Title: Metrology for hydrogen vehicles 3

Abstract

The number of hydrogen refuelling stations in the European Union (EU) will increase significantly over the coming years, as stipulated in the EU Regulation 2023/1804 on the deployment of alternative fuels infrastructure. The hydrogen refuelling infrastructure is maturing rapidly: achieving higher flow rates for fast heavy-duty refuelling, tapping into new hydrogen sources to guarantee sufficient supply, and reducing downtime to cope with the increasing demand. To support these developments, proposals addressing this SRT should aim to develop metrology infrastructure, providing new measurement standards, methods, and best practices for measurement of both hydrogen quality and quantity.

Keywords

Hydrogen, heavy duty vehicles, refuelling stations, flow metering, quantity, sampling, gas analysis, sensors, hydrogen quality

Background to the Metrological Challenges

In 2023, The Council of the European Union has adopted a new Regulation on the deployment of alternative fuels infrastructure (AFIR) [1], supporting the European Green Deal. The Regulation sets specific deployment targets that will have to be met in 2025 or 2030. Regarding hydrogen refuelling stations (HRS), the target is set to have HRS in all urban nodes and every 200 km along the so-called 'Trans-European Transport Network' (TEN-T), to serve both cars and lorries, from 2030 onwards. Consequently, the number of HRS will increase significantly over the coming years. Furthermore, the Regulation notes that in the hydrogen strategy for a climate-neutral Europe, the heavy-duty segment was identified as the most likely segment for the early mass deployment of hydrogen-powered vehicles. Hydrogen refuelling infrastructure should focus on that segment initially, while also allowing light-duty vehicles to fuel. Moving towards a market focused on heavy-duty applications, refuelling protocols are being developed with higher flow rates and vehicles with larger storage capacity, to keep refuelling frequency and duration as low as possible. Additionally, the AFIR states that users of hydrogen-fuelled vehicles must be able to pay easily at refuelling points with payment cards or contactless devices, without a need for a subscription and in full price transparency. To achieve this, HRS must adhere to local legal metrology requirements, where most European countries rely on certification according to OIML R139. Furthermore, the quality of the hydrogen should comply with EN 17124. Similar requirements for hydrogen as a fuel for mobility are noted in ISO 14687.

In recent years, the European metrology community has made considerable progress on quality (gas composition and particulates) and quantity (delivered mass) measurements at HRS, notably in the EMPIR projects 16ENG01 MetroHyVe and 19ENG04 MetroHyVe 2, and the ongoing Metrology Partnership project 22NRM03 MetHyTrucks which deals with the standardisation of sampling. However, numerous challenges that needs to be addressed remain.

There are several gravimetric (primary) standards for light-duty vehicles in operation in Europe, most of which were developed in the EMPIR project 16ENG01 MetroHyVe. The EMPIR project 19ENG04 MetroHyVe 2 has delivered a few gravimetric standards for larger delivered mass and first experiences with secondary standards (master meters). However, their respective storage capacity (up to 24 kg) and operating flow rates are limited. Type approval testing with primary standards, required for OIML R139 certification, takes several days to complete. Building on acquired knowledge, gravimetric standards for quantities up to 100 kg and 18 kg/min are considered unfeasible, so that alternative strategies (e.g., using parallel master meters) must be developed. Additionally, the type approval process for flow meters relies on field measurements with hydrogen at an HRS, which is costly. Research is required to find out if alternative calibrations using surrogate fluids could be a suitable replacement for field measurements.

The metrological verification of HRS takes a significant amount of time, reducing the availability of the HRS for customers. Due to the pressure on a small number of HRS supplying a quickly growing fleet of hydrogen vehicles, any downtime leads to serious customer dissatisfaction and loss of business. A promising way to reduce downtime is by integration of the different processes of sampling for quality and measuring for quantity. So far, there are no parties which offer this combined service. There are numerous practical difficulties in achieving this combined service, for example, the quantity of hydrogen needed for sampling gas quality should still be measured by the flow standard. Hence, research and development are needed to make this a reality.

