Mass and Related Quantities at Inmetro

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INMETRO
MINISTÉRIO DA ECONOMIA
PÁTRIA AMADA BRASIL GOVERNO FEDERAL

Topics

General administration structure of Inmetro

Mass and related quantities at Inmetro

Mechanical Metrology Division

Flow and Dynamic Metrology Division

Main research areas

17th meeting of the CCM

BIPM 16 - 17 May 2019

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17th meeting of the CCM

BIPM 16 - 17 May 2019

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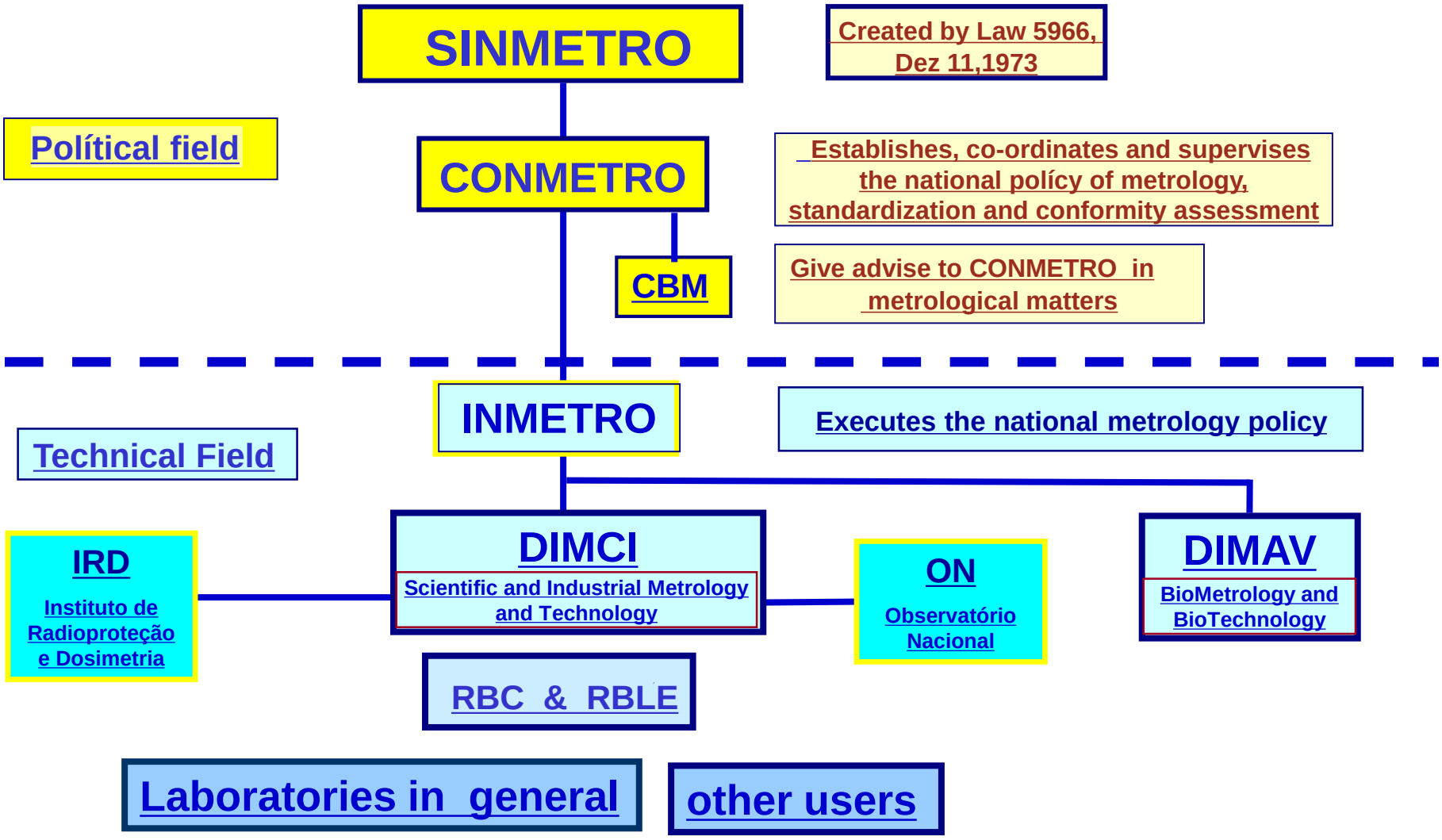

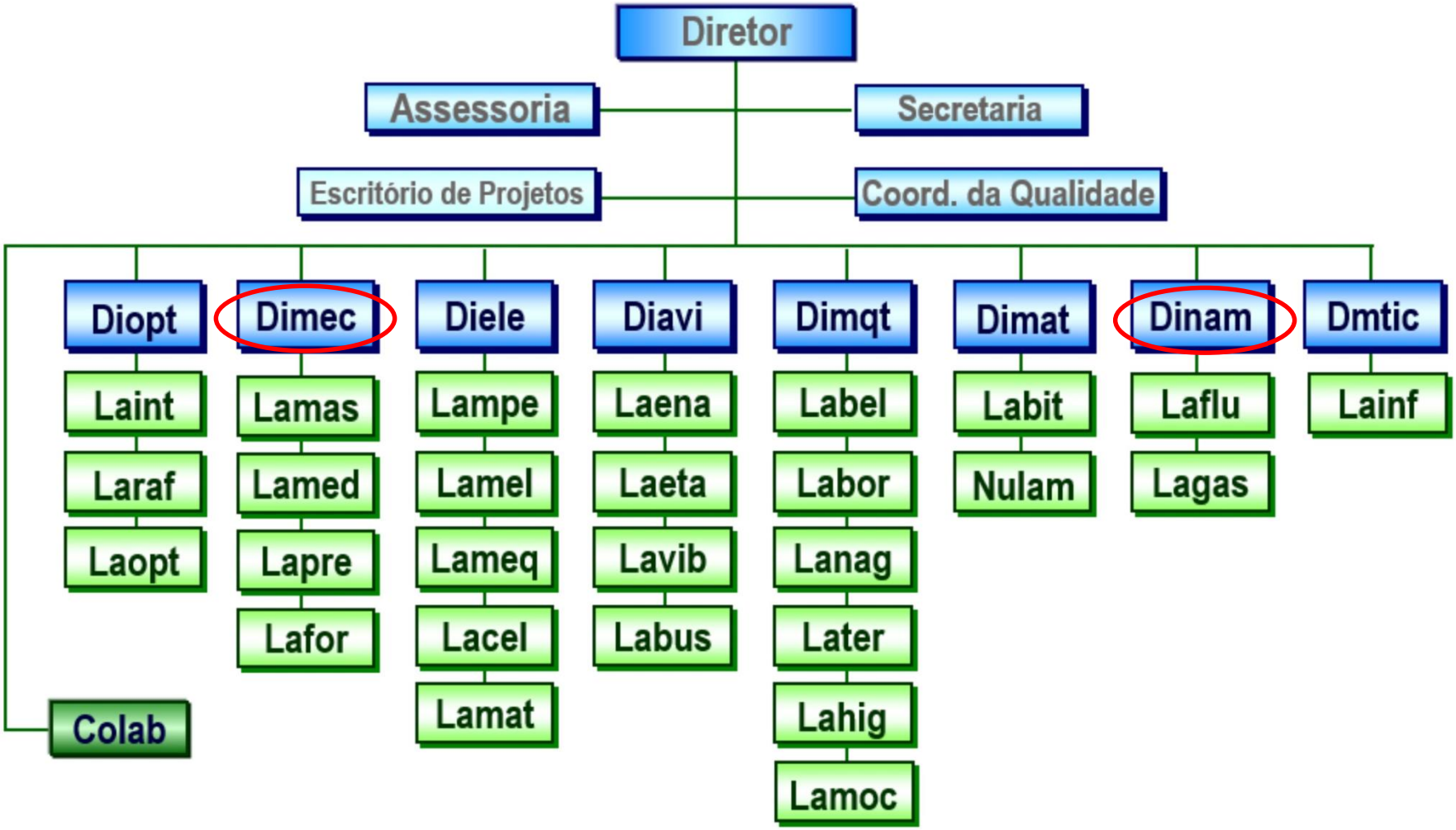
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Assessoria
Secretaria
Escritório de Projetos
Coord. da Qualidade
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Lavib
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Colab

