TECHNICAL PROTOCOL
FOR REGIONAL KEY COMPARISON
APMP.AUV.A-K5.1

Jun. 2025

National Institute of Metrology, China

TECHNICAL PROTOCOL FOR KEY COMPARISON APMP.AUV.A-K5.1

1. BACKGROUND

The key comparison of microphone calibration CCAUV.A-K5, concerning the pressure calibration of laboratory standard microphones type LS1P, was completed in May 2013. In APMP region, the key comparison APMP.AUV.A-K5 was completed in December 2024 to keep the consistency and link to the KCRV for the calibration of this type of microphone. In the meantime, the need of the bilateral comparison with National Institute of Metrology (NIM, China) was proposed by NMC, CSIR-NPLI, SNSU-BSN and SASO (NMCC) respectively. Therefore, NIM decided to pilot the multilateral comparison denoted by APMP.AUV.A-K5.1, which was approved in the 24th APMP TCAUV meeting. This document defines the protocol for the multilateral comparison APMP.AUV.A-K5.1.

2. PARTICIPANTS

The following laboratories have agreed to join APMP.AUV.A-K5.1.

1	NIM, China
2	NMC-A*STAR, Singapore
3	CSIR-NPLI, India
4	SNSU BSN, Indonesia
5	SASO-NMCC, Kingdom of Saudi Arabia

3. MICROPHONES TO BE CIRCULATED

Two LS1P microphones have been selected for this comparison. The microphones are Brüel & Kjær type 4160 with serial numbers 2652767 and 2620606. 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 the pilot laboratory to supply an ATA carnet (or any other documentation) for this purpose, they must inform the pilot laboratory, 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.

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 ℃. Each participant also should inform the pilot laboratory by email when it receives the microphones from the previous participant and when it transports them to the next participant.

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.

4. MEASUREMENTS

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

The microphones require a polarizing voltage of 200 V. Any protection grid fitted to the microphone shall be removed before conducting measurements.

Table 1. Scope of key comparison

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (1/3-octave)	Optional	Optional
20 Hz – 10 kHz (1/12-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 APMP.AUV.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).

In the optional low frequency region, the third-octave calibration frequencies f_n between 2 Hz to 20 Hz shall be calculated from:

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

where n is an integer between –27 and –17.

In the mandatory frequency region the twelfth-octave calibration frequencies f_n between 20 Hz to 10 kHz shall be calculated from[1]:

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

where n is an integer between –68 and 40.

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.

It is expected that most laboratories will fulfill the measurement requirements by implementing reciprocity calibration. Where reciprocity calibration is to be used, this shall be according to 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.

5. PRE-PARTICIPATION

The key comparison is scheduled to begin on 3 Jun. 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' 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.

6. 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 data reported in the proforma spreadsheet is consistent with that reported in the certificates**, as

[1] The twelfth-octave frequencies calculated according to IEC 61260 correspond to the centre frequencies of band-pass filters. However these frequencies do not coincide with the third-octave frequencies normally used in acoustic measurement. In order to maintain consistency with existing data in the KCDB and with laboratories who perform their calibrations at only third-octave frequencies, Eq. (2) specifies lower band edge frequencies of twelfth-octave bands, which do periodically coincide with third-octave frequencies.

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.

Results shall be accompanied by a statement of the associated measurement uncertainty, estimated for a coverage 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 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. Where a frequency dependent analysis is carried out, this summary should cover the whole frequency range, but be limited to the third-octave frequencies only for brevity.

The final results and the accompanying information should be received at the pilot laboratory 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 dispatched. 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 analyzed 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.

7. 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.

8. 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.

Each participating laboratory has been allocated a 4-week period in the schedule. The first three weeks should be used to acclimatize the reference microphones to their laboratory environment and to carry out measurements. During the fourth week, the participating laboratory must finalize their measurements and dispatched the microphones to the next participant or back to the pilot laboratory, 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 the pilot laboratory 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 the pilot laboratory 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 the pilot laboratory will find a substitute, though this may make the analysis of the results more complicated.

