TECHNICAL PROTOCOL FOR REGIONAL SUPPLEMENTARY COMPARISON SIM.AUV.A-S2

August 17, 2018

National Institute of Metrology, Quality and Technology – INMETRO (Brazil)

Preface

It was agreed during the SIM MWG-9 Meeting held at Rio de Janeiro / Brazil in November 2017 that a SIM Regional Supplementary Comparison on pistonphone calibration should be carried to compare reference sound pressure level capabilities.

The National Institute of Metrology, Quality and Technology – INMETRO was chosen to be the pilot laboratory and will provide the circulating artefact to be calibrated by each participant. This technical protocol specifies the basic procedures necessary for the comparison, but not the procedures for the calibration of the artefact.

Participants

The national metrology institutes below will participate in this comparison and their contact details are presented at the end of this document.

1. INMETRO, Brazil (pilot laboratory);
2. CENAM, Mexico;
3. INACAL, Peru;
4. INTI, Argentina;
5. LACOMET, Costa Rica;
6. NIST, USA; and
7. NRC, Canada.

Artefact to be circulated

For this comparison, the artefact to be circulated will be the pistonphone manufactured by Brüel and Kjær, type 4228 [1], serial number 2836183, with its one-inch to half-inch adaptor type DP 0776 for coupling half-inch measurement microphones. The stability of this artefact will be monitored by the pilot laboratory prior to and during the period of its circulation for calibration by the participants.

Each participant is responsible for the transportation of the artefact to the next one. The artefact should be carried preferably as hand luggage other than as checked baggage. As a result, no special carrying case will be provided. In any case, the artefact must be carefully packaged to avoid sudden shocks and prevent it from becoming less stable. It weighs approximately 700 g and its cost is estimated at USD 3 200.

Furthermore, careful manipulation of the artefact by properly trained staff of each participant is an essential requirement. The artefact must not be used for any other purpose than those associated with the calibration for this comparison.

Unpacking, preparation and packing

Upon arrival of the artefact, the participant is requested to check if any damage has occurred to the protective package or to the artefact during transportation. If any damage is observed, the participant shall contact the pilot laboratory with urgency. For

calibration, each participant must use new batteries. After calibration is concluded, the batteries must be removed from the pistonphone before its re-packing and transportation to the next participant.

Measurements

Each participant shall determine the sound pressure level generated by the pistonphone according to the international standard IEC 60942:2017 [2]. It is required for this comparison that sound pressure level be determined with and without the one-inch to half-inch adaptor type DP 0776, i.e. using a half-inch as well as a one-inch reference measurement microphones. If a participant can only measure with one type of microphone, this is acceptable, but the reported result shall clearly state which type of microphone was used to carry out the measurements.

The generated sound pressure level shall be measured by the microphone method (insert voltage technique) using calibrated standard microphones of type LS2P and LS1P as specified in the international standard IEC 61094-1:2000 [3].

Results shall be corrected for the load volume corresponding to the microphones used and for the reference environmental conditions specified in IEC 60942:2017 (air temperature: 23 ^{o}C, static pressure: 101,325 kPa and relative humidity: 50 %rh) [2] using the information presented in the pistonphone user manual [4]. The user manual will be circulated with the artefact to avoid the use of a different source of data by the participants.

Moreover, it is suggested that each participant reports the following additional information: frequency, total harmonic distortion in percent, and total distortion + noise in percent (measured over a bandwidth of 22.4 Hz to 22.4 kHz) [2] of the sound pressure level generated by the pistonphone. If the participant measured the total distortion + noise, the reported result shall clearly state which method of measurement was used, i.e. using a rejection filter device (distortion factor meter) or an appropriate FFT analyzer. These measurements should be performed using both a half-inch and a one-inch measurement microphones. If a participant can measure with only one type of microphone, the report result shall clearly state which type of microphone was used. These additional measurements are for investigation purposes only.

