

# Title: Improved gas flowmetering at industrial conditions

## Abstract

Accurate gas flow rate measurements are vital for process control and custody transfer in industry. They are used to define the quality of products and for the economical and safe operation of processes. Flowmeter diagnostics are also currently used to identify potential flow disturbances and to provide end-users with a warning for off-limit operating conditions. However, such flowmeter diagnostics are not yet validated. Further to this, the accuracy of industrial gas flow rate measurements can be significantly lower than those in laboratory conditions, due to the variability of flow conditions such as the velocity profile, geometric integrity of the meter, fouling or wear. Therefore, validated flowmetering diagnostics and methods for determining realistic uncertainty budgets for on-site gas flow rate measurements are required.

## Keywords

flowmetering, gas flow rate measurements, flowmetering diagnostics, on-site measurements, uncertainty

## Background to the Metrological Challenges

Industrial gas flow measurements are used to define the quality of products and for the economical and safe operation of processes. Furthermore, accurate flowmetering is required for custody transfer, and for legal applications the uncertainty required for flow rate measurements is between 0.2 % and 2.0 %. However, many parameters can interact with flowmeters and thereby increase the measurement uncertainty; examples include distorted flow profiles, fouling or wear and operational conditions such as pressure, temperature and viscosity. Indeed, in a survey conducted in 2012, 60 % to 80 % of flowmeter end-users responded that flowmetering accuracy was negatively affected by distorted flow profiles, pulsations and fouling or erosion.

It is not feasible to have one primary standard that covers all ranges of flow; therefore there are currently, a variety of primary standards for different flow gas rates, e.g. primary standards with flow rates from  $10^{-6}$  to  $2.5 \times 10^4$  m<sup>3</sup>/h for ambient conditions and to  $2 \times 10^6$  nm<sup>3</sup>/h for pressures of 60 bar. However, there are currently very few facilities, using these standards that can determine the impact of effects such as swirl, asymmetry, (flow) unsteadiness, fouling and/or wear on gas flow rate measurements.

In addition to this, some flowmeters are equipped with diagnostic functions, that can be used warn end-users when flowmetering conditions are off-limit. However, this flowmeter diagnostic functionality is not yet validated and therefore warning may be either too early or too late.

Existing ISO and OIML standards provide requirements for the hardware configuration for flowmetering, e.g. the flowmeter should be placed 10 diameters downwards of the nearest disturbance but typically only provide qualitative recommendations for flow rate conditions, e.g. 'try to get the flow rate as stable as possible'. There are no quantitative requirements in the standards for measuring conditions such as flow profile, stability, temperature homogeneity or environmental conditions and consequently, flow rate measurements may be unable to achieve the required legal measurement uncertainty. To try and address this issue and minimise the effect of calibrating and using a flowmeter in different conditions, computational fluid dynamics (CFD) simulations are often used. CFD is used to predict the (unsteady) flow profile which can then be used to correct flowmeter readings. However, this approach has, two disadvantages; firstly, the results from the CFD models are prone to deviation from actual measurements results (e.g. due to turbulence modelling). Secondly, CFD modelling does not use actual (raw) measurement data. Therefore, a methodology that combines CFD and actual measurement data is required.

## 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 proposal.

The JRP shall focus on the traceable measurement and characterisation of gas flow rate  $\geq 10\text{m}^3/\text{h}$  in industrial applications.

The specific objectives are

1. To develop realistic uncertainty budgets for industrial, non-ideal, measuring conditions, based on novel mathematical models and physical measurements. The following uncertainty sources should be considered: flow disturbances like asymmetry and swirl, pressure, temperature, viscosity, surface roughness, fouling, wear and (flow) unsteadiness.
2. To develop a novel and improved flowmetering capability based on 'integrating' physical measurements with numerical modeling. The capability should provide improved accuracy in the flow profile, pressure, temperature, viscosity, unsteadiness, surface roughness, fouling or wear, and reduced constraints on the flowmetering conditions. In addition, the improved capability should reduce the constraints on flowmetering conditions.
3. To validate flowmeter diagnostics and provide warning of off-limit operating conditions.
4. To support amendments of existing ISO and OIML standards with respect to flow measurements at non-ideal conditions.
5. To ensure that the outputs from the JRP are effectively disseminated to, and exploited by industry to facilitate the take up of the technology and measurement infrastructure developed by the project.

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 EMRP JRPs ENG58 Multiphase Flow Metrology in Oil and Gas Production (MultiFlowMet) and NEW04 'Novel mathematical and statistical approaches to uncertainty evaluation' (Uncertainty) and how their proposal will build on these.

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 meter 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.