EMRP Call 2013 – Energy and Environment

Selected Research Topic number: **SRT-g05**
Version: 1.0

Title: Metrology for hydrogen transport

Abstract

Hydrogen metering remains a challenge and metrological tools, test methods and regulations need to be developed for use with the hydrogen technologies that have been developed for transportation and refuelling. The operating conditions, comprising a large temperature window (-30 °C to +50 °C), a large dynamic range (< 0.1 kg/min to 4 kg/min) and a large pressure window (10 bar to 800 bar) are unlikely to be realised by the NMIs. Stakeholders with existing European test rigs for hydrogen metering should be identified so that the test rigs can be transformed into the required standards. Metrologically sound and accepted models of the influence of process conditions on flow metering will also need to be developed at these operating conditions.

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 8 and 23.

Keywords

Hydrogen, filling station, modelling of influence parameters, verification, regulation, consumer protection, leak detection, leak measurement, hydrogen gas flow, leakage

Background to the Metrological Challenges

Fuel cells and hydrogen technologies have been recognised as a key technology by "The European Strategic Energy Technology Plan (SET Plan)" [1]. This led to the "Fuel Cells and Hydrogen Joint Undertaking" [2] which brings public and private interests together with the objective of accelerating the commercialisation of hydrogen and fuel cell technologies. The "Power to Gas" process is used in hydrogen production. This is where excess electrical power is used to produce hydrogen by electrolysing water. Currently, there are no reliable standards for hydrogen metering. The development of a standard to guarantee traceability for such a challenging environment is an urgent requirement for the calibration of flow sensors as the automotive industry has pledged to bring fuel-cell cars to market by 2015. Such a standard would support the use of flow sensors and would help to develop and adapt test methods. Mandate M/349 will elaborate a feasibility study in the area of hydrogen and fuel cells [3].

A metrological framework and traceable schemes for the flow meters used in hydrogen applications need to be developed, flow meters need to be characterised and a procedure for the verification of hydrogen dispensers needs to be developed. In parallel to this, hydrogen leak testing and measurement should be developed so that hydrogen technologies are safe. Traceability up to primary standards and information about outflow under real conditions is required. Metrological standards and methods have to be developed, principles of hydrogen detection evaluated and a theoretical understanding of hydrogen gas flow measurement improved to enable European guidelines and standards to be developed for hydrogen leak measurements.

There is currently only one international standard, SAE J2601, which establishes safety limits and performance requirements for gaseous hydrogen fuel dispensers. Several demonstration hydrogen filling stations exist in Europe and verification is performed by weighing the amount of hydrogen delivered. No devices with type approval currently exist and this could hinder the introduction of hydrogen-powered vehicles as no reliable billing system would be available at the fuel dispenser.

Technically hydrogen gas is considered to be one of the most suitable gas species for leak detection and measurement. Not least because it has the highest ability to flow through extremely narrow ducts, but also because some methods of hydrogen detection are very sensitive and relatively inexpensive. Currently, helium is employed in leak detection more often than hydrogen because hydrogen is flammable, explosive and has higher background levels which can lead to measurement uncertainty. However, the use of hydrogen gas is likely to increase in the near future as the cost of helium is increasing as the supply is declining. In addition, hydrogen will need to be used to test for leaks in the equipment for the production, distribution and end-use of hydrogen in the hydrogen based economy. Metrologically sound guidelines, rules and recommendations need to be developed for this purpose.

Although hydrogen is more environmentally-friendly than most other energy carriers, the mass application of hydrogen technologies has been delayed by hydrogen storage issues and by safety concerns i.e. it is highly flammable in its gaseous phase and it creates explosive mixtures with air. To ensure the safe application of these technologies a metrological system of hydrogen leakage testing and of the measurement of the equipment for the production, distribution and end-use of hydrogen with traceability to primary standards needs to be developed. A metrological system of leakage measurement utilising other gas species also needs to be developed (i.e. hydrogen is often mixed with some other inflammable gas species). However, this can lead to an additional level of uncertainty during leak measurement. The majority of the detection and measurement principles developed for the other gas species are also suitable for hydrogen. However, some of this knowledge cannot readily be transferred to hydrogen due to its unique properties (i.e. its very low molecular mass, its very high heat conductivity, its ability to flow in molecular conditions, its high solubility and its permeability in many metals). These unique properties can influence hydrogen flow through leaks, its detection and the uncertainty of such measurements. Some hydrogen specific detection principles are known, which could make the equipment cheaper and more versatile but, these principles have yet to be evaluated metrologically.

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 safe hydrogen technologies for use in transportation and refuelling.

The specific objectives, to be covered over the temperature range of -30 °C to +50 °C and pressures up to 80 MPa, are

1. To develop safe measurement methods and measurement capabilities for traceable hydrogen flow measurements covering the range of flow from less than 0.1 kg/min to 4 kg/min.
2. To test and evaluate hydrogen quantity metering systems and develop a procedure for the verification of hydrogen dispensers.
3. To develop traceable hydrogen leak measurement methods and measurement capabilities for hydrogen leak testing giving information about leakages under real conditions.
4. To improve the understanding of hydrogen-specific effects under operation conditions with influence to hydrogen flow and leak measurements and uncertainty evaluation of measurements.

It is expected that the JRP-Consortium will include partners from the hydrogen technology user community, such as the automotive industry and inspection bodies, in order to enhance the impact and development of guidelines and standards.

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. Reference should also be made to work being undertaken in the FCH JU FP7 Joint Technology Initiative [2].

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. 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 for use in the hydrogen economy

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 NMIs 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] SET-Plan, further information can be found at http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

[2] FCH JU is a Joint Technology Initiative (JTI) within the 7th Framework Programme FP7.

[3] EC Mandate M/349, Mandate addressed to CEN, CENELEC and ETSI for the elaboration of a feasibility study in the area of hydrogen and fuel cells.