17th meeting of the CCM

BIPM 16 - 17 May 2019

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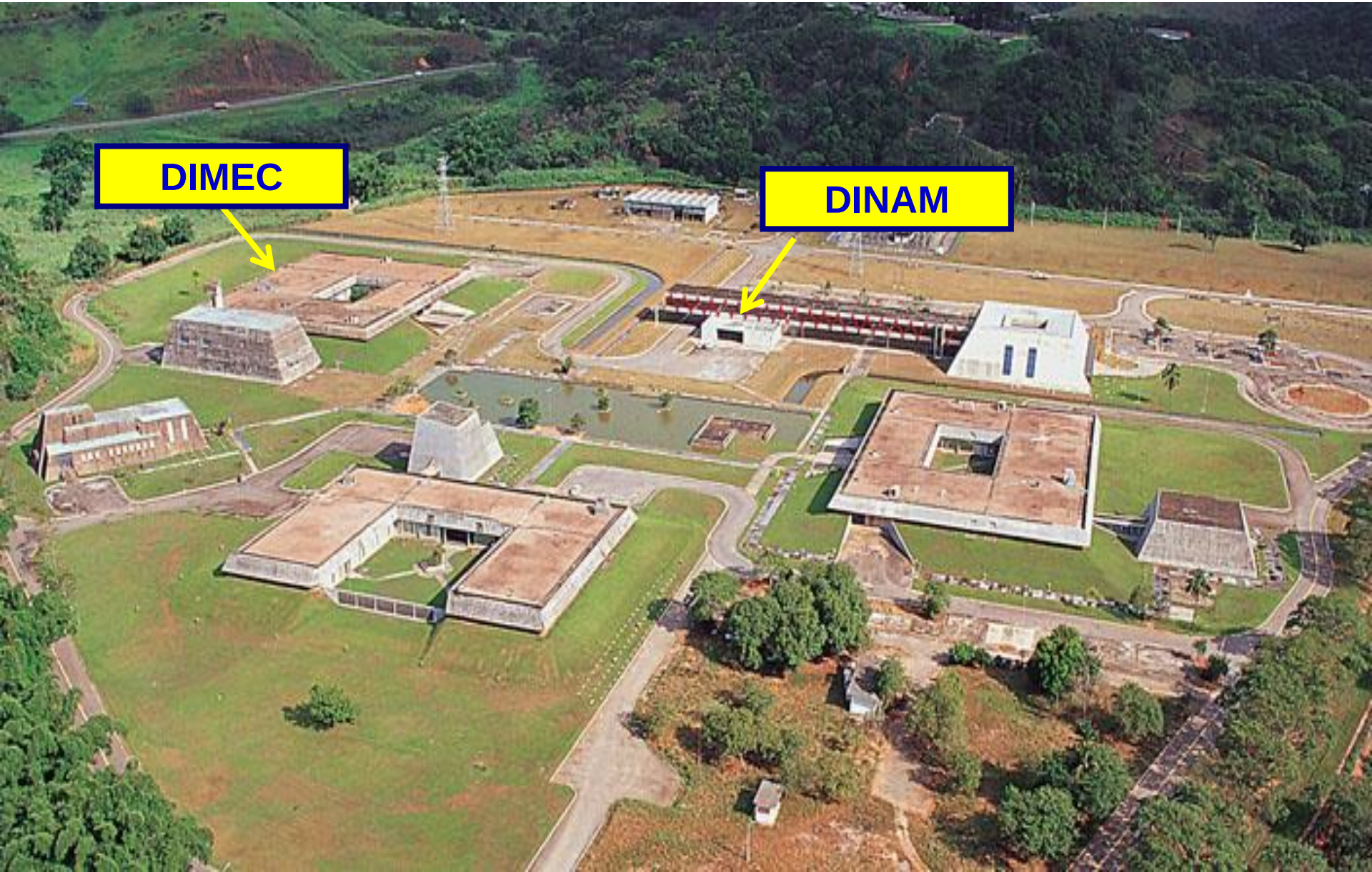
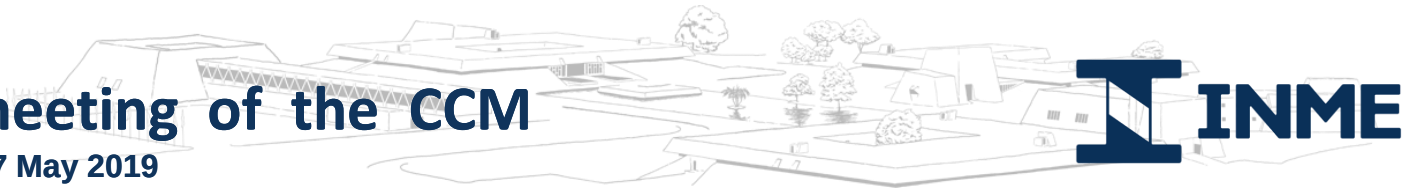


Mechanical Metrology Division
DIMEC

Mechanical Metrology Division (Dimec)

It comprises three mass and related quantities laboratories:

- **Lamas - Mass Laboratory (mass, volume and volume magnetic susceptibility of weights and mass standards)**
- **Lafor - Force Laboratory (force, torque, hardness and Charpy impact, now being implemented)**
- **Lapre - Pressure Laboratory (Pressure and vacuum)**



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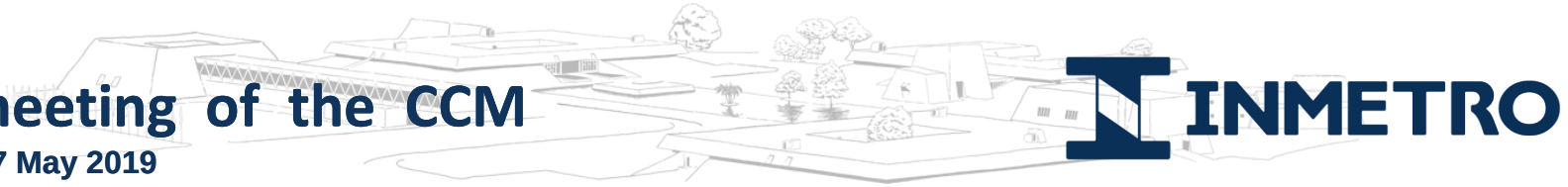
Mechanical Metrology Division (Dimec)



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Lamas - Mass Laboratory

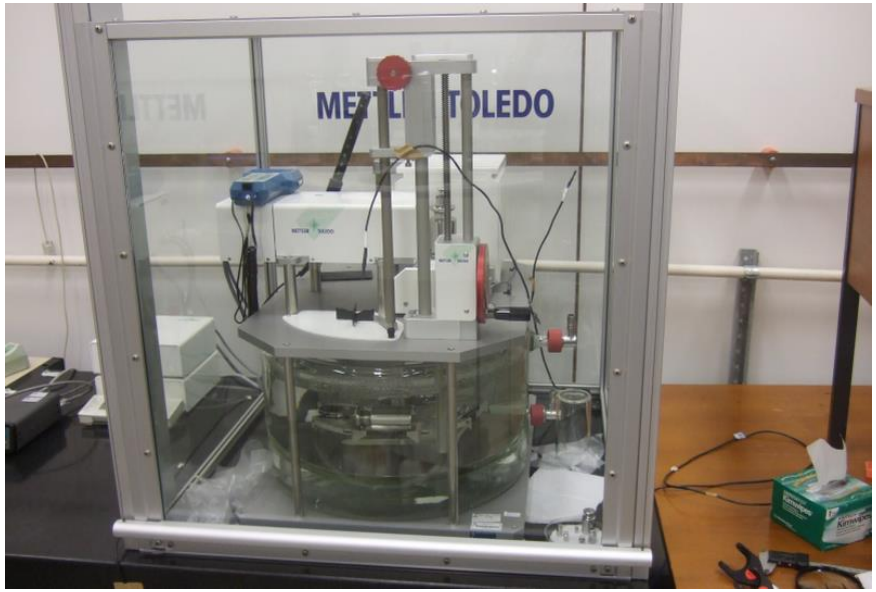
mass, volume & magnetic susceptibility of mass standards

