INTERNATIONAL STANDARD

ISO
8042

First edition
1988-08-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Shock and vibration measurements — Characteristics to be specified for seismic pick-ups

Mesurage des chocs et des vibrations — Caractéristiques à spécifier pour les capteurs sismiques

Reference number
ISO 8042 : 1988 (E)

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 8042 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.

Printed in Switzerland

Shock and vibration measurements — Characteristics to be specified for seismic pick-ups

1 Scope and field of application

This International Standard lays down rules for the presentation of important characteristics for electro-mechanical shock and vibration pick-ups (seismic pick-ups), the electrical outputs of which are known functions of the uniaxial, multiaxial or angular accelerations, velocities or displacements of objects the motions of which are being measured.

It is intended as a guide to instrument manufacturers for indicating characteristics of their pick-ups and as a help to users in selecting a particular type of pick-up or preparing performance specifications. The intention is to ensure that the user receives an adequate description of the characteristics of any particular pick-up.

Throughout this International Standard, shock and vibration pick-ups will be referred to simply as "pick-ups".

2 References

ISO 2041, *Vibration and shock — Vocabulary*.

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

ISO 5347, *Methods for the calibration of vibration and shock pick-ups*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2041 and ISO 5347 apply.

4 General information

4.1 General

The information specified in 4.2 to 4.16 may be helpful to the user of pick-ups. It is recommended that the manufacturer provide this information, in full or in part, in his literature and in any descriptive leaflet supplied with the pick-up.

4.2 Type

The manufacturer shall state whether the output of the pick-up is substantially proportional to the displacement, velocity or acceleration of the vibration or shock input.

4.3 Type of motion

The manufacturer shall indicate the nature of the motion to which the pick-up will respond, such as

— uniaxial;

— multiaxial;

— angular.

4.4 Sensing element

The type of sensing element shall be indicated, for example, as follows:

— strain-sensitive resistance wire, bonded or unbonded;

— resistive potentiometer;

— variable capacitance;

— variable inductance;

— differential transformer;

— electromagnetic element;

— piezoelectric element;

— electronic tube;

— photoelectric element;

— electrokinetic element;

— piezoresistive element;

— optical element;

— magnetostrictive.

4.5 Orientation

The suitability of the pick-up for use in vertical, horizontal and inverted mounting positions shall be stated.

4.6 Indication of sensitive direction

The sensitive direction of the pick-up, called the axis of measurement, shall be indicated, for example by an arrow. If practical, the positive direction shall be marked or indicated by the orientation of an arrow and the polarity of output for motion in the positive direction shall be described.

4.7 Overall dimensions

Overall outline dimensions of the pick-up shall be given in a diagram.

4.8 Material

The material of the mounting base and surfaces exposed to its operational environment shall be stated.

4.9 Attachment

It shall be indicated whether the pick-up

a) is screwed, clamped, cemented, etc. to the vibrating surface, or whether it

b) may be hand-held, as for a probe type.

4.10 Mounting

The method of mounting and the location and size of the mounting holes or the studs in the pick-up shall be given. If screws are used to mount the pick-up, the mounting torque shall be recommended. For all factors relating to mounting, see ISO 5348.

4.11 Mass and moment of inertia

For uniaxial and multiaxial pick-ups, the mass and centre of gravity of the pick-up should be given; for angular vibration pick-ups, the moment of inertia, referred to the axis of measurement, should be given. If a pick-up is normally used above its natural frequency, the magnitude of the seismic mass shall be specified.

4.12 Position of sensing element

If applicable, the location of the centre of gravity of the sensing element shall be given. (This information is needed in the calibration of accelerometers on a centrifuge and in other applications where there may be a spatial gradient or a combination of uniaxial and rotational motion in the quantity being measured.)

4.13 Connections

If electrical connections between the pick-up and auxiliary equipment are required for its use, their type (e.g. low noise), length, mass, shielding, connection to case and type of connectors (if any) shall be stated, together with the recommended method of fixing the cable assembly to avoid unwanted dynamic effects on the pick-up.

4.14 Energy source

The manufacturer shall state whether the pick-up is self-generating and, if not, shall indicate the nature of the energizing or polarizing source.

4.15 Nature of output

The nature of the output of the pick-up shall be indicated. Various indications may be useful, for example, as follows:

a) that the output is a voltage or, furthermore, that it is a modulated carrier voltage or a frequency-modulated voltage; or

b) that the output is linearly, logarithmically or otherwise related to the input vibration.

4.16 Auxiliary equipment

The manufacturer shall state the type of or certain relevant characteristics of any required auxiliary equipment, for example, as follows:

— a charge amplifier to convert the charge output of a piezoelectric pick-up to a low impedance voltage;

— a specified input impedance — this may be required for auxiliary equipment such as an impedance convertor;

— a demodulator, used to eliminate the carrier frequency;

— a filter, used to remove undesired signals;

— a biasing voltage or bridge network, used to obtain zero output when a zero value of the motional function is applied;

— certain non-linear devices, used to correct for non-linearity of the output signal;

— integrating and differentiating circuits, their frequency range being stated.

A wiring diagram shall be given to enable the pick-up to be correctly connected to the auxiliary equipment.

5 Characteristics

5.1 Measurement range

The maximum and minimum measurement range for reliable indication shall be given in terms of acceleration, velocity and/or displacement.

The maximum range may be limited by maximum motion within a specified accuracy which could lead to loss of linearity, motions exceeding the setting of stops, motions exceeding the

ability of a pick-up mechanism to follow faithfully, and motions which would damage a pick-up.

