



## COMPARISON ON LIQUID DENSITY MEASUREMENTS BETWEEN SIM NMIs – SIM.M.D-S7

### Technical Protocol

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**Coordinating institutes:** LATU – Uruguay and CENAM – Mexico.

### 1. Outline

The aim of this comparison is to compare measurement results on liquid density at 20°C and at atmospheric pressure among National Metrology Institutes (NMIs) belonging to the Inter-American Metrology System (SIM, by its acronym in Spanish).

Liquid density is an important quantity for quality control of products, which is highly correlated with specific gravity, alcoholic strength, sugar concentration, of a liquid, by other side, density meters usually are calibrated using liquid densities as reference e. g. by oscillation type density meters among others; that is why for National Metrology Institutes it is very important to support their measurement capabilities on liquid density.

For this comparison, CENAM will prepare four batches of a liquid (polyalphaolefin) which will be measured, divided, and sent to participant laboratories according to their needs (requirements of their hydrostatic weighing systems).

The sample liquid will be packaged in 1-litre bottles for sending to participant laboratories and the packed liquid will be sent by private courier.

Participant institutes will receive the liquid sample and they will measure it in their own facilities, hydrostatic weighing system, and measurement procedures.

For this comparison LATU - Uruguay will act as the pilot laboratory and CENAM - México will help to prepare the liquid samples, making the pivot measurements of the liquids as well as the packing and sending the liquid samples to participant laboratories.

## 2. Purpose of this document

The purpose of this document is to provide the participating laboratories with instructions for handling the sample liquids and to report on the measurement results.

It is important that all instructions given in this document are followed. This will ensure that the measurement data are obtained under comparable conditions and presented in the same format. Any deviation from the instructions must be reported to the Coordinating Institutes.

## 3. Participant Laboratories

In April and May of 2021, a density questionnaire was circulated among SIM NMIs. An important output of this questionnaire was the need of a comparison in measurement results of liquid density by hydrostatic weighing. The SIM NMIs that expressed their intention to participating in this comparison were the followings,

**Table 1.** Participant laboratories

No.	National Institute of Metrology	Acronym	Technical Contact
1	<b>Laboratorio Tecnológico del Uruguay</b> Avenida Italia 6201 Montevideo, Uruguay	LATU	Sheila Preste <a href="mailto:spreste@latu.org.uy">spreste@latu.org.uy</a> Gabriel Almeida <a href="mailto:galmeida@latu.org.uy">galmeida@latu.org.uy</a>
2	<b>Centro Nacional de Metrología</b> km. 4,5 Carretera a los Cués, Municipio El Marqués Querétaro, México	CENAM	Luis Omar Becerra <a href="mailto:lbecerra@cenam.mx">lbecerra@cenam.mx</a>  César Augusto Mata <a href="mailto:cmata@cenam.mx">cmata@cenam.mx</a>
3	<b>Laboratorio Costarricense de Metrología</b> 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	LACOMET	Francisco Sequeira <a href="mailto:fsequeira@lcm.go.cr">fsequeira@lcm.go.cr</a>
4	<b>Instituto Nacional de Metrología de Colombia</b> Av. Carrera 50 No.2755 Int. 2, Bogotá, Colombia	INM	Luis Carlos Castro <a href="mailto:lcastro@inm.gov.co">lcastro@inm.gov.co</a>
5	<b>Instituto Ecuatoriano de Normalización</b> Baquerizo Moreno E8-29 y Almagro, Quito, Ecuador	INEN	Víctor Hugo Guevara <a href="mailto:vguevara@normalizacion.gob.ec">vguevara@normalizacion.gob.ec</a>
6	<b>Instituto Nacional de Calidad</b> Calle De la Prosa 150, San Borja - Lima 27, Perú	INACAL	Luz Cori Almonte <a href="mailto:lcori@inacal.gob.pe">lcori@inacal.gob.pe</a>

7	<b>CESMEC Ltda.</b> Av. Marathon 2595, 781-0552 Macul, Santiago, Chile	CESMEC	Fernando Andres Garcia González <a href="mailto:fernando.a.garcia@bureauveritas.com">fernando.a.garcia@bureauveritas.com</a>  Diosimir Rodriguez <a href="mailto:diosimir.rodriguez@bureauveritas.cl">diosimir.rodriguez@bureauveritas.cl</a>
8	<b>Instituto Nacional De Tecnología Industrial Metrología Física</b> Parque Tecnológico Miguelete Avenida General Paz 5445, B1650KNA San Martín – Buenos Aires, Argentina	INTI	Rubén Quille <a href="mailto:rquille@inti.gob.ar">rquille@inti.gob.ar</a>
9	<b>Instituto Boliviano de Metrología</b> Av. Camacho No. 1488 - Edificio Anexo – La Paz, Bolivia	IBMETRO	Romer Larico <a href="mailto:rlarico@ibmetro.gob.bo">rlarico@ibmetro.gob.bo</a>

#### 4. Timetable of the comparison

Date	Activity
Sep-Oct, 2021	Test of candidates of reference liquids
Oct-Dec, 2021	Developing and agreeing the protocol of the comparison
Nov, 2021	Sending of the quotations of sample liquid (reference liquid)
Feb 2022	Deadline for paying the sample liquid
Apr-Jun, 2022	Production and Measurement at CENAM of the reference liquid
Apr-Jun, 2022	Sending of the sample liquid to participant laboratories
May-Jul, 2022	Sending to CENAM the form report (excel sheet) with their measurement results
Jun-Jul, 2022	Second density measurement of the reference liquid at CENAM (sample kept at CENAM)
Aug-Sep, 2022	Analysis of measurement results
Oct-Nov, 2022	Writing draft report of the comparison

**Note:** This timetable could change depending on the time required by purchasing department at CENAM and delivery time of providers,

#### 5. Reference Liquid

For this comparison, a volume of **48** litres of a polyalphaolefin will be prepared for CENAM. This volume will be prepared in 4 batches of 12 litres each.

