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BSI Standards Publication

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

National foreword

This Published Document is the UK implementation of CEN/TR 15350:2013. It supersedes PD CEN/TR 15350:2006 which is withdrawn.

This Published Document was prepared by CEN Technical Committee CEN/TC 231, Mechanical vibration and shock, to provide guidance on the assessment of exposure to hand-transmitted vibration, as required by the European Directive on Physical Agents (Vibration), 2002/44/EC. It is not a European or British Standard. The European Union has commissioned separate guidance on implementing the Directive.

This Published Document does not constitute guidance on the British implementation of Directive 2002/44/EC. Guidance on the Control of Vibration at Work Regulations 2005 has been published by the Health and Safety Executive. The Health and Safety Executive has found that advice in the Annexes to this Published Document can be unreliable, particularly that relating to the content of column 6 of Tables E.1, F.1 and H.1.

The EU Guide 'Non-binding guide to good practice with a view to implementation of Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents vibrations' can be found at the EU Bookshop URL below.

http://bookshop.europa.eu/en/non-binding-guide-to-good-practicewith-a-view-to-implementation-of-directive-2002-44-ec-on-theminimum-health-and-safety-requirements-regarding-the-exposureof-workers-to-the-risks-arising-from-physical-agents-vibrations--pbKE7007108/

Further information concerning preparation of the EU Guide can be found at:

www.humanvibration.com/EU/VIBGUIDE.htm

The UK participation in its preparation was entrusted by Technical Committee GME/21, Mechanical vibration, shock and condition monitoring, to Subcommittee GME/21/6, Mechanical vibration, shock and condition monitoring - Human exposure to mechanical vibration and shock.

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

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

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

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

This Technical Report was approved by CEN on 8 June 2013. It has been drawn up by the Technical Committee CEN/TC 231.

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Foreword

This document (CEN/TR 15350:2013) has been prepared by Technical Committee CEN/TC 231 “Mechanical vibration and shock”, the secretariat of which is held by DIN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TR 15350:2006.

The main technical changes compared to CEN/TR 15350:2006 are the following ones:

— an annex on a simplified method for a quick estimate of machine equivalent acceleration has been added;

— an annex on estimation of the daily vibration exposure for hydraulic machines has been added;

— lists of machines in the annexes have been expanded and further vibration emission test codes have been considered.

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, which means 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 organisations. 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 2006/42/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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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)*

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 document, 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 1 to entry: 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 1 to entry: 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 1 to entry: The exposure proportion varies depending on the machinery and its use. It can be determined in time studies. Some indication is given in G.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:

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

Note 1 to entry: 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 G.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:

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

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

Note 1 to entry: 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:

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

This relationship is plotted in Figure 1.

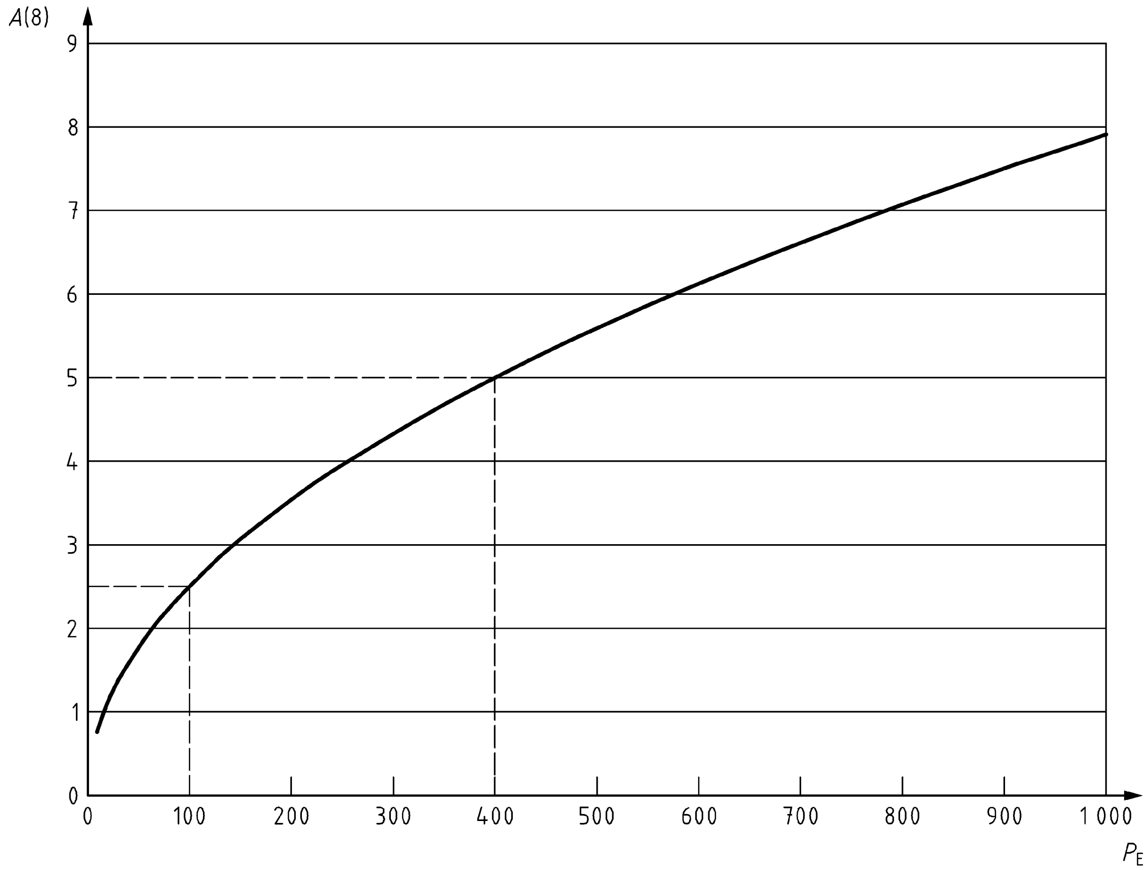
3.6
total vibration exposure points
$P_{E\,tot}$
sum of the partial vibration exposure points P_E within one day:

$$P_{E\,tot} = \sum_{i=1}^{n} P_{E\,i} \tag{4}$$

where

n is the number of partial vibration exposures considered

Note 1 to entry: A score of 100 points for the total vibration exposure in a day is equal to the exposure action value of $A(8) = 2{,}5\ \text{m/s}^2$ and a score of 400 points is equal to the exposure limit value of $A(8) = 5\ \text{m/s}^2$ (see Note 1 to entry 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 2.2.1.1 of the Machinery Directive 2006/42/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 D).

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' organisations (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 E.1, F.1, G.3 or H.1. This estimated value should be used only where the information in Annexes E to H 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 E.1, F.1, G.3 and H.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 standardised measuring and operating conditions which are defined in the appropriate vibration test code for the family of machines. Following the first 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, some vibration test codes pre-date EN ISO 20643 and do not meet these new requirements.

Since still some vibration test codes pre-date EN ISO 20643 and do not represent the way machines perform in practical use, the 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.

EXAMPLE 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).

EXAMPLE 2 Vibration is measured only in one direction, whereas three-axes values should be used for the evaluation of exposure (some older test codes).

EXAMPLE 3 Specified direction of measurement is not always the axis of highest magnitude (some older test codes specifying one measurement direction only).

EXAMPLE 4 Specified real or simulated machinery operating mode generates magnitudes below those likely to be found in normal use.

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.

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 E.1, F.1, G.3 or H.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 shall 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.

Also when vibration emission values below 2,5 m/s^2 are given and reference is made to emission standards that pre-date 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 E to H.

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 standardised assumptions regarding the proportions of the exposure duration for each operating mode (see, e.g., Table G.2). If necessary, $a_{hv,eq}$ can be recalculated using proportions more representative of the work being assessed.

Tables E.1, F.1, G.3 and H.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 G.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:

$$a_{hv} = c\, a_{hw} \qquad (5)$$

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 E.1, F.1, G.3 and H.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.

EXAMPLE 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.

EXAMPLE 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.

5 Estimation of the daily exposure duration

The daily exposure duration for each relevant machine or process should be determined. This should generally be done directly by observing the work (see EN ISO 5349-2:2001, 5.5). Alternatively, this can be done with reduced accuracy by multiplying the user time (e.g., that estimated by the operator) by an appropriate exposure proportion.

It should be recognised that for most machines the vibration exposure duration is shorter than the user time, i.e. that the exposure proportion is lower than 100 % (see Examples in 3.2, 7.2.2 and E.3).

In some special cases it may be possible to estimate the daily exposure duration using generic exposure durations obtained from time studies (see E.3 and G.2.2).

