EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-v07**
Version: 1.0

Title: Improved vehicle exhaust quantification by portable emission measurement systems metrology

Abstract

NO_x and soot emitted from cars are leading causes of air pollution. Legislation was recently introduced for on-road type approval (TA) real driving emission (RDE) tests using portable emissions measurement systems (PEMS) but metrological validation is still lacking, limiting accuracy and comparability of vehicle emission values. Metrological PEMS characterisation (for NO_x, particle number and exhaust flow) and development of the associated infrastructure is required. This is most relevant for the accurate verification of vehicle emission limits and thus for the European vehicle manufacturers, the measurement device industry and the legislative bodies responsible for ensuring adequate air quality despite increasing traffic emissions.

Keywords

Air quality, on road vehicle emission tests, vehicle exhaust emissions, RDE, PEMS, PN (particle number), NO_x emissions, NO_2, exhaust flow meter, calibration

Background to the Metrological Challenges

Air quality networks have highlighted mismatches between the measurement of actual NO_x emissions and the predicted air pollution by NO_x emissions. Despite strict European regulations the transport sector still significantly contributes to the overall NO_x emissions in air. There are also discrepancies between stationary and mobile RDE TA tests on vehicles. To address these problems existing lab-based TA test cycles were revised in Europe aiming at more realistic driving conditions for mobile vehicle emissions tests. In addition, legislation requiring on-road emission tests and rules for more realistic RDE TA tests during on-road performance using PEMS have been implemented. PEMS quantify CO, CO_2, NO, NO_2 amount fractions and ultrafine particle number (PN) densities in the vehicle's exhaust gas and often use techniques which are, compared to stationary instruments, significantly modified to be compatible with rigorous weight, size and power limitations when used during on-road field tests. In order to provide reliable emission data, PEMS need to be legally calibrated, and made traceable to the SI. The characteristics of such instruments have neither been extensively tested under metrological control nor are there standardised tests for performance characterisation. Calibration methods and the support infrastructure for PEMS validation and TAs to meet existing and upcoming regulation in the EU need to be developed, in particular for the challenging pollutants particle number (PN) and NO_x/NO_2.

NO_2 PEMS measurements have to cover values up to 2500 µmol/mol (ppm) during, for example, a catalyst failure and up to 10 µmol/mol during normal vehicle conditions. At the very low concentration levels, the analysers should not show any zero or span drift. NO_2 analyser calibrations use static reference gas mixtures, but these are only covered metrologically to 1000 µmol/mol via the K74 key comparison. Improved reference gas stability is needed via dedicated chemical passivation of the gas cylinders to compensate for the NO_2 reactivity. In addition, gas impurities need to be characterised in order to minimise uncertainties and the accuracy of dynamic generators for NO_2 emission gas standards assessed. Particle number (PN) limits during TA have been applied to diesel and direct-injection gasoline cars. Two counting principles are used for PN-PEMS but improved calibration methods and an improved definition of a reference aerosol to ensure comparability between these principles are required. The size dependence and particle losses also need to be addressed (emphasised by future legislation concerned with lowering the size cut-off-range). Currently, calibrations are based on manufacturers' own standards and are typically not publicly accessible and there is still no common approach for a suitable aerosol that allows the calibration of PEMS for use in stationary TA. Analytical techniques implemented in PEMS can differ substantially from each other and from stationary lab-based TA instrumentation for dynamometer tests. Standardisation and improved metrological validation over the wide range of operation conditions is required.

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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 vehicle exhaust emissions using portable emission measurement systems.

The specific objectives are

1. To develop traceable methods to validate and calibrate portable NO_X emissions measurement systems (PEMS), in particular for NO_2, for concentrations from below 10 µmol/mol up to at least 2500 µmol/mol. This should include the generation of a PEMS 'state-of-the-art' with respect to high accuracy reference gases, development of improved gas standards, calibration methods and uncertainty evaluations, as well as the validation of commercial NO_X-PEMS.
2. To evaluate the performance of commercial particle number (PN) PEMS by comparison with traceable particle number facilities; to include the characterisation of i) linearity and counting efficiencies ii) particle size dependence (at least up to 10^4 particles/cm^3 and four sizes), iii) dynamic flow behaviour including the determination of aerosol sampling and handling effects.
3. To develop application-oriented calibration procedures and uncertainty budgets for PEMS exhaust flow meters (EFM) for relevant carrier gases and to investigate the effect of dynamic flow behaviour on PEMS uncertainty.
4. To quantify the correlation between: i) RDE-PEMS measurements and laboratory dynamometers, ii) individual PEMS "channels" for CO_2, CO, NO, NO_2, PN, exhaust flow and iii) validated "reference" PEMS and commercially available PEMS.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by: the measurement supply chain (instrument and car manufacturers, accredited calibration laboratories), standards developing organisations (e.g. CEN, ISO) and end users (automotive industry).

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, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

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

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % 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 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.