PROTOCOL FOR THE SIM MASS COMPARISON ON 50 kg STAINLESS STEEL STANDARD
SIM.M.M-K6?
piloted by CENAM-MEXICO

1. OUTLINE

This inter-laboratory comparison was agreed within the SIM Working Group of Mass and Related Quantities, SIM MWG7.

For this key comparison the CENAM-Mexico agreed to act as pilot laboratory.

The aims of this key comparison are to compare the results obtained by participating laboratories in calibration of 50 kg stainless steel weight and to link the results of this comparison to the CCM key comparison CCM.M-K6.

For this mass comparison, CENAM will provide a 50 kg weight to be use as travelling standard.

2. PURPOSE OF THIS DOCUMENT

The purposes of this document are:

- to define the organization of the comparison
- to provide instructions for the participants for the transport and handling of the transfer standards and
- to explain the way for reporting results.

3. PARTICIPANTS

Six National Metrology Institutes and one designated Institute will take part to this SIM comparison. The participating laboratories are listed in table 1.

Table 1. Participant laboratories of the comparison

National Institute of Metrology	Acronym	Technical Contact
Centro Nacional de Metrología km. 4,5 Carretera a los Cués, Mpio. El Marqués, C.P. 76246 Querétaro, MEXICO	**CENAM**	Luis Manuel Peña Luis Omar Becerra Luis Manuel Ramírez lpena@cenam.mx lbecerra@cenam.mx Tel: +52 442 2 11 05 00 to 04

REFINERÍA COSTARRICENSE DE PETRÓLEO[1] San Nicolás , Cartago, Costa Rica	**RECOPE**	Gilberto Arce Esteban Castillo Gilberto.Arce@recope.go.cr Esteban.Castillo@recope.go.cr Tel: (506) 25503717
LABORATORIO COSTARRICENSE DE METROLOGÍA Ciudad de la Investigación, UCR, San Pedro de Montes de Oca, San José, Costa Rica	**LACOMET**	Olman Ramos Alfaro Marcela Prendas Peña oramos@lacomet.go.cr mprendas@lacomet.go.cr Tel:(506) 2283-6580, ext. 111
INSTITUTO NACIONAL DE TECNOLOGÍA INDUSTRIAL Parque Tecnológico Miguelete, C.C. 157 - (1650) San Martin - Buenos Aires, Argentina	**INTI**	Jorge Sánchez sanchezj@inti.gob.ar Tel: (54 11) 4724 6200/300/400 Interno 6437
SERVICIO ECUATORIANO DE NORMALIZACIÓN Autopista General Rumiñahui, puente peatonal No. 5, Sector Conocoto - Quito, Ecuador	**INEN**	Wilson Naula Mary Amores wnaula@normalizacion.gob.ec mamores@normalizacion.gob.ec Tel: (593) 2 2343 716 ext 231
INSTITUTO NACIONAL DE METROLOGÍA DE COLOMBIA Av. Cra 50 No 26-55 Int. 2 CAN Bogotá, D.C., Colombia	**INM**	Jhon Escobar Soto Jorge García Benavides jjescobar@inm.gov.co jgarcia@inm.gov.co Tel: 57 1 2542222 Ext 1615 - 1628
LABORATORIO TECNOLÓGICO DEL URUGUAY Av. Italia 6201 C.P: 11.500 Montevideo - Uruguay	**LATU**	Sheila Preste spreste@latu.org.uy Tel: (598) 2601 3724

[1] RECOPE is the designated institute for Costa Rica within the range of 50 kg to 1 000 kg.

4. TRAVELLING STANDARDS

The travelling standard for this comparison is a 50 kg weight, made in one piece of stainless steel, cylindrical shaped (Fig. 1).

Fig.1. Travelling standard

4.1 Characterization of the travelling standards

Values of volume and density of the weight were measured at CENAM before its circulation.

The data of the travelling standard are listed in table 2.

Table 2. Data of the travelling standard

Identification	LPM.00.10
Nominal Value	50 kg
Density at 20 ºC *	8 009.48 kg m^{-3}
Standard uncertainty	0.64 kg m^{-3}
Volume at 20 ºC *	6 242.6 cm^3
Standard uncertainty	0.5 cm^3
Magnetic susceptibility (□)	< 0.02
Magnetization	< 2.5 µT
Height	289 mm
Diameter	183 mm
Height of centre of gravity above base	162.6 mm

* Values measured by Pilot laboratory.

At the beginning and at the end of the circulation, the mass of the travelling standard will be measured by the pilot laboratory.