Lamas - Mass Laboratory

Module 1

Lamas - Mass Laboratory

Module 2



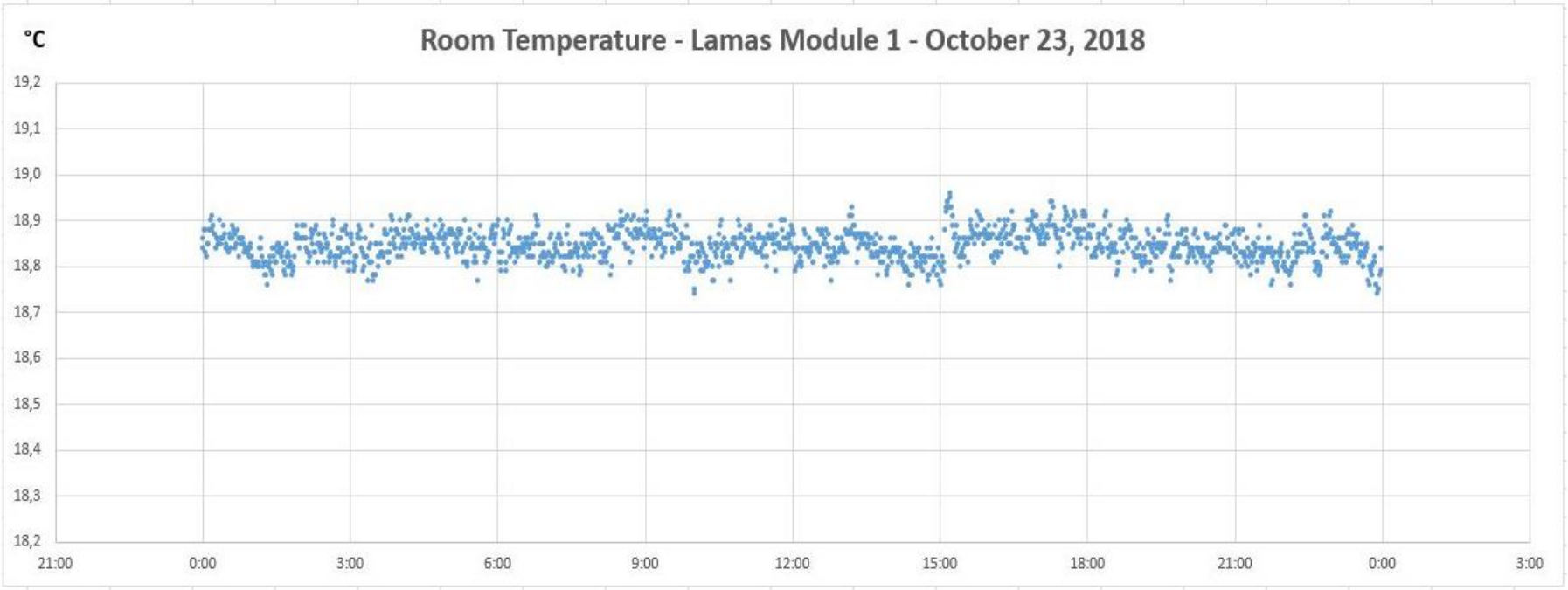
Lamas - Mass Laboratory

Prototype K66

Lamas - Mass Laboratory

Module 1 – *Lambrecht* station

Typical 24-hour room temperature stability

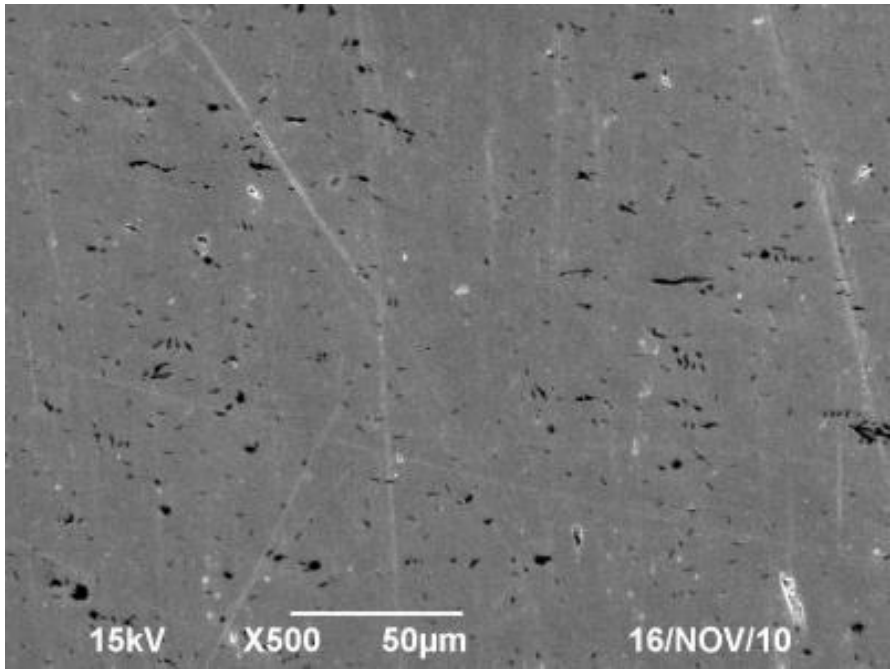


Lamas - Mass Laboratory

Subdivision method applied to determining the volume of mass standards submultiples of the kilogram

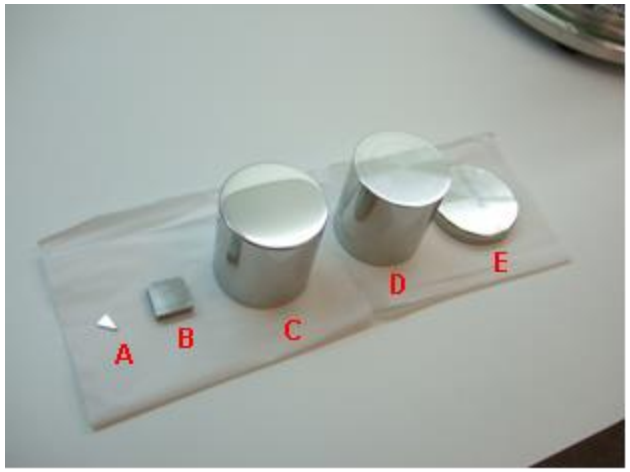
Lamas - Mass Laboratory

Factors that affect the long term stability of high accuracy mass standards

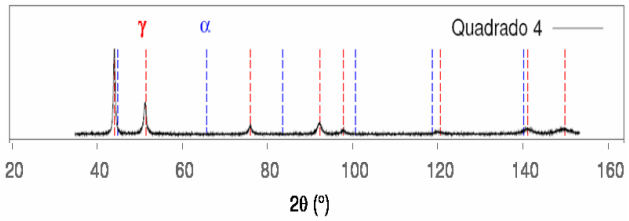


Lamas - Mass Laboratory

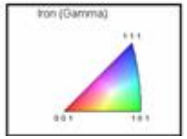
Characterization of St-St alloy to make high accuracy mass standards



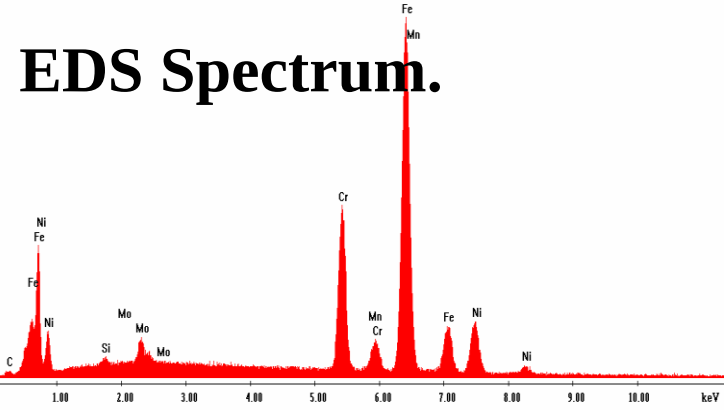
X-rays diffraction pattern



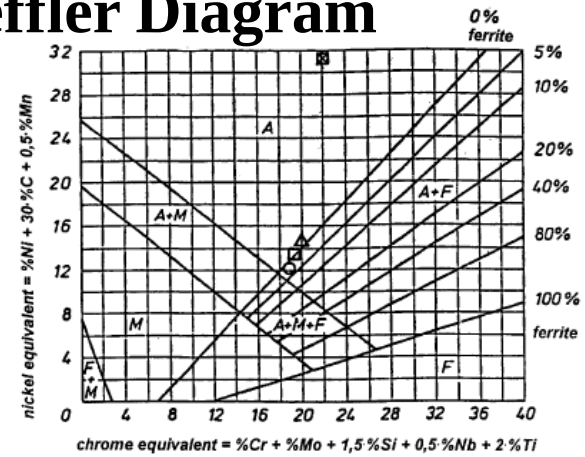
EBSD orientation map



EDS Spectrum.

