EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

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

Title: Metrology for hydrogen vehicles 2

Abstract

Climate change, air quality and reliance on imported fuels from non-renewable sources require immediate deployment of alternatives such as hydrogen to meet the 2050 Europe carbon neutral targets (net-zero emission from transport). Hydrogen fuel cells are an alternative power supply for electric drive trains and could represent 32 % of fuel demand by 2050. Current barriers to mass implementation of hydrogen in transport arise from European Directive 2014/94/EU and OIML recommendations that must be met by all European hydrogen refuelling stations. Several measurement challenges have been identified by stakeholders (e.g. online analysis, sampling, fuel standards) that currently prevent the hydrogen market from mass adoption.

Keywords

Hydrogen, renewable, energy, fuel cell, vehicles, refuelling stations, gas analysis, hydrogen sampling, flow metering.

Background to the Metrological Challenges

Fuel cell electrical vehicles (FCEV) have been rolled out worldwide with more than 8000 vehicles on the road. The number of hydrogen refuelling stations (HRSs) is increasing across Europe (> 100 HRSs in 2018) to support FCEVs roll-out. Hydrogen is now moving towards new transport sector areas (i.e. heavy duty FCEV, train). However, measurement challenges are still preventing the overall sector from growing quickly enough to meet 2050 targets of the European Commission in line with the COP21 agreement. These measurement challenges arise from international regulations and recommendations; some enforced by European Directive 2014/94/EU. Continuing on from the results of the EMPIR project 16ENG01 - MetroHyVe, good practices guides, standards and reliable measurements are required to resolve the urgent measurement challenges for the industry and end-users in the areas of flow metering, fuel standards, hydrogen sampling and investigations on critical contaminations in hydrogen.

The accuracy achieved at HRS dispensers is at best ± 5 %, when for better public billing purposes higher accuracies (i.e. ± 2 % or ± 4 % in accordance to OIML R139-1) are required, depending on local implementation of OIML recommendations. Flow metering need to be accurate at 700 bar at temperatures as low as -40 ºC. In 16ENG01-MetroHyVe, primary standards are being developed for regular FCEV with uncertainties of 0.3 %. For the higher flow rates and total mass associated with heavy-duty FCEV, new standards may need to be validated. If heavy duty FCEVs are developed for example for public transport buses, traceability of these measurements needs to be assured by development of new primary standards or a transfer standard (traceable to the 16ENG01 - MetroHyVe primary standards). For faster and more cost-effective testing of HRS, secondary standards would also need to be developed to allow faster verification or in service inspection while refuelling a FCEV using an HRS in service, for which the maximum permissible error can range from 2 % to 5 %.

According to European Directive 2014/94/EU, HRSs shall comply with ISO 14687-2 which provides maximum limits for 14 contaminants. These contaminants cause degradation of the FCEV and dramatically reduce its lifetime. End users require quality control RMs to evaluate commercial laboratory performance and ensure measurement reliability. As for conventional fuel, the automotive industry is looking towards hydrogen fuel RMs to be used as trade standard, quality control material for offline and online analysis or for international equivalence (inter-laboratory comparison). EN 17124 mentions that hydrogen quality can be continuously monitored for key contaminants. Whereas few online instruments have been tested at HRS, no metrological guidelines are available for their operations at HRS (i.e. drift, calibration, validation). Reliable online analyses at HRS are needed to ensure continuous operation, avoid contaminant transfer from HRS to FCEV and therefore justify lowering the frequency of offline analysis. 16ENG01 - MetroHyVe supported the validation of online analysers in the laboratory. Some companies organised field trials, but the results are confidential and therefore impossible to replicate. These field trials reported hydrogen contamination due to specific events

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(i.e. maintenance). Considering the importance of contaminant monitoring onsite, online analyser and sensor are key for the industry and need to be studied in the field over long periods to provide metrological guidance on implementation and operation.

Sampling standardisation is an industrial need requiring experimental comparison, metrological understanding and reproducibility studies to ensure European and worldwide equivalence in measurements (i.e. ASTM-D7606 does not follow the whole refuelling event). 16ENG01 MetroHyVe worked on sampling guidance but new sampling equipment is now coming into market (i.e. Hy-Lab). Sampling is currently not standardised at HRS nozzle and at other locations leading to potential discrepancies between methodologies. Secondly, contaminants stability in the gas phase has not been studied at the EN 17124 thresholds. Therefore, the reliability of hydrogen fuel sampling is currently unknown. Contaminant stability is a challenge to ensure reliable measurement in safe conditions. Furthermore, hydrogen sampling should be developed at other locations of the supply chain including at the FCEV. Understanding contaminant origins is critical and requires safe and reliable measurements.

The contaminant thresholds in ISO 14687-2 and EN 17124 are based on experimental studies using different methodologies. Fuel cell (FC) stack testing using an anode recirculation loop is most representative of an actual FCEV system. The testing procedure requires standardisation to allow inter-comparability of the results. Several operational parameters may affect the final results, in particular crossover gases from the air side to the hydrogen side (N_2, O_2, CO_2). Single cell testing was recently standardised in IEC TS 62282-7-1. EU harmonised test protocols in single cell configuration for automotive applications has been developed by EU-JRC (guidelines published in 2015), now progressing toward a proposal for standardisation of FC hardware. These guidelines do not include FC stack testing, which also requires a similar level of standardisation and which is not currently available. Several test protocols for assessing FC stack performance and durability exist without a set of reference operating conditions representative of automotive applications. Studying and defining the critical parameters in FC stack testing with a recirculation loop will allow step forward in reliability of contaminant impact studies. This will support equivalence worldwide (Europe, North America and Asia) and provide solid and reliable evidence for future revision of ISO 14687 and EN 17124.

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 the development of metrological capacity in order to support the European hydrogen industry

The specific objectives are

1. To develop new primary standards (< 1 % accuracy) or a transfer standard (< 5 % accuracy) for testing hydrogen meters used to measure the mass of hydrogen dispensed from a hydrogen fuelling station (HRS) into small (i.e. motorcycle, bicycle) or heavy-duty fuel cell electrical vehicles (FCEV) (i.e. truck, train).
2. To develop reference materials (RM) suitable to monitor hydrogen quality laboratory performance by proposing the first inter-laboratory comparison on hydrogen fuel including all contaminants regulated in EN 17124 and ISO/DIS 14687. In addition, to produce guidelines for the validation and calibration of online analysers at HRS over long periods and make recommendations to ISO/DIS 21087 for the online analysers and sensors.
3. To improve hydrogen sampling methods by establishing and validating sampling methods and procedures. In addition, to develop Good Practice Guides on hydrogen sampling at HRS nozzle and other locations (e.g. FCEV) in order to provide input for the revision of ISO 19880-1.
4. To develop standard test protocols for automotive FC stack testing with online analysis to determine threshold limits for critical contaminants in hydrogen, as well as a good practice guide on measuring the impact of contaminants on FC stacks, including a detailed description of the parameters that should be monitored.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (hydrogen quality laboratories, instrument manufacturers), standards developing organisations (ISO/TC 197, CEN/CENELEC and IEC TC105) and end users (hydrogen fuelling stations, vehicle manufacturers).

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 research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

In particular, proposers should outline the achievements of EMPIR project 16ENG01-MetroHyVe and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

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 the Hydrogen Fuel Transport 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.