5. TRANSPORTATION OF THE TRAVELLING STANDARD

For this comparison a 50 kg weight will be circulated between participants. The circulation will be done in one petal according to table 3.

CENAM will measure the mass of the travelling standard at the beginning and at the end of the circulation in order to evaluate their possible drift.

Table 3. Petal 1, timetable for the circulation of the standard

NMI	Date of Arrival	Date of departure	Sending of results
CENAM		2015-11-16	
RECOPE	2015-11-23	2015-12-14	2016-01-10
LACOMET	2015-12-21	2016-01-25	2016-02-22
INTI	2016-02-01	2016-02-22	2016-03-28
LATU	2016-02-29	2016-03-28	2016-04-25
INM	2016-04-04	2016-04-25	2016-05-23
INEN	2016-05-02	2016-05-23	2016-06-20
CENAM	2016-05-30		

Table 3 gives the dates of arrival and departure of the travelling standards and the date for sending results.

The circulation of the weight will be done by a Courier Company. With the exception of the first participant[2], each participant will take care of the transportation of the travelling standard to the next participating laboratory according to the timetable of table 3. When the package arrives or leaves the country, the appropriate forms should be filled in very carefully under the auspices of the two laboratories concerned.

[2] At the scheduled time RECOPE will pick up the travelling standard at CENAM facilities before its measurements. RECOPE will make his measurements and will contact LACOMET technical contact to inform that the package is ready for been carry to LACOMET.

LACOMET will pick up the travelling standard at RECOPE facilities before its measurements. After finishing its measurements, LACOMET will return the package with the travelling standard to RECOPE facilities.

RECOPE will send the package with the travelling standard to the next participant (INTI), according to the timetable for the circulation of the travelling standard.

6. TIMETABLE OF THE COMPARISON

Table 4. Participant laboratories of the comparison

Activity	**Date**
Protocol agreed	October 2015
Measurements at the pilot laboratory	October 2015
Circulation and measurements by participants	November 2015 to May 2016
Return to pilot laboratory and control measurements	May 2016
Reception of the last measurements results reported by participants	June 2016
Analysis of results reported by participants	July ï September 2016
Elaboration of Draft A	October ï December 2016
Circulation of Draft A for comments/corrections	January ï May 2017
Elaboration of Draft B	June 2017
Circulation of Draft B for comments/corrections	July ï September 2017
Final report	October 2017

7. RECEIPT OF THE TRAVELLING STANDARD

7.1 Receipt the package

Upon receipt of the package, the laboratory should send by fax or e-mail to the pilot and dispatching laboratories a filled ñArrival of the travelling standardò and ñList of content at arrivalò forms given in appendix A.

7.2 Opening the package

At the arrival of the standard, the weights should be unpacked according to the following steps:

1. Move the package into the mass laboratory
2. Open the two padlocks and the six throw latches of the plastic box,
3. Remove the inner container (aluminum mass standard case) from the outer container. In order to remove the mass standard container, lift it using lifting means.
4. Gently put the mass standard container in a carriage avoiding any shock.
5. Take the mass standard handling fork and the set of tools out of the outer container
6. Open the manual valve by unscrewing its cover.
7. Remove the eight socket head cap screws with the fitted spanner of the set of tools.
8. Lift very carefully the cover of the case using lifting means.
9. Lift very carefully the mass standard from the case using the handling fork.
10. Fill the ñTravelling standard visual inspection formò given in appendix C of this protocol.
11. Close again the mass standard case with its cover and its screws.

Note: Additional information concerning the package, (photos, dimensions and total weight), as well as the combination of the padlocks will be sent soon.

7.3 Visual inspection

The travelling standard shall be examined on receipt, and any scratches or other marks shall be recorded in the ñtravelling standard visual inspection formò given in appendix C. This form should be sent by fax or e-mail to the pilot laboratory within 24 hours after the inspection.

8. MEASUREMENTS

The standards should be manipulated with pincers or other appropriate tools. They should never be touched with bare hands. When not in the balance, the standards should be stored at such a place where they are protected from dust, aerosols and vapor, for example on a plate covered with a clean bell jar.

Measurements should be done after an appropriate acclimatization time and according to own weighing procedure and results should be reported on the forms annexed (Annex D and F).

Before mass determination, dust particles should be removed from the surface of the standard by a soft brush.

The participating laboratories shall determine the mass of the travelling standard. For the buoyancy correction, the air density should be determined using the CIPM 2007 formula.

9. REPORTING RESULTS

The forms of Annexes D, E and F (calibration results, Environmental data during calibration, characteristics of the balance and instruments used for the calibration, traceability and uncertainty budget) should be copied, filled in and returned to the pilot laboratory within one month after the measurements.

