Inter-American Metrology System (SIM)

Supplementary Comparison
Protocol for the determination of the susceptibility and magnetic polarization of weights by means of the susceptometer method.

2011-08-08

1. Background.

In October 2009, a workshop was carried out at the Peruvian National Institute for the Defense of Competition and Protection of Intellectual Property (INDECOPI), regarding the International Recommendation 111 [1] of the International Organization of Legal Metrology (OIML), so as to establish common criteria to interpret this document. Among other activities, there were experiments to determine the susceptibility and magnetic polarization of weights, overseen by Dr. Richard Davis, who at the time headed the Mass Department at the International Bureau of Weights and Measures (BIPM). He kindly accepted SIM's invitation.

It is necessary to establish these magnetic properties in order to confirm that the limits set forth in charts 3 and 4 [1] are being met, given a class of weights. Hence, we aim to assure that the measurement model for the calibration of weights described in the same reference is applicable, according to a given mass uncertainty value, as informed by the OIML class. Were this not the case, significant magnetic interactions could be occurring between weights and the magnetic fields generated within the scales, by virtue of the electric currents required for their functioning.

Considering the above, it can be concluded that the determination of the magnetic properties of weights is a relevant activity to ensure the Calibration and Measurement Capabilities of the laboratories performing calibration of mass standards. In other words, to ensure their technical competence given an uncertainty value reached while determining the mass.

Therefore, among its conclusions, the workshop recommended for SIM members to execute a comparison on the determination of magnetic properties of weights.

As an outcome of their participation in the 2009 workshop, a number of laboratories developed a capacity to perform this type of measurements.

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 measurements 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. This protocol reflects the conclusions drawn from the workshop.

Additionally, SIM MWG7 members know that the EURAMET region is engaging in another exercise to compare the magnetic properties of weights, with the participation of regional national metrology institutes as well as the BIPM. On this account, we invited the BIPM to participate in the SIM comparison, so that results of both investigations could eventually be linked.

2. Objective.

Given the importance of keeping the susceptibility and magnetic polarization values under control, in order to guarantee the uncertainty in the calibration of weights, this comparative study was drafted to evaluate the ability of national metrology institutes belonging to SIM to perform measurements of the magnetic properties of weights. Particularly, the magnetic susceptibility and magnetic polarization of weights using the susceptometer method [7].

3. Organization.

The pilot laboratory will request the Inter-American Metrology System to record this comparison in the International Comparison Database, as well as to send a supplementary comparison to the Key Comparison Database.

Below, the Table 1 shows the institutes that are participating in this comparison; included are the names of the technical contact persons and, particularly the addresses where objects to be used in the exercise can be sent.

Table 1: Contact information of participating institutes.

1	**Name of Institute**	**Centro Nacional de Metrología (CENAM) / Mexico.**
	Names of staff involved	Luis Omar Becerra, Luis Manuel Peña
	Postal address	Km. 4,5 carretera a los Cués, Mpio El Marqués, Qro. Mexico, C.P. 76241
	Telephone number	+52 442 2 11 05 00 al 04 ext 3602 +52 442 2 11 05 68
	E-mail	lbecerra@cenam.mx, lpena@cenam.mx
2	**Name of Institute**	**Laboratorio Costarricense de Metrologia (LACOMET) / Costa Rica**
	Names of staff involved	Olman Ramos, Sandra Rodríguez
	Postal address	500 m N, 50 m O del Supermercado Muñoz & Nanne, Ciudad de la Investigación, Universidad de Costa Rica, San Pedro de Montes de Oca, Costa Rica
	Telephone number	Tel: 506 2283 65 80 ext 111-112,
	E-mail	oramos@lacomet.go.cr srodriguez@lacomet.go.cr
3	**Name of Institute**	**Centro Nacional de Metrología de Panamá (CENAMEP)/Panamá**
	Names of staff involved	Julio Dimas
	Postal address	Ciudad del Saber, Edificio 215, Panamá
	Telephone number	507 517 3122
	E-mail	jdimas@cenamep.org.pa
4	**Name of Institute**	**Superintendencia de Industria y Comercio (SIC)/Colombia**
	Names of staff involved	Álvaro Bermúdez
	Postal address	Avenida Carrera 50 No. 26-55 Interior 2, CAN Bogotá D.C., Colombia
	Telephone number	(571) 5880235 - 5880234
	E-mail	abermudez@correo.sic.gov.co; **labmasa@sic.gov.co**