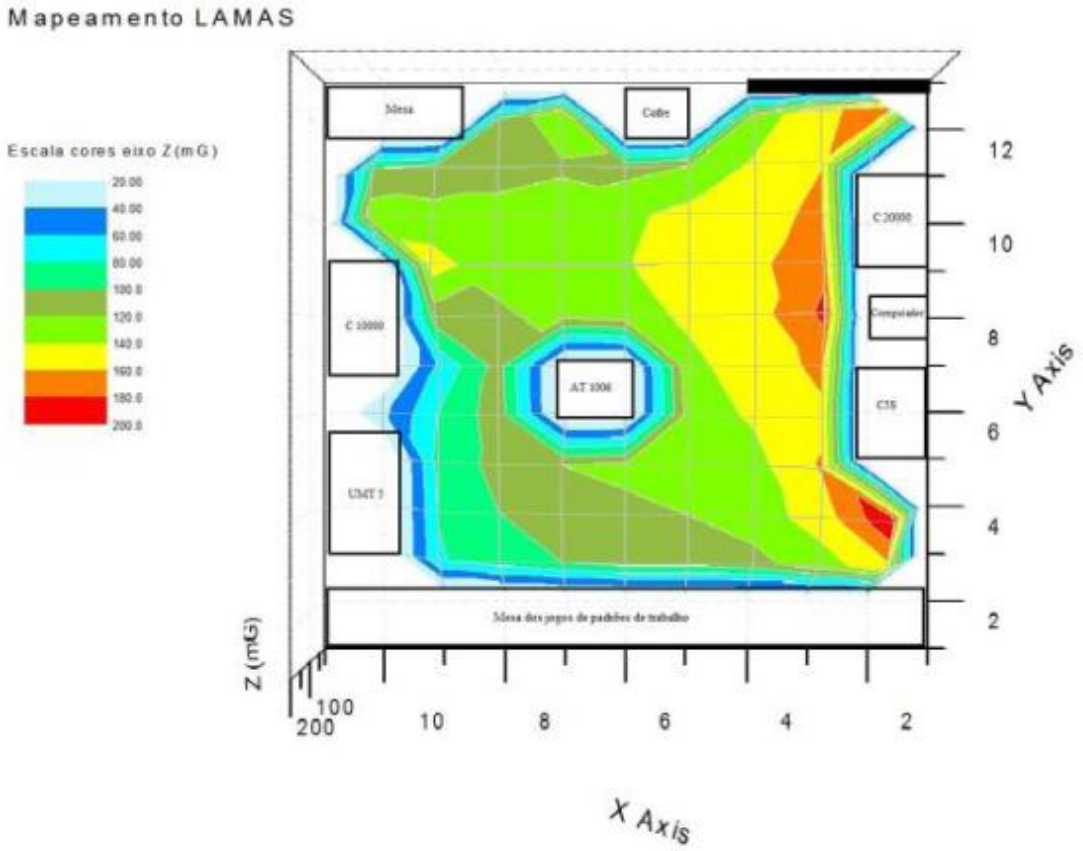


Schaeffler Diagram



Lamas - Mass Laboratory

Magnetic characterization of weighing laboratories and EMFC mass comparators



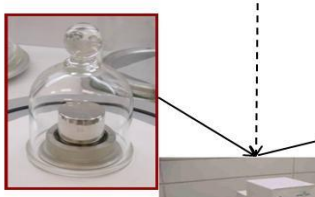
Lamas - Mass Laboratory

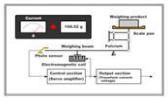
Improving the measurement uncertainty in mass scale realization from kilogram Prototype N° 66 (CMCs 1 kg, July 2017 100 μg, target 50 μg)

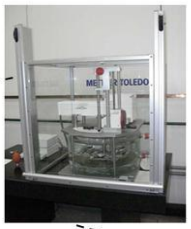
Revised formula for the density of moist air (CIPM-2007)

$$\rho_a = \frac{pM_a}{ZRT}\left[1 - x_v\left(1 - \frac{M_v}{M_a}\right)\right]$$

$$\Delta m = k \cdot \Delta I + \rho_a(P,t,h) \cdot \Delta V + C_g \cdot \Delta h + e_M$$







$$\beta_{ML} = CX^T Y + hm_r$$

Table 3 Maximum polarization, $\mu_0 M$, (μT)

Weight class	E_1	E_2	F_1	F_2	M_1	M_{1-2}	M_2	M_{2-3}	M_3
Maximum polarization, $\mu_0 M$, (μT)	2.5	8	25	80	250	500	800	1 600	2 500

Table 4 Maximum susceptibility, χ

Weight class	E_1	E_2	F_1	F_2
$m \le 1$ g	0.25	0.9	10	-
2 g $\le m \le$ 10 g	0.06	0.18	0.7	4
20 g $\le m$	0.02	0.07	0.2	0.8

$$\begin{pmatrix} X^T W^{-1} X & A \\ A^T & 0 \end{pmatrix}\begin{pmatrix} \beta \\ \lambda \end{pmatrix} = \begin{pmatrix} X^T W^{-1} Y \\ M_R \end{pmatrix}$$

$$s^2 = \frac{(\Delta M - X M)^T W^{-1} (\Delta M - X M) + \sigma_0^2 \sum_{i=1}^{N} (n_i - 1)}{\sum_{i=1}^{N} n_i - c + 1}$$

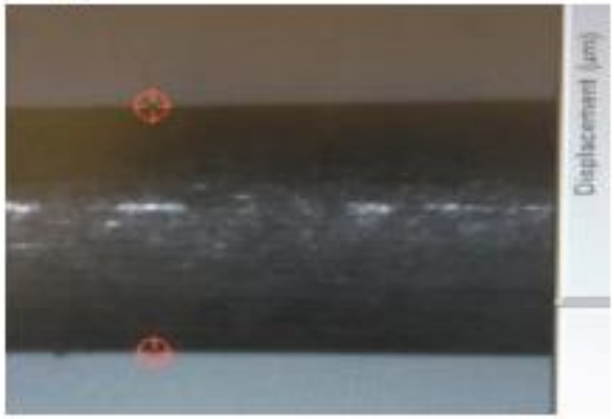
$$J_z = \begin{bmatrix} \partial \Delta m_1 / \partial z_1 & \cdots & \cdots & \cdots & \partial \Delta m_1 / \partial z_k \\ \vdots & \ddots & & & \vdots \\ \vdots & & \ddots & & \vdots \\ \vdots & & & \ddots & \vdots \\ \partial \Delta m_L / \partial z_1 & \cdots & \cdots & \cdots & \partial \Delta m_L / \partial z_k \end{bmatrix}$$

$$\psi_{\Delta M - B} = J_u \psi_u J_u^T$$

Lamas - Mass Laboratory

Micromass standards manufacturing and characterization

Tungsten wire.



MetGlass strip.

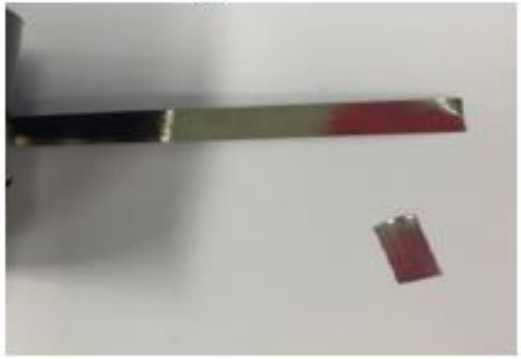


Table 1. Tungsten characterization.

Tungsten	Tabulated value	Measured value
Density	19.2 g/cm³	19.1 g/cm³
Elastic Modulus	400 GPa	

Table 2. MetGlass 2705M characterization.

Density (g/cm³)	Vicker's hardness (50g load)	Tensil strentgth (GPa)	Elastic Modulus (GPa)
7.80	900	1-2	100-110

Table 3. Standards mass in microgram.

Standard weigh identification	Mean Value (µg)	Standard deviation (µg)
1 (MG)	47.00	0.87
2 (Al)	47.50	0.58
3 (MG)	50.00	1.04
4 (MG)	52.50	2.18
5 (MG)	96.50	1.60
6 (MG)	97.50	0.76
7 (MG)	99.00	0.76
8 (MG)	102.50	1.29
9 (MG)	201.00	1.92
10 (MG)	201.00	3.21
11 (W)	497.50	1.80
12 (MG)	499.50	2.32

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Lamas - Mass Laboratory

SI kilogram redefinition promotion in Brasil

Metrologia
Fortaleza - CE
2017

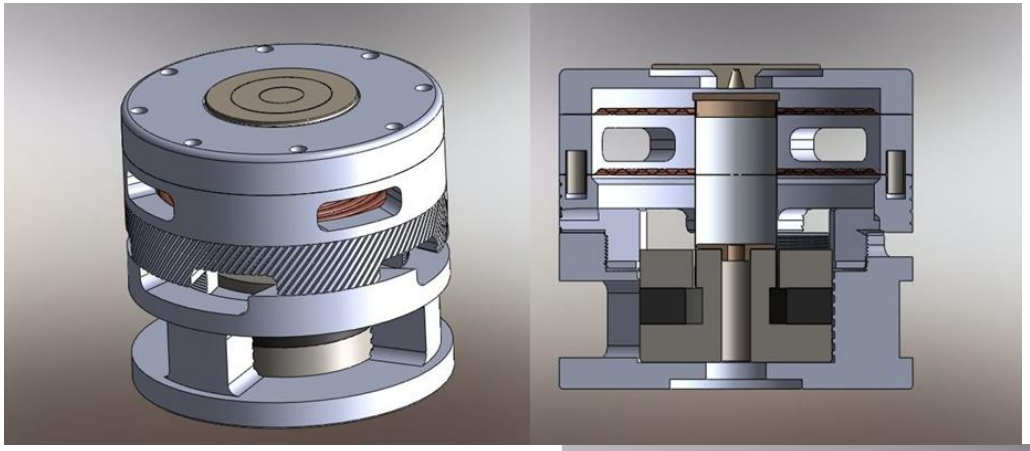
Redefinição do Kilograma III: Preparação e Consequências

