FIRST CONVENTIONAL MASS COMPARISON IN CHILE

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Abstract: In this paper we report the results obtained at the first national conventional mass comparison that was carried out in Chile. This comparison was organized by the National Metrology Network (NMN) with the support of the Mass Committee of the National Institute of Standards (Instituto Nacional de Normalización, INN).

1. INTRODUCTION

Within the National Metrology framework no previous comparison activity had been carried out in conventional mass. Almost all participant laboratories of this comparison were already accredited or applied for an accreditation within ISO/IEC 17025 [1] to the National Accreditation Body at INN. These comparison results will be useful for all them in order to provide evidence of their competence and the suitability of the accreditation resolutions.

The aim is to estimate the degrees of equivalence [2] and levels of measurement agreement [3] between each calibration laboratory and the pilot laboratory: CESMEC-LCPN-Masa. The nominal values that considered are: 200 mg, 1 g, 50 g, 200 g, 1 kg, 2 kg, 10 kg and 20 kg.

The construction characteristics of the weights of 200 mg to 2 kg were according E2 and for the 10 kg and 20 kg weights according to M1, but their conventional mass values were adjusted at CESMEC's workshop outside of the maximum permissible errors.

2. COMPARISON PROCESS

A protocol that stated all comparison process was agreed between the participants before the calibration round [4]. In the protocol was agreed that each laboratory had to perform the measurements in conventional mass according to [5] and that the evaluation and reporting of the results to be done using an excel spreadsheet distributed among the participant laboratories [6].

The distribution of a common excel spread sheet for he evaluation of the results was a decision with a disadvantage: It is not possible to evaluate the implementation of the measurement procedure done by each laboratory, but has the advantage to provide the participant laboratories the possibility to review or update their calibration procedures using a "reference" evaluation tool and for that reason it was finally agreed to use a common spreadsheet.

3. RESULTS

Table 1 contains the reference values as determined by the pilot laboratory from measurements done at the beginning and the end of the comparison round.

The uncertainty of this results were evaluated according to [5] and reported according to the construction characteristics of the weights: for 1 mg to 2 kg according to E2 and for 10 kg to 20 kg according to OIML M1.

Table 1. *Reference value assigned to the test objects evaluated from results obtained after and before the comparison round by CESMEC-LCPN-Mass*

Conventional Mass Value	Expanded Uncertainty (k=2)
200 mg -0.098 mg	0.006 mg
1 g -0.112 mg	0.010 mg
50 g -1.71 mg	0.03 mg
200 g -1.24 mg	0.10 mg
1 kg -3.4 mg	0.5 mg
2 kg -41.4 mg	1.0 mg
10 kg -191 mg	160 mg
20 kg +12 mg	300 mg

4. DISCUSSION

The degrees of equivalence are given by the pair of values $\left(d_{ij}, U\left(d_{ij}\right)\right)$, where

$$d_{ij} = m_{ct}^{(i)} - m_{ct}^{(j)} \quad (1)$$

$m_{ct}^{(i)}$ is the conventional mass value of the test weight determined by the laboratory i and $m_{ct}^{(j)}$ is the conventional mass value of the test weight determined by the pilot laboratory.

The expanded uncertainty is given by

$$U\left(d_{ij}\right) = 2 \cdot \sqrt{u^2\left(m_{ct}^{(i)}\right) + u^2\left(m_{ct}^{(j)}\right)} \quad (2)$$

And the level of measurement agreement is given by the normalized error, E_n,

$$E_n = \frac{d_{ij}}{U\left(d_{ij}\right)} \quad (3)$$

Figures 1 to 8 present the results as reported by the participant laboratories and Tables 2 to 9 present the degrees of equivalence and levels of measurement agreement.

