EMRP Call 2010 - Industry & Environment

Topic number: SRT-11e

Title: Metrology for particles and aerosols in air

Abstract

Consistent, accurate measurements of airborne particulate matter are a major problem in the enforcement of regulations designed to limit their effects on human health, for determining their effects on climate change, and understanding the relevant atmospheric chemical processes. At present a sound metrological framework for traceable, comparable measurements is lacking. The challenges concern gravimetrical measurements, which are assumed to be state of the art (but where comparability and uncertainties are highly questionable) and also for more 'advanced' routes required for sound measurements of ultrafine particles. There is a need for these issues to be addressed and for underpinning metrological research to provide greater understanding of particle size and number concentrations, measurement methodology, particle compositions, sources and distribution.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "*Grand Challenges"* related to *Environment* on pages 9 and 24-25.

Keywords

Atmospheric aerosols, air quality, size distribution, particle gravimetry, number concentration, airborne particles, validated chemical and physical methods, on-site measurements, PM10, PM2.5, ultrafine particles, particle composition, calibration, traceability, humidity

Background to the Metrological Challenges

Exposure to airborne particles is known to be hazardous to health, with numerous epidemiological studies showing the effect of increased ambient pollution [1] and especially of ultrafine combustion particles, for example [2]. Human exposure to airborne particles is therefore limited by national and European regulations, however the practical implementation of measurements to comply with legislation for PM is currently a major problem across Europe. Although particulate matter is a priority, it is only measured at comparatively few (~20) regional background stations, which is not sufficient for an integrated atmospheric observing system for air quality and climate studies. The European Parliament "calls especially on the European Commission to evaluate the need to review emission limit values and environmental quality standards in air and water legislation aiming to supplement the mass-based measurements by metrics based on particle number and/or surface to adequately address nanomaterials" [3].

There are a number of generic problems with airborne particle measurements:

- Concentrations and composition in ambient air are highly variable both temporally and spatially.
- The range of particle sources is very diverse, from natural and anthropogenic primary (directly emitted) particles to natural and anthropogenic secondary (formed from gaseous precursors) particles;
- There can be a high proportion of semi-volatile particles, such as ammonium nitrate and many organic compounds, whose presence is a function of temperature;
- Many particles are hygroscopic, so that their mass and size depends strongly on the humidity;

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- There can be significant sampling issues such as impaction (removing larger particles), diffusive losses to walls (removing smaller particles) and possibly from the flow profile at the point of sampling;
- Collecting PM on filters for subsequent analysis can bring additional sampling issues relating to chemical interactions and differing filter materials.

Traditionally the concentration of particulate matter is represented as mass concentration of particles below a certain size, typically 1, 2.5 or 10 µm, expressed as PMx, where x is 1, 2.5 or 10. However, particle number concentration has been shown to be as important or even the governing parameter in various aerosol effects. The utilization of particle-number-concentration-based control schemes is hindered by the lack of adequate measurement standards and procedures. For instance, European standards EN 12341 (PM10) and EN 14907 (PM2.5) state that there are no traceable reference standards and the outcome is only "true" by convention. The freedom within these written standards for the selection of filter materials, sampling methods and weighing conditions may however lead to errors of up to 20%. Research is needed to establish a common methodology for the validation of measurement procedures and the calibration of instruments. Attention needs to be paid to the calibration of the entire measurement system and procedure instead of just its individual components.

The need for NMIs to provide an infrastructure for number concentration has been explicitly acknowledged within ISO 24, and substantial work on this started with EURAMET comparison 1027, for particle number concentration and size, undertaken in 2008-2009. Related Key Comparisons within EURAMET and CCQM are also planned. The European EUSAAR project (European Supersites for Atmospheric Aerosol Research) states that a clear lack of coordination exists for a range of key parameters which provide the basic information required to detect any long-term change in aerosol source emissions and assess possible climatic effects of aerosols that may result from these changes. A standardization of accurate number size distribution measurements for an environmental aerosol has been developed within the EUSAAR project, which could be a starting point to develop general traceable standard techniques.

Work within CEN is in many cases supported by the participation of teams working within EMEP (European Monitoring and Evaluation Programme), a programme under the UNECE Convention on Long-range Transboundary Air Pollution. EMEP has its own set of measurement protocols, which are in some cases different from those used for regulatory ambient air measurements.

Some preliminary work on the lack of traceability of airborne nanoparticle (ultrafine) size measurement and distribution has taken place within iMERA-Plus project T3.J1.1 on 'Traceable characterization of nanoparticles' [4], where a measurement standard is being developed for traceable aerosol particle measurements (in terms of number concentration) for the range between micrometer and few tens of nanometres. Proposals should show how they would take account of this work and go beyond the existing activities.

