SLOVENSKI STANDARD
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Mehanske vibracije - Smernice za ocenjevanje izpostavljenosti vibracijam preko rok z uporabo podatkov o stroju, vključno s podatki proizvajalca

Mechanical vibration - Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery

Mechanische Schwingungen - Anleitung zur Beurteilung der Belastung durch Hand-Arm-Schwingungen aus Angaben zu den benutzten Maschinen einschließlich Angaben von den Maschinenherstellern

Vibrations mécaniques - Guide pour l'évaluation de l'exposition aux vibrations transmises a la main a partir de l'information disponible, y compris l'information fournie par les fabricants de machines

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Foreword

This Technical Report (CEN/TR 15350:2006) has been prepared by Technical Committee CEN/TC 231 "Mechanical vibration and shock", the secretariat of which is held by DIN.

Introduction

This Technical Report provides information on how to assess the vibration exposure from hand-held power tools and hand-guided machines. The methods described use existing vibration emission values declared for the machine of interest or information coming from other sources. It should be noted that vibration usually varies a lot over time, with different workstations and different operators. It is therefore not possible to get precise exposure figures from limited investigations. But also the declared values need to be used with great care since they are measured for a limited number of defined work situations. The actual work situation for a specific operator, however, may be very different thus creating different vibration. On the other hand values from real work that can be found in literature are only correct for the specific work situation and time when they were measured. The user of this Technical Report should be aware that the exposure to vibration does not only depend on the machine used but also to a large extent on things like quality of inserted tools, the work situation and operator behaviour. These factors need to be taken into account to make an ideal assessment of vibration exposure.

The daily vibration exposure to be assessed depends on both the average magnitude of vibration at the surface in contact with the hand and the total daily duration for which an employee is in contact with that vibration.

As there is a big difference between a rough estimation of the daily vibration exposure to identify workers at risk and the definition of the state of the art regarding machine vibration emission, vibration total values calculated by applying correction factors are not suitable to determine the state of the art for machine categories. To define the state of the art a high level of accuracy is needed, meaning that this can only be obtained by measurements in all three axes.

1 Scope

This Technical Report gives guidelines for estimating, assessing and documenting the daily vibration exposure due to the use of hand-held power tools and hand-guided machines, according to the requirements of the European Physical Agents Directive (vibration) 2002/44/EC. This Technical Report is addressed to competent services for the assessment of vibration exposure at the workplace and to national authorities and industrial organizations. It helps to establish documentation for specific machinery or work situations and can also be useful for employers.

It follows the method of EN ISO 5349-1 and EN ISO 5349-2 but instead of measuring the vibration magnitudes at the specific workplaces, the methods in this Technical Report use existing vibration values from other sources of information including those provided by the manufacturers of the machinery according to the requirements of the Machinery Directive 98/37/EC. It is important that the vibration values used in the exposure assessment are representative of those in the specific use of the machinery. Workplace measurements, however, are required if suitable data are not available to represent the vibration under the specific working conditions or if the calculation results do not help to decide whether or not the vibration exposure limit value or exposure action value is likely to be exceeded.

This Technical Report gives guidance on how to estimate the exposure duration and the daily vibration exposure A(8) as defined in EN ISO 5349-1. It also offers a simple method for estimating the daily vibration exposure by means of a table which indicates the vibration exposure as a function of the equivalent vibration total value and the associated exposure duration. Both methods can be used even in cases of multiple exposures on the same day.

Annex A gives guidance for manufacturers and suppliers of machinery concerning information that warns of risks from vibration, which should be reported to the customer.

2 Normative references

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

EN ISO 5349-1, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements (ISO 5349-1:2001)*

EN ISO 5349-2:2001, *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)*

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions given in EN ISO 5349-2:2001 and the following apply.

3.1
user time
daily duration of the work involving the use of the machinery, i.e. including the interruptions required by the work and the break periods directly related to the use

NOTE This is more likely to be reported by the operator than the exposure duration (see 3.2).

3.2
exposure duration
T
total duration the hand is in direct contact with the vibrating surface (handle, work piece, etc.)

NOTE The exposure duration is often confused with the user time when estimating the daily exposure duration T (see Example in 7.2.2).

EXAMPLE The user time for mounting wheels on five automobiles is estimated by the operator at 1 h per day; but the exposure duration is just 5 cars x 4 lug nuts x 4 wheels x 2 loosening/tightening actions x 4 s which yields T = 0,18 h. The exposure proportion (see 3.3) is only 18 %.

