

**TECHNICAL PROTOCOL FOR
AFRIMETS RMO COMPARISON
AFRIMETS.AUV.A-K5**

19 August 2015

INTRODUCTION

The first CIPM CCAUV key comparison with LS1P microphones was CCAUV.A-K1 and most recently CCAUV.A-K5. The final report of CCAUV.A-K5 was published in 2014. The scope of CCAUV.A-K5 included not only the modulus, but also the phase sensitivities of the LS1P microphone in accordance with IEC 61094-2: 2009 [3].

This is a new Regional Key Comparison that will mirror the CCAUV.A-K5 Key Comparison [1], which will be performed under the auspices of AFRIMETS. The purpose of this comparison will be to provide a link to and for the same scope, as the aforementioned CIPM Key Comparison where the measurement artefacts was LS1P microphones [2]. The comparison will aid in proving and establishing measurement equivalence for the submission of Calibration Measurement Capabilities (CMCs) in the BIPM Key Comparison Data Base (KCDB).

PARTICIPANTS

Participation in the AFRIMETS Regional Metrology Organisation (RMO) Key comparison includes AFRIMETS National Metrology Institutes (NMIs) or Designated Institutes (DIs) and other NMIs or DIs from other RMOs. An agreement to participate has been circulated. In order to keep the life cycle of this comparison short and feasible, only a very limited number of participants have been considered.

Where reference to NMIs is made, it also refers to DIs in the remainder of this document.

This comparison is to be piloted by the NMISA and co-piloted by the NPL.

MICROPHONES TO BE CIRCULATED

Two LS1P microphones will be used for this comparison. The microphones are Brüel & Kjær type 4160's with serial numbers 811014 and 2036126. These microphones are sponsored and on loan from the National Physical Laboratory (NPL) in the UK. These Brüel & Kjær 4160 microphones have also been used in the EURAMET.AUV.A-K5. The use of these particular microphones should not pose any problems as the results of EURAMET.AUV.A-K5 will only be published by the end of February 2016 and the measurement phase of this comparison will end before then. A benefit of using these particular microphones will be that AFRIMETS.AUV.A-K5 and EURAMET.AUV.A-K5 results can in principle be compared directly, although both RMO Key Comparisons will still be of equal standing.

The NPL has participated in the CIPM CCAUV.A-K5 comparison and will also form the principle link to CCAUV.A-K5. Additionally, NMISA also participated in CCAUV.A-K5 with a limited scope. These microphones are referred to as the reference microphones in the remainder of this document.

Each participant is responsible for transporting the reference microphones to the next participant according to a schedule.

The reference microphones are not supplied with an ATA Carnet. All local applicable customs formalities will need to be adhered to. It is strongly advised that once the reference microphones is to be sent to the next participant that the issued invoice is to reflect an amount of zero, as no monetary value will have been added, as seen in the context of this comparison.

The reference microphones will be packaged inside a stainless steel thermal flask that will be placed inside a hardwearing instrument case. An instruction notice about the packaging method is also included. It is essential that this packaging is used when transporting the microphones between participants. The microphones shall be stored appropriately while in the possession of the participating NMI. Ideally this should be in temperature controlled environment maintained at the reference temperature of 23 °C and relative humidity of >25 to < 75 %RH.

The reference microphones must not be used for any purpose other than that associated with its calibration for the proposed comparison. Sudden shocks can be caused by applying sound calibrators, piston phones or dehumidifiers to the microphones and these actions shall be avoided.

MEASUREMENT SCOPE & METHOD

This comparison is concerned only with primary methods of calibration according to IEC 61094-2: 2009. Should alternative methods be used, those results must be clearly identified and reported. The alternative method is also to be described.

The reference microphones require a polarising voltage of 200 Vdc. **No sealing agent, e.g. petroleum jelly, grease or the like, will be allowed to be used with the reference microphones.** The reference microphones do have a suitably flat front surfaces making the use of a sealing agent on the contact surface unnecessary for couplers filled with air. **The use of hydrogen-filled couplers will also not be allowed for this comparison.**

Participants are encouraged to seek alternative means to reduce influences of noise which might include, but is not limited to utilising an enclosure shielding the receiver-transmitter microphone setup, using a vibration isolation table etc. The driving voltage must be such that it will not damage the microphones.

The measurement parameters, or equivalent, that will need to be reported are:

- modulus (mandatory),
- phase (optional, but desirable),
- microphone lump parameters, see Table 1 (mandatory).

Microphone lump parameters to be reported	Unit
Equivalent volume	mm ³
Resonant frequency	kHz
Loss factor	
Front cavity volume	mm ³
Front cavity depth	mm
Static pressure coefficient @ 250 Hz	dB/kPa
Temperature coefficient @ 250 Hz	dB/K

Table 1. Lump parameters.

