

Guide to

Measurement and evaluation of human exposure to vibration transmitted to the hand

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Foreword

This British Standard has been prepared under the direction of the General Mechanical Engineering Standards Committee. It replaces DD 43:1975 “*Guide to the evaluation of exposure of the human hand-arm system to vibration*”, which is withdrawn, and takes into account the international work carried out to date in this field.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, 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.

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 uses tools such as pneumatic, electric, hydraulic or engine driven chain-saws, percussive tools, or grinders. Depending on the work situation, the vibration may be transmitted to one arm only or to both arms simultaneously. It may also be transmitted through the hand and arm to the shoulder. The vibration of the body parts and the perceived vibration are frequently a source of discomfort and, possibly, reduced proficiency. Habitual use of many vibrating tools has been found to be connected with various patterns of disease affecting the blood vessels, nerves, bones, joints, muscles and connective tissues of the hand and forearm. Many of these diseases can also be caused by mechanical strain of the hand-arm system, but there is a specific association between vibration and diseases affecting the blood vessels.

The vibration exposures required to cause these disorders are not known exactly, with respect to either the vibration magnitude, frequency spectrum and direction or the daily and cumulative exposure duration.

The standard takes into account international work and is a consensus based upon data available from practical experience and laboratory experimentation in the field of human response to hand-transmitted vibration.

In view of the complexity of the problem and the paucity of quantitative data concerning the occupational health effects of hand-transmitted vibration, it is difficult to propose a firm standard regarding the evaluation of such vibration. However, based on the limited information available, this standard will guide designers, manufacturers, etc. on how vibration likely to cause risk of injury should be measured, together with the weighting to be given at different frequencies.

NOTE Appendix A summarizes the dose-effect information which is likely to form the basis of future development. Appendix B gives preventive measures which may help those responsible for industrial hygiene to reduce the incidence of vibration injury. Appendix C is a bibliography of references relating to vibration.

1 Scope

This British Standard provides guidance on measuring and evaluating hand-transmitted vibration exposure in three orthogonal axes over the frequency range 8 Hz to 1 000 Hz.

The purpose of this standard is to provide a uniform method of measuring and reporting hand-transmitted vibration so that consistent data may be gathered. This will extend the present knowledge of dose-effect relationships.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Characterization of hand-transmitted vibration

2.1 General considerations

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

- a) the frequency spectrum of vibration;
- b) the magnitude of vibration;
- c) the temporal exposure pattern and working method (i.e. length and frequency at work and rest spells; whether the tool is laid aside or held idling during breaks in work, etc.);
- d) the duration of exposure per working day;
- e) the cumulative exposure to date;
- f) the direction of the vibration transmitted into the hand;
- g) the magnitude and direction of forces applied by the operator through his hands to the tool or workpiece;
- h) the posture of the hand, arm and body during exposure (i.e. the angles of fingers, wrist, elbow and shoulder joints);
- i) the area and location of the parts of the hands which are exposed to vibration;
- j) the type and condition of the vibrating machinery, hand tool or workpiece;
- k) the method of working and the operator's skill;
- l) predisposing factors in the health of the individual.

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

- 1) climate or environmental conditions;
- 2) certain medical conditions;
- 3) agents affecting the peripheral circulation, such as smoking, certain medicines or chemicals in the working environment;
- 4) noise.

The importance of the factors listed with respect to the generation of vibration disorders is not yet known in detail. Improved understanding of the effects of vibration may arise from reporting of the above factors in future epidemiological studies. Where variations on the method in this standard are used it is important that the differences are clearly reported.

2.2 Direction of vibration

The directions of vibration transmitted to the hand should be reported in the appropriate directions of an orthogonal coordinate system.

The orientation of the coordinate system should, for vibration measurements, be defined with reference to an appropriate basicentric coordinate system (see Figure 1) originating, for example, in a vibrating appliance, workpiece, handle or control device grasped by the hand.

NOTE 1 A basicentric coordinate system is one whose axes are related to specific directions in the tool or workpiece, e.g. one of the axes will be parallel to the direction of the blow in a chisel or hammer. The anatomical coordinate system for the hand is described and illustrated in Figure 1. Where possible the axes of the basicentric system should be labelled x, y and z, so that these axes are approximately parallel to the appropriate anatomical coordinate system of the hand when held in normal use.

NOTE 2 In order to avoid conflict between the terminology for the hand-arm system and that of the whole body, it is proposed that the motions of the hand for the various directions of the coordinate systems be designated by the subscript "h". The acceleration of the hand along the z-axis would be designated $a_{z,h}$ and similarly for the x-axis and y-axis. Weighted acceleration should be designated by the subscript "w", so that the weighted acceleration of the hand along the z-axis would be designated $a_{z,h,w}$.

