

1 kg Comparison in Mass SIM/ANDIMET/SURAMET

Speaker: Francisco García
Laboratorio Custodio De Los Patrones Nacionales De Masa en
CESMEC LTDA (CESMEC-LCPN-M), CHILE
Marathon 2595
781-0552 Macul, Chile
fgarcia@cesmec.cl

Authors: René Chanchay, Instituto Ecuatoriano De Normalización (INEN), ECUADOR
Francisco García, Laboratorio Custodio De Los Patrones Nacionales De Masa en
CESMEC LTDA (CESMEC-LCPN-M), CHILE.
Fernando Leyton, Laboratorio Custodio De Los Patrones Nacionales De Masa en
CESMEC LTDA (CESMEC-LCPN-M), CHILE.
Mirta Passarino[†], Instituto Nacional De Tecnología Industrial (INTI), Argentina;
Gerson Vallejos, Instituto Boliviano De Metrología (IBMETRO), Bolivia;
[†] Now not working at INTI

1. Abstract

A mass comparison was carried out between the Instituto Nacional de Tecnología Industrial (INTI, Argentina), Instituto Boliviano de Metrología (IBMETRO, Bolivia), Instituto Ecuatoriano de Normalización (INEN, Ecuador) y 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 a mass artifact and the uncertainty associated to its measurement. This comparison was carried out in a nominal value of 1 kg. The results obtained by each laboratory are presented in this document for first time.

2. Introduction

Within the framework of SIM few comparison activities were carried out between the participants of the present comparison in mass. For this reason we think that present results are interesting for being submitted to 2005 NCSL International Workshop and Symposium.

3. Objective

To compare mass measurements in 1 kg, estimate degrees of equivalence and levels of measurement agreement.

4. Comparison

4.1 Comparison Standard

One 1 kg standard weight of OIML E1 design was provided for this comparison by LCPN-M
Volume at 20 °C = 124.21 cm³
Uncertainty of the volume (k=2) = ± 0.04 cm³

Source of the volume value: Certificate 29-PTB-93
Manufacturer: Häfner Gewichte GMBH, Hohenhardtsweiler Strasse 4, DE 74420 Oberrot ,
Germany
Marks: none

4.2 Comparison Round

The comparison was performed in round including one initial and final measurement at the pilot laboratory.

The round was designed according to the geographical location of the laboratories to avoid excessive handling of the comparison standard and to shorten the time consumed for its transportation (Figure 1)

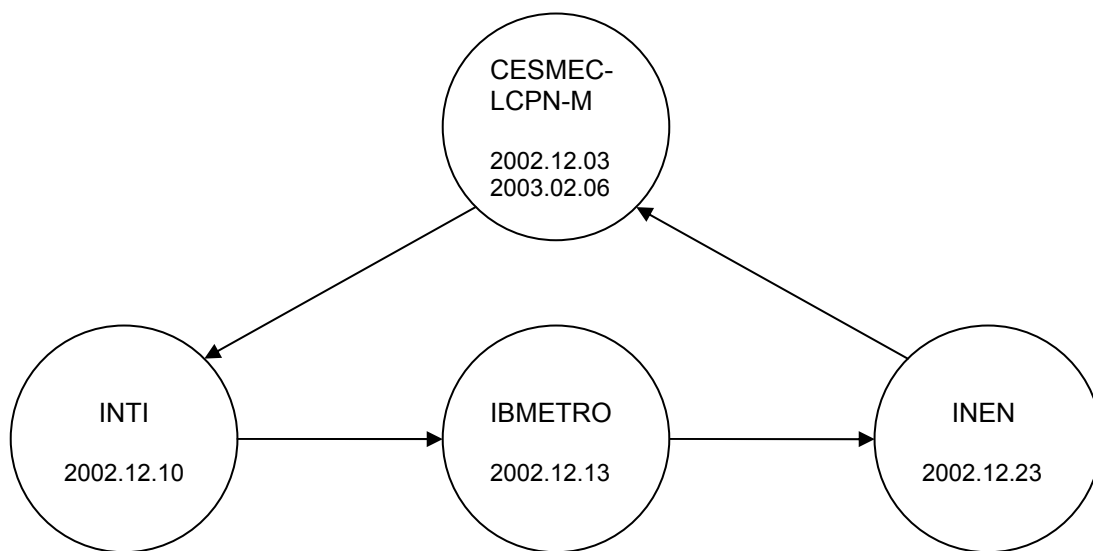


Figure 1: Comparison round.

