Technical Protocol for SIM.AUV.V-K5 & SIM.AUV.V-S1

2023-05-03

Task and Purpose of the Comparison

The Centro Nacional de Metrología (CENAM, Mexico) is motivated to participate in the bilateral comparison SIM.AUV.V-K5 to confirm technical competence and get evidence to support CENAM's CMCs for primary calibration of vibration transducers.
CENAM and the Instituto Nacional de Calidad (INACAL, Peru) are motivated to participate in the trilateral comparison SIM.AUV.V-S1 to confirm their technical competence and provide evidence to establish CMCs in secondary calibration.
Physikalisch-Technische Bundesanstalt (PTB) will be acting as pilot and linking laboratory, as it had taken part in the global CCAUV.V-K5.
The reported sensitivities and associated uncertainties are then to be used for the calculation of the Degrees of Equivalence (DoE) between CENAM, INACAL and the CCAUV.V-K5 KCRVs. CENAM and INACAL will be linked to the KCRV of this former comparison via the pilot laboratory. The results of the comparison will be used to provide additional support to the revised CMCs to get compatibility with the results of the CCAUV.V-K5. These results are expected to serve as evidence to be the foundation for the registration of the CMCs of CENAM and INACAL considering primary and secondary calibration of vibration transducers, as applicable.
Although separated in two distinct RMO-comparisons the measurements will be performed with a single set of artifacts, which is the reason to combine the technical protocols into a single document.

SIM.AUV.V-K5

The specific task of this bilateral comparison is to measure magnitude and phase of the complex charge sensitivity of two different accelerometers at specified frequencies with primary means i.e., according to ISO 16063-11 "Methods for the calibration of vibration and shock transducers – Part 11: Primary vibration calibration by laser interferometry".

SIM.AUV.V-S1

The specific task is the measurement of the magnitude of the charge sensitivity of the same set of accelerometers at specified frequencies with secondary means i.e., according to ISO 16063-21 "Methods for the calibration of vibration and shock transducers – Part 21: Vibration calibration by comparison to a reference transducer".

Note 1: Pilot laboratory will measure only by primary means.
Note 2: SIM.AUV.V-K5 will be linked to the CCAUV.V-K5.

Participants

SIM.AUV.V-K5:

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SIM.AUV.V-S1

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Devices under Test

For the calibration tasks of both comparisons, a set of two piezoelectric accelerometers will be circulated among the participating laboratories. The individual transducers are:

- a Brüel & Kjær 8305-001 (SN: 2825607) “single ended” (SE) type
- a Brüel & Kjær 8305 S (SN: 895042) “back-to-back” (BB) type.

Figure 1. Devices under test

Conditions of measurement

SIM.AUV.V-K5 Primary means (ISO 16063-11)

The accelerometers are to be calibrated for magnitude and phase of their complex charge sensitivity according to those procedures and conditions implemented by the NMI in conformance with ISO 16063-11, which provide magnitude and phase information of the artefact. The sensitivities reported shall be for an accelerometer alone, excluding any effects from the charge amplifier used for signal conditioning.
The frequency range of the measurements was agreed to be from 10 Hz to 20 kHz. Specifically, the laboratories are supposed to measure at the following frequencies (all values in Hz):

10, 12.5, 16, 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, 10 000, 11 000, 12 000, 13 000, 14 000, 15 000, 16 000, 17 000, 18 000, 19 000, 20 000.

The charge amplifier used for the calibration is not provided within the set of the artifacts, it must therefore be provided by the individual participant and calibrated properly. As a guideline for calibration the document “Calibration of conditioning amplifiers for dynamic application: Guideline DKD-R 3-2” shall be used (https://doi.org/10.7795/550.20190425EN). The simplified Method presented in section 3.2.1 shall be used by both participants using a 100 pF standard capacitor.

The calibrations shall be carried out in accordance with the usual procedure of the laboratory for the calibration of customer accelerometers, except as otherwise indicated in this protocol.

The SE type accelerometer is mounted on a mechanical adapter, which was designed and manufactured according to the drawing below:

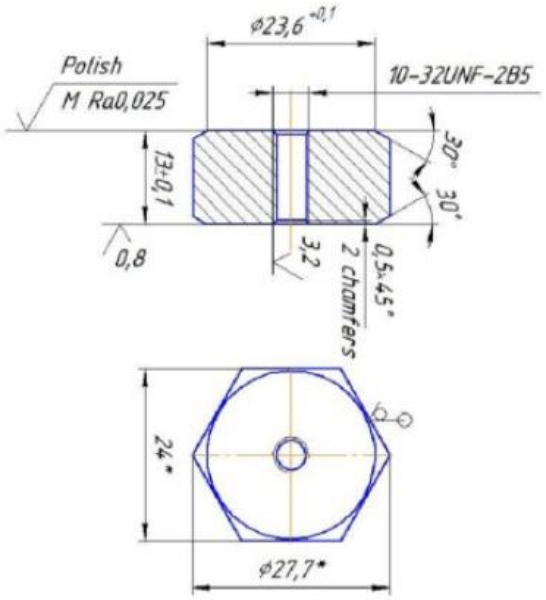

Figure 2. Mechanical adapter for SE type accelerometer (all dimensions in mm)

SIM.AUV.V-S1 Secondary means (ISO 16063-21)

The accelerometers are to be calibrated for magnitude of their complex charge sensitivity according to those procedures and conditions implemented by the NMI in conformance with ISO 16063-21, which provide magnitude information of the artefact. The sensitivities reported shall be for an accelerometer alone, excluding any effects from the charge amplifier.

