

A NEW CALIBRATION METHOD TO SUPPORT SMALL MASS MEASUREMENTS - SIM GUIDELINES ON THE CALIBRATION OF NON-AUTOMATIC WEIGHING INSTRUMENTS WITH RESOLUTION LESS THAN 0.010 mg

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ABSTRACT

The weighing industry is in a continuum development of new weighing instruments (known as microbalances) to satisfy the growing demand to improve the accuracy and precision of measurement in small masses. Therefore, the mass metrology community needs to develop new methods or techniques of calibration to support the quality of these measurements. Currently, the calibration of microbalances in the SIM region is performed using the document *Guidelines for the calibration of non-automatic weighing instruments SIM MWG7/cg-01/v.00*, which is identical to *EURAMET/cg-18/v.02*, nevertheless the uncertainty obtained calibration method described in this Guide is about ten times higher than the resolution when small masses are weighted. The main contributions to the combined uncertainty are the uncertainties due to the standard weights and the air buoyancy. In 2012, Kornblit et.al. proposed an alternative method to calibrate microbalances, with uncertainties about two or three times smaller than the resolution of the equipment, using only one standard weight OIML class E₁ close to the maximum capability of the microbalance, and some auxiliar weights without calibration with metrological characteristics of weights class E₁ or E₂. To validate this method, some National Metrology Institutes of the SIM region (INACAL, INTI, CESMEC, INM(CO), LATU, LACOMET and CENAM), developed the research project *Strengthening National Metrology Institutes in the Hemisphere, in support of emerging technologies. Calibration of weighing instruments - microbalances* with financial support of Interamerican Development Bank (IDB).

As a result of the research project, a document is published on the SIM webpage in 2025, titled *Guidelines on the calibration of non-weighing instruments with resolution minor than 0.010 mg*, which authors expect to be a useful method to support high accuracy mass measurements in the SIM region and worldwide.

RESULTS

The SIM Mass Group - SIM MWG7, developed a guidance for the static calibration of non-automatic self-indicating weighing instruments with a resolution of less than 0.010 mg (commonly known as microbalances), with the objective to present an alternative method applicable to these kind of instruments, in addition to the recommendations provided by the calibration guide EURAMET cg No 18, in order to minimize calibration uncertainties at small measurements intervals.

The implementation and validation of the method was done through the research project SIM-BID-ATN/OC-15264-RG “Strengthening National Metrology Institutes in the Hemisphere, in support of emerging technologies, calibration of weighing instruments microbalances”, funded by Interamerican Development Bank (IDB). The validation had two steps:

First, the calibration of a microbalance at each participant NMI with the same set of standard and auxiliar weights was performed. With this, although the indication error of each microbalance will be different, the conventional mass value of the auxiliar weights will be statistically comparable.

Figure 1 shows the results obtained by each NMI for the set of six auxiliary weights (2 × 500 mg, 2 × 1 g and 2 × 2 g) are shown. In these graphics, the blue square and bars indicate the conventional mass correction value calculated for each auxiliary weight and its expanded uncertainty, the black line indicates the average value and the red lines indicates maximum limits of these weights.

All the reported values are statistically comparables using the normalized error criteria.

