

International Standard



5349

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Mechanical vibration — Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration

Vibrations mécaniques — Principes directeurs pour le mesurage et l'évaluation de l'exposition des individus aux vibrations transmises par la main

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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 5349 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.

Mechanical vibration — Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration

0 Introduction

Intensive vibration can be transmitted to the hands and arms of operators from vibrating tools, vibrating machinery or vibrating workpieces. Such situations occur, for example, when a person handles tools such as pneumatic, electric, hydraulic or engine-driven chain saws, percussive tools or grinders. Depending on the type and place of work, vibration can enter one arm only or both arms simultaneously, and may be transmitted through the hand and arm to the shoulder. The vibration of body parts and the perceived vibration are frequently the source of discomfort and possibly reduced proficiency. Continued, habitual use of many vibrating tools has been found to be connected with various patterns of diseases affecting the blood vessels, nerves, bones, joints, muscles or connective tissues of the hand and forearm.

The vibration exposures required to cause these disorders are not known exactly, either with respect to vibration intensity and frequency spectrum, or with respect to daily and cumulative exposure duration. In view of the complexity of the problem and the shortage of quantitative data concerning the occupational health effect of hand-transmitted vibration, it is difficult to propose a comprehensive method for assessing vibration exposure. However, based on the limited data available and on experience with current exposure conditions, the information proposed in this International Standard together with its annexes represents the best guidance available to protect the majority of workers against serious health impairment and to assist in the development of hand-operated tools the use of which will reduce the risk of disorders in man caused by vibrations.

The purpose of this International Standard is to further the gathering of consistent data in order to improve occupational safety. In particular, it is hoped that the data will serve to extend the present knowledge on the dose-effect relationship.

1 Scope and field of application

This International Standard applies to periodic and to random or non-periodic vibration. Provisionally, this International Standard may also be applied to repeated shock type excitation.

This International Standard specifies general methods for measuring and reporting hand-transmitted vibration exposure in three orthogonal axes for the one-third octave bands, having

centre frequencies from 6,3 to 1 250 Hz, the octave bands, having centre frequencies from 8 to 1 000 Hz and a frequency-weighted measure which covers the frequency range from 5,6 to 1 400 Hz.

This International Standard, together with its annexes, provides guidance for the evaluation of hand-transmitted vibration specified in terms of a frequency-weighted vibration acceleration and daily exposure time. It does not define the limits of safe exposure.

The guidance proposed in this International Standard is derived from a consensus of opinion based upon data available from both practical experience and laboratory experimentation concerning human response to hand-transmitted vibration. It cannot be taken to define completely safe exposure ranges in which vibration diseases cannot occur.

This International Standard does not specify the risk factor of health impairment for different operational processes, tools and machines.

To facilitate further progress in this field and to allow the quantitative comparison of exposure data, uniform methods for measuring and reporting exposure of human beings to hand-transmitted vibration are desirable. Additional standards are to be considered for the vibration measurement of specific tools and processes.

2 References

ISO 2631, *Evaluation of human exposure to whole-body vibration*.

ISO 5347, *Methods for the calibration of vibration and shock pick-ups*.¹⁾

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*.¹⁾

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

ISO 8041, *Human-response vibration measuring instrumentation*.¹⁾

1) At present at the stage of draft.

IEC Publication 184, *Methods for specifying the characteristics of electro-mechanical transducers for shock and vibration measurements*.

IEC Publication 222, *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement*.

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

3 Characterization of hand-transmitted vibration

3.1 General considerations

The severity of the biological effects of hand-transmitted vibration in working conditions is influenced by

- the frequency spectrum of vibration;
- the magnitude of vibration;
- the duration of exposure per working day;
- the temporal exposure pattern and working method, that is the length and frequency of work and rest spells; whether the tool is laid aside or held idling during breaks, etc.;
- the cumulative exposure to date;
- the magnitude and direction of forces applied by the operator through his hands to the tool or the workpiece;
- the posture of the hand, arm and body position during exposure (angles of wrist, elbow and shoulder joints);
- the type and condition of vibrating machinery, hand-tool or workpiece;
- the area and location of the parts of the hands which are exposed to vibration.