The minimum range may be limited by the minimum resolving power of a pick-up, sticking where rubbing friction is present, thermal or electrical noise interference, or reduced accuracy due to loss of linearity.

5.2 Sensitivity, frequency response

Data concerning output *versus* input for a specified frequency in the operating range shall be given. For pick-ups the output of which is proportional to input, the proportionality factor shall be given in the form of a rated sensitivity. The probable error of sensitivity calibration shall be stated. The effect of frequency on sensitivity may be presented graphically by plotting the sensitivity as a function of frequency. The terminating impedance which applies to this presentation, as well as to other sensitivity presentations, shall always be specified. In pick-ups requiring an energizing voltage (alternating or direct), a carrier voltage or a biasing voltage, the rated sensitivity shall be either the value obtained when the recommended voltage is applied or the value obtained per volt. The recommended value of the biasing voltage shall be stated. The relationship of output to input shall be given in compatible units such as r.m.s. voltage or charge in conjunction with r.m.s. velocity, or peak voltage or charge in conjunction with peak velocity, and not as r.m.s. voltage or charge with peak velocity. Some of the appropriate units are given in the table.

Table — Appropriate units for measured quantities

Quantity measured	Output unit*	Input unit*
Uniaxial displacement	V; C	m
Uniaxial velocity		m/s
Uniaxial acceleration		m/s^{2}**
Angular displacement		degree; rad
Angular velocity		degree/s; rad/s
Angular acceleration		$degree/s^{2}$; rad/s^{2}

* Sub-multiples, preferably in powers of 10^{-3}, are used in practice for convenience, e.g. µm for displacement.

** Reference should also be made to ISO 2041.

5.3 Frequency range

In well defined mounting conditions, the operating frequency range over which the pick-up sensitivity does not vary from the rated sensitivity by more than a stated percentage shall be given, together with its seismic resonance frequency and any spurious resonance frequencies which affect the output signal. Where applicable, the approximate magnification (Q-factor) shall be stated for each resonance frequency.

5.4 Phase shift, frequency response

The maximum phase shift or phase angle between an impressed sinusoidal vibration and the resulting sinusoidal output signal, with a specified output termination, shall be given for operation in the recommended frequency range. The phase shift *versus* frequency may be presented graphically. If the phase shift is zero, this shall be stated.

NOTE — The phase response may be given relative to a known reference.

5.5 Damping

In well defined mounting and electrical termination conditions, the damping ratio shall be given. This may be stated in terms of logarithmic decrement or Q-factor.

5.6 Transverse sensitivity

The maximum sensitivity to motions transverse to the measurement axis of the pick-up and the frequency at which it is measured shall be given, together with its sensitivity to other kinds of motion which will affect its output, e.g. rotational motion.

If the sensitivity to transverse motions varies depending on the direction of the motion, the maximum sensitivity, its direction and frequency shall be stated.

5.7 Limits for maximum motion without damage

The maximum vibration and shock motion in both sensitive and transverse axes, given in terms of acceleration, velocity and/or displacement (and, where applicable, its frequency), for reliable operation without damage shall be given.

5.8 Linearity and hysteresis

The maximum deviation from a straight line for output *versus* input over the whole range of the pick-up shall be stated. This deviation may be expressed as a percentage of the reading or as a percentage of the full scale.

5.9 Electrical impedance

The electrical impedance of a pick-up is the ratio of the open circuit voltage to the short-circuit current. Where appropriate, the magnitude and phase angle of this impedance shall be tabulated for several frequencies over the range of operation, or, alternatively, a plot of these values as a function of frequency shall be included. If applicable, the impedance shall be stated in terms of equivalent values of inductance, resistance and capacitance, as appropriate, which apply over the range of frequencies for which the pick-up is recommended.

6 Environmental effects

6.1 Temperature and humidity effects

The operating temperature and/or humidity range over which the pick-up sensitivity and damping do not vary from their rated values by more than a stated percentage shall be given. The change of these quantities with temperature can be shown graphically.

Minimum and maximum storage temperatures and humidity shall be given. The temperature and humidity limits beyond which the pick-up might be damaged shall also be given. The effects and limitations of any pick-up mounting accessories and cables over the specified temperature range shall be stated.

6.2 Thermal transients

Any error outputs due to transient temperature changes should be stated in terms of output proportional to magnitude and length of time of the temperature change applied to the pick-up.

6.3 Disturbing acoustic fields

The effect of external acoustic fields on the electrical output of the pick-up shall be stated.

6.4 Disturbing electromagnetic fields

Where applicable, the effect of both constant and alternating electromagnetic fields on the operation of the pick-up shall be stated.

Such a statement shall include

a) the effect of constant magnetic fields on the sensitivity;

b) the effect of neighbouring ferromagnetic masses on the sensitivity; and

c) the effect of alternating electromagnetic fields in generating voltages in the pick-up and its connecting cable, for example, by giving the equivalent vibration for a magnetic field of 1 T and of specified frequency in the direction which gives maximum response; any effects of magnetic fields shall be stated for the relevant frequencies.

6.5 Earth currents

If an insulated coupling is provided to avoid interference from earth currents (ground loops), any effect on the performance of the pick-up shall be stated.

6.6 Base-strain sensitivity

The effect of base strain on the electrical output of the pick-up shall be stated.

6.7 Radiation exposure

The effect of radiation exposure on the performance and long-term behaviour of the pick-up shall be stated if the pick-ups are in a radiation environment.