6 Consideration of uncertainties

The uncertainty of the overall evaluation of the exposure depends on the uncertainty of the established vibration value and its ability to represent the actual vibration total value. It also depends on the uncertainty of the exposure duration as estimated.

The uncertainty of the declared vibration emission value from the manufacturer is given as a *K* value estimated in accordance with EN 12096. The uncertainty of the vibration value in real use is normally much greater.

The uncertainty of the vibration value has more influence on the uncertainty of the daily vibration exposure than that of the exposure duration because the vibration exposure is proportional to the vibration value and to the square root of the exposure duration.

7 Estimation and assessment of the vibration exposure

7.1 General

The daily vibration exposure depends on two key elements:

a) average magnitude of vibration at the surface in contact with the hand and

b) total daily duration for which an employee is in contact with that vibration.

The daily vibration exposure is determined from vibration magnitude and exposure duration values obtained using the procedures in Clauses 4 and 5. The principle of the procedure for the estimation of the daily vibration exposure based on existing vibration values is outlined in Annex B. Estimation and assessment can be performed either using *A*(8) values or more easily using vibration exposure points P_E.

7.2 Using the daily vibration exposure *A*(8)

7.2.1 General procedure

The daily vibration exposure *A*(8) can be calculated by using the equivalent vibration total value $a_{hv,eq}$ and the daily exposure duration T for the specific machine and work task as follows:

$$A(8) = a_{hv,eq}\sqrt{\frac{T}{T_0}} \tag{6}$$

where

T_0 = 8 h.

If the work of the day consists of usage of n machines with the individual equivalent vibration total value $a_{hv,eq\ i}$ and exposure duration T_i for the i-th machine, calculate the partial vibration exposure for each machine, $A_i(8)$, according to Formula (6) and combine the $A_i(8)$ values as follows:

$$A(8) = \sqrt{\sum_{i=1}^{n} A_i^2(8)} \tag{7}$$

This procedure is described in EN ISO 5349-1 and further guidance is given in EN ISO 5349-2. An example of the use of this procedure is shown in 7.2.2.

NOTE When a machine is used under several different working conditions with known vibration values, it can be regarded as several machines each with its own vibration magnitude and exposure duration.

The daily vibration exposure is assessed by comparison with the exposure action value of *A*(8) = 2,5 m/s^2 and the exposure limit value of *A*(8) = 5 m/s^2 in order to establish the necessary action by the employer according to the Physical Agents Directive 2002/44/EC (see Table 2). The daily exposure values have a high level of uncertainty. If the estimated value is close to the exposure action value or the exposure limit value it is better to assume that the value is likely to be exceeded and employers should take necessary actions.

7.2.2 Example: Combined application of a mower and a brush cutter

NOTE This example also shows how to estimate the vibration total value from measured/established single-axis values.

The daily use of a hand-guided mower is 4 h. The work-related breaks are included in this user time (see 3.1), by this the effective exposure duration is only 3 h. Assuming that the vibration magnitude is not changing significantly over time, the measurement of the vibration needs not to be conducted over the entire exposure duration. The average vibration a_{hw1x}, a_{hw1y} and a_{hw1z} is determined out of three single measurements during a short time interval (measurement duration approximately 1 min), they can be considered as representative for the entire duration of the vibration exposure, T_1 = 3 h.

After the mowing work task a brush cutter is used for T_2 = 1,5 h. Within this time period, the hands of the operator are in touch with the running brush cutter, so the user time is equal to the exposure duration. The exposure duration T_2 consists of $T_{2,Id}$ = 0,75 h for idling and $T_{2,Ra}$ = 0,75 h for racing and cutting.

The established vibration values are:

Mower	a_{hw1x} = 1,5 m/s^2	a_{hw1y} = 2 m/s^2	a_{hw1z} = 1,8 m/s^2
Brush cutter, idling	$a_{hw2x,Id}$ = 3,5 m/s^2	$a_{hw2y,Id}$ = 1,5 m/s^2	$a_{hw2z,Id}$ = 4 m/s^2
Brush cutter, racing	$a_{hw2x,Ra}$ = 2,8 m/s^2	$a_{hw2y,Ra}$ = 1,7 m/s^2	$a_{hw2z,Ra}$ = 3,5 m/s^2

The vibration total values are:

Mower	$a_{hv1} = \sqrt{a_{hw1x}^2 + a_{hw1y}^2 + a_{hw1z}^2}$ = 3,1 m/s^2
Brush cutter, idling	$a_{hv2,Id} = \sqrt{a_{hw2x,Id}^2 + a_{hw2y,Id}^2 + a_{hw2z,Id}^2}$ = 5,5 m/s^2
Brush cutter, racing	$a_{hv2,Ra} = \sqrt{a_{hw2x,Ra}^2 + a_{hw2y,Ra}^2 + a_{hw2z,Ra}^2}$ = 4,8 m/s^2

For the mower, the work task consists of one operating mode only with the exposure duration T_1 = 3 h; so the equivalent vibration total value for this machine is (normally a_{hv} is the vibration emission value declared by the manufacturer in accordance with EN 12733):

$$a_{hv,eq1} = a_{hv1}$$

The partial vibration exposure for the mower is according to Formula (6):

$$A_1(8) = a_{hv,eq1}\sqrt{\frac{T_1}{T_0}} = 1{,}9 \text{ m/s}^2$$

For the brush cutter, the work task consists of two operating modes with the exposure duration $T_2 = T_{2,Id} + T_{2,Ra}$ = 0,75 h + 0,75 h = 1,5 h; so the equivalent vibration total value for this machine is according to 3.4 (normally $a_{hv,eq}$ is the vibration emission value declared by the manufacturer in accordance with EN ISO 22867):

$$a_{hv,eq2} = \sqrt{\frac{1}{T_2}\left(a_{hv2,Id}^2\, T_{2,Id} + a_{hv2,Ra}^2\, T_{2,Ra}\right)} = 5{,}2 \text{ m/s}^2$$

The partial vibration exposure for the brush cutter is:

$$A_2(8) = a_{hv,eq2} \sqrt{\frac{T_2}{T_0}} = 2,3 \text{ m/s}^2$$

The daily vibration exposure *A*(8) is according to Formula (7):

$$A(8) = \sqrt{A_1^2(8) + A_2^2(8)} = 3 \text{ m/s}^2$$

Conclusion: Since the vibration exposure action value of *A*(8) = 2,5 m/s^2 is exceeded, measures for reduction of the vibration risk are necessary. Implement a programme of measures to reduce exposure and risks to a minimum. Ensure health surveillance is provided for exposed workers.

7.3 Using vibration exposure points P_E

7.3.1 General procedure

This procedure allows a simple estimation of the vibration exposure by using the equivalent vibration total value $a_{hv,eq}$ for the specific machine (see Clause 4) and the associated exposure duration T (see Clause 5). The corresponding vibration exposure points P_E can be read directly from Table 1 or calculated using Formula (2).

In cases of multiple exposures (i.e. the use of two or more machines or processes in one day) the total vibration exposure points $P_{E\,tot}$ can be determined by simple summation of all n partial vibration exposure points $P_{E\,i}$ for each exposure i considered (see 3.6).

Table 1 — Determination of vibration exposure points from the equivalent vibration total value and the associated exposure duration

Equivalent vibration total value $a_{hv,eq}$ m/s²	Exposure duration T									
	0,1 h	0,2 h	0,5 h	1 h	2 h	3 h	4 h	5 h	6 h	8 h
	6 min	12 min	30 min	60 min	120 min	180 min	240 min	300 min	360 min	480 min
2,5	1	3	6	13	25	38	50	63	75	100
3	2	4	9	18	36	54	72	90	108	144
3,5	2	5	12	25	49	74	98	123	147	196
4	3	6	16	32	64	96	128	160	192	256
4,5	4	8	20	41	81	122	162	203	243	324
5	5	10	25	50	100	150	200	250	300	400
5,5	6	12	30	61	121	182	242	303	363	484
6	7	14	36	72	144	216	288	360	432	576
6,5	8	17	42	85	169	254	338	423	507	676
7	10	20	49	98	196	294	392	490	588	784
7,5	11	23	56	113	225	338	450	563	675	900
8	13	26	64	128	256	384	512	640	768	1 024
8,5	14	29	72	145	289	434	578	723	867	1 156
9	16	32	81	162	324	486	648	810	972	1 296
9,5	18	36	90	181	361	542	722	903	1 083	1 444
10	20	40	100	200	400	600	800	1 000	1 200	1 600
10,5	22	44	110	221	441	662	882	1 103	1 323	1 764
11	24	48	121	242	484	726	968	1 210	1 452	1 936
11,5	26	53	132	265	529	794	1 058	1 323	1 587	2 116
12	29	58	144	288	576	864	1 152	1 440	1 728	2 304
12,5	31	63	156	313	625	938	1 250	1 563	1 875	2 500
13	34	68	169	338	676	1 014	1 352	1 690	2 028	2 704
13,5	36	73	182	365	729	1 094	1 458	1 823	2 187	2 916
14	39	78	196	392	784	1 176	1 568	1 960	2 352	3 136
14,5	42	84	210	421	841	1 262	1 682	2 103	2 523	3 364
15	45	90	225	450	900	1 350	1 800	2 250	2 700	3 600
15,5	48	96	240	481	961	1 442	1 922	2 403	2 883	3 844
16	51	102	256	512	1 024	1 536	2 048	2 560	3 072	4 096
16,5	54	109	272	545	1 089	1 634	2 178	2 723	3 267	4 356
17	58	116	289	578	1 156	1 734	2 312	2 890	3 468	4 624
17,5	61	123	306	613	1 225	1 838	2 450	3 063	3 675	4 900
18	65	130	324	648	1 296	1 944	2 592	3 240	3 888	5 184
18,5	68	137	342	685	1 369	2 054	2 738	3 423	4 107	5 476
19	72	144	361	722	1 444	2 166	2 888	3 610	4 332	5 776
19,5	76	152	380	761	1 521	2 282	3 042	3 803	4 563	6 084
20	80	160	400	800	1 600	2 400	3 200	4 000	4 800	6 400