5	**Name of Institute**	**Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual (Indecopi) / Perú**
	Names of staff involved	Aldo Quiroga, Luz Marina Cori
	Postal address	Calle de la Prosa 104, San Borja. Lima.
	Telephone number	51 12247800
	E-mail	aquiroga@indecopi.gob.pe; maryna1cc@gmail.com
6	**Name of Institute**	**Centro de Estudios, Medición y Certificación de Calidad S.A. (CESMEC) / Chile**
	Names of staff involved	Francisco García / Fernando Leyton / Raúl Hernández
	Postal address	Av. Marathon 2595, 781-0552 Macul, Santiago, Chile
	Telephone number	56-2-3502185
	E-mail	fgarcia@cesmec.cl; fleyton@cesmec.cl; rhernandez@cesmec.cl
7	**Name of Institute**	**Laboratorio Tecnológico del Uruguay (LATU) / Uruguay**
	Names of staff involved	Joselaine Cáceres
	Postal address	Avenida Italia 6201, Montevideo, Uruguay
	Telephone number	598 2 601 27 30
	E-mail	jcaceres@latu.org.uy;shoize@gmail.com
8	**Name of Institute**	**Instituto Nacional de Tecnología Industrial INTI / (Argentina)**
	Names of staff involved	Fernando Kornblit
	Postal address	Avenida General Paz 5445 entre Albarellos y Constituyentes, B1650WAB, Buenos Aires Province, Argentina
	Telephone number	54 11 4752 5402
	E-mail	ferk@inti.gob.ar; leiblich@inti.gob.ar

Participants have designated INDECOPI as the pilot laboratory for this comparison, which will have to coordinate related activities, gather results and draft the final report.

Additionally, Table 2 shows the schedule of deliveries of objects used in the comparison and due dates for results.

Results that are not received before the deadline will be discarded.

Table 2: Schedule of deliveries of objects used in the comparison and due dates for results to be submitted to the pilot laboratory.

Institute	Date of delivery to the next institute	Due date for delivery of results to INDECOPI
INDECOPI	August 15, 2011	
SIC	September 15, 2011	September 29, 2011
LACOMET	October 15, 2011	October 30, 2011
CENAM	November 15, 2011	November 30, 2011
CESMEC	January 15, 2012	December 30, 2011
CENAMEP	February 15, 2012	March 1, 2012
LATU	March 15, 2012	March 31, 2012
INTI	April 15, 2012	May 1, 2012
BIPM	May 15, 2012	May 31, 2012
INDECOPI	Finishes the measurement process on June 30	

Deliveries will be done via courier and each institute will be responsible for the delivery to the next stage. Weights are the property of SIM and participating institutes are accountable for their replacement, each institute must subscribe an insurance against loss. Once the participating institute receives the weights and stainless steel cylinder, it must complete the forms included in Appendix 1, and send them to the pilot laboratory within five consecutive days.

By accepting this protocol, all participants agree to abide by the guidelines set forth in [2], with regard to matters falling within their respective spheres of competence.

4. Objects

The objects to be used in this comparison should be handled with gloves or tweezers and should not be exposed to processes which could affect their magnetic properties, particularly demagnetization, mechanical surface treatments or washing.

The comparison objects will be two 1 kg and two 2 g weights plus a stainless steel disc. These weights do not have an OIML grip handle and are stored in individual plastic cases.