10. DISPATCH OF THE TRAVELLING STANDARD

After completion of the measurements the participant laboratory should pack the travelling standard and send it to the next laboratory according to timetable of table 3.

Within 24 hours after dispatch, the dispatching laboratory should fill and send to the pilot laboratory the ñDeparture of the travelling standardò and ñList of content as departureò forms given in appendix A.

11. ANNEXES

- Annex A. List of content of package
  - A.1. Arrival of the travelling standard
  - A.2. List of content as arrival
  - A.3. Departure of the travelling standard
  - A.4. List of content as departure

- Annex B. Transportation form (arrival), contact in the laboratory
  - B1. Conditions of the weights at arrival

- Annex C. Travelling standard visual inspection form

- Annex D. Calibration results, environmental data during calibration
  - D.1. Calibration results
  - D.2. Environmental data during calibration
  - D.3. Characteristics of the balance used for the measurements and instruments for measurement the environmental conditions
  - D.4. Characteristics of the equipment for the measurement of the environmental conditions (for the air density evaluation)

- Annex E. Traceability

- Annex F. Uncertainty budget

ANNEX A. LIST OF CONTENT OF PACKAGE

Laboratory:		Date:	
Filled by:			

Fill the form and send it to the pilot laboratory and to the previous lab within 24 hours from package receipt.

A.1. Arrival of the travelling standard

Delivery by (Courier Company):	
Arrival date:	

A.2. List of content as arrival

	YES	NO
Outer container (plastic box)		
Was the outer container in good conditions?		
Was the container locked with the two padlocks?		
Mass standard handling fork		
Was the handling fork in the plastic bag?		
Mass standard aluminum case		
Was the mass standard aluminum case in good conditions?		
Mass standard		
Two spanners for the socket head cap screws (M8 x 1.25)		

ANNEX A. LIST OF CONTENT OF PACKAGE

Laboratory:		Date:	
Filled by:			

A.3. Departure of the travelling standard

Delivery by (Courier Company):	
Departure date:	

A.4. List of content as departure

	YES	NO
Outer container (plastic box)		
Was the outer container in good conditions?		
Was the container locked with the two padlocks?		
Mass standard handling fork		
Was the handling fork in the plastic bag?		
Mass standard aluminum case		
Was the mass standard aluminum case in good conditions?		
Mass standard		
Two spanners for the socket head cap screws (M8 x 1.25)		

ANNEX B. TRANSPORTATION FORM (ARRIVAL), CONTACT IN THE LABORATORY

Laboratory:		Date:	
Filled by:			

Fill the format and send it the pilot laboratory and to the previous lab within 24 hours from package receipt.

