



El Marqués, Querétaro México 06 May, 2021

SUMMARY OF CENAM ACTIVITIES ON MASS AND RELATED QUANTITIES 2019 – 2021

1. MASS AND DENSITY

Main research and development activities related to Mass and Density activities

CENAM is still working in the following projects,

- The implementation of the air density measurements by using buoyancy artefacts 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.
- Developing of the calibration procedures for tensiometer calibration and developing 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: Report in progress
------------	--





SIM.M.M-S16	Comparison of mass standards 2016 Supplementary comparison in Mass, Mass Standards Mass: 2 kg, 1 kg, 200 g 50 g, 1 g and 200 mg Status: Approved
SIM.M.M-S18	Comparison of mass standards 2018 Supplementary comparison in Mass, Mass Standards Mass: 20 kg Status: Report 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: Report in progress
Pilot Study	Comparison of mass standards at sub-milligram level 2017-2020 Pilot Study in Mass, Mass Standards Mass: 1 mg, 500 µg, 200 µg, 200 µg*, 100 µg, 50 µg, 50 µg* Status: Measurements completed
Pilot Study	Comparison of calibration of microbalances with 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: Measurements completed

Participation in relevant comparisons in Density

CCM.D-K5	Comparison in Liquid Density 2018 Key comparison in Mass, Density Oscillation Type Density Meters Status: Protocol Completed
SIM.M.D-S6	Hydrometer calibration 2017 - 2018 Supplementary comparison in Mass, Density Status: In progress





AFRIMETS.M.D-S4 Hydrometer calibration
2017 - 2018
Supplementary comparison in Mass, Density
Status: In progress

List of relevant publications on Mass and Density

- **Associated uncertainty to the indication of verified weighing instrument**
Incertidumbre asociada con la indicación de los instrumentos para pesar verificados
Revista Ingeniería (Revista Digital) de la Universidad de Costa Rica
Vol. 31 Núm. 2 (2021): Julio - diciembre 2021
DOI 10.15517/ri.v31i2.45134
Publicado: Mar 9, 2021
<https://revistas.ucr.ac.cr/index.php/ingenieria/article/view/45134>
- **Determinación de la densidad del gas natural sintético por medio del método de elemento finito.**
Determination of synthetic natural gas by finite element method
J. L. Rivera, J. Pérez, L. O. Becerra, T. de J. Gómez
Congreso Internacional de Investigación, Academia Journals
Tepic, 2019
ISSN 1946-5351
- **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. Taípe, 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".
To be published in 2021.

2. FORCE AND TORQUE

Main research and development activities related to CCM activities

- Improvements to the 2 kN·m torque primary standard (higher mass class, lower length uncertainty, absolute local gravity acceleration measurement, better arm stability).
- Improvements to the 20 kN·m torque transfer standard (increase in range, better alignment).





- Improvements to the 50 kN force primary standard (higher mass class, absolute local gravity acceleration measurement).
- Improvements to the 150 kN force primary standard (absolute local gravity acceleration measurement, electronics and control).
- Improvements to the 5 MN force transfer standard (better alignment and better hydraulic force stability control, better reference force transducer).
- 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, 2019.
- CENAM (Jorge Torres-Guzman) performed peer review of South Africa force capabilities, 2019.

Participation in relevant comparisons

- CCM.F.K23. CIPM force key comparison 500 N range. Ongoing.
- SIM.M.T-S2. Bilateral torque comparison, INM (Colombia)-CENAM 500 N·m range. CENAM was the pilot laboratory. Accepted by CCM and published at *metrologia supplement* in Jan 2020.
- 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. Draft B finished.

List of relevant publications

Title	Author	Event
SIM.M.T-S2 supplementary bilateral comparison calibration of a reference torque wrench final report.	J. J. Galvan, J. C. Torres-Guzmán, J. A. Arias, and I. D. Betancur.	January 2020 • Metrologia, Volume 57, Number 1A.
Ensayo de aptitud en fuerza para la calibración de transductores de fuerza en modo compresión, de 10 kN a 100 kN	Cárdenas Moctezuma A., Martínez Juárez F., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud en fuerza para la calibración de máquinas de ensayos en modo compresión de 10 kN a 100 kN	Cárdenas Moctezuma A., Martínez Juárez F., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.





Ensayo de aptitud en fuerza para la calibración de máquinas de ensayos en modo compresión de 50 kN a 500 kN	Cárdenas Moctezuma A., Martínez Juárez F., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud en fuerza para la calibración de máquinas de ensayos en modo tracción de 15.00 kN a 150.00 k	Cárdenas Moctezuma A., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud en par torsional para torquímetros de selección de bajo intervalo	Galván Mancilla J J., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud en par torsional, para la calibración de transductores, hasta 1 kN·m	Galván Mancilla J J., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Sistema de transferencia de par torsional hasta 20 kN·m, Cenam México (Estudio para incremento de intervalo)	J. C. Torres-Guzmán, J. J. Galván Mancilla, O. Segovia Arriola, C. V. Gómez Chávez	Congreso de Metrologia 2019. Florianópolis Brasil.
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

3. PRESSURE AND VACUUM

Main research and development activities related to CCM activities

- Improvements to the vacuum primary standard (improvements on expansion paths, re-evaluation of degasification rate, re-evaluation of uncertainty, change of valves and change of turbopump).
- Establishment of the FPG as standard for barometric, differential and absolute pressure.





