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TECHNICAL PROTOCOL FOR KEY COMPARISON CCAUV.A-K6

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TECHNICAL PROTOCOL FOR KEY COMPARISON CCAUV.A-K6

BACKGROUND

The key comparison of microphone calibration CCAUV.A-K3, concerning the pressure calibration laboratory standard microphones type LS2P, was completed in May 2006. At the 11th meeting of CCAUV in Sèvres, France on September 2017 it was affirmed the need to maintain a KCRV for the calibration of this type of microphone. 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 CCAUV.A-K6.

This document defines the protocol for the key comparison. It should be read in conjunction with the “Guidelines for key comparisons carried out by Consultative Committees” by T J Quinn 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

Given the large number of institutes expressing interest in taking part in this key comparison, a questionnaire was circulated to assess the scope of the key comparison and the range of capability of potential participants. The responses to the questionnaire survey and the criteria used to select the participants listed below, can be found in Annex A.

The following laboratories have been selected based on the questionnaire responses.

- ◆ BKSVDPLA, Denmark
- ◆ CENAM, Mexico
- ◆ GUM, Poland
- ◆ INMETRO, Brazil
- ◆ KRISS, Korea
- ◆ LNE, France
- ◆ METAS, Switzerland
- ◆ NMIA, Australia
- ◆ NMIJ, Japan
- ◆ NMISA, South Africa
- ◆ NRC, Canada
- ◆ UME, Turkey
- ◆ VNIIFTRI, Russia

Contact details can be found in Annex A.

These participating laboratories provide representation for the following RMOs in this key comparison: EURAMET have four participants (excluding the pilot laboratory), APMP have three participants, SIM have three participants, and AFRIMETS and COOMET have one participant each.

MICROPHONES TO BE CIRCULATED

Two LS2P microphones have been selected for this comparison. The microphones are Brüel & Kjær type 4180 serial numbers 2124385[†] and 2412872. These microphones are referred to as the reference microphones in the remainder of this document. Additional microphones will be maintained by the pilot laboratory should any reference microphone fail during the key comparison.

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' shown in Annex A. In this regard, please bear in mind that the reference microphones may come to you directly from another participant (see Timetable in Annex A).

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 KC and retain ownership of these devices.

Table 1. Scope of key comparison

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

Table 1 shows the measurands and frequency ranges within the scope of this key comparison. Participants shall complete the mandatory elements and at least one optional element of the scope, unless agreed in advance with the pilot laboratory. Each laboratory is to determine the open-circuit pressure sensitivity level of each reference microphone, and optionally the open-circuit pressure sensitivity phase.

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 180° at low frequency and is 90° at the resonance frequency of the microphone, i.e. the sensitivity phase shall be reported as positive values.

It is IEC TC29 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 CCAUV. A 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 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.

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.

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 on **18 February 2019**, 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' shown in Annex A. 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.

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 and an estimate of the affect 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 A. 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 secretariat.

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 A.

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 two 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-K3. It is the responsibility of the pilot laboratory to identify anomalous results and notify the participant according to CIPM Guidelines.

ANNEX A – PARTICIPANTS

A questionnaire was circulated ahead of preparing this protocol to gauge interest in participation and help formulate a realistic but challenging scope.

The questionnaire was circulated by CCAUV, and 16 responses were received. The responses received are summarised in Table A1.

Table A1 – Summary of responses from questionnaire

Responding NMI	Country/Economy	RMO	Frequency step		LF	Phase	Selected
			1/3	1/12			
BKSV-DPLA	Denmark	Euramet	●	●	●	●	●
CENAM	Mexico	SIM	●	●	●	●	●
GUM	Poland	Euramet	●	●	●	●	●
INMETRO	Brazil	SIM	●	●	●	●	●
KEBS	Kenya	AFRIMET	●	●			
KRISS	Korea	APMP	●	●	●	●	●
LNE	France	Euramet	●	●	●	●	●
METAS	Switzerland	Euramet	●	●	●	●	●
NMC	Singapore	APMP	●	●		●	
NMIA	Australia	APMP	●		●		○
NMIJ	Japan	APMP	●	●	●	●	●
NMISA	South Africa	AFRIMET	●	●	●	●	●
NRC	Canada	SIM	●	●	●	●	●
PTB	Germany	Euramet	●	●			
UME	Turkey	Euramet	●	●	●	●	●
VNIIFTRI	Russia	COOMET	●	●	●	●	●
			● Acceptable frequency	● Participation in full scope			
			● Preferred frequency resolution	○ Participation in partial scope			

In order to constrain the duration of the key comparison, it is proposed that the maximum number of participants should be limited to 12 (excluding the pilot laboratory) and to have all RMOs represented proportionally to the number of countries providing CMCs. The number of responding laboratories therefore meant that some degree of selection was necessary.

Using the information provided in the questionnaire, the following criteria were therefore used in addition to the above, to select the final list of participants:

1. Participant expects to be able to perform full proposed scope
2. Participant expects to be able to perform mandatory element of scope
3. Participant expects to be able to perform low frequency calibration
4. Participant expects to be able to perform phase calibration
5. Uncertainties of participants are within the lowest in the RMO in order to allow future linking of future subsequent regional key comparisons.
6. Participant implements a unique or distinctive measurement system

The outcome of the selection process is indicated in Table A1. It can be seen that EURAMET have four participants (excluding the pilot laboratory), APMP have three participants, SIM have three participants, and AFRIMETS and COOMET have one participant each.

