FINAL REPORT
Supplementary Comparison

DETERMINATION OF THE MAGNETIC SUSCEPTIBILITY AND MAGNETIC POLARIZATION OF WEIGHTS BY MEANS OF THE SUSCEPTOMETER METHOD

SIM.M.M - S9

Index

ABSTRACT:
This report summarizes the results of a SIM comparison of magnetic properties by means of the susceptometer method carried out between seven SIM laboratories and BIPM. The travelling standards for the comparison were four weights Class OIML E2 belonging to OAS, with the nominal values of 1 kg (2 uu) and 2 g (2uu) and a special steel disc. The majority of the results from the participants are consistent with each other. This final report shows the degree of equivalence of the participants and their normalized deviations.

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Supplementary Comparison

DETERMINATION OF THE MAGNETIC SUSCEPTIBILITY AND MAGNETIC POLARIZATION OF WEIGHTS BY MEANS OF THE SUSCEPTOMETER METHOD (SIM.M.M-S9)

Aldo Quiroga[1], Álvaro Bermúdez[2], Fernando Kornblit[3], Francisco García[4], Hao Fang[5], Joselaine Cáceres[6], Luis Manuel Peña[7], Olman Ramos[8].

1) Introduction

This final report describes the results of the supplementary comparison of the determination the magnetic properties of the travelling weight standards "DETERMINATION OF THE MAGNETIC SUSCEPTIBILITY AND MAGNETIC POLARIZATION OF WEIGHTS BY MEANS OF THE SUSCEPTOMETER METHOD - SIM.M.M-S9".

In October 2010, a survey was sent to all SIM MWG7 members, in which they were asked to state their interest in participating in a comparative study to determine the magnetic properties of weights and to gather information regarding the measurement techniques used, mostly the method B.6.4 [1], "Magnetic susceptibility and permanent magnetization, the susceptometer method". However, certain doubts were raised on the methodology to evaluate the uncertainty of this type of measurements, and so in June 2011, a workshop was organized for the respondents of the survey, in which this particular issue was addressed. This meeting served as a first and definitive step to establish the aspects to be considered in the comparison protocol.

The supplementary comparison was piloted by INDECOPI. Seven NMIs and the BIPM participated. This comparison was registered as an official supplementary comparison under the designation SIM.M.M-9.

The travelling weight standards belong to Organization of American States (OAS). They were OIML E_2 weights.

The travelling weight standards were prepared by INDECOPI. INDECOPI measured the magnetic susceptibility and magnetic polarization of the travelling weight standards.

All the weight standards were circulated among the National Metrology Institutes (NMI). Each NMI measured the magnetic susceptibility and magnetic polarization for each weight using their procedures and methods. The measurements were carried out from August 2011 to April 2013.

[1]Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual (Indecopi) / Perú.
[2] Instituto Nacional de Metrología (INM) /Colombia.
[3] Instituto Nacional de Tecnología Industrial (INTI) / Argentina.
[4] Centro de Estudios, Medición y Certificación de Calidad S.A. (CESMEC) / Chile.
[5] Bureau International des Poids et Mesures (BIPM) / France.
[6] Laboratorio Tecnológico del Uruguay (LATU) / Uruguay.
[7]Centro Nacional de Metrología (CENAM) / México.
[8]Laboratorio Costarricense de Metrología (LACOMET) / Costa Rica.

2) List of participatingNMIs

The participating laboratories and their respective technical contacts are listed below:

- *Bureau International des Poids et Mesures (BIPM) / France.*
    - Dr. Hao FANG
- *Centro de Estudios, Medición y Certificación de Calidad S.A. (CESMEC) / Chile.*
    - Raúl A. Hernández G.
    - Francisco J. García Leoro
- *Centro Nacional de Metrología (CENAM) / México.*
    - Luis Manuel Peña Pérez
    - Luis Omar Becerra Santiago
- *Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual (INDECOPI) / Perú.*
    - Aldo Martín Quiroga Rojas
    - Luz Cori Almonte
    - Donny Taipe Araujo
- *Instituto Nacional de Tecnología Industrial (INTI) / Argentina.*
    - Fernando Kornblit
    - Agustina Viaggio
    - Jorge Sanchez
- *Laboratorio Costarricense de Metrología (LACOMET) / Costa Rica.*
    - Olman Ramos Alfaro
- *Laboratorio Tecnológico del Uruguay (LATU) / Uruguay.*
    - Joselaine Cáceres González
- *Instituto Nacional de metrología (INM) /Colombia.*
    - Álvaro Bermúdez Coronel

CESMEC, CENAM, INDECOPI, INTI, LACOMET, LATU and INM are NMIs belonging to SIM. BIPM is the International Bureau of Weights and Measures.

Acknowledge: The participating laboratories of the SIM wish to thank the BIPM and EURAMET for all their support. It is noteworthy that the EURAMET provided protocol and copies of spreadsheet of EURAMET project 1110, which were served as a support for the development of this comparison.

3) Travelling weight standards

The travelling weight standards used were four weights Class OIML E_2 belonging to OAS, with the following nominal values of 1 kg (2 uu) and 2 g (2uu); and a special steel disc. The shape and material of the traveling standards are shown in table 1. Annex A shows specifications and photographs of the travelling weight standards.

Table 1

Nominal Value	Accuracy Class	Material	Shape
2 g	E_2	Stainless Steel	Cylindrical
2 g	E_2	Stainless Steel	Cylindrical with a lifting knob
1 kg	E_2	Stainless Steel	Cylindrical
1 kg	E_2	Stainless Steel	Cylindrical with a lifting knob
----	----	Steel	Disc

4) Circulation Schedule

The circulation schedule of the traveling weight standards are shown in table 2. INDECOPI started the measurements in August 2011 and the last measurements were also made by LATU in February 2013. The original schedule was modified due to difficulties in the transportation and retention of the standards at customs in some countries.

Table 2
Sequence of the measurements

Institute	Period of measurements
Instituto Nacional de Defensa de la Competencia y de la Propiedad Intelectual – INDECOPI-PERU	July 2011
Instituto Nacional de Metrología – INM-COLOMBIA	September 2011
Laboratorio Costarricense de Metrología (LACOMET) - COSTA RICA	October 2011
Centro Nacional de Metrología – CENAM-MEXICO	December 2011
Bureau International des Poids et Mesures (BIPM) / France.	March 2012
Centro De Estudios, Medición y Certificación De Calidad – CESMEC-CHILE	June 2012
Instituto Nacional de Tecnología Industrial INTI- ARGENTINA	September 2012
Laboratorio Tecnológico del Uruguay LATU-URUGUAY	May 2013
INDECOPI-PERU	April 2013

5) Surface damages of the standards

The traveling standards were examined by each NMI at the reception and departure of the weights in order to register all marks and damages during circulation.
The participating laboratories sent to the pilot laboratory the forms used to register the superficial conditions of the traveling standards, at both reception and departure. The data sent by the participating laboratories showed that there was no significant damage on the traveling standards.

6) Measurement Conditions

The environmental conditions for determination of the susceptibility and magnetic polarization reported by the participating laboratories are listed in table 3.

Table 3

	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
T (º C)	20,52 º C	20 º C	18,85 º C	22,1 º C	19,9 º C	20 º C	20,18 º C	21 º C
H / rh	49,8 %	45 %	49,79 %	43 %	48,5 %	45 %	49,48%	50 %

The resolutions of the weighing instruments used by the different laboratories are showed in Table 4.

Table 4

Units in mg	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
2 g	0,0001	0,0001	0,001	0,0001	0,0001	0,0001	0,001	0,0001
2 g (.)	0,0001	0,0001	0,001	0,0001	0,0001	0,0001	0,001	0,0001
1 kg	0,0001	0,0001	0,001	0,0001	0,0001	0,0001	0,001	0,0001
1 kg (.)	0,0001	0,0001	0,001	0,0001	0,0001	0,0001	0,001	0,0001
Steel disc	0,0001	0,0001	0,001	0,0001	0,0001	0,0001	0,001	0,0001

Table 5 shows the traceability of the magnets that were used by the NMIs, for each determination of the susceptibility and magnetic polarization.

Table 5

	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
2 g 2 g (.) 1 kg 1 kg (.) Steel disc	CENAM	National Physical Lab NPL-UKAS	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU

Table 6 shows the traceability of the weight standards that were used by the NMIs to indicate the possible correlation between them.

Table 6

	INDECOPI	**INM**	**LACOMET**	**BIPM**	**CESMEC**	**INTI**	**CENAM**	**LATU**
2 g 2 g (.) 1 kg 1 kg (.) Steel disc	PTB Standard (Stainlesss teel)	British Estándar 5884:1999 Standard (Alacrite)	PTB Standard (Stainlesss teel)	VNIIM, NPL and PTB Standards: (2 g: Titanium 1 kg and Steel disc: Alacrite)	Direct determination with micrometer	INTI Standard (Alacrite)	BIPM Standard (Alacrite)	PTB Standard (Alacrite)

7) Procedures and measurement methods

The measurement method used by all the laboratories was the susceptometer method [1] / Richard S. Davis [2].

INDECOPI, INM, LACOMET, BIPM, INTI, CENAM and LATU used weight standards for determination of Zo. CESMEC used a micrometer for determination of Zo.

Note: Zo is the distance from the mid-height of magnet to the base of the weight (susceptometer method).

The NMIs and BIPM used the information of the National Geophysical Data Center for determining the vertical component of the ambient magnetic induction [3].

CESMEC used the information of the Gravity Information System, [4], for determining the value of the acceleration due to gravity. The other NMIs and BIPM determined the value of the acceleration due to gravity by direct measurements.

INDECOPI, BIPM, CESMEC, CENAM and LATU reported the uncertainty contributions of magnetic susceptibility and magnetic polarization according to the GUM [5], [6]. INM, INTI and LACOMET reported final uncertainty by the Monte Carlo Method [7]. Additionally INTI reported with approximated figures the uncertainty contributions of magnetic susceptibility and magnetic polarization according to the GUM.

8. Results of the measurements

Table 7 shows the values of the magnetic susceptibility reported by the NMIs and its associated standard uncertainties.

Table 7

NOMINAL VALUE	2 g Cylindrical		2 g Cylindrical with a lifting knob		1 kg Cylindrical		1 kg Cylindrical with a lifting knob		Steel Disc	
	x	***u***	***x***	***u***	***x***	***u***	***x***	***u***	***x***	***u***
INDECOPI 1	0,00365	0,00058	0,00333	0,00048	0,00398	0,00005	0,00393	0,00003	0,0929	0,0035
INM	0,00384	0,00013	0,00375	0,00045	0,00384	0,00025	0,00383	0,00013	0,0855	0,0058
LACOMET	0,00320	0,00033	0,00260	0,00045	0,004	0,00022	0,0039	0,0001	0,0824	0,0010
BIPM	0,00370	0,00030	0,00330	0,00030	0,0039	0,0002	0,0039	0,0002	0,0918	0,0037
CESMEC	0,00360	0,00060	0,00380	0,00110	0,0039	0,0001	0,0038	0,0001	0,0875	0,0017
INTI	0,00362	0,00044	0,00365	0,00048	0,00393	0,00024	0,0039	0,00026	0,0901	0,0062
CENAM	0,00406	0,00031	0,00400	0,00034	0,00426	0,00026	0,00416	0,00025	0,0983	0,0054
LATU	0,00367	0,00031	0,00364	0,00031	0,00392	0,00003	0,00388	0,00002	0,0880	0,0040
INDECOPI 2	0,00380	0,00058	0,00409	0,00048	0,00398	0,00005	0,00392	0,00003	0,0864	0,0035

Table 8 shows the values of the magnetic polarization reported by the NMIs and its associated standard uncertainties.

Table 8

NOMINAL VALUE	2 g Cylindrical		2 g Cylindrical with a lifting knob		1 kg Cylindrical		1 kg Cylindrical with a lifting knob		Steel Disc	
	u_0M_z (uT)	u (uT)	u_0M_z (uT)	u (uT)	u_0M_z (uT)	u (uT)	u_0M_z (uT)	u (uT)	u_0M_z (uT)	u (uT)
INDECOPI 1	0,033	0,126	0,104	0,338	0,005	0,010	0,007	0,003	-7,69	1,84
INM	-0,020	0,062	0,0124	0,015	-0,017	0,004	-0,020	0,002	-22,82	0,71
LACOMET	0,240	0,048	0,340	0,068	0,030	0,006	0,070	0,014	16,55	3,31
BIPM	0,056	0,108	0,072	0,125	0,020	0,011	0,022	0,010	-10,77	0,44
CESMEC	-0,210	0,445	-0,021	0,670	0,004	0,018	-0,008	0,018	-15,60	0,76
INTI	-0,011	0,259	0,029	0,250	-0,002	0,006	-0,002	0,006	-5,21	1,97
CENAM	0,085	0,149	0,094	0,100	-0,009	0,014	-0,013	0,013	-20,82	1,55
LATU	-0,028	0,058	-0,004	0,051	-0,078	0,007	-0,076	0,007	-8,47	1,55
INDECOPI 2	-0,068	0,126	0,290	0,34	0,011	0,010	0,017	0,003	-2,79	1,84

The uncertainty contributions of magnetic susceptibility and magnetic polarization assigned by the NMIs for each nominal value are shown in the Annex B, according to the format established in Annex III of the Technical Protocol.

The stabilities of the travelling standards were assessed by INDECOPI by measuring the magnetic properties values before and after the comparison. The uncertainties due to the stability of each artifact from July 2011 to April 2013 were calculated using the next equations:

Magnetic susceptibility (χ):

$$u(\Delta\chi) = \sqrt{\frac{(\chi_{INDECOPI\,1} - \chi_{INDECOPI\,2})^2}{12}}$$

Magnetic polarization (M):

$$u(\Delta \mathrm{M}) = \sqrt{\frac{(\mathrm{M}_{INDECOPI\,1} - \mathrm{M}_{INDECOPI\,2})^2}{12}}$$

Where:

$\chi_{INDECOPI\,1}$: Magnetic susceptibility measurement by INDECOPI in July 2011

$\chi_{INDECOPI\,2}$: Magnetic susceptibility measurement by INDECOPI in April 2013

$\mathrm{M}_{INDECOPI\,1}$: Magnetic polarization measurement by INDECOPI in July 2011

$\mathrm{M}_{INDECOPI\,2}$: Magnetic polarization measurement by INDECOPI in April 2013

9. References values of the intercomparison and χ^2 test [8]:

9.1 Magnetic susceptibility

<u>Magnetic susceptibility values of the intercomparison</u>:

- Model of the measurement intercomparison:

$$\begin{bmatrix} \chi_{INDECOPI} \\ \chi_{INM} \\ \chi_{LACOMET} \\ \chi_{BIPM} \\ \chi_{CESMEC} \\ \chi_{INTI} \\ \chi_{CENAM} \\ \chi_{LATU} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} . \hat{\chi}$$

where:

$$\boldsymbol{X} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}; \qquad \boldsymbol{Y} = \begin{bmatrix} \chi_{INDECOPI} \\ \chi_{INM} \\ \chi_{LACOMET} \\ \chi_{BIPM} \\ \chi_{CESMEC} \\ \chi_{INTI} \\ \chi_{CENAM} \\ \chi_{LATU} \end{bmatrix}$$

