

Human response to vibration — Measuring instrumentation

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National foreword

The Draft for Development has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee and is the English language version of ENV 28041:1993 *Human response to vibration — Measuring instrumentation*, published by the European Committee for Standardization (CEN). It is identical with ISO 8041:1990 published by the International Organization for Standardization (ISO). ENV 28041:1993 was produced as a result of international discussion in which the UK took an active part.

The United Kingdom did not support the publication of ISO 8041:1990 or this European Prestandard. BS 7482:1991 Parts 1, 2 and 3 are considered to define better methods for the testing of instrumentation. British Standard 7482 is consistent with both BS 6841 and BS 6842. Parts of ISO 8041 reflect ISO 2631 which is in the process of revision. BS 7482-3 is based on the requirements of BS 6841 which is more up-to-date than ISO 2631. ISO 8041 is now also the subject of revision.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because it is considered that it does not describe the current state of the art. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained and reported to the responsible CEN Technical Committee. Users of this Draft for Development are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted to an EN. Comments should be sent in writing to BSI, 2 Park Street, London W1A 2BS, quoting this Draft for Development, the relevant clause and any proposed revision, within 2 years of the issue of this Draft for Development.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the ENV title page, pages 2 to 28, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Descriptors: Vibration, human body, frequency response, vibration tests, measurements, measuring instruments, characteristics, marking, technical notices, tables (Data)

English version

Human response to vibration — Measuring instrumentation

(ISO 8041:1990)

Réponse des individus aux vibrations —
Appareillage de mesure
(ISO 8041:1990)

Schwingungseinwirkung auf den Menschen —
Meßeinrichtung
(ISO 8041:1990)

This European Standard was approved by CEN on 1991-10-01 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

Following consideration of the result of a Primary Questionnaire among members, the CEN Technical Board decided in October 1991 to submit the International Standard ISO 8041:1990 *Human response to vibration — Measuring instrumentation* to the Formal Vote for approval as European Prestandard.

The result of the Formal Vote was positive.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to announce this European Prestandard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Introduction to the European Prestandard

This European Prestandard defines performance requirements for instrumentation suitable to assess the vibration to which persons are exposed at workplaces. In view of the complexity of situations in which people are exposed to vibration it may sometimes be necessary to use instrumentation with other characteristics.

1 Scope

This International Standard specifies instrumentation for a method of measurement of vibration in a given frequency range, given in ISO 2631-1 for assessing the vibration as perceived by human beings. It applies to instrumentation for the measurement of hand-arm vibration and/or whole-body vibration. For other methods of measurement, ISO 2631 and ISO 5349 should be consulted.

This International Standard specifies electrical, vibration and environmental tests to verify compliance with the characteristics specified (see clause 4). It also determines the method for sensitivity calibration.

The purpose of this International Standard is to ensure consistency and compatibility of results and reproducibility of measurements realized with different measuring instrumentation using this method of measurement.

An instrument or an instrument collection may be realized which fulfils only the necessary requirements for measurement of hand-arm or whole-body vibrations under certain conditions, for example in the *z* direction, provided that the purpose is clearly stated and pertinent requirements of this International Standard are fulfilled.

In conjunction with spectral analysis, proper filter characteristics shall be applied (see clause 4).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. ISO 266:1975, *Acoustics — Preferred frequencies for measurements*.

ISO 1683:1983, *Acoustics — Preferred reference quantities for acoustic levels*.

ISO 2041, *Vibration and shock — Vocabulary*¹⁾.

ISO 2631-1:1985, *Evaluation of human exposure to whole-body vibration — Part 1: General requirements*.

ISO 2631-2:1989, *Evaluation of human exposure to whole-body vibration — Part 2: Continuous and shock-induced vibrations in buildings (1 to 80 Hz)*.

ISO 2631-3:1985, *Evaluation of human exposure to whole-body vibration — Part 3: Evaluation of exposure to whole-body *z*-axis vertical vibration in the frequency range 0,1 to 0,63 Hz*.