3.3
exposure proportion
exposure duration expressed as percentage of the user time

NOTE The exposure proportion varies depending on the machinery and its use. It can be determined in time studies. Some indication is given in D.2.

3.4
equivalent vibration total value
$a_{hv,eq}$
time-averaged sum of the vibration total values of the various machinery operating modes, a_{hvi}, during their associated exposure durations T_i:

$$a_{hv,eq} = \sqrt{\frac{1}{T}\sum_{i=1}^{m} a_{hv\,i}^{2}\, T_i} \qquad (1)$$

NOTE For the vibration total value a_{hv}, see EN ISO 5349-1. The total exposure duration T for a machine is the sum of all m individual exposure durations T_i within the entire work cycle considered (see Table D.1 and Example in 7.2.2). If there is one operating mode only, then $a_{hv,eq} = a_{hv}$.

3.5
partial vibration exposure points
P_E
index describing the vibration exposure from a single machine or work task during the associated exposure duration:

$$P_E = \left(\frac{a_{hv,eq}}{2{,}5\ \text{m/s}^2}\right)^2 \frac{T}{8\ \text{h}} \times 100 \qquad (2)$$

with the equivalent vibration total value $a_{hv,eq}$ and the associated exposure duration T

NOTE Vibration exposure points are a simple alternative to the A(8) value for describing a person's partial or total daily vibration exposure. The relationship is:

$$A(8) = \frac{2{,}5\ \text{m/s}^2}{10}\sqrt{P_E} \qquad (3)$$

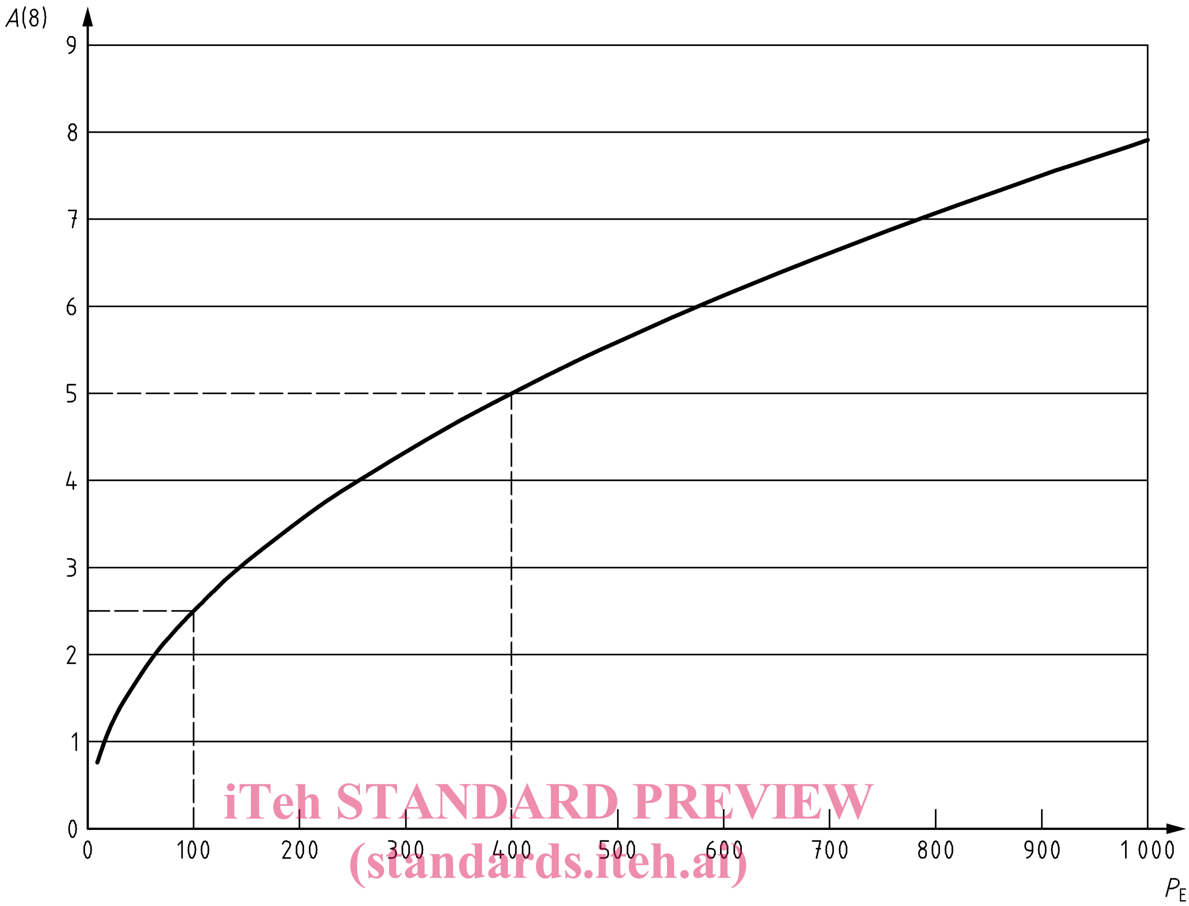
This relationship is plotted in Figure 1.