The frequency range of the measurements was agreed to be from 10 Hz to 10 kHz. Specifically, the laboratories are supposed to measure at the following frequencies (all values in Hz):
10, 12.5, 16, 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, 10 000.

The charge amplifier used for the calibration is not provided within the set of the artifacts, it must therefore be provided by the individual participant and calibrated properly. As a guideline for calibration the document “Calibration of conditioning amplifiers for dynamic application: Guideline DKD-R 3-2” shall be used (https://doi.org/10.7795/550.20190425EN). The simplified Method presented in section 3.2.1 shall be used by the secondary laboratory of CENAM using a 100 pF standard capacitor.

The calibrations shall be carried out in accordance with the usual procedure of the laboratory for the calibration of customer accelerometers, except as otherwise indicated in this protocol.

For comparison calibration, the mechanical adapter should not be used. The measurements for comparison method shall be carried out after the conclusion of the primary calibrations by laser interferometry.

PTB takes part in SIM.AUV.V-S1 as linking laboratory using the calibration results from the primary calibration by laser interferometry acquired in SIM.AUV.V-K5 (c.f. previous section)

General Specifications:
Specific conditions for the measurements are:

- Acceleration amplitudes: preferably 50 m/s² to 100 m/s² but a range of 2 m/s² to 200 m/s² is admissible for both, primary and secondary means.
- Ambient temperature and accelerometer temperature during the calibration: (23 ± 3) 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.

Measurement instructions

SIM.AUV.V-K5 Primary means (ISO 16063-11)

- The measurand is the magnitude and phase of the complex charge sensitivity.
- The motion of the SE accelerometer shall be measured on the polished top surface of the mechanical adapter, close to the accelerometer's mounting surface since the mounting (reference) surface is usually not directly accessible.
- The motion of the BB accelerometer mounted in the normal position shall be measured with the laser directly on the (polished) top surface of the transducer without any additional reflector or dummy mass.
- The mounting surfaces of the accelerometer and the moving part of the exciter shall be slightly lubricated before mounting.
- The cable between the accelerometer and charge amplifier will be provided by the pilot laboratory (PTB).
- To reduce the influence of non-rectilinear motion, the measurements shall be performed for at least four different laser positions, which are equally spaced over the respective measurements surface.
- It is advised that the measurement results shall be compiled from complete measurement series carried out on 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.
- The charge amplifier used for the measurement of the accelerometer's response shall be calibrated with the equipment traceable to national measurements standards and the method used shall be reported.

SIM.AUV.V-S1 Secondary means (ISO 16063-21)

- The measurand is the magnitude of the complex charge sensitivity.
- No mechanical adapters shall be used for the accelerometer calibrations.
- The SE type accelerometer shall be calibrated against a reference accelerometer previously calibrated by primary means.
- The BB type accelerometer shall be calibrated with a SE accelerometer previously calibrated by primary means.
- The mounting surfaces of the accelerometers and the moving part of the exciter shall slightly be lubricated before mounting.
- The cable between the accelerometer and charge amplifier will be provided by the pilot laboratory (PTB).
- It is advised that the measurement results shall be compiled from complete measurement series carried out on 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.
- The charge amplifier used for the measurement of the accelerometer's response shall be calibrated with the equipment traceable to national measurements standards.

Communication of the results

The pilot laboratory will provide a spreadsheet template to all participants in which the reported results will be transferred to the pilot.
In addition, the participants will provide a PDF of their result spread sheet in order to avoid or detect any transmission errors, a tabulated uncertainty budget covering all calibration done within the scope of the relevant comparison, a description of the used calibration equipment.

These documents must be submitted to the pilot laboratory within six weeks after the measurements.

Circulation type

The set of artifacts is at PTB since June 2022. PTB will start the loop of the comparison measurements within SIM.AUV.V-K5. Then the artifacts be primary calibrated at CENAM followed by the secondary calibration at CENAM for SIM.AUV.V-S1. Finally, INACAL will receive the same set of artifacts for their calibration in the scope of SIM.AUV.V-S1

The cost of transportation between PTB and CENAM will be covered by CENAM. As an alternative, the artifacts may be hand carried by a member of the participating laboratory.

From CENAM to INACAL and back: The cost of transportation will be covered by INACAL. As an alternative, the artifacts may be hand carried by a member of the participating laboratory.

Time schedule

The measurement period is 4 weeks for both devices for primary means and 4 weeks for secondary means (both devices). The schedule is planned as follows

Participant	**Measurement (Calendar week)**
PTB	44-47 / 2023
Transportation	48 / 2023
CENAM (primary)	49-50 / 2023 and 01-02 / 2024
CENAM (secondary)	03-06 / 2024
Transportation	07 / 2024
INACAL (secondary)	08-11 / 2024