- Covariance Matrix **Σ**:

$$\boldsymbol{\Sigma} = \boldsymbol{\Sigma_{measurement}} + \boldsymbol{\Sigma_{drift}}$$

$$\boldsymbol{\Sigma_{measurement}} =$$

$$\begin{bmatrix}
u^2(\chi_{INDECOPI}) & u(\chi_{INDECOPI,INM}) & u(\chi_{INDECOPI,LACOMET}) & u(\chi_{INDECOPI,BIPM}) & u(\chi_{INDECOPI,CESMEC}) & u(\chi_{INDECOPI,INTI}) & u(\chi_{INDECOPI,CENAM}) & u(\chi_{INDECOPI,LATU}) \\
u(\chi_{INM,INDECOPI}) & u^2(\chi_{INM}) & u(\chi_{INM,LACOMET}) & u(\chi_{INM,BIPM}) & u(\chi_{INM,CESMEC}) & u(\chi_{INM,INTI}) & u(\chi_{INM,CENAM}) & u(\chi_{INM,LATU}) \\
u(\chi_{LACOMET,INDECOPI}) & u(\chi_{LACOMET,INM}) & u^2(\chi_{LACOMET}) & u(\chi_{LACOMET,BIPM}) & u(\chi_{LACOMET,CESMEC}) & u(\chi_{LACOMET,INTI}) & u(\chi_{LACOMET,CENAM}) & u(\chi_{LACOMET,LATU}) \\
u(\chi_{BIPM,INDECOPI}) & u(\chi_{BIPM,INM}) & u(\chi_{BIPM,LACOMET}) & u^2(\chi_{BIPM}) & u(\chi_{BIPM,CESMEC}) & u(\chi_{BIPM,INTI}) & u(\chi_{BIPM,CENAM}) & u(\chi_{BIPM,LATU}) \\
u(\chi_{CESMEC,INDECOPI}) & u(\chi_{CESMEC,INM}) & u(\chi_{CESMEC,LACOMET}) & u(\chi_{CESMEC,BIPM}) & u^2(\chi_{CESMEC}) & u(\chi_{CESMEC,INTI}) & u(\chi_{CESMEC,CENAM}) & u(\chi_{CESMEC,CENAM}) \\
u(\chi_{INTI,INDECOPI}) & u(\chi_{INTI,INM}) & u(\chi_{INTI,LACOMET}) & u(\chi_{INTI,BIPM}) & u(\chi_{INTI,CESMEC}) & u^2(\chi_{INTI}) & u(\chi_{INTI,CENAM}) & u(\chi_{INTI,LATU}) \\
u(\chi_{CENAM,INDECOPI}) & u(\chi_{CENAM,INM}) & u(\chi_{CENAM,LACOMET}) & u(\chi_{CENAM,BIPM}) & u(\chi_{CENAM,CESMEC}) & u(\chi_{CENAM,INTI}) & u^2(\chi_{CENAM}) & u(\chi_{CENAM,LATU}) \\
u(\chi_{LATU,INDECOPI}) & u(\chi_{LATU,INM}) & u(\chi_{LATU,LACOMET}) & u(\chi_{LATU,BIPM}) & u(\chi_{LATU,CESMEC}) & u(\chi_{LATU,INTI}) & u(\chi_{LATU,CENAM}) & u^2(\chi_{LATU})
\end{bmatrix}$$

$$\boldsymbol{\Sigma_{drift}} =$$

$$\begin{bmatrix}
u^2(\Delta\chi) & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & u^2(\Delta\chi) & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & u^2(\Delta\chi) & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & u^2(\Delta\chi) & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & u^2(\Delta\chi) & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & u^2(\Delta\chi) & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & u^2(\Delta\chi) & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & u^2(\Delta\chi)
\end{bmatrix}$$

According to the table 6, the reference standards fromINDECOPI, $\chi^{r}_{INDECOPI}$, and LACOMET, $\chi^{r}_{LACOMET}$, are similar and theywere calibratedin PTB. These references standards are correlated.

$$r(\chi^{r}_{INDECOPI}, \chi^{r}_{LACOMET}) = 1.$$

As

$$u(\chi_{INDECOPI,LACOMET}) = \left(\frac{\partial \chi_{INDECOPI}}{\partial \chi^{r}_{INDECOPI}}\right) . \left(\frac{\partial \chi_{LACOMET}}{\partial \chi^{r}_{LACOMET}}\right) . u(\chi^{r}_{INDECOPI}, \chi^{r}_{LACOMET})$$

Then

$$u(\chi_{INDECOPI,LACOMET}) = \left(\frac{\partial \chi_{INDECOPI}}{\partial \chi^{r}_{INDECOPI}}\right) . \left(\frac{\partial \chi_{LACOMET}}{\partial \chi^{r}_{LACOMET}}\right) . u(\chi^{r}_{INDECOPI}) . u(\chi^{r}_{LACOMET})$$

Similarly, the reference standards fromINDECOPI and LATU, LACOMET and LATU, and BIPM and CENAM are correlated.Then their covariances are given by:

$$u(\chi_{INDECOPI,LATU}) = \left(\frac{\partial \chi_{INDECOPI}}{\partial \chi^{r}_{INDECOPI}}\right) . \left(\frac{\partial \chi_{LATU}}{\partial \chi^{r}_{LATU}}\right) . u(\chi^{r}_{INDECOPI}) . u(\chi^{r}_{LATU})$$

$$u(\chi_{LACOMET,LATU}) = \left(\frac{\partial \chi_{LACOMET}}{\partial \chi^{r}_{LACOMET}}\right) . \left(\frac{\partial \chi_{LATU}}{\partial \chi^{r}_{LATU}}\right) . u(\chi^{r}_{LACOMET}) . u(\chi^{r}_{LATU})$$

$$u(\chi_{BIPM,CENAM}) = \left(\frac{\partial \chi_{BIPM}}{\partial \chi^{r}_{BIPM}}\right) . \left(\frac{\partial \chi_{CENAM}}{\partial \chi^{r}_{CENAM}}\right) . u(\chi^{r}_{BIPM}) . u(\chi^{r}_{CENAM})$$

Note: The covariances are obtained using the values of the INMs given in the table B1 of Annex B.

The magnets from INDECOPI and CENAM are correlated (table 5) but their covariances are negligible because the uncertainty percentage contributions for the magnetic susceptibility are very low (table B2, Annex B).

The Covariance Matrices $\boldsymbol{\Sigma}$ obtained are shown in the Annex B (table B3)

- Magnetic susceptibility value of the intercomparison (method of least squares):

$$\hat{\chi} = (\boldsymbol{X}^{T} . \boldsymbol{\Sigma}^{-1} . \boldsymbol{X})^{-1} . (\boldsymbol{X}^{T} . \boldsymbol{\Sigma}^{-1} . \boldsymbol{Y})$$

$$u(\hat{\chi}) = [(\boldsymbol{X}^{T} . \boldsymbol{\Sigma}^{-1} . \boldsymbol{X})^{-1}]^{1/2}$$

- The chi square value:

$$\chi^{2}_{obs} = (\boldsymbol{Y} - \boldsymbol{X} . \hat{\chi})^{T} . \boldsymbol{\Sigma}^{-1} . (\boldsymbol{Y} - \boldsymbol{X} . \hat{\chi})$$

- Number of degrees of freedom:

$$\upsilon = 7$$

Evaluation table of the consistency of the intercomparison

The table 9 includes magnetic susceptibility values of each NMI, χ_i, and the magnetic susceptibility values of the intercomparison, $\hat{\chi}$, with the uncertainties of the travelling standards. It also includes the observed chi squared values χ^2_{obs} as well as the probability: $Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\}$.If this probability is more than or equal to 0,05 the measurements values are consistent.

Table 9
Evaluation of the consistency of the intercomparison for magnetic susceptibility

NMIs	NOMINAL VALUE	χ_i	$u(\chi_i)$	$\hat{\chi}$	$u(\hat{\chi})$	χ^2_{obs}	$Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\}$
INDECOPI	2 g	0,00373	0,00058	0,00374	0,00010	5,28	0,63
INM		0,00384	0,00013				
LACOMET		0,0032	0,00033				
BIPM		0,0037	0,00030				
CESMEC		0,0036	0,00060				
INTI		0,00362	0,00044				
CENAM		0,00406	0,00031				
LATU		0,00367	0,00031				
INDECOPI	2 g (OIML)	0,00371	0,00048	0,00353	0,00018	6,56	0,48
INM		0,00375	0,00045				
LACOMET		0,0026	0,00045				
BIPM		0,0033	0,00030				
CESMEC		0,0038	0,00110				
INTI		0,00365	0,00048				
CENAM		0,004	0,00034				
LATU		0,00364	0,00031				
INDECOPI	1 kg	0,00398	0,00005	0,00391	0,00003	7,21	0,41
INM		0,00384	0,00025				
LACOMET		0,004	0,00022				
BIPM		0,0039	0,00020				
CESMEC		0,0039	0,00010				
INTI		0,00393	0,00024				
CENAM		0,00426	0,00026				
LATU		0,00392	0,00003				
INDECOPI	1 kg (OIML)	0,00393	0,00003	0,00391	0,00003	1,83	0,97
INM		0,00383	0,00013				
LACOMET		0,0039	0,00010				
BIPM		0,0039	0,00020				
CESMEC		0,0038	0,00010				
INTI		0,0039	0,00026				
CENAM		0,00416	0,00025				
LATU		0,00388	0,00002				
INDECOPI	Steel Disc	0,08964	0,00350	0,08643	0,00133	9,54	0,22
INM		0,08552	0,00580				
LACOMET		0,0824	0,00100				
BIPM		0,0918	0,00370				
CESMEC		0,0875	0,00170				
INTI		0,0901	0,00620				
CENAM		0,0983	0,00540				
LATU		0,088	0,00400				

Degrees of equivalence of theNMIs[9]**:**

Degree of equivalence withthe referencevalue of the intercomparison:

INDECOPI:

$D_{INDECOPI} = \chi_{INDECOPI} - \hat{\chi}$ $\quad U(D_{INDECOPI}) = 2\sqrt{u^2(\chi_{INDECOPI}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{\mathrm{INDECOPI}} = \frac{\chi_{INDECOPI} - \hat{\chi}}{\sqrt{u^2(\chi_{INDECOPI}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{INDECOPI}| > 2$ (k=2, at a 95% level of confidence), the measured value $\chi_{INDECOPI\,1}$ is classified as outlying at a 5% level of significance.

INM:

$D_{INM} = \chi_{INM} - \hat{\chi}$ $\quad U(D_{INM}) = 2\sqrt{u^2(\chi_{INM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{INM} = \frac{\chi_{INM} - \hat{\chi}}{\sqrt{u^2(\chi_{INM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{INM}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{INM} is classified as outlying at a 5% level of significance.

LACOMET:

$D_{LACOMET} = \chi_{LACOMET} - \hat{\chi}$ $\quad U(D_{INM}) = 2\sqrt{u^2(\chi_{LACOMET}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{LACOMET} = \frac{\chi_{LACOMET} - \hat{\chi}}{\sqrt{u^2(\chi_{LACOMET}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{LACOMET}| > 2$ (k=2, at a 95% level of confidence), the measured value $\chi_{LACOMET}$ is classified as outlying at a 5% level of significance.

BIPM:

$D_{BIPM} = \chi_{BIPM} - \hat{\chi}$ $\quad U(D_{BIPM}) = 2\sqrt{u^2(\chi_{BIPM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{BIPM} = \frac{\chi_{BIPM} - \hat{\chi}}{\sqrt{u^2(\chi_{BIPM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{BIPM}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{BIPM} is classified as outlying at a 5% level of significance.

CESMEC:

$D_{CESMEC} = \chi_{CESMEC} - \hat{\chi}$ $\qquad U(D_{CESMEC}) = 2\sqrt{u^2(\chi_{CESMEC}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{CESMEC} = \frac{\chi_{CESMEC} - \hat{\chi}}{\sqrt{u^2(\chi_{CESMEC}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{CESMEC}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{CESMEC} is classified as outlying at a 5% level of significance.

INTI:

$D_{INTI} = \chi_{INTI} - \hat{\chi}$ $\qquad U(D_{INTI}) = 2\sqrt{u^2(\chi_{INTI}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{INTI} = \frac{\chi_{INTI} - \hat{\chi}}{\sqrt{u^2(\chi_{INTI}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{INTI}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{INTI} is classified as outlying at a 5% level of significance.

CENAM:

$D_{CENAM} = \chi_{CENAM} - \hat{\chi}$ $\qquad U(D_{CENAM}) = 2\sqrt{u^2(\chi_{CENAM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{CENAM} = \frac{\chi_{CENAM} - \hat{\chi}}{\sqrt{u^2(\chi_{CENAM}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{CENAM}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{CENAM} is classified as outlying at a 5% level of significance.

LATU:

$D_{LATU} = \chi_{LATU} - \hat{\chi}$ $\qquad U(D_{LATU}) = 2\sqrt{u^2(\chi_{LATU}) + u^2(\Delta\chi) - u^2(\hat{\chi})}$

$$d_{LATU} = \frac{\chi_{LATU} - \hat{\chi}}{\sqrt{u^2(\chi_{LATU}) + u^2(\Delta\chi) - u^2(\hat{\chi})}}$$

Note: If $|d_{LATU}| > 2$ (k=2, at a 95% level of confidence), the measured value χ_{LATU} is classified as outlying at a 5% level of significance.

χ_i	: Mean measurement result of each institute.
$u(\chi_i)$	: Standard uncertainty of χ_i.
$\hat{\chi}$	: Reference value of the intercomparison.
$u(\hat{\chi})$	: Standard uncertainty of $\hat{\chi}$.
D_i	: Deviation of the measured value χ_i from the reference value.
$U(D_i)$	: Standard uncertainty of D_i.
$u(\Delta\chi)$	: Standard uncertainty due to the stability of $\chi_{INDECOPI}$
d_i	: Normalized deviation.

Degrees of equivalence of the NMIs are shown in table 10, table 11, table 12, table 13, table 14, Graph1,Graph2, Graph 3, Graph 4, Graph 5, Graph 6, Graph 7, Graph 8, Graph 9 and Graph10.

