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AMENDMENT 2
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Methods for the calibration of vibration and shock transducers —

Part 21: Vibration calibration by comparison to a reference transducer

AMENDMENT 2

Méthodes pour l'étalonnage des transducteurs de vibrations et de chocs —

Partie 21: Étalonnage de vibrations par comparaison à un transducteur de référence

AMENDEMENT 2

Reference number
ISO 16063-21:2003/Amd.2:2024(en)

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This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

A list of all parts in the ISO 16063 series can be found on the ISO website.

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Methods for the calibration of vibration and shock transducers —

Part 21:
Vibration calibration by comparison to a reference transducer

AMENDMENT 2

Introduction

Add the following paragraph at the end of the Introduction:

ISO 16063-21:2003/Amd 2 aims to explain better the use of reference transducers, different calibration set-ups and opens up the frequency limits for the applicable calibration range.

1 Scope

Add the following sentence at the end of the scope before the NOTE:

"This document is applicable to calibrations outside the frequency range from 0,4 Hz to 10 kHz, considering the additional facts described in 4.3. Systems have been demonstrated to cover the range from 0,01 Hz to 30 kHz."

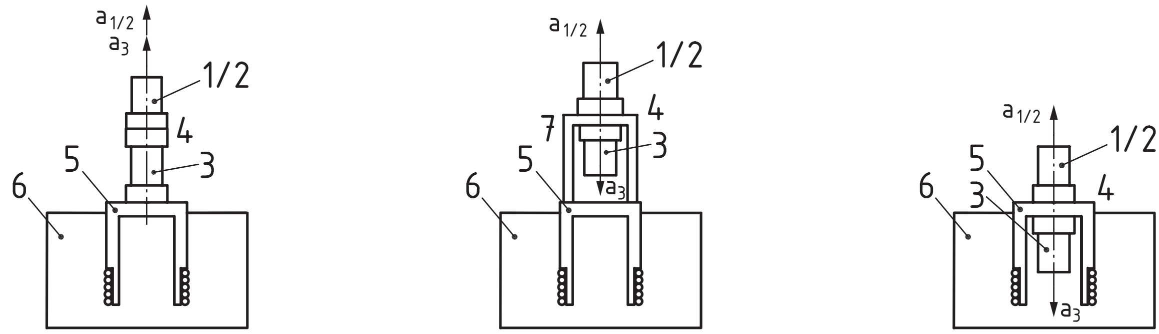
4.3

Replace the last but one paragraph by the following:

"The reference transducer may be of the back-to-back type meant for direct mounting of the transducer to be calibrated on top of it, in a back-to-back configuration, see Figure 1 a). It may also be a transducer used in a fixture, see Figure 1 b), or underneath the exciter mounting platform (built-in reference transducer), see Figure 1 c), always in line with the transducer to be calibrated. In the setup shown in Figure 1 c) the reference might even be an integral part of the exciter (which means it cannot be detached). To reduce the influence of rocking motions, the centres of the seismic elements of both transducers should be superimposed on one axis coinciding with the axis of vibration. It is not recommended to mount the two transducers side by side as rocking motions will often be present, causing large errors in many circumstances.

For low frequency calibrations requiring measurements below a few Hz, long stroke exciters are used giving displacements of 100 mm or more. The setups are normally like the one shown schematically in Figure 2. The principle is the same as Figure 1 b) but the armature is a sledge driven by an electromagnetic system or otherwise. The sledge configuration permits heavy transducers to be calibrated. Some transducers (e.g. seismometers) are sensitive in the transverse direction with respect to their mounting surface. They can then be mounted directly on the sledge without the fixture 7 in Figure 2.

For these low frequency setups, the influence of rocking motion typically is very low, so side by side measurements can be performed with low uncertainty.



a) Calibration set-up with back-to-back reference transducer

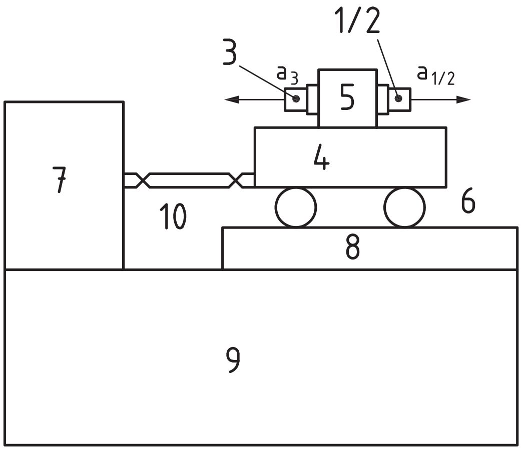
b) Calibration set-up with mounting fixture (contains single ended transfer reference transducer)

c) Calibration set-up with vibration exciter internal reference transducer

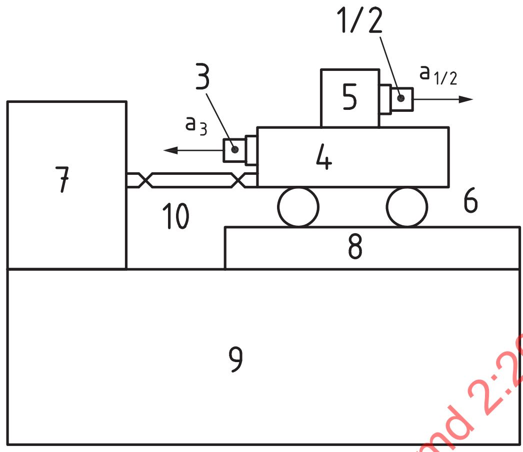
Key

1	transducer to be calibrated (see Note 1)
2	transfer standard, used for transfer calibration of transducer 3 (see Note 1 and ISO 16063-21:2003/Amd 1:2016, Annex E)
3	reference transducer (see Note 1)
4	top surface of back-to-back transducer (subfigure a)), mounting surface of mounting fixture (subfigure b)) or mounting surface of vibration exciter (subfigure c))
5	vibration exciter armature
6	vibration exciter body
7	mounting fixture (providing back-to-back configuration)
$a_{1/2}$	nominal sensitivity axis of transducer 2/1 (standard set-up: transducer to be calibrated)
a_3	nominal sensitivity axis of transducer 3 (standard set-up: reference transducer)