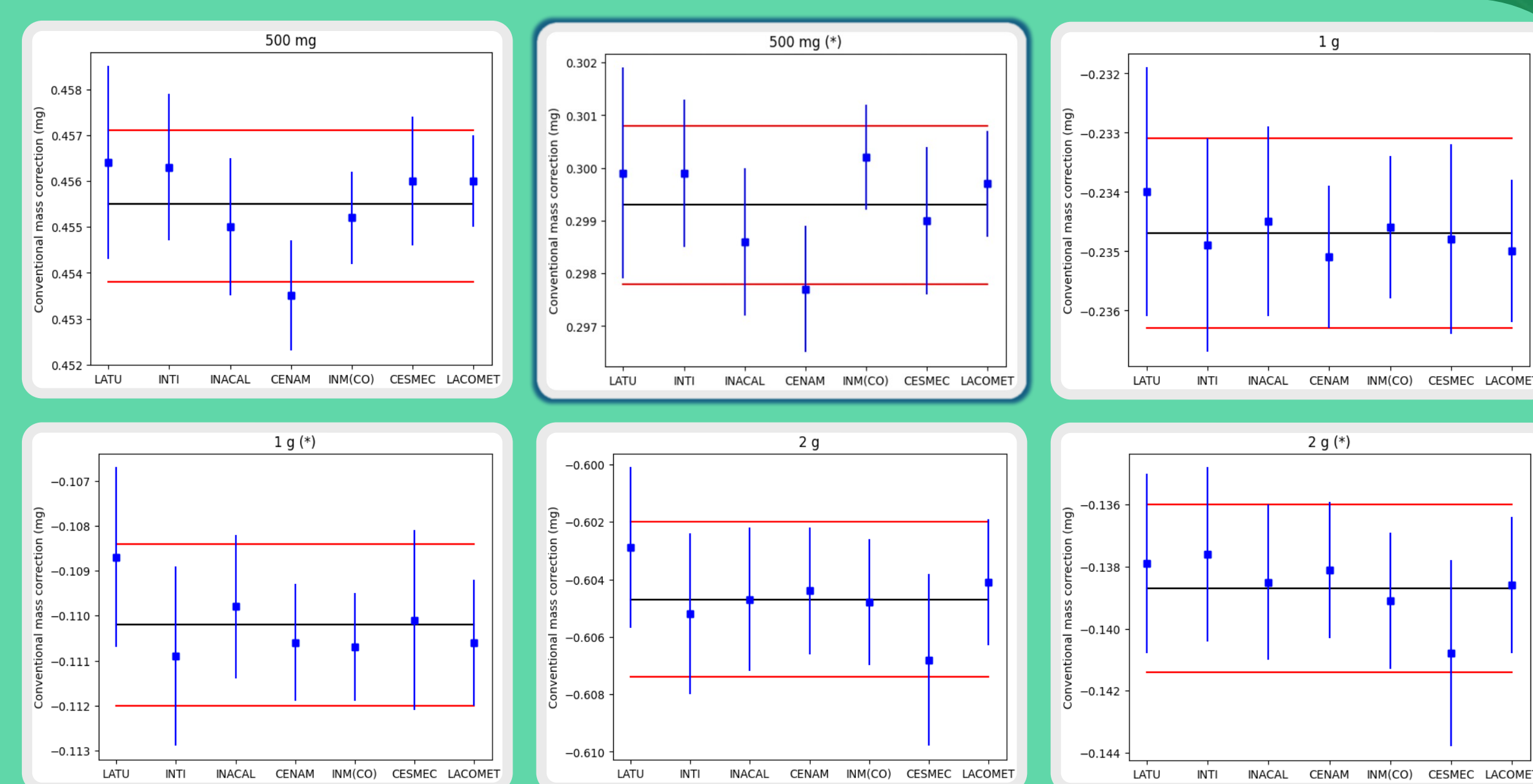


Figure 1. Conventional mass correction of travelling auxiliar weights

Second, each participant laboratory calibrated a single microbalance located at LATU - Uruguay, with its own set of standard and auxiliary weights. In this case, the conventional mass value of the weights is different, but the errors of indication of the microbalance are the statistically comparable.

The microbalance has a resolution of 0.001 mg and was calibrated in the range from 0.5 g to 5 g. Each participant laboratory used a standard weight of 5 g OIML class E₁, and six auxiliary weights whose nominal values were 2 g × 2, 1 g × 2 and 500 mg × 2, with metrological characteristics of OIML class E₁ or E₂.

The results of this second step of the validation are shown in Figure 2.

