

**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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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 2019.

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

- Mechanical Metrology Division (Dimec)
It comprises three laboratories:
 - 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)

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 activities carried out in Mass and Related Quantities

2.1 – Mass

Research activities

a) Kibble balance single pan table-top approach 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) Acoustic volumeter

This is an ongoing development project based on designs from NMIJ and Measurement Science Laboratory/Japan with the aim of reaching uncertainty level for standard weights up to 2 kg, E₂ class.

c) Improved traceability for Radionuclide samples

This project aims to improve the traceability for radionuclides samples preparation by using improved methods of preparation. This project involves the Dosimetry Laboratory of the Instituto de Radiação e Dosimetria (IRD), a Designate Institute by Inmetro for ionizing radiation.

d) Metrological traceability of stem cell spheroids biomechanical properties.

Providing metrological traceability to the measurements results and its respective measurement uncertainties in the Biotechnology research field using a parallel plates tensiometer. Applied force resistance, surface tension and Young's modulus measurement results are used to describe biomechanical proprieties of cellular spheroids formed by stem cells of several tissues kinds, for instance: fat, bone, cartilage and lung cancer stem cells.

Technical activities with other NMIs:

The technical staff of the Mass Laboratory is also participating in the NIST-NRC: “SIM Kilogram Dissemination Project”. 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.

2.2 – Force, Torque and Hardness

Research activities

a) *Study for the manufacture of Charpy impact specimens for the calibration of machines. Partner: IPT / SP. Cooperation Agreement for R&D&I between Inmetro and IPT and valid for 5 years from 12/28/2020].*

Status: This project was already part of the previous Cooperation Agreement between INMETRO and IPT/SP in April 2019, which continues to be executed with the new Cooperation Agreement started on 12/28/2020.

b) *Development of processes for measuring multicomponent forces in testing machines and force standardization machines. Partner: IPT / SP. Cooperation Agreement for R&D&I between Inmetro and IPT and valid for 5 years from 12/28/2020].*

Status: This project was already part of the previous Cooperation Agreement between INMETRO and IPT / SP in April 2019, which continues to be executed with the new Cooperation Agreement started on 12/28/2020.

c) *“Research Engagement Opportunity - Industrial Dynamic Measurements (from industry to primary standard) / Strengthening National Metrology Institutes in the Hemisphere, in support of emerging technologies”.*

Status: This project was completed in 2019.

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

Status: This project started in September 2019 and is in force.

e) *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 developed by partners on a laboratory scale - taking as an example the technology transfer carried out*

by Inmetro to the industry, and registered with the INPI (Brazilian National Patent and Trademark Office) in 2002].

Status: This project is in force.

f) 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 force.

g) Development of a 1 kN primary force standard, between Brazil (INMETRO, Brazilian NMI) and Italy (INRiM, Italian NMI)

Status: Both, the Project and the Cooperation Agreement between Brazil and Italy, are in force.

h) Development of composite membranes applied to fuel cells. Partner: UEZO (University Center Zona Oeste).

Status: The project is in force and has been developed since the previous Cooperation Agreement. This project shall be included in the new Cooperation Agreement under discussion.

2.3 – Pressure

Research activities

a) Primary standardization of pressure

The methodology for the implementation of pressure standardization in Inmetro's Pressure Laboratory is based on the dimensional measurement of a piston cylinder assembly with 50 mm of diameter.

b) System of mass flowmeters calibration from 3 kg/h to 120 kg/h using a differential pressure measurement standard.

The initial objective of the research is to create a system for the calibration of low flowmeters (Coriolis), used in the field, from differential pressure and mass measurements.

3. – Interlaboratory Comparisons Participation

3.1 – Force, Torque and Hardness

a) Bilateral comparison between NMISA (National Metrology Institute of South Africa) and INMETRO (Brazil's National Institute of Metrology, Quality and Technology). Measurand: torque from 50 N m to 1000 N m. Period: March 2020 – March 2021.

b) Bilateral comparison (Supplementary) between IDIC (Chile's Instituto de Investigaciones y Control) and INMETRO (Brazil's National Institute of Metrology, Quality and Technology). Measurand: force from 500 kN to 1000 kN. Period: January 2018 – in progress (ongoing process). KCDB identifier: SIM.M.F-S7.