- CENAM (Jorge Torres-Guzman) performed peer review of Argentina pressure capabilities, 2019.
- CENAM (Jorge Torres-Guzman) performed peer review of Brazil pressure capabilities, 2019.

Participation in relevant comparisons

- CCM.P-K2.2021 (K18), Key Comparisons on Gas Pressure (25 – 350) kPa, Absolute Mode. CENAM is the pilot laboratory. Undergoing
- CCM.P-K1.b.2021 (K16), Key Comparisons on Gas Pressure (25 – 350) kPa, Gauge Mode. CENAM is the pilot laboratory. Undergoing
- CCM.P-K1.c.2021 (K17), Key Comparisons on Gas Pressure (0.7 – 7) MPa, Gauge Mode. CENAM is the pilot laboratory. Undergoing.
- SIM.M.P-K1, 0.6 MPa to 7 MPa gauge pressure. CENAM was the pilot laboratory. Accepted by CCM (to be published at *metrologia supplement*) in Feb 2021.
- SIM.M.P-K6, 10 to 120 kPa manometric pressure. CENAM was the pilot laboratory. Accepted by CCM (to be published at *metrologia supplement*) in Feb 2021.
- SIM.M.P-S10, 700 kPa to 7 000 kPa. CENAM was the co-pilot laboratory. Accepted by CCM and published at *metrologia supplement* in Nov 2020.
- SIM.M.P-K6.1, Positive Gauge Pressure Comparison 10 kPa to 100 kPa. CENAM is the pilot laboratory. Ongoing, first loop finished.
- SIM.M.P-K2, Absolute Pressure Comparison 10 kPa to 120 kPa. CENAM is the pilot laboratory. Ongoing, first loop finished.
- SIM.M.P-K7, 10 MPa to 100 MPa. Final report published at an International Conference. To be approved by the CCM.

List of relevant publications

Title	Author	Event
SIM.M.P-S10, 700 kPa to 7 000 kPa.	Leonardo De la Cruz, Jorge Torres-Guzman, Adrián Solano, Marcial Espinoza, Maria Neyra, Pablo Constantino, Jesús Aranzolo, Ricardo Sánchez	Metrologia Supplement. November 2020.





Medición primaria de presión	Torres-Guzmán J. C., Aranzolo Suárez J.	De la Metrología, Vol. 18 No. 2, 2019.
Investigación y evaluación del efecto de la contaminación por ruido en vivienda de México. Uso de aislamiento con vacío (Etapa 1)	Torres-Guzmán J. C., Servín López K. L., Verdejo Guerrero Y. C., Aranzolo Suárez J.	De la Metrología, Vol. 18 No. 2, 2019.
3er seminario sobre técnicas avanzadas de calibración de presión	Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud de calibración de manómetro digital de presión relativa negativa -3 kPa a -80 kPa	Flores Martínez F. J., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Ensayo de aptitud de presión para la calibración de manómetros digitales de 7 MPa a 70 MPa	Flores Martínez F. J., Torres-Guzmán J. C.	De la Metrología, Vol. 18 No. 3, 2019.
Manual de mantenimiento del sistema de expansión estático SEE-1	Torres-Guzmán J. C., Verdejo Guerrero Y. C., Barajas Rueda M.	De la Metrología, Vol. 18 No. 3, 2019.
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.
Measurement systems for the calibration of leaks and holes in dynamic pressure (micro flow)	J. C. Torres-Guzman, Y. C. Verdejo	Congreso de Metrologia 2019. Florianópolis Brasil.
Balanza de presión - influencia de la medición del volumen del ensamble pistón/cilindro	J. C. Torres-Guzmán, J. Aranzolo Suárez, J. L. Rivera Ramírez	Congreso de Metrologia 2019. Florianópolis Brasil.
Impacto de los valores de referencia de presión en la calibración de barómetros.	J. C. Torres-Guzmán, E. A. Manríquez Martínez, J. M. López Manzano	Congreso de Metrologia 2019. Florianópolis Brasil.





4. FLOW AND VOLUME

Main research and development activities related to flow activities

- Improvement to the liquid flow primary standard; automation of the weighing system calibration.
- Improvement to the liquid flow primary standard; automation of the data acquisition and control system.

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: Report 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: 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: Report in progress
----------------	--

List of relevant publications on Flow and Volume

- **Estimation of the uncertainty associated with the measurement of gas flow with differential pressure type meters using orifice plate**
Estimación de la incertidumbre asociada a la medición de caudal de gas con medidores tipo presión diferencial usando placa de orificio.
Juan José Mercado Pérez
Uncertainty Workshop 2019
Universidad Politécnica de Santa Rosa Jáuregui, Querétaro, México.





ECONOMÍA
SECRETARÍA DE ECONOMÍA



- **Calibration times for ultrasonic flow meters (Hydrocarbons in gaseous state).**
Tiempos de calibración para medidores de gasto tipo ultrasónicos (Hidrocarburos en estado gaseoso)
Juan José Mercado Pérez
Exposición Internacional del Sector Energético; El Futuro de la Energía
Boca del Río, Ver. México. 2019

Dr. Ignacio Hernández

Head of Mechanical Metrology

CENAM-Mexico

ihernan@cenam.mx

