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Technical Paper

Performance Testing of Commercial Gas Meters with Renewable Energy Gases

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1 INTRODUCTION

As Europe moves towards renewable energy sources, the characteristics of energy gases being transported in European gas infrastructure will change significantly. Depending on local requirements, gas grids are foreseen transporting pure hydrogen in some cases, and hydrogen-enriched natural gas (HENG), in others. It is expected that these changes will impact the accuracy of measuring instruments that are used for billing and custody transfer. Hydrogen has a lower density and viscosity than natural gas. The density of "pure" hydrogen may change significantly due to impurities. For example, 2 % nitrogen in pure hydrogen has approximately 25 % higher density than pure hydrogen. Hence, the admixture of hydrogen to natural gas grids may pose measurement challenges. There are still many unknowns with respect to how flow meters, calibrated using natural gas (NG) or air, perform when used with HENG or hydrogen.

In this paper, we discuss three European projects, in which commercially available gas meters are tested with renewable energy gases (hydrogen and HENG) at VSL, in the context of joint research projects of the European Metrology Programme for Innovation and Research (EMPIR) and the European Partnership on Metrology. The paper describes both completed work as well as ongoing and future efforts to understand the effect of renewable gases on the behavior of gas flow meters used in the gas grid.

Table 1 – Overview of the three European projects discussed in this paper.

Project title	Flow metering of renewable gases	Metrology for decarbonising the gas grid	Metrology for the hydrogen supply chain
Acronym	NewGasMet	DECARB	MET4H2
Project number	18NRM06	20IND01	21GRD05
Start date	June 2019	June 2021	October 2022
Status (2023)	Completed	Ongoing	Ongoing
Website	newgasmet.eu	decarbgrid.eu	met4h2.eu

2 FLOW METERING OF RENEWABLE GASES (NewGasMet)

The overall objective of the project was to increase knowledge about the accuracy and durability of commercially available gas meters when exposed to renewable

gases. This has led to the improvement of existing meter designs and flow calibration standards [1].

VSL yielded results from two technical activities in the project:

1. Adapt the primary standard for high pressure natural gas flow (Gas Oil Piston Prover, GOPP) for use with HENG, and perform tests of a rotary meter with this facility, at pressures up to 16 bar(a).
2. Participate in an intercomparison using hydrogen, methane, and nitrogen using a mercury-seal piston prover.

To investigate the effect of HENG on the performance of the flow meter, VSL's GOPP was used, as shown in Figure 1. The GOPP is the primary standard for high-pressure natural gas flow measurements in the Netherlands [2]. The meter under test (MuT) was calibrated at 9 and 16 bar(a) at 7 different flow rates from 5 to 160 m^3/h, with both natural gas and HENG. Although differences between errors with NG and HENG are mostly negative (meter indicates less with HENG), these changes are deemed insignificant from a metrological standpoint. Results indicate that, for the rotary flow meter and hydrogen admixtures (<20 % H_2) used, the meter error differences between high-pressure hydrogen admixture calibration and high-pressure natural gas calibration are smaller than the meter error differences between atmospheric pressure air calibration and high-pressure natural gas calibration. For full details on these tests, see reference [3].

Fig. 1 – MuT mounted on VSL's GOPP, accompanied by hydrogen gas cylinders.

Furthermore, VSL participated in an intercomparison with a mercury-seal piston prover. Test gases were hydrogen, methane and nitrogen. The maximum flow rate was 0.06 m^3/h due to the relatively limited size of the piston prover. The transfer package contained a set of sonic nozzles and a laminar flow element,

which were calibrated using the prover. In general, there was good agreement between the results of the comparison participants, which can be considered a success given the fact that there's little long-term experience using these gases in calibration laboratories. For more information about the NEWGASMET intercomparison, see [4].

3 METROLOGY FOR DECARBONISING THE GAS GRID (DECARB)

The overall aim of this project is to develop metrology that will support decarbonisation of the gas grid [5]. One of the objectives of this project is to develop metrology infrastructure to support new flow metering requirements. This also includes development of new traceable facilities to enable calibration of flow meters with hydrogen and HENG (in accordance with the Measuring Instruments Directive), but also for CO_2 relevant to carbon capture and storage (CCS) processes (in accordance with EU Emissions Trading Scheme).

As part of this objective, VSL aims to perform gas meter tests with hydrogen, HENG, and CO_2, as well as CO_2 with impurities (up to 2%). To this end, a facility was developed to calibrate gas meters up to 0.6 Nm^3/h (normal cubic meters per hour). The facility uses an upgraded version of the piston prover used in NEWGASMET project, which can now be used at a pressure of up to 10 bar(a). Due to the increased pressure level, the piston prover, that displaces no more than 0.06 m^3/h (actual), can be used to calibrate meters up to 0.6 Nm^3/h. The system, of which a P&ID is shown in Figure 2, can be used with various gases, including hydrogen, HENG, and CO_2.