3.6
total vibration exposure points
$P_{E\,tot}$
sum of the partial vibration exposure points P_E within one day:

$$P_{E\,tot} = \sum_{i=1}^{n} P_{E\,i} \qquad (4)$$

with n being the number of partial vibration exposures considered

NOTE A score of 100 points for the total vibration exposure in a day is equal to the exposure action value of A(8) = 2,5 m/s^2 and a score of 400 points is equal to the exposure limit value of A(8) = 5 m/s^2 (see Note in 3.5 and Figure 1).



Key

P_E vibration exposure points

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

Figure 1 — Relationship between the vibration exposure points P_E **and the daily vibration exposure** A(8)

4 Estimation of the vibration magnitude

4.1 General

The vibration magnitude is expressed as a frequency-weighted root-mean-square acceleration value in metres per second squared (m/s^2) as defined in EN ISO 5349-1.

The vibration magnitude for a particular machine can be highly variable. For example, operators, different operating conditions and different inserted tools all influence the actual magnitude. The magnitude also often varies over time. It is usually difficult or impossible to obtain a precise value or narrow value range, so an indication of the average value is all that can be expected. For exposure estimation, it is usually necessary to take into account the fact that values are obtained within a range of uncertainty (see Clause 6).

4.2 Sources of information

Vibration magnitudes may be measured at the workplace by the employer, or on his behalf. However, this can be expensive and difficult and it is not always necessary. An important source of information is the manufacturer or supplier of the machinery. Annex A lists the information employers can expect from manufacturers and suppliers to help them identify and manage vibration risks. In most cases at present, especially for older machines, only the declared value in accordance with essential requirement 2.2 of the Machinery Directive 98/37/EC is available. However, only in the case the vibration test code used for the determination of the declared vibration emission value is named, a rough estimation of the equivalent vibration total value can be possible (see Annex C).

There are other sources of information on vibration magnitudes, which are often sufficient to roughly estimate the daily vibration exposure of workers and help to decide whether the exposure action value or the exposure limit value is likely to be exceeded.

Some employers are making vibration measurement data available to others in the same industry (often through trade associations); sharing information in this way can be cost effective for companies using similar machinery for similar work. Other sources of vibration data include specialist vibration consultants, employers' organizations (trade associations) and government bodies. Data can also be found in various technical or scientific publications and on the internet. If data from one of these sources are used, the quality and accuracy of the data should be checked, e.g. by comparing data from two or more sources; comparing data from several sources is generally recommended. It should be tried to find a value (or range of values) which represents the likely vibration magnitude for the particular machine and operating conditions.

4.3 Manufacturers' declared vibration emission values

4.3.1 General

In the absence of information on vibration in practical use of the machinery, a rough estimation of the vibration total value can be obtained, in a limited number of cases, from the declared vibration emission value, using Table D.3, E.1 or F.1. This estimated value should be used only where the information in Annex D, E or F shows it is likely to be representative of the specific use of the machinery. Where this is not possible, measurement of the vibration, in accordance with EN ISO 5349-1, will be required for the specific use of the machine.

The principle of the procedure for the estimation of the daily vibration exposure based on existing vibration values is outlined in Annex B. This method can be used only if all of the following conditions are met:

- declared vibration emission values(s) for the machine, and the test code used, are given, e.g. by the manufacturer;
- actual operating conditions of the machine are similar to those for which declared values are provided (detailed information is given in Tables D.3, E.1 and F.1);
- machine is in good condition and is maintained in accordance with the manufacturer's recommendations;
- inserted tools or attachments are similar to those used for the determination of the vibration emission values.

