LABORATOIRE NATIONAL DE METROLOGIE ET D'ESSAIS

TECHNICAL PROTOCOL FOR REGIONAL KEY COMPARISON EURAMET.AUV.A-K6

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TECHNICAL PROTOCOL FOR REGIONAL KEY COMPARISON EURAMET.AUV.A-K6

BACKGROUND

It was agreed at the meeting of EURAMET TC-AUV in April 2023 that a regional comparison on primary calibration of laboratory standard microphones type LS2aP in pressure field should be carried to compare sensitivity measurement capabilities, as a follow-up of the key comparison CCAUV.A-K6.

It was therefore agreed that preparations for repeating the key comparison would be initiated and that LNE would be the pilot laboratory. The key comparison has been denoted EURAMET.AUV.A-K6.

This document defines the protocol for the key comparison. It should be read in conjunction with the CIPM MRA-G-11 "Measurement comparisons in the CIPM MRA", which includes more details on the purpose and conduct of key comparisons in general. The purpose of this document is to "specify the procedures necessary for the comparison, but not the procedures used for the realization of the standards being compared."

PARTICIPANTS

The participating laboratories are listed in Table 1. HBKA-DPLA, LNE and UME are the link laboratories to the Key comparison CCAUV.A-K6. Contact details can be found in Annex A.

Table 1. List of participating laboratories

Laboratory	Country
BIM - Bulgarian Institute of Metrology	Bulgaria
HBK-DPLA - Hottinger Brüel & Kjaer A/S - Danish Primary Laboratory for Acoustics	Denmark
DFM - Danish Fundamental Metrology	Denmark
MIKES - VTT Technical Research Centre of Finland Ltd, Centre for Metrology MIKES	Finland
LNE - Laboratoire National de métrologie et d'Essais	France
PTB - Physikalisch-Technische Bundesanstalt	Germany
EIM - Hellenic Institute of Metrology	Greece
INRIM - Istituto Nazionale di Ricerca Metrologica	Italy
DMDM - Directorate of Measures and Precious Metals	Serbia
CEM - Centro Español de Metrología	Spain
RISE - Research Institutes of Sweden AB	Sweden
UME - Ulusal Metroloji Enstitüsü	Türkiye
SE "NDI Systema" - State Enterprise "Scientific and Research Institute for Metrology of Measurement and Control Systems"	Ukraine
NMCC - Saudi Standards, Metrology and Quality Organization	Saudi Arabia

MICROPHONES TO BE CIRCULATED

Two LS2aP microphones have been selected for this comparison. The microphones are Brüel & Kjær type 4180 serial numbers 2124385† and 2124386†. These microphones are referred to as the reference microphones in the following part of this document.

Each participant is responsible for transporting the reference microphones to the laboratory scheduled to next receive them. Local customs formalities must be observed and if the participating laboratory requires LNE to supply an ATA carnet (or any other documentation) for this purpose, they must inform LNE, using the 'agreement to participate form' presented in Annex C. In this regard, please bear in mind that the reference microphones may come to you directly from another participant (see Timetable in Annex B).

The reference microphones will be packaged in a suitable form for transportation by courier. It is essential that this packaging is used when using air or land couriers to transport the microphones between participating laboratories. The microphones may also be hand carried, but it is recommended that the same packaging be used. The microphones shall be stored appropriately while in the possession of the participating laboratory. Ideally this should be in temperature controlled environment maintained at the reference temperature of 23 °C. No grease or similar substances must be applied to the microphones.

The microphone cases will be marked as key comparison reference standards and the microphones must not be used for any purpose other than that associated with their calibration for this comparison. Sudden shocks can be caused by applying sound calibrators, pistonphones or dehumidifiers to the microphones and these actions should also be avoided.

MEASUREMENTS

This key comparison is concerned only with **primary methods** of calibration and will only consider results from such methods.

The microphones require a polarising voltage of 200 V.

† NPL have kindly provided the microphone for this key comparison and retain ownership of these devices.

Table 2 shows the measurands and frequency ranges within the scope of this key comparison. Participants shall complete the mandatory elements. Each laboratory is to determine the open-circuit pressure sensitivity level of each reference microphone, and optionally the open-circuit pressure sensitivity phase.

Table 2. Scope of key comparison

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3-octave)	Optional	Optional
20 Hz – 20 kHz (1/3-octave)	Mandatory	Optional
20 kHz – 25 kHz (1/3-octave)	Optional	Optional

The open-circuit pressure sensitivity level shall be reported in decibels with a reference value of 1V/Pa. The convention to be used for reporting the sensitivity phase is that it approaches 180º at low frequency and is 90º at the resonance frequency of the microphone, i.e. the sensitivity phase shall be reported as positive values.