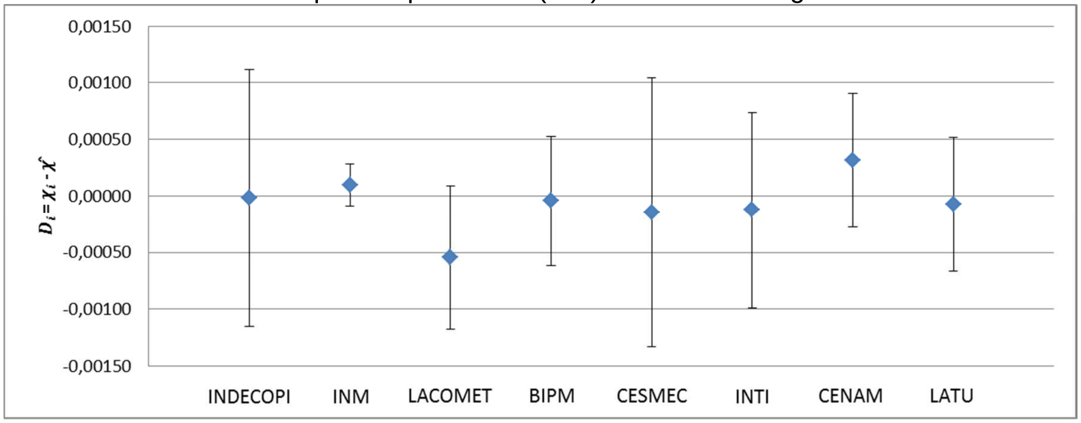
Table 10

Degree of equivalence of the NMIs for 2 g

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	2 g	-0,00002	0,00114	-0,03
INM		0,00010	0,00018	1,04
LACOMET		-0,00054	0,00063	-1,72
BIPM		-0,00004	0,00057	-0,16
CESMEC		-0,00014	0,00119	-0,24
INTI		-0,00012	0,00086	-0,29
CENAM		0,00032	0,00059	1,06
LATU		-0,00007	0,00059	-0,25

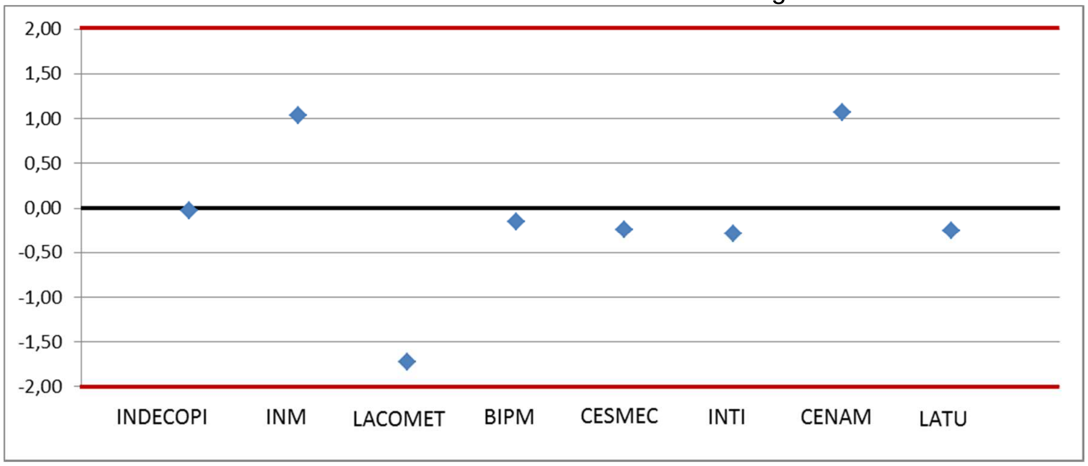
Graph1

Graph of equivalence (k=2) of results for 2 g



Graph 2

Normalized deviations d of results for 2 g

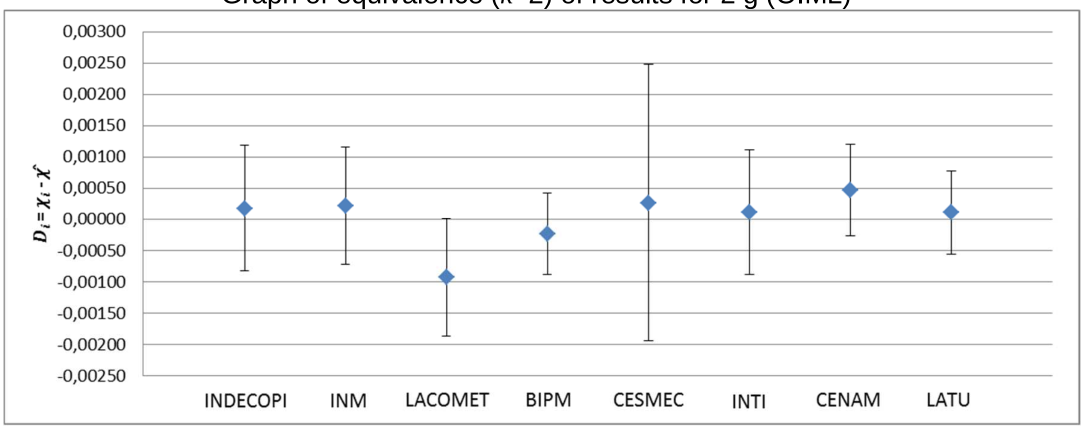


Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance.

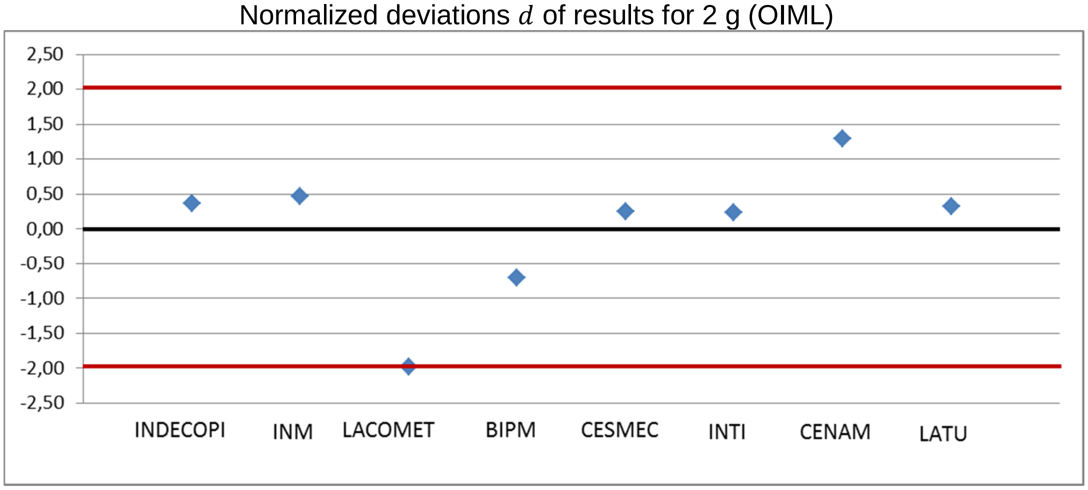
Table 11
Degree of equivalence of the NMIs for 2 g (OIML)

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	2 g (OIML)	0,00018	0,00100	0,36
INM		0,00022	0,00094	0,47
LACOMET		-0,00093	0,00094	-1,98
BIPM		-0,00023	0,00066	-0,70
CESMEC		0,00027	0,00222	0,24
INTI		0,00012	0,00100	0,24
CENAM		0,00047	0,00073	1,29
LATU		0,00011	0,00067	0,33

Graph3
Graph of equivalence (k=2) of results for 2 g (OIML)



Graph 4
Normalized deviations d of results for 2 g (OIML)

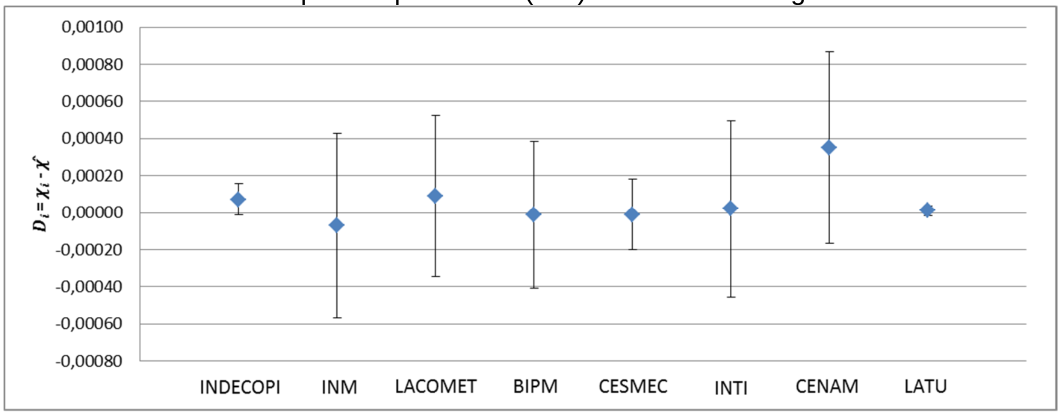


Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance.

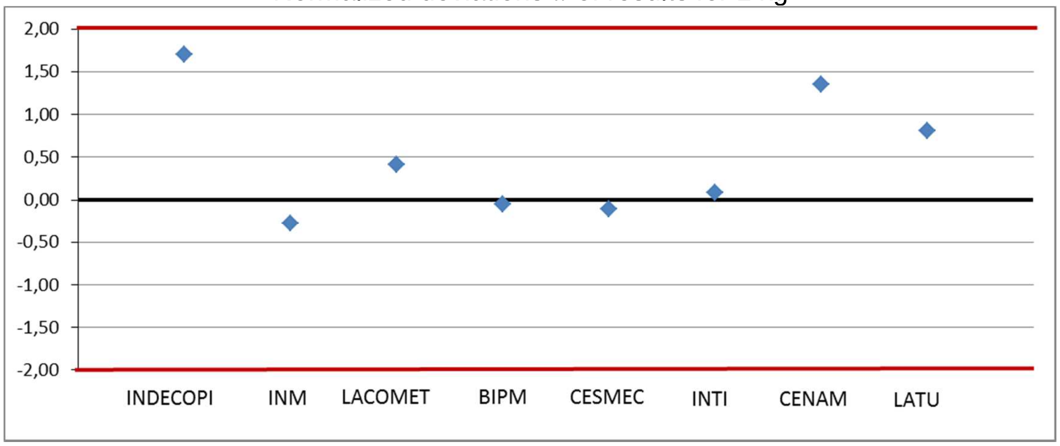
Table 12
Degree of equivalence of the NMIs for 1 kg

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	1 kg	0,00007	0,00008	1,70
INM		-0,00007	0,00050	-0,28
LACOMET		0,00009	0,00044	0,41
BIPM		-0,00001	0,00040	-0,05
CESMEC		-0,00001	0,00019	-0,10
INTI		0,00002	0,00048	0,08
CENAM		0,00035	0,00052	1,35
LATU		0,00001	0,00003	0,81

Graph5
Graph of equivalence (k=2) of results for 1 kg



Graph 6
Normalized deviations d of results for 1 kg

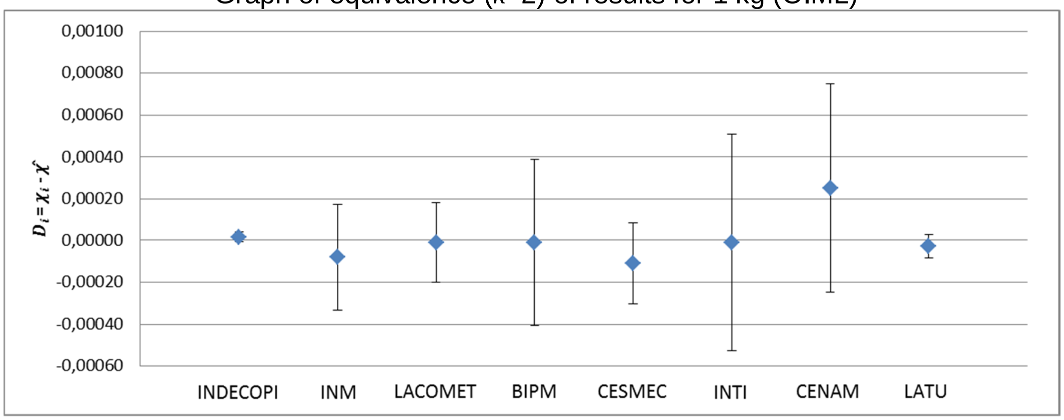


Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance.

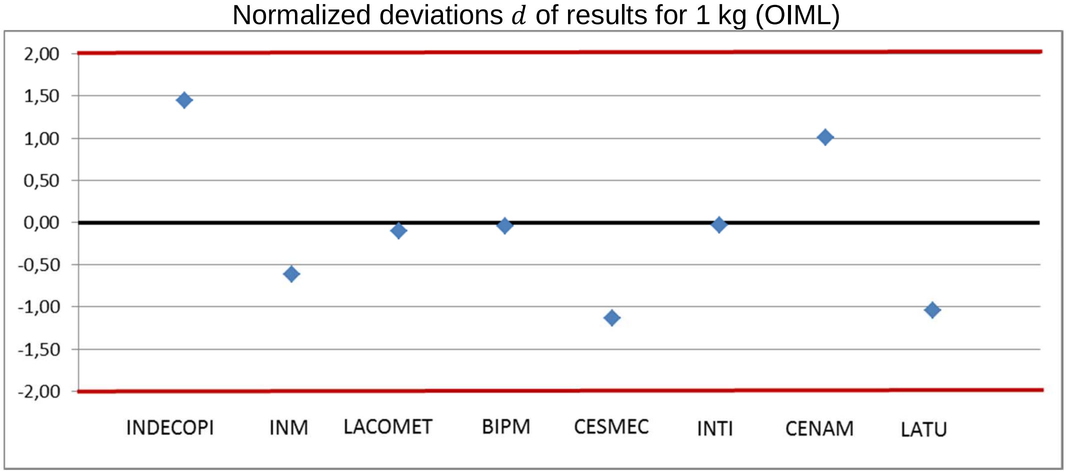
Table 13
Degree of equivalence of the NMIs for 1 kg (OIML)

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	1 kg (OIML)	0,00002	0,00002	1,44
INM		-0,00008	0,00025	-0,62
LACOMET		-0,00001	0,00019	-0,09
BIPM		-0,00001	0,00040	-0,05
CESMEC		-0,00011	0,00019	-1,13
INTI		-0,00001	0,00052	-0,03
CENAM		0,00025	0,00050	1,01
LATU		-0,00003	0,00006	-1,04

Graph7
Graph of equivalence (k=2) of results for 1 kg (OIML)



Graph 8
Normalized deviations d of results for 1 kg (OIML)

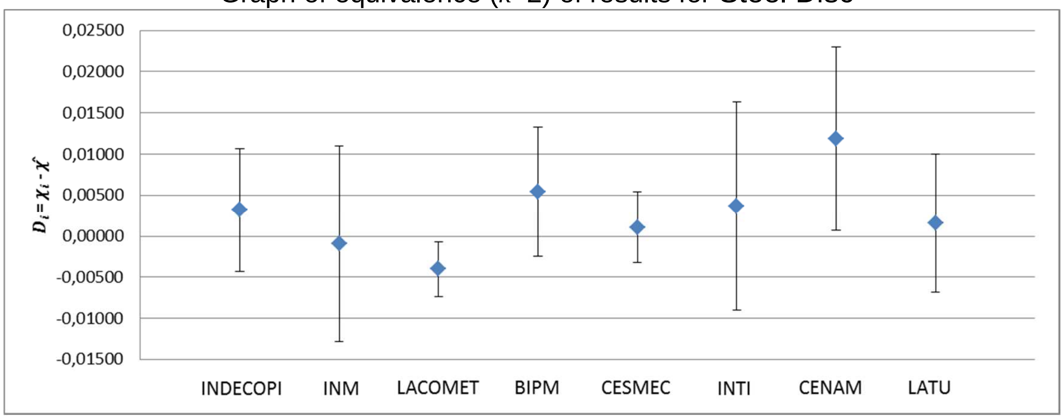


Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance.

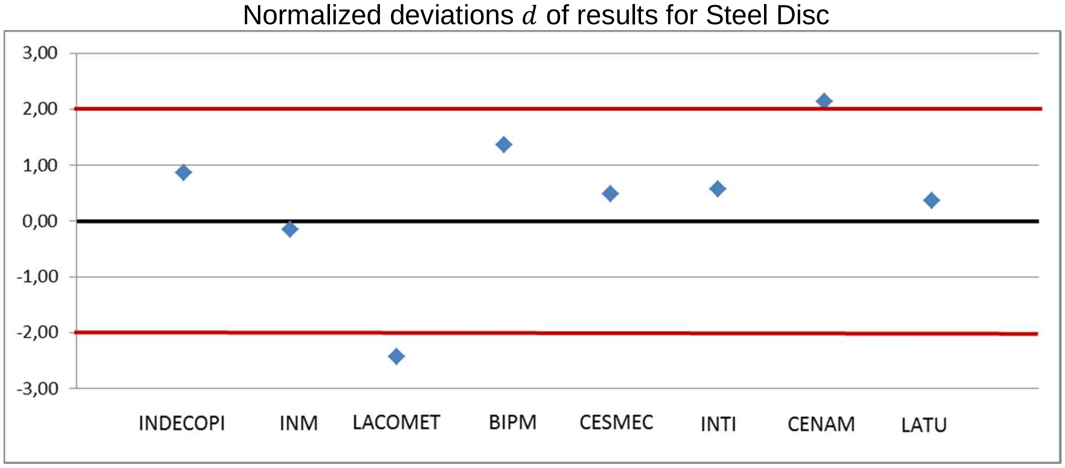
Table 14
Degree of equivalence of the NMIs for Steel Disc

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	Steel Disc	0,00321	0,00749	0,86
INM		-0,00091	0,01190	-0,15
LACOMET		-0,00403	0,00333	-2,42
BIPM		0,00537	0,00786	1,36
CESMEC		0,00107	0,00432	0,49
INTI		0,00367	0,01268	0,58
CENAM		0,01187	0,01112	2,13
LATU		0,00157	0,00843	0,37

Graph9
Graph of equivalence (k=2) of results for Steel Disc



Graph 10
Normalized deviations d of results for Steel Disc



Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance. Note that the measured values from two laboratories are classified as outlying at a 5 % level of significance although overall consistency of the measurements could not be rejected ($Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\} = 22$ %).

