BRITISH STANDARD

BS EN 14253:2003 +A1:2007

Mechanical vibration — Measurement and calculation of occupational exposure to whole-body vibration with reference to health — Practical guidance

ICS 13.160

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Full document details: BS EN 14253:2003+A1:2007

National foreword

This British Standard is the UK implementation of EN 14253:2003+A1:2007. It supersedes BS EN 14253:2003 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by ▌A1⟩ ⟨A1▌.

The UK participation in its preparation was entrusted to Technical Committee GME/21/6, Human exposure to mechanical vibration.

A list of organizations represented on this committee can be obtained on request to its secretary.

European legislation (The Physical Agents (Vibration) Directive, 2002/44/EC) requires employers to assess workers' exposure to whole-body vibration and sets a daily exposure action value and limit value. These exposure levels are defined in the Directive in terms of the eight-hour energy-equivalent frequency-weighted acceleration (known as the *A*(8) value) or, alternatively, the daily vibration dose value (VDV).

This Standard was developed by CEN TC231 to support the requirements of the Directive by supplementing the information in ISO 2631-1:1997 with practical guidance. However, the United Kingdom committee was concerned that the standard considers only exposures based on the eight-hour energy-equivalent frequency-weighted acceleration (known as the *A*(8) value) and not on the daily vibration dose value (VDV), although both methods are given equal prominence in the Directive. In response to this concern National Annex NA has been added to this standard to provide guidance on the evaluation of exposures using the VDV method.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

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English Version

Mechanical vibration - Measurement and calculation of occupational exposure to whole-body vibration with reference to health - Practical guidance

Vibrations mécaniques - Mesurage et calcul de l'effet sur la santé de l'exposition professionnelle aux vibrations transmises à l'ensemble du corps - Guide pratique

Mechanische Schwingungen - Messung und rechnerische Ermittlung der Einwirkung von Ganzkörper-Schwingungen auf den Menschen am Arbeitsplatz im Hinblick auf seine Gesundheit - Praxisgerechte Anleitung

This European Standard was approved by CEN on 1 September 2003 and includes Amendment 1 approved by CEN on 21 October 2007.

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Foreword

This document (EN 14253:2003) has been prepared by Technical Committee CEN/TC 231 “Mechanical vibration and shock”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2004, and conflicting national standards shall be withdrawn at the latest by May 2004.

Annexes A and B are informative

Users of this EN, prepared in the field of application of Article 137 (formerly 118a) of the EC Treaty, should be aware that standards have no formal legal relationship with Directives which may have been made under Article 137 of the Treaty. In addition, national legislation in the Member states may contain more stringent requirements than the minimum requirements of a Directive based on Article 137. Information on the relationship between the national legislation implementing Directives based on Article 137 and this EN may be given in a national foreword of the national standard implementing this EN.

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Foreword to amendment A1

This document (EN 14253:2003+A1:2007) has been prepared by Technical Committee CEN/TC 231 “Mechanical vibration and shock”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2008, and conflicting national standards shall be withdrawn at the latest by May 2008.

This document supersedes EN 14253:2003.

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Users of this EN, prepared in the field of application of Article 137 (formerly 118a) of the EC Treaty, should be aware that standards have no formal legal relationship with Directives which may have been made under Article 137 of the Treaty. In addition, national legislation in the Member states may contain more stringent requirements than the minimum requirements of a Directive based on Article 137. Information on the relationship between the national legislation implementing Directives based on Article 137 and this EN may be given in a national foreword of the national standard implementing this EN.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

Occupational exposure to whole-body vibration can, in some circumstances, contribute to illness. The general requirements for measuring and evaluating whole-body vibration exposure are specified in ISO 2631-1. The aim of this European Standard is to provide practical guidelines to develop an effective strategy for evaluation of whole-body vibration exposure at the workplace.

The use of the strategy described in this European Standard will lead to a realistic picture of the daily exposure of a subject and of the relevant uncertainties.

