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

Part 10:

Primary calibration by high impact shocks

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

Partie 10: Étalonnage primaire de chocs à impact élevé

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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.

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 5347-10 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*

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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 10: Primary calibration by high impact shocks

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 high impact shock calibration of accelerometers. It applies to rectilinear accelerometers, mainly of the piezoelectric and piezoresistive type, to primary standards and working accelerometers.

This part of ISO 5347 is applicable for a time range from $10\text{ }\mu\text{s}$ to $100\text{ }\mu\text{s}$ and a dynamic range from 10^3 m/s^2 to 10^5 m/s^2 .

The limit of uncertainty applicable is $\pm 10\%$ of reading.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 5347. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5347 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5347-1:1993, *Methods for the calibration of vibration and shock pick-ups — Part 1: Primary vibration calibration by laser interferometry*.

3 Apparatus

3.1 Equipment capable of maintaining room temperature at $23^\circ\text{C} \pm 3^\circ\text{C}$.

3.2 High impact shock machine, with two long thin steel rods, one acting as a hammer and the other as an anvil to which the accelerometer is attached.

The hammer-rod can be shot or permitted to fall freely and to strike the anvil-rod which is permitted to accelerate freely and later to be caught up by a spring or braking device.

At the strike, the longitudinal resonance frequency is excited in the anvil-rod.

The contact of the two rod surfaces and the cushion material between them shall be made so that the generated stress pulse approximates a half-sine pulse having a duration equal to half the period of resonance of the rod in its fundamental longitudinal mode.

A number of anvil-rods shall be used, one for each desired pulse duration.

The resonance period of the rod, T , in seconds, can be estimated from the following formula:

$$T = \frac{l}{2\,500}$$

where l is the rod length, in metres.

In order to avoid coupling of reflected stress pulses in the hammer-rod into the anvil-rod at the moment of impact, the length of the hammer-rod should be about half the length of the anvil-rod.

Strain gauges, having a maximum effective length of $0,3\text{ mm}$, shall be mounted on the anvil-rod in order to

measure strain for acceleration calculations. The centre of the strain gauges shall be applied at a distance of one rod diameter from the end where the accelerometer is mounted. The cross-sectional area of the rod at the point where the strain gauges are applied shall be measured with an error of less than $\pm 1\%$. The rod mass between the point where the strain gauges are applied and the point at which the accelerometer is mounted and the accelerometer mass shall be determined with an error of less than $\pm 1\%$.

3.3 Acceleration/time and strain/time recording equipment, comprising a digital memory oscilloscope or digital transient recorder for two channels with peak amplitude detector and a three-digit indicator display for peak pulse amplitude, or a strip chart or X-Y recorder to obtain a readout of the stored transient.

The equipment shall have the following characteristics:

- range: 0,1 μs to 100 μs and 0 to 50 V;
- uncertainty for amplitude: maximum $\pm 2\%$ of reading;
- amplitude linearity: 1 % max. deviation from best fit line.

3.4 Filters.

The use of filters shall be avoided.

If filters have to be used, the -3 dB lower limiting frequency shall be lower than $0,008/T$ and the -3 dB upper limiting frequency shall be higher than $10/T$, where T is the pulse duration.

3.5 Strain gauge, with a d.c. voltage supply, and **amplifier**, with no filtering and having the following characteristics:

- frequency response: flat within ± 3 dB from $0,008/T$ to $10/T$, where T is the pulse duration;
- linearity: better than $\pm 0,05\%$ from best fit line;
- amplification tolerance: $\pm 0,5\%$ of signal;
- calibrated amplification ranges within $\pm 0,5\%$.

3.6 Other apparatus requirements.

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

If there are filters in the amplifier, the filter cut-off frequency settings shall comply with the filter settings specified in 3.4. The frequency response shall be flat within ± 3 dB from $0,008/T$ to $10/T$, where T is the pulse duration.

4 Preferred pulse durations and accelerations

Shock pulse durations shall be chosen from between 10 μs and 100 μs .

Accelerations shall be chosen from between 10^3 m/s^2 and 10^5 m/s^2 .

5 Method

5.1 Test procedure

For high impact shock calibrations, the sinusoidal vibration calibration factor determined according to ISO 5347-1 shall be used as reference calibration factor.