Table 1: Participant laboratories, their standards and measurement schedule.

Laboratory	Country	Contact person	Standard	Institute that performed its calibration	Date of measurement
INTI	Argentina	Mrs. Mirta Passarino passarin@inti.gov.ar	K30	BIPM	2002.12.10
IBMETRO	Bolivia	Mr. Gerson Vallejos gvallejos@ibmetro.org	042604/99	PTB	2002.12.13
INEN	Ecuador	Mr. René Chanchay inen1@ecnet.ec	207630	NBS	2002.12.23
CESMEC-LCPN-M (Pilot Laboratory)	Chile	Mr. Francisco García fgarcia@cesmec.cl	NMSCL	BIPM	2002.12.03 and 2003.02.06

4.3 General Guidelines and Procedure

A measurement protocol was given to each participant. The measurement protocol stated the following relevant technical aspects:

Measurements were done after an acclimatization time as specified in OIML R111 Draft for class E1 [1].

No washing was performed. Before measurements, dust particles were removed from the surface of the standard by a soft brush.

All weightings were performed in air.

Uncertainties were estimated and combined according to the ISO *Guide to the Expression of Uncertainty in Measurement* [2].

5. Results

Table 2: Results

Result Identification	Laboratory	Mass Value	Uncertainty (k=2)	Calibration Certificate
CESMEC-LCPN-M initial	CESMEC-LCPN-M (Pilot)	1 kg – 1,31 mg	0,05 mg	NLM-177
2	INTI	1 kg – 1, 283 mg	0,050 mg	Intercomparación CESMEC-INTI January 20, 2003
3	IBMETRO	1 kg – 1,38 mg	0,50 mg	CCI-LM-001-2002
4	INEN	1 kg - 0,82 mg	0,53 mg	LPC-2002-672
CESMEC-LCPN-M final	CESMEC-LCPN-M (Pilot)	1 kg – 1,33 mg	0,05 mg	NLM-180

Before continuing the to the discussion, measurement results by LCPN-M at CESMEC are re-defined as follows

$$\frac{x_{CESMEC-LCPN-M \text{ initial}} + x_{CESMEC-LCPN-M \text{ final}}}{2} \equiv x_1$$

$$\sqrt{\left(\frac{U^2(x_{CESMEC-LCPN-M \text{ initial}}) + U^2(x_{CESMEC-LCPN-M \text{ final}})}{2} \right)} \equiv U(x_1),$$

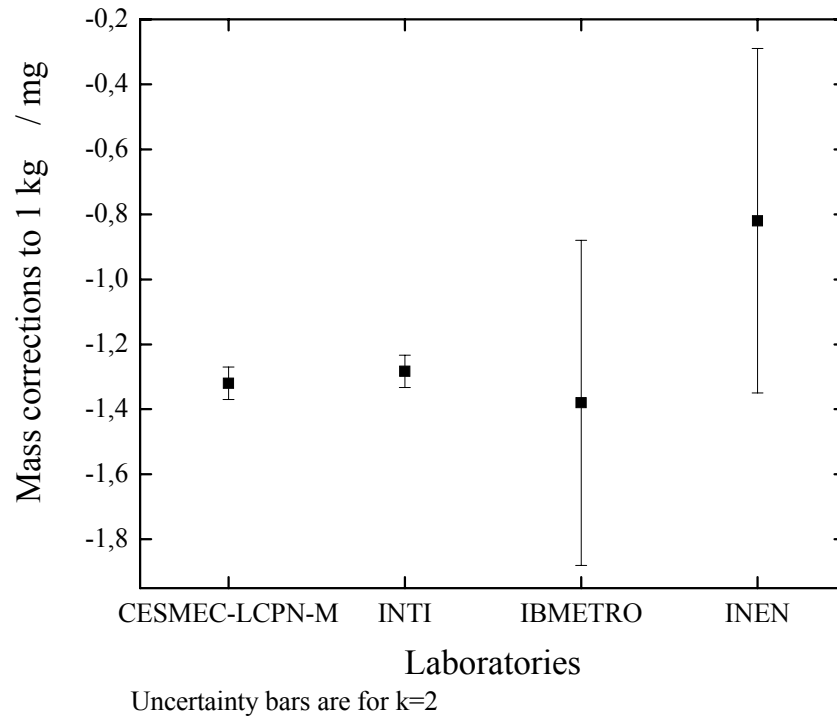


Figure 2: Comparison results.

