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Methods for the calibration of vibration and shock transducers —

Part 16: Calibration by Earth’s gravitation

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

Partie 16: Étalonnage par gravitation tellurique

Reference number
ISO 16063-16:2014(E)

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 3, *Use and calibration of vibration and shock measuring instruments*.

This first edition of ISO 16063-16 cancels and replaces the first edition of ISO 5347-5:1993, which has been technically revised.

This corrected version of ISO 16063-16:2014 incorporates the following corrections:

— Table 1, last row, + sign added before 240°

— Paragraph 2, after Formula (2), k = 1 changed to k = 2 and the uncertainty value adapted.

— Formula (5) has been corrected, and a degree sign has been added after 180 in the explanation.

— Formula (7) has been corrected, and in the explanation, the superfluous rows for $a_{\alpha 0}$ and $a_{\alpha 180}$ have been removed.

— In Figure 1, the equal sign has been removed.

— Keys have been added under Figures 2 and 3.

— In Formula (A.2), the 8 above the summation sign has been removed.

— In the explanation to Formula (A.2), u_i has been replaced by $u(x_i)$.

— In Formula (A.3) and in its explanation, $u(e_g)$ has been replaced by $u(a_g)$.

— In addition, the following list of parts has been updated:

ISO 16063 consists of the following parts, under the general title *Methods for the calibration of vibration and shock transducers*:

— *Part 1: Basic concepts*

— *Part 11: Primary vibration calibration by laser interferometry*

— *Part 12: Primary vibration calibration by the reciprocity method*
— *Part 13: Primary shock calibration using laser interferometry*
— *Part 15: Primary angular vibration calibration by laser interferometry*
— *Part 16: Calibration by Earth's gravitation*
— *Part 21: Vibration calibration by comparison to a reference transducer*
— *Part 22: Shock calibration by comparison to a reference transducer*
— *Part 31: Testing of transverse vibration sensitivity*
— *Part 32: Resonance testing — Testing the frequency and the phase response of accelerometers by means of shock excitation*
— *Part 41: Calibration of laser vibrometers*
— *Part 42: Calibration of seismometers with high accuracy using acceleration of gravity*
— *Part 43: Calibration of accelerometers by model-based parameter identification*

The following parts are under preparation:

— *Part 17: Primary calibration by centrifuge*
— *Part 33: Testing of magnetic field sensitivity*

Methods for the calibration of vibration and shock transducers —

Part 16: **Calibration by Earth's gravitation**

1 Scope

This part of ISO 16063 specifies the instrumentation and procedure to be used for performing primary calibration of accelerometers using Earth's gravitation. It is applicable to rectilinear accelerometers with DC (zero hertz frequency) response, such as straingauge, piezoresistive, variable capacitance, and servo accelerometer types.

This part of ISO 16063 is applicable to the calibration of the magnitude of the sensitivity, referenced to the acceleration due to the local gravitation at 0 Hz.

With the use of appropriate calibration equipment, this part of ISO 16063 can be applied to the calibration of the magnitude of the sensitivity, referenced to fractional parts of the acceleration due to the local gravitation at 0 Hz. The specification of the instrumentation used contains requirements on environmental conditions, as well as specific requirements for the apparatus to be used.

The sensitivity obtained using this part of the ISO 16063 standard for accelerometers with a DC response can be used over the flat part of the low-frequency range of the accelerometer. The degree of flatness of the applicable frequency range is intended to be taken into account in the uncertainty of measurement (UoM).

This part of ISO 16063 is applicable to reference standard accelerometers and working standard accelerometers, as well as complete acceleration measurement chain (accelerometer complete with amplifier and readout unit).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16063-1, *Methods for the calibration of vibration and shock transducers — Part 1: Basic concepts*

3 Uncertainty of measurement

All users of this part of ISO 16063 are expected to make an uncertainty budget according to Annex A in order for them to document their UoM estimation. A calibration arrangement example is given in order to help set up systems that fulfil different uncertainty requirements.