The severity of the biological effects of hand-transmitted vibration in working conditions may be influenced by

- the direction of the vibration transmitted to the hand;
- the method of working and the operator's skill;
- any predisposing factors in the individual's health.

The following factors may specifically affect the circulation changes caused by hand-arm vibration:

- climatic conditions;
- diseases which affect the circulation;
- agents affecting the peripheral circulation, such as smoking, certain medicines or chemicals in the working environment;
- noise.

Although the importance of all the factors listed with respect to the generation of vibration disorders is not yet known in sufficient detail, reporting of all factors is considered desirable in order to enable the collection of meaningful exposure histories. It is also important to report the measurement procedure and the statistical techniques used to evaluate the vibration data.

3.2 Direction of vibration

The directions of vibration transmitted to the hand should be reported in the appropriate directions of an orthogonal co-ordinate system as suggested in figure 1.

For vibration measurements, the orientation of the coordinate system may be defined with reference to an appropriate basicentric coordinate system [see figure 1a)] originating, for example, in a vibrating appliance, workpiece, handle or control device gripped by the hand.

NOTE — Current methods of vibration assessment are based on the directional component with the largest weighted vibration acceleration.

In order to avoid a conflict between the terminology proposed here and that used generally in biodynamics to define human whole-body vibration exposure (see ISO 2631), it is proposed that the motions of the hand for the various directions of the coordinate system be designated by the parenthetical word "(hand)" or the subscript "h". (The acceleration of the hand in the z direction would be designated $a_{z(\text{hand})}$ or $a_{z,h}$, and similarly for directions x and y . Whole-body acceleration in the longitudinal axis is designated by a_z , and similarly for directions x and y .)

3.3 Magnitude of vibration

3.3.1 The primary quantity used to describe the magnitude of the vibration shall be acceleration which should normally be expressed in metres per second squared (m/s^2). The magnitude of the vibration should be expressed as a root-mean-square (r.m.s.) acceleration value. The acceleration may also be measured with a weighting network as defined in 3.4.5 and table 1.

Acceleration measured in conjunction with frequency analysis equipment (for example one-third octave band filters) should not be weighted.

The weighting characteristics of the filter described in table 1 require that the attenuation of the filter be zero up to a frequency of 16 Hz and then increase at 6 dB/octave above that frequency.

The data for these weighting characteristics are derived from laboratory studies of human response to hand-transmitted vibration.

3.3.2 The magnitude of the vibration may also be expressed in terms of an acceleration level, in decibels (dB). This is defined as