For the assessment, the total vibration exposure points are allocated to the corresponding exposure range (see Table 2) which implies further action by the employer according to the Physical Agents Directive 2002/44/EC as appropriate.

Examples of using the vibration exposure points are given in Annexes E to H.

Table 2 — Actions required by the employer at different levels of vibration exposure according to EU Directive 2002/44/EC

Total vibration exposure points $P_{E\ tot}$	**Daily vibration exposure** $A(8)$	**Vibration exposure range**	**Action required by the employer**
$P_{E\ tot} \leq 100$	$A(8) \leq 2{,}5\ m/s^2$	The exposure action value not exceeded	Take reasonable action to reduce risks from vibration exposure to a minimum. Provide worker information and training on vibration.
$100 < P_{E\ tot} \leq 400$	$2{,}5\ m/s^2 < A(8) \leq 5\ m/s^2$	Above the exposure action value, but the exposure limit value not exceeded	Implement a programme of measures to reduce exposure and risks to a minimum. Ensure health surveillance is provided for exposed workers.
$400 < P_{E\ tot}$	$5\ m/s^2 < A(8)$	Above the exposure limit value	Take immediate action to bring exposure below the exposure limit value.
NOTE Regarding the values 100 and 400, see Note 1 to entry in 3.6.			

7.3.2 Examples

7.3.2.1 General

When using several machines on the same working day, the total vibration exposure points $P_{E\ tot}$ can be determined by summation of the vibration exposure points of the individual machines. Estimate the equivalent vibration total value $a_{hv,eq}$ and the associated exposure duration T for each machine, read from Table 1 the vibration exposure points P_E and calculate the sum of these points. Then compare the sum with the values in Table 2 and take further action as appropriate.

7.3.2.2 Example 1

Four different machines are used on a single day:

	$a_{hv,eq}$	T	P_E from Table 1
Machine 1	10,0 m/s^2	0,1 h	20
Machine 2	8,0 m/s^2	0,2 h	26
Machine 3	6,0 m/s^2	0,2 h	14
Machine 4	5,0 m/s^2	0,5 h	25
Total vibration exposure points $P_{E\ tot}$			85

Conclusion: Since the daily total vibration exposure points clearly do not exceed 100, the vibration exposure action value is not exceeded. However, take reasonable action to reduce risks from vibration exposure to a minimum. Provide worker information and training on vibration.

7.3.2.3 Example 2

Four different machines are used on a single day:

	$a_{hv,eq}$	T	P_E from Table 1
Machine 1	6,0 m/s^2	0,1 h	7
Machine 2	8,0 m/s^2	0,2 h	26
Machine 3	3,5 m/s^2	1 h	25
Machine 4	13,0 m/s^2	0,5 h	169
Total vibration exposure points $P_{E\ tot}$			227

Conclusion: Since the daily total vibration exposure points are above 100 but do not exceed 400, only the vibration exposure action value is exceeded. Measures for reduction of the vibration risk are necessary. Implement a programme of measures to reduce exposure and risks to a minimum. Ensure health surveillance is provided for exposed workers.

7.3.2.4 Example 3

Three different machines are used on a single day:

	$a_{hv,eq}$	T	P_E from Table 1
Machine 1	12,0 m/s^2	1 h	288
Machine 2	8,0 m/s^2	2 h	256
Machine 3	11,0 m/s^2	0,5 h	121
Total vibration exposure points $P_{E\ tot}$			665

Conclusion: Since the daily total vibration exposure points are above 400, the vibration exposure limit value is exceeded. Take immediate action to bring exposure below the exposure limit value and implement a suitable programme of control measures and health surveillance if the vibration exposure remains above the exposure action value.

8 Documentation

EN ISO 5349-2 contains a list of information to be reported when evaluating vibration exposure. Where vibration is not measured at the workplace, the following information should also be documented:

— sources of vibration data used and observations on their quality;

— description of vibration data, e.g. vibration total value or single-axis value, operating conditions;

— description of exposure duration and how it was estimated;

— periods of observation;

— any corrections (correction factor) to the vibration magnitude and the reasons for that;

— consideration of uncertainty for vibration magnitude and exposure duration.

Annex A
(informative)

Guidance on the information which users could expect from machinery manufacturers and suppliers

A.1 Legal duties of manufacturers and suppliers

The European Machinery Directive 2006/42/EC requires machinery manufacturers to make their products as safe as possible and to provide information on residual risks so that the machinery can be used safely. This annex explains the duties of manufacturers and suppliers of machinery to provide information that warns of risks from human exposure to vibration.

The instructions provided with a machine shall contain warnings about residual risks which have not been eliminated in the design (see CR 1030-1) and manufacture of the machine, and which shall be managed.

For hand-held and hand-guided machinery, information on vibration emission shall be given in the instruction handbook and in any sales literature or official publication in so far there is also information on performance characteristics (e.g. power, input power, blowing performance). This is known as the manufacturer's declared vibration emission: the weighted r.m.s. acceleration value to which the hands and arms are subjected where this exceeds 2,5 m/s^2 when determined by the appropriate vibration test code (or a declaration that it does not exceed 2,5 m/s^2).

A.2 Vibration emission data

The vibration emission data provided by machine manufacturers and suppliers should help employers to:

- compare different manufacturers' models of the same class of machinery to identify (and avoid) any machines that have unusually high vibration emissions;
- identify any significant differences between the vibration emissions of different machines which are, in other respects, suitable for the particular task;
- identify a likely range of vibration values in normal use of the machine.

Useful vibration information may also be available from the manufacturer for the assessment of the risk from human exposure to vibration and a decision on the need to control the exposure and risk.

Suppliers should usually report vibration emission data which have been measured according to European vibration test codes. Examples of such test codes are EN ISO 28927 series (which replaced EN ISO 8662/EN 28662) (for pneumatic and some other machines) and the test methods included in EN 60745 series (which replaced EN 50144) (for electric machines).

Where no test code exists for a specific type of machinery, the general standard method given in EN ISO 20643 is available to manufacturers to determine the vibration emission. They should select realistic machine operating conditions for vibration tests with care to give values typical of the upper range produced by the machine in its intended use. Manufacturers should report the test procedures they have adopted, including the machine configuration, operating and loading conditions during the test; and the locations and directions in which the vibration was measured.

In accordance with EN 12096, two values should be reported by machine manufacturers when declaring the vibration emission of their product (see 4.3):

— *a* (the average measured acceleration value) and

— *K* (the uncertainty of *a*).

By declaring the *a* and *K* values, the supplier states that the value obtained from a reproduction of the vibration emission test is likely to produce the *a* value of less than *a* + *K*. In some cases *K* can be more than 40 % of *a*. The difference between the *a* values for two machines should not be considered significant if it is smaller than one of the quoted *K* values.

Annexes E to H give detailed information if and how manufacturer's declared values can be used for a rough vibration exposure estimation.

A.3 Additional information

If a vibration test code does not produce emission values (*a* and *K* values) which reflect adequately the vibration during the intended use of the machine, the declared vibration emission may not be sufficient to warn of the residual risk to be managed and more information should be provided. Supplementary information on the likely magnitude (or range of magnitudes) for the machine in real use is one method of compliance with the manufacturer's duty to warn of residual risks. Other essential information includes any actions needed to prevent unnecessarily high vibration exposures when the machine is used (see CR 1030-2). These might include:

— maintenance (e.g. periodic inspection and sharpening of the chain of a chainsaw may be required to prevent vibration increasing);

— training for correct operation (e.g., if the vibration emission of a breaker with vibration-isolating handles is dependent on the force applied by the operator, information on correct operation and on requirements for the training of operators should be included);

— selection of appropriate types of inserted tools or consumables where this affects the vibration exposure.

