



ECONOMÍA
SECRETARÍA DE ECONOMÍA



**SUMMARY OF ACTIVITIES AT CENAM
ON
MASS AND RELATED QUANTITIES
2021 – 2023**

07 March 2023

1. FLOW AND VOLUME.

Main research and development activities related to flow activities

- Development of the gas flow secondary standard; a software of calibration in site, automation of the data acquisition, and estimate of error and uncertainty.
- Improvement of the gas flow secondary standard (0.5 to 6 500 m³/h); automation of the data acquisition and control system. In addition, these improvements allow the system to be operated remotely by the Internet.
- Improvement of the gas flow primary standard (0.5 to 160 m³/h); automation of the data acquisition and control system. In addition, these improvements allow the system to be operated remotely by the Internet.
- Research on the effects of different fluids on the calibration results for ultrasonic flow meters. An ultrasonic flowmeter (FLOWSIC600) was calibrated at CEESI at the (80 – 3200) m³/h interval using natural gas; when returning to Mexico, the meter was sent to CENAM for calibration; atmospheric air was used as working fluid. The results were consistent.

Participation in relevant comparisons in flow

SIM.M. FF-S9	Water flow 2016 Supplementary comparison Flow rate from 10 m ³ /h to 130 m ³ /h CENAM is acting as Co-Pilot Status: Draft B in progress
SIM.M. FF-K6	Gas Flow 2017- 2018 Key comparison Flow rate from 2 m ³ /h to 100 m ³ /h Status: Draft A in progress

Participation in relevant comparisons in Volume

SIM.M. FF-K4.1	Comparison of volume standards 2017 Key comparison Volume of Liquids at 20 L Volume of Liquids at 100 mL Status: In progress
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Bilateral comparison in Liquid Flow

CENAM – PTB

Transfer standard: Coriolis flow meter DN250
Flow rate: (150 – 720) m³/h
Status: Report in progress

List of relevant publications on Flow and Volume

- **Guide to estimate the volume at reference conditions for liquefied petroleum gas, as well as its uncertainty associated with the measurement.**
Guía para estimar el volumen a condiciones de referencia para gas licuado petróleo, así como su incertidumbre asociada a la medición.
Juan José Mercado Pérez
Simposio de Metrología CENAM
Querétaro, Qro., México 2022.
- **Traceability of gas volumetric flow results in the range of 0.5 to 6 500 m³/h in the CENAM low-pressure gas volumetric flow standard.**
Trazabilidad de los resultados de caudal volumétrico de gas en el intervalo de 0.5 a 6 500 m³/h en el patrón de caudal volumétrico de gas a baja presión del CENAM.
Juan Carlos Gervacio Sánchez
Simposio de Metrología CENAM
Querétaro, Qro., México 2022.

Peer Reviews at the laboratories

Liquid flow, peer reviewed by Enrico Frahm (PTB), May 2022
Large Volume of Liquids, peer reviewed by Tobias Nickshick (PTB), May 2022
Viscosity and Small Volume of Liquids, peer reviewed by Andrea Malengo (INRIM),
March 2022
Gas Flow, peer reviewed by Hernán Brenta (INTI), June 2022

2. MASS AND DENSITY

Main research and development activities related to Mass and Density activities

CENAM is still working on the following projects,

- The implementation of the air density measurements by using buoyancy artifacts and the M-One mass comparator
- Study of the mass change due to the vacuum air transfer in the mass calibration of stainless-steel mass standards
- Design of a top table Kibble balance. CENAM is in the stage of the mechanical design of a top table Kibble balance.
- SIM Kilogram Dissemination Project, Collaboration Co-led by NRC and NIST. One of the main objectives of this project is to study the correlating mass behavior with surface and environment at SIM countries, with mass traceability to the Planck Constant by Kibble Balances of NIST and NRC.
- Study of the mass change after cleaning and storage of natural silicon sphere of 1 kg.
- Development of calibration procedures for tensiometer calibration and development of reference materials in surface tension.