3.2– Pressure

Key comparison between INTI (Argentina's Instituto Nacional de Tecnología Industrial), CENAM (Mexico's Centro Nacional de Metrología), INACAL (Peru's National Institute for Quality), INM (Instituto Nacional de Metrología de Colombia), LACOMET (Costa Rica's Laboratorio Costarricense de Metrología), NIST (United States' National Institute of Standards and Technology), United States, and INMETRO (Brazil's National Institute of Metrology, Quality and Technology). Measurand: Pressure: 10 kPa to 120 kPa. Period: January 2018 – in progress (ongoing process). KCDB identifier: SIM.M.P-K2.

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

4.1 – Mass

Beatrici, C. P.; Beatrici, A. *Hydrostatic buoyancy alternative correction for weighing using high-resolution single-pan balances*. 2021, J. Phys.: Conf. Ser. 1826 012075. <https://doi.org/10.1088/1742-6596/1826/1/012075>

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Cacais, F. L.; Delgado, J. U.; Loayza, V. M.; Rangel, J. A. *Comparison between three weighing methods for source preparation in radionuclide metrology*. 2021 J. Phys.: Conf. Ser. 1826 012038 <https://doi.org/10.1088/1742-6596/1826/1/012038>

Quintão, D. *Development of a virtual balance for didactic purposes applied to mass metrology*. 2021 J. Phys.: Conf. Ser. 1826 012072 <https://doi.org/10.1088/1742-6596/1826/1/012072>

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Kronemberger, G. S.; Dalmônico, G. M. L.; Rossi, A. L.; Leite, P. E. C.; Saraiva, A. M.; Beatrici, A.; Silva, K. R.; Granjeiro, J. M. and Baptista, L. S. *Scaffold- and serum-free hypertrophic cartilage tissue engineering as an alternative approach for bone repair*. Artificial Organs (Online). v.44, p.1-10, 2020. DOI 10.1111/aor.13637

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Cacais, F. L., Loayza, V. M. *Adoção Mundial da Redefinição do Kilograma em 2019*. Volume 1 da revista 'Cadernos de Metrologia'. Brasil. Maio 2019. <http://www.inmetro.gov.br/imprensa/releases/cadernos-de-metrologia.pdf>

Book chapter published

Cacais, F. L., Loayza, V. M. *Efeito da Redefinição do Kilograma para a Metrologia de Massa*. In: Pinheiro, E. M.; Araújo, F. P. M.; Coelho, G. T. F. (Org.). *Engenharia 4.0: a era da produção inteligente*. 1 ed. São Luís: Editora Pascal, 2021, v. 5, p. 455-466.

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Cacais, F. L.; Landim, R. P; Godinho, I.; *et al.* Sistema Internacional de Unidades: SI. — PT-Caparica, PT: IPQ / BR-Brasília, DF: Inmetro, 2021, 1a ed. da Tradução Luso-Brasileira do *Le Système international d'unités – The International System of Units* 9a ed. 2019 . (Translation/Book).

PhD Thesis

- Fábio André Ludolf Cacais

“Melhoria da Confiabilidade das Medições de Massa no Processo de Preparação de Fontes Padronizadas em Metrologia de Radionuclídeos”

Tese de Doutorado - Programa de pós-graduação em Radioproteção - CNEN/IRD.

Rio de Janeiro, 2020

Advisor: José Ubiratan Delgado

4.2 – Force, Torque and Hardness

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Savarin, A.; Serrano, F.; Silva, G. P.; Guzman, J. T., Arias, J. A. P.; Betancur, I. D. P.; Chijioke, A.; Vlajic, N.; Machado, R. R.; Oliveira, R. S. *Industrial Dynamic Measurements of Mechanical Quantities within the Inter-*

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Fratari, R. Q.; Trota, J.; Pinheiro. S. O. *Comparison Between Mechanical Properties of Five Trademarks for Male Condoms*. Marcelo Máximo Purificação, Miriam Ines Marchi, and Nélia Maria Pontes Amado (Orgs.). Ciências Exatas e da Terra: Exploração e Qualificação de Diferentes Tecnologias. 1st edition, Ponta Grossa/Brazil: Atena Editora, 2020, pp. 13-21. DOI 10.22533/at.ed.8582003062.

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4.3 – Pressure

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