

**REPORT ON SCIENTIFIC ACTIVITIES AT THE INSTITUTO PORTUGUÊS DA QUALIDADE  
IN CONSULTATIVE COMMITTEE FOR MASS AND RELATED QUANTITIES - CCM**

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## 1. Introduction

The measurement infrastructure of Portugal is underpinned by its National Metrology Institute (NMI), who provides metrological traceability to the network of national accredited laboratories working in contact with the national industry, linking the SI units to measurement reference standards onto working reference standards and measuring instruments.

The Portuguese Institute for Quality (IPQ) is a public institute with the mission to coordinate the Portuguese System for Quality and to support and stimulate activities aiming at the improvement of product and services quality to ensure accuracy and consistency of measurement, with impact in relevant areas such as health, environment, safety, energy and industry, helping to secure a better quality of life across society.

As a NMI one of IPQ's main duties is to develop and maintain the most accurate measurement standards, underpinning a national measurement system infrastructure of traceability throughout Portugal, by participating in R&D projects with other NMI, academia and research centres.

Portugal was one of the original signatories of the Metre Convention. It has always been a national objective in the metrology framework to assure the development, application and maintenance of the national standards of the measurement units and their traceability to the International System of Units (SI), fostering its dissemination nationwide.

The National Metrology has the following **Mission**:

*“To guarantee the Accuracy and Traceability of measurement nationwide, aiming at the sovereignty of the Measurement National Standards, and to perform metrological control to the measuring instruments, to accommodate the needs of the national industry and of the society as a whole”;*

and **Vision**:

*“To be the mainstay of national competitiveness and welfare of citizens through a technologically advanced metrological framework” and “To be a national reference institution in the developing European metrology network, contributing to the European leadership in the context of the world economy”.*

## 2. Relevant Publications

To promote and disseminate national metrological capabilities in the context of the activities in the field of CCM, they have been published several works, as follows:

### Papers published in peer-reviewed journals:

- Batista, E., Alves e Sousa J., Cardoso, S., Silvério, V., (2000) Experimental testing for metrological traceability and accuracy of liquid microflows and microfluidics, Flow Measurement and Instrumentation, Vol. 71.  
<https://doi.org/10.1016/j.flowmeasinst.2020.101691>
- Batista, E., do Céu Ferreira, M., Furtado, A., & e Sousa, J. A. (2019). New EMPIR project– Metrology for Drug Delivery, the role of IPQ. In 2019 *IEEE International Symposium on Medical Measurements and Applications (MeMeA)* (pp. 1-5). IEEE.  
DOI: [10.1109/MeMeA.2019.8802198](https://doi.org/10.1109/MeMeA.2019.8802198)

- Batista, E., Furtado, A., Pereira, J. & Godinho, I., (2020). Uncertainty calculation in nanoflow measurements using interferometry. To be published at the Multi author book Advanced Mathematical and Computational Tools in Metrology and Testing XII vol.12, Series “Advances in Mathematics for Applied Sciences”, World Scientific, Singapore.
- Batista, E., Furtado, A., Pereira, J., Ferreira, M., Bissig, H., Graham, E., Niemann, A., Timmerman, A., Ogheard, F. & Alves e Sousa, J. (2019) Metrology for Drug Delivery II: a new joint research project for metrology in healthcare. In 19<sup>th</sup> International Congress of Metrology (CIM2019) (p. 15004). EDP Sciences. DOI: <https://doi.org/10.1051/metrology/201915004>
- Batista, E., Furtado, A., Pereira, J., Ferreira, M., Bissig, H., Graham, E., Niemann, A., Timmerman, A., Ogheard, F. & Alves e Sousa (2019) New EMPIR project MeDDII. In 18<sup>th</sup> International Flow Measurement Conference, FLOMEKO2019 Book of Abstracts, Lisboa, Portugal <https://doi.org/10.1016/j.flowmeasinst.2020.101716>
- Batista, E., Furtado, A., Pereira, J., Ferreira, M., Bissig, H., Graham, E., Niemann, A., Timmerman, A., Ogheard, F. & Alves e Sousa (2019) Metrology for Drug Delivery II: a new joint research project for metrology in healthcare. In 19th International Congress of Metrology (CIM2019) (p. 15004). EDP Sciences.  
DOI: <https://doi.org/10.1051/metrology/201915004>
- Batista, E., Godinho, I., Martins, R., Mendes, R., Robarts, J., (2020) Development of an experimental setup for microflow measurement using interferometry, Flow Measurement and Instrumentation, vol. 75. <https://doi.org/10.1016/j.flowmeasinst.2020.101789>
- Batista, E., Mendes, R., Furtado, A., Ferreira, M. C., Godinho, I., Sousa, J. A., ... & Martins, R. (2020). Calibration of Syringe Pumps Using Interferometry and Optical Methods. International Journal of Biomedical and Biological Engineering, 14(10), 318-321. ISNI:0000000091950263
- Final report EURAMET.M.FF-K4.1.2016 - Volume comparison at 20 L Metrologia 2020 57 Tech. Suppl. 07021
- Final report on AFRIMETS.FF-K4.2.2015- Volume comparison at 100 µL—calibration of micropipettes. Metrologia 2020 57 Tech. Suppl. 07016
- Final report on COOMET.M.FF-S8 - Volume comparison at 10 µL, 100 µL and 1000 µL—calibration of micropipettes. Volume comparison at 10 mL—calibration of burette. Metrologia 2020 57 Tech. Suppl. 07013
- Final report on EURAMET.M.M-K4.2015 (Project number: EURAMET 1346) - comparison on 1 kg stainless steel mass standards. Metrologia 2020 57 Tech. Suppl. 07011
- Furtado, A., Frank, L. & Wolf, W. (2020) New apparatus for liquids high-pressure density measurement. *Metrologia* <https://doi.org/10.1088/1681-7575/ab8d7a>
- Furtado, A., Gavina, J., Napoleão, A., Pereira, J., Cidade, M.T. & Sousa, J. (2019) Density measurements of viscoelastic samples with oscillation-type density meters. *J. Phys.: Conf. Ser.* 1379 012020. doi:10.1088/1742-6596/1379/1/012020.
- Furtado, A., Pereira, J., Quendera, R., & Cidade, M. T. (2019). Robustness studies of oscillation-type density meters with viscoelastic fluids. In 19<sup>th</sup> International Congress of

