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

Part 0 :
Basic concepts

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

Partie 0: Concepts de base

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5347-0 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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0   Introduction

The calibration of vibration and shock pick-ups has become increasingly important as the need has grown for accurate measurements of the shocks and vibrations to which man and a wide variety of equipment are subjected in service. Several methods have been used or proposed for these calibrations and some of them are described in this part of ISO 5347. Clause 6 describes methods which have proved to be reliable means for the absolute calibration of vibration and shock pick-ups.

Methods of calibration for both vibration and shock pick-ups are included in this International Standard because it has proved to be impracticable to make a distinction between pick-ups used in measurements of vibrations and those used in measurements of shocks.

This International Standard is limited to the calibration of acceleration, velocity and displacement pick-ups. It does not deal with pick-ups used for measurements of force, pressure or strain, even though some of these may be calibrated using similar methods. Furthermore, pick-ups used to measure rotational vibratory motion are also excluded because, at present, they are few in number and the calibration hardware and methods are somewhat different from those for the rectilinear pick-ups covered by this International Standard.

This part of ISO 5347 contains definitions and describes basic absolute calibration. In addition, it describes, in general terms, various methods for the calibration of vibration and shock pick-ups as well as methods for measuring characteristics other than sensitivity. In order to be able to carry out a calibration with known accuracy, detailed specifications for instruments and procedures have to be laid down. Information of this kind for each method of calibration is specified in the following subsequent parts of ISO 5347.

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.

Part 9 : Primary 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.

NOTE — Further parts are under study.

The pick-up may be calibrated as a unit by itself; it may include a cable connection and/or a conditioning device. The calibration system shall always be properly described.

A bibliography is included and is referred to by numbers in square brackets.

1   Scope

This International Standard describes methods of calibration of vibration and shock pick-ups. It also includes methods for the measurement of characteristics in addition to the sensitivity.

One absolute calibration method has been selected as the preferred method (see 6.2.1). Comparison calibration methods for vibration and shock are also described (see 6.3). More detailed descriptions are given in the other parts of this International Standard.

2 Field of application

This International Standard is applicable to continuous-reading rectilinear acceleration, velocity and displacement pick-ups and recommends a preferred method which has proved to give reliable and reproducible results.

It is not applicable to methods for the calibration of rotational pick-ups.

3 References

ISO 1101, *Technical drawings — Geometrical tolerancing — Tolerances of form, orientation, location and run-out — Generalities, definitions, symbols, indications on drawings.*

ISO 2041, *Vibration and shock — Vocabulary.*

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity.*

4 Definitions

For the purpose of this part of ISO 5347, the definitions given in ISO 2041, together with the following, apply.

4.1 pick-up: Device for converting the mechanical motion to be measured, for example acceleration in a given direction, into a quantity which may be conveniently measured or recorded.

NOTE — A pick-up may include auxiliary equipment for amplifying, supplying necessary operating power, providing necessary circuit elements, indicating or recording its output, etc.

4.1.1 operating range: That range in frequency and amplitude for which the pick-up behaves as a linear pick-up within specified limits of tolerance.

4.1.2 reciprocal pick-up: Bilateral electromechanical pick-up for which the ratio of the applied current to force produced (when the pick-up is restrained so the velocity is zero) equals the ratio of the applied velocity to the voltage produced (when the pick-up is open-circuited so the current is zero). Examples of such pick-ups are electromagnetic and piezo-electric pick-ups.

4.1.3 unilateral pick-up: Pick-up employing strain gauges as sensing elements for which an electrical excitation does not cause a perceptible mechanical effect in the pick-up.

4.2 input signal: Signal applied to the input of the pick-up, for example the attenuation applied to the mounting surface.

4.3 output signal: Signal generated by the pick-up in response to a given input signal.

4.4 sensitivity: For a linear pick-up, the ratio of the output to input during sinusoidal excitation parallel to a specified axis of sensitivity at the mounting surface. In general, the sensitivity includes both amplitude and phase information and is, consequently, a complex quantity which varies with frequency. The sinusoidal input motion may be represented by the following equations:

$$d = \hat{d} \exp[j(\omega t + \varphi_1)]$$
$$= \hat{d}[\cos(\omega t + \varphi_1) + j\sin(\omega t + \varphi_1)] \qquad \ldots (1)$$

$$u = j\omega d = \hat{u} \exp[j(\omega t + \varphi_1 + \pi/2)]$$
$$= \hat{u}[\cos(\omega t + \varphi_1 + \pi/2) + j\sin(\omega t + \varphi_1 + \pi/2)] \qquad \ldots (2)$$

$$a = j\omega u = \hat{a} \exp[j(\omega t + \varphi_1 + \pi)]$$
$$= \hat{a}[\cos(\omega t + \varphi_1 + \pi) + j\sin(\omega t + \varphi_1 + \pi)] \qquad \ldots (3)$$

$$x = \hat{x} \exp[j(\omega t + \varphi_2)]$$
$$= \hat{x}[\cos(\omega t + \varphi_2) + j\sin(\omega t + \varphi_2)] \qquad \ldots (4)$$

where

d is the complex quantity of the displacement;

u is the complex quantity of the velocity;

a is the complex quantity of the acceleration;

x is the complex quantity of the output;

$\hat{d}$ is the peak amplitude of sinusoidal displacement;

$\hat{u}$ is the peak amplitude of sinusoidal velocity;

$\hat{a}$ is the peak amplitude of sinusoidal acceleration;

ω is the angular frequency;

φ_1 and φ_2 are the phase angles;

t is the time;

j is the imaginary unit.

The displacement sensitivity, S_d, expressed in the units of the output signal per metre, is

$$S_d = \frac{x}{d} = \hat{S}_d \exp[-j(\varphi_1 - \varphi_2)] \qquad \ldots (5)$$

where

$\hat{S}_d = \dfrac{\hat{x}}{\hat{d}}$ is the magnitude of the displacement sensitivity;

$(\varphi_1 - \varphi_2)$ is the phase lag.