Robust sensor technology is crucial for the operation of HRS. However, sensor development for HRS is complex due to the risks associated with flammability and the measurement challenges. There is a lack of metrological procedures and infrastructure to test sensors in a hydrogen matrix within the expected range. Only a few laboratories have such capabilities and often provide limited pressure or flow ranges. Suitable test capabilities are critical to speed up the development and implementation of sensors at the required pace. Once installed, online sensors and analysers need to be verified and calibrated at the HRS to limit downtime of the HRS. It is crucial to develop deployable and transportable standards, as currently, there are only few.

The hydrogen market is evolving quickly and new ways to produce, transport and store hydrogen are being developed. Depending on the source, hydrogen can contain various impurities, which may have detrimental effects to hydrogen-powered vehicles. So far, most hydrogen is produced either from electrolysis or steam-methane reforming. Following the evolution of the market, hydrogen from novel sources should be investigated to find all relevant impurities. The demand of heavy-duty HRS will require a flexible supply chain and understanding the new quality challenges associated to this is critical. The new impurities need to be identified quickly, so that standardisation in this field can follow the rapid technological advancements in the hydrogen market, and quality incidents can be avoided.

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 proposal shall focus on the development of metrology infrastructure to support the measurement of hydrogen quantity and quality at hydrogen refuelling stations.

The specific objectives are:

1. To extend the existing flow measurement traceability to very high flow refuelling of heavy-duty vehicles (up to 18 kg/min) and to demonstrate its applicability to larger vehicles (e.g. ships, trains, planes). To investigate the potential of surrogate flow meter calibrations by calibrating most frequently used HRS flow meters using hydrogen in HRS operating conditions and surrogate fluids (water, nitrogen, and air). In addition, to determine measurement uncertainty at the HRS dispenser of the meter calibrated by surrogate fluids only.
2. To develop a universal integrated HRS metrology verification method, deploying traceable flow standards and validated sampling systems during the same site visit, to verify hydrogen quality (particulates and gas composition with focus on main and most common sources of impurities) and dispenser accuracy in less than 50 % of the current sampling and verification time, maintaining the required measurement performance, at light-duty and heavy-duty HRS (upgradable for larger applications, e.g., ships, trains, planes).
3. To develop traceable and deployable methods and test procedures to test sensors and analytical instruments for online monitoring (for quality, safety, and process control) in a laboratory environment and to demonstrate their use in real life conditions at HRS. Test procedures will include validation, calibration/testing, quality control and influence parameters specific to the location of the measurand. To develop primary standards to perform on-site calibrations of sensors and analysers in real conditions.

4. To extend the knowledge on hydrogen quality by analysing a representative number of real-life samples (> 40 samples) with sample intervals and frequency reflecting the complexity and size of the energy infrastructure, using calibrated analysers (e.g., in-line or via a sampling container). The analysis will consider various sources: production, transportation, or storage (e.g., gas grids, ammonia cracking, LOHC, underground or chemical storage) and chemical compounds outside of the EN 17124 and ISO 14687 specifications.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers, notified bodies), standards developing organisations (OIML, ISO, CEN), and end users (e.g., HRS operators, hydrogen vehicle manufacturers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. Proposers shall give priority to work that meets documented needs, in particular those supporting the European Green Deal. 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 the EMPIR projects 16ENG01 MetroHyVe and 19ENG04 MetroHyVe 2, and the Metrology Partnership project 22NRM03 MetHyTrucks, and how their proposal will build on those.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.8 M€ and has defined an upper limit of 3.5 M€ for this proposal.

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

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

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 proposal’s 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,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the hydrogen 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 the Metrology Partnership 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.

Timescale

The project should be of up to 3 years duration.

Additional information

The links provided in this section are only correct at the time of publication up until the end of the Call year.

The reference below was provided by PRT submitters; proposers should therefore establish its relevance.

[1] Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU. http://data.europa.eu/eli/reg/2023/1804/oj