Uncertainty analysis

Each participant shall submit its final uncertainty budget to the pilot laboratory with the reported data. Failure to do so might result in the exclusion of the participant. The ISO document “Evaluation of measurement data – Guide to the expression of uncertainty in measurement” [5] shall be used as the reference document for the calculation of measurement uncertainty. Uncertainty budget should be based on a coverage factor of $k = 2$.

Reporting results

Each participant shall report calibration results by using an Excel template to be sent by the pilot laboratory and the standard certificate in the format that would be normally issued to a customer. This certificate must include details of any deviations from IEC 60942:2017 (Periodic tests). Estimated uncertainty components caused by these deviations shall also be included in the uncertainty budget. The certificate shall also include the following information:

1. The method used to determine the pressure sensitivity level of the microphone;
2. The environmental conditions (air temperature, static pressure and relative humidity) at the time calibration was performed;
3. The orientation of the pistonphone during the calibration; and
4. The values of each correction applied to the measured sound pressure level.

The results shall be sent to pilot laboratory by e-mail within three weeks of the transportation of the artefact to the next participant. The official signed paper copy of the certificate shall be mailed to the pilot laboratory in sequence.

Each participant shall inform the pilot laboratory when it receives the artefact from the previous participant and also when the artefact is delivered to the next participant. This is important to keep the schedule of the comparison under control.

Finance

Each participant is responsible for its own costs related to calibrations and also for any transportation costs and associated fees of the artefact to the next participant. It is agreed that the receiver shall not be responsible for any payment if a door-to-door delivery service is employed by the sender. Each participant is also responsible for any damage to the artefact while it is under its responsibility/care. This includes the period from date of receipt of the artefact by each participant to the date of receipt by the next participant.

Timetable

The timetable of the comparison is presented in Table 1. It is essential that the artefact is transported to the next participant on time even if the measurements have not been completed by a participant. Any change of the timetable must be justified and approved in advance by the pilot laboratory and subsequent participants.

Table 1 – Timetable for the comparison.

1) Check of artefact stability	
National Metrology Institute	Period
INMETRO	January to September, 2018
2) Circulation of the artefact	
National Metrology Institutes	Period
INMETRO	September 24 to October 5, 2018
Transportation of the artefact by previous participant to the next one	
NRC	October 22 to November 2, 2018
Transportation of the artefact by previous participant to the next one	
NIST	November 19 to 30, 2018
Transportation of the artefact by previous participant to the next one	
CENAM	December 17, 2018 to January 11, 2019
Transportation of the artefact by previous participant to the next one	
INMETRO	January 28 to February 8, 2019
Transportation of the artefact by previous participant to the next one	
INTI	February 25 to March 15, 2019
Transportation of the artefact by previous participant to the next one	
INACAL	April 1 to April 12, 2019
Transportation of the artefact by previous participant to the next one	
Lacomet	April 29 to May 10, 2019
Transportation of the artefact by previous participant to the next one	
INMETRO	May 27 to June 07, 2019
3) Analysis of the reported results	
National Metrology Institute	Period
INMETRO	June, 2019 to February, 2020

Notes:

1. The period for the calibration by each participant is ten weekdays with exceptions of the period allocated for CENAM because the interval from December 24, 2018 to January 4, 2019 is considered a traditional recess period; and the period allocated for INTI because the interval from March 1-6, 2019 is Carnival holiday.
2. A period of ten weekdays is also allocated for the transportation of the artefact between participants. Because of the difference between customs formalities of each country, it is difficult to know how long it actually takes to clear the goods. Therefore, each participant shall consider the transportation as early as possible within the period in order to avoid any delays due to customs.
3. INMETRO will carry out measurements in three periods during the circulation of the artefact to monitor its stability, but only the results obtained during the first period will be used for comparison with the reference value.

