Title: Metrology for small- and midscale flow devices

Abstract

In many industrial processes, gas and liquid flow rates need to be regulated for precision delivery. This includes the mixing of different fluids for manufacturing chemicals or other materials and the combining of smaller and larger flows. However, the performance of the flow devices used to monitor the delivery of the flow can be influenced by many factors, such as temperature, pressure and the composition of the flow being regulated. Therefore, differences in flow device performance in calibration laboratory and on-site conditions are common. In addition, although the measurement principles of such flow devices are known, appropriate conversion factors and/or models for the correction of gas and liquid flow devices are rarely applied. In order to address these issues, improved conversion factors and/or models are needed for flow devices, as well as a realistic uncertainty evaluation and a portable calibration standard for use in industrial sites.

Keywords

flow measuring devices, liquid flow rates, gas flow rates, conversion factors, calibration standard

Background to the Metrological Challenges

Currently, low- and midscale flow devices are calibrated approximately every year depending on intensity of use, contamination, wear and thermal cycling effects etc. In general the devices are calibrated in situ or at the plant's industrial calibration room, where devices are calibrated and evaluated for maximum permissible errors and re-adjusted or replaced. However, very few of the devices are returned to a primary calibration laboratory, as industry regards this as costly and time consuming, and it does not take into account the uncertainties associated with variations in on site/field conditions.

In order to enable the use of non-conventional fluids (i.e. those towards more extreme conditions of higher temperature and pressure) in industrial delivery and control processes, there is a need to ensure their traceable measurement. However, little progress has been made in transferring traceable measurements from the calibration laboratory to field conditions. Furthermore, current devices used for flow measurements are not robust enough for site measurements and can be influenced by many factors, such as temperature and pressure.

Examples of existing standards for flow devices include mercury piston provers, graphite provers, wet gas meters, laminar flow elements and critical nozzles. However, mercury piston provers are being phased out in order to avoid the use of open-mercury and graphite piston provers and wet gas meters are not suitable for pressures higher than ambient. In addition to this, due to the lack of primary standards for field conditions, the behaviour of laminar flow elements and sonic nozzles are extrapolated for field conditions; which adds another level of uncertainty.

Another common method for calibrating flow devices, is to use air or nitrogen to define the uncertainty for devices in these conditions and then to use correction factors when using other gases. However, the traceability of these correction factors is only based on the physical properties of the gases used and in most cases the specific behaviour of the gases (e.g. internal heat-leaks, heat conductivity of gas-metal interface) is unknown. Modelling techniques can also be used to provide information on flow device performance and to identify changes in conditions. But, such models need to be tested and validated to provide confidence in their results.

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

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maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the proposal.

The JRP shall focus on the traceable measurement and characterisation of flow controlling and measuring devices for a variety of gas and liquid flows.

The specific objectives are

1. To develop conversion factors and/or models for the correction of gas and liquid flow devices that cannot currently be calibrated at normal operated fluids. Parameters should include boundary layers, viscosity, thermal conductivity, thermal capacity, the density of the gas or liquids and the flow ranges 10^{-4} to 5 m^3 h^{-1}.

2. To evaluate the uncertainty of existing conversion tables commonly used for flow controllers and to establish the scope of these tables, including relate them to different thermal controllers. Models should also be provided for uncertainty estimation related to process fluids when calibrating with surrogate gases and liquids;

3. To investigate the influence of pressure, temperature and the effects of combining flows on the performance of liquid and gas flow devices;

4. To develop a low budget, portable primary gas flow standard based on the displacement principle. The flow standard requirements should include; a flow range of 0.1 to 500 dm^3 h^{-1}, temperature range of 5 to 40 °C, pressure range of 0.1 to 1 MPa (abs), gas dependency of less than 0.05 % on volume and target uncertainty <0.2 % of reference volume flow at the location of the flow device. The flow standard should also be explosion proof, easy to use and rigid for industrial (field) use.

5. To engage with the industry that produces and exploits flow measurement devices, to facilitate the take up of the technology and measurement infrastructure developed by the project, to support the development of new, innovative products, thereby enhancing the competitiveness of EU industry.

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 and EMRP JRPs ENG58 Multiphase Flow Metrology in Oil and Gas Production (MultiFlowMet) and ENG59 'Sensor development and calibration method for inline detection of viscosity and solids content of non-Newtonian fluids' (NNL).

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded 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,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the flow device sector.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects"

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.