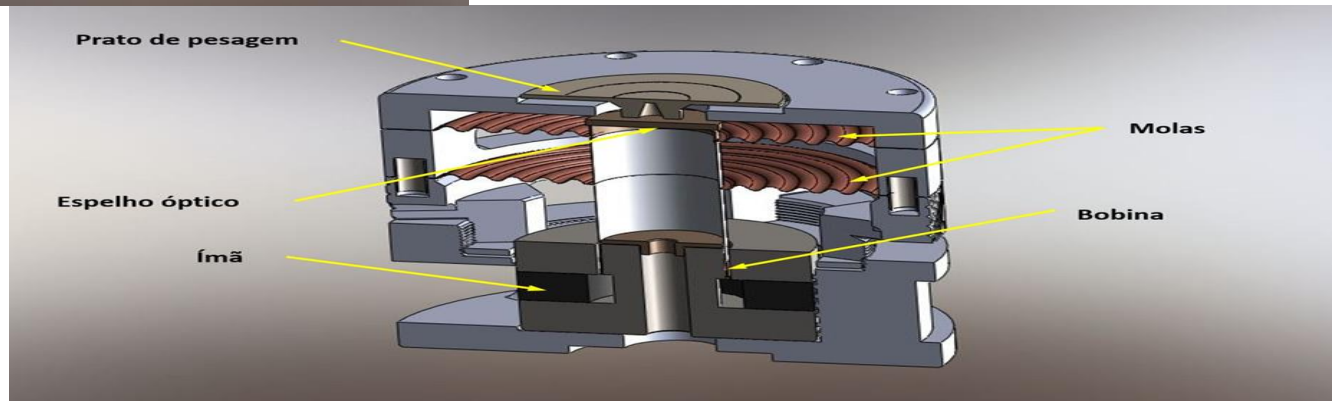
Redefinição do Kilograma II: Decisões

Redefinição do Kilograma I: Motivações e Justificativas

Lamas - Mass Laboratory

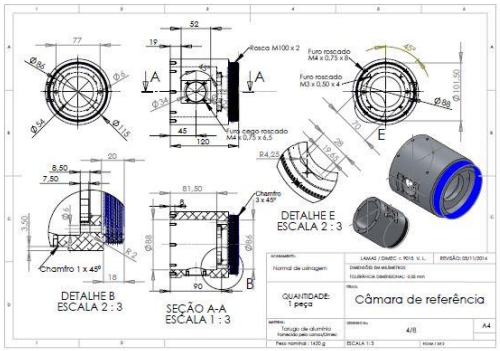
Table Top/ Planck Balance – Simplified Kibble balance

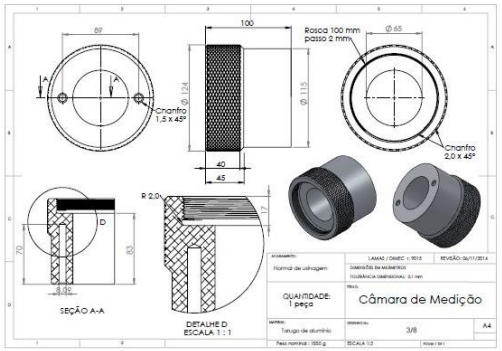


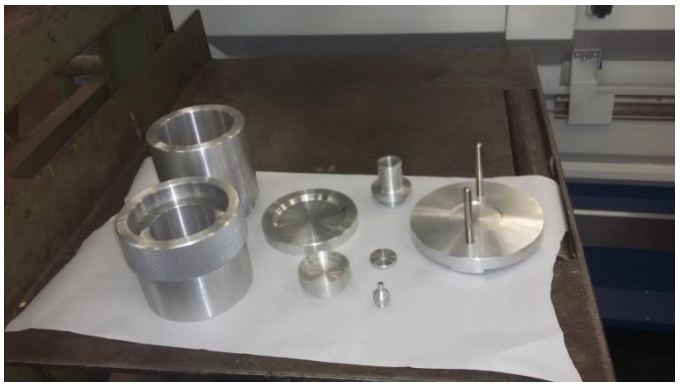


Lamas - Mass Laboratory

Acoustic Volumeter for volume measurement of mass standards

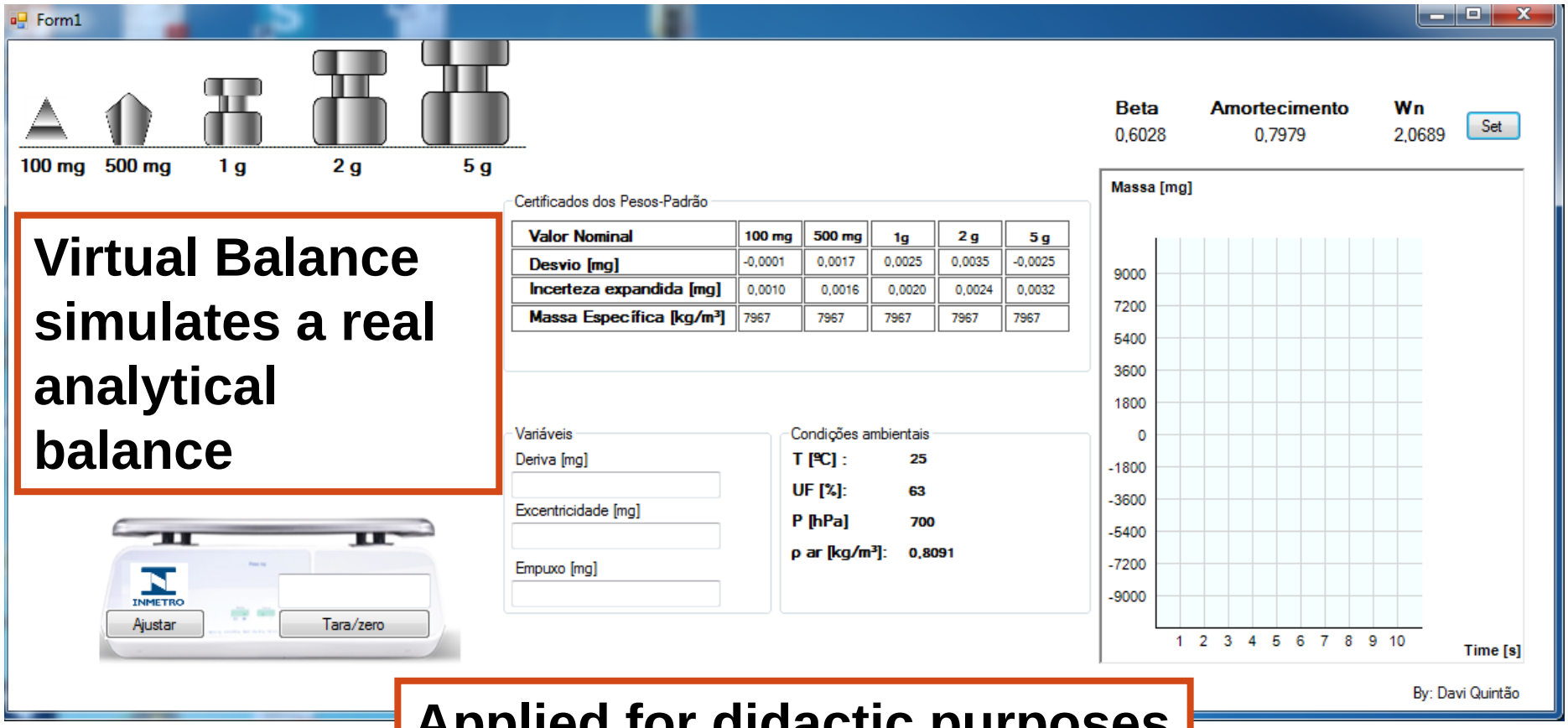






Lamas - Mass Laboratory

Virtual weighing instrument (Balance)



Virtual Balance simulates a real analytical balance

Applied for didactic purposes

Lamas - Mass Laboratory

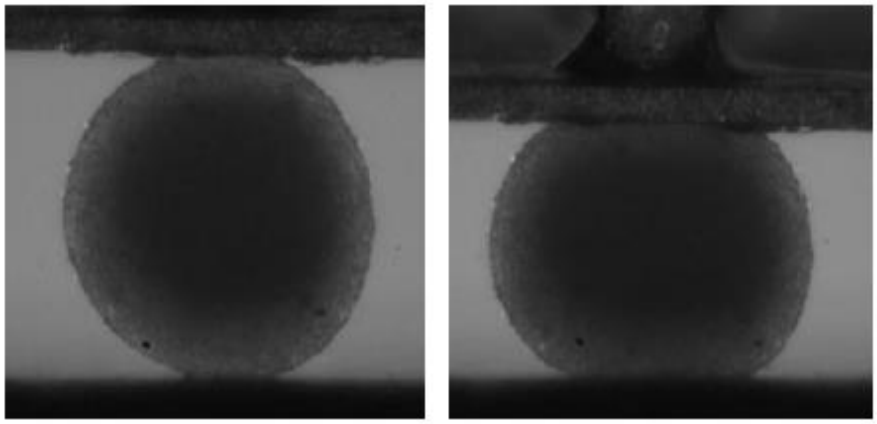
Uncertainty calculation modeling on measurements results of cell spheroids biomechanical properties in compressive tests

Metrologia
Fortaleza - CE
2017

Measurement uncertainty evaluation of cellular spheroids surface tension in compressing tests using Young-Laplace equation

Anderson Beatrici[1,2], Leandra Santos Baptista[2,3], José Mauro Granjeiro[2]

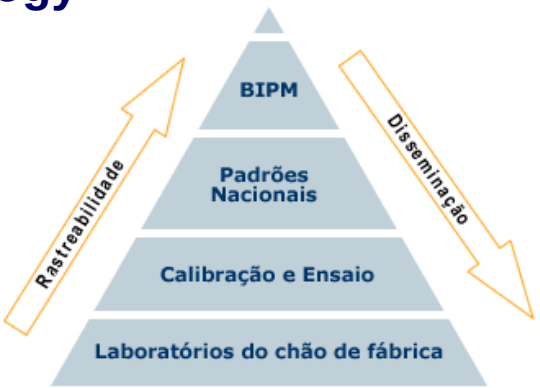
Figure 1. Cellular spheroid in the mechanical tester.



