FINAL REPORT OF THE BILATERAL COMPARISON OF THE CALIBRATIONS OF STANDARD WEIGHTS BETWEEN CENAM-MEXICO AND INEN-ECUADOR SIM.M.M-S4 (SIM.7.42)

[1] Luis Omar Becerra, [2] René Chanchay
[1] Centro Nacional de Metrología (CENAM), km 4.5 Carretera a los Cués Mpio. El Marqués Querétaro México
[2] Instituto Ecuatoriano de Normalización (INEN), Baquerizo Moreno E8-29 y Diego de Almagro-Quito, Ecuador

Introduction

Mass calibration is an important activity for National Institutes of Metrology, due to the amount of measurements on scientific, industrial and legal activities that have traceability to the national mass standards of each country.

In order to evaluate the stated uncertainty and degrees of equivalence between CENAM-Mexico and INEN-Ecuador on mass calibration a bilateral comparison was agreed between both laboratories.

Participant laboratories

The data of the participant laboratories are listed in table 1.

Table 1. Participants of mass comparison

National Institute of Metrology	Acronym	Country	Technical Contact(s)
Centro Nacional de Metrología, km 4.5 Carretera a los Cués, Mpio. El Marqués Querétaro, México	**CENAM**	**MEXICO**	Luis Omar Becerra A. Leticia Luján
Instituto Ecuatoriano de Normalización Baquerizo Moreno E8-29 y Diego de Almagro-Quito, Ecuador	**INEN**	**ECUADOR**	René Chanchay Marcelo Paucar

Travelling standards (Weights)

For the bilateral comparison, INEN supplied two weights with the following characteristics,

Table 2. Data of the traveling standards for the SIM mass comparison

	Weight 1	**Weight 2**
Manufacturer	Mettler Toledo	Mettler Toledo
Material	Stainless Steel	Stainless Steel
Nominal Value	1 kg	100 g
Accuracy Class	E2	E2
Shape	OIML	OIML
Construction	No adjusting cavity	No adjusting cavity
Volume	124.781 4 ± 0.004 2 cm^3 , k=2	12.479 0 ± 0.001 7 cm^3 , k=2

Figure 1. Travelling standards

Circulation and date of measurements

The travelling standards were measured first at INEN and them at CENAM according to the dates of table 3.

Table 3. Dates of measurement of the travelling standards

Acronym	Date
INEN	February, 2009
CENAM	March, 2009

Calibration Methods and Traceability of results reported by participants

For the calibration of the weights, both laboratories used their own facilities, instruments and methods. Each participant laboratory determined the corrections to the nominal value of the weights (in mass value), and their associated uncertainties.

Both laboratories used subdivision methods for the mass measurement of the travelling standards. These kind of methods are widely used for the calibration of the submultiples of the kilogram at the highest level of accuracy.

In table 4 are listed the calibration methods, the mass standards and the balances used in this bilateral comparison, as well as the source of traceability for the mass values.

Table 4. Calibration methods, mass standards, traceability and balances

Acronym	Calibration Method	Mass standard / Identification	Traceability	Balance
CENAM	Subdivision	1 kg stainless steel, LPN-00-08	CENAM-Mexico	Sartorius, Type C1000S, Max=1 000.5 g, d=0.002 mg Mettler-Toledo, Type AT1005, Max= 1 100 g, d=0.01 mg
INEN	Subdivision	1 kg stainless steel (dot)	NIST-USA	Mettler-Toledo, Type AX1005, Max=1 109 g, d=0.01 mg Mettler-Toledo, AX206, Max= 211 g, d=0.001 mg

Results

For each traveling standard the participant laboratories measured the mass and calculated the correction and the associated uncertainty.

Corrections and their associated uncertainties reported by participants are listed in table 5.

Table 5. Corrections and associated uncertainties reported by participants.

	1 kg		100 g	
NMIs	**Correction mg**	**U, k=2 mg**	**Correction mg**	**U, k=2 mg**
CENAM	0.172	0.060	0.016 4	0.009 4
INEN	0.154	0.065	0.027	0.011

Figure 2. Results reported by participant laboratories for the 1 kg weight.

