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Methods for the calibration of vibration and shock pick-ups —

Part 1:

Primary vibration calibration by laser
interferometry

Méthodes pour l'étalonnage de capteurs de vibrations et de chocs —

Partie 1: Étalonnage primaire de vibrations avec interféromètre de laser



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Foreword

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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.

International Standard ISO 5347-1 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Sub-Committee SC 3, *Use and calibration of vibration and shock measuring instruments*.

ISO 5347 consists of the following parts, under the general title *Methods for the calibration of vibration and shock pick-ups*:

- *Part 0: Basic concepts*
- *Part 1: Primary vibration calibration by laser interferometry*
- *Part 2: Primary shock calibration by light cutting*
- *Part 3: Secondary vibration calibration*
- *Part 4: Secondary shock calibration*
- *Part 5: Calibration by Earth's gravitation*
- *Part 6: Primary vibration calibration at low frequencies*
- *Part 7: Primary calibration by centrifuge*
- *Part 8: Primary calibration by dual centrifuge*

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- *Part 9: Secondary vibration calibration by comparison of phase angles*
- *Part 10: Primary calibration by high-impact shocks*
- *Part 11: Testing of transverse vibration sensitivity*
- *Part 12: Testing of transverse shock sensitivity*
- *Part 13: Testing of base strain sensitivity*
- *Part 14: Resonance frequency testing of undamped accelerometers on a steel block*
- *Part 15: Testing of acoustic sensitivity*
- *Part 16: Testing of mounting torque sensitivity*
- *Part 17: Testing of fixed temperature sensitivity*
- *Part 18: Testing of transient temperature sensitivity*
- *Part 19: Testing of magnetic field sensitivity*
- *Part 20: Primary vibration calibration by the reciprocity method*

Annexes A and B form an integral part of this part of ISO 5347.

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Methods for the calibration of vibration and shock pick-ups —

Part 1:

Primary vibration calibration by laser interferometry

1 Scope

ISO 5347 comprises a series of documents dealing with methods for the calibration of vibration and shock pick-ups.

This part of ISO 5347 lays down detailed specifications for the instrumentation and procedure to be used for primary calibration of rectilinear accelerometers using laser interferometry for dynamic displacement measurements.

It is applicable for a frequency range from 20 Hz to 5 000 Hz and a dynamic range from 10 m/s² to 1 000 m/s² (frequency-dependent).

The limits of uncertainty applicable are as follows:

± 0,5 % of reading at reference frequency (160 Hz or 80 Hz) and reference amplitude (100 m/s² or 10 m/s²) and reference amplifier gain setting;

± 1 % of reading for frequencies ≤ 1 000 Hz;

± 2 % of reading for frequencies > 1 000 Hz.

2 Apparatus

2.1 Equipment capable of maintaining the ambient conditions, within the requirements specified in clause 3.

2.2 Frequency generator and indicator, having the following characteristics:

- uncertainty, for frequency: maximum ± 0,01 % of reading;

- frequency stability: better than ± 0,01 % of reading over the measurement period;

- amplitude stability: better than ± 0,01 % of reading over the measurement period.

2.3 Power amplifier/vibrator combination, having the following characteristics:

- total distortion: 2 % maximum;
- transverse, bending and rocking acceleration: kept to a minimum, maximum 10 % of the acceleration in the intended direction at frequencies used; above 1 000 Hz, a maximum of 20 % is permitted;
- hum and noise: 70 dB min. below full output;
- acceleration amplitude stability: better than 0,05 % of reading over the measurement period.

The attachment surface shall not introduce base strain to the accelerometer.

2.4 Seismic block for vibrator and laser interferometer (the same block), with a mass at least 2 000 times the mass of moving elements of vibrator, fixture and transducer.

The seismic block shall be suspended by low damped springs. If floor vibrations influence, the suspension resonance frequency vertically and horizontally shall be < 2 Hz.

2.5 Laser, of helium-neon type; in laboratory conditions of air pressure 100 kPa, temperature 23 °C and relative humidity 50 % the wavelength is 0,632 8 μm, which value is used in this part of ISO 5347.

If the laser has manual or automatic atmospheric compensation, this shall be set to zero or switched off.

2.6 Interferometer, of Michelson type, with light detector for sensing the interferometer bands and having a frequency response from d.c. to 15 MHz.

2.7 Counting instrumentation, (for Method 1, frequency range from 20 Hz to 800 Hz), having the following characteristics:

- frequency range: 10 Hz to 20 MHz;
- uncertainty, maximum: $\pm 0,01$ % of reading.

The counter can be substituted by a ratio counter having the same uncertainty.

2.8 Tunable band-pass filter or spectrum analyser, (for Method 2, frequency range from 1 000 Hz to 5 000 Hz), having the following characteristics:

- frequency range: 100 Hz to 10 000 Hz;
- bandwidth: < 12 % of centre frequency;
- filter slopes: better than 24 dB/octave;
- signal-to-noise ratio: better than 70 dB below maximum signal;
- dynamic range: better than 60 dB.

2.9 Instrumentation for zero detection, (for Method 2 — not needed with spectrum analyser), with a frequency range from 30 Hz to 5 000 Hz. The range shall be sufficient for detection of output noise from the bandpass filter.

2.10 Voltage instrumentation, measuring true r.m.s. accelerometer output, having the following characteristics:

- frequency range: 20 Hz to 5 000 Hz;
- uncertainty, maximum: $\pm 0,01$ % of reading; below 40 Hz: 0,1 %.

The r.m.s. value shall be multiplied by a factor of $\sqrt{2}$ to obtain the (single) amplitude used in the formulae.

2.11 Distortion-measuring instrumentation, capable of measuring total distortion of 0 to 5 % and having the following characteristics:

- frequency range: 5 Hz to 10 kHz;
- uncertainty, maximum: ± 10 % of reading.

2.12 Oscilloscope (optional), for checking the waveform of the accelerometer signal, with a frequency range from 5 Hz to 5 000 Hz.

2.13 Other apparatus requirements.

In order to achieve the required 0,5 % accuracy, the accelerometer and accelerometer amplifier shall be considered as one unit and calibrated together.

The accelerometer shall be structurally rigid. The base strain sensitivity shall be $< 0,2 \times 10^{-8}$ m/s² at a base strain of $2,5 \times 10^{-4}$ m/s², the transverse sensitivity shall be < 1 % and the stability of the accelerometer/amplifier combination shall be better than 0,2 % of the reading per year.

3 Ambient conditions

Calibration shall be carried out in the following ambient conditions:

- room temperature: (23 ± 3) °C;
- air pressure: (100 ± 5) kPa;
- relative humidity: (50 ± 25) %.

4 Preferred amplitudes and frequencies

Six amplitudes and six frequencies equally covering the accelerometer range shall be chosen from the following series:

a) **Acceleration** (Method 1 only), in metres per square second:

10, 20, 50, 100, 500;

reference acceleration 100 m/s² (second choice: 10 m/s²).

b) **Frequency**, in hertz:

20, 40, 80, 160, 315, 630, 1 250, 2 500, 5 000;

reference frequency 160 Hz (second choice: 80 Hz).

5 Method 1, for frequency range from 20 Hz to 800 Hz

5.1 Test procedure

After optimizing the interferometer (2.6) settings, determine the reference calibration factor at preferably 160 Hz (second choice: 80 Hz), 100 m/s² (second choice: 10 m/s²) and the standard position of amplifier range switch by measuring either the fringe frequency with the counter (2.7) — the fringe-counting method