9.2 Magnetic polarization

<u>Magnetic polarization values of the intercomparison</u>:

- Model of the measurement intercomparison:

$$\begin{bmatrix} M_{INDECOPI} \\ M_{INM} \\ M_{LACOMET} \\ M_{BIPM} \\ M_{CESMEC} \\ M_{INTI} \\ M_{CENAM} \\ M_{LATU} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} . \hat{M}$$

where:

$$\boldsymbol{X} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}; \qquad \boldsymbol{Y} = \begin{bmatrix} M_{INDECOPI} \\ M_{INM} \\ M_{LACOMET} \\ M_{BIPM} \\ M_{CESMEC} \\ M_{INTI} \\ M_{CENAM} \\ M_{LATU} \end{bmatrix}$$

- Covariance Matrix **Σ**:

$$\boldsymbol{\Sigma} = \boldsymbol{\Sigma_{measurement}} + \boldsymbol{\Sigma_{drift}}$$

$$\boldsymbol{\Sigma_{measurement}} =$$

$$\begin{bmatrix}
u^2(M_{INDECOPI}) & u(M_{INDECOPI,INM}) & u(M_{INDECOPI,LACOMET}) & u(M_{INDECOPI,BIPM}) & u(M_{INDECOPI,CESMEC}) & u(M_{INDECOPI,INTI}) & u(M_{INDECOPI,CENAM}) & u(M_{INDECOPI,LATU}) \\
u(M_{INM,INDECOPI}) & u^2(M_{INM}) & u(M_{INM,LACOMET}) & u(M_{INM,BIPM}) & u(M_{INM,CESMEC}) & u(M_{INM,INTI}) & u(M_{INM,CENAM}) & u(M_{INM,LATU}) \\
u(M_{LACOMET,INDECOPI}) & u(M_{LACOMET,INM}) & u^2(M_{LACOMET}) & u(M_{LACOMET,BIPM}) & u(M_{LACOMET,CESMEC}) & u(M_{LACOMET,INTI}) & u(M_{LACOMET,CENAM}) & u(M_{LACOMET,LATU}) \\
u(M_{BIPM,INDECOPI}) & u(M_{BIPM,INM}) & u(M_{BIPM,LACOMET}) & u^2(M_{BIPM}) & u(M_{BIPM,CESMEC}) & u(M_{BIPM,INTI}) & u(M_{BIPM,CENAM}) & u(M_{BIPM,LATU}) \\
u(M_{CESMEC,INDECOPI}) & u(M_{CESMEC,INM}) & u(M_{CESMEC,LACOMET}) & u(M_{CESMEC,BIPM}) & u^2(M_{CESMEC}) & u(M_{CESMEC,INTI}) & u(M_{CESMEC,CENAM}) & u(M_{CESMEC,CENAM}) \\
u(M_{INTI,INDECOPI}) & u(M_{INTI,INM}) & u(M_{INTI,LACOMET}) & u(M_{INTI,BIPM}) & u(M_{INTI,CESMEC}) & u^2(M_{INTI}) & u(M_{INTI,CENAM}) & u(M_{INTI,LATU}) \\
u(M_{CENAM,INDECOPI}) & u(M_{CENAM,INM}) & u(M_{CENAM,LACOMET}) & u(M_{CENAM,BIPM}) & u(M_{CENAM,CESMEC}) & u(M_{CENAM,INTI}) & u^2(M_{CENAM}) & u(M_{CENAM,LATU}) \\
u(M_{LATU,INDECOPI}) & u(M_{LATU,INM}) & u(M_{LATU,LACOMET}) & u(M_{LATU,BIPM}) & u(M_{LATU,CESMEC}) & u(M_{LATU,INTI}) & u(M_{LATU,CENAM}) & u^2(M_{LATU})
\end{bmatrix}$$

$$\boldsymbol{\Sigma_{drift}} =$$

$$\begin{bmatrix}
u^2(\Delta M) & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & u^2(\Delta M) & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & u^2(\Delta M) & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & u^2(\Delta M) & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & u^2(\Delta M) & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & u^2(\Delta M) & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & u^2(\Delta M) & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & u^2(\Delta M)
\end{bmatrix}$$

According to the table 6, the reference standards from INDECOPI, $\chi^r_{INDECOPI}$, and LACOMET, $\chi^r_{LACOMET}$, are similar and they were calibrated in PTB. These references standards are correlated.

$$r(\chi^r_{INDECOPI}, \chi^r_{LACOMET}) = 1.$$

As

$$u(M_{INDECOPI,LACOMET}) = \left(\frac{\partial M_{INDECOPI}}{\partial \chi^r_{INDECOPI}}\right).\left(\frac{\partial M_{LACOMET}}{\partial \chi^r_{LACOMET}}\right).u(\chi^r_{INDECOPI}, \chi^r_{LACOMET})$$

Then

$$u(M_{INDECOPI,LACOMET}) = \left(\frac{\partial M_{INDECOPI}}{\partial \chi^r_{INDECOPI}}\right).\left(\frac{\partial M_{LACOMET}}{\partial \chi^r_{LACOMET}}\right).u(\chi^r_{INDECOPI}).u(\chi^r_{LACOMET})$$

Similarly, the reference standards from INDECOPI and LATU, LACOMET and LATU, and BIPM and CENAM are correlated. Then their covariances are given by:

$$u(M_{INDECOPI,LATU}) = \left(\frac{\partial M_{INDECOPI}}{\partial \chi^r_{INDECOPI}}\right).\left(\frac{\partial M_{LATU}}{\partial \chi^r_{LATU}}\right).u(\chi^r_{INDECOPI}).u(\chi^r_{LATU})$$

$$u(M_{LACOMET,LATU}) = \left(\frac{\partial M_{LACOMET}}{\partial \chi^r_{LACOMET}}\right).\left(\frac{\partial M_{LATU}}{\partial \chi^r_{LATU}}\right).u(\chi^r_{LACOMET}).u(\chi^r_{LATU})$$

$$u(M_{BIPM,CENAM}) = \left(\frac{\partial M_{BIPM}}{\partial \chi^r_{BIPM}}\right).\left(\frac{\partial M_{CENAM}}{\partial \chi^r_{CENAM}}\right).u(\chi^r_{BIPM}).u(\chi^r_{CENAM})$$

Note: The covariances are obtained using the values of the INMs given in the table B4 of Annex B.

The magnets from INDECOPI and CENAM are correlated (table 5) but their covariances are negligible because the uncertainty percentage contributions for the magnetic polarization are very low (table B5, Annex B).

The Covariance Matrices $\mathbf{\Sigma}$ obtained are shown in the Annex B (table B6)

- Magnetic susceptibility value of the intercomparison (method of least squares):

$$\widehat{M} = (\boldsymbol{X}^T.\boldsymbol{\Sigma}^{-1}.\boldsymbol{X})^{-1}.(\boldsymbol{X}^T.\boldsymbol{\Sigma}^{-1}.\boldsymbol{Y})$$

$$u(\widehat{M}) = [(\boldsymbol{X}^T.\boldsymbol{\Sigma}^{-1}.\boldsymbol{X})^{-1}]^{1/2}$$

- The chi square value:

$$\chi^2_{obs} = (\boldsymbol{Y} - \boldsymbol{X}.\widehat{M})^T.\boldsymbol{\Sigma}^{-1}.(\boldsymbol{Y} - \boldsymbol{X}.\widehat{M})$$

- Number of degrees of freedom:

$$\upsilon = 7$$

Evaluation table of the consistency of the intercomparison

The table 15 includes magnetic polarization values of each NMI, M_i,and the magnetic polarization values of the intercomparison,$\widehat{M}$, with the uncertainties of the travelling standards. It also includes the observed chi squared values χ^2_{obs} as well as the probability: $Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\}$.If this probability is more than or equal to 0,05 the measurements values are consistent.

Table 15

Evaluation of the consistency of the intercomparison for magnetic polarization

NMIs	NOMINAL VALUE	M_i (uT)	$u(M_i)$ (uT)	$\widehat{M}$ (uT)	$u(\widehat{M})$ (uT)	χ^2_{obs}	$Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\}$
INDECOPI	2 g	-0,0175	0,12615	0,0733	0,0321	14,12	0,05
INM		-0,0196	0,06180				
LACOMET		0,2400	0,04800				
BIPM		0,0561	0,10848				
CESMEC		-0,2098	0,44542				
INTI		-0,0113	0,25942				
CENAM		0,0850	0,14900				
LATU		-0,0280	0,05800				
INDECOPI	2 g (OIML)	0,1971	0,3385	0,0778	0,0356	11,93	0,10
INM		0,0124	0,0154				
LACOMET		0,3400	0,0680				
BIPM		0,0715	0,1251				
CESMEC		-0,0207	0,6703				
INTI		0,0289	0,2504				
CENAM		0,0940	0,1000				
LATU		-0,0045	0,0510				
INDECOPI	1 kg	0,0079	0,0105	------	------	**144,57** The chi square test failed. The reference value can't be calculated as the weighted mean.	**0,00** The probability is smaller than 0,05. The measurements values are inconsistent.
INM		-0,0167	0,0044				
LACOMET		0,0300	0,0060				
BIPM		0,0199	0,0105				
CESMEC		0,0036	0,0183				
INTI		-0,0021	0,0056				
CENAM		-0,0090	0,0140				
LATU		-0,0779	0,0070				
INDECOPI	1 kg (OIML)	0,0120	0,0025	------	------	**155,87** The chi square test failed. The reference value can't be calculated as the weighted mean.	**0,00** The probability is smaller than 0,05. The measurements values are inconsistent.
INM		-0,0203	0,0023				
LACOMET		0,0700	0,0140				
BIPM		0,0223	0,0100				
CESMEC		-0,0077	0,0182				
INTI		-0,0023	0,0059				
CENAM		-0,0130	0,0130				
LATU		-0,0762	0,0071				
INDECOPI	Steel Disc	-5,24	1,84	------	------	**150,81** The chi square test failed. The reference value can't be calculated as the weighted mean.	**0,00** The probability is smaller than 0,05. The measurements values are inconsistent.
INM		-22,82	0,71				
LACOMET		16,55	3,31				
BIPM		-10,77	0,44				
CESMEC		-15,60	0,76				
INTI		-5,21	1,97				
CENAM		-20,82	1,55				
LATU		-8,47	1,55				

Degrees of equivalence of theNMIs [9]:

Degree of equivalence with the reference value of the intercomparison:

INDECOPI:

$$D_{INDECOPI} = M_{INDECOPI} - \widehat{M}$$

$$U(D_{INDECOPI}) = 2\sqrt{u^2(M_{INDECOPI}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{INDECOPI} = \frac{M_{INDECOPI} - \widehat{M}}{\sqrt{u^2(M_{INDECOPI}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{INDECOPI}| > 2$ (k=2, at a 95% level of confidence), the measured value $M_{INDECOPI\,1}$ is classified as outlying at a 5% level of significance.

INM:

$$D_{INM} = M_{INM} - \widehat{M}$$

$$U(D_{INM}) = 2\sqrt{u^2(M_{INM}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{INM} = \frac{M_{INM} - \widehat{M}}{\sqrt{u^2(M_{INM}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{INM}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{INM} is classified as outlying at a 5% level of significance.

LACOMET:

$$D_{LACOMET} = M_{LACOMET} - \widehat{M}$$

$$U(D_{INM}) = 2\sqrt{u^2(M_{LACOMET}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{LACOMET} = \frac{M_{LACOMET} - \widehat{M}}{\sqrt{u^2(M_{LACOMET}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{LACOMET}| > 2$ (k=2, at a 95% level of confidence), the measured value $M_{LACOMET}$ is classified as outlying at a 5% level of significance.

BIPM:

$$D_{BIPM} = M_{BIPM} - \widehat{M}$$

$$U(D_{BIPM}) = 2\sqrt{u^2(M_{BIPM}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{BIPM} = \frac{M_{BIPM} - \widehat{M}}{\sqrt{u^2(M_{BIPM}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{BIPM}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{BIPM} is classified as outlying at a 5% level of significance.

CESMEC:

$$D_{CESMEC} = M_{CESMEC} - \widehat{M}$$

$$U(D_{CESMEC}) = 2\sqrt{u^2(M_{CESMEC}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{CESMEC} = \frac{M_{CESMEC} - \widehat{M}}{\sqrt{u^2(M_{CESMEC}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{CESMEC}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{CESMEC} is classified as outlying at a 5% level of significance.

INTI:

$$D_{INTI} = M_{INTI} - \widehat{M}$$

$$U(D_{INTI}) = 2\sqrt{u^2(M_{INTI}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{INTI} = \frac{M_{INTI} - \widehat{M}}{\sqrt{u^2(M_{INTI}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{INTI}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{INTI} is classified as outlying at a 5% level of significance.

CENAM:

$$D_{CENAM} = M_{CENAM} - \widehat{M}$$

$$U(D_{CENAM}) = 2\sqrt{u^2(M_{CENAM}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{CENAM} = \frac{M_{CENAM} - \widehat{M}}{\sqrt{u^2(M_{CENAM}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{CENAM}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{CENAM} is classified as outlying at a 5% level of significance.

LATU:

$$D_{LATU} = M_{LATU} - \widehat{M}$$

$$U(D_{LATU}) = 2\sqrt{u^2(M_{LATU}) + u^2(\Delta M) - u^2(\widehat{M})}$$

$$d_{LATU} = \frac{M_{LATU} - \widehat{M}}{\sqrt{u^2(M_{LATU}) + u^2(\Delta M) - u^2(\widehat{M})}}$$

Note: If $|d_{LATU}| > 2$ (k=2, at a 95% level of confidence), the measured value M_{LATU} is classified as outlying at a 5% level of significance.

M_i	: Mean measurement result of each institute.
$u(M_i)$	: Standard uncertainty of M_i.
$\widehat{M}$	: Reference value of the comparison.
$u(\widehat{M})$	: Standard uncertainty of $\widehat{M}$.
D_i	: Deviation of the measured value χ_i from the reference value.
$U(D_i)$	: Standard uncertainty of D_i.
$u(\Delta M)$	: Standard uncertainty due to the stability of $M_{INDECOPI}$
d_i	: Normalized deviation.