4.3.2 Vibration test codes

The vibration values given by manufacturers in their instruction handbooks or other publications (declared vibration emission values) are determined under standardized measuring and operating conditions which are defined in the appropriate vibration test code for the family of machines. Following the publication, in 2005, of EN ISO 20643, the vibration test codes developed should use three axes and give values representative of the upper quartile of vibration total values produced by the machines in their intended use. However, most vibration test codes pre-date EN ISO 20643 and do not meet these new requirements.

At present, most vibration test codes pre-date EN ISO 20643 and do not represent the way machines perform in practical use, and vibration magnitudes at the workplace can be higher or lower than those obtained in this type of laboratory test. This means that the manufacturer's declared vibration emission value may not be representative of the real use of the machine.

EXAMPLES

1) Vibration is not measured at the handle/grip position producing the greatest vibration emission (e.g. current needle scaler and chipping hammer test codes where vibration is measured at the rear handle but vibration is often greater at the front hand position);

2) vibration is measured only in one direction, whereas three-axes values should be used for the evaluation of exposure (most current test codes);

3) specified direction of measurement is not always the axis of highest magnitude (e.g. current needle scaler, chipping hammer and grinder test codes);

4) specified real or simulated machinery operating mode generates magnitudes below those likely to be found in normal use (e.g. current grinder test code).

NOTE Many European vibration test codes are currently under review and the revised standards should, in future, yield vibration emission values which provide a more accurate and realistic guide to likely vibration emissions during the intended use of the machine (see, e.g., EN ISO 20643).

If the declared vibration emission value is not representative of the vibration likely in the intended use of the machine, machine manufacturers and suppliers should provide additional information which may include more appropriate information on likely vibration magnitudes in practical use (see Annex A).

However, only if the vibration test code used for the determination of the declared vibration emission value is named, a rough estimation of the vibration total value can be performed using Table D.3, E.1 or F.1.

4.3.3 Interpreting manufacturers' declared vibration emission values

4.3.3.1 General

If the machine manufacturer or supplier is unable to confirm that the declared vibration emission value (and uncertainty *K*) represent the vibration in the intended use, and does not provide additional information, then the employer may need to seek information from other sources or make measurements at the workplace in order to assess the exposure of his employees (see 4.2 and 4.4).

Manufacturers will usually not publish vibration emission values if they are below 2,5 m/s^2 but in this case they must state that it is less than 2,5 m/s^2. In this case the value of 2,5 m/s^2 shall be used and the correction factors given in the annexes should be used.

NOTE Also when vibration emission values below 2,5 m/s^2 are given and reference is made to emission standards that pre-dated EN ISO 20643 it is recommended to use 2,5 m/s^2 for exposure assessment instead of the declared value given.

In the following, influences of various parameters and conditions are discussed. The consequences emanating from some of these influences are described in Annexes D, E and F.

4.3.3.2 Influence of machine operating conditions

Vibration test codes should specify operating conditions for the machine while the vibration emission is measured. The operating conditions given in most test codes were developed to be reproducible, and in some cases this has resulted in artificial operating conditions. For example, grinders are tested while free-running (not grinding) and fitted with an aluminium test wheel of known unbalance; chipping hammers and breakers are operated against an artificial loading device. EN ISO 20643 states that operating conditions based on a typical real working situation are preferred to artificial conditions, and that the operating conditions should be selected to represent the highest vibration likely to occur in typical and normal use of the machine. However, in some vibration test codes that pre-dated EN ISO 20643 the operating conditions can produce vibration emission values which do not give a good representation of typical use of the machine.

In some cases, such as machines powered by internal combustion engines, vibration emission measurements according to (mostly newer) vibration test codes are made separately for different modes of operation (e.g. idling, racing and cutting for a chain saw) and the equivalent vibration total value $a_{hv,eq}$ (see 3.4) is calculated from several a_{hv} values using standardized assumptions regarding the proportions of the exposure duration for each operating mode (see Table D.2). If necessary, $a_{hv,eq}$ can be recalculated using proportions more representative of the work being assessed.

Tables D.3, E.1 and F.1 contain current vibration test codes and list categories for the operating modes as specified in these standards. The tables give some indications of how the operating mode of the vibration test code influences the declared vibration emission value and how this compares with likely vibration magnitudes in real use.

Table D.2 shows how, for some types of machines, a typical work cycle is composed of several operating modes.

In some cases it may be possible to obtain a more realistic vibration emission value than that measured using the vibration test code by applying a correction. It is not always important (or possible) to be accurate or precise when doing this. For example, if the daily exposure, calculated using manufacturer's emission value, is just below the exposure limit value, and the test code is thought likely to produce low values, it is reasonable to conclude that the limit value is likely to be exceeded and that preventive action is required.

