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Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 2: Practical guidance for measurement at the workplace (ISO 5349-2:2001)

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Swedish Standards corresponding to documents referred to in this Standard are listed in "Catalogue of Swedish Standards", issued by SIS. The Catalogue lists, with reference number and year of Swedish approval, International and European Standards approved as Swedish Standards as well as other Swedish Standards.

Vibration och stöt – Mätning och bedömning av vibrationer som överförs till handen – Del 2: Praktiska riktlinjer för mätning vid arbetsplats (ISO 5349-2:2001)

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Mechanical vibration - Measurement and evaluation of human exposure to hand-transmitted vibration - Part 2: Practical guidance for measurement at the workplace (ISO 5349-2:2001)

Vibrations mécaniques - Mesurage et évaluation de l'exposition des individus aux vibrations transmises par la main - Partie 2: Guide pratique pour le mesurage sur le lieu de travail (ISO 5349-2:2001)

Mechanische Schwingungen - Messung und Bewertung der Einwirkung von Schwingungen auf das Hand-Arm-System des Menschen - Teil 2: Praxisgerechte Anleitung zur Messung am Arbeitsplatz (ISO 5349-2:2001)

This European Standard was approved by CEN on 22 June 2001.

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Foreword

The text of EN ISO 5349-2:2001 has been prepared by Technical Committee CEN/TC 231 "Mechanical vibration and shock", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 108 "Mechanical vibration and shock".

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of an identical text or by endorsement, at the latest by February 2002, and conflicting national standards shall be withdrawn at the latest by February 2002.

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.

Annexes A to E of this European Standard are informative.

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Introduction

Operating machinery may expose workers to hand-transmitted mechanical vibration which can interfere with comfort, working efficiency and, in some circumstances, health and safety. The general requirements for measuring and evaluating hand-transmitted vibration exposure are specified in ISO 5349-1. The aim of the present part of ISO 5349 is to provide practical guidelines in accordance with ISO 5349-1 to perform measurements correctly and to develop an effective strategy for measurement of hand-transmitted vibration at the workplace.

The use of the strategy described in this part of ISO 5349 will lead to a realistic picture of the daily exposure of the operator at the workplace and of the relevant uncertainties.

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

- identifying a series of discrete operations which make up the subject's normal working pattern;
- selection of operations to be measured;
- measuring the r.m.s. acceleration value for each selected operation;
- evaluation of the typical daily exposure time for each operation identified;
- calculating the 8-h energy-equivalent vibration total value (daily vibration exposure).

The evaluation of vibration exposure as described in ISO 5349-1 is solely based on the measurement of vibration magnitude at the grip zones or handles and exposure times. Additional factors, such as gripping and feed forces applied by the operator, the posture of the hand and arm, the direction of the vibration and the environmental conditions, etc. are not taken into consideration. This part of ISO 5349, being an application of ISO 5349-1, does not define guidance to evaluate these additional factors. However, it is recognized that reporting of all relevant information is important for the development of improved methods for the assessment of vibration risk.

1 Scope

This part of ISO 5349 provides guidelines for the measurement and evaluation of hand-transmitted vibration at the workplace in accordance with ISO 5349-1.

This part of ISO 5349 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 8-h energy-equivalent vibration total value (daily vibration exposure). This part of ISO 5349 provides a means to determine the relevant operations which should be taken into account when determining the vibration exposure.

This part of ISO 5349 applies to all situations where people are exposed to vibration transmitted to the hand-arm system by hand-held or hand-guided machinery, vibrating workpieces, or controls of mobile or fixed machinery.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO 2041, *Vibration and shock – Vocabulary*.

ISO 5349-1:2001, *Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 1: General requirements*.

ISO 5805, *Mechanical vibration and shock – Human exposure – Vocabulary*.

ISO 8041, *Human response to vibration – Measuring instrumentation*.

ISO 8662 (all parts), *Hand-held portable power tools – Measurement of vibrations at the handle*.

3 Terms and definitions and symbols

3.1 Terms and definitions

For the purposes of this part of ISO 5349, the terms and definitions given in ISO 2041 and ISO 5805 and the following apply.

