Technical Protocol of the APMP Key Comparison

APMP.AUV.V-K1.1

1. Task and purpose of the comparison

In the field of vibration and shock, this regional comparison is organized in order to compare measurements of sinusoidal linear accelerations in the frequency range from 40 Hz to 5 kHz. Moreover, the magnitude of the complex sensitivity calibration and measurement capabilities (CMCs) of the NMIs for accelerometer calibration are to be examined and compared and linked to the CIPM comparison CCAUV.V-K1. It is the task of the comparison to measure the magnitude of the complex sensitivity of two accelerometer standards (two piezoelectric accelerometers of back-to-back type and single ended type) at different frequencies with acceleration amplitudes as specified in section 4. The results of this APMP KC will, after approval for equivalence, be linked to CCAUV.V-K1 as the foundation for the registration of “calibration and measurement capabilities” (CMC) in the framework of the CIPM MRA.

The charge sensitivity is calculated as the ratio of the amplitude of the accelerometer output charge to the amplitude of the acceleration at its reference surface. The magnitude of the complex charge sensitivity shall be given in pico coulomb per metre per second squared (pC/(m/s²)) for the different measurement conditions specified in section 4. A calibrated charge amplifier is to be used to measure the output charge of the accelerometer standards, applying appropriate electrical calibration methods.

For the calibration of the accelerometer standards, laser interferometry in compliance with any method from methods 1, 2, and 3 of the international standard ISO 16063-11:1999 has to be applied, in order to cover the entire frequency range.

The reported sensitivities and associated uncertainties will, after approval for equivalence, be used for the calculation of the “degrees of equivalence” (DoE) between the participating NMI and the key comparison reference value.

2. Pilot laboratory

Pilot laboratory for this Key Comparison, who had also participated in CCAUV.V.K-1, is

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Acoustics and Vibration Metrology Division

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3. Participants

Three National Metrology Institutes (NMIs) of APMP will participate in the comparison.

Participant number	Participant (laboratory name)	Acronym	Country	Country Code	Planed calibration period
1	National Metrology Institute of Japan	NMIJ	Japan	JP	October
2	Center for Measurement Standards/Industrial Technology Research Institute	CMS/ITRI	Chinese Taipei	TW	November (Nov. 22-Dec.17)
	National Metrology Institute of Japan	NMIJ	Japan	JP	Interim check
3	National Institute of Metrology Thailand	NIMT	Thailand	TH	January (Jan.17-Feb.11)
4	National Metrology Centre, Agency for Science, Technology and Research	NMC, A*Star	Singapore	SG	February (Feb. 21-Mar. 18)

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4. Devices under Test and Measurement conditions

For the calibration task of this KC, a set of two piezoelectric accelerometers with connecting cable will be circulated among the participating laboratories. The individual transducers being a “single ended” (SE) type, namely a Brüel & Kjær 8305-001 and a “back to back” (BB) type, namely a Brüel & Kjær 8305. . No additional mass shall be attached to the top surface of BB type accelerometer

The accelerometers are to be calibrated for their complex charge sensitivity according to those procedures and conditions implemented by the NMI in conformance with ISO 16063-11 which provide magnitude information of the artefact. The sensitivities reported shall be for the accelerometers alone, excluding any effects from the charge amplifier.

The frequency range of the measurements was agreed to be from 40 Hz to 5 kHz. Specifically the laboratories are supposed to measure at the following frequencies (all values in Hz):

40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, 5000 (160 Hz is reference frequency).

The charge amplifier (CA) used for the calibration is not provided within the set of the artefacts, it must therefore be provided by the individual participant.

The measurement condition should be kept according to the laboratory's standard conditions for calibration of customer accelerometers for claiming their CMCs. This presumes that these conditions comply with those defined by the applicable ISO standards [references 1, 2 and 3], simultaneously.