Equivalent lump parameter models may be used, but should be clearly identified.

The coefficients to apply for correcting differing static pressures and temperatures will be at the discretion of the participant, i.e. a participant can choose to use only the nominal known coefficients at 250 Hz, or a polynomial based coefficient at each frequency of interest. Regardless of which method is chosen, it should be reported which method was used.

The modulus and phase results will need to be reported at the **exact frequencies** as determined by Equation 1 for the third octave band frequencies and Equation 2 for one-twelfth octave band. In the event that the frequencies have been reported at nominal midband frequencies, the results will be referred back to the participant for recalculation and reporting at exact frequencies.

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

$$f = 10^{n/40} \cdot f_r \quad (2)$$

where

n are integers between -27 to -17 for $1/3$ octave bands and -68 to 40 for $1/12$ octave bands

f_r is the reference frequency of 1 000 Hz

The scope of this comparison is as per Table 2. The preferred frequency spacing is $1/12$ octave bands for 20 Hz to 10 kHz, but $1/3$ octave is allowed. Phase sensitivity results are also preferred, but it is not mandatory.

Frequency spacing	Frequency range	Parameter	
		Modulus	Phase
$1/3$ octave	2 Hz to 20 Hz	optional	optional
$1/12$ octave	20 Hz to 10 kHz	mandatory	optional

Table 2. Comparison scope.

The modulus of each one of the reference microphones will need to be determined as the open-circuit pressure sensitivity. The phase of each one of the reference microphones will need to be determined as the open-circuit pressure sensitivity phase.

The open-circuit pressure sensitivity level will need to be reported in decibels with a reference value of 1V/Pa.

The convention to be used for reporting the open-circuit pressure sensitivity phase will be that it approaches 180° at low frequency and is 90° at the resonance frequency of the microphone, i.e. the sensitivity phase will be reported as positive values only.

Measurements of the reference microphones shall be performed with the protection grid(s) removed.

Any data reported not in the required formats will not be considered for analysis and drafting of the reports.

REPORTING OF THE RESULTS

Each participant will need to report their results using the standard certificate format (the format of the certificate is to be as that which the participant issues normally to a client, but the reported sensitivities are to be at the exact frequencies) that they would normally issue to a customer. **Results shall also be reported in the provided Microsoft Office Excel spread sheet template. Only the results as provided in the spread sheet shall be considered for reporting the results of this comparison.**

All results shall be corrected to the reference environmental conditions as stated in IEC 61094-2: 2009 and shall be reported to the 3rd decimal for M_p and the 2nd decimal for the phase results, e.g. -27,000 dB re 1 V/Pa and/or 180,00 °. An accompanying uncertainty matrix for the submitted parameters and ranges will also need to be submitted as well as a brief overview of the participant's chosen method and the implementation thereof.

The results shall be reported with a statement of the associated measurement uncertainty (modulus and/or phase) with a coverage factor of $k = 2$, with a level of confidence which approximates 95 %.

It is kindly requested that all participants provides a brief description of their measurement methodology used, including a description of the system in addition to their certificates. As a minimum such details may include, but will not limited to:

- details of any deviations from IEC 61094-2: 2009, including accurate estimate of the influence(s) thereof on the results reported,
- microphone lump parameters if not reported in the certificate and a description of how these parameters were obtained,
- the measured environmental parameters (temperature, humidity and ambient static pressure) under which the measurements were performed,
- a brief explanation of the system employed in performing the measurements and an explanation of the calculations performed to obtain the reported results
- a summary of the uncertainty calculations listing each contributor/component with a statement of the method employed in calculating the final uncertainties,

- an indication of the polarization voltage.

The final results of each participant will need to reach the pilot NMI within 4 weeks after the end of the scheduled measurement period of the participant. All hard copies of results and additional information will need to follow in the post or be couriered.

The pilot NMI will also perform its measurements as indicated in the time table and submit it to the CCAUV Secretariat to facilitate transparency.

Once all the participants' measurement reports have been received, the data will be analysed. Should any anomalies be identified, the respective participant(s) will be informed and given two weeks to respond. NPL will provide the stability data and assistance with the statistical analysis and linking of this comparison to the CIPM CCAUV.A-K5 comparison. A Draft A.1 report will then be drafted and circulated to all the participants for comments and approval.

FINANCES

Each participant is responsible for their own costs, the cost of delivering the reference microphones to the next recipient and any costs (if applicable) relating to customs clearing of the reference microphones.

Each participant will also be responsible for any damage to the reference microphones while it is in their possession. The reference microphones must be inspected upon receipt and any damage is to be reported to the pilot NMI immediately.