It is IEC TC 29 policy that specifications referring to frequency in all new or revised standards, use the base 10 system of frequencies specified in IEC 61260. It is therefore appropriate to adopt this policy for all key comparisons. Accordingly, measurements shall be carried out and reported at frequencies generated by the formulae given below. In all calculations, the reference frequency f_r is 1000 Hz (NB. the octave frequency ratio of $G = 10^{(3/10)}$ described in IEC 61260, is implicit in these equations).

The third-octave calibration frequencies f_n between 2 Hz to 25 kHz shall be calculated from:

$$f_n = f_r 10^{n/10} \quad (1)$$

where n is an integer between –27 and 14.

The actual frequency that can be set during a measurement will be determined by the particular equipment used. The effect of any significant variation in the set frequency from that calculated above, on the measured sensitivity level shall be accounted for in the uncertainty analysis.

Any other frequencies (for example, preferred nominal frequencies) reported by the participants will not be collated by the pilot laboratory.

The frequency range of any calibration and measurement capability (CMC) that the laboratory has declared or intends to declare under the CIPM MRA, as being supported by this key comparison, must correspond or fall within the range where data is reported.

It is expected that most laboratories will fulfil the measurement requirements by implementing reciprocity calibration. Where reciprocity calibration is to be used, this shall be according to IEC 61094-2:2009 + Amd1:2022.

Laboratories are encouraged to make measurement data available in a way that allows recalculation in future with calculation methods alternative to those of IEC 61094-2:2009 + Amd1:2022.

The reference microphones will have suitably flat front surface to make the use of grease on the contact surface unnecessary for couplers filled with air.

The use of hydrogen-filled couplers is not recommended, but where a participating laboratory intends to use such a method, the reference microphones shall only be used as receivers. This intention must be stated on the 'agreement to participate' form.

PRE-PARTICIPATION

The key comparison is scheduled to begin in **July 2025**, when the pilot laboratory will start their measurements. The reference microphones will then be circulated to other participants for the first time.

Prior to the circulation of the microphones, participants shall complete the 'Agreement to participate form' presented in Annex C. This includes a statement of the measurements they expect to carry out and report. An electronic version of this form has been circulated with this protocol.

REPORTING RESULTS

Each laboratory shall report their results using the standard certificate that they would normally issue to a customer. However, results shall also be reported in the pilot laboratory's proforma spreadsheet, that has been circulated with this protocol. Please remember to **check the box confirming that the data reported in the proforma spreadsheet is consistent with that reported in the certificates**, as the spreadsheet data will be used as the basis for the analysis.

Results shall be corrected to the reference environmental conditions given in IEC 61094-2:2009 + Amd1:2022.

Results shall be accompanied by a statement of the associated measurement uncertainty, estimated for a confidence probability of 95 %.

Where necessary an additional covering letter or report shall be provided to include any details not covered in the certificate, including:

- Details of any deviations from the recommendations in IEC 61094-2:2009 + Amd1:2022 and an estimate of the effect this has on the reported results.
- The values of the front cavity volume, cavity depth, and microphone acoustic impedance parameters used in the calculation, where appropriate.
- Values of the temperature and static pressure coefficients of the microphones used in the calculations.
- A summary of the uncertainty calculation, listing and quantifying each of the components considered, and indicating the method used to produce the overall estimate of measurement uncertainty.
- The final results and the accompanying information should be received at LNE within **four weeks** of the end of the scheduled measurement period. Dated deadlines can be found in the schedule shown in Annex B. A reminder will be sent by email one week before the due date and this deadline shall be strictly enforced: failure to submit results by the deadline may result in the exclusion of the participant laboratory. An email to the pilot laboratory should be sent to announce that the results have been despatched. The completed proforma spreadsheet should be attached to this email. It is also acceptable to send all other material by email to meet the deadline, but hardcopies of calibration certificates should follow in the post.

The pilot laboratory will carry out their measurements at the start of the circulation period and the results lodged with the CCAUV Executive Secretary.

When all participants have completed the measurements, the data will be analysed by the pilot laboratory. If a result is found to be anomalous the laboratory in question will be notified and given **three weeks** to respond. A Draft A report will then be prepared.

FINANCE

Participants are responsible for their own costs, the cost of delivering the microphones to the next recipient, any ATA carnet required and for any damage to the microphones while they are in their possession.

TIMETABLE

The timetable is given in Annex B.

The timetable must be followed regardless of any delays caused by customs irregularities and this could cause a laboratory to lose the opportunity to participate in the comparison. If measurements cannot be completed at a laboratory then it may be possible for the microphones to go to that laboratory after the termination of the measurement round. However, LNE cannot guarantee to perform check measurements after this date.