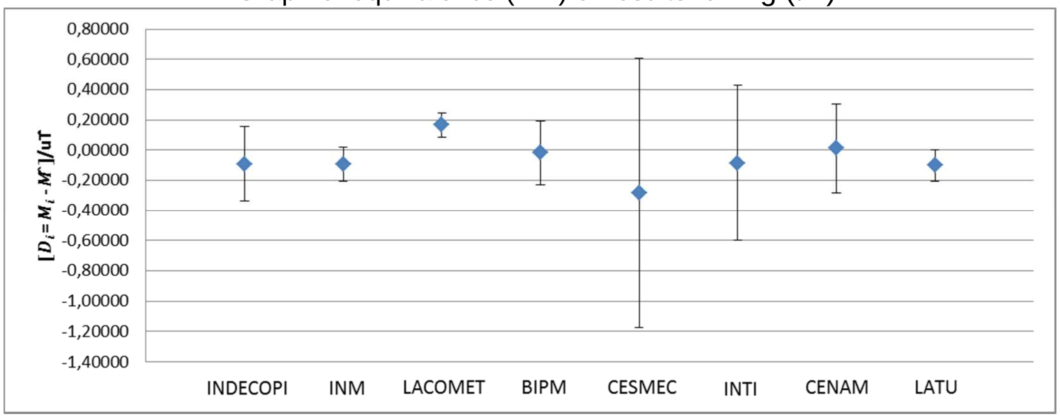
Degrees of equivalence of the NMIs are shown in table 16, table 17,Graph 11, Graph 12, Graph 13 and Graph14.

The magnetic polarization valuesare inconsistent for the weights with nominal values of 1 kg, 1 kg (OIML) and the steel disc. The chi square tests failed. The chi square values χ^2_{obs} observed are significantly larger than the expectation. The reference values can't be calculated as the weighted means.

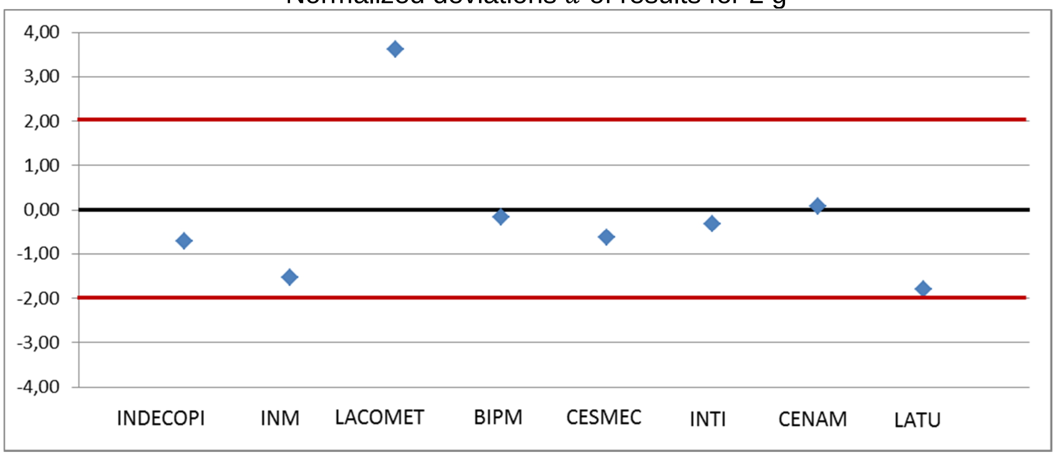
Table 16
Degree of equivalence of the NMIs for 2 g (uT)

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	2 g	-0,09082	0,25085	-0,72
INM		-0,09289	0,12064	-1,54
LACOMET		0,16671	0,09215	3,62
BIPM		-0,01716	0,21529	-0,16
CESMEC		-0,28305	0,89044	-0,64
INTI		-0,08457	0,51815	-0,33
CENAM		0,01171	0,29678	0,08
LATU		-0,10129	0,11284	-1,80

Graph11
Graph of equivalence (k=2) of results for 2 g (uT)



Graph 12
Normalized deviations d of results for 2 g

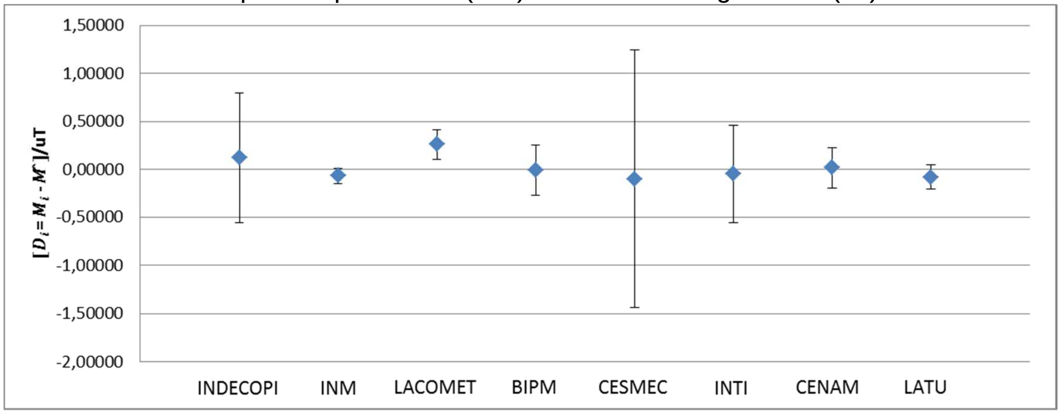


Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance. Note that the measured value from one laboratory is classified as outlying at a 5% level of significance although the overall consistency of the measurements could not be rejected ($Pr\{\chi(\upsilon = 7) > \chi^2_{obs}\} = 5$ %).

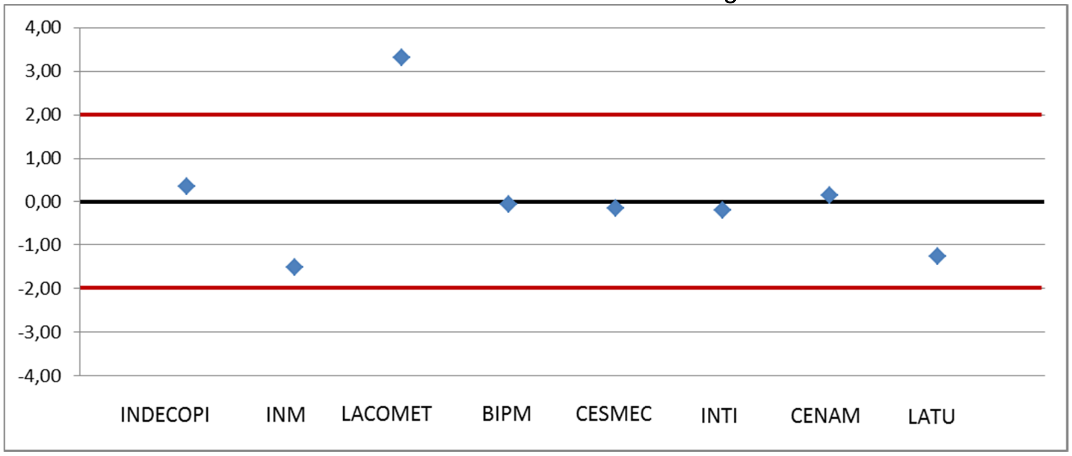
Table 17
Degree of equivalence of the NMIs for 2 g – OIML (uT)

NMIs	NOMINAL VALUE	D_i	$U(D_i)$	d_i
INDECOPI	2 g (OIML)	0,11930	0,68178	0,35
INM		-0,06543	0,08657	-1,51
LACOMET		0,26217	0,15825	3,31
BIPM		-0,00630	0,26295	-0,05
CESMEC		-0,09855	1,34298	-0,15
INTI		-0,04893	0,50738	-0,19
CENAM		0,01617	0,21575	0,15
LATU		-0,08229	0,13019	-1,26

Graph13
Graph of equivalence (k=2) of results for 2 g - OIML (uT)



Graph 14
Normalized deviations d of results for 2 g – OIML



Note: The results with $|d| > 2$ are classified as outlying at a 5% level of significance. Note that the measured value from one laboratory is classified as outlying at a 5 % level of significance although the overall consistency of the measurements be rejected ($Pr\{\chi(v=7) > \chi^2_{obs}\} = 10\ \%$).

10. Conclusions

Magnetic susceptibility:

- From magnetic susceptibility measurements of the weights E_2 we found that the normalized deviations d_i are less than 2 (see tables 10 to 13 and Graphs 1 to 8) and the probabilities of χ^2_{obs} is more than 0,05. As a conclusion, the intercomparison measurement valuesare consistent.
- All four class E_2 weights were found to meet the susceptibility specification for class E_1 [1].
- For the steel disc we found that two INM have d_i a little bigger than two but probabilities of χ^2_{obs} is more than 0,05. As a conclusion, the intercomparison measurement values are consistent.
- If the steel disc is considered to be a mass standard, it meets the susceptibility specification for class F_1 [1].

Magnetic polarization:

- From magnetic polarization measurements of the weights of 2 g and 2 g (OIML), we found that one NMI has their normalized deviations d_i larger than 2 (see tables 16 and 17 and Graphs 11to 14) and the probability of χ^2_{obs} is more than or equal to 0,05. As a conclusion, the intercomparison measurement values for weights of 2 g and 2 g (OIML) are consistent.

- For the weights of 1 kg, 1 kg (OIML) and Steel disc, we found that the chi square values observed χ^2_{obs}(table 15) are larger than expectation υ and the probability of $\chi^2_{obs}$is less than 0,05 (table 15). As a conclusion, the intercomparison measurement values for weights of 1 kg, 1 kg (OIML) and Steel disc are not statistically consistent. Nevertheless, participants agree that all four class E_2 weights actually meet the specification on permanent magnetization for class E_1 weights [1]. If the steel disc is considered to be a mass standard, it would meet the specification on permanent magnetization for class E_2 weights according to some participants and for class F_1 for the rest. (Note above that the susceptibility of the steel disc is only class F_1).

11. References

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[8] Lars Nielsen Evaluation of measurement intercomparisons by the method of least squares, DFM-99-R39, 3208 LN, 2000-02-25.

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ANNEX A

Figure A1

Dimension characteristics measured in objects to be used, as specified in Table A1

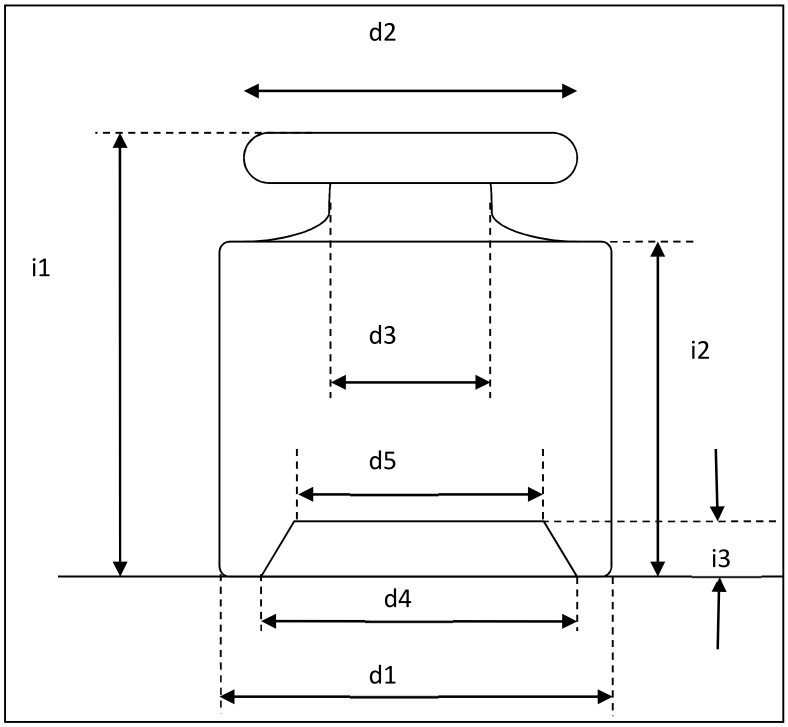


Table A1

Distances measured in the weights

	2 g Weight	2 g OIML	1 kg Weight	1 kg OIML	Steel disc
i1	--	10,78 mm ± 10 um	--	80,13 mm ± 10 um	--
i2	3,37 mm ± 10 um	7,62 mm ± 10 um	69,89 mm ± 10 um	57,68 mm ± 10 um	24,92 mm ± 70 um
i3	--	0,15 mm ± 10 um	1,01 mm ± 10 um	0,96 mm ± 10 um	--
d1	9,98 mm ± 10 um	5,90 mm ± 10 um	47,90 mm ± 10 um	47,96 mm ± 10 um	63,58 mm ± 50 um
d2	--	5,38 mm ± 10 um	--	43,03 mm ± 10 um	--
d3	--	3,00 mm ± 50 um	--	27,50 mm ± 50 um	--
d4	--	3,90 mm ± 50 um	36,60 mm ± 50 um	36,85 mm ± 50 um	--
d5	--	2,30 mm ± 50 um	26,80 mm ± 50 um	26,80 mm ± 50 um	--

Note:

- The values shown in Table A1 after the symbol “±” correspond to the expanded uncertainty (k=2).
- INDECOPI measured the geometric properties of the weights to be used by all participants.

Photograph A1

Photograph of weights and steel cylinder.

ANNEX B

B.1 Uncertainty contributions values reported by the NMIs for the magnetic susceptibility

Table B1.1
Uncertainty contributions reported by the NMIs for 2 g cylindrical weight

INFLUENCE MAGNITUDE X_i	2 g UNIT	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	A m^2	0,000062	0,000036	0,0000377	0,00000	0,0000809	0,0003
Zo	mm			0,0000056			0,000019
$\Delta m_{1\ (unknown)}$	mg			0,0004108	-0,00012		0,000000
$\Delta m_{2\ (unknown)}$	mg			0,0004151	-0,00013		0,0000027
$\Delta m_{1\ (Alacrite)}$	mg				0,00001		
$\Delta m_{2\ (Alacrite)}$	mg				0,00001		
g	m/s^2	0.0000022		0	0,00000		
Ia (unknown)	1	0.00000085	0,0000026	0,0000077	-0,00014		
Ia (standard)	1	0.0000000019			0,00000		
Reproducibility	1		0,000072	0,0001104	0,00007	0,00005	0,00007
$-(\Delta m_1+\Delta m_2)/2$ standard	mg	0.0000012	0,000090			-0,000063	
$-(\Delta m_1+\Delta m_2)/2$ sample	mg	0,000572	0,00014			0,000050	
Susceptibility of transfer standard	1	0,000019	0,00020		0,00024	0,000285	
Combined uncertainty	1	0,00058	0,00028	0,000596	0,00034	0,000311	0,00031

Table B1.2
Uncertainty contributions reported by the NMIs for 2 g weight with a lifting knob

INFLUENCE MAGNITUDE X_i	2 g (OIML) UNIT	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	A m^2	0.000067	0,000028	0,000040	0,00000	0,000113349	0,00026
Zo	mm			0,000006			0,000026
$\Delta m_{1\ (unknown)}$	mg			0,000809	-0,00020		0,000127
$\Delta m_{2\ (unknown)}$	mg			0,000708	-0,00015		0,000055
$\Delta m_{1\ (Alacrite)}$	mg				0,00001		
$\Delta m_{2\ (Alacrite)}$	mg				0,00001		
g	m/s^2	0.0000022		0,000000	0,0000		
Ia (unknown)	1	0.000013	0,000059	0,000027	-0,00013		
Ia (standard)	1	0.0000000016			0,00000		
Reproducibility	1		0,000069	0,000298	0,00004	0,00002	0,00013
$-(\Delta m_1+\Delta m_2)/2$ standard	mg	0.000000	0,000078			0,000072	
$-(\Delta m_1+\Delta m_2)/2$ sample	mg	0.000478	0,00020			0,000057	
Susceptibility of transfer standard	1	0.000017	0,00018		0,00024	0,000308331	
Combined uncertainty	1	0.00048308	0,00029	0,00112	0,00038	0,00034	0,00031

