Technical Protocol of the EURAMET Supplementary Comparison

EURAMET.AUV.V-S2

2021-08-30

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 Metrology Institutes (NMI).

The specific task of this RMO comparison is to measure the magnitude of the charge sensitivity of an accelerometer 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”. METAS will perform a primary calibration according to ISO 16063-11 “Methods for the calibration of vibration and shock transducers – Part 11: Primary vibration calibration by laser interferometry”. The results of the METAS calibration will provide the reference value. The reported sensitivities and associated uncertainties are then supposed to be used for the calculation of the DoE between the participating NMI and the primary calibration value of METAS.

Pilot and Co Pilot Laboratories

Pilot laboratory for this Supplementary RMO Comparison is

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Devices under Test and Measurement Conditions

For the calibration task of this supplementary comparison a piezoelectric accelerometer will be circulated among the participating laboratories:

• Endevco 2270M8 (SN: 14612) “single ended” (SE) type

Fig. 1. Endevco 2270 type accelerometer

The accelerometer is to be calibrated for magnitude of the complex charge sensitivity according to those procedures and conditions implemented by the NMI in conformance with ISO 16063-21. If phase calibration is desired, it may be included since METAS will perform a primary calibration according to ISO 16063-11, including phase calibration.

The sensitivities reported shall be for the 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, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800,
1 000, 1 250, 1 600, 2 000, 2 500, 3 150, 4 000, 5 000, 6 300, 8 000, 10 000

Note: this set does deviate from the standard frequencies of ISO 266.

The charge amplifier (CA) used for the calibration is not provided within the set of the artifact, 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 best achievable CMC. This presumes that these conditions comply with those defined by the applicable ISO documentary standards [1, 2], simultaneously.

Specific conditions for the measurements of this comparison are:

- Acceleration amplitudes: preferably 50 m/s² to 100 m/s², a range of 2 m/s² to 200 m/s² is admissible.
- Ambient temperature during the calibration:
  (23 ± 2) ºC (actual values to be stated within tolerances of ± 0.3 ºC).
- Relative humidity: max. 75 %rh
- Mounting torque of the accelerometer: (2.0 ± 0.1) N·m

Circulation Type, Schedule and Transportation

A measurement period of three weeks is provided for each participant plus one week for transportation. The transducers are measured at METAS in order to monitor the long-term stability. The schedule is planned as follows starting in fall 2021:

METAS→ BEV→ METAS

For transportation, the artifact is packed in a protective box, which in turn is put into a card-board container. The cost of transportation shall be covered by the participating laboratories, except METAS. The accelerometers have to be sent by an international logistic service

providing a tracking system. The transportation has to include an insurance covering a total value of € 6.000, in case the accelerometer gets damaged or lost during transportation. As an alternative the artifact may be hand carried by a member of the participating laboratory.

Handling, Measurement and Analysis Instructions

The participating laboratories have to observe the following instructions:

- Any instrument used for the measurement of the accelerometer's response has to be calibrated with equipment traceable to national measurement standards.
- The mounting surface of the accelerometers and the moving part of the exciter must be slightly lubricated before mounting.
- The cable between accelerometer and charge amplifier must be a Brüel & Kjaer, 10-32 UNF (M) to 10-32 UNF (M) 1.2 m cable (Fig.2).

Fig. 2. Brüel & Kjaer, 10-32 UNF (M) to 10-32 UNF (M) 1.2 m cable

Note:

In contrast to almost simultaneously performed CCAUV.V-K5 no mechanical adapter is provided and none should be used for the single-ended accelerometer calibration. This is, because, opposed to the Laser measurement in primary calibration the accuracy of the secondary calibration relies on the direct proximity of the reference surfaces of reference accelerometer and device under test. Where, for single ended calibration the reference surface is typically given by a back-to-back reference or by an instrumented and calibrated shaker armature.

Communication of the Results to the Pilot Laboratory

Each participating laboratory will submit one printed and signed calibration report to METAS including the following:

- a description of the calibration systems used and the mounting techniques for the accelerometer,
- a description of the calibration methods used,
- a description of the mounting method (simple screw, tripod, etc.) of the transfer standards to the reference sensor and the type of reference sensor (back-to-back sensor, built-in sensor of the shaker, etc.),
- a 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, [2]). Including among others information on the type of uncertainty (A or B), assumed distribution function and repeatability component,
- A record of the traceability chain of the laboratories' used reference accelerometers up to the primary source of acceleration traceability.

In addition, each participating laboratory will receive an electronic spreadsheet 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 spreadsheet 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.

Ensuring formally the impartiality may be a delicate issue - particularly with bilateral comparisons. In order to tackle this issue, the participants will submit their respective measurement results to an independent third party, which will in the present case be the EURAMET TC-AUV Chair, before exchanging them. They will only be shared with the pilot laboratory for further analysis, once all the measurements are completed.

Results have to be submitted to the EURAMET TC-AUV Chair within six weeks after completion of measurements.

Remarks on the Post Processing

- Presuming consistency of the results, calculation of the results will be done according to EN ISO 17043:2010, Annex B.3.1.3 e), formula B.5 [3]. The report will include the DoE to the primary calibration value of METAS.
- In case of damage or loss of the artifact the comparison will be evaluated as far in the schedule as possible, all further action concerning continuation will be decided in coordination with the participants.

References

[1] ISO 16063-21:2003 "Methods for the calibration of vibration and shock transducers - Part 21: Vibration calibration by comparison to a reference transducer"

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

[3] ISO/IEC 17043:2010 "Conformity assessment - General requirements for proficiency testing"