3.1.1

hand-fed machine

machine where the operator feeds workpieces to the working part of the machine, such that the vibration exposure is obtained through the hand-held workpiece

EXAMPLE band-saw, pedestal grinder

3.1.2

hand-guided machine

machine which is guided by the operator with his hands, such that the vibration exposure is obtained through the handles, steering wheel or tiller

EXAMPLE ride-on lawn mower, powered pallet truck, swing grinder

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3.1.3 hand-held workpiece

workpiece which is held in the hand, such that vibration exposure is obtained through the hand-held workpiece rather than, or as well as, through the power tool handle

EXAMPLE casting held against a pedestal grinder, wood fed into a band-saw

3.1.4 hand-held power tool

powered tool which is held in the hand

EXAMPLE electric drill, pneumatic chisel, chain saw

3.1.5 inserted tool

interchangeable or replaceable attachment which fits into or onto a power tool or machine

EXAMPLE drill bit, chisel, chain saw chain, saw-blade, abrasive wheel

3.1.6 operation

identifiable task for which a representative vibration magnitude measurement is made, this may be for the use of a single power tool, or hand-held workpiece type or for a single phase of a task

3.1.7 operator

person using a hand-fed, hand-guided or hand-held machine or power tool

3.1.8 tool operation

any period during which a power tool is operating and the operator is being exposed to hand-transmitted vibration

3.1.9 workpiece

item being operated upon by a power tool

3.2 Symbols

In this part of ISO 5349, the following symbols are used:

a_{hwi} single-axis root-mean-square (r.m.s.) value of the frequency-weighted hand-transmitted vibration for operation i , in m/s^2 . An additional suffix x , y or z is used to indicate the direction of the measurement, i.e. a_{hwix} , a_{hwiy} and a_{hwiz}

a_{hvi} vibration total value (formerly denoted vector sum or frequency-weighted acceleration sum) for operation i (root-sum-of-squares of the a_{hwi} values for the three axes of vibration), in m/s^2

$A(8)$ daily vibration exposure, in m/s^2

$A_i(8)$ contribution of operation i to the daily vibration exposure, in m/s^2 (for convenience, this is referred to as the "partial vibration exposure")

T_0 reference duration of 8 h (28800 s)

T_i total duration (per day) of vibration exposure to operation i .

4 Quantities to be evaluated

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

- the vibration total value a_{hvi} , expressed in metres per second squared (m/s^2); this value is calculated from the three single-axis root-mean-square values of the frequency-weighted hand-transmitted vibration a_{hwix} , a_{hwiy} and a_{hwiz} ;
- the duration (per day) T_i of vibration exposure to operation i .

The principal parameter to be reported is the daily vibration exposure $A(8)$. This is calculated from the values of a_{hvi} and T_i for all operations i (see clause 8).

5 Preparation of the measurement procedure

5.1 General

The work of an operator at a workplace is composed of a series of operations, some of which may be repeated. The vibration exposure may vary greatly from one operation to another, either due to the use of different power tools or machines or different modes of operation of one power tool or machine.

To evaluate daily vibration exposure, it is first necessary to identify the operations which are likely to contribute significantly to the overall vibration exposure. For each of these operations, it is then necessary to decide on procedures for measuring the vibration exposure. The methods to be used will depend on the characteristics of the work environment, the work pattern and the vibration source.

5.2 Selection of operations to be measured

It is important to make measurements for all the power tools or workpieces which may give a significant contribution to the daily vibration exposure. To obtain a good picture of the average daily vibration exposure it is necessary to identify all

- a) sources of vibration exposure (i.e. the machines and tools being used);
- b) modes of operation of the power tool, e.g.:
 - chain saws may be idling, operating under load while cutting through a tree trunk, or operating under low load while cutting side branches,
 - a power drill may be used in impactive or non-impactive modes and may have a range of speed settings available;
- c) changes in the operating conditions where this might affect vibration exposure, e.g.:
 - a road breaker being used initially on a hard concrete surface followed by use on the softer soil underneath,
 - a grinder being used initially for bulk metal removal followed by more intricate operations of cleaning and shaping;
- d) inserted tools which might affect vibration exposure, e.g.:
 - a sander may be used with a series of different grades of abrasive paper, ranging from coarse to fine,
 - a stonemason may use a pneumatic chisel with a range of different chisel bits.

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In addition, it can be useful to obtain

- e) information from workers and supervisors on which situations they believe produce the highest vibration magnitude;
- f) estimates of the potential vibration hazards for each operation, using information from manufacturers on vibration emission values, see annex A, or using published results of previous measurements on similar power tools.

5.3 Organization of the measurements

The organization of measurements can be approached in four basic ways:

- a) Long-term measurement of continuous tool operation

The operation time is long and continuous, and during this time the operator maintains contact with the vibrating surface. In this case the vibration measurement can be made over long periods during the normal use of the power tool. The operation may include changes in vibration magnitude, provided that they are part of the normal working procedure.

