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Methods for the calibration of vibration and shock transducers —

Part 42:
Calibration of seismometers with high accuracy using acceleration of gravity

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

Partie 42: Étalonnage des diomomètres de haute exactitude utilisant l'accélération due à la pesanteur

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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*.

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 41: Calibration of laser vibrometers*

— *Part 42: Calibration of seismometers with high accuracy using acceleration of gravity*

The following parts are under preparation:

— *Part 17: Primary calibration by centrifuge*

— *Part 32: Resonance testing — Testing the frequency and the phase response of accelerometers by means of its excitation*

— *Part 33: Testing of magnetic field sensitivity*

— *Part 43: Calibration of accelerometers by model-based parameter identification*

Angular vibration calibration by comparison to reference transducers, calibration of hand-held accelerometer calibrators, and calibration of vibration transducers with built-in calibration coils are to form the subjects of future parts 23, 44 and 45.

Methods for the calibration of vibration and shock transducers —

Part 42: Calibration of seismometers with high accuracy using acceleration of gravity

1 Scope

This part of ISO 16063 specifies the instrumentation and procedure to be used for the accurate calibration of seismometer sensitivity using local gravitational acceleration (local Earth's gravitation; local value for the acceleration due to the Earth's gravity) as a reference value.

It is intended generally to be applied to a servo-type accelerometer with/without a velocity output, which usually has a mass position output in the category of a wide-band seismometer with a bandwidth from 0,003 Hz to 100 Hz.

The method specified enables the user to obtain static sensitivity for the seismometers up to 10^{-5} m/s^2 (which corresponds to 1 mGal and approximately 1 ppm of the gravitational acceleration).

The combined and expanded (k = 2) uncertainty of applied acceleration achieved by this method is 10^{-6} m/s^2 (0,1 mGal). When the absolute gravimeter described in this part of ISO 16063 is used, the uncertainty of applied acceleration can be suppressed to 5 × 10^{-8} m/s^2 (5 μGal). The relative expanded uncertainty of calibration, excluding the uncertainty due to the device under test (DUT), is 0,5 %.

The intended end-usage of the seismometer to be applied is as follows:

a) measurement and observation for the earth science including geophysics usage;

b) measurement and observation for disaster prevention, such as detecting the precursor of a land slide;

c) diagnosis for the soundness of a building structure and foundation soil in civil engineering;

d) observation for nuclear-test detection.

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.

IGSN-71, *International Gravity Standardization Network 1971*. (Morelli, 1974) Morelli, Carlo, ed., 1974, The International Gravity Standardization Net 1971: International Association of Geodesy Special Publication No. 4, 194p

3 Traceability of measurement

The traceability of measurement in this method is shown in Annex B.

4 Determination of local gravity

4.1 Method using absolute gravimeter

Determine the absolute local gravitational acceleration using a free-fall absolute gravimeter (FG-5 or other apparatus). The uncertainty of the thus-obtained local gravitational acceleration is approximately 5×10^{-8} m/s^2 (5 µGal).

4.2 Method using gravitational acceleration standardization network and relative gravimeter

At a reference point where the local gravitational acceleration has been established from the IGSN-71, the absolute local gravitational acceleration may be determined by using a relative gravimeter. In this case, no correction for latitude and altitude is required. The value of uncertainty of the relative gravimeter is to be specified by the manufacturer.

Geological survey institutes, meteorology institutes, geodetic surveys or geophysical institutions in each country may provide measured values of smaller uncertainty than those in IGSN-71 and, if available, those values may be used.

4.3 Method using gravitational acceleration standardization network

Calculate the local gravitational acceleration based on the latitude and altitude of the point at which measurements are to be conducted relative to the nearest geographical point in the IGSN-71 database.

The uncertainty of the thus-obtained local gravitational acceleration is approximately 10^{-5} m/s^2 (1 mGal). Here, this is only applied to the case without any geometrical anomaly.

