European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-s08**
Version: 1.0

Title: Flow measurement traceability for hydrogen in gas networks and storage

Abstract

Hydrogen is key to achieving the decarbonisation of energy systems in European nations. Accurate flow measurement will underpin the use of hydrogen in future energy systems as it does now for natural gas. There are currently insufficient testing and calibration facilities for industrial flow meters used in the gas networks at distribution and transmission scale and in the geological storage of hydrogen. Where the metrological infrastructure for gas meters does exist, testing with hydrogen introduces additional cost burdens to manufacturers and notified bodies. Proposals should establish new metrological infrastructure for industrial gas meters used with hydrogen, including comparing calibration results for flow meters using hydrogen and alternative fluids for determining the transferability between different gases, and to use this information as the basis for establishing safer and more cost-effective calibration methods for flow meters.

Keywords

Hydrogen, hydrogen-enriched natural gas, flow metering, gas networks, gas storage, gas distribution, gas transmission, decarbonisation

Background to the Metrological Challenges

The European Green Deal commits EU Member states to making Europe the first climate neutral continent by 2050, with the current goal to reduce net greenhouse gas emissions by at least 55 % by 2030, compared to 1990 levels. This requires radical changes to how the EU generates, distributes, stores and consumes energy, supported by large-scale carbon-free power generation, increased energy efficiency and the decarbonisation of transport, buildings, and industry. Hydrogen is one of the key energy sources to enable this transition, with the potential to provide energy with low or even net-zero greenhouse gas emissions. Decarbonisation of transport and of heat can be achieved through the use of fuel-cell electric vehicles and introduction of hydrogen to the gas networks respectively. In addition, hydrogen provides a clean burning option for industrial combustion processes that cannot be converted to electrical heating. Hydrogen can be transported over long distances (by pipeline, compressed gas or liquid storage vessels, metal hydrides or conversion to ammonia), facilitating efficient trade within and between countries.

New metrological techniques and testing infrastructure are required to support the use of hydrogen. Flow measurement in particular is required for process monitoring and control, for fiscal metering, for billing and at each point of custody transfer. The need for traceability for hydrogen flow measurement in the gas network was identified in the strategic research agenda of the EMN for Energy Gases. The Partnership project 21GRD05 Met4H2 addresses a number of topics related to the measurement infrastructure for hydrogen, but flow metering forms only a part of the project and the research does not consider aspects such as cost effective calibration routes and the transferability of calibrations using gases other than hydrogen. While many of the existing flow measurement technologies are applicable, the distinct physical properties of hydrogen present challenges for instrumentation previously optimised for use with natural gas. Additionally, there is no single flow measurement technique which is suitable to every hydrogen application. The emerging flow measurement needs for hydrogen vary greatly in terms of flow rate ranges and pipe sizes, hydrogen purity levels, and operating pressures and temperatures. Selection of an appropriate meter technology must be tailored to the specific application, and in many cases calibrated under representative conditions. This necessitates the development of new primary flow standards and calibration facilities of greatly differing sizes and operating ranges. The required infrastructure is very expensive, not only to cover wide operating ranges and operate safely with hydrogen, but also to reach the lowest possible measurement uncertainty. For example, to calibrate a flow meter to MID Accuracy Class 1.0, the measurement uncertainty of the facility should be 0.33 % or less.

For residential metering flow meters have been developed for use with both hydrogen and hydrogen enriched-natural gas, and well-developed metering and calibration options for residential gas billing and for dispensing to light duty hydrogen vehicles now exist. Since both these applications are relatively small scale, it was economically feasible for several measurement institutes to develop their own flow standards and calibration loops. However, manufacturers have noted that testing with hydrogen is much more expensive than with air, and there is significant interest in establishing more cost-effective methods for type approval. The UK HyDeploy project found that the error curves for most of the domestic gas meters tested were very similar for pure methane compared to a 20 % hydrogen blend with methane. The results suggested that for diaphragm meters, the established practice of accuracy testing with air may still be appropriate for meters operated with hydrogen/natural gas blends. The EMPIR project 18NRM06 NEWGASMET provided accuracy data for several residential gas meters operated with pure hydrogen, but the sample was not large enough for an overall assessment of the feasibility of calibrating with air (or alternative fluids) and applying a correction for use with hydrogen.