The shock motion calibrations are then used to measure the amplitude linearity deviations at high accelerations.

By using rods of different lengths and consequently different resonance frequencies and dropping them from different heights determine the shock sensitivity at the standard selected shock pulse durations and accelerations and for the standard amplifier range switch positions.

The results shall be given as a percentage deviation from the sinusoidal reference calibration factor.

5.2 Expression of results

Calculate the acceleration, a_{str} , in metres per second squared, from the strain measurements in accordance with the following formula (see also annex A):

$$a_{\text{str}} = \frac{E \times A}{m_1 + m_2} \times \varepsilon$$

where

- E is the modulus of elasticity, in newtons per square metre;
- A is the cross-sectional area of the rod, in square metres, at the point where the strain gauges are applied;
- m_1 is the rod mass, in kilograms, between the point where strain gauges are applied and the transducer;
- m_2 is the pick-up mass, in kilograms;
- ε is the strain as a function of time.

Calculate the shock sensitivity, S_{sh} , expressed in volts per (metre per second squared) $[V/(m/s^2)]$, using the following formula:

$$S_{sh} = \frac{m_1 + m_2}{E \times A} \times \frac{a_{peak}}{\epsilon_{peak}}$$

where

m_1 , m_2 , E and A are as given above;

ϵ_{peak} is the peak value of the strain curve;

a_{peak} is the peak value of the acceleration curve, in volts.

The acceleration and strain curves shall always be checked directly on an oscilloscope or recorder without filters and amplifiers.

NOTE 1 If there is a zero shift in the signal, the zero point immediately before the shock and the shifted zero point immediately after the shock shall be connected by a straight line, this line being the baseline for acceleration determination.

When the calibration results are reported, the total uncertainty of the calibration and the corresponding confidence level calculated in accordance with annex B, shall also be reported.

A confidence level of 95 % shall be used.

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Annex A

(normative)

Formulae for the calculating of acceleration

A schematic diagram for aid in calculating acceleration from strain measurements is shown in figure A.1

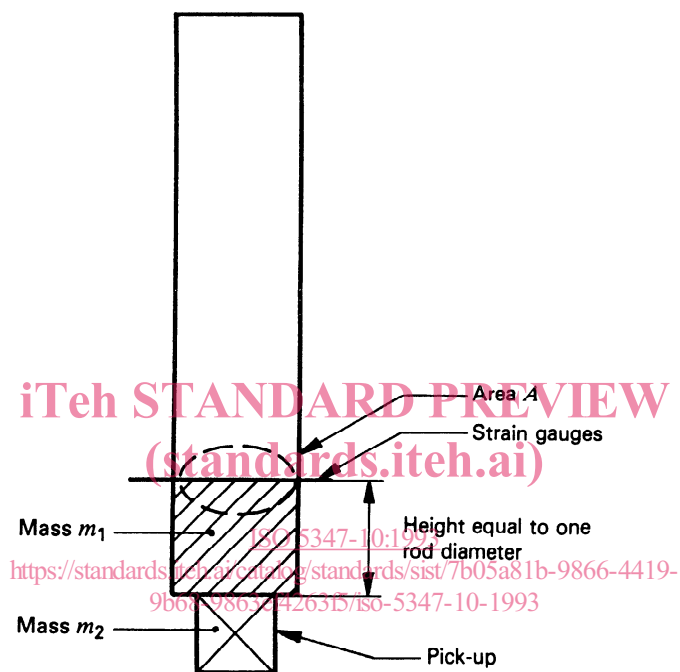


Figure A.1

The mass below the strain gauges shall be considered as being rigid.

At the cross-section at the point where the strain gauges are applied, the following formulae apply;

$$F = (m_1 + m_2) \times a$$

$$F = p \times A$$

$$p = E \times \varepsilon$$

$$E \times \varepsilon \times A = (m_1 + m_2) \times a$$

$$a = \frac{E \times A}{m_1 + m_2} \times \varepsilon$$

where

F is the force;

m_1 is the mass between the strain gauges and the pick-up;

m_2 is the mass of the pick-up;

A is the cross-sectional area at the point where the strain gauges are applied;

- E is the modulus of elasticity;
 ε is the strain measured by the strain gauges;
 p is the pressure in pascals.

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