INDECOPI measured the geometric properties of the weights to be used by all participants. They are specified in Table 3, with reference to Diagram 1.

Diagram 2 includes photographs of the weights and the stainless steel cylinder.

Table 3. Distances measured in the weights

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

The values showcased in Table 3 after the symbol "±" correspond to the expanded uncertainty (k=2). These were determined using a mechanical dial gauges with standard gauges blocks and a vernier calipers.

Diagram 1. Dimension characteristics measured in objects to be used, as specified in Table 3.

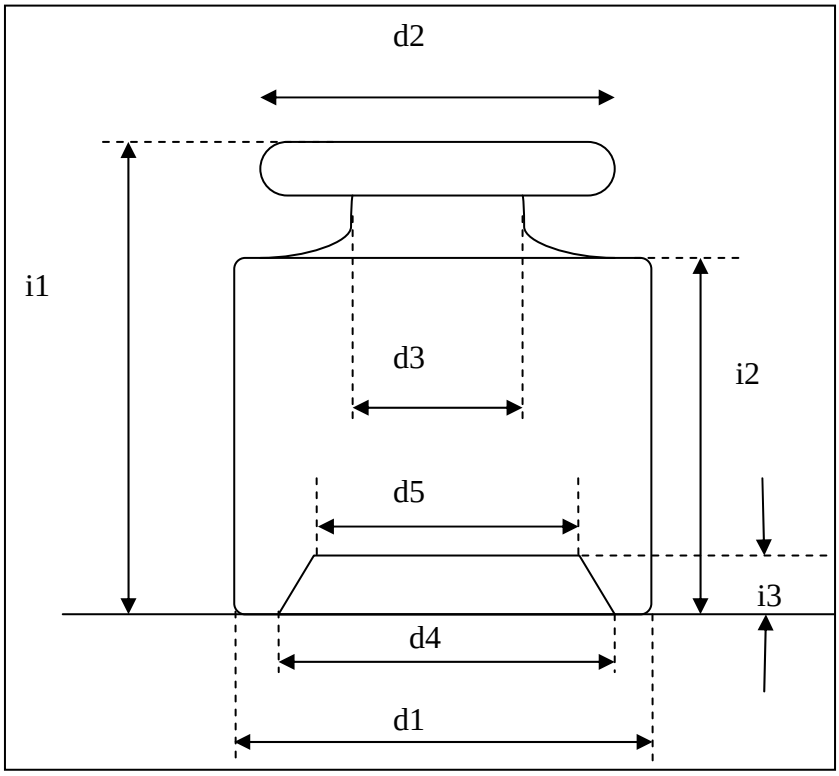


Diagram 2. Photograph of weights and steel cylinder.

5. Methodology

Laboratories will perform their measurements according to the method B.6.4 [1], "Magnetic susceptibility and permanent magnetization, the susceptometer method".

It is prohibited to use other measurement methods. We also reiterate the prohibition to carry out any process that could potentially interfere with the magnetization of the weights. The intense magnitude of the magnetic field at the base of the weights should not go beyond 800 A/m.

Properties to be measured are magnetic susceptibility and magnetic polarization.

During the measurement process, the weights will be placed on their base, which is defined as the i3-height concavity side, as indicated in Diagram 1. As for the cylinder, it must be positioned so that its marking appears on the upper part. As for non-cylindrical weights, they will require the superposition method described in [3].

Each laboratory will use the information provided by the US National Oceanic and Atmospheric Administration in its Web site [4], to establish the Earth's magnetic induction value, allowing for an expanded uncertainty of 10% from the reported value. If measured values are readily available, the laboratory can use them.

Each laboratory will use the information available to it (for example, a measurement report), to determine the gravity acceleration value. If the data is not readily available, the value to be used is that provided by the Physikalisch Technische Bundesantalt in its web page [5].