The evaluation of vibration exposure can be broken up into a number of different stages:

— identifying a series of discrete operations which make up the subject's working pattern;

— selection of operations to be evaluated;

— establishing the r.m.s. acceleration value for each selected operation;

— evaluation of a typical daily exposure time for each operation identified;

— calculating the daily vibration exposure.

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1 Scope

This European Standard provides guidelines for the measurement and evaluation of whole-body vibration at the workplace.

This European Standard describes the precautions to be taken to make representative vibration measurements and to determine the daily exposure time for each operation in order to calculate the daily exposure value standardized to an 8 h reference period. This European Standard provides a means to determine the relevant operations that should be taken into account when determining the vibration exposure.

This European Standard applies to situations where people are exposed to whole-body vibration at the workplace, transmitted through the buttocks for a seated person or through the feet for a standing person.

This European Standard is restricted to the evaluation of exposure to whole-body vibration using quantities derived from frequency-weighted root-mean-square acceleration. The frequency range considered is 0,5 Hz to 80 Hz. Where the vibration includes shocks or impacts, methods in this European Standard may underestimate the severity of the exposure. There is a need to assess the risks arising from exposure to whole-body shocks and high crest factor vibration. Methods for this are beyond the scope of this European Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[A1] EN ISO 8041, *Human response to vibration - Measuring instrumentation (ISO 8041:2005)* [A1]

EN 30326-1, *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements (ISO 10326-1:1992)*

ISO 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 5347 (all parts), *Methods for the calibration of vibration and shock pick-ups*

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

ISO 16063 (all parts), *Methods for the calibration of vibration and shock transducers*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1
operation
identifiable activity for which a representative vibration magnitude measurement is made, being a combination of a type of work and a working condition

EXAMPLE The type of work can be travelling for a lorry, lifting for a fork-lift truck, etc.; a working condition can be good or poor travelling surface, soft or hard material to excavate, etc.

3.2
work cycle
operation or series of different operations, which is repeated

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4 Quantities to be evaluated

There are two principal quantities to be evaluated for each operation *i* during exposure to vibration:

— The frequency-weighted acceleration in metres per second squared (m/s^2), expressed as the root-mean-square (r.m.s.) values a_{wi} for each of the three axes at the supporting surface;

— the total duration per day T_i of vibration exposure for operation *i*.

The daily vibration exposure $A_l(8)$, in m/s^2, for each direction *l* is defined as:

$$A_l(8) = k_l \sqrt{\frac{1}{T_0} \sum_i a_{wli}^2 T_i} \qquad (1)$$

where

a_{wli} is the frequency-weighted r.m.s. value of the acceleration, determined over the time period T_i

$k_x = k_y = 1{,}4$ for the x- and y-directions; $k_z = 1$ for the z-direction

l = x, y, z

T_0 is the reference duration of 8 h (28800 s)

NOTE 1 The Physical Agents Directive 2002/44/EC allows an 8-h vibration dose value (VDV) instead of A(8). Where VDV is used, the $A_l(8)$ in this European Standard should be replaced by the daily vibration dose value in the *l* direction. The use of VDV instead of *A*(8) will generally result in a different evaluation of the health risk.

NOTE 2 The values of k_l in the x- and y-directions are based on sensitivity of seated persons but the same factors should be applied for other postures, e.g. standing.

NOTE 3 If it can be shown that there is clearly a dominant direction it is sufficient to measure only this direction.

The individual contribution of an operation or work cycle *i* to the daily vibration exposure can be calculated as:

$$A_{li}(8) = k_l \, a_{wli} \sqrt{\frac{T_i}{T_0}} \qquad (2)$$

5 Preparation of the measurement procedure

5.1 General

The vibration exposure of an individual during a working day may involve a series of different operations, some of which may be repeated. The vibration exposure may vary greatly from one operation to another, e.g. due to the operator's behaviour, the use of different machines or differences between the operations, or due to seasonal effects.