Each participating laboratory has been allocated a 4-week period in the schedule. The first three weeks should be used to acclimatise the reference microphones to their laboratory environment and to carry out measurements. During the fourth week, the participating laboratory must finalise their measurements and despatched the microphones to the next participant or back to LNE, so that they are received by the start date assigned to the next laboratory, as indicated in the timetable.

It is essential that the microphones are passed on to the next participating laboratory or back to LNE on time even if measurements are not complete. If an individual laboratory has difficulty with their allocated time, it may be possible for two participants to exchange their place in the timetable.

The microphones will return to LNE for an interim calibration, typically after calibration by three participating laboratories. This is so that the stability of the devices can be monitored and so that results from different laboratories can still be compared should a change occur.

In the event of one of the microphones failing then LNE will find a substitute, though this may make the analysis of the results more complicated.

KEY COMPARISON REFERENCE VALUE

The determination of the Comparison Reference Values is an important outcome of this project. It is expected that the analysis of the results can be conducted in the same way as used for the previous key comparison CCAUV.A-K6. It is the responsibility of the pilot laboratory to identify anomalous results and notify the participant according to CIPM Guidelines.

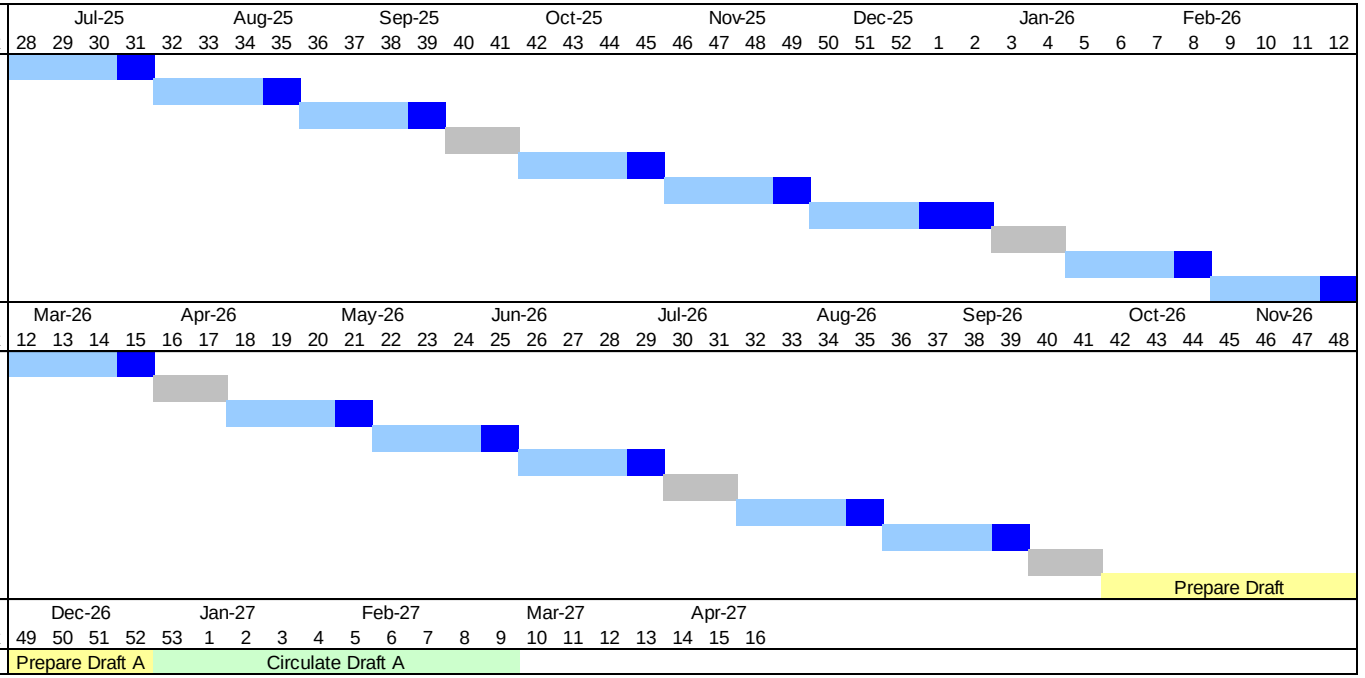
ANNEX A – PARTICIPANTS

LIST OF CONTACT PERSONS

BIM Elitsa Petrova 2, Prof. Petar Mutafchiev, Str. 1784 Sofia, Bulgaria Tel: +359 2 974 08 96 Email: e.petrova@bim.government.bg	**HBK-DPLA** Erling Sandermann Olsen Teknikerbyen 28 DK-2830 Virum, Denmark Tel: +45 77 41 24 61 Email: erlingsandermann.olsen@hbkworld.com
DFM Salvador Barrera-Figueroa Kogle Allé 5 2970 Hørsholm, Denmark Tel: +45 2545 9020 Email: sbf@dfm.dk	**MIKES – VTT** Kari Ojasalo Tekniikantie 1 FI-02044 VTT, Finland Tel: +358 50 410 5557 Email: kari.ojasalo@vtt.fi
LNE Dominique Rodrigues 29 avenue Roger Hennequin 78197 Trappes, France Tel: +33 1 30691487 Email: dominique.rodrigues@lne.fr	**PTB** Thomas Fedtke Physikalisch-Technische Bundesanstalt, Braunschweig Bundesallee 100 D-38116 Braunschweig, Germany Tel: +49 531 592 1511 Email: Thomas.Fedtke@ptb.de
EIM Konstantinos Zacharias Industrial Area of Thessalonki, Block 45, TK 57022, Thessalonki, Greece Tel:+30 2310 569 999 Email: zacharias@eim.gr	**INRiM** Fabio Saba Strada delle Cacce 91, 10135 Torino, Italy Tel: +39 011 3919619 Email: f.saba@inrim.it