Metrology (CIM2019) (p. 13002). EDP Sciences. DOI:

<https://doi.org/10.1051/metrology/201913002>

- Furtado, A., Pereira, J., Quendera, R., *et al.* (2020). First density comparison on viscoelastic samples by oscillation-type densimetry. *ACTA IMEKO*, 9(5), 79-84.  
[http://dx.doi.org/10.21014/acta\\_imeko.v9i5.943](http://dx.doi.org/10.21014/acta_imeko.v9i5.943)
- Furtado, A., Pereira, J., Sousa, J. Cox, M. & Ribeiro, A., (2020). Uncertainty evaluation in rheology measurements. To be published at the Multi author book *Advanced Mathematical and Computational Tools in Metrology and Testing XII vol.12, Series "Advances in Mathematics for Applied Sciences"*, World Scientific, Singapore
- Simões, D., Furtado, A., Pereira, J., & Martins, R. F. (2020). Enhancing the handling of standard substitution weights on a hydrostatic weighing apparatus. *ACTA IMEKO*, 9(5), 27-32. [http://dx.doi.org/10.21014/acta\\_imeko.v9i5.933](http://dx.doi.org/10.21014/acta_imeko.v9i5.933)

### Oral communications presented in conferences

- Participation at 18<sup>th</sup> International Flow Measurement Conference - FLOMEKO2019, held at Laboratório Nacional de Engenharia Civil, Lisboa, Portugal, 26-28 June 2019. Organized by RELACRE, IMEKO, IPQ, LNEC and SPMet (21 h).
- Furtado, A., Pereira, J., Quendera, R., & Cidade, M. T. Robustness studies of oscillation-type density meters with viscoelastic fluids. 19<sup>th</sup> International Congress of Metrology (CIM2019), September 24-26, 2019, Paris, France
- Furtado, A., Gavina, J., Napoleão, A., Pereira, J. and Cidade, M.T, Density measurements of viscoelastic samples with oscillation type density meters, Joint IMEKO TC1-TC7-TC13-TC18, July 2-5, 2019, St. Petersburg, Russia
- Elsa Batista, João Alves e Sousa, Susana Cardoso, Vania Silverio, FLOW accuracy and traceability in a lab-on-a-chip device, ANALITICA 2020 (Online), 28-10-2020
- E. Batista, R. Mendes, A. Furtado, M. C. Ferreira, I. Godinho, J. A. Sousa, M. Alvares, R. Martins, Calibration of Syringe Pumps Using Interferometry and Optical Methods, ICMMS2020 (Online), 29-10-2020

### 3. Master Thesis and Doctoral Dissertations

IPQ has collaboration with several Portuguese Universities, promoting the orientation of Master thesis and Doctoral dissertations. This gives the opportunity to develop the research activities and to broaden our services.

