techniques and sensors for measuring dynamic pressure and temperature up to 100 MPa and 3000 ˚C, with an accuracy of 1 %. Development should focus on mitigating the effects of process conditions, such as measurement media and temperature, on the measured signal in order to improve the accuracy and reliability of sensors.
4. To validate all of the developed methods and sensors through demonstrations in selected industrial applications. Validation should include comparison of different measurement technologies in laboratory and in actual process environments.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (NMIs, research and calibration laboratories), standards developing organisations (CEN, ISO/TC 108/WG 34) and end users (engine manufacture, safety testing). Workshops and best practice guides will be prepared for effective dissemination of results.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

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 EMPIR project 17IND07 DynPT and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the engine manufacture and safety testing 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.