To determine the distance between the center of the magnet and the upper edge of the table on which the weight stands, Z0, each laboratory will use the available method, according to its own procedures.

The evaluation of uncertainty will be established in accordance to GUM [6,8,9].

6. Submitting results

Participants must submit their results as indicated in the schedule shown in Table 2; results that are not received within their deadline, will be discarded. The pilot laboratory will send an acknowledgment upon receiving the information.

Results must be emailed to the pilot laboratory, using the integrated Excel file included as Appendix 2. This chart also specifies the variables whose contribution to uncertainty should be evaluated as a minimum standard. Participants may add more variables if they

consider it necessary, but they should record it in the penultimate line of each table. This is to say, after the "Reproducibility" line and before the end result line.

Given that they are following the [2] guidelines for a SIM supplementary comparison, laboratories must not share results among themselves or ask for the submitted results to be modified.

7. Reports

After all measurements are taken and in compliance with [2], the pilot laboratory will issue the first report draft, called Draft A which will be sent to all participants for them to confirm that results were transcribed correctly. This report cannot link results to specific participants and will be reserved. In other words, only laboratories taking part in the comparison will be allowed to review it. Each laboratory will have 15 consecutive days to report their acceptance or, otherwise, justified rejection.

Once Draft A has been approved, the pilot laboratory will issue a Draft B within the next 20 consecutive days, which will include the names of all participants, correlating them to their specific results. Likewise, the report will feature the equivalence degree and levels of coherence in the measurements registered in each laboratory. The possibility to establish a reference value remains open.

Each laboratory will have 15 consecutive days to report their acceptance or justified rejection of Draft B, together with their suggestions to improve the document; these will be included in the final report. Also, this is the stage in which participating labs should ask the pilot laboratory to publish the final report in a congress or directly in the KCDB.

Upon approval of Draft B, the pilot laboratory will issue the final report within the next 15 consecutive days, and will submit it to the Chair of SIM MWG7 for its approval. Once approved, it can be sent to a congress and then for publication in the KCDB, or directly to the KCDB through the Chair.

The pilot laboratory will align the answers to the observations of arbitrators, if eventually the report is sent to a congress.

8. Bibliographic References

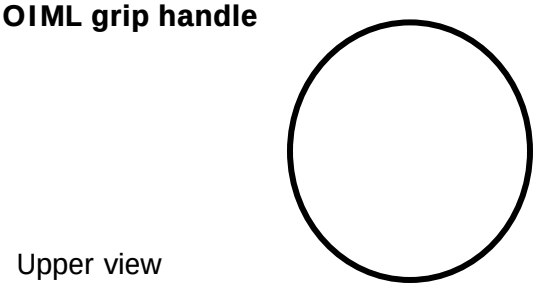
1. OIML R 111-1 Edition 2004 (E) Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3 Part 1: Metrological and technical requirements. International Organization of Legal Metrology.
2. CIPM MRA-D-05. Measurement comparisons in the CIPM MRA. http://www.bipm.org/utils/common/CIPM_MRA/CIPM_MRA-D-05.pdf

3. Davis, R. S., “Determining the magnetic properties of 1 kg mass standards” J. Res. National Institute of Standards and Technology (USA), 100, 209-25, May-June 1995; Errata, 109, 303, March-April 2004
4. National Geophysical Data Center. National Oceanic and Atmospheric Administration. USA. http://www.ngdc.noaa.gov/geomagmodels/IGRFWMM.jsp
5. Gravity Information System. Physikalisch-Technische Bundesanstalt. Alemania. http://www.ptb.de/cartoweb3/SISproject.php
6. JCGM 100:2008. Evaluation of measurement data – Guide to the expression of uncertainty in measurement. http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf
7. RS Davis New method to measure magnetic susceptibility, Meas. Sci. Technol. 4 (1993) 141-147.
8. JCGM 101:2008. Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method
9. J. W. Chung, K. S. Ryu and R. S. Davis, “Uncertainty analysis of the BIPM Suceptometer” Metrologia, 2001, 38, pp. 533-541.