- Lourenço, D. (2019). Design and dimensioning of a standard system to measure flow between 20 L/h and 50000 L/h using a gravimetric method (master's thesis, NOVA School of Science and Technology, Caparica, Portugal). Retrieved from Universidade Nova de Lisboa's Repository. (Accession: <http://hdl.handle.net/10362/72830>)

- Alvares, M. (2020). Implementation of a new calibration method for microflow measurements using optical technology (master's thesis, NOVA School of Science and Technology, Caparica, Portugal). Not Published yet.
- Simões, D. (2019). Optimization and automation of the hydrostatic weighing system for the determination of the liquid density of IPQ (master's thesis, NOVA School of Science and Technology, Caparica, Portugal). Retrieved from Universidade Nova de Lisboa's Repository. (Accession: <https://run.unl.pt/handle/10362/92306>)
- Furtado, A. (2019). Metrological traceability of density measurements and rheological determinations of liquids (Doctoral dissertation, NOVA School of Science and Technology, Caparica, Portugal). Retrieved from Universidade Nova de Lisboa's Repository. (Accession: <http://hdl.handle.net/10362/92677>)
- Filipe, S. (2020). Development and optimization of a system for measuring the density of liquids at high pressure (master's thesis, NOVA School of Science and Technology, Caparica, Portugal). (Confidential document)

#### 4. Participation in International Joint Research Projects

Since 2007, IPQ has had an important role in several European research projects, to push forward knowledge transfer and better and more robust metrological procedures to ensure measurement quality. Considering mass and related quantities, IPQ has been involved in the following R&D EMPIR projects in the scope of EURAMET:

- (2018-05/2021-10) **EMPIR Project 17RPT02 rhoLiq** (IPQ Coordination) “Establishing traceability for liquid density measurements”. The overall objective of this project is to develop the national metrological capacity in liquid density metrology in the less experienced partners, with the target of achieving the lowest measurement uncertainty possible when using state of the art density measuring systems. This will include coverage of the quantities that influence the measurement of density, i.e. temperature, pressure, viscosity and surface tension. This will also include a review and upgrade of the existing capabilities and needs, validation of the existing measuring systems and, if required, the development of new systems, with the support of the most experienced NMI for density, temperature and pressure intervals that are relevant for scientific and industrial needs, i.e. [600, 1 700] kg/m<sup>3</sup>, [5, 60] °C and [1, 600] bar, respectively.
- (2019-2022) **EMPIR Project HLT07 MeDDII** “Metrology for Drug Delivery”, Coordination of the project, coordination of WP6 and WP5, LVC and LPL are participating actively in the project by characterizing the fluid properties used in the infusion systems, in the development of new calibration methods for microflow measurements and characterization of infusion devices.

2020 EMPIR call PRTs participation that lead to new funded projects in 2021:

- **EMPIR 20NRM02 MFMET** - Establishing metrology standards in microfluidic devices. (IPQ Coordination) 2021
- **EMPIR 20NRM06 SApHTIES** -Metrology for standardised seawater pH measurements in support of international and European climate strategies 2021

## 5. Development or Revision of Guides and Standards

- Coordination of revision of standards: ISO 8655-1, ISO 8655-6, ISO 8655-9 and ISO 4787
- Coordination of EURAMET 1483 – Revision of EURAMET Calibration Guide 21, published in May 2020
- Coordination of EURAMET 1486 - Calibration of a motorised syringe (single stroke dispenser without valve) - Comparison between the procedure of ISO 8655-6 and the new working document ISO 8655-8.
- Participation in the ASTM E41.01 group - revision of ASTM E542 - Standard Practice for Calibration of Laboratory Volumetric Apparatus.
- Participation in the IEC TC62/MT 23 Infusion Pump Device Committee – revision of IEC 60601-2-24:2012 - Medical electrical equipment - Part 2-24: Particular requirements for the basic safety and essential performance of infusion pumps and controllers.
- Development of 3 EURAMET Guides for liquids density measurements under the scope of EMPIR project rhoLiq ((1) Density measurements with hydrostatic weighing apparatus (2) with oscillation-type density meters (including high-pressure) and (3) density reference materials).

## 6. Comparisons

The requirements of CIPM-MRA includes the participation in international comparisons and the implementation of a Quality Management System, based on EN ISO IEC 17025. The Quality Management System of IPQ - National Metrology Laboratory is evaluated annually by peers, within the framework of the EURAMET project # 1123 - On site peer review.

IPQ, as a signatory of CIPM-MRA, has its measurement and calibration capabilities in the KCDB database, published under the auspices of BIPM. The following list details the main interlaboratory comparisons made in recent years:

- SIM.M.FF-S11 (Coordinator) - Calibration of micropipettes;
- AFRIMETS.FF-K4.2.2015 (coordinator) - Volume comparison at 100 mL – Calibration of micropipettes;
- EURAMET.M.FF-K4.2.2014 (EURAMET 1322) (coordinator) - Calibration of micropipettes;
- EURAMET 1353 (coordinator) - Calibration of micropipettes by the gravimetric and photometric method.