Participation in relevant comparisons in Mass

SIM.M.M-K6	Comparison of mass standards 2015 - 2017 Key comparison in Mass, Mass Standards Mass: 50 kg Status: Draft B in progress
SIM.M.M-S18	Comparison of mass standards 2018 Supplementary comparison in Mass, Mass Standards Mass: 20 kg Status: Draft A in progress
SIM.M.M-S19	Comparison of mass standards 2019 Supplementary comparison in Mass, Mass Standards Mass: 10 mg, 500 mg, 10 g, 100 g, 1 kg and 2 kg Status: Draft B Report

Pilot Study	Comparison of mass standards at sub-milligram level 2017-2020 Pilot Study in Mass, Mass Standards Mass: 1 mg, 500 mg, 200 mg, 200 mg*, 100 mg, 50 mg, 50 mg* Status: Report in progress.
Pilot Study	Comparison of calibration of microbalances with an alternative method. 2017-2020 Pilot Study in Mass. Phase 1: Mass: 5 g, 2 g, 2 g*, 1 g, 1 g*, 500 mg, 500 mg* Phase 2: NAWI under test: Max: 31 g / 0.001 mg Errors of indication: 5 g, 4.5 g, 4 g, 3.5 g, 3 g, 2.5 g, 2 g, 1.5 g, 1 g, 0.5 g Status: Report in progress

Participation in relevant comparisons in Density

CCM.D-K1:2023	Key comparison in Density measurement of a silicon sphere 2022 - 2023 Status: Measurements in progress
CCM.D-K5	Key comparison in Liquid Density by Oscillation Type Density Meters 2018 - 2023 Status: Measurements in progress
SIM.M.D-S6	Supplementary comparison in Hydrometer calibration 2017 - 2018 Status: Approved
AFRIMETS.M.D-S4	Supplementary comparison in Hydrometer calibration 2017 - 2018 Status: Approved
SIM.M.D-S7	Supplementary comparison in Liquid density using a hydrostatic weighing method 2022 Status: Measurements in progress

List of relevant publications on Mass and Density

- **Final report - Comparison of the calibrations of hydrometers for liquid density determination among SIM laboratories, SIM.M.D-S6**
L O Becerra and L M Peña
Published 6 October 2022 • © 2022 BIPM & IOP Publishing Ltd
Metrologia, Volume 59, Number 1A

Citation L O Becerra and L M Peña 2022 Metrologia 59 07018
<https://iopscience.iop.org/article/10.1088/0026-1394/59/1A/07018>

- **Supplementary comparison - Final report of AFRIMETS.M.D-S4 - hydrometer calibrations**
Mohamed Hamdy, Luis Omar Becerra and Ramaite Thomas Mautjana
Published 27 April 2022 © 2022 BIPM & IOP Publishing Ltd
Metrologia, Volume 59, Number 1A
- **Guía SIM para la calibración de instrumentos para pesar de funcionamiento no automático con resolución menor a 0.010 mg**
SIM Guidelines for calibration of non-automatic weighing instruments with resolution less than 0.010 mg.
D. Taipe, F. A. García, J. C. Sánchez, J. J. Escobar, J. P. García, L. O. Becerra, L. M. Peña, L. M. Cori, M. Prendas, R. A. Quille, S. M. Ramírez, S. V. Preste.
Inter-American Development Bank (IADB) project: “Strengthening National Metrology Institutes in the Hemisphere, in support of emerging technologies” - Sub-project: “Calibration of weighing instruments – Microbalances”.
Draft approved by SIM mass technical contacts.
- **Estudio de la Estabilidad del Método Alternativo en Calibración e Instrumentos de Pesar de Funcionamiento No Automático con Resolución menor a 0.010 mg – Microbalanzas.**
Sheila Preste, Daniel Gonzalez, Gabriel Almeida, Fernando Garcia, Juan Garcia, Rubén Quille, Javier Barbagría, Luz Cori, Donny Taipe, Luis M. Peña, Luis O. Becerra, Sandra Ramírez, Jhon Escobar, Álvaro Bermúdez, Marcela Prendas, Olman Ramos, Jorge Sanchez
Simposio de Metrología 2022 – October 26-28, 2022. CENAM. El Marqués, Querétaro, México.
Proceedings and ISBN in progress.
- **Medición de densidad de gas natural con un densímetro de tipo oscilatorio.**
José L. Rivera, Luis O. Becerra, Luis M. Peña
Simposio de Metrología 2022 – October 26-28, 2022. CENAM. El Marqués, Querétaro, México.
Proceedings and ISBN in progress.
- **Incertidumbre asociada con la indicación de los instrumentos para pesar verificados (*Uncertainty associated with the indication of verified weighing instruments*).**
Luis O. Becerra, Luis M. Peña
Ingeniería 31(2): 22-37, Enero-Junio, 2021. ISSN: 2215-2652. San José, Costa Rica
DOI 10.15517/ri.v31i2.45134.