Determination of supplementary comparison reference values

To determine the supplementary comparison reference values, the measurements performed with the pistonphone fitted with an one-inch to half-inch adaptor and without the adaptor will be analyzed separately. The procedure employed will follow the analysis of Cox [6, 7], with the criterion for determining discrepant values applied only after careful inspection of the data in graphical form. In summary, for each parameter of interest, calculations will be made to obtain the weighted mean along with its uncertainty, the differences between each laboratory's measurement and the weighted mean, and the uncertainty associated to this difference. A statistical test of consistency will be applied to identify inconsistent data.

References

[1] BRÜEL & KJÆR SOUND & VIBRATION. **Products**. Available in: <www.bksv.com>. Access in: January 09, 2018.

[2] INTERNATIONAL ELECTROTECHNICAL COMMISSION, **IEC 60942 Electroacoustics – Sound calibrators**, 4th ed. Geneva, 2017.

[3] INTERNATIONAL ELECTROTECHNICAL COMMISSION, **IEC 61094-1 Measurement Microphones – Part 1: Specifications for laboratory standard microphone**, 2nd ed., Geneva, 2000.

[4] BRÜEL & KJÆR SOUND & VIBRATION, **Technical Documentations – Pistonphone Type 4228: User Manual**, Denmark, 1989.

[5] JOINT COMMITTEE FOR GUIDES IN METROLOGY, **Evaluation of measurement data – Guide to the expression of uncertainty in measurement**, 1st ed., 2008.

[6] COX, M. G., **The evaluation of key comparison data**, Metrologia, **39**, 589-595 (2002).

[7] COX, M. G., **The evaluation of key comparison data: determining the largest consistent subset**, Metrologia, **44**, 187-200 (2007).

List of contacts for the participating national metrology institutes:

Instituto Nacional de Metrologia, Qualidade e Tecnologia – INMETRO
Brazil
Av. Nossa Senhora das Graças, 50, Prédio 1, Xerém, Duque de Caxias, RJ, 25.250-020
Zemar Martins Defilippo Soares <zmsoares@inmetro.gov.br>
Tel: +55 21 26799192
Thiago Antônio Bacelar Milhomem <tbmilhomem@inmetro.gov.br>
Tel:+55 21 26799221

Centro Nacional de Metrología – CENAM Mexico Carretera a los Cués km 4.5. Municipio El Marqués CP 76246. Querétaro Andrés E Pérez Matzumoto <eperez@cenam.mx> Tel: +52 442 2110500 al 04 ext. 3569 Juan Pablo Ayala Breña <jayala@cenam.mx>
Instituto Nacional de Calidad – INACAL Perú Calle De La Prosa, 150, San Borja, Lima 41 Luis F. Palma < lpalma@inacal.gob.pe> Tel: +511 640 8820 Anx 1512
Instituto Nacional de Tecnología Industrial – INTI Argentina Av. General Paz 5445 - CP 1650 - Edificio 3 y 44 San Martín - Buenos Aires Federico Ariel Serrano < fserrano@inti.gob.ar> Tel: +54 11 4713 2826
Laboratorio Costarricense de Metrologia – LACOMET Costa Rica La Ciudad de la Investigación de la UCR, San Pedro, San José, Costa Rica Adrián Solano Mena < asolano@lacomet.go.cr> Tel: +506 4060 1061 Ext:1061
National Institute of Standards and Technology – NIST USA 100 Bureau Drive, Mail Stop 8120, Gaithersburg MD 20899 Michael Gaitan <michael.gaitan@nist.gov> Tel: (+1 301) 975-2070 Randall Wagner <randall.wagner@nist.gov>
National Research Council Canada – NRC Canada 1200 Montreal Road, Building M-36, Ottawa, Ontario K1A 0R6 Lixue Wu <Lixue.Wu@nrc-cnrc.gc.ca> Tel: +613 993 6966 Peter Hanes <Peter.Hanes@nrc-cnrc.gc.ca> Tel: +613 998 1282