The toxicity of ultrafine particles is related to their chemical composition and respective binding states, to their surface (including attached natural radioactive isotopes) and to their very small size. For an adequate assessment of ultrafine particles for characterising air quality, the actual mass based measurement data in aerosols are not sufficient due to their low mass concentration. The measurement of the particle number concentration, the particle number size distribution, and size-resolved chemical composition and chemical binding states in terms of core-shell/adsorbate structure is also important and not covered by the majority of existing Directives which only consider mass based measurements. The first steps for a standard to establish traceability for the number concentration and the particle diameter measurement of real combustion aerosols are achieved with the EURAMET project 1027 for a moderate size and concentration range [5]. Proposals should show how they will take account of this work to cover the range of particle sizes and number concentrations needed by industry and consumers.

Scientific and Technological 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 JRP protocol.

The general objective is to develop a sound metrological basis for measurement of "fine plus coarse" particles (PM10, below 10 µm), fine particles (PM2.5, below 2.5 µm) and ultra-fine particles and

aerosols. This concerns gravimetric measurements (mass concentration) as well as 'new' routes for fine and ultrafine particles and aerosols (e.g. number concentration, size distribution, chemical measurements, morphology).

The following objectives may exceed the budgetary scope and time frame of a typical JRP. The proposers shall prioritize accordingly, considering opportunities in later EMRP calls. The proposers shall describe how, and on the basis of what stakeholder input, they prioritise the work.

The specific objectives are:

1. Development of a rigorous metrological basis for gravimetric (mass concentration) measurement of PM10 and PM2.5 with significantly reduced uncertainties. This includes:
    a. Developing a harmonised and traceable measurement standard for gravimetric particle measurement instruments.
    b. Validation of measurement procedures with respect to e.g. influence of humidity on different filters and on size/mass of particles, flow profiles around sampling port, water sampled onto filters.
    c. Generation of a stable aerosol, characterisation of the generated aerosol and the implementation of a suitable calibration test bed.
    d. To develop a route from the presently used "mass defined sampling" to a "size and number concentration sampling".

2. Develop a metrological framework and a coherent set of parameters for measurements of fine (<~2.5 µm) and ultrafine (<~100 nm) airborne particulate matter. This includes:
    a. Measurement of parameters such as number concentration, size distribution, morphology, chemical composition.
    b. Development of particle generators producing stable and reproducible aerosol, characterisation of the generated aerosol and the implementation of a suitable calibration test bed.
    c. Definition of methodologies and processes to achieve metrological defined traceability for particle number concentration, number size distribution, shape and surface area, and chemical composition.
    d. Develop a calibration infrastructure with robust uncertainties, through close interaction with those involved in site measurements, such that all relevant aspects of the measurement chain are covered.

Proposers shall give priority to work that meets documented stakeholder needs and may include measures to facilitate the development of European standards and Directives.

Proposers should establish the current state of the art including that associated with the iMERA-Plus project T3.J1.1 on 'Traceable characterization of nanoparticles' and the EURAMET 1027 comparison, and explain how their proposed project goes beyond this.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links with the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project. In your JRP submission please detail the impact that your proposed JRP will have on the Directives:

You should also detail other impact of your proposed JRP as detailed in the document "Guidance for writing a JRP"

You should detail how your JRP results are going to:

- feed into the development of urgent standards through appropriate standards bodies
- transfer knowledge to health, air quality monitoring and affected industrial sectors, together with regulatory and policy makers.
- affect economic issues associated with air pollution.

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of 3 years duration.

Additional information

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

[1] WHO (2004): Health aspects of air pollution, results from the WHO project “Systematic review of air pollution in Europe”: www.euro.who.int/document/E83080.pdf

[2] Tobias Stoeger et al. (2009) Deducing in Vivo Toxicity of Combustion-Derived Nanoparticles from a Cell-Free Oxidative Potency Assay and Metabolic Activation of Organic Compounds, Environmental Health Perspectives, vol 117:1, p54-60

[3] European Parliament resolution of 24 April 2009 on regulatory aspects of nanomaterials, P6_TA(2009)0328

[4] Joint Research Project T3.J1.1 Nanoparticles: http://www.euramet.org/index.php?id=jrps

[5] Jürg Schlatter (2009) EURAMET project 1027 – Comparison of nanoparticle number concentration and size distribution. Report http://www.euramet.org/index.php?id=tc-projects