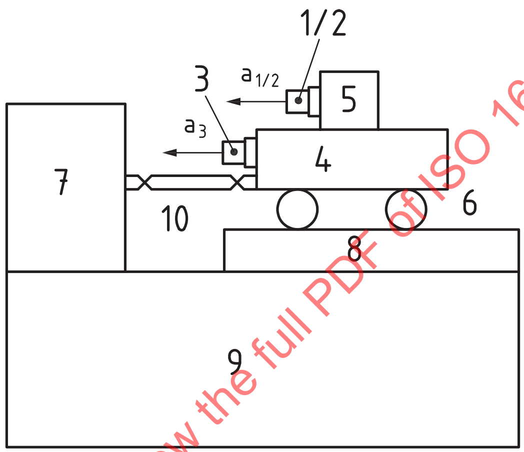
Figure 1 — Permitted calibration set-ups for a standard calibration and transfer calibration



a) Calibration set-up with back-to-back reference transducer



b) Calibration set-up with mounting fixture (contains single ended transfer reference transducer)



c) Calibration set-up with vibration exciter internal reference transducer

Key

1 transducer to be calibrated (see Note 1)
2 transfer standard (see Note 1 and ISO 16063-21:2003/Amd 1:2016, Annex E)
3 reference transducer (see Note 1)
4 vibration exciter armature
5 mounting fixture
6 armature bearing (air or solid)
7 driving force unit
8 bearing fixed part
9 heavy seismic mounting block
10 connecting drive element
$a_{1/2}$ nominal sensitivity axis of transducer 2/1 (standard set-up: transducer to be calibrated)
a_3 nominal sensitivity axis of transducer 3 (standard set-up: reference transducer)

Figure 2 — Permitted calibration set-ups for a standard calibration and transfer calibration

NOTE 1 The configuration given in Figure 1 and Figure 2 are the standard set-ups for transducer calibrations. In the case of a transfer calibration, the back-to-back transducers or the built-in transducers are calibrated by using a transfer standard (key 2 in Figure 1 and Figure 2) preferably of single ended design. This permits uninterrupted calibrations while the transfer standard is being calibrated and only the transfer standard must be shipped. In this case the transfer standard (key 2 in Figure 1 and Figure 2) is the reference and the reference transducer (key 3 in Figure 1 and Figure 2) is the transducer to be calibrated.

NOTE 2 The reference transducers of all configurations in Figure 1 and Figure 2 can be calibrated by using a primary calibration procedure according to ISO 16063-11 in order to get minimum uncertainties. In this case, the transfer standard transducer will be replaced by an equivalent dummy mass.

The configurations shown in Figure 1 a) and Figure 1 b) can lead to a higher influence of cross or rocking motion compared to the configuration in Figure 1 c), depending on actual dimensions and materials. At intermediate frequencies bending resonances in the total structure is often the cause. By decoupling of parts of the structure it is often possible to avoid these phenomena without losing high frequency capabilities. However, this needs careful consideration, potentially including one or both of experimental investigation and finite element simulation.

At high frequencies, relative motion between the sensing part of the reference transducer and the sensing part of the transducer to be calibrated are always present due to the finite stiffness between the two items. For frequencies above about 5 kHz, it can result in significant deviations of the calibration results. This effect is depending on stiffness and mass of the mounting surface, stiffness, and mass of the base of both transducers, and it becomes increasingly important at higher frequencies.

To meet the measurement uncertainties given in Table 1, the effect of relative motion shall be considered. If adequate knowledge of the effect is available, a correction may be applied in the sensitivity calculations. If the effect is low compared to the target total measurement uncertainty, a correction is not mandatory. In this case, a correction can be neglected but the estimated error components shall be considered in the uncertainty budget under contribution $i = 9$ “Effect of relative motion on output voltage ratio” in Table A.1.

The transducers shall be mounted carefully, especially in the case of calibrations performed at high frequencies.

High resonance frequencies of the exciter armature can solve some of these problems. This can be achieved by using vibration exciters with armatures made of materials with a very high propagation velocity of sound (equivalent to a high ratio of the elastic modulus to the mass density)(e.g. beryllium or technical ceramic) combined with a direct mounting of the transducer to be calibrated. The specified resonance frequency of a exciter armature is typically influenced (lowered) additionally by the coupled mass of the transducer under calibration. It should be noted, that in many cases the conditions on the calibration exciter differ from the mounting condition of the intended use afterwards. Therefore, the material of the armature should be documented in the calibration certificate.

At low frequencies the acceleration is limited by the maximum possible displacement of the vibration exciter. In this case a vibration generation with a constant displacement or highest possible displacement at each frequency should be selected.

In the low-frequency range, increased harmonic distortion (THD) will often be present and can disturb the accuracy of the calibration results unless narrow band filtering is used. In all cases, the signal-to-noise ratios of the transducer to be calibrated and the reference transducer shall be considered."