Some laboratories reported an additional result identified as * due to: a) doubts on the units of the density values of the tests weights that had to be considered in the equations of [5], b) the desire to present uncertainty values smaller than those of the best measurement capability declared within their current accreditation scope. It is expected from a calibration laboratory to report only one result, not two, but it was allowed to the laboratories to proceed in this way in order to do not discourage their participation in an activity that for most of them was the first.

In the following graphs it is possible to appreciate that for 10 kg and 20 kg the homogeneity in the technical capabilities of laboratories is greater than in the lower nominal values.

On the other hand, it was found that there is not a uniform use of significant digits. These issues were discussed at the Mass Committee of INN in order to standardize the way to present results in the calibration certificates. It was possible to quickly reach consensus because the calibration laboratories are members of the Mass Committee.

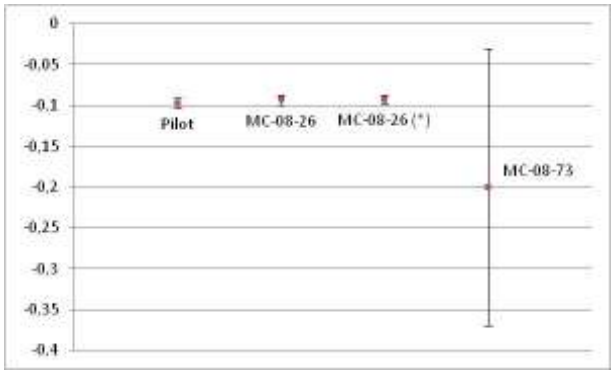

Figure 1. *Results reported by each laboratory for 200 mg*

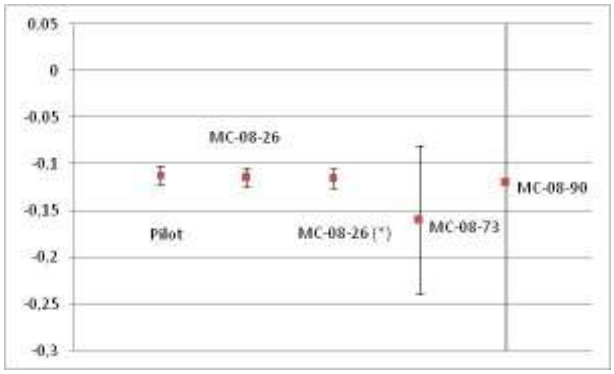

Figure 2. *Results reported by each laboratory for 1 g*

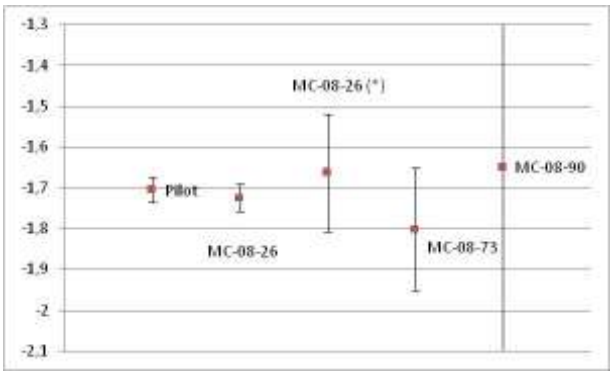

Figure 3. *Results reported by each laboratory for 50 g*

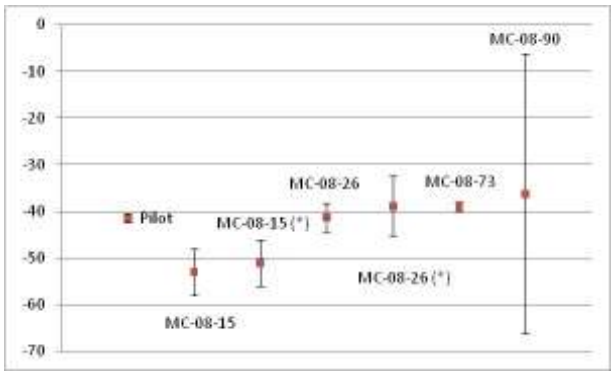

Figure 6. *Results reported by each laboratory for 2 kg*

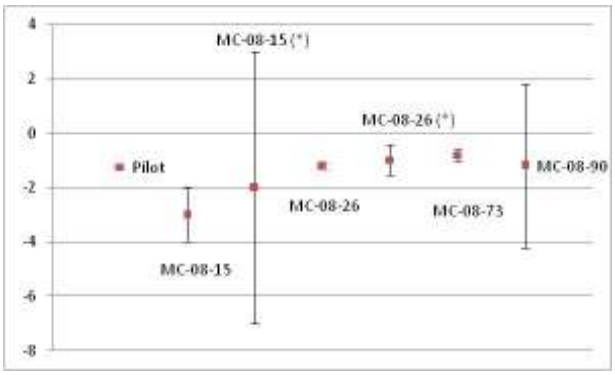

Figure 4. *Results reported by each laboratory for 200 g*

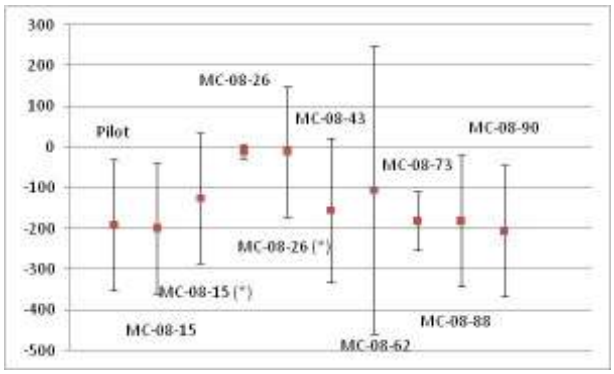

Figure 7. *Results reported by each laboratory for 10 kg*

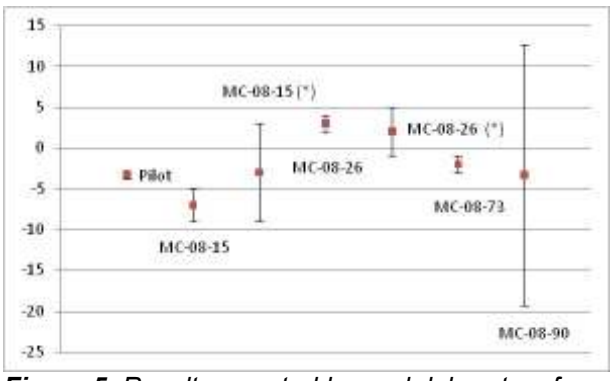

Figure 5. *Results reported by each laboratory for 1 kg*

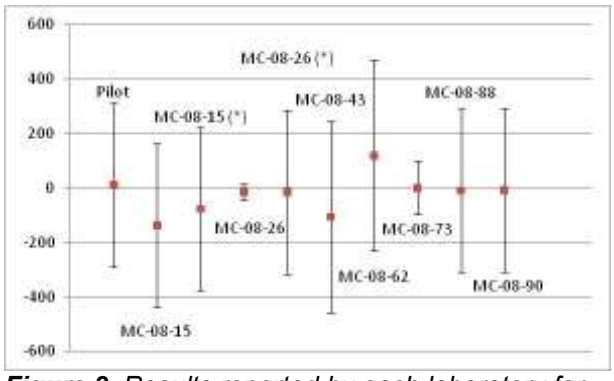

Figure 8. *Results reported by each laboratory for 20 kg*

Table 2. *Results for 200 mg, degrees of equivalence and levels of measurement agreement of each laboratory result with CESME LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-26	0.004	0.009	0.5
MC-08-26 *	0.005	0.009	0.5
MC-08-73	-0.103	0.170	-0.6