4.3.3.3 Influence of vibration measurement direction and location

Vibration of most surfaces in contact with the hand (such as machine handles) is rarely in one direction only. Therefore, according to the Directive 2002/44/EC and EN ISO 5349-1, vibration is measured in three separate directions (x-, y- and z-axes) at right angles to one another. The three measured values are combined to give a single magnitude, the vibration total value a_{hv} (see EN ISO 5349-1).

However, if according to a (mostly older) vibration test code only the vibration magnitude measured in one direction is available the vibration total value a_{hv} can be estimated by applying a correction factor. For many typical hand-held electric or pneumatic machines, the a_{hv} value is suitable (with an appropriate value for exposure duration, see Clause 5) for estimating the daily vibration exposure if the conditions in 4.3.1 are met.

The vibration emission values obtained using several – particularly older – test codes are based on measurements made in a single specified direction, at a single specified measurement location. In some cases, it is also difficult to conduct vibration measurements along all three axes. In cases where a value has been measured in the dominant vibration axis, a_{hw}, the vibration total value a_{hv} can be estimated with the aid of a correction factor:

$$a_{hv} = c\, a_{hw} \tag{5}$$

The correction factor c falls within the range 1,0 to 1,7 and for an individual machine can fall anywhere in this range. For percussive machines, a correction factor of 1,2 is typical if the machine is not equipped with an anti-vibration system, and for pure rotary and reciprocating machines a correction factor of about 1,4 is typical. The correction factors given in Tables D.3, E.1 and F.1 for individual families of machinery include appropriate values for this correction factor.

Some current test codes require vibration to be measured at a location which is not the hand position of greatest vibration exposure (e.g., the rear handle of a chipping hammer or needle scaler is not usually the hand position of greatest vibration). In these cases it is difficult to estimate the magnitude of vibration to which the operator is exposed to both hands by using the declared emission value. However, the knowledge that the true magnitude in real use is greater than the declared value can be sufficient to assess the risk in some cases, such as when demonstrating that the exposure limit value is exceeded.

4.3.3.4 Influence of age and condition of the machine

The manufacturer's declared vibration emission values are determined using new or almost new machines. Irregular or poor maintenance of machines can lead to substantial changes in the vibration emissions, depending on the type of machine in question. Current knowledge of the influence of the aging process is quite poor, particularly for some machines with anti-vibration systems.

Employers should ensure that machines are maintained in accordance with the manufacturer's recommendations. The vibration emission (according to the vibration test code) is then likely to be in the range indicated by the manufacturer.

4.3.3.5 Influence of anti-vibration systems and resilient grips

Some test codes specify a steady-state operating condition and have been developed before modern designs of machinery with vibration reduction features (e.g. breakers with isolating handles or grinders with anti-vibration systems). The emission values obtained with the vibration test code can deviate greatly from the vibration magnitudes measured under real operating conditions.

Constantly changing conditions in practical use, such as frequent shut-off and power-on processes, can limit the effectiveness of the vibration reducing features like resiliently mounted handles on rotary machines. Changing the feed force in real conditions can limit the effectiveness of suspended handles of breakers, particularly if the operator has not been trained to use the machine as the manufacturer intended. Thus, test code operating conditions can produce vibration values which are lower than those found in real use.

4.3.3.6 Influence of inserted tools

In most work situations the properties of the inserted tools have great influence on the vibration emission. Most vibration test codes therefore precisely define the properties of the inserted tools used for the test. In some cases artificial inserted tools (e.g. an unbalanced disc on a grinder) are used. When the inserted tools used in the real work situation are different from those defined in the vibration test code the vibration values may be considerably higher or lower. The machine manufacturer or supplier may have additional information on the vibration emission with different inserted tools. To control the vibration in a real work situation it can be important to choose good quality inserted tools that are suitable for the machine.

4.4 Making vibration measurements

There may be situations in which the vibration exposures cannot adequately be estimated. It may then be necessary to make measurements at the workplace.

EXAMPLE

1) A vibrating machine is used for an unusual purpose, of which the manufacturer has limited previous experience and so cannot provide vibration information;

2) it may not be clear, from the limited information available, whether the exposure action value or the exposure limit value is likely to be exceeded;

3) employer may wish to check the effectiveness of actions taken to control vibration exposure.

Further information and practical guidance on exposure evaluation and vibration measurement at the workplace is given in EN ISO 5349-2.