When the local value of acceleration due to gravitation, g_l, is known and used, an UoM of 0,1 % can be obtained.

When the local value of acceleration due to gravitation, g_l, is not known and the standard acceleration due to gravitation, g_n, is used (ignoring the influence of latitude and altitude), an UoM of 0,5 % can be obtained. This estimation is assuming a value for the acceleration due to Earth's gravitation of 9,806 65 m/s^2 ± 0,026 m/s^2.

The uncertainty limits mentioned in this clause are applicable to devices with a maximum transverse sensitivity of 5 %.

A more detailed description of the uncertainty components is given in Annex A.

The uncertainty of measurement is expressed as the expanded measurement uncertainty in accordance with ISO 16063-1 (referred to in short as uncertainty).

4 Requirements for apparatus and other conditions

4.1 General

This clause gives recommended specifications for the apparatus necessary to fulfil the scope of Clause 1 and to obtain the uncertainties of Clause 3, if the recommended specifications listed below are met for each item.

It is mandatory to document the expanded uncertainty using the methods of Annex A.

4.2 Environmental conditions

The calibration shall be carried out under the following ambient conditions:

a) room temperature: (23 ± 3) °C;

b) relative humidity: maximum 75 % RH.

Care shall be taken that external vibration and noise do not affect the quality of the measurements.

4.3 Mounting platform

The mounting platform shall be arranged so that it is possible to rotate and align the geometric axis of sensitivity of the accelerometer from 0° to 180° relative to the direction of the gravitational acceleration vector.

At the measurement positions, the platform angle in all directions shall be within ±0,1° relative to the vertical plane.

For performing measurements at positions that equal fractions of local gravity (mounting angle >0° and <180°), the preferred orientation angles in accordance with Table 1 shall be used:

Table 1 — Preferred orientation angles

Orientation angle θ	Magnitude of acceleration due to local gravity
−30° and +30° +150° and + 210°	0,866 0 g_l
−45° and +45° +135° and +225°	0,707 1 g_l
±60° +120° and +240°	0,500 0 g_l

The acceleration, in metres per second squared, due to local gravity with the accelerometer mounted at the angle θ is:

$$a_\theta = g_l \cdot \cos \theta \quad (1)$$

where

θ is the accelerometer mounting angle, in degrees;

g_l is the magnitude for the acceleration due to local gravity, in metres per second squared.

4.4 Accelerometer output measuring instrumentation

A voltage measuring instrument, measuring the output from the accelerometer, having the following characteristics shall be used:

a) Frequency: 0 Hz (DC voltage);

b) Maximum uncertainty: 0,05 % of reading.

4.5 Earth's gravitation

The positive and negative magnitudes for the acceleration due to local gravity, expressed in metres per second squared (m/s^2), shall be used.

The value of the local magnitude of acceleration due to gravity, g_l, can be determined by measurement with absolute or relative gravimeters[17] or by use of geodetic formulae[16] or survey.

$$g_l\,(\phi,\mathrm{H}) = 9{,}780\,318\,4\,(1 + 0{,}005\,302\,4 \sin^2 \phi - 0{,}000\,005\,9 \sin^2 2\,\phi) - 0{,}000\,003\,086\,H \quad (2)$$

where

g_l is the magnitude for the acceleration due to gravitation at the given latitude and elevation, in metres per second squared;

ϕ is the given latitude, in radians;

H is the given altitude, in metres above sea level.

Using Formula (2), g_l can be determined with an expanded uncertainty of 0,02 % ($k = 2$).

If the magnitude for the acceleration due to local gravity is not known, then the standard acceleration due to gravity, g_n, shall be used[10]:

$$g_n = 9{,}806\,65 \text{ m/s}^2 \quad (3)$$

5 Method

5.1 General

As the acceleration due to gravitation varies with location and altitude (typical values of acceleration due to local gravity at the locations of metrology institutes are within the range of 9,78 m/s^2 to 9,83 m/s^2), the local value with four significant digits shall be used.