Annex B
(informative)

Principle of the procedure for the estimation of the daily vibration exposure using manufacturers' declared emission values

In general, the following procedure should be followed when estimating the daily vibration exposure at the workplace:

Identify the machines which are used on the working day in question.

Get the manufacturers' declared emission values (which can be found in the instruction handbook).

If additional information regarding vibration magnitude in real use is given in the documentation for the machine, this information should be preferred.

If the manufacturers' declared values are not based on three measurement axes, i.e. no vibration total values are given, the (single-axis) values need to be corrected according to 4.3.3.3 (see information in Annexes E to H).

Check whether these values are reasonably representative of the real use of the machines (see information in Annexes E to H).

Determine the daily exposure duration for each relevant machine. This should be done directly or, alternatively, can be done by multiplying the user time by the respective exposure proportion, or using generic exposure durations (see Table E.2 or G.1).

Calculate the daily vibration exposure in accordance with 7.2 or use the vibration exposure points in accordance with 7.3.

Assess the daily vibration exposure against the vibration exposure action and exposure limit values given in Table 2.

Take into account that the uncertainty of this assessment is very large. If there is doubt if the limit value or the action value is exceeded, actions should be taken or measurements should be conducted.

Annex C
(informative)

Simplified method for a quick estimate of machine equivalent acceleration

C.1 Description of method

Equivalent acceleration estimation based on single tool manufacturer declaration may underestimate or overestimate the equivalent acceleration obtained for the same machine under real conditions even when using the appropriate multiplying factors from Annexes E to H. It has been shown a deviation by more than 50 % (underexposure or overexposure) in 66 % of cases. The simplified method given in this annex uses statistical data describing the vibration from a whole class of machines and thereby overcome the large deviations linked to estimates based on individual machine declaration. On the other hand to use statistically aggregated data to represent any machine in a category may have the disadvantage to mask the effort made by some manufacturers to produce low-vibration machines. The method does not distinguish between machines treated against vibration and conventional machines. In case of overexposure, users are encouraged to select the machines with the lowest vibration declaration.

The 50th, 75th and 90th percentile values of vibration equivalent acceleration for all machines in a class are determined from the manufacturers' declarations multiplied by the appropriate factors from Annexes E to H (see Table C.1). The employer is then guided towards the most appropriate percentile value to select according to answers to questions about the conditions of use.

NOTE Some data bases on human vibration provide measured emission values and declared values for a large number of machines. An estimate of the 50th, 75th and 90th percentile values can be obtained for the main families of machines using those values.

C.2 Illustration of method

The following is an illustration of the possibility of the method. Numbers are only given to facilitate the understanding of the method.

Table C.1 — 50th, 75th and 90th percentile values of vibration equivalent acceleration for a class of machines based on manufacturer declaration

Machine family	Tool	Typical operating condition	Average percentile m/s^2		
			50th	75th	90th
Angle grinder	Wheel	Grinding	3,8	5,5	8,5

The conditions of use may be classified under 3 levels: favourable, normal, severe from the questionnaire (see Table C.2). Each level is associated to the number of negative answers: 0 = favourable, 1 = normal, 2 = severe. It corresponds respectively to 50th, 75th and 90th percentile values of all declared vibration values for a given class of machines.

Table C.2 — Questionnaire on conditions of tool use

Question	Answer
Is the machine equipped with an anti-vibration system designed by the manufacturer such as suspension handles, rubber or spring isolator, balance item?	yes/no
Are all machine accessories (grinding wheel, polishing pad and support, drill bit, etc.) recommended by the manufacturer?	yes/no/no answer
Are the machine and accessories adapted to the task?	yes/no
Is the accessory periodically maintained?	yes/no/no answer
Is the machine periodically maintained?	yes/no
Are the anti-vibration systems periodically maintained?	yes/no/no answer
Is the operator been trained in the use of the machine (use and replacement of worn accessories)?	yes/no

Example: Operator using an angle grinder

Parameters

— no suspension handle or balance system,

— new machine equipped with grinding wheels recommended by the manufacturer,

— correct wheels for the task (grinding some welding),

— highly experienced operator,

— average daily duration of exposure: 4 h.

Estimation of equivalent acceleration based on 75th percentile (only one negative answer):

a_{hv} = 5,5 m/s^2

Estimation of exposure $A(8) = 5{,}5\ (4/8)^{½} = 3{,}9$ m/s^2.

Annex D
(informative)

Use of manufacturer's declared values or other values measured according to current vibration test codes

D.1 General

In this annex, additional information is provided to understand the differences between the vibration values according to vibration test codes (standards) and during real work. It gives guidance in which cases the values measured according to current vibration test codes can be used for an estimate of the exposure for a specific work task.

For machines listed in Annexes E to H, information is given on the declared vibration emission values for the purpose of vibration exposure assessment at the workplace. Three different groups of machines, depending on the power source of the machines are covered: internal combustion, electrical and pneumatic powered machines.

In general, the following procedure should be used:

— select Annex E, F, G or H, depending on the power source;

— search for the machine in the corresponding table;

— find the vibration emission value and the relevant test standard in the instruction handbook;

— from the table search for the work task;

— if found, read how the declared vibration emission value can be used for the exposure estimation at the workplace.

For many machines, the declared vibration values according to published vibration test codes were only intended for comparison of machines within one category. These values may not be suitable for the exact evaluation of the vibration exposure but in some cases a rough estimation of the vibration exposure is possible and helpful to identify the workplaces with low and those with high risk.

Column 6 in Tables E.1, F.1, G.3 and H.1 gives information under which circumstances a value for this rough estimation can be determined.

It is important to know, that a vibration exposure calculated from this vibration magnitude is not the vibration exposure at the workplace, which may be higher or lower than this.

These calculated values have a high grade of uncertainty. Manufacturers, suppliers and organisations shall not use these values for comparison purposes of vibration exposure or to determine the state of the art.

Where references to standards in Tables E.1, F.1, G.3 and H.1 are dated, this procedure should not be applied to emission data measured using earlier or later versions of those standards.

D.2 Categories

D.2.1 Category for the machine operating condition

Machine operating conditions specified in current vibration test codes can be categorised as follows:

1 Measurements are made during a standardised example of realistic work. The values are representative of the highest vibration values likely to occur at typical and normal use of the machine. Different modes of operation have been accounted for in the declared vibration emission value. However, for inserted tools, etc., additional information may be required.

2 Measurements are made during a standardised example of realistic work. The values are representative of the highest vibration values likely to occur at typical and normal use of the machine. However, for different modes of operation, inserted tools, etc., additional information may be required.

3 Measurements are made while the machine is operated under standardised artificial conditions. The values are representative of the highest vibration values likely to occur at typical and normal use of the machine. However, for different modes of operation, inserted tools, etc., additional information may be required.

4 Measurements are made while the machine is operated under standardised conditions which do not represent typical operation; e.g. measurements are made only at maximum no-load conditions (i.e. free running) although the load has a significant influence on the vibration. The values can rarely be used to estimate the vibration exposure at the workplace because the operating conditions are not representative of real use.

D.2.2 Category for the axis measured

From the data declared in the instruction handbook it can be verified whether or not the values are single-axis values or vibration total values or equivalent vibration total values (see 4.1). A “vibration total value” can be identified by the designation “vibration total values” or “triaxial vibration values” or a_{hv} combined with the uncertainty K. If this combination cannot be found, the values shall be considered a single-axis value.

A Vibration total value a_{hv} (or where appropriate equivalent vibration total value $a_{hv,eq}$) declared (this is obtained from measurements made in three directions);

B Single-axis value a_{hw} declared (generally measured in the direction of vibration believed to be dominant).

D.2.3 Category for the handle/hand position measured

Vibration measurements according to some vibration test codes are made only at one hand position (measurement location) and that may not be the hand position delivering the worst case vibration exposure. This is categorised as follows:

I Measured at both handles, worst case value declared;

II Measured at one handle but this handle is known as the vibration worst case handle;

III Measured at one handle which is probably not the vibration worst case handle.

Annex E
(informative)

Estimation of the daily vibration exposure for electric machines

E.1 General

Prior to 2005, the declared emission values for electric machines are based on single-axis values according to EN 50144 or the first edition of EN 60745, if not explicitly specified to be “vibration total values”.