9. Linking APMP.AUV.A-K5.1 to CCAUV.A-K5

The APMP.AUV.A-K5.1 key comparison results will be analyzed and then linked to the CCAUV.A-K5 key comparison by using results of NIM served as the linking laboratory, which participated in CCAUV.A-K5. The degree of equivalence (DoE) for each participant relative to the CCAUV.A-K5 KCRV (Key Comparison Reference Value) will be provided, as required in the Mutual Recognition Arrangement (MRA). The DoE between two participants will be also estimated.

The way the results are linked will be decided at the stage of Draft A report by referring to the other RMO key comparison reports.

ANNEX A – PARTICIPANTS

List of contact persons

NIM: Feng Xiujuan National Institute of Metrology, Acoustic Laboratory, No 18, Bei San Huan Dong Lu 100029 Beijing China Tel: +86 10 6452 6238 Email: fxj@nim.ac.cn	**NMC-A*STAR**: Thomas Wu National Metrology Centre (NMC), Agency for Science, Technology and Research (A*STAR) 8 Cleantech Loop, #01-20, 637145 Singapore Tel: +65 6714 9267 Email: thomas_wu@nmc.a-star.edu.sg
CSIR-NPLI Naveen Garg CSIR-National Physical Laboratory New Delhi - 110 012, India Tel: +91-9868377370, 011-45609386 Email: ngarg@nplindia.res.in	**SNSU BSN** Maharani Ratna Palupi, Nurvita Aji SNSU BSN Gedung 420 Kawasan Perkantoran PUSPIPTEK, Tangerang Selatan, Banten, 15314 Indonesia Tel: +6285781089920 Email: maharani.rp@gmail.com
SASO-NMCC Abdulrahman A. Alanazi Saudi Standards, Metrology and Quality Organization/ National Measurement and Calibration Center (SASO-NMCC) PO. B 3437 Riyadh 11471 Kingdom of Saudi Arabia Tel: +966 1 252 9786, +966 53 363 6989 Email: aa.anazi@saso.gov.sa	

Timetable for APMP.AUV.A-K5

NMI	Economy	Receipt of microphone	Dispatch of microphone	Final report Deadline wk	Sep-25				Oct-25					Nov-25				Dec-25					Jan-26					Feb-26				Mar-26				Apr-26					May-26			
					36	37	38	39	40	41	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
NIM	China	1-Sep-25	22-Sep-25	24-Oct-25																																						
NMC	Singapore	29-Sep-25	20-Oct-25	21-Nov-25																																						
SNSU-BSN	Indonesia	27-Oct-25	17-Nov-25	19-Dec-25																																						
NIM	China	24-Nov-25	1-Dec-25																																							
CSIR-NPLI	India	8-Dec-25	12-Jan-26	13-Feb-26																																						
SASO	Saudi Arabia	19-Jan-26	9-Feb-26	13-Mar-26																																						
NIM	China	16-Feb-26																																								
Reports		2-Mar-26																											Prepare DRAFT A											Circulate DRAFT A			

*Dispatch date of microphone to the next participant is tentative. It is the responsibility of the laboratory in possession of the reference microphones to ensure that they reach their destination by the receipt date indicated.

*Taking into account the Christmas and New Year holidays, CSIR-NPLI has been allocated a 6-week period in the schedule.

Agreement to participate

Agreement to participate in APMP.AUV.A-K5.1

Name and address of laboratory

Contact person

Name:
E-mail:
Phone:

Methodology

	IEC 61094-2: 2009
	Other (please give details in Additional Information below)

Scope

Frequency range	Sensitivity level	Sensitivity phase
2 Hz - 20 Hz (N3)		
20 Hz – 10 kHz (N12)		

Will you require an ATA Carnet? Yes ☐ No ☐

The proposed date for participation is acceptable ☐

Additional information (please mention any planned use of gas other than air)

Please return this form to fxj@nim.ac.cn

The pilot laboratory has distributed this form electronically to participating laboratories. A further copy is available by contacting fxj@nim.ac.cn

The completed form shall be returned to the pilot laboratory by 31 January 2025.