2.3 Magnitude of vibration

The primary quantity used to describe the magnitude of the vibration is acceleration, which should normally be expressed in metres per second per second (m s^{-2}). The magnitude of the vibration should be expressed as a root mean square (r.m.s.) acceleration value. The acceleration should be measured with the frequency weighting network defined in 3.8, and for the three axes is represented as $a_{x,h,w}$, $a_{y,h,w}$ and $a_{z,h,w}$.

3 Measurement of hand-transmitted vibration

3.1 Measurement equipment

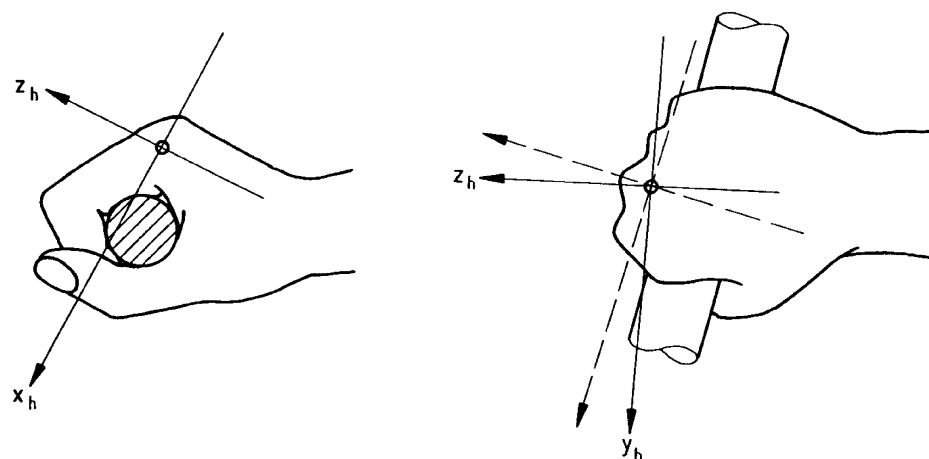
Vibration measurement equipment generally consists of a transducer, an amplifying device, filter and amplitude or level indicator or recorder. Where practicable and appropriate, networks may be included to limit the frequency range of the equipment. For many applications, where it is not essential to rely solely upon on-the-spot determinations, a suitable recorder may be used to obtain representative records for subsequent analysis. An r.m.s. measuring device may also be included for convenience, so that r.m.s. values may be read off or recorded directly.

All vibration measurement equipment should be calibrated in accordance with existing standards or recommendations which govern the calibration of such equipment. The basis of operation and the characteristics of any measurement equipment used should be reported, together with the results obtained. It is important to report characteristics such as the frequency response, the dynamic properties (for example the time constant, the dynamic range and resolution of the equipment), and when appropriate, the precision of the r.m.s. rectification, tape recording, frequency analysis or similar operations performed upon the signal.

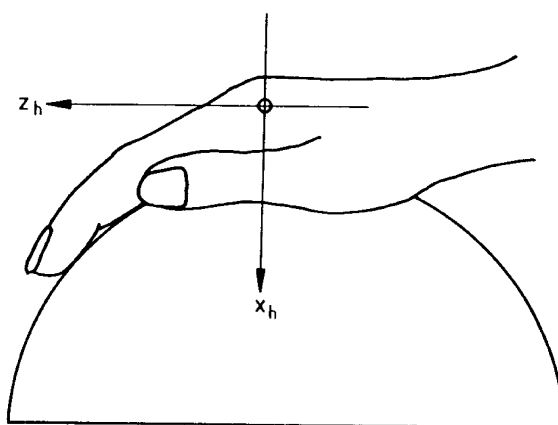
The dynamic range of the complete system should be as large as possible over the frequency range of interest. It may be necessary to attenuate signals above 2 000 Hz; this attenuation should be made as near to the transducer as possible in the vibration measurement chain.

3.2 Measurement of r.m.s. values

If the signal for analysis is of short duration or its magnitude varies substantially with time, a simple analysis cannot be made. In order to obtain the r.m.s. values under these circumstances it is necessary to use an integrating meter or analyser. It is recommended that true integration be adopted in preference to exponential averaging, which is only appropriate when the signal is relatively steady with time and of sufficient duration.



(a) 'Handgrip' position (showing a standardized grip on a cylindrical bar of radius 2 cm)



(b) 'Flat palm' position (showing a hand pressed onto ball of radius 5 cm)

Key

- Anatomical coordinate system
 - - - - - Basicentric coordinate system

NOTE The origin of the anatomical system is deemed to lie in the head of the third metacarpal and the z-axis (i.e. hand axis), is defined by the longitudinal axis of the bone. The x-axis projects forwards from the origin 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. In cases where the hand is gripping a cylindrical handle the system will be rotated so that the y_h -axis is parallel to the handle axis.

Figure 1 — Coordinate system for the hand