TECHNICAL PROTOCOL
FOR EURAMET.AUV.V-K2 COMPARISON

(vibration acceleration)

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1. Introduction

The Bulgarian Institute for Metrology (BIM) - National Metrology Institute in Bulgaria in the field of vibration has forwarded to the Central Office of Measures (GUM) the request for bilateral comparison concerning the primary calibration of vibration transducers and asked GUM to pilot the comparison.

BIM is motivated to participate in this bilateral comparison in order to confirm technical competence and to get evidences to support BIM CMCs for primary calibration of vibration transducers. The last comparison in which BIM took part was EUROMET.AUV.V-K1.1 in 2006. Since this period, situation in BIM has changed as BIM lost expertise. GUM participated in the CCAUV.V-K2 and is hence in position to provide linking to other institutes.

The comparison will be registered as EURAMET.AUV.V-K2 key comparison. It is intended to disseminate the KCRV established in CCAUV.V-K2 comparison to BIM.

This document outlines the devices and the conditions for this bilateral comparison with GUM as pilot and is in line with the Technical Protocol of CCAUV.V-K2. It should be applied in conjunction with the CIPM MRA-D-05 document.

2. Participants

The following two laboratories are the participants of this bilateral comparison:

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3. Aim and task of the comparison

The aim of this bilateral EURAMET comparison is to measure the magnitude sensitivity of two standard accelerometers with primary means in accordance with ISO 16063-11 "Methods for the calibration of vibration and shock transducers -- Part 11: Primary vibration calibration by laser interferometry". The reported sensitivities and associated uncertainties are then to be used for the calculation of the Degrees of Equivalence (DoE) between the participating NMIs. One laboratory (GUM) will be acting as pilot and linking laboratory, as it had taken part in the CCAUV.V-K2. The second participant (BIM) will be linked to the KCRV of this former comparison via the pilot laboratory. The results of the comparison will be used as an evidence to be the foundation for the registration of their CMCs considering primary calibration of vibration transducers.
In the frame of this EURAMET comparison, the magnitude of charge sensitivity of two standard accelerometers, a single-ended (SE) and back-to-back (BB), will be measured at different frequencies and acceleration amplitudes as specified in clause 3. The charge sensitivity shall be calculated as the ratio of the amplitude of the output charge of the accelerometer to the amplitude of the acceleration at its reference surface. The reference surface is the base/mounting surface of the accelerometer of single-ended design and the top surface of the accelerometer of back-to-back design. The magnitude of complex charge sensitivity shall be given in picocoulombs per meters per second squared: $pC/(m/s^2)$.

4. Device under test

As transfer standards two piezoelectric accelerometers are to be used:

- standard accelerometer (single-ended, SE) BK type 8305 WH2335 SN 2208358
- standard accelerometer (back-to-back, BB) BK type 8305 SN 1655958.

Both accelerometers will be provided by GUM (property of GUM).

5. Conditions of measurement

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 16063-11 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 1 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.

The charge amplifier used for the calibration is not provided within the set of the artefacts, it must therefore be provided by the individual participant and calibrated properly.

The calibrations should be carried out in accordance with the usual procedure of the laboratory for the calibration of customer accelerometers.

Specific conditions for the measurements are:

- acceleration amplitudes: 5 m/s^2 to 70 m/s^2.
- 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) Nm.

6. Measurement instructions

- The measurand is the magnitude of the complex charge sensitivity.
- 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 motion of the BB accelerometer mounted in the normal position should 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 slightly be 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 equally spaced over the respective measurements 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.
- The charge amplifier used for the measurement of the accelerometer's response should be calibrated with the equipment traceable to national measurements standards.

7. Communication of the results

For transparency, GUM will perform an initial calibration of the accelerometers and submit the calibration results to the EURAMET AUV secretary before sending the artefacts to BIM. BIM shall perform calibration of the artefacts and submit its calibration report to the EURAMET AUV secretary as well as the pilot laboratory within 4 weeks after the calibration.

The calibration report shall contain detailed description of:

- the calibration equipment
- the calibration method(s) used
- the ambient conditions
- the mounting technique

- the calibration results including the relative expanded uncertainty
- the uncertainty budget

In addition to the calibration report, the measurements results shall be submitted to the pilot laboratory by electronic mail, with the data in Excel format.

For reporting the calibration results, clause 10 of ISO 16063-11:1999 shall be taken into account. For uncertainty, the following instructions are given:
The list(s) of the principal components of the uncertainty budget shall be in accordance with ISO 16063-11:1999, Annex A for the primary calibration by laser interferometry. In each case, the uncertainties shall be determined in accordance with the Guide to the expression of uncertainty in measurement.

8. Circulation type

From GUM to BIM and back: GUM will send the accelerometers to BIM. BIM calibrates the accelerometers and send them back to GUM, which will perform its own calibration.

9. Time schedule

- Calibration and transportation time period: a total time period of 4 weeks is allocated for each laboratory covering both calibration and transportation.
- Total circulation period: 2 months
- Start of circulation period: April 2019
- End of circulation period: June 2019
- Final report: 2019.

10. Transportation and financial aspects

The transfer standards will be transported in a closed box by an international transportation service (e.g. TNT, UPS). The transportation has to include an insurance covering a value of 9.000,-euro in the case the set of accelerometers gets damaged or lost during transportation.

Each participating laboratory is responsible for its own costs of measurements, transportation as well as any damage that may occur within its country. Pilot laboratory is responsible for other costs of the organization of the comparison.

11. Linking

The results of the BIM obtained in this comparison will be linked to the CCAU V.V-K2 key comparison through GUM. The degrees of equivalence will be compu ted for Bulgaria with respect to the CCAUV.V-K2 KCRV by linking both sensor' s results to the one SE sensor results as no KCRV was determined for the BB a mplitude sensitivity.