Table 3. *Results for 1 g, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	**d_i / mg**	**U_i / mg**	**E_n**
MC-08-26	-0.002	0.014	-0.2
MC-08-26*	-0.003	0.014	-0.2
MC-08-73	-0.05	0.08	-0.6

Table 4. *Results for 50 g, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-26	-0.018	0.045	-0.4
MC-08-26*	0.042	0.146	0.3
MC-08-73	-0.10	0.15	-0.6
MC-08-90	0.06	1.0	0.1

Table 5. *Results for 200 g, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-15	-2	1.0	-1.8
MC-08-15 *	-1	5.0	-0.2
MC-08-26	0.02	0.1	0.1
MC-08-26 *	0.26	0.6	0.5
MC-08-73	0.4	0.2	2.0
MC-08-90	0.04	3.0	0.0

Table 6. *Results for 1 kg, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-15	-3.7	2.1	-1.8
MC-08-15 *	0.4	6.0	0.1
MC-08-26	6.4	1.1	5.7
MC-08-26 *	5.4	3.0	1.8
MC-08-73	1.6	0.8	2.0
MC-08-90	0.1	16.0	0.0

Table 7. *Results for 2 kg, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-15	-11.6	5.1	-2.3
MC-08-15 *	-9.6	5.1	-1.9
MC-08-26	0.2	3.2	0.0
MC-08-26 *	2.5	6.4	0.4
MC-08-73	2.4	1.6	1.5
MC-08-90	5.2	30.0	0.2

Table 8. *Results for 10 kg, degrees of equivalence and levels of measurement agreement of each laboratory result with CESMEC LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-15	-8	226	0,0
MC-08-15 *	65	226	0,3
MC-08-26	180	161	1,1
MC-08-26 *	180	226	0,8
MC-08-43	36	239	0,2
MC-08-62	85	388	0,2
MC-08-73	10	176	0,1
MC-08-88	10	226	0,0
MC-08-90	-15,0	177,4	-0,1

Table 9. *Results for 20 kg, degrees of equivalence and levels of measurement agreement of each laboratory result with CESME LCPN-Mass*

Laboratory	d_{ij} / mg	$U(d_{ij})$ / mg	E_n
MC-08-15	-150	424	-0.4
MC-08-15 *	-88	424	-0.2
MC-08-26	-26	302	-0.1
MC-08-26 *	-26	424	-0.1
MC-08-43	-118	461	-0.3
MC-08-62	108	461	0.2
MC-08-73	-11	316	0.0
MC-08-88	-21	424	0.0
MC-08-90	-20.1	321.5	-0.1

5. CONCLUSIONS

Degrees of equivalence and levels of measurement agreement are listed in section 4.

In general, participants have a good level of measurement agreement (i.e. En ≤ 1) with the pilot laboratory but further awareness or training activities have to be done at national level in order to solve doubts among the use of reference OIML R111-1.

For 10 kg and 20 kg the homogeneity in the technical capabilities of laboratories is greater than in the lower nominal values.

A comparison puts in evidence problems that are present in routine measurements that otherwise would be difficult to detect by each participant individually.

REFERENCES

[1] "General requirements for the competence of testing and calibration laboratories". ISO/IEC 17025. ISO. 2005.
[2] Key Comparison Data Base. Bureau International des Poids et Mesures Web Page. http://www.bipm.org/en/bipm/sections/kcdb/
[3] Document No. 8. Noramet. 1998.
[4] Protocolo de Intercomparación Nacional. Calibración de pesas. 2008. Available at http://www.metrologia.cl/medios/PROTOCOLODEINTERCOMPARACIONDEPESAS2.docx
[5] "Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3 Part 1: Metrological and technical requirements," OIML R 111-1, International Organization Of Legal Metrology (OIML), 2004. Freely available at http://www.oiml.org/publications/R/R111-1-e04.pdf
[6] Excel spreadsheet "pesas.xls". Available at http://www.metrologia.cl/medios/pesas.xls