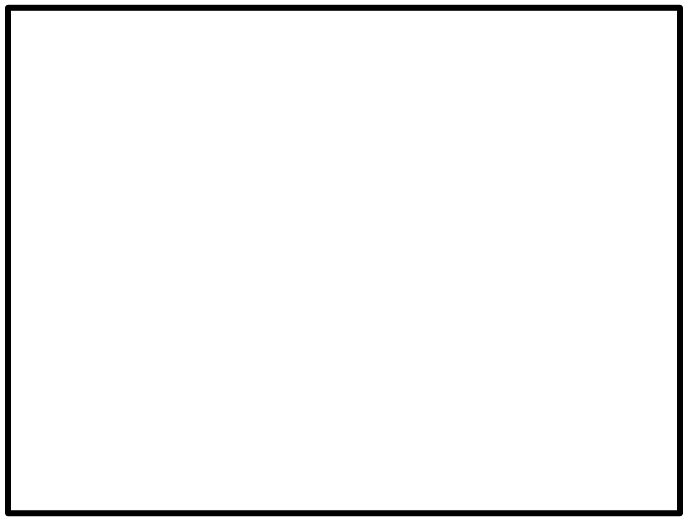
APPENDIX 1
Reception Record

Laboratory:		**Date:**	

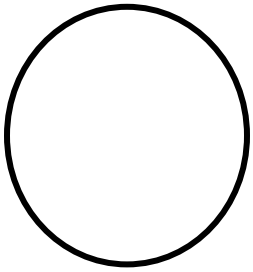
2 g weight without OIML grip handle



Upper view

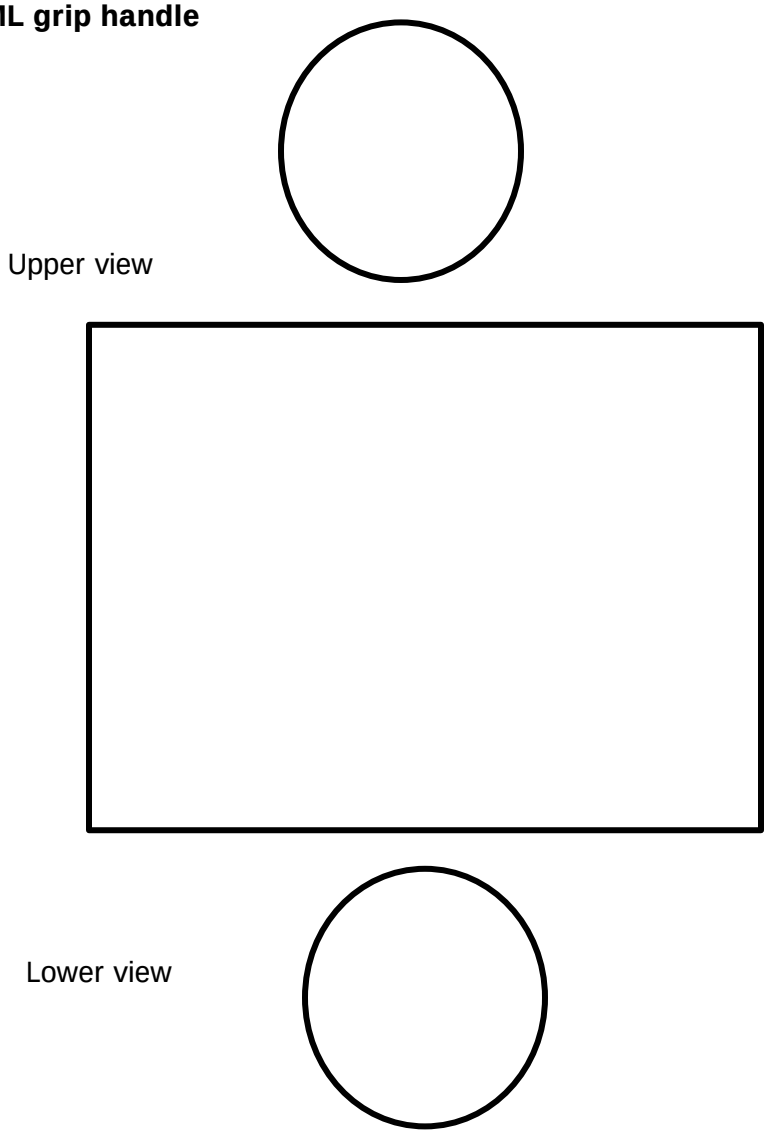


