

## **Title: Flow measurement traceability for hydrogen in gas networks**

### **Abstract**

Hydrogen is key to achieving the decarbonisation of energy systems in Europe. 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**

New metrological techniques and testing infrastructure are required to support the use of hydrogen, which will be key to achieving the goal of decarbonising energy systems in the European Union. Flow measurement in particular is required for process monitoring and control, for fiscal metering, for billing and at each point of custody transfer. Indeed, traceability for hydrogen flow measurement in the gas network was identified in the strategic research agenda of the European Metrology Network (EMN) for Energy Gases and as a key stakeholder need in the 2022 joint sessions held between the EMN for Energy Gases, Hydrogen Europe, and Hydrogen Europe Research.

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, it must be 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 due to the need to cover wide operating ranges and operate safely with hydrogen, but also to reach the lowest possible measurement uncertainty. The required measurement uncertainty for flow calibration facilities is typically no more than one third of the maximum permissible error for the flow meter, 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.

Significant progress has been made in recent years with the development both of new commercially available flow meters for hydrogen service and the flow calibration capabilities of metrology institutes and accredited laboratories. There are now well-developed metering and calibration options for residential gas billing and for dispensing to light duty hydrogen vehicles. The small scale of these applications made it economically feasible for several measurement institutes to develop their own flow standards and calibration loops. The current state-of-the-art for residential metering is that flow meters have been developed for use with both hydrogen and hydrogen enriched-natural gas. Two traceable flow calibration facilities were developed by two European metrology laboratories which can be used to assess those meters with respect to the MID accuracy requirements, with more planned by other measurement institutes. 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. A test programme carried out to support 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 suggest that for diaphragm meters, the established practice of accuracy testing with air may remain the norm for meters operated with hydrogen/natural gas blends. The previous EMPIR project 18NRM06 NEWGASMET provided accuracy data for several residential gas meters operated with pure hydrogen, however despite some positive findings, a larger data sample is needed to reliably assess the feasibility to calibrate with air and apply a correction for hydrogen service. CEN/TC 234 and CEN/TC 237 working groups have also expressed the need to test a larger sample of meters to evaluate cost-effective calibration methods based on alternative fluids to hydrogen.

Larger flow meters (typically rotary and turbine) are used in gas distribution networks for flow rates of up to 400 m<sup>3</sup>/h and pressures up to 1.6 MPa(g). For hydrogen blends of up to 30 %, a high-pressure primary piston prover established at a European NMI has proven suitable for providing the calibrations, and data has been collected in 18NRM06 NEWGASMET. However, there are currently no facilities available to calibrate those meters for pure hydrogen.

There are no accredited flow facilities which can provide calibration with hydrogen or hydrogen/natural gas blends at the maximum flow rates of the gas transmission metering (above 10000 m<sup>3</sup>/h). Facilities are available for smaller gas transmission meters, these are based on the same measurement principles (turbine, ultrasonic, orifice plate) as meters used for larger flow rates, so relevant insight can be gained for the accuracy that can be achieved at the higher flow rate range. A facility in Groningen can currently test with hydrogen blends up to 30 % by volume and flow rates up to 1000 m<sup>3</sup>/h at 3.4 MPa(g), and a new natural gas primary standard facility is planned for flow rates up to 65000 m<sup>3</sup>/h and maximum pressures of 6.4 MPa(g) with the capability to operate with up to 25 % hydrogen by volume. However, no facilities are currently available for pure hydrogen in similar flow rate and pressure ranges.

Targeting a maximum flow rate 10000 m<sup>3</sup>/hr at 6.2 MPa(g) strikes a balance between relevance to stakeholders and cost of the test programme and additional investment required. 6.2 MPa(g) is consistent with the maximum pressure for the unit of high-pressure natural gas flow in the EuReGa consortium. While metering requirements exist for flow rates above 10000 m<sup>3</sup>/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. Additionally, a potential finding from the proposed research is that traceability for hydrogen flow measurement can be achieved by calibrations with alternative fluids, which would undermine the economic case for investment in large-scale hydrogen calibration facilities.

## 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<sup>3</sup>/h to 400 m<sup>3</sup>/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<sup>3</sup>/h to 10 000 m<sup>3</sup>/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 jointly develop a traceability transfer skid for pure hydrogen and hydrogen/natural gas blends. 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<sup>3</sup>/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<sup>3</sup>/h and pressures of up to 6.2 MPa(g). Subsequently, to compare air and hydrogen calibration results from a large, representative sample of domestic and industrial flow meters in order to determine the achievable uncertainty in hydrogen flow measurement with meters calibrated using only alternative fluids and develop reliable multi-fluid calibration models for applicable meter types.

5. 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 (e.g. 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. Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

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 18NRM06 NEWGASMET and 20IND10 Decarb and 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 2.3 M€ for this project.

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 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,
- 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 energy gas transmission, distribution and storage operators 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 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.