5. Discussion

5.1 Degrees of equivalence and levels of measurement agreement for pairs of results.

Degrees of equivalence are expressed by the pair of terms

$$d_{i,j} = x_i - x_j \quad (1)$$

$$U(d_{i,j}) = \sqrt{U^2(x_i) + U^2(x_j) + U_t^2} \quad (2)$$

, its expanded uncertainty (k=2).

Where,

x_i is the result i

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

U_t is the uncertainty associated with transportation of the measured device between the laboratories and is estimated by:

$$U_i = \frac{|x_{CESMEC-LCPN-M \text{ initial}} - x_{CESMEC-LCPN-M \text{ final}}|}{\sqrt{3}} = 0,01$$

For the comparison results, the degrees of equivalence are as follows:

$$d_{i,j} = \begin{bmatrix} - & -0,04 & 0,06 & -0,50 \\ 0,04 & - & 0,10 & -0,46 \\ -0,06 & -0,10 & - & -0,56 \\ 0,50 & 0,46 & 0,56 & - \end{bmatrix}, \quad U(d_{i,j}) = \begin{bmatrix} - & 0,07 & 0,50 & 0,53 \\ 0,07 & - & 0,50 & 0,53 \\ 0,50 & 0,50 & - & 0,73 \\ 0,53 & 0,53 & 0,73 & - \end{bmatrix}$$

In order to evaluate the level of measurement agreement between any pair of results (i, j) , the normalized error and criteria stated in [3] is used:

$$E_{i,j} = \frac{d_{i,j}}{U(d_{i,j})} \quad (3)$$

From (3), we get:

$$E_{i,j} = \begin{bmatrix} - & -0,52 & 0,12 & -0,94 \\ 0,52 & - & 0,19 & -0,87 \\ -0,12 & -0,19 & - & -0,77 \\ 0,94 & 0,87 & 0,77 & - \end{bmatrix}$$

5.2 Degree of equivalence and levels of measurement agreement of laboratory i with respect to the reference value.

The degree of equivalence of laboratory i is expressed by the pair of terms

$$d_i = x_i - x_{ref} \quad (4)$$

$$U(d_i) = \sqrt{U^2(x_{ref}) + U^2(x_i) + U_i^2} \quad (5)$$

, its expanded uncertainty (k=2).

Where,

x_{ref} is the reference value agreed by the participants and it is:

$$x_{ref} = \frac{\sum_{i=1}^4 \frac{x_i}{U^2(x_i)}}{\sum_{i=1}^4 \frac{1}{U^2(x_i)}}$$

$U(x_{ref})$ is the expanded uncertainty (k=2) of the reference value. It is given by

$$U(x_{ref}) = \frac{1}{\sqrt{\sum_{i=1}^4 \frac{1}{U^2(x_i)}}$$

From equation (4) and (5) it is obtained that:

$$d_i = \begin{bmatrix} -0,02 \\ 0,02 \\ -0,08 \\ 0,48 \end{bmatrix} \quad U(d_i) = \begin{bmatrix} 0,06 \\ 0,06 \\ 0,50 \\ 0,53 \end{bmatrix}$$

In order to evaluate the level of measurement agreement of result i with respect to the reference value the normalized error and criteria stated in [3] is used:

$$E_i = \frac{d_i}{U(d_i)} \quad (6)$$

$$E_i = \begin{bmatrix} -0,33 \\ 0,33 \\ -0,16 \\ 0,91 \end{bmatrix}$$

6. Conclusion

There are satisfactory levels of measurement agreement between results and with respect to the reference value. Degrees of equivalence are listed in 5.

7. References

1. Committee Draft OIML/2nd CD R 111, OIML/TC 9 / SC 3, 2000
2. Guide To The Expression Of Uncertainty In Measurement; ISO TAG 4 WG 3. BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML; 1995.
3. Document No. 8, Noramet, 1998.