Technical Protocol of the APMP Key Comparison

APMP.AUV.V-K1.2

1 Task and Purpose of the Comparison

In the field of vibration and shock, this regional key comparison is organized in order to compare measurements of sinusoidal linear accelerations in the frequency range from 40Hz 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 method 1 or method 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 then supposed to be used for the calculation of the 'degrees of equivalence' (DoE) between the participating NMIs and the key comparison reference value.

2 Pilot Laboratory

Pilot laboratory for this regional key comparison, which has also participated in CCAUV.V.K-1.1, is

Vibration and Shock Section
Mechanics and Acoustics Metrology Division
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This is the delivery address for the set of artefacts and the written and signed reports.

Contact Persons are

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3 Schedule

The schedule is planned as follows:

NMIs	Date of receipt of artefacts from the previous participant	Period for calibration	Date of sending the artefacts to the next participant
NIM		2 weeks	September 20, 2009
KIM-LIPI	October 01, 2009	4 weeks	October 29, 2009
NIM	November 10, 2009	2 weeks	November 15, 2009
NPLI	November 25, 2009	4 weeks	December 23, 2009
NIM	January 03, 2010	2 weeks	

Note:

Date of sending the artefacts to the next participant is tentative. It is scheduled to take about 10 days to send the artefacts to the next participant.

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4 Device under Test and Measurement Conditions

For the calibration task of this KC a set of two piezoelectric accelerometers will be circulated between the participating laboratories. The individual transducers being a 'sing ended' (SE) type, namely a Brüel & Kjær 8305-001 (SN: 2519436), and a 'back to back' (BB) type, namely a Brüel & Kjær 8305 S (SN: 2440139).

The accelerometers are to be calibrated of their complex charge sensitivity according to those procedures and conditions implemented by the NMI in conformance with ISO 16063-11 which provides 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.

The charge amplifier (CA) used for the calibration is not provided within the set of 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 customers' accelerometers for claiming their best measurement capability or CMC where applicable. This presumes that these conditions comply with those defined by the applicable ISO documentary standards [1,2,3], 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 ± 0.3ºC).
- relative humidity: max. 75 %
- mounting torque of the accelerometer: (2.0 ±0.1) N·m

5 Circulation and Transportation

The transducers are circulated with a measurement period of four weeks provided for each participant. At the beginning and the end of the circulation as well as between two subsequent measurements of any participating laboratory, the transducers are measured at the pilot lab 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 send by an international logistic service providing a tracking system. The transportation has to include an insurance covering a value of 9 000,- € in case the set of accelerometers gets damaged or lost during transportation.

6 Measurement and Analysis Instruction

The participating laboratories have to observe the following instructions:

- The charge amplifier used in the laboratory is to be calibrated with equipment traceable to national standards.
- The motion of the BB accelerometer should be measured with the laser directly on the (polished) top surface of the transducer without any additional reflector or dummy mass.
- The motion of the SE accelerometer should be measured on the moving part of the vibration exciter, close to the accelerometer's mounting surface, since the mounting (reference) surface is usually not directly accessible.
- The mounting surface of the accelerometer and the moving part of the exciter must be slightly lubricated before mounting.
- The cable between accelerometer and charge amplifier should be taken from the set of DUT delivered to the laboratory.
- In order to reduce the influence of non-rectilinear motion, the measurements should be performed for at least three different laser positions which are symmetrically distributed over the respective measurement surface.
- It is advised that the measurement results should be compiled from complete measurement series 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 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 [4,5]). 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 use of the electronic spreadsheets for reporting is mandatory, 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 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 in advance to the first measurement of the participating laboratory.

8 Remarks on post processing

Presuming consistency of the results, the degrees of equivalence will be calculated according to the established methods agreed upon already for CCAUV.V-K1. The results of this APMP KC will, after approval for equivalence, be linked to CCAUV.V-K1 via pilot laboratory as the foundation of the participating NMIs for their registration of 'calibration and measurement capabilities' (CMC) in the framework of the CIPM MRA.

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'