The reference microphones are not supplied with an ATA Carnet and an invoice will therefore need to be issued to the pilot NMI when it is returned to the pilot NMI. Such an invoice will need to state an amount of zero (0,00) in the applicable currency, as no monetary value will have been added to the reference microphones for the purposes of this comparison. Each participant will be kindly requested to ensure that the correct procedures are followed w.r.t. their local import and export policies/law/requirements.

TIMETABLE

The comparison will begin in September 2015 with the pilot NMI performing their measurements, where after the reference microphones will be circulated according to the timetable as per Annex A. In order to make this comparison feasible, all participants will need to have completed and submitted their results by **end February 2016** (this is a fixed deadline and it will not be changed). At present a 5 week period for measurements and transport is a possibility.

The timetable will need to be followed regardless of any delays caused by customs irregularities and this could cause a NMI to lose the opportunity to participate in the comparison.

The reference microphones will need to be sent to the next participant according to the timetable. Any delays by any one participant will cause delays in the entire comparison. The pilot NMI will need to be informed immediately should any participant experience any difficulties. As this comparison will have a very short life cycle, participants will not be allowed to exchange their allocated time slots.

In the event of one of the reference microphones not being credible anymore, the pilot NMI may substitute it with another. This will however not be advisable as it can overcomplicate the analysis of the results and depending upon which microphone, it might place the comparison in jeopardy.

KEY COMPARISON REFERENCE VALUES

The linking of the AFRIMETS.AUV.A-K5 results to the CCAUV.A-K5 comparison is an important outcome of this comparison. An initial approach can be taken whereby the Degrees of Equivalence (DoE) are determined by calculating the deviations between a participant's results and the linking NMIs results, while taking into account the linking NMIs DoE achieved in the CCAUV.A-K5 Key Comparison.

Any anomalous results identified by the pilot NMI will be reported to the participant in accordance with the CIPM guidelines. Other suitable means of evaluating the results may also be considered.

The CIPM guidelines for comparisons deal with the principles of this issue and sets out useful procedures but does not provide a solution if anomalies remain. The BIPM guidelines will be followed initially but if a problem remains, the participants will decide how to deal with this situation prior to completing the final report.

ANNEX A

The participant who has the reference microphones will be responsible to ensure that the next participant receives the reference microphones in time according to the timetable. The timetable allows for a 3 week measurement period and a 2 week transportation period.

The pilot NMI will aim to have the Draft A.1 report ready for circulation by March 2016.

Activity	Participant NMI timeslot 2015 - 2016			
	NMISA	MIKES	CMI	NPL
Measure	14 Sept – 2 Oct Weeks 38 - 40			
Courier	5 – 16 Oct Weeks 41 – 42			
Measure		19 Oct – 6 Nov Weeks 43 – 45		
Courier		9 – 20 Nov Weeks 46 – 47		
IEC TC29		16 – 21 Nov Week 47		
CCAUV			23 – 27 Nov Week 48	
Measure			23 Nov – 11 Dec Weeks 48 – 50	
Festive Season			14 Dec – 8 Jan Weeks 51 – 2	
Courier			11 – 22 Jan Weeks 3 – 4	
Measure				25 Jan – 12 Feb Weeks 5 – 7

ANNEX B

All the participants contact details are listed below.

<p>CMI – Czech Metrology Institute (Czech Republic)</p> <p>Contact person: Marek Blabla</p> <p>Physical address: Czech Metrology Institute V Botanice 4 150 72 Prague 5 Czech Republic</p> <p>Tel: +420 257 288 316 e-mail: mblabla@cmi.cz</p>	<p>MIKES – VTT Technical Research Centre of Finland Ltd, Centre for Metrology (Finland)</p> <p>Contact person: Jussi Hämäläinen</p> <p>Physical address: Tekniikantie 1 02150 Espoo Finland</p> <p>Tel: + 358 50 410 5518 e-mail: Jussi.hamalainen@vtt.fi</p>
<p>NMISA – National Metrology Institute of South Africa (South Africa)</p> <p>Contact person: Riaan Nel</p> <p>Physical address: CSIR Campus, building 5 Meiring Naude Road Brummeria Pretoria 0184</p> <p>Postal address: Private Bag X34 Lynnwood Ridge Pretoria 0040 South Africa</p> <p>Tel: +2712 841 2534 e-mail: RNel@nmisa.org</p>	<p>NPL – National Physical Laboratory (United Kingdom)</p> <p>Contact person: Janine Avison</p> <p>Postal & Physical address: F10-A2 National Physical Laboratory Hampton Road Teddington Middlesex TW11 0 LW UK</p> <p>Tel: ++4420 8943 6706 e-mail: Janine.avison@npl.co.uk</p>

Table 3. Contact information of participants.