Lower view



Laboratory:		**Date:**	

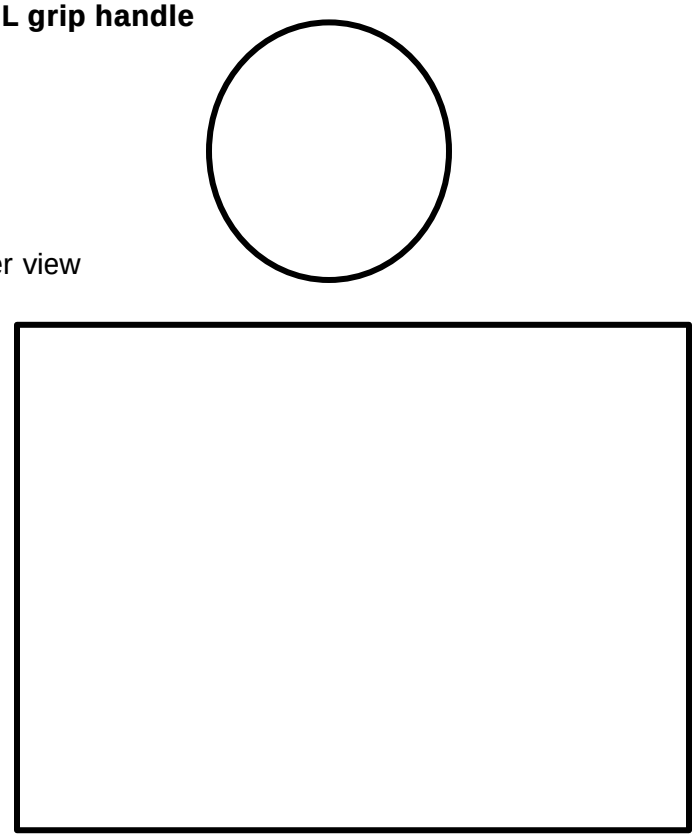
2 g weight with OIML grip handle



Laboratory:		**Date:**	

1 kg weight without OIML grip handle

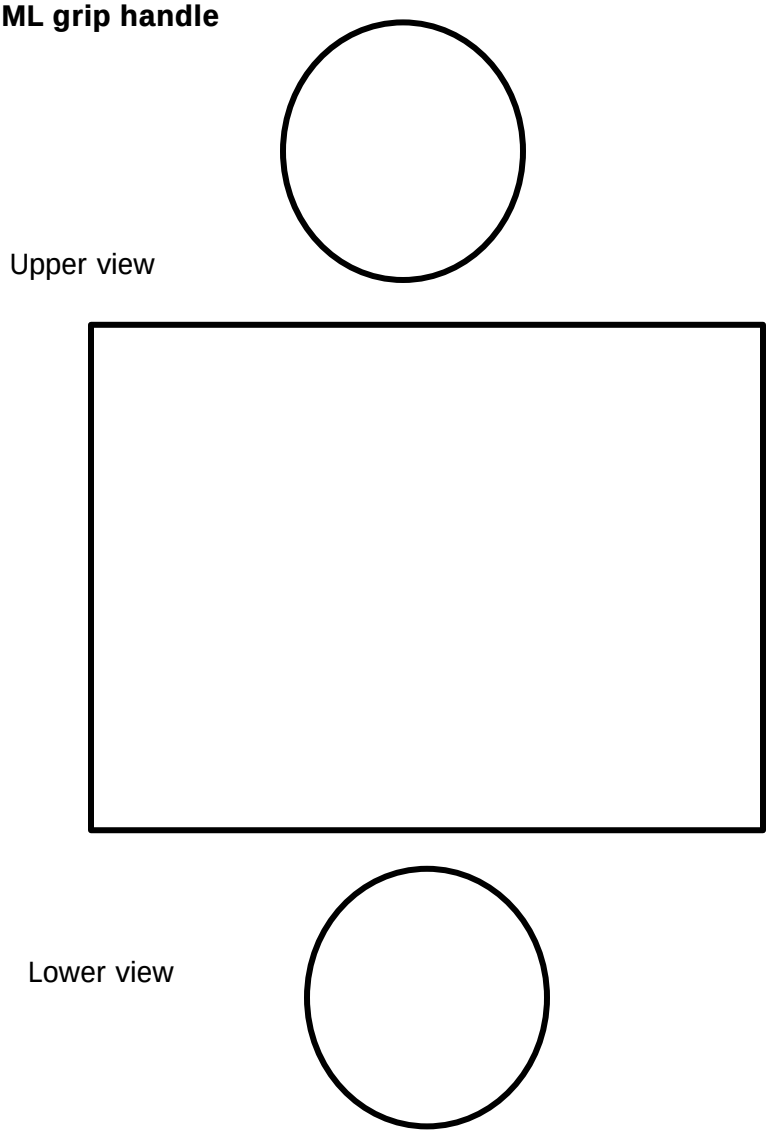
Upper view