Exceptions are values for chain saws, which always have been “vibration total values”. Clause E.2 gives assistance for the use of these values.

It needs to be taken into account, that an *A*(8) value calculated from single-axis vibration magnitude has a high level of uncertainty.

Vibration emission values declared according to EN 60745 standards series published after 2007 follow the requirements of the machinery directive 2006/42/EC. These values are representative triaxial “vibration total values" and can be usually used as such without any further correction factors for the risk assessment. EN 60745-2 standards which have never addressed single-axis vibration values are not listed in Table E.1.

If the vibration emission in the instruction handbook is declared as “vibration total value” (or “triaxial vibration” or “vibration vector sum”) together with the uncertainty K it is identified as a “vibration total value”. Otherwise it should be considered as vibration single-axis value.

In addition the daily exposure duration for electric machines is needed to calculate the daily vibration exposure. Clause E.3 gives specific assistance how the exposure duration can be estimated for different electric machines.

Care shall be taken because often different types of machines are used during one typical working day, so that the individual vibration exposures of the used machines have to be summed up according to Clause 7.

E.2 Use of manufacturer’s declared vibration values determined according to specific test codes

Table E.1 gives information about the possible use of vibration emission values determined according to test codes published prior to 2007.

Improper maintenance of the machine or cutting attachment can lead to higher vibration emissions. Damaged or hardend rubber elements of the anti-vibration system can reduce the vibration isolation of the machine. Furthermore, improper sharpening, dull or unbalanced cutting attachments are likely to increase vibration emissions. Especially old machines with an anti-vibration system based on a rubber the anti-vibration system ages. That means that the efficiency of the anti-vibration system could be significantly reduced, which results in a higher vibration value compared to the declared vibration emission value.

Table E.1 — Electric machines: Use of declared vibration data in the vibration exposure estimation

1	2	3	4		5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Category of the test code**		**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Drill	EN 50144-2-1 (all editions) EN 60745-2-1:2003	No-load measurement at maximum speed	4, B, I		Drilling, screwdriver applications	Value in real use likely to be equal
	EN 60745-2-1:2003/A11:2007 (and later) (triaxial)	Drilling downward into steel	1, A, I		Drilling (without impact)	Value in real use likely to be equal
					Screwdriver applications	Value in real use likely to be equal
Impact drill	EN 50144-2-1 (all editions) EN 60745-2-1:2003	Drilling into concrete with small aggregates	1, B, I		Impact drilling	Multiply with factor 1,5
	EN 60745-2-1:2003/A11:2007 (and later) (triaxial)	Drilling into concrete with small aggregates	1, A, I		Impact drilling	Value in real use likely to be equal
		Drilling into masonry	2, A, I		Impact drilling	Value in real use likely to be equal or lower
Diamond drill	EN 60745-2-1:2003/A11:2007 (and later) (triaxial)	Drilling with water downwards into concrete	1, A, I		Wet diamond drilling (with water)	Value in real use likely to be equal
		Drilling horizontally into sand-limestone	1, A, I		Dry diamond drilling (without water)	Value in real use likely to be equal
		Drilling horizontally into masonry	2, A, I		Dry diamond drilling (without water)	Value in real use likely to be equal
Screw-drivers	EN 50144-2-2 (all editions) EN 60745-2-2:2003	No-load maximum speed	3, B, I		Fastening screws, drilling	Multiply with 1,5
	EN 60745-2-2:2003/A11:2007 (and later) (triaxial)	No-load maximum speed	3, A, I		Fastening screws, drilling	Value in real use likely to be equal

Table E.1 *(continued)*

1	2	3	4		5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Category of the test code**		**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Impact wrenches	EN 50144-2-2 (all editions) EN 60745-2-2: 2003	Loading device test	3, B, I		Impact fastening of screws	Multiply with 1,5
	EN 60745-2-2:2003/A11:2007 (and later) (triaxial)	Hard joint screw fastening	1, A, I		Impact fastening of screws	Value in real use likely to be equal
		Soft joint screw fastening	1, A, I		Impact fastening of screws	Value in real use likely to be equal or lower
Grinder	EN 50144-2-3 (all editions)	A disc with defined unbalance is operated on the grinder (reduced speed)	3, B, I		Grinding	Multiply with factor 1,5 [a]
			3, B, I		Sanding	Multiply with factor 1,5
			3, B, I		Polishing	Value in real use likely to be lower
	EN 60745-2-3:2007 (and later) (triaxial)	A disc with defined unbalance is operated on the grinder (max speed)	3, A, I		Grinding and cutting different materials	Value in real use likely to be equal
		Sanding a steel plate	1, A, I		Sanding different materials and coatings	Value in real use likely to be equal
		Polishing a steel plate	1, A, I		Polishing different materials and coatings	Value in real use likely to be equal
Sander	EN 50144-2-4 (all editions) EN 60745-2-4:2003	Sanding steel plate downwards	1, B, I		Sanding different materials and coatings	Multiply with factor 1,5
	EN 60745-2-4:2003/A11:2007 (and later) (triaxial)	Sanding steel plate downwards	1, A, I		Sanding different materials and coatings	Value in real use likely to be equal
Circular saw	EN 50144-2-5 (all editions) EN 50260-2-5 (all editions) EN 60745-2-5:2003	Cutting chipboard	1, B, I		Cutting wood and soft materials	Multiply with factor 1,5
	EN 60745-2-5:2007 (and later) (triaxial)	Cutting 38 mm chipboard	1, A, I		Cutting wood and soft materials	Value in real use likely to be equal

Table E.1 *(continued)*

1	2	3	4		5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Category of the test code**		**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Hammer drill (combi drill)	EN 50144-2-6 (all editions) EN 60745-2-6:2003	Hammer-drilling downwards into concrete	1, B, I		Hammer drilling	Multiply with factor 2
					Drilling without percussion	Value in real use likely to be lower
					Chiselling, breaking	Multiply with factor 2
					Other applications	Multiply with factor 2 for orientation only: Values in real use likely to be higher or lower
	EN 60745-2-6:2003/A11:2007 (and later) (triaxial)	Hammer-drilling downwards into concrete	1, A, I		Hammer drilling	Value in real use likely to be equal [b]
		Chiselling downwards into steel ball absorber	3, A, I		Chiselling, breaking brick or concrete	Value in real use likely to be equal [b]
					Other applications with percussion to the wall	Values in real use likely to be equal or lower [b]
	EN 60745-2-1:2003/A11:2007 (and later) (triaxial)	Drilling downward into steel	1, A, I		Drilling (without percussion)	Value in real use likely to be equal
					Other applications without percussion	Value in real use likely to be equal
Breaker (combi drill in breaking mode)	EN 50144-2-6 (all editions) EN 60745-2-6:2003	Chiselling downwards into steel ball absorber	3, B, I		Breaking concrete	Multiply with factor 1,5
					Breaking masonry	Multiply with factor 1,5
	EN 60745-2-6:2003/A11:2007 (and later) (triaxial)	Chiselling downwards into steel ball absorber	3, A, I		Breaking concrete	Value in real use likely to be equal [b]
					Breaking masonry	Value in real use likely to be equal [b]
Spray guns	EN 50144-2-7 (all editions)	No-load maximum speed	3, B, I		Spraying fluids	Multiply with factor 1,5
Sheet metal sheers and nibblers	EN 50144-2-8 (all editions)	No-load maximum speed	4, B, I		Cutting sheet metal	Multiply with factor 1,5 [c]
	EN 60745-2-8:2003/A11:2007 (and later) (triaxial)	Cutting steel sheet metal	1, A, I		Cutting sheet metal	Value in real use likely to be equal

Table E.1 *(continued)*

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Category of the test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Tappers	EN 50144-2-9 (all editions)	No measurement, declaration < 2,5 m/s²		Tapping	Multiply with factor 1,5
	EN 60745-2-9:2003/A11:2007 (triaxial) (and later)	No-load maximum speed	3,A,I	Tapping holes	Value in real use likely to be equal
Sabre saw	EN 50144-2-11 (all editions) EN 60745-2-11:2003	Cutting chipboard	3,B, I	Sawing different materials	Multiply with factor 2
	EN 60745-2-11:2003/A11:2007 (and later) (triaxial)	Cutting 38 mm Chipboard	1, A, I	Cutting boards	Value in real use likely to be equal [b]
			2, A, I	Cutting beams and pipes and demolition work	Multiply with factor 1,5 [b]
	EN 60745-2-11:2003/A12:2009 (and later) (triaxial)	Cutting 38 mm Chipboard	1, A, I	Cutting boards	Value in real use likely to be equal [b]
		Cutting wooden beam	1, A, I	Cutting beams and pipes and demolition work	Value in real use likely to be equal [b]
Jig saw	EN 50144-2-10 (all editions) EN 60745-2-11:2003	Cutting chipboard	3,B, I	Sawing different materials	Multiply with factor 1,5
	EN 60745-2-11:2003/A11:2007 (and later) (triaxial)	Cutting 38 mm Chipboard	1, A, I	Cutting boards	Value in real use likely to be equal [b]
		Cutting 3 mm sheet metal	1, A, I	Cutting sheet metal	Value in real use likely to be equal [b]
Planers	EN 50144-2-14 (all editions)	Planing soft wood	1, B, I	Planing soft wood	Multiply with factor 1,5
	EN 60745-2-14:2003/A11:2007 (and later) (triaxial)	Planing soft wood	1, A, I	Planing soft wood	Value in real use likely to be equal
Routers	EN 50144-2-17 (all editions) EN 60745-2-17:2003	Cutting groves into chip board	1, B, I	Cutting groves and edges	Multiply with factor 1,5
	EN 60745-2-17:2003/A11:2007 (and later) (triaxial)	Cutting groves into MDF-board	1, A, I	Cutting groves and edges	Value in real use likely to be equal

