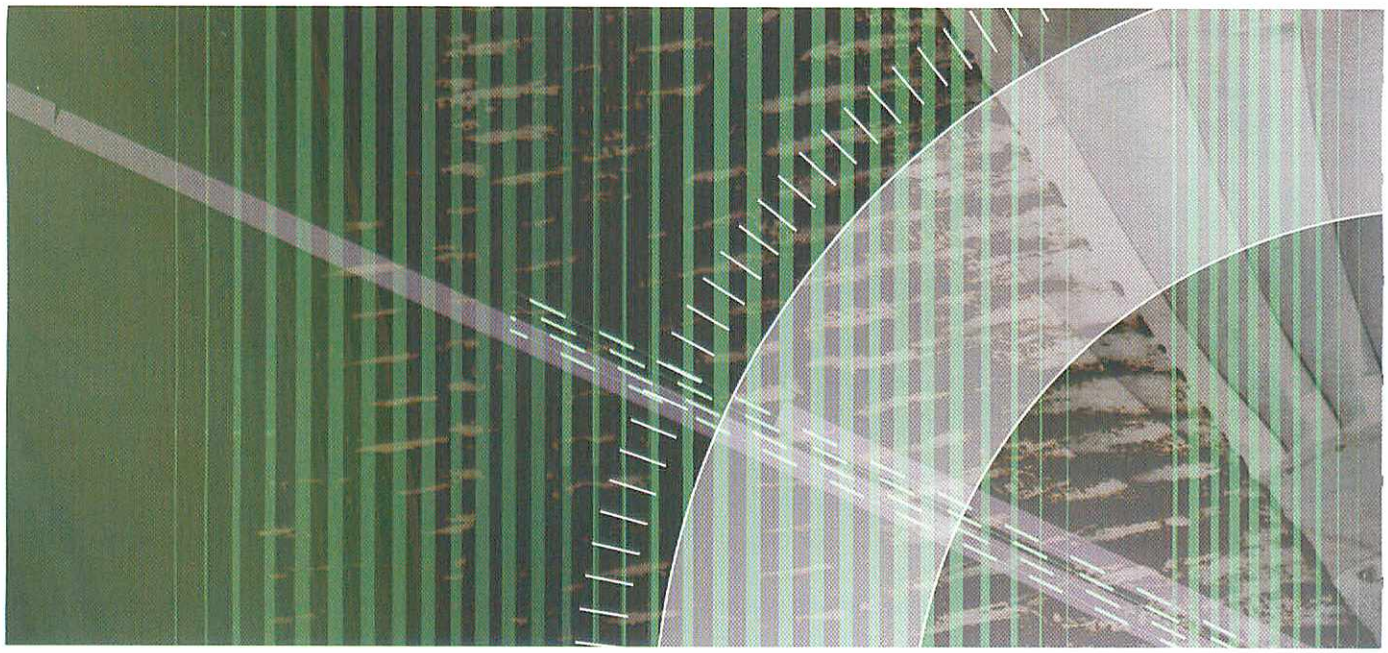

A Comparison in Mass Measurement Between INEN (Ecuador) and CESMEC-LCPN-M (Chile)

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Abstract: A mass comparison was carried out between the Instituto Ecuatoriano de Normalización (INEN, Ecuador) and Laboratorio Custodio de los Patrones Nacionales de Masa at CESMEC Ltda. (CESMEC-LCPN-M, Chile), in order to estimate the degrees of equivalence for calibration of mass artifacts and the uncertainty associated with their measurements. This comparison was carried out using the following nominal values: 100 mg, 2 g, 20 g, 200 g and 1 kg. The results obtained by each laboratory are presented in this document.

1. Introduction & Objective

Within the framework of the Inter-American Metrology System (SIM), only one previous comparison activity [1] had been carried out between the participants of the present comparison in mass.

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The objective of this intercomparison is to compare mass measurements at 100 mg, 2 g, 20 g, 200 g and 1 kg, and to estimate the degrees of equivalence and levels of measurement agreement between the two laboratories.

The Instituto Ecuatoriano de Normalización (INEN, Ecuador) has not declared Calibration and Measurement Capabilities (CMCs) within the International Committee for Weights and Measures, Mutual Recognition Arrangement (CIPM MRA) framework at this time. However, this comparison will be useful in that process. CMCs declared by the Laboratorio Custodio de los Patrones Nacionales de Masa at CESMEC Ltda. (CESMEC-LCPN-M, Chile) can be found at the Bureau International des Poids et Mesures, Key Comparison Data Base (BIPM KCDB). [2]

2. Comparison Process

2.1 General Guidelines

Prior to the comparison, a measurement protocol was given to each participant that defined the comparison technical guidelines as follows:

- Measurements were to be performed after the acclimatization time as specified in *OIML R111* for class E1. [3]
- The participating laboratories would measure the mass of the artifacts with the method each laboratory decided to apply: INEN would perform the com-

Nominal Value	Volume (cm^3)	Expanded uncertainty of the volume (k = 2) (cm^3)
1 kg	124.7958	0.0089
200 g	25.4156	0.0136
20 g	2.49469	0.00051
2 g	0.24919	0.00079
100 mg	0.011630	0.000080

Table 1. Comparison objects.

