EMPIR Call 2017 – Industry, Fundamental, Normative and Research Potential

Selected Research Topic number: **SRT-i01**
Version: 1.0

Title: Metrology for portable emissions measurement systems

Abstract

Emissions of NO_x gases (particularly NO_2) and particulates from diesel vehicles are amongst the leading causes of air pollution throughout the European Union. EC regulations, standards and directives set emissions ceilings, but more stringent procedures are needed in order to close the gap between the emissions measured at type approval and the emissions occurring during real driving. On-road Real Driving Emissions (RDE) testing requires the use of portable emissions measurement systems (PEMS), a few of which are already commercially available. However, in order to support PEMS use, an independent metrology infrastructure is needed for their validation and type approvals, and this should include calibration via standardised calibration processes and traceability to the SI. This should ensure that vehicle manufactures meet current and future emission limits, thus improving air quality.

Keywords

Vehicle exhaust gas emissions, PEMS (portable emissions measurement systems), RDE (real driving emissions), ultrafine particles, particle number (PN) concentration, NO_x emissions, NO_2, calibration

Background to the Metrological Challenges

Air pollution caused by road traffic emissions is a problem throughout Europe with NO_2 and particle emissions from diesel engines being major contributors. Although such emissions have decreased since 1990, partly due to stricter regulation, the road transport sector remains the primary cause of NOx emissions, contributing ~50 % of EU-28 NO_x emissions in 2013. In addition, several EU member states have not met their emission targets for NOx emissions since 2010, due to both discrepancies between official type approval measurements on vehicles and real driving emissions, and also because the sector has grown more than expected.

Traditionally the emissions testing of light-duty vehicles has used laboratory-based type approval test cycles, however, such tests can be beaten by emissions-compliance 'defeat devices'. Therefore it has become important to test vehicles under real-life or more realistic and unpredictable laboratory-based conditions. To address this, more stringent procedures are currently being developed with the aim of closing the gap between the emissions measured at type approval and the emissions occurring during real driving. These are known as the RDE and the Worldwide Harmonised Light-duty Vehicles Testing Procedure. However, for such on-road RDE testing to become a reality portable emissions measurement systems (PEMS) are required. A few PEMS are already commercially available, however, their development has not been easy as they use relatively new instrument principles or formats and there are weight, size and power limitations associated with their use.

Currently there is also a lack of comparability between measurements made using different PEMS equipment. Therefore, a metrology infrastructure, focused on NO_x (particularly NO_2) and particle number (PN) measurements, is needed for PEMS validation and type approvals. PEMS equipment also needs to be able to be legally calibrated via standardised calibration processes, and to be traceable to the SI. In addition, accurate methods are needed for quantifying the correlation between RDE measurements using PEMS and laboratory dynamometers, as well as procedures for validating PEMS measurements and for the processing of RDE measurements. Development of this metrology infrastructure will enable upcoming EC regulations (e.g. EC regulations 715/2007/EC [1], 692/2008/EC [2] and 459/2012/EC [3] on type-approval of motor vehicles) to be met. These EC regulations include the Euro 5b and Euro 6 emissions standards, the latter of which was implemented in September 2014, but due to difficulties in developing a robust PN measurement method there has been a three-year waiver in its enforcement, which ends in September 2017. Therefore robust new methods novel analytical techniques and instruments for measuring NO_2 emissions and PN concentrations are needed for PEMS.

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

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

For PN measurement, diffusion charging or a condensation particle counter can be used. However, these two types of instruments may not produce the same results and the results may not be the same as those produced in the laboratory. Therefore these PN measurement methods need to be validated for use with PEMS equipment. In addition, the reliability and performance of commercial PN PEMS needs to be evaluated by comparison with traceable particle number facilities. A further issue is that PN calibrations are based on manufacturers' own standards and these are not usually publically available.

Finally, for NO_2, the analysers can be calibrated using either static or dynamically generated reference gas mixtures. However, both approaches have their limitations. Dynamic NO_2 standards are less practical to use whereas static NO_2 standards have limited stability as the NO_2 reacts with the cylinders it is stored in, even when they are chemically passivated. The measurement methods for NO_2 PEMS also need to be validated by comparison with laboratory-based techniques before they can be used for type approvals.

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 portable emissions measurement systems.

The specific objectives are

1. To develop validated and traceable methods for NOx portable emissions measurement systems (PEMS), in particular for NO_2, at emission concentrations of up to 2500 µmol/mol. This should include (i) improved calibration methods for NO_x PEMs, (ii) spectroscopic methods for NOx stability and composition assessment of reference gas standards, (iii) the characterisation of commercial NO_x PEMS and (iv) the validation of NO_x PEMS responses and dynamics.
2. To evaluate the reliability and performance of commercial particle number (PN) PEMS by comparison with traceable particle number facilities. This should include (i) determination of linearity and counting efficiencies, (ii) characterisation of the PN PEMS for particle size-dependent responses at concentrations up to 10000 particles per cm^3 behind the dilution section, (iii) measuring the dynamic behaviour of PN PEMS under real driving emissions (RDE) and (iv) determining the effects of sampling and dilution during and after particle filter regeneration.
3. To develop accurate methods for quantifying the correlation between RDE measurements, using PEMS and laboratory dynamometers. This should include a comparison of validated PEMS with commercially available PEMS.
4. To recommend procedures for validating PEMS measurements and for the processing of RDE measurements.
5. To facilitate the rapid take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g. accredited laboratories, instrument manufacturers), standards developing organisations (e.g. CEN, ISO and those associated with European Regulations 715/2007/EC and 692/2008/EC on type-approval of motor vehicles, and Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants) and end users (e.g. the automotive industry).

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 EMRP project ENV02 and EMPIR projects 14SIP03 and 16ENV05 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 to the project.

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 automotive 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] COMMISSION REGULATION (EU) No 715/2007/EC of 20 June 2007.

[2] COMMISSION REGULATION (EU) No 692/2008/EC of 18 July 2008.

[3] COMMISSION REGULATION (EU) No 459/2012/EC of 29 May 2012.