Specific conditions for the measurements of this KC are:

- acceleration amplitudes: A range of 10 m/s^2 to 200 m/s^2 is admissible.
- ambient temperature and accelerometer temperature during the calibration: (23 ± 2) ºC (actual values to be stated within tolerances of ± 0.3 ºC).
- relative humidity: max. 75 %
- mounting torque of the accelerometer: (2.0 ± 0.1) N·m

5. Circulation and Transportation

The transducers will be circulated with a measurement period of four weeks for each participant. At the beginning and the end of the circulation, the transducers will be measured at the pilot laboratory in order to fix reference value and to monitor the stability of the transducers.

The cost of transportation to and from a participating laboratory shall be covered by the participating laboratory. The accelerometers have to be sent by an international logistic service system. Insurance of transfer devices is decided by agreement among the participants taking account of the responsibility of each participant for any damage in its country.

6. Measurement and Analysis Instructions

The participating laboratories have to observe the following instructions:

- The charge amplifier used in the laboratory is to be calibrated using a standard capacitor and standard voltmeter, both traceable to national standards. The

calibration of the charge amplifier has to be carried out shortly before the calibration, using values of the electric quantities similar to those expected in the accelerometer calibration.

- In order to suppress the effect of any non-rectilinear motion, the displacement has to be measured at least at four different points. These points should be equally spaced on the top surface of the back-to-back accelerometer or the basis surface of the single-ended accelerometer.
- Primary calibration of BB accelerometer by laser interferometry: The motion is to be sensed at the top surface of the transducer without any additional reflector or dummy mass..
- Primary calibration of SE accelerometer by laser interferometry: The reference surface for acceleration measurement is by definition the base or mounting surface of the accelerometer. If this surface is covered during the calibration, the motion is to be sensed on the moving part close to the accelerometer. Alternatively, the motion can be sensed at the mounting surface of the accelerometer via longitudinal holes in the moving part of the vibration exciter. ISO 16063-11 is to be observed.
- The mounting surface of the accelerometer and the moving part of the vibration exciter must be slightly lubricated before mounting.
- It is advised that the measurement results should be compiled from complete measurement series (normally twice) carried out at different days under nominally the same conditions, except that the accelerometer is remounted and the cable reattached. The standard deviation of the subsequent measurements should be included in the report.

7. Communication of the Results to the Pilot laboratory

Each participating laboratory will submit one printed and signed calibration report for each accelerometer to the pilot laboratory including the following:

- a description of the calibration systems used for the comparison and the mounting techniques for the accelerometer
- a description of the calibration methods used
- documented record of the ambient conditions during measurements
- the calibration results, including the **relative expanded** measurement uncertainty, and the applied coverage factor for each value
- a detailed uncertainty budget for the system covering all components of measurement uncertainty (calculated according to GUM (references 4 and 5) and ISO (reference 2)). Including among others information on the type of uncertainty (A or B), assumed distribution function and repeatability component.

In addition each participating laboratory will receive two electronic spreadsheets prepared by the pilot laboratory, where the calibration results have to be filled in following the structure given in the files. The consistency between the results in electronic form and the printed and signed calibration report is the responsibility of the participating laboratory. The data submitted in the electronic spreadsheet shall be deemed to be the official results submitted for the comparison.

The results have to be submitted to the pilot laboratory within six weeks after the

measurements.

The pilot laboratory will submit its set of results to the executive secretary of CCAUV prior to the first measurement of a participating laboratory.

8. Remarks on the post processing

- Presuming consistency of the results, the degrees of equivalence will be calculated according to the established methods agreed already for CCAUV.V-K1.

9. References

[1] ISO 16063-1:1998 “Methods for the calibration of vibration and shock transducers -- Part 1: Basic concepts

[2] ISO 16063-11:1999 “Methods for the calibration of vibration and shock transducers -- Part 11: Primary vibration calibration by laser interferometry”

[3] ISO/IEC 17025:2005 “General requirements for the competence of testing and calibration laboratories”

[4] ISO/IEC Guide 98-3:2008 “Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

[5] ISO/IEC Guide 98-3:2008/Suppl 1:2008 “Propagation of distributions using a Monte Carlo method”