Other activities on Mass and Density

- **Online forum “El Club de la Balanza 2022”**
On December 22nd and 23rd of 2022, CENAM organized the on-line forum “El Club de la Balanza”. This event has the goal to spread the topics of mass metrology to final users.

This 2022 was the third edition of this event and we have the valuable participation of speakers as Stuart Davidson (NPL-UK), Richard Green (NRC – Canada) and Leon Chao (NIST – USA) among others.

<https://www.cenam.mx/cb/Flyer2022.html>

3. FORCE AND TORQUE

Main research and development activities related to CCM activities

- Improvements to the 2 kN·m torque primary standard (system control and computing programming).
- Improvements to the 20 kN·m torque transfer standard (gearing improvements).
- Improvements to the 50 kN force primary standard (masses calibration, realignment).
- Improvements to the 150 kN force primary standard (electronics and control).
- Improvements to the 5 MN force transfer standard (better power supply system - gear and band).
- Development of a comparison system for low forces underway, up to 100 N.
- CENAM (Jorge Torres-Guzman) performed peer review of Costa Rica force capabilities, 2022.
- CENAM had a peer review of torque capabilities by Juan Alberto Arias Prieto from INM Colombia in 2022.
- CENAM had a peer review of force capabilities by Juan Alberto Arias Prieto from INM Colombia in 2022.
- CENAM had an approval of its quality management system from SIM for force and torque in May 2022.

Participation in relevant comparisons

- Bilateral comparison in torque transducer calibration between CENAM, Mexico and CEM, Spain. Measurement target points: 0 N·m, 10 N·m, 20 N·m, 50 N·m. Accepted by CCM and published at Metrologia 2022 59 Tech. Suppl. 07014.
- CCM.F.K23. CIPM force key comparison 500 N range. Finished, final report in edition.
- CCM.F-K1.a.2022 force key comparison (5 kN and 10 kN). Technical protocol-R2 approved. Measurements underway.

List of relevant publications

Title	Author	Event
Bilateral comparison in torque transducer calibration between CENAM, Mexico and CEM, Spain, SIM.M.T-S1	Jorge C. Torres-Guzman, M N Medina Martin, Carmen Garcia Izquierdo, Jesús	August 2022. Metrologia 59(1A):07014 DOI: 10.1088/0026-1394/59/1A/07014

	Galván, J L Robles Verdecia	
Ensayo de aptitud en par torsional para la calibración de torquímetros	J. Jesus Galvan, Juan M. Lopez	Simposio de Metrología 2022 26 - 28 de octubre, 2022
Actualización de la norma mexicana NMX-CH-6789-IMNC-2006 (herramientas de ensamble para tornillos y tuercas)	J Jesús Galván M., Jorge C. Torres G.	Simposio de Metrología 2022 26 - 28 de octubre, 2022
Diferencia entre una comparación interlaboratorios y un Ensayo de Aptitud	Jesús Galván Mancilla	De la metrologia. Volumen 21. Año 2022. N° 1
IMEKO XIX world congress fundamental and applied metrology scientific program	D. I. Kang, Jorge. A. P. Cruz, Nieves Medina, Pedro Silva Girau, Leo Van Biesen, Dirk Röske, M. Peters, K. Iizuka, R. Kaarls, Rolf Kumme, Jorge C. Torres-Guzman, A. J. Wallard	May 2021 DOI: 10.13140/RG.2.2.32769.38242 Conference: IMEKO XIX world congress fundamental and applied metrology
Industrial Dynamic Measurements of Mechanical Quantities within the Inter-American Metrology System (SIM)	Alejandro Savarin, Federico Serrano, Guillermo Silva Pineda, Jorge Torres-Guzman, Juan Alberto Arias Prieto, Ivan David Betancur Pulido, Akobuije Chijioke, Nick Vlajic, Renato Reis Machado and Rafael Soares de Oliveira	Journal of Physics. IoP Science. Volume 1826. 2021. 012078 IOP Publishing doi:10.1088/1742-6596/1826/1/012078

4. PRESSURE AND VACUUM

Main research and development activities related to CCM activities

- Improvements to the vacuum primary standard (improvements on heating system, valves and turbopump).
- Improvements to the isobaric chamber (better door seal).

- Improvements to the sealing between metal and ceramic of the piston cylinder assembly for (5 to 350) kPa.
- Improvements to the mounting system of the piston cylinder assembly to reduce friction for (5 to 175) kPa.
- CENAM had a peer review of pressure capabilities by Mayckol Jesid Morales Castro from INM Colombia in 2022.
- CENAM had a peer review of vacuum capabilities by Mayckol Jesid Morales Castro from INM Colombia in 2022.
- CENAM had an approval of its quality management system from SIM for pressure and vacuum in May 2022.