Lamas - Mass Laboratory

Improvement of mass measurement of source preparation in Radionuclide Metrology

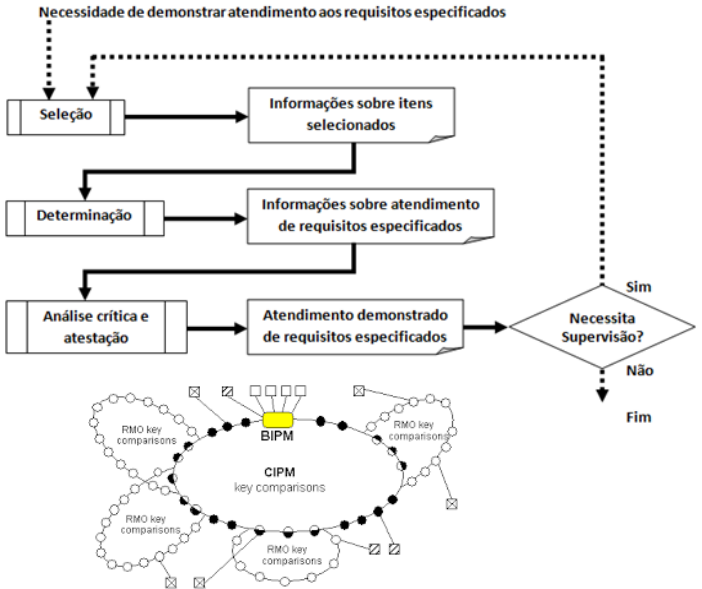
INMETRO → CNEN / IRD / LNMRI → CIPM MRA



Bq	A
m^{-2}	ϕ
C kg^{-1}	X
Gy	K
Sv	H

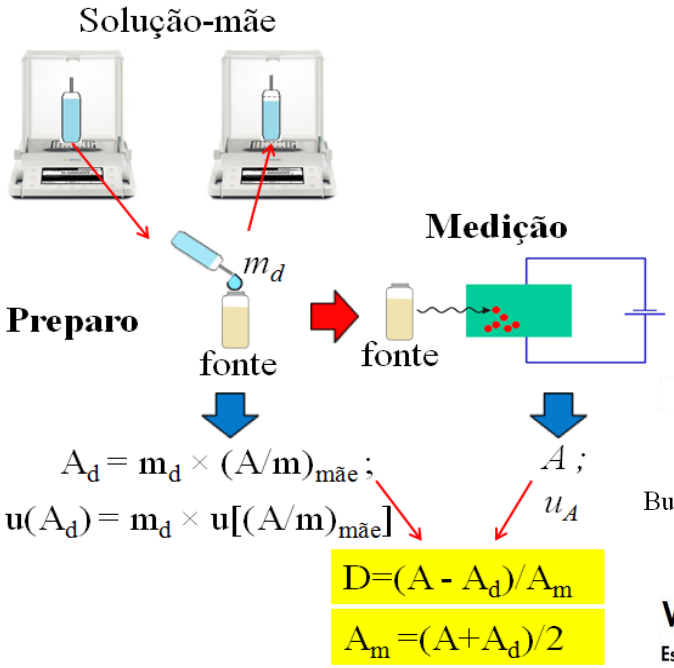
Brazil, LNMRI/IRD (Laboratorio Nacional de Metrologia das Radiacoes Ionizantes, IRD)
Complete CMCs in Ionizing Radiation for Brazil (.pdf file)

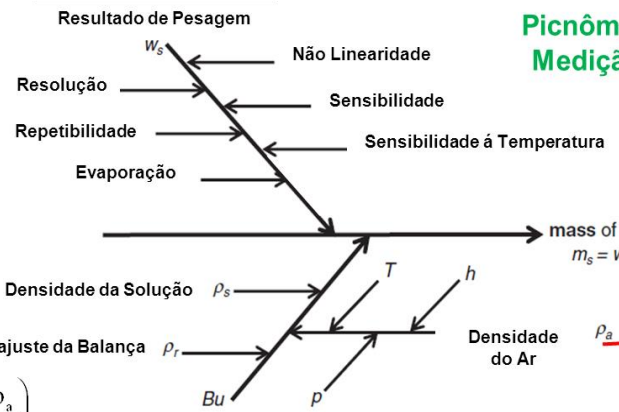
Activity per unit mass. Single nuclide, solid, **5.2E+02 Bq g^{-1} to 7.4E+05 Bq g^{-1}**
Relative expanded uncertainty (k = 2, level of confidence ~95%) in %: **3.0**
Planar NaI(Tl) crystals, measured or calculated efficiency, balance
Ba-133: 3 mL, LNMRI/IRD glass ampoule
Reference standard: 4 pi [e+X]-gamma coincidence, weight set
Source of traceability: LNMRI/IRD
Approved on 03 November 2004
Internal NMI service identifier: SIM-RAD-LNMRI/IRD-2059



Lamas - Mass Laboratory

Improvement of mass measurement of source preparation in Radionuclide Metrology





Picnômetro: Modelo de Medição Indicação da Balança

$\rho_a \rightarrow \rho_a = \dfrac{0,34848P - 0,009he^{0,061T}}{273,15+T}$

$$Bu = \frac{\rho_s(\rho_r - \rho_a)}{\rho_r(\rho_s - \rho_a)} = \frac{\left(1 - \frac{\rho_a}{\rho_r}\right)}{\left(1 - \frac{\rho_a}{\rho_s}\right)}$$

Weighing Accuracy
Estimating Measurement Bias & Uncertainty Of A Weighing
© METTLER TOLEDO
Arthur Reichmuth
V2.1 Sept. 2001

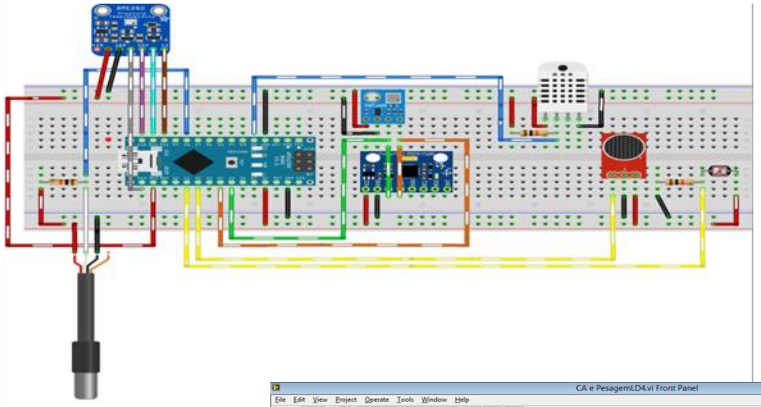
IOP Publishing | Bureau International des Poids et Mesures
Metrologia 51 (2014) 441–451
Andrea Malengo

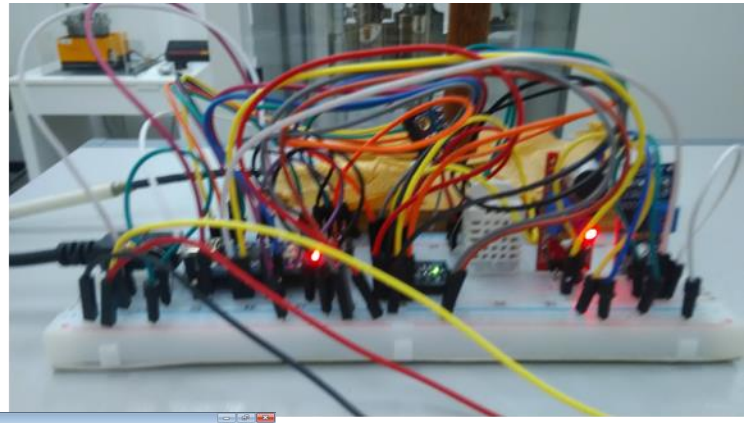
EURAMET
Guidelines on the Calibration of Non-Automatic Weighing Instruments

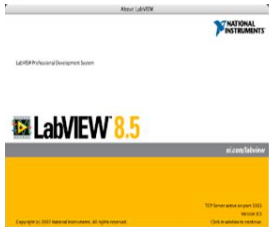
$$W_S = \frac{m_S}{Bu} + e_S + e_{ST} + e_{NL} + e_{EV} + e_R + e_d + e_{REP}$$

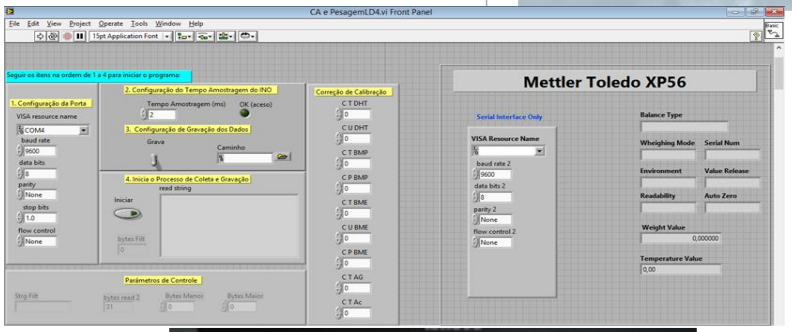
Lamas - Mass Laboratory

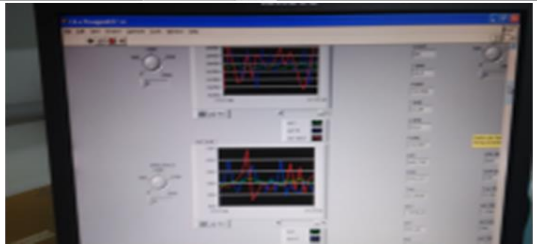
Improvement of mass measurement of source preparation in Radionuclide Metrology