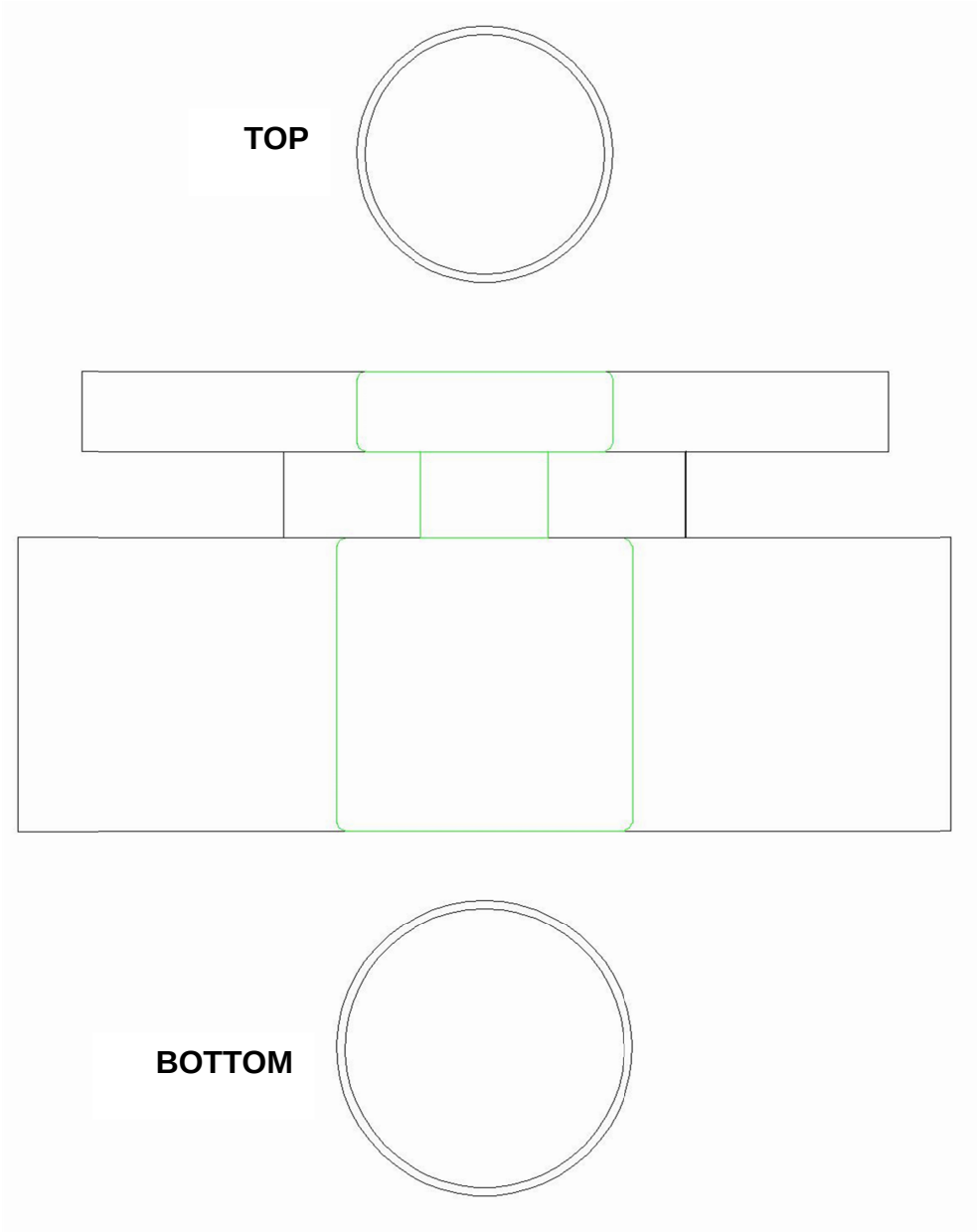
B1. Conditions of the weights at arrival

Package and mass standard case:	
Surface conditions:	
Observations:	

ANNEX C. TRAVELLING STANDARD VISUAL INSPECTION FORM

Laboratory:		Date:	
Filled by:			

Record on the diagrams any mark seen on the travelling standard (scratches, contamination, etcé), and send it the pilot laboratory.



ANNEX D. CALIBRATION RESULTS, ENVIRONMENTAL DATA DURING CALIBRATION

Laboratory:		Date:	
Filled by:			

D.1. Calibration Results

Nominal Value	Mass, □	Standard uncertainty, □□	Number of measurements	Number of effective degrees of freedom, □□□□
50 kg	50 kg + mg	mg		

D.2. Environmental data during calibration

Insert the maximum, minimum and average values of the measured quantities.

Parameter	Minimum	Maximum	Average
Air density (kg/m^3)			
Temperature (ºC)			
Pressure (kPa)			
Dew point (ºC) or Relative Humidity (%)			
CO_2 (x10^{-6})			

D.3. Characteristics of the balance used for the measurements and Instruments for measurement the environmental conditions

Manufacturer	Type	Range	Resolution	Standard deviation*

* Please indicate the weighing procedure and number of measurements

D.4. Characteristics of the equipment for the measurement of the environmental conditions (for the air density evaluation)

	Manufacturer	Type	Range	Resolution	Standard uncertainty u
Temperature t /ºC					
Barometric pressure p /Pa					
Relative humidity h_r, %					
Mole fraction of CO_2 (if appropriate)					

ANNEX E. TRACEABILITY

Laboratory:		Date:	
Filled by:			

Insert the standards including additional weights used for the calibration and its traceability to the international prototype of the kilogram.

Identification	Mass	Uncertainty	Volume	Uncertainty	Date of Calibration

Add lines as necessary.

ANNEX F. UNCERTAINTY BUDGET

Laboratory:		Date:	
Filled by:			

The uncertainty should be evaluated and combined following the GUM (JCGM 100:2008, Evaluation of measurement data ð Guide to the expression of uncertainty in measurement).

Parameter	Standard uncertainty of component (*) *u* / mg
Mass (correction) of the standard	
Stability of mass standard	
Compensation weight	
Stability of compensation weight	
Weighing reproducibility	
Position effect (automatic loading comparator)	
Comparator resolution	
Air density	
Travelling standard density	
Mass standard density	
Otheré	

(*) Units expressed in mg. Is the result of the uncertainty component u_i, multiplied by the sensitivity coefficient c_i.

Add lines as necessary.