#### Participation:

- EURAMET 1452 - 20, 50, 250 L prover tank
- Project 767/GE/18 – COOMET (COOMET.M.FF-S8)- Calibration of micropipettes and burettes (co-pilot)
- Project 766/GE/18 – COOMET Calibration of micropipettes (co-pilot)
- EURAMET 1479 - 1000 L prover tank (co-pilot)
- APMP key comparison APMP.M.FF-K4.2.2020 -Volume comparison at 100  $\mu\text{L}$  – Calibration of micropipettes.
- EURAMET.M.D.-K4.2020 – EURAMET Project 1496 – Hydrometers calibration comparison from 600  $\text{kg}/\text{m}^3$  to 2000  $\text{kg}/\text{m}^3$  (at 20 °C) (waiting for draft report)
- rhoLiq Project Diagnostic Comparisons on density of liquids by hydrostatic weighing and by oscillation-type density meters.
- CCM Key Comparison CCM.D-K5 - Comparison on density determination of liquid samples using oscillation-type density meters (start delayed due to COVID-19).
- EURAMET Comparison on the surface tension determination of liquid samples (start delayed due to COVID-19).

#### 7. CMCs

The 34 CMCs for the technical committee of Mass and related quantities are covered by the quality system and may be found on the KCDB website at:

<https://kcdb.bipm.org/appendixC/search.asp?reset=1&met=M>.

A **revised CMC on 2019** -the range of the flow CMC was increased from 0,12 mL/h to 2000 mL/h with an uncertainty of 2,5 to 0,11 %.

#### 8. Trainings

The expertise and experience in some fields of activity have been used in the organization of some training actions, given by IPQ staff to colleagues of other laboratories, including NMI, namely:

- New KCDB at EURAMET TC F, in cooperation with Isabelle Care and Petra Milota (Elsa Batista) May 2020
- Video on intermedium verification of micropipettes (Elsa Batista, May 2020) (<https://youtu.be/yumLVNTwGmk>)
- Video on calibration of infusion pumps, selected by BIPM as dissemination of NMIs activities regarding metrology and COVID-19 (<https://youtu.be/yumLVNTwGmk>)
- Case study MeDD II and COVID-19, published at [www.drugmetrology.com](http://www.drugmetrology.com) selected by the EU to be published [https://ec.europa.eu/info/research-and-innovation/research-area/health-research-and-innovation/coronavirus-research-and-innovation\\_en](https://ec.europa.eu/info/research-and-innovation/research-area/health-research-and-innovation/coronavirus-research-and-innovation_en)



- Video on Properties of Liquids Laboratories and fields of action (Andreia Furtado and Jorge Pereira, May 2020)  
(<https://www.youtube.com/watch?v=9ukk5rM7xw8>)

## 9. Conclusions

In line with IPQ's mission and vision, it is our intention to continue promoting existing collaborations in the domains of metrology and to establish other collaborations that prove necessary for the development of technical and scientific activities, multi-disciplinary, that may enhance the impact of the national metrology.

In the volume and flow laboratory one of the main challenges is the development of new infrastructures to allow traceability to drug delivery devices already in the market. This will be done within the EMPIR project MeDD II, coordinated by IPQ, and the new project MFMET of Call 2020, also coordinated by IPQ. It is also one of our main missions to promote the knowledge exchange within the medical and metrological community.

In the Property of Liquids Laboratory, the coordination of project rhoLiq will bring improved metrological capabilities in the specific area of density measurements, to provide traceability to a broader community of NMIs from emergent countries, with significant impact on economic activities.

In the Kibble balance project, linked with the redefinition of the kilogram, IPQ was invited to join the project coordinated by NPL, and the corresponding proposal has been submitted to the Board of Directors of IPQ.

All these scientific activities, in the various sub-domains, are also interconnected by a horizontal EMPIR project 17NRM05 – EMUE related to the evaluation of measurement uncertainties whose output will provide for the BIPM JCGM 110 document. IPQ is involved as task leader in a few activities related to the evaluation of measurement uncertainty in those areas. This project was approved under the umbrella of MATHMET, a European Centre of Mathematics and Statistics, now also a European Metrology Network, where IPQ is a full member since 2017.

IPQ also ensures the traceability of the proving tanks and standards test measures that are used for verification of water meters, gas meters and meter for liquids other than water.

Having as a main goal to assure the traceability in these domains at national level and to promote and develop the national metrology activity, it is essential to consider the following aspects:

- On one hand, the consolidation of synergies to foster interdisciplinary cooperation, between the scientific and technological community and the society.
- On the other hand, bearing in mind the present national metrology infrastructure, the main priorities are the reinforcement of the technical and scientific staff and find the necessary investment to permit to continue facing current metrological progress and challenges, increasing the capability of the national measurement infrastructure, underpinned by traceable measurement standards of high accuracy, building knowledge and competence for the emergent society demands, thus providing the country with the means and resources necessary for the quality of life and national economy development.