

# European Metrology Programme for Innovation and Research

Delivering Impact



Courtesy Air Liquide



## New reference standards to support engine emission monitoring

Air pollution is a leading cause of premature death in Europe. Major contributors to this are nitrogen oxides (NO<sub>x</sub>) such as nitrogen dioxide (NO<sub>2</sub>) emitted by motor vehicles. To meet Europe's 2050 aim of reducing these pollutants to levels not considered harmful, monitoring instruments must be accurately calibrated with robust links to the SI.

### Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

# Challenge

Nitrogen dioxide (NO<sub>2</sub>) gas is a harmful pollutant mainly produced by the combustion of fossil fuels. It can react with water in the atmosphere to form nitric acid (HNO<sub>3</sub>), producing acid rain, harmful to vulnerable ecosystems. In humans, it can impair lung function and exacerbate respiratory conditions and is a precursor of ground-level ozone and fine particulate matter (PM 2.5) - which together lead to around 300 000 premature deaths in Europe each year.

The revised Air Quality Directive of 2024 targets a 50% reduction of NO<sub>2</sub> atmospheric levels from 40 µg/m<sup>3</sup> to 20 µg/m<sup>3</sup> by 2030 and, to further reduce this and other pollutants, the EU Zero Pollution Action Plan aims to achieve levels to those not considered harmful by 2050.

As more than 30% of NO<sub>2</sub> is generated by road transport, in 2016 the EU introduced the Real Driving Emission (RDE) regulation, requiring car makers to test emissions directly at a vehicle's tail pipe under real-world conditions. To do this, "Portable Emission Measurement Systems" (PEMS) are used, which require accurate calibration with reference gases. However, NO<sub>2</sub> can react with trace water or other gases in cylinders and can also adhere to the inside of sampling tubes. This reduces the stability of reference materials, especially at the low-level concentrations required for emission monitoring, leading to increased measurement uncertainty which poses a barrier to the accurate calibration of measurement instruments.

# Solution

During the MetroPEMS project, fifteen NO<sub>2</sub> standards at 1 and 10 µmol/mol were produced using gravimetric preparation by LNE and NPL, the National Metrology Institutes (NMIs) of France and the UK, and the company Air Liquide.

These were prepared in pre-dried synthetic air and stored in two different passivated cylinder types (aluminium or steel). These were then transferred to NPL where their stability was assessed for more than 12 months and levels of nitric oxide (NO) were measured using chemiluminescence and NO<sub>2</sub> by Non-Dispersive Ultraviolet or Cavity Attenuated Phase Shift spectroscopy. The amount of contaminating HNO<sub>3</sub> was calculated by subtracting these values from the total nitrogen species present.

In addition, VSL (the NMI of the Netherlands), NPL and Air Liquide produced nine reference standards in synthetic air at 500, 1 500, 2 000 and 2 500 µmol/mol.

Results indicated a good stability for all gases, with a relative measurement uncertainty of around 3.5 % or less over 14 months.

# Impact

For over 120 years, Air Liquide has provided gases, technologies and services for industry and health. Due to their expertise in producing reference gases, they were invited to join the MetroPEMS consortium to help generate the low-level NO<sub>2</sub> gas mixtures. The company has now expanded its comprehensive range of ISO 17025 accredited NO<sub>2</sub> calibration gases, such as its ALPHAGAZ™ MIX range which can be used for calibrating PEMS, catalytic converters, or exhaust gas analysers.

During the project, Air Liquide also worked with VSL to produce six multicomponent reference standards containing NO<sub>2</sub>, NO,

carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>) – mixtures considered extremely challenging to manufacture by many other companies working in this area.

The company acknowledges that working closely with some of the world's most prestigious NMIs has allowed them to assess the stability of highly reactive gases in cylinders, as well as providing SI traceability and demonstrating the accuracy of their products to their customers.

The reference gases produced in MetroPEMS will help the automotive industry to demonstrate compliance to EU regulations and directives on emissions, whether it be measurements from automobiles, industrial stacks or environmental monitoring stations.

## Providing the metrology to support emission legislation

The MetroPEMS project addressed an urgent need for new emission metrology.

The project:

- developed SI traceable measurements for NO<sub>2</sub>, and particle number (PN) including proving particle penetration and the assessment for flow.
- prepared static mixtures containing nitrogen dioxide at concentrations of 1 and 10 µmol/mol which were subjected to stability assessments over durations exceeding 12 months.
- performed an instrument intercomparison for linearity, particle counting efficiency and particle concentration dilution factor in three different laboratories.
- provided an uncertainty budget in representative RDE-driving conditions and SI-traceable calibrations for two exhaust flow meters.
- developed and deployed a "golden" PEMS device along with a transfer standard for particle number (PN) calibration.
- successfully demonstrated solutions enabling in-field linearity checks for PN PEMS analysers used in RDE tests.

By providing high quality reference standards and traceability to PEMS measurements, this project supported the improvement of air quality across the EU.



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[www.euramet.org/19ENV09](http://www.euramet.org/19ENV09)

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