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

- b) Long-term measurement of intermittent tool operation

The operation time is long but includes short breaks where there is no vibration exposure, however, during the operation and breaks the operator maintains contact with the (vibrating) surface. In this case the vibration measurement can be made over long periods during the normal use of the power tool, provided that any breaks in operation are part of the normal working procedure and that the operator does not lose contact with the power tool or hand-held workpiece, or significantly alter position of his hands on the power tool or hand-held workpiece.

In addition to vibration magnitude information, the evaluation of daily vibration exposure requires an evaluation of the duration of exposure to the operation per day. In this case the duration of exposure to the operation includes the short breaks in vibration exposure and so will be longer than the duration of exposure to vibration.

- c) Short-term measurement of intermittent tool operation

In many situations the hand is often taken off the power tool or hand-held workpiece, e.g. the power tool is put down, the hand is moved to a different part of the power tool, or another hand-held workpiece is picked up. In other situations, changes have to be made to the power tools being used, e.g. different abrasive belts or drill bits fitted or alternative power tools used. In these cases short-term measurements can only be made during each phase of the work operation.

In some cases it is difficult, or impossible, to get reliable measurements during the normal work process, due to the exposure durations being too short for measurement purposes. In this case measurements may be made during simulated work operations which artificially arrange longer uninterrupted exposures with work conditions as near to normal as possible.

In addition to vibration magnitude information, the evaluation of daily vibration exposure requires an evaluation of the exposure duration associated with each work phase.

- d) Fixed-duration measurement of bursts of tool operation or single or multiple shocks

Some operations involve exposure to short-duration bursts of vibration exposure, this may be single or multiple shocks, such as riveting hammers, nail guns, etc., or bursts of exposure, such as powered impact wrenches. In such cases it is often difficult to make an evaluation of actual exposure times, although the number of bursts of vibration per day can be estimated. In this case measurements may be made over a fixed duration which includes one or more complete tool operations. The duration of measurement should include as little time before, between and after bursts of vibration as possible.

In addition to vibration magnitude information and the estimate of the number of bursts of vibration exposures per day, the evaluation of daily vibration exposure requires information on the measurement duration and the number of bursts of vibration during the measurement period.

NOTE 1 In the case of exposing the worker to multiple single shocks or transient vibration (e.g. fastening tools), the method described in ISO 5349-1 may not be adequate and underestimate the severity of shock exposure. However, in the absence of a better method, ISO 5349-1 may be applied but this should be done with caution and be indicated in the information to be reported.

NOTE 2 Where measurements of vibration magnitude are to be compared (e.g. to compare the vibration produced by two different power tool or inserted tool options) it is important to make measurements of continuous tool operation, i.e. with no breaks in vibration exposure.

5.4 Duration of vibration measurements

5.4.1 Measurement during normal working

A measurement should be an average over a period which is representative of the typical use of a power tool, machine or process. Where possible, the measurement period should start when the worker's hands first contact the vibrating surface, and should finish when the contact is broken. This period may include variations in the vibration magnitude and may even include periods when there is no exposure.

Where possible, a series of sample measurements should be taken at different times of the day, and averaged, so that variations in vibration through the day are accounted for.

NOTE The average vibration magnitude of a series of N vibration magnitude samples is given by

$$a_{hw} = \sqrt{\frac{1}{T} \sum_{j=1}^N a_{hwj}^2 t_j}$$

where

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

t_j is the measurement duration of sample j

$$T = \sum_{j=1}^N t_j$$

Vibration exposures are often for short periods, which are repeated many times during a working day. Although measurements can be averaged over complete cycles of operation (including periods when the vibration source is switched off), normally it is only possible to average over the short period that the hand is in contact with the vibrating surface.

The minimum acceptable duration of measurements depends on the signal, instrumentation and operation characteristics. The total measuring time (i.e. the number of samples multiplied by the duration per measurement) should be at least 1 min. A number of shorter duration samples should be taken in preference to a single long duration measurement. For each operation, at least three samples should be taken.

Measurements of very short duration (e.g. less than 8 s) are unlikely to be reliable, particularly in their evaluation of low-frequency components, and should be avoided where possible. Where very short duration measurements are unavoidable (e.g. certain types of pedestal grinding for which contact times can be very short), it is advisable to take many more than three samples to ensure a total sample time greater than 1 min.