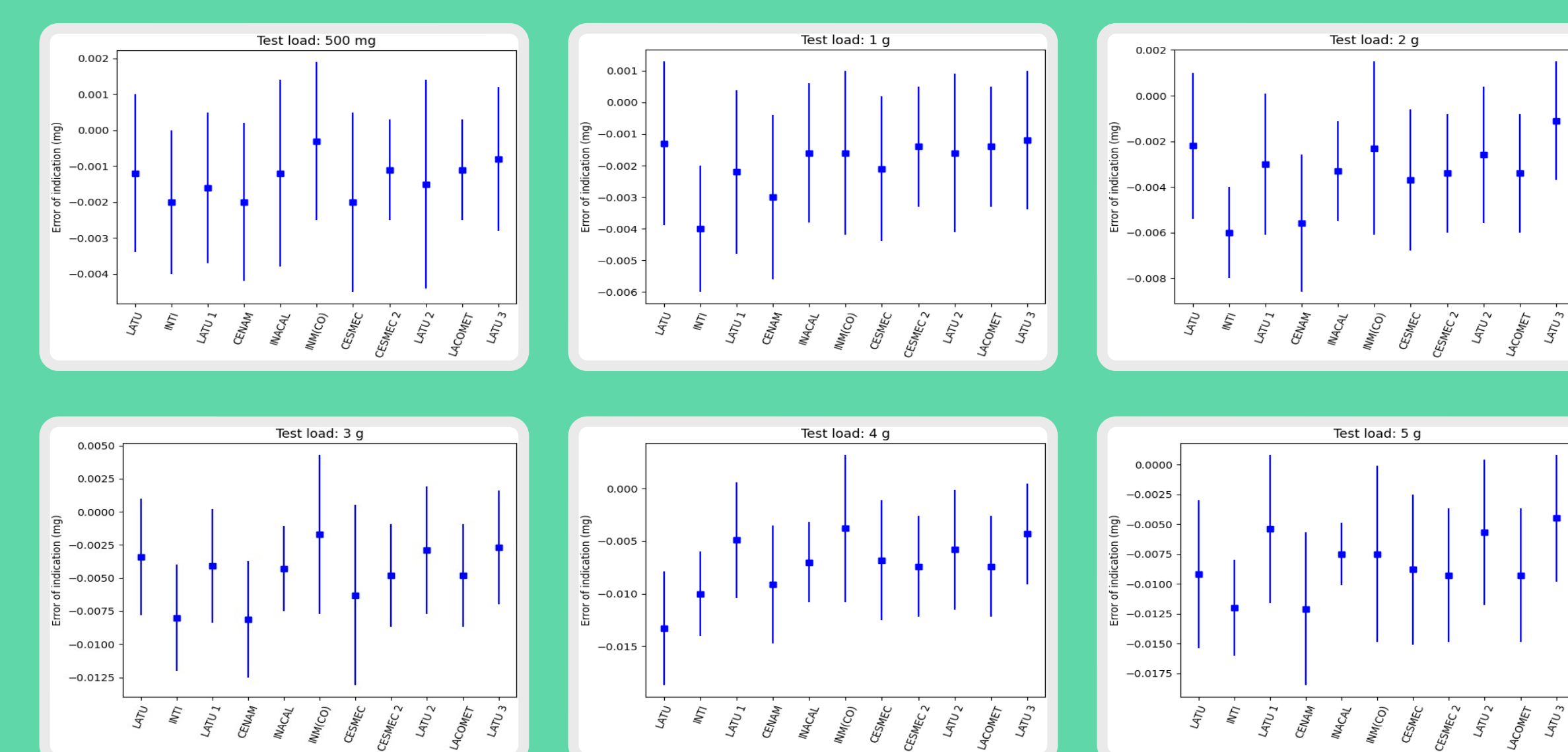


Figure 2. Indication error of a microbalance calibrated at LATU - Uruguay

Advantages of the method:

- A smaller expanded uncertainty is achieved compared with the method established in SIM MWG7/cg-01/v.00 Guidelines. See Figure 3.
- Only one calibrated standard weight is needed for the calibration.
- Auxiliary weights could be used as check standards to assess the validity of results.

Disadvantages of the method:

- The calibration time and effort is greater compared with SIM SIM MWG7/cg-01/v.00 guidelines.
- The standard weight should be OIML class E₁.
- The expanded uncertainty highly depends on the repeatability and eccentricity test.