Laboratory	Country	Standard used in the comparison by each laboratory	Institute that calibrated the standard	Date of measurement for this comparison
INEN	Ecuador	1 kg National Standard	NIST	04/17/2006
CESMEC–LCPN–M	Chile	1 kg standard NSCCL (for 1 kg) 1 mg to 5 kg set of weights 112091/98 (for 200 g, 20 g, 2 g and 100 mg)	BIPM PTB	04/29/2006

Table 2. Participant laboratories and measurement standards.

Laboratory	Mass Value	Uncertainty (k = 2)
INEN (Ecuador)	1 kg + 0.014 mg 200 g + 0.539 mg 20 g + 0.0238 mg 2 g + 0.0203 mg 100 mg + 0.0175 mg	0.100 mg 0.017 mg 0.0051 mg 0.0020 mg 0.0018 mg
CESMEC–LCPN–M (Chile)	1 kg + 0.010 mg 200 g + 0.519 mg 20 g + 0.0251 mg 2 g + 0.0170 mg 100 mg + 0.0166 mg	0.050 mg 0.030 mg 0.0080 mg 0.0052 mg 0.0063 mg

Table 3. Results as reported by each participant.

parison by subdivision with the Gauss-Markov method [4] and CESMEC-LCPN-M would directly compare to weights of the same nominal value. All weighings were to be performed in air and buoyancy corrections were to be applied according to reference [5].

- No washing of the artifacts was to be performed. Before measurements, dust particles were to be removed from the surface of the standard by a soft brush.
- Uncertainties would be evaluated according to the ISO Guide to the Expression of *Uncertainty in Measurement*. [6]

2.2 Comparison Objects

The weight standards were provided by INEN and have the nominal values and volumes stated in Table 1:

The weights were manufactured by Mettler-Toledo[1]. Volume values were measured by INEN applying Method C of reference [3] except for the volume of the 100 mg weight which was determined using Method F of reference [3].

2.3 Comparison Round

The comparison was performed in round. See Table 2.

3. Results

Results as reported by each laboratory for each nominal value and the expanded uncertainty (k = 2) are presented in Table 3.

It should be noted that the expanded uncertainties reported by CESMEC-LCPN-M are smaller than its CMCs declared in the BIPM KCDB. [2] This is because the CMCs declared by Chile are larger than those evaluated by applying the recommendations of the *Guide To The Expression Of Uncertainty In Measurement* (GUM). [6] The larger CMC uncertainties are in order to: a) assure that the calibration results reported to customers indicate larger, but reasonable, uncertainties, b) satisfy the administrative requirements of the accreditation body that evaluated the laboratory, and c) assure that the CMCs uncertainties are larger than the accredited uncertainties documented in the Deutscher Kalibrierdienst (DKD) scope of accreditation [7], in agreement with *JCRB-10/8(1c)* document. [8]

4. Discussion

The analysis and presentations of results in this report is based on references [1] and [9].

For each nominal value, the degree of equivalence is expressed by the pair of terms (1) the difference, d, and (2) the expanded uncertainty (k = 2) in d, $U(d)$, as follows:

$$d = x_{INEN} - x_{CESMEC-LCPN-M} \quad (1)$$

$$U(d) = \sqrt{U^2(x_{INEN}) + U^2(x_{CESMEC-LCPN-M})}, \quad (2)$$

where,

x_i is the result i

$U(x_i)$ is the expanded uncertainty (k = 2) of result i.

The uncertainty component due to transport effects is not included. This is because it has not been a relevant factor

[1] Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately describe the experimental procedure. Such identification does not imply recommendation or endorsement by the author or NCSL International, nor does it imply that the materials or equipment identified are the only or best available for the purpose.

in other experiences with similar or smaller measurement uncertainties, as reported in references [1] and [10], even for long traveling times and many participants. In these cases, the drift of the mass values measured by the pilot laboratory was less than two times the expanded uncertainty reported by the pilot laboratory; the factor "2" comes from the correlation of both results. In the comparison reported here, there were only 12 days between both measurements, and the standards were transported by hand.

For each nominal value, in order to evaluate the level of measurement agreement between any pair of results, the normalized error, E, and criteria stated in reference [11] are used:

$$E = \frac{d}{U(d)} \cdot \qquad (3)$$

Then, the comparison results are shown in Table 4. It can be seen that for all nominal values $|E| \leq 1$.

Nominal Value	d (mg)	$U(d)$ (mg)	E
1 kg	0.004	0.112	0.04
200 g	0.020	0.034	0.58
20 g	–0.0013	0.0095	–0.14
2 g	0.0033	0.0056	0.59
100 mg	0.009	0.0066	0.14

Table 4. Degrees of equivalence and levels of measurement agreement.

5. Conclusions

There are satisfactory level of measurement agreement between measurement results at 100 mg, 2 g, 20 g, 200 g, and 1 kg between INEN, Ecuador, and CESMEC-LCPN-M, Chile. Degrees of equivalence, noted by the normalized error, ranged from –0.14 to +0.59 and are listed in Table 4.

6. Acknowledgements

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