Participation in relevant comparisons

- CCM.P-K16, Key Comparisons on Gas Pressure (25 – 350) kPa, Absolute Mode. CENAM is the pilot laboratory. Technical protocol approved. Measurements underway.
- CCM.P-K17, Key Comparisons on Gas Pressure (25 – 350) kPa, Gauge Mode. CENAM is the pilot laboratory. Technical protocol approved. Measurements underway.
- CCM.P-K18, Key Comparisons on Gas Pressure (0.7 – 7) MPa, Gauge Mode. CENAM is the pilot laboratory. Technical protocol approved. Measurements underway.
- SIM.M.P-K1, 0.6 MPa to 7 MPa gauge pressure. CENAM was the pilot laboratory. Approved for equivalence by CCM 2021-02-03.
- SIM.M.P-K6, 10 to 120 kPa manometric pressure. CENAM was the pilot laboratory. Accepted by CCM published in Metrologia 2022 59 Tech. Suppl. 07011.
- SIM.M.P-K6.1, Positive Gauge Pressure Comparison 10 kPa to 100 kPa. CENAM is the pilot laboratory. Partially completed, only first loop finished. To be renamed.
- SIM.M.P-K2, Absolute Pressure Comparison 10 kPa to 120 kPa. CENAM is the pilot laboratory. Partially completed, only first loop finished. To be renamed.
- CCM.P-K13.1, 10 MPa to 100 MPa. Final report published at an International Conference. Waiting for approval by the CCM.

List of relevant publications

Title	Author	Event
SIM key comparison in pneumatic gauge pressure for high accuracy pressure balances up to 120 kPa (SIM.M.P-K6)	Jorge C. Torres-Guzman, J Aranzolo-Suarez, Francisco Flores Martínez, L de la Cruz, Douglas A Olson, J Forastieri, A Solano, C Neira, P Couto, J Palma, S Garcia	April 2022. Metrologia 59(1A):07011 DOI: 10.1088/0026-1394/59/1A/07011
Ensayo de aptitud de calibración de balanza de presión relativa hidráulica de 7 MPa a 70 MPa	Francisco Flores, Jorge Torres	Simposio de Metrología 2022 26 - 28 de octubre, 2022
La importancia de la utilización de un barómetro en la calibración de manómetros de presión negativa utilizando una balanza de presión como patrón de referencia	Francisco Flores, Jorge Torres	Simposio de Metrología 2022
Mantenimiento Correctivo de Pistón Cilindro 108 A.	Yolanda Cristina Verdejo Guerrero, Jesus Aranzolo Suarez	Simposio de Metrología 2022
IMEKO XIX world congress fundamental and applied metrology scientific program	D. I. Kang, Jorge. A. P. Cruz, Nieves Medina, Pedro Silva Girau, Leo Van Biesen, Dirk Röske, M. Peters, K. Iizuka, R. Kaarls, Rolf Kumme, Jorge C. Torres-Guzman, A. J. Wallard	May 2021 DOI: 10.13140/RG.2.2.32769.38242 Conference: IMEKO XIX WORLD CONGRESS Fundamental and Applied Metrology
Ensayo de aptitud de calibración de balanza de presión relativa hidráulica de 7MPa a 70MPa	Flores Martínez F. J., Torres-Guzmán J. C.	De la Metrología, Vol. 20 No. 1, 2021.

5. HARDNESS AND GRAVITY

Main research and development activities related to Hardness and Gravity laboratories

Hardness Laboratory:

- CENAM is still working on the characterization of the primary standard for Rockwell hardness method.
- Development of calibration procedures of the direct method for the calibration of durometers in accordance with the standards ISO 6508-3 and ASTM E-18.
- Development of calibration procedures for the calibration of hardness reference blocks by the Vickers Method according to the standard ISO 6507-3.

Gravity Laboratory:

- Primary standard on Gravity Acceleration (FG5X-252) was out of service. Its preventive maintenance was carried out, in December 2022.
- Since January 2023, the primary standard on Gravity Acceleration is operating normally within the facilities of the Gravity Acceleration Laboratory.
- Logistics were carried out to evaluate the possibility of making absolute measurements of the acceleration of gravity in laboratories where the contribution of this magnitude is important, at the request of some laboratories of the National Institute of Metrology of Colombia (INM) and INMETRO from Brazil.

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