Table E.1 *(continued)*

1	2	3	4		5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Category of the test code**		**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Laminate trimmers	EN 50144-2-18 (all editions) EN 60745-2-17:2003	No-load maximum speed	4, B, I		Cutting grooves for joints	Multiply with factor 1,5
	EN 60745-2-17:2003/A11:2007 (and later) (triaxial)	Cutting grooves into MDF-board	1, A, I		Cutting groves and edges	Value in real use likely to be equal
Oscillating knives					Cutting big rubber	Multiply with factor 2
					Cutting small rubber	Multiply with factor 1,5

a High-frequency angle grinder: For machines with a rough grinding wheel, the real work vibration emission can be significantly higher than declared (before 2010). Tests on angle grinders have showed that the results in practical use differ very much.

Flexible-shaft grinders are not covered by the standards. Therefore no factor in the table is applicable.

Reference to a test report showing details of the test is necessary.

b Some older data (declared before 2010) do not generally reflect the in-use vibration. For more information, see references [31] to [40].

c Nibbler: Especially for machines with support handle working on stiff steel, the real work vibration emission can be significantly higher than declared (before 2010).

Sheet metal sheers: The test code gives not enough information about the material to use the vibration emission value for strong work on stiff steel real work.

NOTE 1 For machines which are not listed in this table and only a single-axis value is declared, a correction factor of at least 1,5 is applied. If made available ”vibration total values” or “triaxial vibration values” are suitable for the exposure assessment, if the values have been measured in three axes and are declared as such.

NOTE 2 For all machines, declared values below 2,5 m/s^2 are raised to 2,5 m/s^2 before the recommendations in this table are applied.

NOTE 3 The explanation of column 4 is given in Annex D.

E.3 Simplified method for the estimation of the exposure duration

The daily exposure duration for each relevant machine or process should be determined, e.g. by observing the work (see Clause 5).

Alternatively, this can be done by multiplying the estimated user time by an appropriate exposure proportion which normally is only 20 % of the user time for electric machines, except for breakers where it is up to 80 %.

Operators and users asked for information on their typical daily vibration duration will normally give an estimate which includes periods of time when there is no vibration since the machine operator can more easily estimate the user times and spread them among several devices used in the course of a day. Therefore, such an approach often results in an overestimation of the exposure duration.

Not just the contact time of the hand to the operating machine (equivalent to trigger time) is taken into account but also additional job-related times without any vibration, so that the estimated time needs correction to find the relevant vibration exposure duration.

In some special cases it may be possible to estimate the daily exposure duration using generic exposure durations obtained from time studies, as given in Table E.2.

Table E.2 — Typical daily exposure durations during an 8-h working day

Machine	Normal craftsmen applications	Excessive craftsmen applications	Industry applications [a]
Angle grinder < 1 500 W	0,5 h	1,5 h	3 h
Angle grinder ≥ 1 500 W	0,5 h	1 h	2 h
Straight grinder	0,25 h	0,5 h	
Chiseling hammer < 12 kg	0,25 h	0,5 h	1,5 h
Demolition hammer ≥ 12 kg	0,5 h	0,75 h	
Rotary hammer < 4 kg	0,25 h	0,5 h	
Rotary hammer ≥ 4 kg	0,25 h	0,5 h	1 h
Combination hammer	0,25 h	0,5 h	
Percussion drill	0,15 h		
Drill	0,25 h	0,5 h	
Screwdriver	0,25 h	1 h	
Cordless screwdriver	0,25 h	0,5 h	
Impact wrench	0,15 h	0,5 h	
Circular saw	0,25 h	0,5 h	
Reciprocating saw	0,25 h	0,5 h	
Jig saw	0,15 h	0,5 h	
Chain saw	0,5 h		
Sabre saw	0,15 h	0,5 h	
Orbital sander	0,5 h	1 h	
Belt sander	0,25 h	0,5 h	
Delta sander	0,5 h		
Polisher	0,75 h	1,5 h	
Hedge trimmer	0,75 h	1,5 h	
Wall chaser	0,5 h	1,5 h	
Planer	0,25 h	0,5 h	
Nibbler	0,25 h	0,5 h	
Plate jointer	0,15 h	0,5 h	
Router	0,25 h	0,5 h	
Hot air gun	0,25 h		

[a] Especially in industrial application higher values can be found so that normally an individual evaluation of the exposure duration needs to be performed.

If the exposure duration by time measurement on site cannot be determined it is good practice to compare the exposure duration calculated using the exposure proportion for the machine (e.g. 20 % of the user time) with the typical daily exposure duration according to Table E.2. If the calculated exposure duration is longer than the typical one and the work done is not special, a better investigation of the exposure duration is recommended. If the typical exposure duration is longer than the calculated one, it is recommended to use the higher value.

If the daily vibration exposure limit is exceeded with the value estimated by this method, a more precise risk assessment is necessary.

E.4 Other methods

Some manufacturers and institutes try to convert the vibration exposure limit into the dimension of possible work-performance per day. The possible daily performance, e.g. of a hammer drill, is sometimes published as "number of holes per day" that can be drilled before the exposure action value or the exposure limit value is exceeded.

These values can be determined by measuring vibration and drilling speed of the machine for the relevant application at the same time and by calculating the number of holes of a specified depth using the maximum exposure duration T (calculated from the vibration magnitude) and the drilling performance per time, by using statistical methods and taking uncertainties into account.

Using this method, the employer does only have to compare the numbers of holes he wishes to drill with the relevant machine and drill bit combination with the maximum allowed number of holes per day to find out, whether or not the action value or the limit value is exceeded.

Another method, e.g. for angle grinders, is to measure the time a grinding wheel can be used until it is worn down in a typical application. If the vibration magnitude is known (e.g. by measurement or rough estimation as explained above) and the time to wear the grinding wheel is measured, the number of grinding wheels that can be worn per day can be calculated in the same way as in the examples given in F.4.

E.5 Example

A plumbing installation craftsman is doing installation work and uses two different machines. Looking to the instruction handbooks he finds the following declared vibration values. A precise time study was not done but he knows that he uses the wall chaser about 2 h and the combi hammer about 1 h. With these data and the help of Table E.1, the relevant correction factor can be identified and the vibration value for the rough estimation of the vibration exposure can be calculated (as for the wall chaser is no standard available, the factor 1,5 is used, see NOTE 1 to Table E.1).

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Combi hammer (drilling and breaking modes)	7 m/s^2	EN 50144-2-6	2	7 m/s^2 × 2 = 14 m/s^2
Wall chaser	4 m/s^2	–	1,5	4 m/s^2 × 1,5 = 6 m/s^2

Now the relevant vibration exposure duration is calculated taking the normal exposure proportion of 20 % into account. The value is checked with the typical exposure durations for normal craftsmen application in Table E.2.

Machine	Estimated user time T_e	Relevant exposure duration T (20 %)	Relevant typical value T from Table E.2	Used duration T for further calculation
Combi hammer	1 h	0,2 h	0,25 h	0,25 h
Wall chaser	2 h	0,4 h	0,5 h	0,5 h

The longer exposure duration is selected to take into account that just a rough estimation is done.

Since the vibration value and the exposure duration are estimated, the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Table 1	P_E from Formula (2)
Machine 1	14 m/s^2	0,25 h	between 78 and 196	98
Machine 2	6 m/s^2	0,5 h	36	36
Total vibration exposure points $P_{E\ tot}$			between 114 and 232	134

The total vibration exposure points are above 100 and far below 400. The vibration action value is exceeded but the vibration exposure is still far below the limit value. The employer should implement a programme of measures to reduce exposure and risks to a minimum. Ensure health surveillance is provided for exposed workers.