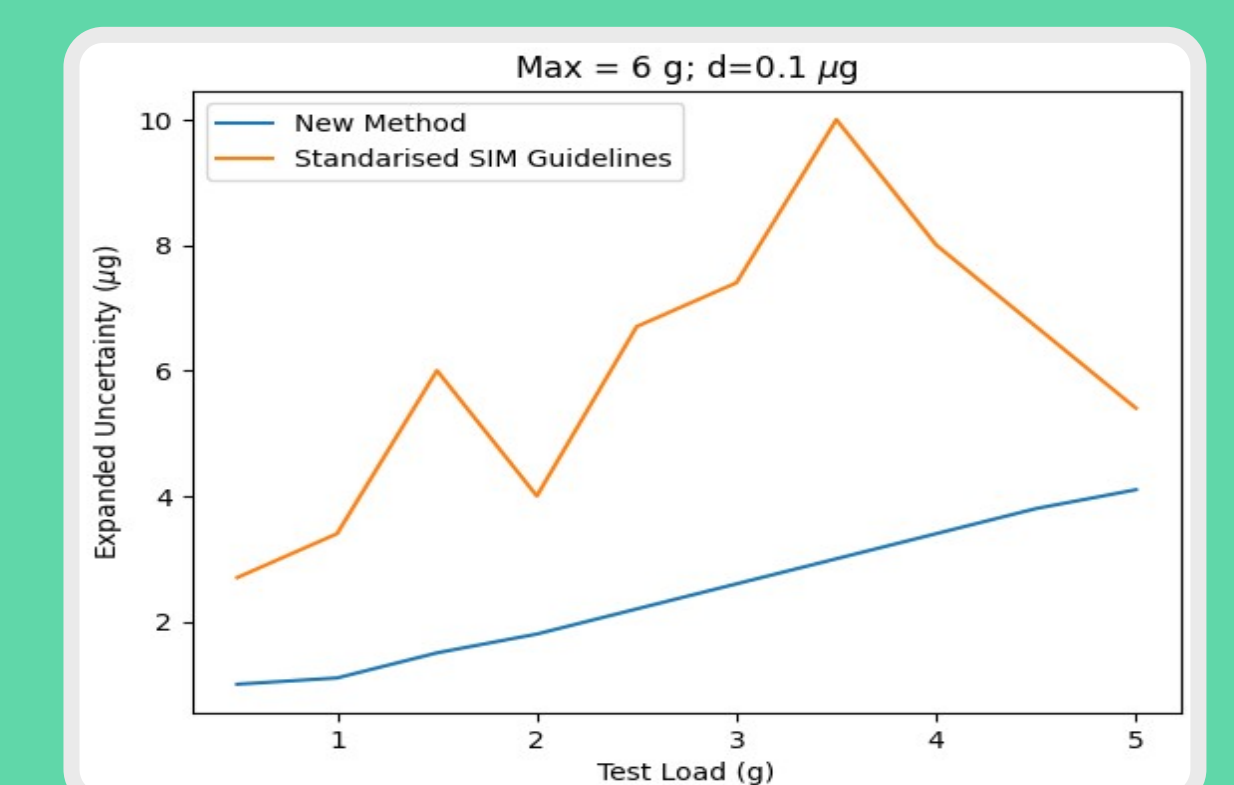


Figure 3. Comparison of the expanded uncertainties obtained with the new method against the standard method established in MWG7/cg-01/v.00 Guideline.

CONCLUSION

This work validated that, for the calibration of a microbalance, consistent errors are obtained both in its calibration and in the values of the auxiliary masses used by applying the proposed method and mathematical model.

Future studies will focus on determining the robustness of the method itself through numerical simulations with different mass standard values, as well as optimizing the method in terms of the time spent on calibration. Additionally, the application of other mathematical models will be explored to assess their influence on the results obtained.

Based on the results obtained and the experience gained from the work carried out, a document entitled “SIM Guidelines on the calibration of non-automatic weighing instruments with resolution less than 0.010 mg” was completed and reviewed by the technical experts of the SIM MWG7 mass subgroup. The Guidelines is published in the website of Sistema Interamericano de Metrología – SIM. For more details see the QR code.

REFERENCES

- [1] Guía para la calibración de los instrumentos para pesar de funcionamiento no automático SIM MWG7/cg-01/v.00 (2009).
- [2] Kornblit, F., Leiblich, J., Sánchez, J. “Método alternativo para la determinación de errores de indicación y linealidad en microbalanzas”. Simposio de Metrología CENAM, 2012.
- [3] Valcu, A. “The provision of mass calibrations for Micro/Nano force measurements”. ICQNM 2013: the seventh International Conference on Quantum, Nano and Micro Technologies.
- [4] Quille, R. “Estudio de factibilidades para la fabricación de pesas con valores de masa inferiores al miligramo” Trabajo final presentado en UNSAM/INCALIN, 2020.
- [5] Chao, L., Seifert, F., Haddad, D. “The design and development of a Table Top Kibble balance at NIST”. IEEE Transactions on Instrumentation and Measurements, Vol 68, No 6. June 2019.
- [6] Shaw, G. “Scaling of mass and force using electrical metrology”. U.S National Institute of Standards and Technology (NIST), CPEM 2018.
- [7] International Recommendation OIML R76-1. “Non-automatic weighing instruments, Part 1: Metrological and technical requirements. Test. Edition (E) 2006.
- [8] EURAMET Calibration Guide No 18. “Guidelines on the calibration of non-automatic weighing instruments, version 4.0 (11/2015).
- [9] Preste, S., et.al. “Estudio de la estabilidad del método alternativo en la calibración de instrumentos para pesas de funcionamiento no automático con resolución menor a 0.010 mg - microbalanzas”. Simposio de Metrología CENAM, 2022. Publicado en noviembre 2024.

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