Instituto Nacional de Metrologia, Qualidade e Tecnologia
(National Institute of Metrology, Quality and Technology)

Report on metrology activities, in Mass and Related Quantities, performed by the National Institute of Metrology, Quality and Technology – INMETRO (Brazil)

Diretoria de Metrologia Científica e Tecnologia - Dimci

(Directorate of Scientific Metrology and Technology)

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Summary

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1. – Introduction

Brazil is a Member State of the BIPM. The National Institute of Metrology, Quality and Technology (INMETRO), the Brazilian NMI, has signed the CIPM MRA on 14th October, 1999.

INMETRO is Official Member of the CCM, CCAUV, CCL, CCEM, CCT and CCQM.

The INMETRO's leadership and the expertise of its technicians are recognized in the SIM Region. INMETRO gives technical support to several countries in different metrology fields. This support is mainly given through training programs and technical assessments.

The purpose of this report is to present to the CCM Board the metrological activities performed since the last CCM meeting in 2021.

Mass and Related Quantities at INMETRO are distributed into two Metrology Divisions. They are:

- Mechanical Metrology Division (Dimec)
  - Lafor - Force Metrology Laboratory (force, torque, hardness and impact Charpy: under way)
  - Lamas - Mass Metrology Laboratory (mass, volume and magnetic susceptibility of weights and mass standards)
  - Lapre - Pressure Metrology Laboratory (pressure and vacuum)

- Dynamic of Fluids Division (Dinam)
  - Laflu – Fluids Laboratory (volume, surface tension, viscosity and density of liquids and solids)
  - Laliq – Liquid Flow Metrology Laboratory (fluid flow and volume of liquids over 20 L)
  - Lagas – Gas Flow Metrology Laboratory (gas flow calibration and fluid velocity)

Note: The last peer review of all above-mentioned laboratories were undertaken in mid 2019 and their Quality System evaluated and approved by the SIM QSTF also in 2019.

2. – Research and development work related to Mass and Related Quantities

2.1 – Mass

Research activities

a) Kibble balance single pan table-top approach, a simplified design. The Mass Metrology Laboratory is developing a single pan table-top design as a first step of a bottom up approach to a higher accuracy Kibble balance capable of realization of the kilogram as a national reference.

b) Establishment of reference mass standards for experiments of realization of the unit of mass and for devices used in research and development based on ultramicro balances.

Technical activities with other NMIs:

The Mass Laboratory is also participating in the NIST/NRC: “SIM Kilogram Dissemination Project - SKDP”. In September 2018 was received a 1 kg stainless steel mass standard calibrated against the primary standards derived from a Kibble Balance using the Planck constant as a reference for the kilogram. The second round of measurement series is under way.

2.2 – Force, Torque and Hardness

Research activities

a) Dynamic Force Traceability “18SIB08 ComTraForce Comprehensive traceability for force metrology services” EMPIR / EURAMET.

   Status: Project concluded.

b) Dynamic Torque Traceability for Wind Turbine Efficiency “19ENG08 WindEFCY - Traceable mechanical and electrical power measurement for efficiency determination of wind turbines”

   Status: This project started in September 2020 and is in torque.

c) “Development of National Vickers Standard Hardness Blocks” – Project aims to transfer to the industry the technology for manufacturing standard hardness blocks on the Vickers scale that is on-going by partners on a laboratory scale.

Status: This project is in hardness.

d) “Development of Polymeric Matrix Composite Materials´ Membranes to be Applied to Fuel Cells”.

Status: This project is in hydrogen energy.

e) “Hydrogen Energy Metrology”.

Status: This project is in hydrogen energy.

2.3 Dynamic of Fluids Division (Dinam)

a) Development and provision of a test and measurement service for the coefficient of compressibility and thermal expansion of liquids (in progress)

b) Development of a calibration procedure for metallic pycnometers for measuring gases in different ranges of temperature and internal pressure

c) Multiphase flow measurement and microscale fluid flow characterization

Inmetro intends to become capable of dealing with such flows complexity, and then contribute to metrological discussions and knowledge production for overcoming challenges on evaluation of technologies applied to multiphase flow measurement, as well as on the development of microphysiological systems for health area.

d) Realization of the national scale of kinematic viscosity (2nd calibration in this methodology)

e) Boundary conditions study for flow meter calibration

f) New calibration methodology for ultrasonic natural gas flow meter

g) Improvement of accuracy and extension of the capacity of kinematic viscosity, mass flow and volumetric flow measurements of fluids, totalized mass and totalized volume of fluids, fluid velocity, and materialized volume measurements of liquids of Inmetro.

Technical activities with other NMIs:

a) Recalibration of the silicon sphere (Brazilian national volume and density standard) with AIST/Japan

b) 2° Airspeed Interlaboratory Program GTVazão (Anemometry)

c) SIM Regional Comparison on Airspeed (Nist/Cenam/Inmetro)

3. – Interlaboratory Comparisons Participation

3.1 – Force, Torque and Hardness

Torque bilateral comparison between NMISA and INMETRO. Points 500 N·m and 1000 N·m. (2019-2021).