List of contact persons

<p>BKSV-DPLA: Erling Sandermann Olsen Brüel & Kjær Sound & Vibration A/S Research & development, Microphones Skodsborgvej 307 DK-2850 Nærum Denmark Tel: +45 77 41 24 61 Email: mailto:ErlingSandermann.Olsen@bksv.com</p>	<p>CENAM: Andrés E. Pérez Matzumoto Centro Nacional de Metrologia Vibration and Acoustics Division Carretera a los Cués km 4.5. Municipio El Marqués CP 76246 Querétaro, MÉXICO Tel (52) 442 2110500 to 04 ext. 3569 Email: eperez@cenam.mx</p>
<p>GUM: Danuta Dobrowolska Central Office of Measures, Sound and Vibration Division Ul Elektoralna 2 PO Box P 10 PL 00 950 Warszawa Poland Tel: +48 22 620 4259 Email: d.dobrowolska@gum.gov.pl</p>	<p>INMETRO: Zemar M. Defilippo Soares INMETRO – Instituto Nacional de Metrologia, Qualidade e Tecnologia LAETA - Laboratório de Eletroacústica Av. Nossa Senhora Das Graças, 50, Prédio 1, Xerém Duque de Caxias, RJ, 25250-020 Brazil Tel: +55 21 2679 9192 Email: zmsoares@inmetro.gov.br</p>
<p>KRISS: Cho, Wan-Ho Korea Research Institute of Standards and Science Division of Physical Metrology 1 Doryong Dong, Yuseong 305-340 Daejeon Republic of Korea Tel: +82-42-868-5872 Email: chowanho@kriss.re.kr</p>	<p>LNE: Dominique Rodrigues Laboratoire National de métrologie et d'Essais Laboratoire national de métrologie et d'essais 29 avenue Roger Hennequin 78197 Trappes Tel : +33 1 30691487 Email: Dominique.rodriques@lne.fr</p>
<p>METAS: Christian Hof Institut fédéral de métrologie METAS Laboratoire Acoustique et Vibration Lindenweg 50, 3003 Bern-Wabern, Suisse Tél. +41 58 387 07 50 Fax +41 58 387 02 10 Email: christian.hof@metas.ch</p>	<p>NMIA: Laurence Dickinson National Measurement Institute 36 Bradfield Road, West Lindfield NSW 2070, Australia GPO Box 2013, Canberra, ACT, 2601 Australia Tel: +61 2 8467 3759 Fax: +61 2 8467 3610 Email: Laurence.Dickinson@measurement.gov.au</p>
<p>NMIJ: Hironobu Takahashi National Metrology Institute of Japan, AIST Acoustics and Ultrasonics Standard group, Tsukuba Central 3, 1-1-1 Umezono, Tsubuka 305-8563 Japan Tel: +81 29 861 4131 Email: h.takahashi@aist.go.jp</p>	<p>NMISA: Riaan Nel National Metrology Institute of South Africa Building 5, CSIR Campus Meiring Naude Road Brummeria Pretoria 0183 South Africa Tel: +2712 841 2534 Email: RNel@nmisa.org</p>
<p>NRC: Peter Hanes National Research Council Canada 1200 Montreal Road, Building M-36 Ottawa, Ontario K1A 0R6 Canada Tel: 613-998-1282 Email: peter.hanes@nrc-cnrc.gc.ca</p>	<p>UME: Enver Sadikoglu TÜBİTAK UME TÜBİTAK Gebze Yerleşkesi 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</p>
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Timetable for CCAUV.A-K6

NMI	Country	Receipt of microphones	Final report deadline	wk	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19																									
					8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
LNE	France	18 February 2019	15 April 2019																																			
BKSV-DPLA	Denmark	18 March 2019	13 May 2019																																			
METAS	Switzerland	15 April 2019	10 June 2019																																			
LNE		13 May 2019																																				
KRISS	Korea	27 May 2019	22 July 2019																																			
NMIJ	Japan	24 June 2019	19 August 2019																																			
LNE		22 July 2019																																				
GUM	Poland	5 August 2019	30 September 2019																																			
UME	Turkey	2 September 2019	28 October 2019																																			
LNE		30 September 2019																																				
					Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20																										
					42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
NMISA	S. Africa	14 October 2019	9 December 2019																																			
NMIA	Australia	11 November 2019	6 January 2020																																			
LNE		9 December 2019																																				
CENAM	Mexico	6 January 2020	2 March 2020																																			
NRC	Canada	3 February 2020	30 March 2020																																			
LNE		2 March 2020																																				
VNIIFTRI	Russia	16 March 2020	11 May 2020																																			
INMETRO	Brazil	13 April 2020	8 June 2020																																			
LNE		11 May 2020																																				
Reports																																						
					Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20																											
					24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53				
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

Agreement to participate

Agreement to participate in CCAUV.A-K6

Name and address of laboratory

Contact person

Name:
E-mail:
Phone:

Methodology

<input type="checkbox"/>	IEC 61094-2:2009
<input type="checkbox"/>	Other (please give details in Additional Information below)

Scope

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3 octave)		
20 Hz - 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.rodriques@lne.fr](mailto:dominique.rodriques@lne.fr)

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

The completed form shall be returned to the pilot laboratory by 28 January 2019.