Table B1.3

Uncertainty contributions reported by the NMIs for 1 kg cylindrical weight

INFLUENCE MAGNITUDE X_i	1kg UNIT	INDECOPI $u(xi)$	BIPM $u(xi)$	CESMEC $u(xi)$	INTI $u(xi)$	CENAM $u(xi)$	LATU $u(xi)$
m_d	A m^2	0.000015	-0,0000016	0,000040	0,00000	0,000022	0,0000011
Zo	mm			0,000006			0,000020
$\Delta m_{1\ (unknown)}$	mg			0,000032	-0,00001		0,0000047
$\Delta m_{2\ (unknown)}$	mg			0,000029	-0,00001		0,0000089
$\Delta m_{1\ (Alacrite)}$	mg				0,00001		
$\Delta m_{2\ (Alacrite)}$	mg				0,00001		
g	m/s^2	0.0000022		0,000000	0,00000		
Ia (unknown)	1	0.0000000043	0,000044	0,0000036	-0,00003		
Ia (standard)	1	0.0000000022			0,00000		
Reproducibility	1		0,0000071	0,0000137	0,00001	0,00004	0,00001
$-(\Delta m_1+\Delta m_2)/2$ standard	mg	0.000032	0,000011			-0,000054	
$-(\Delta m_1+\Delta m_2)/2$ sample	mg	0.000027	0,000011			0,0000428	
Susceptibility of transfer standard	1	0.000021	0,00016		0,00026	0,000242	
Combined uncertainty	1	0.00005	0,00016	0,000061	0,00027	0,00026	0,000025

Table B1.4

Uncertainty contributions reported by the NMIs for 1 kg weight with a lifting knob

INFLUENCE MAGNITUDE X_i	1kg (OIML) UNIT	INDECOPI $u(xi)$	BIPM $u(xi)$	CESMEC $u(xi)$	INTI $u(xi)$	CENAM $u(xi)$	LATU $u(xi)$
m_d	A m^2	0.000015	-0,0000015	0,0000398	0,00000	0,000021	0,000002
Zo	mm			0,0000059			0,000020
$\Delta m_{1\ (unknown)}$	mg			0,0000322	0,00000		0,000007
$\Delta m_{2\ (unknown)}$	mg			0,0000290	-0,00001		0,000004
$\Delta m_{1\ (Alacrite)}$	mg				0,00001		
$\Delta m_{2\ (Alacrite)}$	mg				0,00001		
g	m/s^2	0.0000022		0,0000000	0,00000		
Ia (unknown)	1	0.0000019	0,000041	0,0000055	-0,00004		
Ia (standard)	1	0.0000000022			0,00000		
Reproducibility	1		0,0000022	0,000021	0,00002	0,000047	0,000002
$-(\Delta m_1+\Delta m_2)/2$ standard	mg	0.000010	0,000010			-0,000048	
$-(\Delta m_1+\Delta m_2)/2$ sample	mg	0.0000064	0,0000083			0,000042	
Susceptibility of transfer standard	1	0.000020	0,000154		0,00026	0,000233	
Combined uncertainty	1	0.00003	0,00016	0,000063	0,00026	0,00025	0,000022

Table B1.5

Uncertainty contributions reported by the NMIs for Stainless steel disc

INFLUENCE MAGNITUDE X_i	STEEL DISC UNIT	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	A m^2	0.00045	0,000066	0,000940	0,000000	-0,000048	0,000327
Zo	mm			0,000140			0,000707
$\Delta m_{1\ (unknown)}$	mg			0,000622	-0,0002		0,004413
$\Delta m_{2\ (unknown)}$	mg			0,001289	-0,0005		0,000095
$\Delta m_{1\ (Alacrite)}$	mg				0,0003		
$\Delta m_{2\ (Alacrite)}$	mg				0,0003		
g	m/s^2	0.0000022		0,0000001	0,0000		
Ia (unknown)	1	0.0000011	0,000017	0,000027	-0,0007		
Ia (standard)	1	0.0000018			0,0001		
Reproducibility	1		0,00037	0,000311	0,0010	0,00051	0,00030
$-(\Delta m_1+\Delta m_2)/2$ standard	mg	0.000470	0,00092			-0,002315	
$-(\Delta m_1+\Delta m_2)/2$ sample	mg	0.003438	0,00021			0,002481	
Susceptibility of transfer standard	1	0.000480	0,00357		0,0060	0,004158	
Combined uncertainty	1	0.0035	0,00371	0,00175	0,0062	0,0054	0,0044

B.2 Percentage uncertainty values reported by the NMIs for the magnetic susceptibility

Table B2.1

Percentage uncertainty contributions reported by the NMIs for 2 g cylindrical weight

INFLUENCE MAGNITUDE X_i	2 g	INDECOPI $u(xi)$	BIPM $u(xi)$	CESMEC $u(xi)$	INTI $u(xi)$	CENAM $u(xi)$	LATU $u(xi)$
m_d	%	1.15	1,7	0,4	0,0	6,8	92,96
Zo	%			0,01			0,38
$\Delta m_{1\,(unknown)}$	%			47,57	13,0		0,04
$\Delta m_{2\,(unknown)}$	%			48,56	15,4		0,01
$\Delta m_{1\,(Alacrite)}$	%				0,2		
$\Delta m_{2\,(Alacrite)}$	%				0,2		
g	%	0,00		0	0,0		0
Ia (unknown)	%	0,00		0,02	17,0		0
Ia (standard)	%	0,00			0,0		
Reproducibility	%		6,7	3,44	4,6	2,6	5,49
$-(\Delta m_1+\Delta m_2)/2$ standard	%	0,00	10,6			4,2	
$-(\Delta m_1+\Delta m_2)/2$ sample	%	98,74	26,3			2,6	
Susceptibility of transfer standard	%	0,11	54,6		49,7	84,6	
Combined uncertainty	%	100	100	100	100	101	98
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	101	98

Table B2.2

Percentage uncertainty contributions reported by the NMIs for 2 g weight with a lifting knob

INFLUENCE MAGNITUDE X_i	2 g OIML	INDECOPI $u(xi)$	BIPM $u(xi)$	CESMEC $u(xi)$	INTI $u(xi)$	CENAM $u(xi)$	LATU $u(xi)$
m_d	%	1.95	0,93	0,13	0	11,1	69,55
Zo	%	0,0	0,0	0			0,70
$\Delta m_{1\,(unknown)}$	%		0,0	52,5	28,0		16,90
$\Delta m_{2\,(unknown)}$	%		0,0	40,2	16,6		3,1
$\Delta m_{1\,(Alacrite)}$	%				0,1		
$\Delta m_{2\,(Alacrite)}$	%				0,1		
g	%	0.00	0,0	0	0		0
Ia (unknown)	%	0.08	4,0	0,06	12,1		0
Ia (standard)	%	0.00					
Reproducibility	%		5,6	7,11	1,1	0,3	17,59
$-(\Delta m_1+\Delta m_2)/2$ standard	%	0.00	7,1			4,5	
$-(\Delta m_1+\Delta m_2)/2$ sample	%	97.85	45,7			2,8	
Susceptibility of transfer standard	%	0.13	36,7		41,9	82,2	
Combined uncertainty	%	100	100	100	100	101	108
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	101	108

Table B2.3

Percentage uncertainty contributions reported by the NMIs for 1 kg cylindrical weight

INFLUENCE MAGNITUDE X_i	1 kg	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	%	9.82	0,01	43,22	0	0.7	0,19
Zo	%		0	0,96			67,08
$\Delta m_{1\ (unknown)}$	%		0	27,86	0		3,59
$\Delta m_{2\ (unknown)}$	%		0	22,64	0		12,75
$\Delta m_{1\ (Alacrite)}$	%				0,3		
$\Delta m_{2\ (Alacrite)}$	%				0,3		
g	%	0.20	0	0	0		0
Ia (unknown)	%	0.00	7,4	0,34	1,4		0
Ia (Alacritre)	%	0.00			0		
Reproducibility	%		0,2	4,97	0,2	2,6	16
$-(\Delta m_1+\Delta m_2)/2$ standard	%	41.78	0,4			4,4	
$-(\Delta m_1+\Delta m_2)/2$ sample	%	30.56	0,5			2,7	
Susceptibility of transfer standard	%	17.63	91,5		97,7	86,7	
Combined uncertainty	%	100	100	100	100	97	100
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	97	100

Table B2.4

Percentage uncertainty contributions reported by the NMIs for 1 kg weight with a lifting knob

INFLUENCE MAGNITUDE X_i	1 kg OIML	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	%	28.65	0,01	39.89	0,0	0,7	0,84
Zo	%		0,0	0,89			84,95
$\Delta m_{1\ (unknown)}$	%		0,0	26,09	0,0		9,30
$\Delta m_{2\ (unknown)}$	%		0,0	21,2	0,0		3,97
$\Delta m_{1\ (Alacrite)}$	%				0,3		0
$\Delta m_{2\ (Alacrite)}$	%				0,3		0
g	%	0.62	0,0	0	0,0		0
Ia (unknown)	%	0.48	6,5	0,76	1,8		0
Ia (standard)	%	0.00			0,0		
Reproducibility	%		0,02	11,17	0,4	3,5	0,83
$-(\Delta m_1+\Delta m_2)/2$ standard	%	12.00	0,43			3,6	
$-(\Delta m_1+\Delta m_2)/2$ sample	%	5.24	0,27			2,8	
Susceptibility of transfer standard	%	53.00	92,7		97,1	86,6	
Combined uncertainty	%	100	100	100	100	97	100
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	97	100

Table B2.5

The percentage uncertainty contributions reported by the NMIs for Steel disc

INFLUENCE MAGNITUDE X_i	Steel Disc	INDECOPI *u(xi)*	BIPM *u(xi)*	CESMEC *u(xi)*	INTI *u(xi)*	CENAM *u(xi)*	LATU *u(xi)*
m_d	%	1.62	0,03	28,97	0,0	0,01	0,55
Zo	%		0	0,64			2,58
Δm_1 (unknown)	%		0	12,69	0,1		100,58
Δm_2 (unknown)	%		0	54,49	0,7		0,05
Δm_1 (Alacrite)	%				0,3		
Δm_2 (Alacrite)	%				0,3		
g	%	0.00	0	0	0,0		0
Ia (unknown)	%	0.00	0		1,2		0
Ia (Alacritre)	%	0.00			0,0		
Reproducibility	%		1,0	3,18	2,4	0,9	0,46
$-(\Delta m_1+\Delta m_2)/2$ standard	%	1.77	6,2			18,7	
$-(\Delta m_1+\Delta m_2)/2$ sample	%	94.77	0,3			21,4	
Susceptibility of transfer standard	%	1.84	92,4		94,9	60,2	
Combined uncertainty	%	100	100	100	100	101	104
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	101	104

B.3 The Covariance Matrices obtained for the magnetic susceptibility

Table 3.1

The Covariance Matrix obtained for 2 g cylindrical weight

$3,33x10^{-7}$	0	$9,30x10^{-10}$	0	0	0	0	$1,03x10^{-9}$
0	$1,89x10^{-8}$	0	0	0	0	0	0
$9,30x10^{-10}$	0	$1,11x10^{-7}$	0	0	0	0	$2,69x10^{-9}$
0	0	0	$9,20x10^{-8}$	0	0	$5,82x10^{-8}$	0
0	0	0	0	$3,62x10^{-7}$	0	0	0
0	0	0	0	0	$1,96x10^{-7}$	0	0
0	0	0	$5,82x10^{-8}$	0	0	$9,81x10^{-8}$	0
$1,03x10^{-9}$	0	$2,69x10^{-9}$	0	0	0	0	$9,81x10^{-8}$

Table 3.2

The Covariance Matrix obtained for 2 g weight with a lifting knob

$2,82x10^{-7}$	0	$7,07x10^{-10}$	0	0	0	0	$9,47x10^{-10}$
0	$2,51x10^{-7}$	0	0	0	0	0	0
$7,07x10^{-10}$	0	$2,51x10^{-7}$	0	0	0	0	$2,27x10^{-9}$
0	0	0	$1,38x10^{-7}$	0	0	$5,47x10^{-8}$	0
0	0	0	0	$1,26x10^{-6}$	0	0	0
0	0	0	0	0	$2,79x10^{-7}$	0	0
0	0	0	$5,47x10^{-8}$	0	0	$1,64x10^{-7}$	0
$9,47x10^{-10}$	0	$2,27x10^{-9}$	0	0	0	0	$1,44x10^{-7}$

Table 3.3

The Covariance Matrix obtained for 1 kg cylindrical weight

$2,50x10^{-9}$	0	$9,89x10^{-10}$	0	0	0	0	$9,95x10^{-10}$
0	$6,25x10^{-8}$	0	0	0	0	0	0
$9,89x10^{-10}$	0	$4,84x10^{-8}$	0	0	0	0	$2,33x10^{-9}$
0	0	0	$4,00x10^{-8}$	0	0	$3,75x10^{-8}$	0
0	0	0	0	$1,00x10^{-8}$	0	0	0
0	0	0	0	0	$5,76x10^{-8}$	0	0
0	0	0	$3,75x10^{-8}$	0	0	$6,76x10^{-8}$	0
$9,95x10^{-10}$	0	$2,33x10^{-9}$	0	0	0	0	$9,01x10^{-10}$

Table 3.4
The Covariance Matrix obtained for 1 kg weight with a lifting knob

$9{,}06\text{x}10^{-10}$	0	$9{,}53\text{x}10^{-10}$	0	0	0	0	$9{,}74\text{x}10^{-10}$
0	$1{,}69\text{x}10^{-8}$	0	0	0	0	0	0
$9{,}53\text{x}10^{-10}$	0	$1{,}00\text{x}10^{-8}$	0	0	0	0	$2{,}25\text{x}10^{-9}$
0	0	0	$4{,}00\text{x}10^{-8}$	0	0	$3{,}59\text{x}10^{-8}$	0
0	0	0	0	$1{,}00\text{x}10^{-8}$	0	0	0
0	0	0	0	0	$6{,}76\text{x}10^{-8}$	0	0
0	0	0	$3{,}59\text{x}10^{-8}$	0	0	$6{,}25\text{x}10^{-8}$	0
$9{,}74\text{x}10^{-10}$	0	$2{,}25\text{x}10^{-9}$	0	0	0	0	$4{,}06\text{x}10^{-10}$

Table 3.5
The Covariance Matrix obtained for Stainless steel disc

$1{,}58\text{x}10^{-5}$	0	$5{,}14\text{x}10^{-7}$	0	0	0	0	$4{,}69\text{x}10^{-7}$
0	$3{,}72\text{x}10^{-5}$	0	0	0	0	0	0
$5{,}14\text{x}10^{-7}$	0	$4{,}54\text{x}10^{-6}$	0	0	0	0	$8{,}98\text{x}10^{-7}$
0	0	0	$1{,}72\text{x}10^{-5}$	0	0	$1{,}49\text{x}10^{-5}$	0
0	0	0	0	$6{,}43\text{x}10^{-6}$	0	0	0
0	0	0	0	0	$4{,}20\text{x}10^{-5}$	0	0
0	0	0	$1{,}49\text{x}10^{-5}$	0	0	$3{,}27\text{x}10^{-5}$	0
$4{,}69\text{x}10^{-7}$	0	$8{,}98\text{x}10^{-7}$	0	0	0	0	$1{,}95\text{x}10^{-5}$

B.4 Uncertainty contributions values reported by the NMIs for the magnetic polarization

