EMPIR Call 2020 – Fundamental, Industry and Normative

Selected Research Topic number: **SRT-n05**
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New periodic technical inspection of engine exhaust emissions based on particle number concentration

Abstract

Combustion particles are closely monitored because of their role in climate change and their adverse health effects. Modern combustion engines emit smaller particles with negligible mass, but still at high number concentrations. The conventional metric, particle mass (PM) concentration fails to correctly measure the particle load in exhaust gases from combustion engines. Therefore, there is a need for a new metric, particle number (PN) concentration, and novel portable PN-measuring instruments suitable for tests directly at vehicle exhaust tailpipes. European countries have recently started to develop new PN-based technical inspection procedures for vehicles, however, global standards are currently lacking. Recently the International Organisation of Legal Metrology (OIML), established OIML TC 16/SC 1/p4 on 'New Recommendation: Instruments for measuring the vehicle exhaust soot particle number', however metrological support is needed for this Technical Committee.

Keywords

Combustion engine, exhaust emissions, ultrafine particles, black carbon, particle number concentration, particulate matter, particle mass

Background to the Metrological Challenges

Combustion particles from exhaust emissions consist mainly of black carbon (BC); as such they absorb radiation strongly and then later emit this as heat back into the atmosphere. It is estimated that the radiative forcing of soot particles can be 30 % of the radiative forcing of current CO_2 concentrations within the atmosphere. Since BC has a much shorter atmospheric lifetime than CO_2, BC mitigation strategies could rapidly slow down the rate of climate change, by up to 40 % within 20 years. In addition to the impact on climate change, ultra-fine combustion particles are also highly toxic. Ultra-fine combustion particles act as carriers of polyaromatic hydrocarbons which originate from incomplete combustion processes and have been identified as highly carcinogenic.

Because of their role in climate change and their negative effects on human health, combustion particles from vehicle exhaust have received increasing attention from the scientific community and policy makers. Currently, the periodic technical inspection of engine exhaust in most European countries is based on opacity meters, which measure light attenuation caused by particulate matter in the exhaust gas. Light attenuation is then converted into PM concentration. However, this method is insensitive to ultrafine particles and consequently, opacity meters highly underestimate the particle load in the exhaust gas and fail to detect defective diesel particle filters.

Although modern combustion engines emit smaller particles (with a lower mass), the raw emissions remain very high in terms of particle number (up to several hundred thousand particles per cm^3). Policy makers have therefore started to introduce emission thresholds based on PN for the periodic technical inspection of engine exhausts. For example, Germany and Switzerland may soon make PN-measurements obligatory for all diesel engines and other countries, such as France, Spain, South Africa and the USA are following the progress and actively participating in the new OIML TC 16/SC 1/p4 working group dedicated to the standardisation of PN-measurements of vehicle exhaust.

While PN concentration is becoming the preferred metric for measuring ultrafine particulate emissions, it is relatively new and therefore traceability needs to be extended to higher number concentrations (e.g. within ISO 27891 Aerosol particle number concentration — Calibration of condensation particle counters). There is also a need to define metrological and technical specifications for new portable PN-measuring instruments which are suitable for field tests directly at vehicle exhaust tailpipes (part of the remit of OIML TC 16/SC 1/p4).

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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 metrology research necessary to support standardisation for new periodic technical inspection of engine exhaust emissions based on PN concentration.

The specific objectives are

1. To propose technical specifications for portable PN-measuring instruments to be used for the periodic technical inspection of both diesel and gasoline engine exhaust emissions. In addition, to develop validated calibration methods and determine the measurement uncertainty for such portable PN-measuring instruments.
2. To develop a measurement protocol for measuring PN-concentration directly at an automobile exhaust tailpipe (i.e. field tests in garages). The measurement procedure should define the metrological and technical specifications for new portable PN-measuring instruments used for the periodic technical inspection of engine exhaust.
3. To prepare pre-normative guidelines for portable PN-measuring instruments as well as a validated PN-measurement protocol in order to support the newly established OIML TC 16/SC 1/p4 "New Recommendation: Instruments for measuring the vehicle exhaust soot particle number".
4. To develop new methods for extending the traceability of PN-measurements to higher PN concentrations (up to several hundred thousand particles/cm^3) in order to support the further development of ISO 27891:2015 "Aerosol particle number concentration — Calibration of condensation particle counters".
5. To contribute to the standards development work of the United Nations Economic Commission for Europe (UNECE) Particle Measurement Programme (PMP) and the committees associated with OIML TC 16/SC 1/p4 and ISO 27891:2015 to ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them (e.g. instrument manufacturers and the automotive sector), and in a form that can be incorporated into the standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR project 16ENV02 Black Carbon and 19ENV09 MetroPEMS and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 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 regulatory bodies and 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.