Annex F
(informative)

Estimation of the daily vibration exposure for pneumatic machines

F.1 General

The "precise" vibration exposure from the use of pneumatic machines in industrial applications for specific operators on specific days is almost impossible to find. Both the exposure duration and the vibration magnitudes vary within broad ranges from one day to another. It is possible though to make rough exposure estimates using the declared emission values for the machines combined with estimations of the exposure duration. This annex is intended to guide the employer when making this type of rough exposure estimations.

F.2 Determination of rough estimates of the likely vibration magnitudes in real use

In this subclause guidance is given regarding the use of information given by the manufacturer either in the form of declared vibration emission values or as additional information.

Start to look for additional information regarding vibration values in real use supplied in the documentation accompanying the machines. If found, check that your application is covered by the values given. The values can then be used directly in an exposure estimation combined with relevant exposure durations.

In cases where no additional vibration information is given, the declared emission values may be used. Note that exposure estimations based of modified declared emission values are only rough estimates. When this estimation shows that the operator is likely to be exposed above the action value the employer can either choose to reduce the exposure by e.g. the use of machines with lower vibration magnitudes or he can make a more sophisticated determination to find if the operator is exposed above the action value or not. It should be noted though that such a determination will require that vibration measurements are made at the workplace. In Table F.1 information for using the declared emission values is given.

It should be noted that EN ISO 8662 is currently under revision and the remarks and restrictions apply only to the editions quoted. EN ISO 8662 (EN 28662) series addressed the measurement of single-axis values only. Use Table F.1 to find adequate correction factors.

EN ISO 28927 series replaces EN ISO 8662 series and addresses the measurement of triaxial “vibration total values” which represent the upper quartile of real use vibration. “Vibration total values” according to these standards likely represents real use vibration in general.

Improper maintenance of the machine or cutting attachment can lead to higher vibration emissions. Damaged or hardend rubber elements of the anti-vibration-system, can reduce the vibration isolation of the machine. Furthermore, improper sharpening, dull or unbalanced cutting attachments are likely to increase vibration emissions. Especially old machines with an anti-vibration system based on a rubber the anti-vibration systems ages. That means that the efficiency of the anti-vibration system could be significantly reduced, which results in a higher vibration value compared to the declared vibration emission value.

Table F.1 — Pneumatic machines: Use of declared vibration data in the vibration exposure estimation

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition in test code**	**Category of test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Riveting hammer Chipping hammer	EN 28662-2:1994 A1:1995 A2:2001	Running in steel ball energy absorber	2, B, II	Riveting Cutting	Multiply with factor 1,5
			2, B, III or 2, B, II	Fettling Scaling Other applications	Multiply with factor 2
Rotary hammer Rock drill	EN 28662-3:1994 A1:1995 A2:2001	Drilling into a block of non-reinforced concrete	1, B, II 2, B, II	Hammer drilling Chiselling	Multiply with factor 2
Grinder	EN ISO 8662-4:1995	Free running at specified speed with aluminium unbalanced disc	3, B, I	Angle and vertical grinders: grinding or cutting Straight grinders: grinding	Multiply with factor 1,5
Pavement braker Construction hammer	EN 28662-5:1994 A1:1995 A2:2001	Running in steel ball energy absorber	2, B, II	Breaking concrete	Multiply with factor 2
				Breaking asphalt	Multiply with factor 1,5
					Some machines with anti-vibration handles are very sensitive for push force. For such machines, the above values are only valid when the push force used is in accordance with manufacturer's recom-mendations
Impact drill	EN ISO 8662-6:1995	Impact drilling	2, B, I	Impact drilling	Multiply with factor 1,5
Impact wrench Impulse tool Racheting screwdriver	EN ISO 8662-7:1997	Running on a standard socket fixed in an artificial loading device	3, B, I	Tightening bolts	Multiply with factor 1,5 [a]
Polisher Rotary sander Orbital sander Random orbital sander	EN ISO 8662-8:1997	Polishing or sanding on steel surface in figure-of-eight pattern with fixed feed force, fixed paper grit	2, B, I	Polishing Rotary sanding Orbital sanding Random orbital sanding	Multiply with factor 1,5

Table F.1 *(continued)*

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition in test code**	**Category of test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Rammer	EN ISO 8662-9:1996	Ramming on foam surface	2, B, I	Ramming	Multiply with factor 1,5
Nibbler Shears	EN ISO 8662-10:1998	Cutting sheet metal	2, B, II	Cutting sheet metal	Multiply with factor 1,5
Fastener driving tool	CEN ISO/TS 8662-11:2004	Driving a fastener into specified wood every 3 s	3, B, II	Driving fasteners every 3 s [b]	Emission value likely to repre-sent real use
Saw File	EN ISO 8662-12:1997	Machining specified wood or steel	2, B, II	Machining wood or steel	Multiply with factor 1,5
Straight die grinder Angle die grinder	EN ISO 8662-13:1997	Free running at specified speed with artificial inserted tool with known unbalance	3, B, I	Using rotationg file or using mounted points	Multiply with factor 1,5 [c]
Needle scaler Stone working tool	EN ISO 8662-14:1996	Running in steel ball energy absorber	3, B, III or 3, B, II	Cleaning weld	Multiply with factor 2
Oscillating knives	EN ISO 28927-8:2009			Cutting big rubber	Multiply with factor 2 [d]
				Cutting thin rubber	Multiply with factor 1,5

[a] Slip-clutch screw drivers are declared running freely. In some applications, for example when tightening wood screws into wood, the machine is running with the clutch engaged. This causes significant vibration and if this type of use is necessary, exposure time should be reduced as much as possible, e.g. for very short samples of screwing operation.

[b] When the time interval t_x between the single driving events is shorter than 3 s use for the vibration exposure estimation an exposure duration T according to the relationship $T = N / 5\,000 \times 4{,}2$ h with N being the number of fasteners driven on that working day. The exact interrelationship is $a_{tx} = a_{t\,3s}\,(3\ s/t_x)^{0,5}$.

[c] Wire brushes are not covered by EN ISO 28927-1, EN ISO 28927-4 or EN ISO 28927-12. The vibration is strongly dependent on the unbalance of the attachment and can be significantly higher than the declared value.

[d] Oscillating knives: The test code does not generally reflect the in-use vibration. For work tasks with very big rubber, e.g. 4 cm to 6 cm thick, it is probable that resonance effects occur and the real work vibration emission is significantly higher than declared.

NOTE 1 For machines which are not listed in this table and only a single-axis value is declared, a correction factor of at least 1,5 is applied.

NOTE 2 For all machines, declared values below 2,5 m/s^2 are raised to 2,5 m/s^2 before the recommendations in this table are applied.

NOTE 3 The explanation of column 4 is given in Annex D.

NOTE 4 Values found using the values in the table can only be used when the left hand is never in contact with inserted tools or hand-held workpieces.

F.3 Simplified method for the estimation of the exposure duration

The use of pneumatic machines in industrial applications varies very much from one application to another. It is therefore not possible to give any typical daily exposure duration. Exposure duration should be estimated in every case. To get rough estimates simplified methods can be used.

Since for pneumatic machines the vibration exposure duration is almost equal to the trigger time, one simplified method is: Measurement of the trigger time to wear out one grinding wheel and multiplication with the number of wheels used per day. Identification of the trigger time in line production to produce one unit and multiplication with the number of units produced per day. Some examples are given in Clause F.4.

F.4 Examples

F.4.1 Example 1

A vertical grinder is used to clean castings. The operator is using a 180 mm depressed centre wheel. The declared vibration value given by the manufacturer is 5,2 m/s^2. The value was measured according to EN ISO 8662-4:1995.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Vertical grinder (surface grinding)	5,2 m/s²	EN ISO 8662-4:1995	1,5	5,2 m/s² × 1,5 = 7,8 m/s²

An investigation showed an exposure duration per day of 2 h based on a wheel-consumption of 10 wheels per week and an average lifetime of a wheel, when used by this operator, of 1 h.

Now the vibration value and the exposure duration are both estimated and the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Formula (2)
Angle grinder (surface grinding)	7,8 m/s^2	2 h	243
Total vibration exposure points $P_{E\ tot}$			243

The total vibration exposure points are above 100 and far below 400. The 243 points can be recalculated to an *A*(8) value of 3,9 m/s^2 using Formula (3) or Figure 1. The vibration action value is exceeded but the vibration exposure is far below the limit value. This operator is likely exposed between the action and the limit value and an action programme has to be established for him.