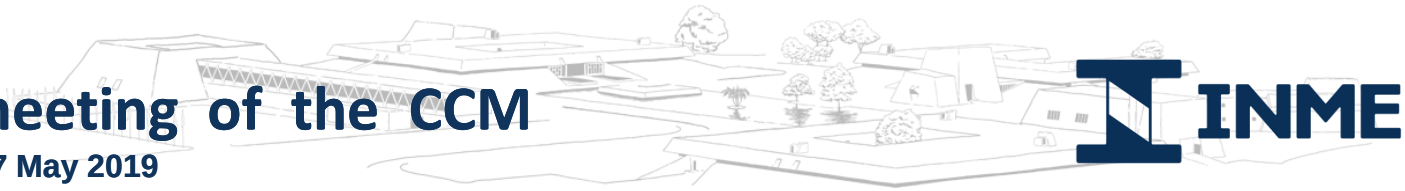












INMETRO

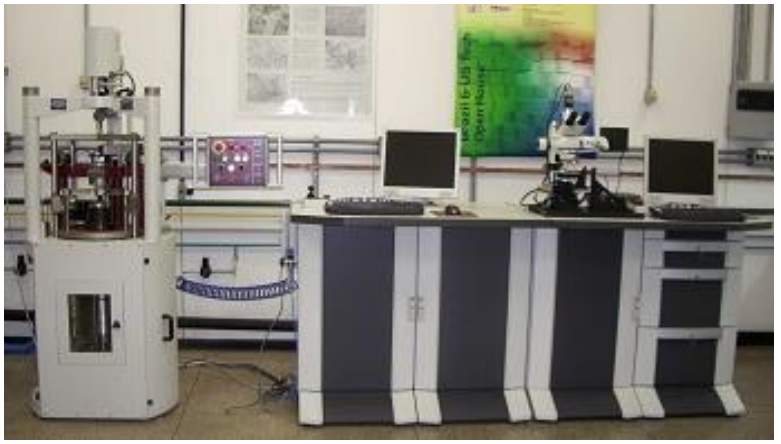
Lafor - Force Laboratory

Force, Torque, Hardness Metrology

Lafor - Force Laboratory

Dead-weight force standard machine for high capacity 10 kN to 1 MN

Primary standard hardness machine to certify hardness reference blocks



Primary standard torque machine (20 N•m to 3 000 N•m)

Reference system to calibrate hardness diamond indenters

Lafor - Force Laboratory

CMCs

Dead-weight force standard machine for high capacity 10 kN to 1.1 MN

- From 10 kN to 110 kN: 0.002%
- From 110 kN to 1.1 MN: 0.01%

Primary standard hardness machine to certify hardness reference blocks

- Brinell: 1%
- Rockwell: 0.2 to 0.3 HR units
- Vickers: 1%

Primary standard torque machine (20 N•m to 3 000 N•m)

- From 20 N•m to 3 000 N•m:0.01 %

Reference system to calibrate hardness diamond indenters

- Rockwell:0.05º (included angle)
- Vickers: 0.05º (opposite faces angle)

Lafor - Force Laboratory

Technical articles

Force metrology

- 08

Torque metrology

- 15

Hardness metrology

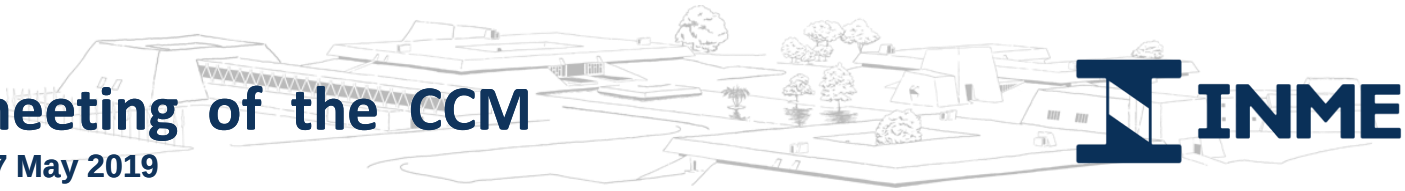
- 35

INMETRO

Lafor - Force Laboratory

main research areas

- Dynamic force;
- Dynamic torque;
- Micro force standard machine;
- Low capacity static torque;
- Vickers hardness reference blocks;
- Charpy impact test reference materials.



INMETRO

Lapre - Pressure Laboratory

Pressure & Vacuum

Lapre - Pressure Laboratory

General view of the Pressure Laboratory

Lapre - Pressure Laboratory

MKS VGCS-200 – Vacuum gauge calibration system

Lapre - Pressure Laboratory

The pressure balances of the Pressure Laboratory

Lapre - Pressure Laboratory

Research projects

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. The measurement includes optical and mechanical contacts for the measurement of shape and diameter of the assembly. A numerical post-processing procedure is applied to generate accurate three-dimensional data of the surfaces of the cylinder piston assembly required to determine its area.

Pressure Balance DHI – PG7000

Piston cylinder assembly - 50 mm of diameter

Lapre - Pressure Laboratory

Research projects

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

Pressure measurements have an extensive and important application in industrial processes. For example, in the petroleum, petrochemical, meteorological, aerospace, aviation, etc. industries. The reliability of these measurements is associated with trade, quality, health, safety, etc.

One of the applications of differential pressure is in flow measurement, which requires increasingly better uncertainties. The meters used in the flow measurements require a calibration with better accuracy to guarantee its performance.

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.

Lafor - Force Laboratory

Dead-weight force standard machine for high capacity 10 kN to 1 MN

INMETRO

Lafor - Force Laboratory

Research projects

Technical collaboration with the NIST/USA for the

"*Establishment of an international scale for measuring absorbed energy in a Charpy impact test*"

Objective: To define a SIM proposal to be adopted internationally.

Lafor - Force Laboratory

Research projects

Joint scientific and technological co-operation with the INRiM/Italy for the

"*Amplification of Primary Force Standardization in Brazil: a Project to develop a Low Force Primary Standard Machine from 10 N to 1000 N*"

Fluid Flow Metrology Division – Dinam

Fluid Flow Metrology Division – Dinam

Laboratories

- **Laflu – Fluids Laboratory**

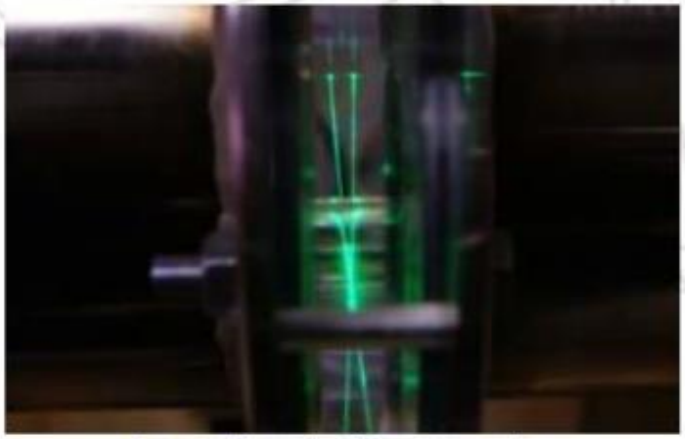
Link to CMCs
https://kcdb.bipm.org/appendixC/country_list_search.asp?CountSelected=BR&sservice=M/FF.9.5

- Lacad – Fluid Flow Laboratory
- Laliq – Liquids Flow Laboratory
- Lagas – Gasous Flow Laboratory