3.2 Dynamic of Fluids Division (Dinam)

a) BIPM CCM.D-K5 (Comparison on density determination of liquid samples using oscillation-type density meters). Measurements taken and results sent to the pilot laboratory. Awaiting publication of results.

b) SIM.M.FF-K4.2017 (Volume Intercomparison at 20 L and 100 mL) Measurements taken and results sent to the pilot laboratory. Awaiting publication of results.

Currently: Difficulties in sending the standards to the next country (of comparison), due to the registration of irregular gateway of the standards in the Brazilian customs.

4. Publications of the Mass and Related Quantities Metrology Areas from INMETRO

4.1 – Mass

Cacais, F. A.; Loayza, V. M.; Beatrici, A.; Quintão, D.; Rebelo, A. S. *Results of Kibble Balance principle demonstration at Inmetro*. 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

Cacais, F. A.; Loayza, V. M.; Beatrici, A.; Quintão, D.; Rebelo, A. S. *Participation of Inmetro at SIM kilogram dissemination project (SKDP) Mass stability analysis of the* SIM21 *mass standard (1 kg) over three years in the* SIM *Kilogram Dissemination Project* (SKDP). 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

Rocha, M.; Quintão, D. *Evaluation of the adjustment of an analytical balance through calibration results*. 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

Beatrici, A.; Quintão, D.; Rebelo, A. S.; Loayza, V. M.; Cacais, F. A. *A simple Kibble balance approach for principle demonstration at Inmetro*. 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

Beatrici, A. *Glass campanula effects on measurement results in high capacity mass comparator*. 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

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Rebelo, A. S. *Evaluation of the performance of the Sartorius CCE6 mass comparator in relation to its use in ABBA weighing cycles applied in standard weight calibrations*. 6° Congresso Internacional de Metrologia Mecânica - CIMMEC, Rio de Janeiro, Outubro 2021.

Cacais, F. A.; Delgado, J. U.; Loayza, V. M.; Rangel, J. A. *In Situ Validation Methodology For Weighing Methods Used In Preparing of Standardized Sources for Radionuclide Metrology.* Metrology, v. 2, p. 446-478, 2022

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Cacais, F. A.; Loayza, V. M.; Beatrici, A.; Quintão, D.; Rebelo, A. S. *Participation of Inmetro at SIM kilogram dissemination project (SKDP) Mass stability analysis of the* SIM21 *mass standard (1 kg) over three years in the* SIM *Kilogram Dissemination Project* (SKDP). Journal of Physics: Conference Series, Institute of Physics, IOP JPCS, (Online) 2023

Books

Landim R. P., Cacais, F. A. *et al*; O Sistema Internacional de Unidades - Tradução luso-brasileira da 9a edição do Inmetro e IPQ, Versão na língua portuguesa específica para o Brasil. ISBN: 978-85-86920-28-8, 2021. [Portuguese version of the BIPM´s *SI Brochure The International System of Units*.].

4.2 – Force, Torque and Hardness

Song, Zihang; Weidinger, Paula; Zweiffel, Maximilian; Dubowik, Alexander; Mester, Christian; Yogal, Nijan; Oliveira, Rafael Soares Traceable efficiency determination of a 2.75-MW nacelle on a test bench Rückführbare Wirkungsgradbestimmung einer 2,75-MW Windenergieanlage auf einem Prüfstand. FORSCHUNG IM INGENIEURWESEN-ENGINEERING RESEARCH. Fator de Impacto(2021 JCR): 0,9920, v.87, p.259 - 273, 2023.

Sasiuk, Taras; Fröhlich, Thomas; Theska, René; de Oliveira, Rafael Soares Ein neuartiger Ansatz zur Erzeugung eines statischen Drehmoments im Bereich von 1-mN·m bis 1-N·m. Tm-Technisches Messen. Fator de Impacto(2021 JCR): 0,7770, v.88, p.103 - 113, 2021.

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Song, Z.; Weidinger, P.; Yogal, N.; Oliveira, R. S.; Lehrmann, C.; Kumme, R. APPLICABILITY OF TORQUE CALIBRATION ON TEST BENCHES FOR ELECTRICAL MACHINES In: Joint IMEKO TC3, T5, TC16 and TC22 International Conference, 2022, Cavtat-Dubrovnik. Proceedings of the 24th IMEKO TC3 Conference on Measurement of Force, Mass and Torque. Budapest: IMEKO, 2023. p.1 -

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Matosse, J.; Dlamini, S.; Sibisi, M.; Oliveira, R. S.; Oliveira, S. P. De; Filho, J. T. TORQUE BILATERAL COMPARISON BETWEEN NMISA AND INMETRO In: Joint IMEKO TC3, T5, TC16 and TC22 International Conference, 2022, Cavtat-Dubrovnik. Proceedings of the 24th IMEKO TC3 Conference on Measurement of Force, Mass and Torque. Budapest: IMEKO, 2023. p.1 -

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Landim R. P., Oliveira, S. P. et al; O Sistema Internacional de Unidades - Tradução luso-brasileira da 9a edição do Inmetro e IPQ, Versão na língua portuguesa específica para o Brasil. ISBN: 978-85-86920-28-8, 2021. [Portuguese version of the BIPM´s *SI Brochure The International System of Units*.].

4.3 – Dynamic of Fluids Division (Dinam)

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