ISO 5347-0:1987, *Methods for the calibration of vibration and shock pick-ups — Part 0: Basic concepts*.

ISO 5348:1987, *Mechanical vibration and shock — Mechanical mounting of accelerometers*.

ISO 5349:1986, *Mechanical vibration — Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration*.

ISO 5805:1981, *Mechanical vibration and shock affecting man — Vocabulary*.

ISO 8042:1988, *Shock and vibration measurements — Characteristics to be specified for seismic pick-ups*.

IEC 225:1966, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 2041 and ISO 5805, together with the following, apply.

3.1 weighted vibration

frequency-weighted overall r.m.s. acceleration. It is expressed in metres per second squared.

Alternatively, instrumentation may express results in metres per second squared and as a level in decibels. The level in decibels is 20 times the logarithm to the base 10 of the ratio of a weighted acceleration, expressed in metres per second squared, to the reference acceleration

the acceleration is weighted in accordance with one of the five frequency weightings listed in Table 1 and specified in Table 4 to Table 8

¹⁾ To be published. (Revision of ISO 2041:1975.)

Table 1 — Frequency ranges

Characteristics of vibration	Frequency range Hz	International Standard
Whole body, severe discomfort, z: designated W.B.S.D.z	0,1 to 1	ISO 2631-3
Whole body, x-y: designated W.B.x-y	1 to 80	ISO 2631-1
Whole body, z: designated W.B.z	1 to 80	ISO 2631-1
Whole body, combined: designated W.B.combined	1 to 80	ISO 2631-2
Hand-arm: designated H.-A.	8 to 1 000	ISO 5349

the acceleration is time-weighted using exponential averaging (see clause A.3 and Annex D) with specified time constants, and peak or integrated mean-square values over a specified time period. When quoting the weighted acceleration, the frequency weighting and linear or exponential time-weighting shall be indicated

NOTE The term “weighted vibration” is often replaced by “weighted acceleration” or “vibration”. Whenever a velocity transducer or displacement transducer is used, the weighting applied should be changed accordingly. The type of transducer used should always be reported.

3.2 reference acceleration

the acceleration for expressing vibration levels given in ISO 1683 as 10⁻⁶ m/s²
if a different reference acceleration is used, this shall be stated

3.3 equivalent continuous vibration value and level

3.3.1 equivalent continuous vibration value

the equivalent continuous weighted acceleration, *a_{w eq}*, defined by the r.m.s. value:

$$a_{w eq} = \left\{ \frac{1}{T_m} \int_0^{T_m} [a_w(t)]^2 dt \right\}^{1/2}$$

... (1)

where

- a_w(t)* is the instantaneous weighted acceleration, in metres per second squared;
- T_m* is the integration time interval, in seconds;
- t* is the time, in seconds.

3.3.2 equivalent continuous vibration level

the equivalent continuous weighted acceleration level, *L_{w eq}*, in decibels, defined by

$$L_{w eq} = 10 \lg \left\{ \frac{1}{T_m} \int_0^{T_m} \frac{[a_w(t)]^2}{a_0^2} dt \right\}$$

... (2)

where

- a₀* is the reference acceleration (*a₀* = 10⁻⁶ m/s²);
- a_w(t)*, *T_m* and *t* are as defined in 3.3.1.

the integration time interval shall always be specified

3.4 crest factor

the ratio of the peak signal value evaluated over a specified time interval to the r.m.s. value over the same time interval

NOTE It is recommended that the r.m.s. value of the signal be measured using 60 s linear integration.