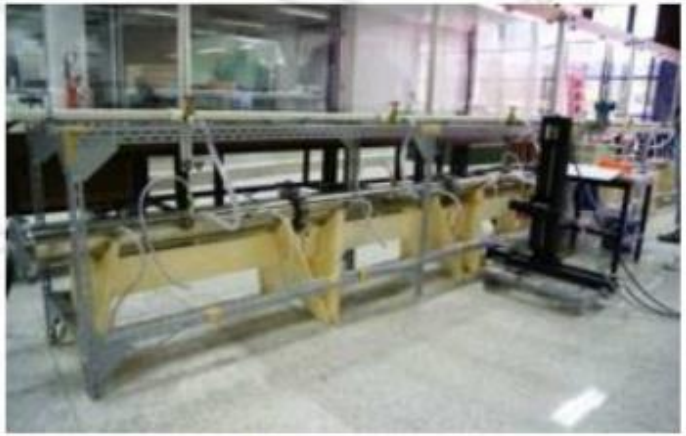
Fluid Flow Metrology Division – Dinam

Túnel Estratificado-Poço Horizontal

Tunel Aerodinâmico

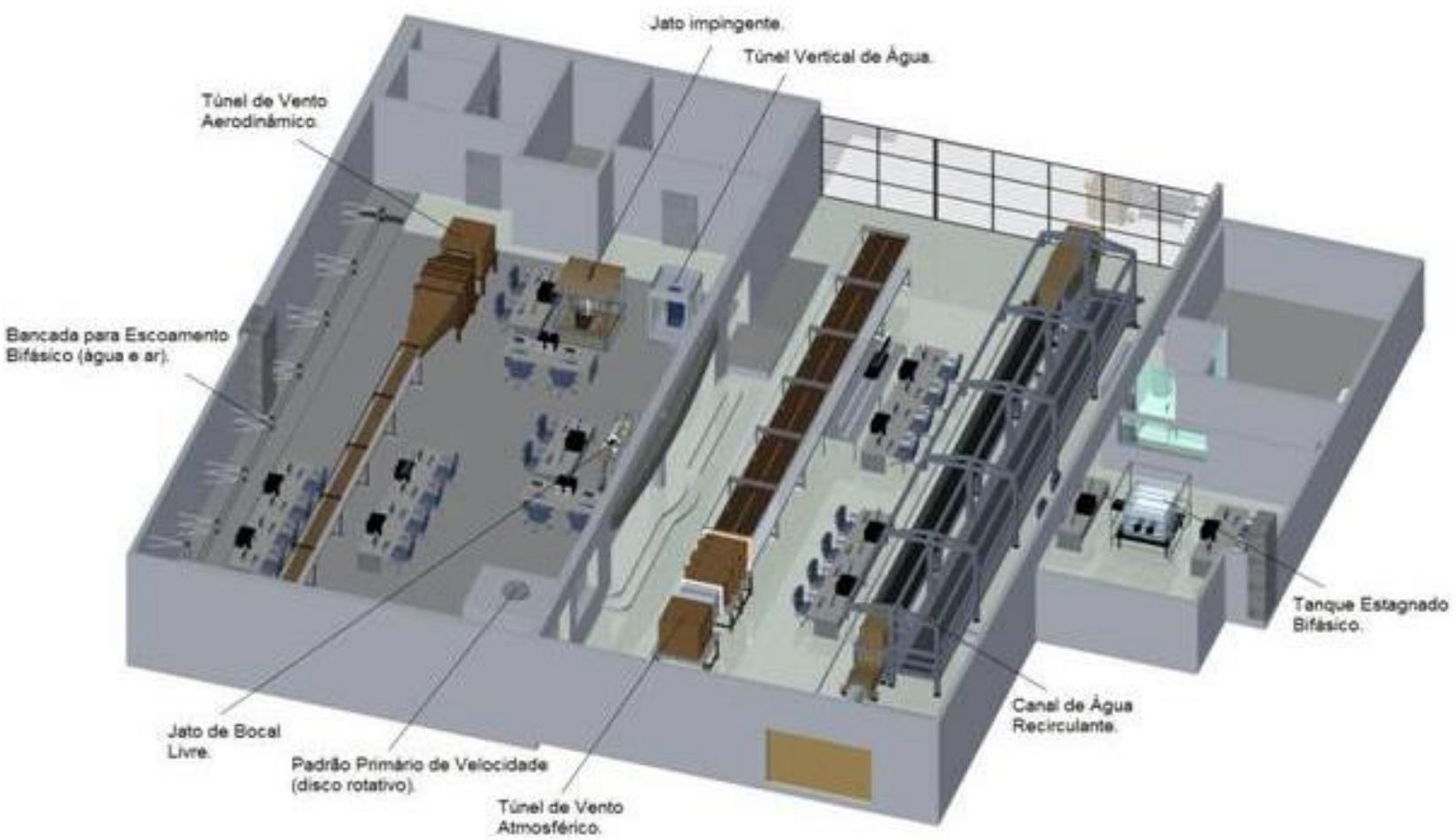


Laser-Doppler Anemometro



Poço Horizontal

Fluid Flow Metrology Division – Dinam



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Laflu - Fluids Laboratory

Volume, density, surface tension, viscosity

Fluids Laboratory – Laflu

QUANTITIES

- ***Volume***
  (volumetric glassware and volumetric standards up to 20 L);
- ***Surface Tension***
- ***Density***
- ***Viscosity***

Fluids Laboratory – Laflu

Hydrostatic weighing apparatus and viscosity set up.

Calibration of Volumetric Glassware

Calibrations
SI glass capillary viscometers
LP gas pycnometer
Titrator
Soap film burette
Burette
Graduated pipettes
Volumetric pipettes
Graduated micropipettes
Volumetric micropipettes
one mark volumetric flask
Glass pycnometer
Butyrometer for milk and dairy products
Metallic vessel (volume material measure)
Digital burette / dispenser
Syringe
Special syringe
Infusion Device Analyzer

Picnometers

Note: Further information regarding calibration services performed at Laflu please go to

http://www.inmetro.gov.br/laboratorios/servicos/calibDinam.asp

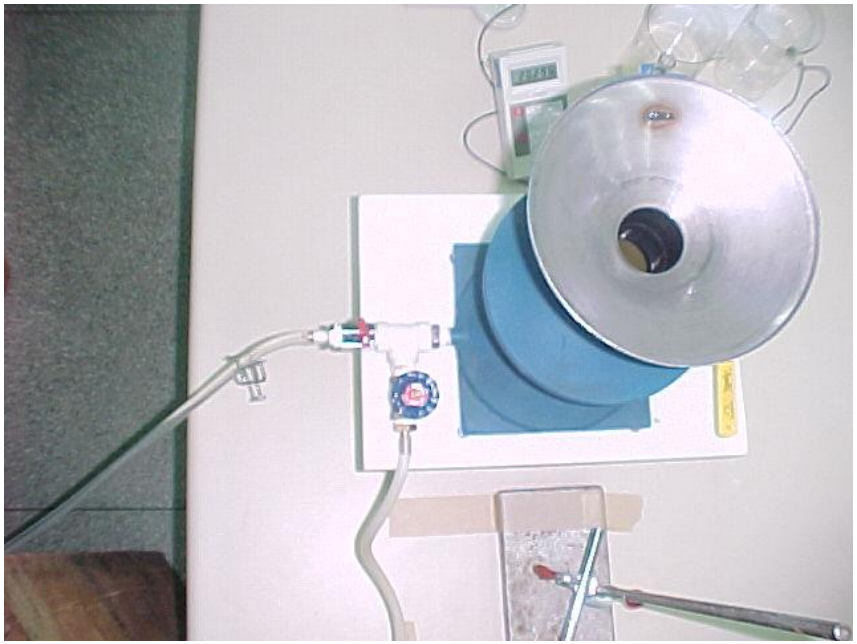
Further information regarding measurement services performed at Laflu please go to

http://www.inmetro.gov.br/laboratorios/servicos/ensDinam.asp

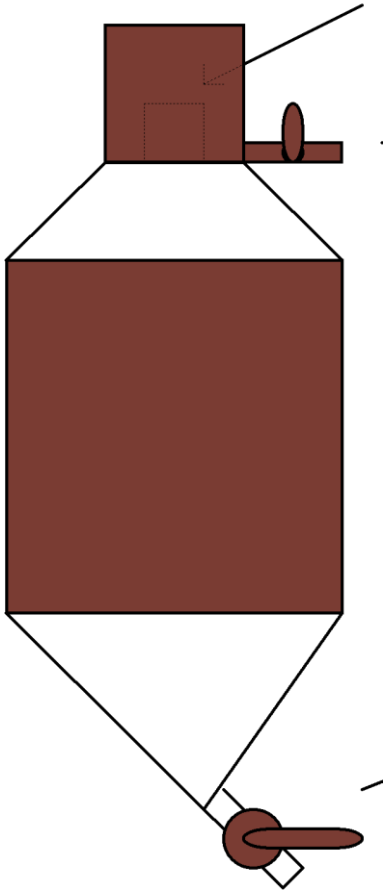
Volumetric Standards up to 20 L

No Laflu is responsible for calibration of volumetric standards up to 20 L.

There are 4 standards 1,5, 10 e 20 L.



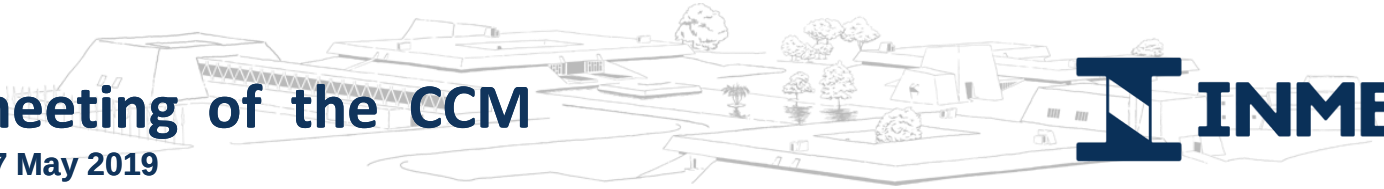
Transfer Vessels



Fluid inlet. Vessel is filled untill the top

Fluid drainage

Cointained fluid is drained untill vassel is completely empty.
Time to empty the vessel is measured.



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Thank you for your attention!