Before making measurements, it is first necessary to identify the individual operations which are likely to contribute substantially to the overall exposure. The location and nature of each operation should be defined accurately and the total duration associated with the individual worker during the single day should be quantified. A survey should be undertaken to establish an "exposure profile". This will help to determine the likely relative importance of each type of operation in the overall value of *A*(8), to identify those for which measurements are required, and to assist in the planning of any necessary exposure controls.

The daily vibration exposure *A*(8) may be determined for a specific individual on a specific day. In some situations it may also be useful to calculate *A*(8) for a notional "typical" day's exposure, using carefully selected representative vibration measurements and carefully considered exposure duration values. There is no method for evaluating the

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combined vibration exposure for more than one day. Therefore, to know what is a typical day when vibration varies from one day to another, it is recommended to evaluate the variability of the daily vibration exposure *A*(8) over days. However, it is not acceptable to determine *A*(8) by averaging over several days on which different levels of variation exposure have occurred.

Representative days of measurement shall be selected with care if evaluation concerns the individual risk. In particular, variation in exposure due to equipment used, work condition, or environments, shall be evaluated.

5.2 Exposure profile

The exposure profile is used to identify those operations which contribute to the overall value of *A*(8) and to define the conditions under which measurements are to be made. It is important to make measurements for all the machines and operations which may give a significant contribution to the daily vibration exposure. For each operation identified, the following should be established:

— the machine being used;

— a full description of the operation (e.g. for a fork-lift truck: travelling or lifting or idling; for an excavator: digging or travelling; or a combination of these);

— operation conditions;

— nature of ground;

— state and tuning of the seat;

— the number of times the operation is performed per day;

— the average duration of the operation;

— if possible, the nature of the vibration (e.g. continuous, impulsive, shocks, principal direction, source).

Identify all changes in the operating conditions where this might affect the vibration exposure.

EXAMPLE

— speed of mobile machines;

— a fork-lift truck may be travelling on a smooth surface inside a building, on an uneven surface inside (pits, thresholds, cables/hoses, debris, etc.) or on a rough surface outside;

— a dumper may be travelling unloaded or loaded;

— additional equipment which might affect vibration exposure, e.g. an agricultural tractor may be fitted with a slurry tanker or a plough.

In addition, it may be useful to obtain:

— information from workers and supervisors on which operations they believe produce the highest vibration magnitude;

— estimates of the potential vibration hazards for each operation, using information from manufacturers on vibration emission values, or using published results of previous measurements on similar machines;

— manufacturers' information on vibration magnitudes and the travelling conditions under which they have been measured;

— subject's posture, seat suspension topping or bottoming, use of backrest.

In the case of short, well-defined exposures, different vibration magnitudes may be associated with each of the individual operations (e.g. loading and travelling over a rough surface with a wheel-loader, travelling and lifting with a fork-lift truck). In such cases, as many measurements as practicable should be performed for each individual

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operation identified in the profile, and averaged as shown in equation (3). The daily duration of overall exposure to each operation should then be used to determine the overall exposure as shown in equation (1).

For the case of long uninterrupted operations (e.g. driving a long-distance in a coach or lorry), two possible situations can exist. The first consists of essentially stationary vibration data, unchanging in its statistical characteristics; this might be true for a long journey at constant speed on a motorway. The measurement should be long enough to determine an accurate average vibration magnitude (see 5.4).

The other possible situation consists of a continuous operation for which the vibration is not statistically stationary but changes with time. An approximate exposure profile can be obtained by grouping periods of substantially different vibration that are statistically stationary. Common examples of logical measurement groupings include grouping by road type (e.g. urban roads, country roads, motorways) or grouping by vehicle operation (e.g. travelling, other operations). As many measurements as possible should then be made for each operational grouping to provide a statistical description of the vibration.

5.3 Organization of the measurements

Ideally, measurement of the daily exposure will be continuous throughout the working day and some modern instruments facilitate this. However, this is often impracticable and it is then necessary to establish a method of sampling appropriate periods of vibration exposure.

The organization of the measurements will depend on the types of vibration exposure of the selected relevant operations.

