Technical Protocol of the APMP Key Comparison

APMP.AUV.V-K3

This comparison was initially registered as APMP.AUV.V-S1, but was redefined as APMP.AUV.V-K3 in November 2013

1 Task and Purpose of the Comparison

According to the rules set up by the CIPM MRA the consultative committees of the CIPM have the responsibility to establish 'degrees of equivalence' (DoE) between the different measurement standards operated by the national NMIs. This is done by conducting key comparisons (KC) on different levels of the international metrological infrastructure. The previous top level KC in the field of Vibration metrology, CCAUV.V-K1 was completed in the year 2001 in the frequency range from 40 Hz to 5 kHz. The ongoing CCAUV.V-K2 is aimed at frequency range from 10 Hz to 10 kHz.

However, recent developments in technology and improvements at the NMIs have extended the low-frequency vibration limit of calibration capabilities down to 0.5 Hz and even 0.1 Hz. Therefore during the meeting of APMP TCAUV in 2008, the decision was taken to make preparations for a further comparison targeted at a low-frequency range.

In the field of vibration, this regional key comparison is organized in order to compare measurements of sinusoidal linear accelerations in the frequency range from 0.5 Hz to 20 Hz. Moreover, the magnitude of the complex sensitivity calibration and measurement capabilities (CMCs) of the participating laboratories for accelerometer calibration are to be examined and compared. It is the task of the comparison to measure the magnitude of the complex sensitivity of two accelerometer standard sets (one set including a quartz-flexure servo accelerometer of single-ended type and a signal conditioner) at different frequencies with acceleration amplitudes as specified in section 3. The results of this APMP Comparison will, after approval by CCAUV, serve as the foundation at low vibration frequency for the registration of 'calibration and measurement capabilities' (CMC) in the framework of the CIPM MRA.

The voltage sensitivity is calculated as the ratio of the amplitude of the accelerometer standard set output voltage to the amplitude of the acceleration at its reference surface. The magnitude of the complex voltage sensitivity shall be given in milli volt per meter per second squared (mV/(m/s^2)) for the different measurement conditions specified in section 4.

For the calibration of the accelerometer standard sets, 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 be used for the calculation of the key comparison reference value.

2 Pilot Laboratory

Pilot laboratory for this regional key comparison is

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Mechanics and Acoustics Metrology Division
National Institute of Metrology, P.R. China
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Co-Pilot laboratory for this regional key comparison is

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3 Device under Test and Measurement Conditions

For the calibration task of this comparison two quartz-flexure accelerometer sets will be circulated between the participating laboratories. The accelerometer sets are a ‘single ended’ (SE) type, namely a SA 704 (SN: 1022) and a SA 704 (SN: 1022), with one common signal conditioner MSA-I (SN: 02011001).

The accelerometer sets are to be calibrated of their complex voltage sensitivity according to those procedures and conditions implemented by the laboratory in conformance with ISO 16063-11 which provides magnitude information of the artefact. The sensitivities reported shall be for the accelerometer sets, including all effects from the signal conditioner.

The frequency range of the measurements was agreed to be from 0.5 Hz to 20 Hz. Specifically the laboratories are supposed to measure at the following frequencies (all values in Hz).

0.5, 0.63, 0.8, 1, 1.25, 1.6, 2, 2.5, 3.15, 4, 5, 6.3, 8, 10, 12.5, 16, 20.

The measurement conditions 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 comparison are:

- acceleration amplitudes: a range of 0.1 m/s^2 to 10 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 % RH

4 Circulation Type, Schedule and Transportation

The transducer sets are circulated in a star type fashion with a measurement period of two weeks provided for each participating laboratory and one week for the pilot laboratory. At the beginning and the end of the circulation as well as between certain subsequent measurements of participating laboratories, the transducer sets are measured at the pilot laboratory in order to fix reference values and to monitor the stability of the transducer sets.

The schedule is planned as follows:

Participant	Measurement (calendar week)	Transportation to next Participant (calendar week)
NIM	23/2011	24/2011
NMIJ	25-26/2011	27/2011
KRISS	28-29/2011	30/2011
NIM	31/2011	32/2011
NIMT	33-34/2011	35/2011
CMS	36-37/2011	38/2011
NIM	39/2011	40/2011
NMIA	41-42/2011	43/2011
NMISA	44-45/2011	46/2011
NIM	47/2011	

The cost of transportation to the next participating laboratory shall be covered by the participating laboratory. The transducer sets have to be sent hand-carried with great caution. In case the transducer sets get damaged or lost during transportation, the participating laboratory for delivery should pay 4 000,- € to pilot laboratory for each set.

5 Measurement and Analysis Instructions

The participating laboratories have to observe the following instructions:

- The motion of the quartz-flexure accelerometer should be measured on the moving part of the vertical (preferably) or horizontal 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 signal conditioner should be taken from the set 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 re-attached. The standard deviation of the subsequent measurements should be included in the report.

6 Communication of the Results to Pilot Laboratory

Each participating laboratory will submit one printed and signed calibration report for each accelerometer set 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, 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 have been completed.

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.

7 Remarks on post processing

Presuming consistency of the results, the comparison reference value will be calculated according to the established methods agreed upon already for CCAUV.V-K1. The results of this APMP comparison will serve as the foundation of the registration of ‘calibration and measurement capabilities’ (CMC) for low-frequency vibration by the participating NMIs 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