Multi-path ultrasonic meters are one of the most popular options for fiscal metering of natural gas and are expected to fulfil a similar role for hydrogen in the future. However, these meters are typically designed for larger pipe sizes (DN50 minimum), hence testing with pure hydrogen at relevant flow rates is not possible with existing flow calibration facilities. Larger flow meters (typically rotary and turbine) are used in gas distribution networks for flow rates of up to 2000 Sm^3/h and pressures up to 16 bar. Calibration facilities for these meters for hydrogen blends of up to 30 % in natural gas exist, but not for pure hydrogen. There are no accredited flow facilities for calibration with hydrogen or hydrogen/natural gas blends at the maximum flow rates of the gas transmission metering (> 10 000 m^3/h), and it is anticipated that similar operating conditions and applied meter technologies will be required for geological storage of hydrogen. While metering requirements exist for flow rates above 10 000 m^3/h, there is no fundamental difference in the flow meter technologies used above these flow rates, unlike when moving from distribution to transmission metering, or when comparing metering in the gas networks to metering for hydrogen vehicles. Facilities are available for smaller gas transmission meters, which are based on the same measurement principles (turbine, ultrasonic, orifice plate) as meters used for larger flow rates, so relevant insight can be gained on the accuracy that can be achieved at the higher flow rate range.

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 traceable measurement of gas flow for hydrogen and hydrogen/natural gas blends in gas networks and storage.

The specific objectives are

1. To establish a robust metrological infrastructure for flow rates of 0.1 m^3/h to 400 m^3/h, and pressures of 0.01 MPa(g) to 1.6 MPa(g) with a primary focus on pure hydrogen, but also enabling traceability for hydrogen/natural gas blends in small industrial meters, with a measurement uncertainty of 0.2 % or less.
2. To establish a robust metrological infrastructure for flow rates of 200 m^3/h to 10 000 m^3/h, and pressures of 0.3 MPa(g) to 6.2 MPa(g) for pure hydrogen and hydrogen/natural gas blends in large industrial meters, with a measurement uncertainty of 0.2 % or less.
3. To develop a traceability transfer skid for pure hydrogen and hydrogen/natural gas blends. In addition, to carry out intercomparisons to determine the equivalence of independent traceability chains based on primary standards, secondary standards using a bootstrapping/upscaling approach, and secondary standards calibrated with alternative fluids to hydrogen.
4. To perform (i) primary calibrations of domestic gas meters (ultrasonic, diaphragm, thermal mass flow) with air and/or methane and with pure hydrogen up to 30 m^3/h at atmospheric pressure and (ii) primary and secondary calibrations of industrial gas meters (ultrasonic, rotary, turbine) with air and/or natural gas and hydrogen/natural gas blends at flow rates of up to 1000 m^3/h and pressures of up to 6.2 MPa(g). Based on these results as well as existing data, to deliver statistically meaningful datasets for air, natural gas, or other alternative fluid calibration for the transferability to hydrogen gas flow conditions for domestic and industrial flow meters.
5. To demonstrate the establishment of an integrated European metrology infrastructure and to facilitate the take up of the technology and measurement infrastructure developed in the project by the

measurement supply chain (accredited calibration and testing laboratories, European Metrology Network for Energy Gases), standards developing organisations (ISO TC30, OIML TC 8/SC 7, CEN/TC 237) and end users (energy gas transmission, distribution and storage operators, FARECOGAZ, ENTSOG, Hydrogen Europe).

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 work, the involvement of the larger community of metrology R&D resources both within and outside Europe, plus engagement with existing European research infrastructures and European Partnerships is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry and end users.

Proposers should establish the current state of the art and explain how their proposed project goes beyond this. In particular, proposers should outline the actual or expected achievements of the EMPIR projects 18NRM06 NEWGASMET and 20IND10 Decarb and the Partnership project 21GRD05 Met4H2 and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.9 M€ and has defined an upper limit of 2.4 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 25 % 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 JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Develop an integrated self-sustaining European metrology infrastructure,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the energy gas transmission, distribution and storage sectors.

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 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.

Time-scale

The project should be of up to 3 years duration.