To evaluate the daily vibration exposure, two types of work pattern can be distinguished:

a) The daily work consists of long uninterrupted operations (e.g. driving a long-distance in a coach or lorry). In this case, vibration measurements are made over a section of an operation or a complete operation, which may include short interruptions, which are valid parts of the normal operation (e.g. stops at traffic lights).

   In addition to vibration magnitude information, the evaluation of daily vibration exposure requires a determination of the duration of exposure to vibration per day.

b) The daily work consists of operations with different vibration magnitudes over short periods in respect to the daily working times (e.g. loading and travelling over a rough surface with a wheel-loader, travelling and lifting with a fork-lift truck). In such cases either the measurements are made separately for each of the different operations at the whole work and the results are combined or where the combination of operation duration is available the measurements are made directly for this combination.

   In addition to vibration magnitude information, the evaluation of daily vibration exposure requires a determination of the exposure duration associated with each operation.

Separate measurements shall be made during those operations believed to cause the greatest vibration magnitudes in order to establish the highest short-term exposure.

When identifying the important operations, it is important to consider events which occur outside the main work. For example, driving an agricultural tractor to and from the field may result in more vibration than the operation undertaken in the field.

5.4 Duration and number of vibration measurements

The duration and number of measurements shall be selected so that a representative 8 h frequency-weighted vibration value can be established. Where continuous measurement throughout the day is not possible, the duration of measurements will be determined by the operation characteristics defined in 5.2.

a) Where the daily work consists of long uninterrupted operations, a series of sample measurements, each of at least 3 min duration, should be taken at different times of the day, and averaged so that variations in vibration through the day are accounted for. The number, *N*, of sample measurements made shall be sufficient to show that the average value obtained is representative of the vibration occurring throughout the day.

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The average vibration magnitude, in m/s^2, of a series of *N* vibration magnitude samples is given by:

$$a_w = \sqrt{\frac{1}{T}\sum_{j=1}^{N} a_{wj}^2\, t_j} \qquad (3)$$

where

a_{wj} is the measured vibration magnitude for sample j

t_j is the measurement duration of sample j

$T = \sum_{j=1}^{N} t_j$ is the total measurement duration

This procedure shall be carried out separately for vibration in each of the axes measured.

b) Where the daily work consists of operations of shorter duration, which are repeated several times during a working day, measurements for determination of the 8 h energy-equivalent vibration value can be made over complete work cycles. The number of work cycles over which measurements are made shall be sufficient to show that the average value obtained is representative of the vibration from the operation throughout the day.

c) Where no operations are repeated, the vibration from every operation shall be measured.

d) Where there is no repeated work cycle of operations of short duration and the individual operations are shorter than 3 min, the operations can be repeated in order to collect measurements over a minimum of 3 min, see example in clause A.3. As an alternative, simulated operations may be organized for making measurements of 3 min duration.

NOTE The requirement of a minimum of 3 min is due to statistical reasons.

5.5 Estimation of exposure time

The total daily exposure duration shall be obtained for each operation or work cycle for which a vibration magnitude has been established. This may be based on;

a) a measurement of the actual exposure duration of a single operation or work cycle; and

b) information on the number of operations or work cycles per working day.

The first of these will be a measurement to determine how long an operator is exposed to vibration, and from what source, during a specified period. Various techniques may be used, for example:

— use of a stopwatch;

— analysis of video recordings;

— activity sampling.

A source of information may be work records, e.g. the number of lorries loaded and unloaded by fork-lift trucks. However, it is important to ensure that the information is compatible with the information required for an evaluation of daily vibration exposure. For example, work records might give very accurate information on the number of completed work items at the end of each day, but where there is more than one operator, or unfinished work items at the end of a shift, this information may not be directly applicable to a vibration exposure evaluation.

NOTE Operators asked for information on their typical daily vibration exposure duration will normally give an estimate which includes periods of time when there is no vibration (e.g. idling, lifting for a fork-lift truck). Therefore, such an approach often results in an overestimation of the exposure duration.

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