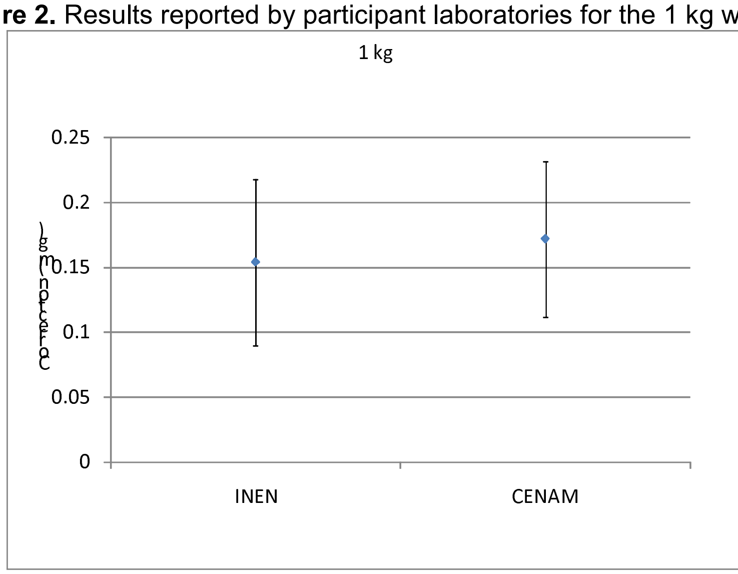
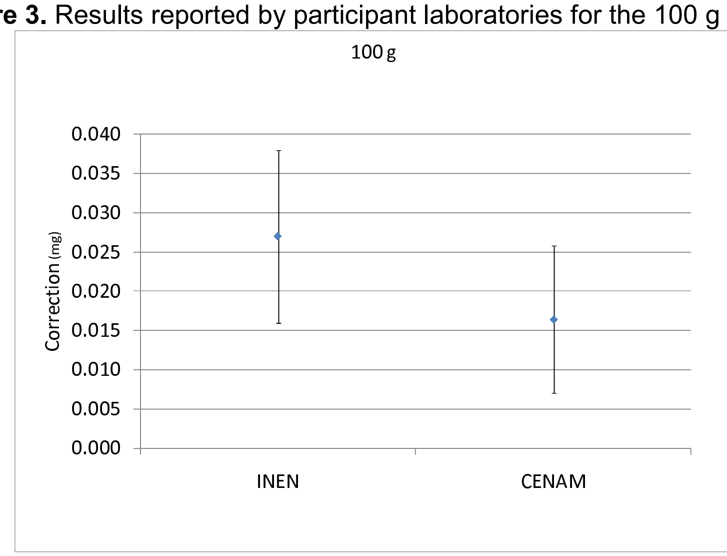


Figure 3. Results reported by participant laboratories for the 100 g weight.



Degree of equivalence between participants

The degree of equivalence among participant laboratories was calculated as the difference between the values reported by participants.

$$D_{CENAM-INEN} = X_{CENAM} - X_{INEN} \tag{1}$$

with the expanded uncertainty as follows,

$$U(D_{CENAM-INEN}) = 2\sqrt{u^2(X_{CENAM}) + u^2(X_{INEN})} \tag{2}$$

For the above formula, the correlation between results reported by CENAM and INEN are considered not significant.

From this difference and corresponding uncertainty, the normalized errors were calculated for each nominal values as follows,

$$En = \frac{|D_{CENAM-INEN}|}{U(D_{CENAM-INEN})} \tag{3}$$

In the table 6 are listed the degrees of equivalence between CENAM and INEN for the measurements done in this bilateral comparison.

Table 6. Degree of equivalence between CENAM and INEN

Nominal Value	Difference CENAM-INEN $D_{CENAM-INEN}$ mg	Expanded uncertainty (approx. 95%) $U(D_{CENAM-INEN})$ mg	Normalized Error En
1 kg	0.018	0.088	0.21
100 g	-0.011	0.014	0.73

Conclusions

The main objectives of this SIM comparison were:

- to evaluate the stated uncertainty offered by CENAM-Mexico and INEN-Ecuador in the calibration of mass standards by subdivision methods and,
- to evaluate the degree of equivalence between CENAM-Mexico and INEN-Ecuador in the calibration of mass standards by subdivision methods.

In order to reach such objectives, two weights of stainless steel were measured in both laboratories from February to March, 2009.

For the measurements each laboratory used their own facilities, equipments, mass standards and procedures.

The traceability of the measurements done by the laboratories are to CENAM's prototype (for CENAM), and NIST's prototype (for INEN).

From results reported by participants (see table 5), there were calculated the degree of equivalence between participants in the scope range of this bilateral comparison as well as the normalized errors, results are reported in table 6.

From data of table 6, it can be noted that results reported by both participants are consistent within the reported uncertainty. The largest normalized error calculated for this comparison was 0.73.

Acknowledge
The technical contacts of participant laboratories wish to thank to **Olman F. Ramos** of LACOMET-Costa Rica for acting as a third laboratory which received results from both participants and checked consistency before to share the results with CENAM and INEN.

Reference
[1] JCGM 100:2008 - Evaluation of measurement data — Guide to the expression of uncertainty in measurement -