DMDM Gordana Stefanovic Mike Alasa 14, 11000 Belgrade, Serbia Tel: +381 11 22 24 421 Email: gocastef@dmdm.rs	**CEM** Virginia Marcos Lucas Calle del Alfar 2 28760, Tres Cantos, Madrid, Spain Tel: +34 918074741 Email: vmarcos@cem.es
RISE Håkan Andersson Brinellgatan 4 50462 Borås, Sweden Tel: +46105165423 Email: hakan.andersson@ri.se	**UME** Enver Sadıkoğlu Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze KOCAELİ, TURKEY Tel +90 262 679 5000 ext. 2044 Email: enver.sadikoglu@tubitak.gov.tr
SE "NDI Systema" Oleksander Kosterov DP NDI "Systema" 6, Krivonosa str, , Lviv, 79008, Ukraine Tel: +380662238525 Email: kosterov@dndi-systema.lviv.ua	**NMCC** Abdulrahman A. AlAnaz Saud University PO. B 3437 Riyadh 11471 Kingdom of Saudi Arabia Tel: +966 53 363 6989 Email: aa.anazi@saso.gov.sa

ANNEX B. Timetable for EURAMET.AUV.A-K6

NMI	Country	Receipt of microphones	Final report deadline
LNE	France	7 July 2025	1 September 2025
DFM	Denmark	4 August 2025	29 September 2025
HBK	Denmark	1 September 2025	27 October 2025
LNE		29 September 2025	
MIKES-VTT	Finland	13 October 2025	8 December 2025
RISE	Sweeden	10 November 2025	5 January 2026
INRIM	Italy	8 December 2025	2 February 2026
LNE		12 January 2026	
BIM	Bulgaria	26 January 2026	23 March 2026
DMDM	Serbia	23 February 2026	20 April 2026
PTB	Germany	23 March 2026	18 May 2026
LNE		20 April 2026	
CEM	Spain	4 May 2026	29 June 2026
UME	Turkey	1 June 2026	27 July 2026
EIM	Greece	29 June 2026	24 August 2026
LNE		27 July 2026	
SE "NDI Systema	Ukaine	10 August 2026	5 October 2026
NMCC	Saudi Arabia	7 September 2026	2 November 2026
LNE		5 October 2026	
Reports			



* It is the responsibility of the laboratory in possession of the reference microphones to ensure that they reach their destination by the date indicated.

ANNEX C - Agreement to participate

Agreement to participate in EURAMET.AUV.A-K6

Name and address of laboratory

Contact person

Name:
E-mail:
Phone:

Methodology

- ☐ IEC 61094-2:2009
- ☐ IEC 61094-2:2009 + IEC 61094-2:2009/AMD1:2022
- ☐ Other (please give details in Additional Information below)

Scope

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3 octave)		
20 Hz - 20 kHz (1/3 octave)		
20 kHz - 25 kHz (1/3 octave)		

Will you require an ATA Carnet? Yes ☐ No ☐

The proposed date for participation is acceptable ☐

Additional information (specify the frequency range covered for the optional elements)

Please return this form to dominique.rodrigues@lne.fr

The pilot laboratory has distributed this form electronically to participating laboratories. A further copy is available by contacting Dominique.rodrigues@lne.fr

The completed form shall be returned to the pilot laboratory by 25 April 2025.