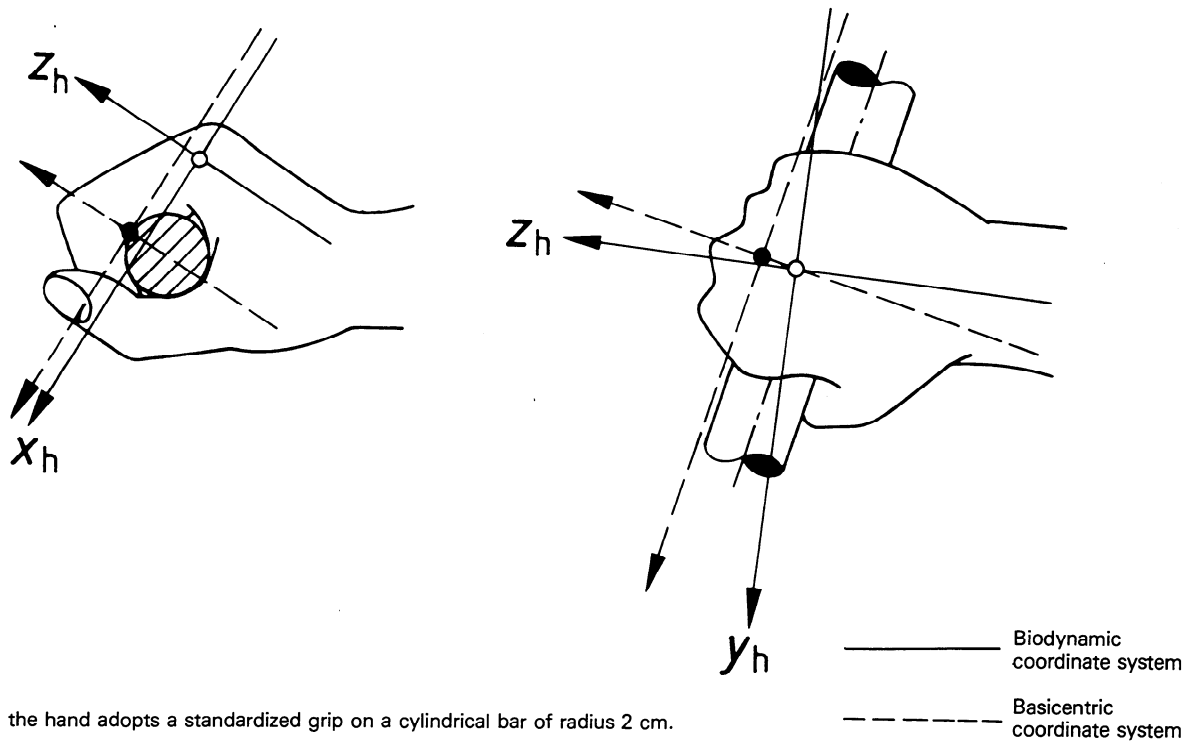
$$L_h = 20 \lg \left(\frac{a}{a_0} \right)$$

where

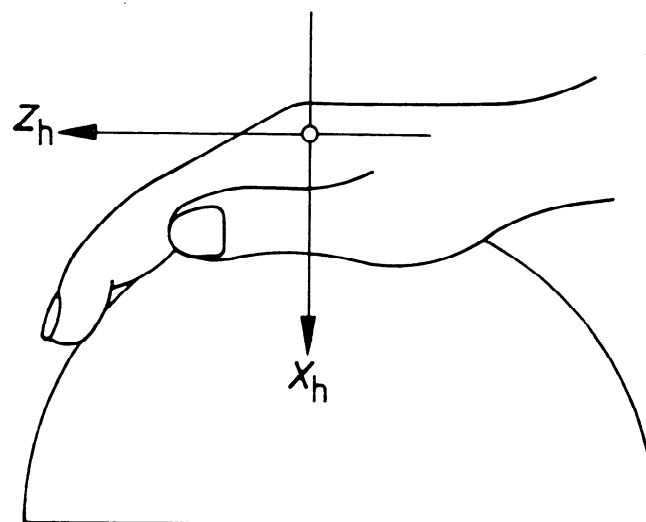
a is the r.m.s. acceleration, in metres per second squared;

a_0 is the reference acceleration of $1 \mu\text{m/s}^2$.

The acceleration level may also be measured with the weighting network described in 3.4.5 and table 1 and is called the weighted acceleration level $L_{h,w}$ (see 4.4). Acceleration levels measured in conjunction with frequency analysis equipment (for example one-third octave band filters) should not be weighted.



a) "Handgrip" position



b) "Flat palm" position

NOTE — The origin of the system is deemed to lie in the head of the third metacarpal and the $z_{(\text{hand})}$ -axis to be defined by the longitudinal axis of that bone.

The x -axis is perpendicular to the palm area, being positive in the direction of the back of the palm, when the hand is in the normal anatomical position (palm facing forwards). The y -axis passes through the origin and is perpendicular to the x -axis.

When the hand is gripping a cylindrical handle, the system may be rotated so that the y_h -axis is parallel to the axis of the handle.

Figure 1 — Coordinate system for the hand