Table 4.1

Uncertainty contributions reported by the NMIs for 2 g cylindrical weight

INFLUENCE MAGNITUDE *Xi*	2 g UNIT	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	A m^2	0.000903	0,000056	0,001342	-0,0006	-0,004299	0,0003
Zo	mm			0,000100		0,000052	0,013
$\Delta m_{1\ (unknown)}$	mg	0.027048		0,31005	-0,1060	0,048608	0,0285
$\Delta m_{2\ (unknown)}$	mg	0.123208		0,31326	0,1116	-0,059764	0,0202
$\Delta m_{1\ (Alacrite)}$	mg				0,0002		
$\Delta m_{2\ (Alacrite)}$	mg				0,0002		
g	m/s^2		0,0000029	0,00000036	-0,000006	0,002112	0,00000002
Ib (unknown)		0.000112	0,00016	0,000603	0,00046	-0,002112	
B_{EZ}	µT	0.000119	0,0080	0,00243	-0,0030	-0,001259	0,00018
Reproducibility	µT		0,0139	0,06370	0,14	0,126500	1,265000
$-(\Delta m_1+\Delta m_2)/2$ standard	mg		0,00095				
$-(\Delta m_1+\Delta m_2)/2$ sample	mg		0,00610				
$-(\Delta m_1-\Delta m_2)/2$ sample	mg		0,10709				
Ia	1		0,00011		0,00003		
Susceptibility of transfer standard	1	0.000027	-0,002155	0,00799	-0,0010	-0,009616	
Combined uncertainty u_0M_z	µT	0.1261456	0,11	0,445	0,21	0,149	0,06

Table B4.2

Uncertainty contributions reported by the NMIs for 2 g weight with a lifting knob

INFLUENCE MAGNITUDE ***Xi***	**2 g (OIML)** **UNIT**	**INDECOPI** $u(u_0M_z)$	**BIPM** $u(u_0M_z)$	**CESMEC** $u(u_0M_z)$	**INTI** $u(u_0M_z)$	**CENAM** $u(u_0M_z)$	**LATU** $u(u_0M_z)$
m_d	A m^2	0.002138	0,00011	0,000376	-0,0003	-0,004447	0,000000
Zo	mm			0,000028		0,000054	0,000000
$\Delta m_{1\ (unknown)}$	mg	0.230675		0,501389	-0,1427	0,071074	0,032
$\Delta m_{2\ (unknown)}$	mg	0.247695		0,438715	0,1057	-0,057318	0,032
$\Delta m_{1\ (Alacrite)}$	mg				0,0003		
$\Delta m_{2\ (Alacrite)}$	mg				0,0003		
g	m/s^2		0,0000036	0,0000001	-0,000002	0,002184	0,000000
Ib (unknown)		0.000346	0,0066	0,000506	-0,0011	-0,002184	
B_{EZ}	µT	0.000108	0,007215	0,0025827	-0,0030	-0,001241	0,0002
Reproducibility	µT		0,02185	0,071889	0,084	0,003950	0,024
$-(\Delta m_1+\Delta m_2)/2$ standard	mg		0,00057				
$-(\Delta m_1+\Delta m_2)/2$ sample	mg		0,008544				
$-(\Delta m_1-\Delta m_2)/2$ sample	mg		0,12245				
Ia	1		0,002529		0,00004		
Susceptibility of transfer standard	1	0.000021	-0,001293	0,014976	-0,0004	-0,010547	
Combined uncertainty u_0M_z	µT	0.3385	0,13	0,67	0,20	0,100	0,051

Table B4.3

Uncertainty contributions reported by the NMIs for 1 kg cylindrical weight

INFLUENCE MAGNITUDE *Xi*	1kg UNIT	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	A m^2	0.000025	-0,00049	0,000251	-0,0004	-0,00250	0,000315
Zo	mm			0,0000187		0,00003	0,00667
Δm_1 (unknown)	mg	0.003819		0,012421	-0,0026	0,00327	0,001181
Δm_2 (unknown)	mg	0.009740		0,0111965	0,0028	-0,00426	0,000781
Δm_1 (Alacrite)	mg				0,0003		
Δm_2 (Alacrite)	mg				0,0003		
g	m/s^2	0,000031	0,000001	0,00000007	-0,000006	0,00123	0,000000
Ib (unknown)		0.000015	0,00083	0,000023	0,00002	-0,00123	
B_{EZ}	µT	0.000130	0,0085	0,002602	-0,0033	-0,00132	0,0002
Reproducibility	µT		0,00016	0,0069969	0,0021	0,01009	0,00085
$-(\Delta m_1+\Delta m_2)/2$ standard	mg		0,00025				
$-(\Delta m_1+\Delta m_2)/2$ sample	mg		0,00048				
$-(\Delta m_1-\Delta m_2)/2$ sample	mg		0,0045				
Ia	1		0,0019		0,00004		
Susceptibility of transfer standard	1	0.0000027	-0,0037	0,0008019	-0,0010	-0,00807	
Combined uncertainty u_0M_z	µT	0.0105	0,11	0,018	0,006	0,014	0,007

Table B4.4

Uncertainty contributions reported by the NMIs for 1 kg weight with a lifting knob

INFLUENCE MAGNITUDE *Xi*	1kg (OIML) UNIT	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	A m^2	0.000034	-0,00049	0,000307	-0,0004	-0,00237	0,000268
Zo	mm			0,0000229		0,00003	0,0057
Δm_1 (unknown)	mg	0.002258		0,012399	-0,002	0,00236	0,0014
Δm_2 (unknown)	mg	0.001093		0,011177	0,002	-0,00467	0,0019
Δm_1 (Alacrite)	mg				0,0003		
Δm_2 (Alacrite)	mg				0,0003		
g	m/s^2		0,0000011	0,00000008	-0,000006	0,00116	
Ib (unknown)		0.000021	0,00021	0,0000683	0,00003	-0,00116	
B_{EZ}	µT	0.000128	0,008435	0,002566	-0,0032	-0,00129	0,0002
Reproducibility	µT		0,000059	0,00672	0,0029	0,00869	0,003565
$-(\Delta m_1+\Delta m_2)/2$ standard	mg		0,00025				
$-(\Delta m_1+\Delta m_2)/2$ sample	mg		0,00036				
$-(\Delta m_1-\Delta m_2)/2$ sample	mg		0,003328				
Ia	1		0,001766		0,00004		
Susceptibility of transfer standard	1	0.0000027	-0,003687	0,0007960	-0,0010	-0,00776	
Combined uncertainty u_0M_z	µT	0.0025121	0,01	0,018	0,005	0,013	0,007

Table B4.5

Uncertainty contributions reported by the NMIs for Stainless steel disc

INFLUENCE MAGNITUDE *Xi*	STEEL DISC UNIT	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	A m^2	0.178710	0,02087	0,08697	-0,0022	0,36174	0,069
Zo	mm			0,0064862		-0,00292	1,203
Δm_1 (unknown)	mg	1.439350		0,326813	-0,139	0,61467	0,919
Δm_2 (unknown)	mg	1.126426		0,6771019	0,298	-0,83787	0,301
Δm_1 (Alacrite)	mg				0,001		
Δm_2 (Alacrite)	mg				0,001		
g	m/s^2		0,00055	0,00002308	-0,00064	-0,17769	
Ib (unknown)		0.017967	0,002524	0,0168126	0,035	0,17769	
B_{EZ}	µT	0.003103	0,19787	0,057569	-0,075	-0,03049	0,0043
Reproducibility	µT		-0,27777	0,0763762	1,93	1,05000	0,180
$-(\Delta m_1+\Delta m_2)/2$ standard	mg		0,06830				
$-(\Delta m_1+\Delta m_2)/2$ sample	mg		0,00924				
$-(\Delta m_1-\Delta m_2)/2$ sample	mg		0,04831				
Ia	1		0,00075		-0,0003		
Susceptibility of transfer standard	1	0.0000479	-0,26409	0,022177	-0,108	-0,16627	
Combined uncertainty u_0M_z	µT	1.8365	0,44	0,76	1,96	1,55	1,55

B.5 Percentage uncertainty values reported by the NMIs for the magnetic polarization

Table B5.1

The percentage uncertainty contributions for magnetic polarization, reported by the NMIs for 2 g cylindrical weight

INFLUENCE MAGNITUDE ***Xi***	**2 g**	**INDECOPI** $u(u_0M_z)$	**BIPM** $u(u_0M_z)$	**CESMEC** $u(u_0M_z)$	**INTI** $u(u_0M_z)$	**CENAM** $u(u_0M_z)$	**LATU** $u(u_0M_z)$
m_d	%	0.01	0,00	0,00	0,00	0,08	0,00
Zo	%		0,00	0,00		0,00	4,74
$\Delta m_{1\ (unknown)}$	%	4.60	0,00	48,45	25,52	10,64	24,15
$\Delta m_{2\ (unknown)}$	%	95.40	0,00	49,46	28,27	16,09	12,13
$\Delta m_{1\ (Alacrite)}$	%				0,00		
$\Delta m_{2\ (Alacrite)}$	%				0,00		
g	%		0,00	0,00	0,00	0,02	0,00
Ib (unknown)	%	0.00	0,00	0,00	0,00	0,02	0,00
B_{EZ}	%	0.00	0,54	0,00	0,02	0,01	0,00
Reproducibility	%		1,65	2,05	46.19	72,08	74,32
$-(\Delta m_1+\Delta m_2)/2$ standard	%		0,01				
$-(\Delta m_1+\Delta m_2)/2$ sample	%		0,32				
$-(\Delta m_1-\Delta m_2)/2$ sample	%		97,45				
Ia	%		0,00				
Susceptibility of transfer standard	%	0.00	0,04	0,03	0,00	0,42	
Combined uncertainty u_0M_z	%	100	100	100	100	99	115
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	99	115

Table B5.2

Percentage uncertainty contributions for magnetic polarization, reported by the NMIs for 2 g weight with a lifting knob

INFLUENCE MAGNITUDE *Xi*	2 g OIML	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	%	0.00	0,00	0,00	0,00	0,20	0,00
Zo	%		0,00	0,00		0	0,00
Δm_1 (unknown)	%	46.44	0,00	55,96	52,83	50,52	39,37
Δm_2 (unknown)	%	53.55	0,00	42,84	28,97	32,85	39,37
Δm_1 (Alacrite)	%				0,00		
Δm_2 (Alacrite)	%				0,00		
g	%		0,00	0,00	0,00	0,05	0,00
Ib (unknown)	%	0.00	0,28	0,00	0,00	0,05	0,00
B_{EZ}	%	0.00	0,33	0,00	0,02	0,02	0,00
Reproducibility	%		3,05	1,15	18,17	15,6	22,15
$-(\Delta m_1+\Delta m_2)/2$ standard	%		0				
$-(\Delta m_1+\Delta m_2)/2$ sample	%		0,47				
$-(\Delta m_1-\Delta m_2)/2$ sample	%		95,85				
Ia	%		0,04				
Susceptibility of transfer standard	%	0.00	0,01	0,05	0,00	1,11	
Combined uncertainty u_0M_z	%	100	100	100	100	100	100
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	100	100

Table B5.3
Percentage uncertainty contributions for magnetic polarization, reported by the NMIs for 1 kg cylindrical weight

INFLUENCE MAGNITUDE *Xi*	1 kg	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	%	0,00	0,21	0,02	0,50	3,20	0,20
Zo	%		0,00	0,00		0,00	90,79
$\Delta m_{1\ (unknown)}$	%	13.32	0,00	45,91	21,97	5,45	2,85
$\Delta m_{2\ (unknown)}$	%	86.66	0,00	37,30	25,04	9,25	1,24
$\Delta m_{1\ (Alacrite)}$	%				0,22		
$\Delta m_{2\ (Alacrite)}$	%				0,22		
g	%			0,00	0,00	0,77	0,00
Ib (unknown)	%	0.00	0,61	0,00	0,00	0,77	0,00
B_{EZ}	%	0.02	64,88	2,02	34,46	0,89	0,08
Reproducibility	%		0,02	14,57	14,51	51,91	1,47
$-(\Delta m_1+\Delta m_2)/2$ standard	%		0,06				
$-(\Delta m_1+\Delta m_2)/2$ sample	%		0,20				
$-(\Delta m_1-\Delta m_2)/2$ sample	%		18,15				
Ia	%		3,24		0,00		
Susceptibility of transfer standard	%	0.00	12,63	0,19	3,07	33,19	
Combined uncertainty u_0M_z	%	100	100	100	100	105	97
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	105	97

Table B5.4

Percentage uncertainty contributions for magnetic polarization, reported by the NMIs for 1 kg weight with a lifting knob

INFLUENCE MAGNITUDE *Xi*	1 kg OIML	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	%	0.02	0,25	0,03	0,51	3,31	0,14
Zo	%		0,00	0,00		0,00	65,08
Δm_1 (unknown)	%	80.77	0,00	46,41	15,42	3,30	4,19
Δm_2 (unknown)	%	18.95	0,00	37,71	16,91	12,93	7,23
Δm_1 (Alacrite)	%				0,22		
Δm_2 (Alacrite)	%				0,22		
g	%		0,00	0,00	0,00	0,80	0,00
Ib (unknown)	%	0.01	0,04	0,00	0,00	0,80	0,00
B_{EZ}	%	0.26	71,56	1,99	34,87	0,99	0,08
Reproducibility	%		0,00	13,66	28,69	44,71	25,46
$-(\Delta m_1+\Delta m_2)/2$ standard	%		0,06				
$-(\Delta m_1+\Delta m_2)/2$ sample	%		0,13				
$-(\Delta m_1-\Delta m_2)/2$ sample	%		11,14				
Ia	%		3,14		0,00		
Susceptibility of transfer standard	%	0.00	13,68	0,19	3,15	35,59	
Combined uncertainty u_0M_z	%	100	100	100	100	102	102
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	102	102

Table B5.5
Percentage uncertainty contributions for magnetic polarization, reported by the NMIs for Steel Disc

INFLUENCE MAGNITUDE *Xi*	STEEL DISC	INDECOPI $u(u_0M_z)$	BIPM $u(u_0M_z)$	CESMEC $u(u_0M_z)$	INTI $u(u_0M_z)$	CENAM $u(u_0M_z)$	LATU $u(u_0M_z)$
m_d	%	0.95	0,23	1,30	0,00	5,45	0,20
Zo	%		0,00	0,01		0,00	60,21
Δm_1 (unknown)	%	61.42	0,00	18,33	0,50	15,73	35,12
Δm_2 (unknown)	%	37.62	0,00	78,67	2,30	29,22	3,77
Δm_1 (Alacrite)	%				0,00		
Δm_2 (Alacrite)	%				0,00		
g	%		0,00	0,00	0,00	1,31	0,00
Ib (unknown)	%	0.01	0,00	0,05	0,03	1,31	0,00
B_{EZ}	%	0.00	20,22	0,57	0,14	0,04	0,00
Reproducibility	%		39,86	1,00	96,72	45,89	1,35
$-(\Delta m_1+\Delta m_2)/2$ standard	%		2,41				
$-(\Delta m_1+\Delta m_2)/2$ sample	%		0,04				
$-(\Delta m_1-\Delta m_2)/2$ sample	%		1,21				
Ia	%		0,00		0,00		
Susceptibility of transfer standard	%	0.00	36,03	0,08	0,30	1,15	
Combined uncertainty u_0M_z	%	100	100	100	100	100	100
$\sum \frac{u_i^2(x_i)}{u_c^2}$		100	100	100	100	100	100

NOTES:

- INM and LACOMET didn't report the uncertainty contributions of magnetic susceptibility and magnetic polarization because they have calculated the final uncertainty by the Monte Carlo Method.

- INDECOPI, BIPM, CESMEC, CENAM and LATU reported the uncertainty contributions of magnetic susceptibility and magnetic polarization according to the GUM.

- INTI reported the uncertainty contributions of magnetic susceptibility and magnetic polarization with approximated figures. They also reported the uncertainty calculated by the Monte Carlo method. Finally they have considered for the final uncertainty to report the uncertainty calculated by the Monte Carlo method.

- Most of the laboratories considered the same influence magnitudes (uncertainty contributions) for the estimation of the uncertainty. This guarantees a greater homogeneity in the determination of the combined uncertainty.

