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Methods for the calibration of vibration and shock transducers —

Part 41: Calibration of laser vibrometers

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

Partie 41: Étalonnage des vibromètres à laser

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 16063-41 was prepared by Technical Committee 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 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*

The following parts are under preparation:

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

Methods for the calibration of vibration and shock transducers —

Part 41: Calibration of laser vibrometers

1 Scope

This part of ISO 16063 specifies the instrumentation and procedures for performing primary and secondary calibrations of rectilinear laser vibrometers in the frequency range typically between 0,4 Hz and 50 kHz. It specifies the calibration of laser vibrometer standards designated for the calibration of either laser vibrometers or mechanical vibration transducers in accredited or non-accredited calibration laboratories, as well as the calibration of laser vibrometers by a laser vibrometer standard or by comparison to a reference transducer calibrated by laser interferometry. The specification of the instrumentation contains requirements on laser vibrometer standards.

Rectilinear laser vibrometers can be calibrated in accordance with this part of ISO 16063 if they are designed as laser optical transducers with, or without, an indicating instrument to sense the motion quantities of displacement or velocity, and to transform them into proportional (i.e. time-dependent) electrical output signals. These output signals are typically digital for laser vibrometer standards and usually analogue for laser vibrometers. The output signal or the reading of a laser vibrometer can be the amplitude and, in addition, occasionally the phase shift of the motion quantity (acceleration included). In this part of ISO 16063, the calibration of the modulus of complex sensitivity is explicitly specified (phase calibration is provided in Annex D).

NOTE Laser vibrometers are available for measuring vibrations having frequencies in the megahertz and gigahertz ranges. To date, vibration exciters are not available for generating such high frequencies. The calibration of these laser vibrometers can be estimated by the electrical calibration of their signal processing subsystems utilizing appropriate synthetic Doppler signals under the following preconditions:

— the optical subsystem of the laser vibrometer to be calibrated has been proven to comply with defined requirements comparable to those given in 5.5.3;

— synthetic Doppler signals are generated as an equivalent substitute for the output of the photodetectors.

More detailed specifications of this approach (see Reference [25]) lie outside the scope of this part of ISO 16063.

2 Normative references

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

ISO 266, *Acoustics — Preferred frequencies*

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO 16063-1:1998, *Methods for the calibration of vibration and shock transducers — Part 1: Basic concepts*

ISO 16063-11:1999, *Methods for the calibration of vibration and shock transducers — Part 11: Primary vibration calibration by laser interferometry*

ISO 16063-21, *Methods for the calibration of vibration and shock transducers — Part 21: Vibration calibration by comparison to a reference transducer*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Classification of laser vibrometers and principles of test methods

3.1 Classification of laser vibrometers

3.1.1 A **laser vibrometer standard** (LVS) is a reference standard containing a laser interferometer, designed and intended to serve as a reference to calibrate laser vibrometers and/or vibration transducers.

NOTE Methods 1, 2, and 3 are applicable to the primary calibration of LVSs.

3.1.2 A **laser vibrometer** (LV) is a measuring instrument containing a laser interferometer, designed and intended to perform vibration measurements.

NOTE Methods 1, 2, and 3 are applicable to the primary calibration of LVs, and method 4 is applicable to the secondary calibration of LVs. The reference accelerometer used for method 4 is calibrated by method 1, 2 or 3. For specific requirements, see 5.11.

3.1.3 A **laser optical transducer** is a measurement transducer sensing, by laser light, the motion quantities of displacement or velocity and transforming these quantities into a proportional time-dependent output signal.

3.2 Principles of test methods

3.2.1 General. Four methods are specified in analogy to ISO 16063-11 (laser interferometry) and ISO 16063-21 (comparison to a reference transducer), respectively. Methods 1, 3, and 4 provide for calibrations at preferred displacement amplitudes, velocity amplitudes and acceleration amplitudes at various frequencies. Method 2 requires calibrations at fixed displacement amplitudes (velocity amplitude and acceleration amplitude vary with frequency).

For each interferometric method specified in this part of ISO 16063 (see 3.2.2 to 3.2.4), currently a specific frequency range applies. In fact, the applicability of the particular methods mainly depends on the displacement or velocity amplitudes measurable within given measurement uncertainties. These, however, not only depend on the measurement method itself but also on the frequency-dependent properties of the vibration exciters available. Using adequate vibration exciters to generate sufficient displacement or velocity amplitudes, the upper frequency limits of all methods can be expanded to 100 kHz and even beyond. The primary method 3 (see 3.2.4) and the comparison method 4 (see 3.2.5) are applicable at frequencies lower than 0,4 Hz.

3.2.2 Method 1, the **fringe-counting method**, is a vibration measurement method using a homodyne interferometer with a single output (see Note 2) in conjunction with instrumentation for fringe counting of the interferometer signal. Considering that the displacement corresponding to the distance between two fringes (intensity maxima or intensity minima) is given by half the wavelength of the principal lines in the emission spectrum of neon of the He-Ne laser, the displacement amplitude can be calculated from the number of fringes counted during a given number (e.g. 1 000) of vibration periods.

For details, see Clause 8 and, for further information, ISO 16063-11:1999, B.1.

NOTE 1 Method 1 is applicable to the primary calibration of the laser vibrometer (modulus only) in the frequency range 1 Hz to 800 Hz and, under special conditions, at lower and higher frequencies. In Reference [26], the applicability of method 1 has been demonstrated at frequencies up to 347 kHz.

NOTE 2 Alternatively, the homodyne interferometer signal from one of the two outputs of a quadrature interferometer can be used.