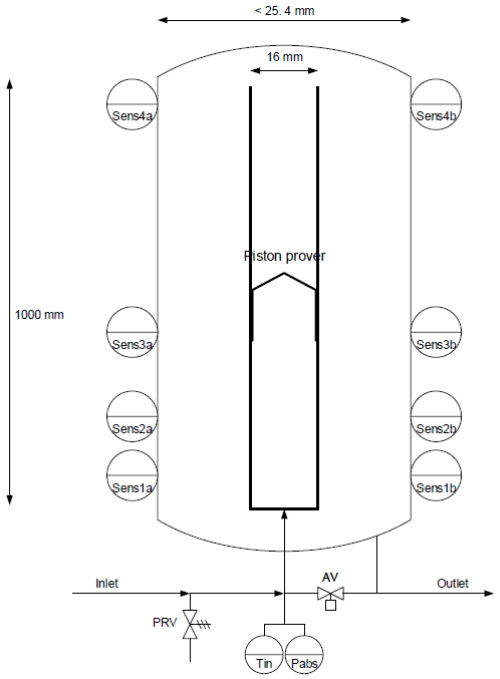

Figure 2 – P&ID of the mercury-seal piston prover with pressure housing.

Two gas meters were obtained to perform tests with: one rotary gas flow meter and one thermal mass flow meter. The thermal mass flow meter is used in the high pressure part of the facility and is hence operated at 10 bar(a), while the

rotary flow meter is situated downstream of the facility and is used at atmospheric pressure level. The test gases are N_2, H_2, 20 % HENG (20 % H_2, 80 CH_4), CO_2 and CO_2 with 2 % N_2. Flow rates to be tested range from 0.06 to 0.6 Nm^3/h. Test results are expected in the coming months.

Additionally, VSL will participate in an intercomparison using the standard presented above, where test gases will be nitrogen and hydrogen. This will take place late 2023 / early 2024.

4 METROLOGY FOR THE HYDROGEN SUPPLY CHAIN (MET4H2)

The overall objective of the MET4H2 project is to further develop and integrate the metrology necessary to support the entire supply chain of hydrogen, from production to storage and end use. The project will disseminate metrological traceability to the field, so that measurement results become fit-for-purpose with respect to health, safety, environmental, and fiscal purposes [6].

Among others, one of the objectives of the project is to develop measurement standards to enable calibration and validation of flow metering equipment under actual conditions (pressure, temperature), used to accurately quantify flow rates of hydrogen (including HENG) through the hydrogen supply chain, and to facilitate compliance with respect to, e.g., OIML R137, OIML R140 and the Measuring Instruments Directive.

As part of this objective, VSL has two main activities:

1. Participate in an intercomparison with HENG using GOPP, for flows up to 200 m^3/h and up to 60 bar(a), and delivering the transfer package for this intercomparison.
2. Developing a traceable calibration facility for domestic gas meters to test the effect of impurities (up to 2 %) in pure hydrogen on the accuracy of these meters.

For the intercomparison, two transfer meters were obtained: one ultrasonic meter and one rotary meter. The intercomparison will be split into two ranges ("large" vs. "small", where VSL will participate in the large scale, aiming to calibrate both meters using GOPP at pressures up to 60 bar and flows up to 200 m^3/h. Hence, the tests at VSL are similar in nature to the NewGasMet tests discussed above, but with a higher flow rate and at a much higher pressure. The intercomparison will run from 2024 to mid-2025.

For the domestic gas meter facility, VSL will use a wet gas meter as reference, traceable to the low-pressure calibration laboratory in Delft, The Netherlands. The facility will use gas from gas cylinders with flow rates up to 10 m^3/h. The facility is currently under development. Tests will run in 2024.

5 CONCLUSION

The change towards renewable energy gases will have an impact on metering systems in the gas grid. Here, three European projects are presented in which VSL participates in order to better understand the consequences of hydrogen (with or without impurities) and HENG on the performance of gas meters, and to develop the required metrological infrastructure for these gases. In this way, VSL aims to support a future-proof gas grid with reliable measurements.

6 ACKNOWLEDGEMENT

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EMPIR EURAMET
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European Partnership Co-funded by the European Union
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6 REFERENCES

[1] Publishable Summary for 18NRM06 NEWGASMET Flow metering of renewable gases (biogas, biomethane, hydrogen, syngas and mixtures with natural gas). Issued: December 2021.

[2] M. van der Beek and R. van den Brink, "Gas Oil Piston Prover, primary reference values for Gas-Volume," Flow Measurement and Instrumentation, vol. 44, pp. 27-33, 2015.

[3] M. Workamp and M. Schakel, "Effect of hydrogen admixture on the accuracy of a rotary flow meter", 2021.

[4] NEWGASMET deliverable: D6 – Report on the inter-comparison – addendum_2023-05-31, available on newgasmet.eu/deliverables.

[5] Publishable Summary for 20IND10 Decarb Metrology for decarbonising the gas grid. Issued: January 2023.

[6] Publishable Summary for 21GRD05 Met4H2 Metrology for the hydrogen supply chain. Issued: August 2023.

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