B.6 The Covariance Matrices obtained for the magnetic polarization

Table 6.1

The Covariance Matrix obtained for 2 g cylindrical weight / (μT)^2

$1,68\times10^{-2}$	0	$9,62\times10^{-8}$	0	0	0	0	$-6,38\times10^{-9}$
0	$4,67\times10^{-3}$	0	0	0	0	0	0
$9,62\times10^{-8}$	0	$3,15\times10^{-3}$	0	0	0	0	$-8,32\times10^{-7}$
0	0	0	$1,26\times10^{-2}$	0	0	$2,07\times10^{-5}$	0
0	0	0	0	1,99x10-1	0	0	0
0	0	0	0	0	$6,82\times10^{-2}$	0	0
0	0	0	$2,07\times10^{-5}$	0	0	$2,31\times10^{-2}$	0
$-6,38\times10^{-9}$	0	$-8,32\times10^{-7}$	0	0	0	0	$4,21\times10^{-3}$

Table 6.2

The Covariance Matrix obtained for 2 g weight with a lifting knob/ (μT)^2

$1,17\times10^{-1}$	0	$-1,83\times10^{-8}$	0	0	0	0	$-1,16\times10^{-8}$
0	$3,14\times10^{-3}$	0	0	0	0	0	0
$-1,83\times10^{-8}$	0	$7,53\times10^{-3}$	0	0	0	0	$4,80\times10^{-7}$
0	0	0	$1,86\times10^{-2}$	0	0	$1,36\times10^{-5}$	0
0	0	0	0	$4,52\times10^{-1}$	0	0	0
0	0	0	0	0	$6,56\times10^{-2}$	0	0
0	0	0	$1,36\times10^{-5}$	0	0	$1,29\times10^{-2}$	0
$-1,16\times10^{-8}$	0	$4,80\times10^{-7}$	0	0	0	0	$5,50\times10^{-3}$

Table 6.3

The Covariance Matrix obtained for 1 kg cylindrical weight/ (μT)^2

$1,13\times10^{-4}$	0	$-3,36\times10^{-9}$	0	0	0	0	$-9,18\times10^{-10}$
0	$2,28\times10^{-5}$	0	0	0	0	0	0
$-3,36\times10^{-9}$	0	$3,95\times10^{-5}$	0	0	0	0	$4,12\times10^{-7}$
0	0	0	$1,15\times10^{-4}$	0	0	$3,02\times10^{-5}$	0
0	0	0	0	$3,40\times10^{-4}$	0	0	0
0	0	0	0	0	$3,52\times10^{-5}$	0	0
0	0	0	$3,02\times10^{-5}$	0	0	$2,00\times10^{-4}$	0
$-9,18\times10^{-10}$	0	$4,12\times10^{-7}$	0	0	0	0	$5,25\times10^{-5}$

Table 6.4

The Covariance Matrix obtained for 1 kg weight with a lifting knob/ (μT)^2

1,54x10^{-5}	0	-3,07x10^{-9}	0	0	0	0	-9,56x10^{-10}
0	1,42x10^{-5}	0	0	0	0	0	0
-3,07x10^{-9}	0	2,05x10^{-4}	0	0	0	0	3,92x10^{-7}
0	0	0	1,08x10^{-4}	0	0	2,86x10^{-5}	0
0	0	0	0	3,40x10^{-4}	0	0	0
0	0	0	0	0	4,43x10^{-5}	0	0
0	0	0	2,86x10^{-5}	0	0	1,78x10^{-4}	0
-9,56x10^{-10}	0	3,92x10^{-7}	0	0	0	0	5,90x10^{-5}

Table 6.5

The Covariance Matrix obtained for Stainless steel disc/ (μT)^2

5,38	0	3,47x10^{-6}	0	0	0	0	8,76x10^{-7}
0	2,51	0	0	0	0	0	0
3,47x10^{-6}	0	1,30	0	0	0	0	1,33x10^{-3}
0	0	0	2,20	0	0	4,39x10^{-2}	0
0	0	0	0	2,59	0	0	0
0	0	0	0	0	5,89	0	0
0	0	0	4,39x10^{-2}	0	0	4,41	0
8,76x10^{-7}	0	1,33x10^{-3}	0	0	0	0	4,41

ANNEX C

NORMALIZED DEVIATIONS BETWEEN PAIRS OF MEASUREMENTS OF THE NMI'S

C.1 MAGNETIC SUSCEPTIBILITY

Table C1.1
Normalized deviations in magnetic susceptibility between the NMI's for 2 g

2 g	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		-0,69	1,16	0,09	0,15	0,18	-0,75	0,15
INM	0,69		1,67	0,71	0,83	0,83	-0,02	0,77
LACOMET	-1,16	-1,67		-1,05	-1,02	-0,97	-1,87	-1,00
BIPM	-0,09	-0,71	1,05		0,06	0,09	-1,31	0,06
CESMEC	-0,15	-0,83	1,02	-0,06		0,03	-0,90	0,01
INTI	-0,18	-0,83	0,97	-0,09	-0,03		-0,92	-0,03
CENAM	0,75	0,02	1,87	1,31	0,90	0,92		0,88
LATU	-0,15	-0,77	1,00	-0,06	-0,01	0,03	-0,88	

Table C1.2
Normalized deviations in magnetic susceptibility between the NMI's for 2 g (OIML)

2 g (OIML)	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		-0,07	1,56	0,69	0,08	0,09	-0,61	0,02
INM	0,07		1,62	0,75	0,16	0,16	-0,53	0,09
LACOMET	-1,56	-1,62		-0,83	-1,53	-1,47	-2,13	-1,50
BIPM	-0,69	-0,75	0,83		-0,64	-0,61	-1,57	-0,64
CESMEC	-0,08	-0,16	1,53	0,64		0,01	-0,71	-0,06
INTI	-0,09	-0,16	1,47	0,61	-0,01		-0,69	-0,06
CENAM	0,61	0,53	2,13	1,57	0,71	0,69		0,61
LATU	-0,02	-0,09	1,50	0,64	0,06	0,06	-0,61	

Table C1.3
Normalized deviations in magnetic susceptibility between the NMI's for 1 kg

1 kg	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		1,36	0,92	1,19	1,17	1,10	0,24	0,88
INM	-1,36		-0,49	-0,16	-0,12	-0,26	-1,15	-0,69
LACOMET	-0,92	0,49		0,32	0,36	0,23	-0,66	-0,43
BIPM	-1,19	0,16	-0,32		0,04	-0,09	-1,87	-0,53
CESMEC	-1,17	0,12	-0,36	-0,04		-0,13	-1,01	-0,51
INTI	-1,10	0,26	-0,23	0,09	0,13		-0,89	-0,46
CENAM	-0,24	1,15	0,66	1,87	1,01	0,89		0,35
LATU	-0,88	0,69	0,43	0,53	0,51	0,46	-0,35	

Table C1.4
Normalized deviations in magnetic susceptibility between the NMI's for 1 kg (OIML)

1 kg (OIML)	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		1,18	1,19	0,91	1,40	0,93	0,27	1,76
INM	-1,18		-0,36	-0,40	0,35	-0,41	-1,14	0,30
LACOMET	-1,19	0,36		-0,03	0,71	-0,04	-0,77	0,67
BIPM	-0,91	0,40	0,03		0,75	-0,01	-1,39	0,71
CESMEC	-1,40	-0,35	-0,71	-0,75		-0,77	-1,49	-0,06
INTI	-0,93	0,41	0,04	0,01	0,77		-0,73	0,71
CENAM	-0,27	1,14	0,77	1,39	1,49	0,73		1,45
LATU	-1,76	-0,30	-0,67	-0,71	0,06	-0,71	-1,45	

Table C1.5
Normalized deviations in magnetic susceptibility between the NMI's for Steel Disc

Disc	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		0,69	2,12	-0,34	0,23	0,19	-0,87	0,33
INM	-0,69		1,48	-1,04	-0,43	-0,51	-1,58	-0,36
LACOMET	-2,12	-1,48		-2,38	-1,69	-1,96	-2,95	-1,86
BIPM	0,34	1,04	2,38		0,56	0,54	-0,86	0,67
CESMEC	-0,23	0,43	1,69	-0,56		-0,06	-1,08	0,08
INTI	-0,19	0,51	1,96	-0,54	0,06		-1,07	0,14
CENAM	0,87	1,58	2,95	0,86	1,08	1,07		1,20
LATU	-0,33	0,36	1,86	-0,67	-0,08	-0,14	-1,20	

C.2 MAGNETIC POLARIZATION

Table C2.1
Normalized deviations in magnetic polarization between the NMI's for 2 g

2 g	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		0,54	-2,83	-0,38	-0,06	-0,28	-0,55	0,71
INM	-0,54		-3,12	-0,91	-0,63	-0,83	-1,08	0,16
LACOMET	2,83	3,12		2,43	2,94	2,68	2,33	3,24
BIPM	0,38	0,91	-2,43		0,33	0,12	-0,16	1,07
CESMEC	0,06	0,63	-2,94	-0,33		-0,22	-0,50	0,80
INTI	0,28	0,83	-2,68	-0,12	0,22		-0,28	1,00
CENAM	0,55	1,08	-2,33	0,16	0,50	0,28		1,25
LATU	-0,71	-0,16	-3,24	-1,07	-0,80	-1,00	-1,25	

Table C2.2
Normalized deviations in magnetic polarization between the NMI's for 2 g (OIML)

2 g (OIML)	INDECOPI	INM	LACOMET	BIPM	CESMEC	INTI	CENAM	LATU
INDECOPI		1,26	-2,05	0,28	0,35	0,38	0,14	1,11
INM	-1,26		-2,92	-0,94	-0,94	-0,88	-1,04	-0,15
LACOMET	2,05	2,92		2,24	2,42	2,40	2,09	2,90
BIPM	-0,28	0,94	-2,24		0,07	0,10	-0,13	0,80
CESMEC	-0,35	0,94	-2,42	-0,07		0,03	-0,21	0,78
INTI	-0,38	0,88	-2,40	-0,10	-0,03		-0,24	0,73
CENAM	-0,14	1,04	-2,09	0,13	0,21	0,24		0,92
LATU	-1,11	0,15	-2,90	-0,80	-0,78	-0,73	-0,92	

ANNEX D

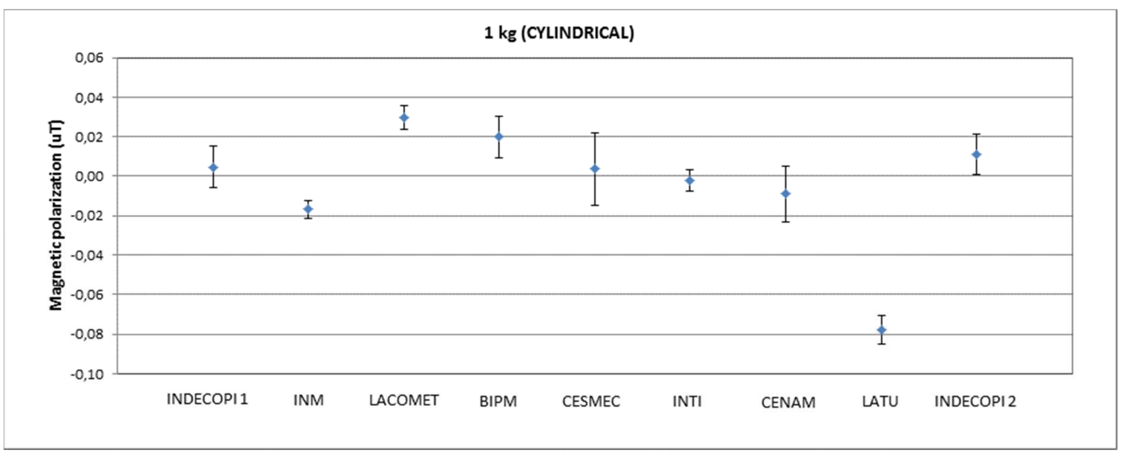
RESULTS OF MAGNETIC POLARIZATION FOR 1 kg, 1 kg (OIML) AND STEEL DISC

D.1 MAGNETIC POLARIZATION FOR 1 kg

Table E1.1
Results of magnetic polarization for 1 kg

NMIs	NOMINAL VALUE	M_i (uT)	$u(M_i)$ (uT)
INDECOPI 1	1 kg	0,0046	0,0105
INM		-0,0167	0,0044
LACOMET		0,0300	0,0060
BIPM		0,0199	0,0105
CESMEC		0,0036	0,0183
INTI		-0,0021	0,0056
CENAM		-0,0090	0,0140
LATU		-0,0779	0,0070
INDECOPI 2		0,0111	0,0105

Graph D1.1
Graph of magnetic polarization measurements for 1 kg

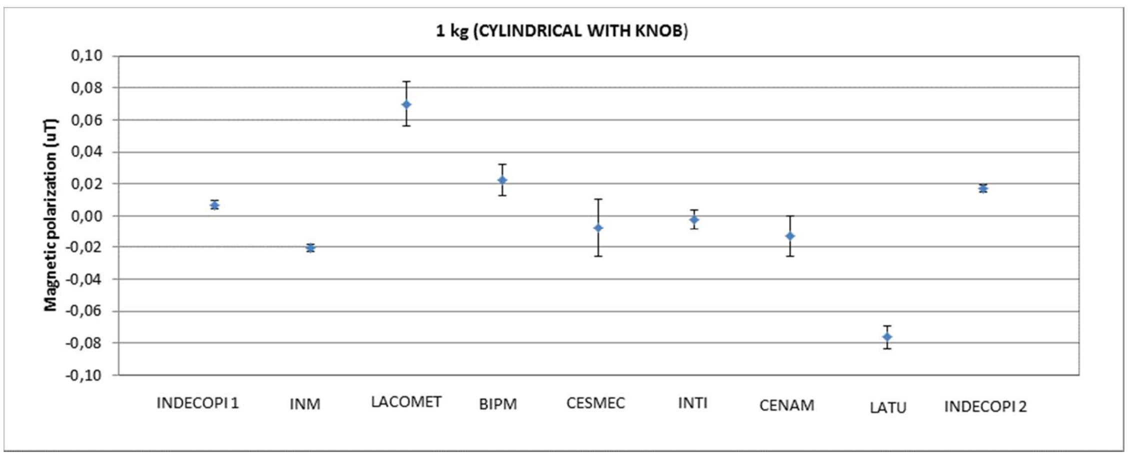


D.2 MAGNETIC POLARIZATION FOR 1 kg (OIML)

Table D2.1
Results of magnetic polarization for 1 kg (OIML)

NMIs	NOMINAL VALUE	M_i (uT)	$u(M_i)$ (uT)
INDECOPI 1	1 kg (OIML)	0,0068	0,0025
INM		-0,0203	0,0023
LACOMET		0,0700	0,0140
BIPM		0,0223	0,0100
CESMEC		-0,0077	0,0182
INTI		-0,0023	0,0059
CENAM		-0,0130	0,0130
LATU		-0,0762	0,0071
INDECOPI 2		0,0172	0,0025

Graph D2.1
Graph of magnetic polarization measurements for 1 kg (OIML)



D.3 MAGNETIC POLARIZATION FOR STEEL DISC

Table D3.1
Results of magnetic polarization for Steel Disc

NMIs	NOMINAL VALUE	M_i (uT)	$u(M_i)$ (uT)
INDECOPI	Steel Disc	-7,69	1,84
INM		-22,82	0,71
LACOMET		16,55	3,31
BIPM		-10,77	0,44
CESMEC		-15,60	0,76
INTI		-5,21	1,97
CENAM		-20,82	1,55
LATU		-8,47	1,55
INDECOPI 2		-2,79	1,84

Graph D3.1
Graph of magnetic polarization measurements for Steel Disc