

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

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National Institute of Metrology, China  
Center for Measurement Standards, Industrial  
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## 1. BACKGROUND

The key comparison of microphone calibration CCAUV.A-K5, concerning the pressure calibration laboratory standard microphones type LS1P, was completed in May 2013. In APMP region, the need to keep the consistency and link to the KCRV for the calibration of this type of microphone is affirmed in APMP TCAUV meeting in 2016. It was therefore agreed that preparations for the key comparison would be initiated and that National Institute of Metrology (NIM, China) and Center for Measurement Standards, Industrial Technology Research Institute (CMS-ITRI, Chinese Taipei) would be the pilot laboratories. NIM will provide two microphones type LS1P to be circulated and implement the interim calibration in the key comparison. The data analysis and the report will be completed by NIM and CMS-ITRI. The scope should be expanded significantly to agree with CCAUV.A-K5 and to reflect recent developments and experience in APMP. The key comparison has been denoted by APMP.AUV.A-K5.

## 2. PARTICIPANTS

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

1	NIM, China
2	CMS-ITRI, Chinese Taipei
3	KRISS, Korea
4	NMIJ/AIST, Japan
5	NMC-A*STAR, Singapore
6	SCL, Hong Kong, China
7	NMIA, Australia
8	NMIM, Malaysia
9	NIMT, Thailand

## 3. MICROPHONES TO BE CIRCULATED

Two LS1P microphones have been selected for this comparison. The microphones are Brüel & Kjær type 4160 serial numbers 2652762 and 2652765. 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 °C. 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<sup>1</sup>:

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

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 1 Jun. 2020, 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

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<sup>1</sup> 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.

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 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 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 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 one of the pilot laboratories for an interim calibration, typically after calibration by two participating laboratories. The interim calibration will be implemented by NIM to avoid the measurement difference between two pilot 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 to CCAUV.A-K5

The APMP.AUV.A-K5 key comparison results will be analyzed and then linked to the CCAUV.A-K5 key comparison by using results of linking laboratories, namely NIM, NMII, and KRISS, which were all included in the CCAUV.A-K5. The results of these three laboratories will give the degree of equivalence (DoE) for each participant relative to the CCAUV.A-K5 KCRV (Key Comparison Reference Value), 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

<p><b>NIM:</b></p> <p>He Longbiao Feng Xiujuan National Institute of Metrology Acoustic Laboratory No 18, Bei San Huan Dong Lu 100029 Beijing China Tel: +86 10 6452 4630</p> <p>Email: <a href="mailto:helb@nim.ac.cn">helb@nim.ac.cn</a> <a href="mailto:fxj@nim.ac.cn">fxj@nim.ac.cn</a></p>	<p><b>CMS-ITRI:</b></p> <p>Yih-Ming Lu Center for Measurement Standards RM. 101, Bldg. 16, 321, Sec. 2, Kuang Fu Rd. Hsinchu, 30011 Chinese Taipei Tel: +886-3-5732136 ; +886-916-170800</p> <p>Email: <a href="mailto:Yihminglu@itri.org.tw">Yihminglu@itri.org.tw</a></p>
<p><b>KRISS:</b></p> <p>Wan-Ho Cho Korea Research Institute of Standards and Science Division of Physical Metrology 267 Gajeong-ro 34113 Daejeon Republic of Korea Tel: +82 42 868 5872</p> <p>Email: <a href="mailto:chowanho@kriss.re.kr">chowanho@kriss.re.kr</a></p>	<p><b>NMIJ/AIST:</b></p> <p>Hironobu Takahashi Research Institute for Measurement and Analytical Instrumentation, NMIJ/AIST Acoustics and Ultrasonics Standards Group AIST Tsukuba central 3 Umezono 1-1-1, Tsukuba, Ibaraki, 305-8563 Japan Tel: +81-29-861-4131</p> <p>Email: <a href="mailto:h.takahashi@aist.go.jp">h.takahashi@aist.go.jp</a></p>
<p><b>NMC-A*STAR:</b></p> <p>Cui Shan National Metrology Centre, A*STAR 1 Science Park Drive Singapore 118221 Tel: +65 6279 1912</p> <p>Email: <a href="mailto:cui_shan@nmc.a-star.edu.sg">cui_shan@nmc.a-star.edu.sg</a></p>	<p><b>SCL:</b></p> <p>Andrew Au Standards and Calibration Laboratory 36/F., Immigration Tower, 7 Gloucester Road, Wanchai HongKong, China Tel: +852 28294848</p> <p>Email: <a href="mailto:andrew.au@itc.gov.hk">andrew.au@itc.gov.hk</a></p>
<p><b>NMIA:</b></p> <p>Laurence Dickinson National Measurement Institute, NMIA 36 Bradfield Road, West Lindfield NSW 2070, Australia GPO Box 2013, Canberra, ACT, 2601 Australia Tel: +61 2 8467 3759</p> <p>Email: <a href="mailto:Laurence.Dickinson@measurement.gov.au">Laurence.Dickinson@measurement.gov.au</a></p>	<p><b>NMIM:</b></p> <p>Shahrul Nizam Abdul Rashid National Metrology Institute of Malaysia Lot PT 4803, Bandar Baru Salak Tinggi 43900 Sepang Selangor, Malaysia Tel: +603 87781710</p> <p>Email: <a href="mailto:snizam@sirim.my">snizam@sirim.my</a></p>

**NIMT:**

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## Timetable for APMP.AUV.A-K5

NMI	Economy	Receipt of microphone	Dispatch of microphone	Final report Deadline	Jun-20		Jul-20					Aug-20					Sep-20					Oct-20					Nov-20					Dec-20					Jan-21					Feb-21									
					23	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	1	2	3	4	5	6	7	8	9	10							
NIM	China	1-Jun-20	22-Jun-20	24-Jul-20																																															
NMIM	Malaysia	29-Jun-20	20-Jul-20	21-Aug-20																																															
NMIA	Australia	27-Jul-20	17-Aug-20	18-Sep-20																																															
NIM	China	24-Aug-20	31-Aug-20																																																
SCL	Hong Kong, China	7-Sep-20	28-Sep-20	30-Oct-20																																															
NMIJ/AIST	Japan	5-Oct-20	26-Oct-20	27-Nov-20																																															
NIM	China	2-Nov-20	9-Nov-20																																																
NIMT	Thailand	16-Nov-20	7-Dec-20	8-Jan-21																																															
CMS-ITRI	Chinese Taipei	14-Dec-20	18-Jan-21	19-Feb-21																																															
NIM	China	25-Jan-21	1-Feb-21																																																
KRISS	Korea	8-Feb-21	1-Mar-21	2-Apr-21																																															
					Mar-21		Apr-21					May-21					Jun-21					Jul-21					Aug-21					Sep-21					Oct-21					Nov-21					Dec-21				
				wk	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	42	43	44	45	46	47	48	49	50							
NMC-A*STAR	Singapore	8-Mar-21	29-Mar-21	30-Apr-21																																															
NIM	China	5-Apr-21																																																	
Reports		19-Apr-21							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, CMS-ITRI has been allocated a 6-week period in the schedule.

## Agreement to participate

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

Name and address of laboratory

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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 (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)

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[Please return this form to fxj@nim.ac.cn](mailto: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](mailto:fxj@nim.ac.cn)

The completed form shall be returned to the pilot laboratory by 1 December 2019.