

## Title: Metrology for marine exhaust gas pollution

### Abstract

Ship engines are the second largest source of sulphur emissions after power plants/industry. Air pollution from ships contributes to overall air quality problems and it has direct health effects on the population e.g. in coastal regions, and in harbour cities. The International Maritime Organisation (IMO) have tightened the regulations for air pollution and GHG emissions from ships and the European Council of Ministers used IMO regulations to control the sulphur content of marine fuels. As the economic advantage of using fuels with higher sulphur contents is large, especially in the Sulphur Emission Control Areas, there is a need for accurate measurements to verify that ships are complying with the new regulations. Multi dilution static volumetric methods need to be improved, spectroscopic techniques need to be evaluated to see if they are suitable for performing traceable measurements in harbours based on open path detection, stack emissions from ships need to be sampled and measured, gas standards for multi-component ship exhaust gases need to be developed and a SO<sub>2</sub>/CO<sub>2</sub> measurement method for determining the sulphur content in marine fuels (2012/33/EU) needs to be developed.

### Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Energy and Environment on pages 24 and 40.

### Keywords

Marine fuels, sulphur, SO<sub>2</sub>, NO, NO<sub>2</sub>, CO<sub>2</sub>, GHG compounds, optical methods, reference standard, gas mixtures, measurement techniques, spectroscopy, stack emissions, pollution, particulates, traceability, 2012/33/EU

### Background to the Metrological Challenges

Air pollution from ships has a cumulative effect on air quality (e.g. 2.7 % of global CO<sub>2</sub> in 2007) and on the natural environment, especially in harbour cities. For example, shipping-related particulate emissions have been estimated to cause approx. 60 000 cardiopulmonary and lung cancer deaths annually. These pollutants can also cause environmental harm to plants and aquatic animals through acid rain and the increase in eutrophication through nitrogen deposition. In particular, NO<sub>x</sub> emissions contribute to ground level ozone and to global warming. In response to these issues, the international agreement defined in the MARPOL Annex VI [1] limits the main air pollutants and it prohibits deliberate emissions of ozone depleting substances. Sulphur limits were reduced to 3.5 % (from 4.5 %) in 2012 and if feasible they will be reduced to 0.5 % in 2020. The limit in Emission Control Areas for fuel sulphur content was reduced to 1 % (from 1.5 %) in 2010 and it will be reduced to 0.1 % in 2015. Similar progressive reductions in NO<sub>x</sub> emissions are also planned. SO<sub>2</sub> emissions from ships in harbours have been implemented in the EU since 2010. Directive 1999/32/EC has been updated into a new directive about the sulphur content of marine fuels (2012/33/EU) [2] to strengthen MARPOL regulations in Europe. In addition to the direct analysis of sulphur in marine fuel, measurements of the ratio of SO<sub>2</sub>/CO<sub>2</sub> and NO<sub>x</sub>/CO<sub>2</sub> in emissions as well as in ship plumes in ambient air could provide reliable estimates of the sulphur content in the marine fuels and the engine power weighted NO<sub>x</sub> emission rate. The online measurement of the ratios of SO<sub>2</sub>/CO<sub>2</sub> and NO<sub>x</sub>/CO<sub>2</sub> may provide an effective way to ensure that ship owners comply with these emissions regulations. The emission control of cruise liners in hotel mode would be a desirable complement to these measures [3, 4]. As a result of these new standards current measurement techniques and the available sample gases available have to be enhanced by European NMIs.

## 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 JRP shall focus on the traceable measurement and characterisation of marine fuel exhaust gases and particulates. In particular, the JRP will develop and validate measurement techniques for the traceable quantification of relevant marine fuel exhaust gases (MARPOL Annex VI), at concentration levels applicable for emission measurements and measurements in plumes of ship emissions in ambient air.

The specific objectives are

1. To improve multi dilution static volumetric methods with the aim of achieving traceable, low concentration levels of SO<sub>2</sub>, NO and NO<sub>2</sub> calibration gas mixtures and GHG compounds.
2. To evaluate if spectroscopic techniques are suitable for performing traceable measurements in harbours based on open path detection.
3. To sample and measure stack emissions from ships using sensors mounted on an unmanned airborne vehicle. In addition, the size distribution and chemical composition of the particulates should be quantified.
4. To develop gas standards for multi-component ship exhaust gases.
5. To develop and validate an SO<sub>2</sub>/CO<sub>2</sub> measurement method for determining the sulphur content in marine fuels (2012/33/EU).

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 R&D work, the involvement of the user community such as industry, and standardisation and regulatory bodies, as appropriate, is strongly recommended.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this and EMRP JRP ENV01 (MACPoll) 'Metrology for Chemical Pollutants in Air'.

EURAMET expects the average size of JRPs in this call to be between 3.0 to 3.5 M€, and has defined an upper limit of 5 M€ for any project. Any proposal received for this SRT is expected to be significantly below 3.0 M€. The available budget for integral Research Excellence Grants is 30 months of effort.

## Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to 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.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to enable marine exhaust gas pollution to be reduced

You should detail other impacts of your proposed JRP as detailed in the document "Guide 4: Writing a Joint Research Project"

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 and includes 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 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 NMI 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] The Protocol of 1997 (MARPOL Annex VI)  
<http://www.imo.org/OurWork/Environment/pollutionprevention/airpollution/pages/the-protocol-of-1997-%28marpol-annex-vi%29.aspx>
- [2] Directive 2012/33/EU of the European Parliament and of the council as regards the sulphur content of marine fuels.
- [3] Survey Report on behalf of the Freien und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt, (in German only) „Realisierbarkeit von Landstromanlagen an den Hamburger Kreuzfahrtterminals HafenCity und Altona“, report no. 90159-01e, 2011
- [4] 2006/339/EC, “Commission Recommendation of 8 May 2006 on the promotion of shore-side electricity for use by ships at berth in Community ports”