Each batch will be measured by CENAM and it will divide and pack in 1 litre bottles for sending to participant laboratories.

The physical characteristics of the reference liquid are the following:

Surface tension at 20°C: approx. 29 mN m<sup>-1</sup>  
 Cubic thermal expansion: approx. 80 x 10<sup>-5</sup> °C<sup>-1</sup>  
 Isothermal compressibility: approx. 79 x 10<sup>-11</sup> Pa<sup>-1</sup>  
 Dynamic viscosity: approx. 7.4 mPa s<sup>-1</sup>

Note: the participant laboratories should avoid direct sunlight to the reference liquid.

The reference liquid will be divided and packed in 1 litre bottles in order to distribute among participant laboratories as follows:

**Table 2.** Amount of reference liquid required by participant laboratories

No	Institute	Amount (litres)
1	CENAM	8*
2	LATU	4
3	LACOMET	8
4	INM	4
5	INEN	4
6	INACAL	4
7	CESMEC	6
8	INTI	6
9	IBMETRO	4
Total		48

\* CENAM will measure the density of the complete amount of reference liquid but will keep 8 litres at CENAM for second measurement to estimate the density stability of the polyalphaolefin.

The participant laboratories should make their measurements as soon as the sample liquid arrived at their facilities and wait for proper thermal stabilization time.

## 6. Sending of the reference liquid

Each participating laboratory bears its own expenses for the transportation of the reference liquid from CENAM to their facilities.

The required amount of reference liquid for each participant laboratory will be properly packed and will be ready to send it by private courier company.

Once the package of the reference liquid of participant laboratory will be available at CENAM, CENAM will communicate to the participant laboratory that package is ready to pick up it.



It is quite important that, each participant laboratory make the proper arrangements for the transportation of the reference liquid in advance to avoid a large period between the density measurements of CENAM and their own measurements.

To monitor the progress of the comparison, the participant laboratories have kindly asked them to send a report by e-mail to coordinating institutes just the package of reference liquid arrive at their facilities mentioning the general conditions the bottles with the reference liquid arrived.

## 7. Measurements

Each participant laboratory is required to measure the density of the liquid by their own hydrostatic weighing system, solid density standard, their own metrological procedures, and at their own facilities and to report the density value at 20°C and 101 325 Pa and the associated uncertainty at 95 % confidence level.

Participant laboratory should carefully pour the total amount of the sample liquid in their measurement system should mixed avoid introducing gasses in the liquid or any other contamination in the sample liquid, e. g. by dust, water, solvent or any other that could change the density of the liquid.

Participant should not heat the sample liquid due to could change its the density (e. g. by outgassing).

Participant laboratory should wait for the proper thermal stabilization time before to start their measurements. This stabilization time do not to be long due to the possibility of evaporation, especially if the relative humidity of air in the laboratory is under 50 %.

Special care should take the participant laboratory with the cleanness of all the vessels, standards and accessories uses for the handling, content and measure the sample liquid (solid density standard, vessel, suspension, tweezers, among others), due to a potential contamination could change the density of the sample liquid.

Participant laboratories are recommended to conclude their measurements in the short period as possible in order to avoid any drift of the reference liquid due to evaporation.

The participant laboratories are required to use the CIPM 2007 [1] for the calculation of the air density and its uncertainty.

## 8. Reports

As soon as the measurements are finished, each laboratory will send to the CENAM the Excel Report Form (Report Form 1 and Report Form 2).

The MS Excel Report Form consists of two parts:

Report Form 1 (Measurements Instruments): It concerns information about the instrumentation used in this comparison. Please add any additional information if required.



Report Form 2 (Measurements Results): In this report form will be reported the data related with the measurements, results and its related uncertainties. Please add any additional information if required.

The uncertainty evaluation should include a list of all influence quantities, values, their degrees of freedom and their combined standard uncertainty. This is obtained by combining the individual standard uncertainties obtained from Type A and Type B evaluations, according to ISO "Guide to the Expression of Uncertainty in Measurement" [2].

The reports are to be sent to CENAM as soon as possible but four weeks after the measurements are completed at the latest. A result will not be considered complete unless an associated uncertainty supported by a complete uncertainty budget is given. The results are confidential until all the participants have completed their measurements and all the results have been received (or until the deadline for receipt of results is over).

### **9. Special problem**

Please, do not hesitate to contact the coordinating laboratories for any questions.

### **10. Late entry of a participant**

Due to the tight timetable and the need to prepare the reference liquid before starting the first measurements at CENAM, it is not possible for any additional participant to join after February 2022.

### **References**

- [1] A Picard, R S Davis, M Glaeser and K Fujii: "Revised formula for the density of moist air (CIPM-2007)" Metrologia 45 (2008) 149–155
- [2] Working Group 1 of the Joint Committee for Guides in Metrology (JCGM/WG 1), "Evaluation of measurement data — Guide to the expression of uncertainty in measurement" JCGM 2008

### **Appendix A. Report Forms**

Excel File with Report form 1 and Report form 2 are part of this protocol.

Report Form 1. –Measuring Instruments

Report Form 2. –Measurement Results.