3.5 signal

3.5.1 pulse duty factor

for a rectangular sequence, the ratio between the pulse duration and the repetition period of the signal

3.5.2 signal burst

one or more complete cycles of sinusoidal signal; for the purpose of this International Standard, the signal burst starts and ends at a zero crossing of the waveform

3.5.3 burst duty factor

for a sequence of signal bursts, the ratio between the burst duration and the repetition period of the signal

3.6 primary indicator range

a specified range of the indicator of a vibration-measuring instrumentation for which the vibration-measuring instrumentation readings are within particularly close tolerances on sensitivity linearity as specified in 6.7

3.7 sensitivity linearity

the term indicating that the reading of the vibration-measuring instrumentation is proportional to the magnitude of the input signal, within stated tolerances

3.8

reference calibration frequency

the frequency, specified by the manufacturer, used for calibration of the sensitivity of vibration-measuring instrumentation. Preferred reference calibration frequencies are given in Table 2

Table 2 — Preferred reference calibration frequencies

Characteristics of vibration	Reference calibration frequency		Weighting factor
	ω s ⁻¹	f Hz	
Whole body, severe discomfort, z	2,5	0,398	0,666 (– 3,53 dB)
Whole body, x - y	50	7,96	0,254 (– 11,91 dB)
Whole body, z	50	7,96	0,905 (– 0,87 dB)
Whole body, combined	50	7,96	0,581 (– 4,71 dB)
Hand-arm	500	79,6	0,202 (– 13,89 dB)

3.9

reference calibration acceleration

an acceleration, specified by the manufacturer, used for calibrating the sensitivity of the vibration-measuring instrumentation

NOTE A reference calibration acceleration of 1 m/s² is preferred at 8 Hz, 80 Hz or 160 Hz. At 0,4 Hz a reference calibration acceleration of 0,1 m/s² is preferred.

4 Characteristics

Vibration-measuring instrumentation is generally a combination of a vibration transducer, an amplifier with a specified frequency weighting, and a detector-averager-indicator device with controlled characteristics. In clauses 5 and 6 specifications are given for these parts of the vibration-measuring instrumentation and tolerances are given for two types of vibration-measuring instrumentation. Any additional items (such as connectors, cables and preamplifiers) are regarded as integral parts of the vibration-measuring instrumentation. The manufacturer shall specify the connecting cable for which the calibration is valid. For instructions concerning mounting and calibration of transducers, see ISO 5348 and ISO 5347-0 respectively.

NOTE This International Standard does not state a preference for either analogue or digital signal processing. Both techniques are compatible with this International Standard as long as the requirements are complied with.

The specified characteristics of measuring instrumentation considered in this International Standard are as follows:

- a) frequency-weighting characteristics;

- b) bandlimiting;

- c) time-weighting, detector and indicator characteristics;

- d) sensitivity to various environments.

The instrumentation specified in this International Standard may also be used for spectral analysis. In this case, filter characteristics shall comply with IEC 225.

4.1 Tolerances

The specifications given for type 1 and type 2 vibration-measuring instrumentation have the same nominal value and differ mainly in the tolerances allowed. Tolerances are generally tighter for type 1 than for type 2 instrumentation and differ for the two types to a degree which affects the manufacturing costs significantly.

4.2 Applications

Type 1 instrumentation is intended especially for use where the vibration environment can be closely specified and/or controlled, and where certain specifications are to be evaluated or met. The measurement accuracy possible with such an instrument will generally not be realized under ordinary conditions. Type 2 instrumentation is suitable for general applications.

4.3 Weighting characteristics

4.3.1 Frequency weighting

Human-response vibration-measuring instrumentation shall have one or more frequency-weighting characteristics designated as follows (for an explanation of the abbreviations, see Table 1): 0,1 Hz to 1 Hz (W.B.S.D. z); 1 Hz to 80 Hz (W.B. x - y and W.B. z); 1 Hz to 80 Hz (W.B.combined); 8 Hz to 1 000 Hz (H.-A.). Other optional weighting characteristics may be included.

If such optional weighting characteristic is designated “flat”, its frequency response with respect to the input signal, for example acceleration or velocity, shall be constant but imposed by the appropriate band limiting characteristic. A flat characteristic enables the instrumentation to function as a preamplifier for an auxiliary device or to measure the un-weighted signal.

Weighting and amplifier circuits shall satisfy the requirements of 5.1. When the flat response is provided, the manufacturer shall specify its frequency range and tolerances. The tolerances shall not be greater than those for the frequency-weighting characteristics (Table 4 to Table 8).