Lower view

Laboratory:		**Date:**	

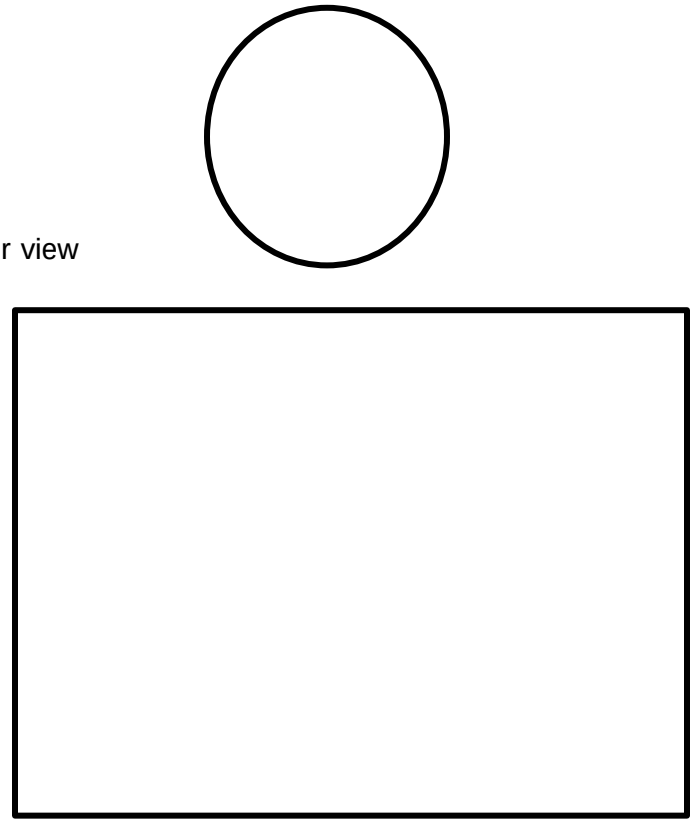
1 kg weight with OIML grip handle



Laboratory:		**Date:**	

Stainless steel cylinder

Upper view



Lower view

APPENDIX 2

Results Report

Annex2.xls