Geological survey institutes, meteorology institutes, geodetic surveys or geophysical institutions in each country may provide measured values of smaller uncertainty than those in IGSN-71 and, if available, those values may be used.

Because an altitude difference of 1 m corresponds to a difference of approximately 3×10^{-6} m/s^2 (0,3 mGal), the uncertainty of altitude should be less than 2 m.

NOTE 1 The effect of a difference of 1° at a latitude of approximately 45° corresponds to approximately 1×10^{-6} m/s^2 (0,1 mGal).

NOTE 2 The local gravity map includes the values of the geoid and altitude components.

5 Requirements for apparatus and environmental conditions

5.1 Calibration environment

The standard reference atmospheric conditions are: (23 ± 3) °C and 75 % relative humidity maximum. The temperature, humidity and atmospheric pressure shall be measured and reported.

5.2 Base and vibration environment (seismic block for calibration apparatus)

The calibration apparatus shall be placed on a sufficiently heavy base which is sufficiently isolated from the building vibration.

5.3 Voltage-measuring instrumentation

The relative expanded measurement uncertainty (k = 2) contribution of the voltmeter by which the output voltage from the seismometer is measured shall be 0,1 % or less (see Table A.1).

5.4 Tuneable low-pass filter

a) **Cut-off frequency**

The cutoff frequency shall be 10 Hz, 30 Hz or 60 Hz. The typical cutoff frequency is 30 Hz.

b) **Attenuation rate (filter slopes)**

The attenuation or insertion loss shall be 24 dB per octave or greater in the stopband of the filter.

5.5 Power supply

The stability of the power supply and the ratio of signal-to-noise shall be adequate to meet the claimed uncertainty contribution(s) at the gain at which the sensitivity of the seismometer is being determined.

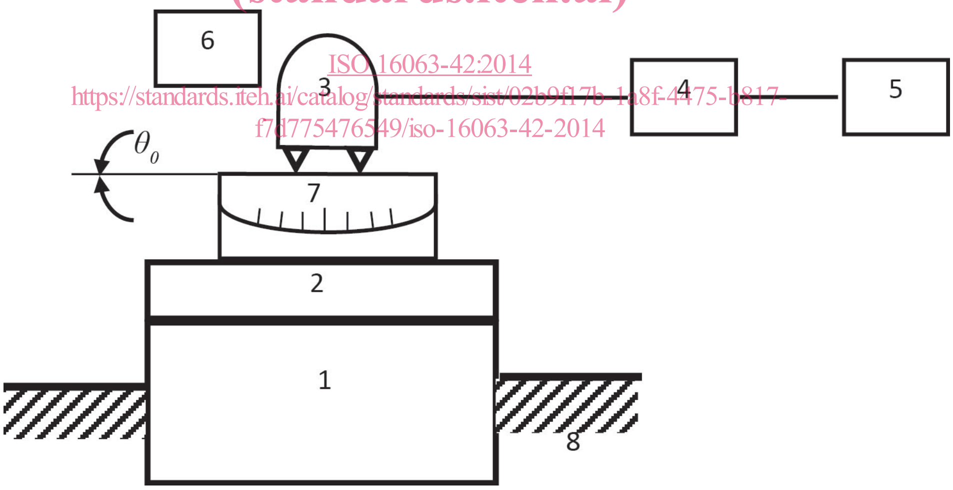
5.6 Tilt table

The angular resolution should be 0,05° or less and the uncertainty contribution should be less than 0,03°. The tilt table should have: sufficient rigidity to support the mass of the seismometer; a sufficiently small amount of backlash and hysteresis; and adequate linearity.

6 Method

6.1 Calibration principle

Figure 1 and Figure 2 show schematics of the calibration apparatus and an example of its operation.



Key

1 base
2 platform
3 seismometer
4 filter
5 voltmeter
6 environment instruments (temperature and atmospheric pressure)
7 tilt table
8 ground

Figure 1 — Calibration apparatus