F.4.2 Example 2

Let's assume we have the same application as in Example 1. The grinder, however, has a declared vibration value of 1,3 m/s^2.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Angle grinder (surface grinding)	1,3 m/s² (use 2,5 m/s² according to Note 2 to Table F.1)	EN ISO 8662-4:1995	1,5	2,5 m/s² × 1,5 = 3,75 m/s², rounded to 3,8 m/s²

This machine is more powerful and the exposure duration is found to be 1 h 30 min.

Now the vibration value and the exposure duration are estimated and the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Formula (2)
Angle grinder (surface grinding)	3,8 m/s^2	1,5 h	45
Total vibration exposure points $P_{E\ tot}$			45

The total vibration exposure points are below 100. This can be recalculated to an *A*(8) value of 1,7 m/s^2 using Formula (3) or Figure 1. This rough estimate shows that this operator is probably not exposed to vibration above the action value.

F.4.3 Example 3

Take the values from the grinding operation in Example 2. This time, the operator is also using a chipping hammer with a declared value of 10 m/s^2.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Angle grinder (surface grinding)	1,3 m/s² (use 2,5 m/s² according to Note 2 to Table F.1)	EN ISO 8662-4:1995	1,5	2,5 m/s² × 1,5 = 3,75 m/s², rounded to 3,8 m/s²
Chipping hammer (fettling)	10 m/s²	EN 28662-2:1994	2	10 m/s² × 2 = 20 m/s²

The operator is cleaning 30 pieces per shift and the chipping time was found to be 1 min per piece. The exposure duration is then 30 min per day.

Now the vibration values and the exposure durations are estimated and the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Table 1 or Formula (2)
Angle grinder (surface grinding)	3,8 m/s^2	1,5 h	45
Chipping hammer (fettling)	20 m/s^2	0,5 h	400
Total vibration exposure points $P_{E\ tot}$			445

The total vibration exposure points are well above 400. This can be recalculated to an *A*(8) value of 5,3 m/s^2 using Formula (3) or Figure 1. This operator is exposed above the limit value, so that the employer shall reduce the daily vibration exposure for the operator.

Annex G
(informative)

Estimation of the daily vibration exposure for machines with internal combustion engine

G.1 General

This annex describes a simplified method for the estimation of daily vibration exposure values as guidance for the verification of the requirements for machines with internal combustion engine. Instead of measuring vibration values at the specific workplaces, the method uses vibration values which are provided by the manufacturer of the machines according to the requirement of the Machinery Directive. Therefore, it is an essential premise for the application of this method that the test procedures used in the vibration test codes (standards) are in a close correlation to the real use of the machines.

Equivalent vibration total values which incorporate all working modes with transmission of vibration from the machine into the hands of the operator are available from the manufacturer of the specific machine. They are given in the instruction handbook and may also be found in catalogues or on the website of the manufacturer.

The other necessary parameter is the daily exposure duration. Guidance on estimating the exposure duration is given in G.2.2.

Using both data, the equivalent vibration total value and the exposure durations, the daily 8-h exposure value can be calculated.

Normally, only the determination of the exposure range will be interesting for the risk assessment performed by the employer, i.e. whether the exposure action value or the exposure limit value is exceeded (see Table 2). For this purpose, this Technical Report offers a simple method for calculating the daily vibration exposure by means of a table which indicates exposure points which indicate the magnitude of the vibration exposure.

G.2 Estimation of exposure values for machines with internal combustion engine

G.2.1 Equivalent vibration total value

Test codes for machines with internal combustion engine produce vibration total values a_{hv} for both hand positions in accordance with EN ISO 20643. They generally produce an equivalent vibration total value $a_{hv,eq}$ as defined in 3.4.

The time sequences used in the test codes calculation of $a_{hv,eq}$ are given in Table G.2. If these are representative of the work considered the manufacturer's emission value can be used.

G.2.2 Exposure duration

For each workplace and operator, the specific daily exposure duration has to be estimated. This estimation can be compared with the typical exposure durations given in Table G.1. These exposure durations will be used in conjunction with stipulated time sequences of the operating modes which were determined by experts for the specific machine. These time sequences of the operating modes are given in Table G.2. The listed machines cover the most representative machines. It might be possible to use exposure durations for similar machines if they are used under similar conditions.

The exposure durations given in Table G.1 were determined under typical conditions (see Table G.2). It is estimated that 90 % of all applications will have shorter exposure durations, in the remaining 10 % of all applications longer exposure durations will occur. In those cases, a work-site specific analysis needs to be performed. Employers should check whether these typical exposure durations are appropriate for the work considered.

Table G.1 — Typical exposure durations for the use of single machines during an 8-h working day

Machine	**Application**	**Typical daily exposure duration T**
Top-handle chain saw	Tree service	2,4 h
Chain saw < 80 cm³	Logging, farming, landscaping	3,7 h
Chain saw ≥ 80 cm³	Heavy logging	3,7 h
Grass trimmer	Landscaping	4 h
Brush cutter	Road maintenance, landscaping	3,5 h
Hedge trimmer	Landscaping	3,5 h
Long-shaft hedge trimmer	Landscaping, municipalities	2 h
Back-pack blower	Municipalities	3 h
Hand-held blower	Municipalities	1,5 h
Vacuum cleaner	Municipalities	1 h
Lawn edger	Landscaping	3 h
Power pruner	Tree maintenance	0,5 h
Power broom	Landscaping, construction	2 h
Mist blower	Agriculture	1 h
Fruit harvester (flap type)	Agriculture	3 h
Olive harvester (hook type)	Agriculture	3 h
Motor hoe	Agriculture	2 h
Hand drill	Agriculture	1 h
Earth auger	Agriculture, municipalities	3 h
Cut-off machine (hand-held)	Construction	1 h
Cut-off machine (hand-guided)	Construction	2,5 h

Table G.2 — Time sequences of the operating modes as used for measurement of the vibration emission

Machine	Idling	Rated speed	Nominal maximum speed	Vibration test code
Chain saw for tree service	1/3	1/3	1/3	EN ISO 22867
Chain saw < 80 cm^3	1/3	1/3	1/3	EN ISO 22867
Chain saw ≥ 80 cm^3	1/2	1/2		EN ISO 22867
Power pruner	1/2		1/2	EN ISO 11680 (all parts)
Hedge trimmer	1/5		4/5	EN 774
Long-shaft hedge trimmer	1/5		4/5	EN 774
Brush cutter	1/2		1/2	EN ISO 22867
Grass trimmer (hand-held)	1/2		1/2	EN ISO 22867
Lawn edger	1/2		1/2	
Vacuum cleaner	1/7		6/7	
Mist blower	1/7		6/7	
Back-pack blower	1/7		6/7	
Hand-held blower	1/7		6/7	
Fruit harvester (flap type)	1/7		6/7	
Olive harvester (hook type)	1/2	1/2		
Motor hoe	1/7		6/7	EN 709
Hand drill	1/5		4/5	
Cut-off machine (hand-held)	1/7		6/7	EN ISO 19432
Cut-off machine (hand-guided)	1/7		6/7	
Power broom	1/7		6/7	
Earth auger	1/5		4/5	

G.3 Determination of rough estimates of the likely vibration magnitudes in real use

In Table G.3 information for using the declared emission values is given.

Improper maintenance of the machine or cutting attachment can lead to higher vibration emissions. Damaged or hardend rubber elements of the anti-vibration system, can reduce the vibration isolation of the machine. Furthermore, improper sharpening, dull or unbalanced cutting attachments are likely to increase vibration emissions. Especially old machines with an anti-vibration system based on a rubber the anti-vibration systems ages That means that the efficiency of the anti-vibration system could be significantly reduced, which results in a higher vibration value compared to the declared vibration emission value.

Table G.3 — Machines with internal combustion engine: Use of declared vibration data in the vibration exposure estimation

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Cate-gory of the test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Chain saw for tree service	EN ISO 22867	Idling, full load and racing	1, A, I	Tree maintenance	Emission value likely to represent real use
Chain saw < 80 cm³	EN ISO 22867	Idling, full load and racing	1, A, I	Felling, bucking, debranching	Emission value likely to represent real use
Chain saw ≥ 80 cm³	EN ISO 22867	Idling and full load	1, A, I	Felling, bucking	Emission value likely to represent real use
Grass trimmer	EN ISO 22867	Idling and full load (load from the flexible line)	1, A, I	Grass cutting with flexible lines	Emission value likely to represent real use
Brush cutter	EN ISO 22867	Idling and racing Test does not include the cutting process.	1, A, I	Cutting brushes and grass with metal blades	Emission value likely to represent real use (vibration value with no-load is representative of the maximum load) [a]
Hedge trimmer	EN 774 EN ISO 10517	Idling and racing Test does not include the cutting process	2, A, I	Cutting bushes and hedges	Emission value likely to represent real use (vibration value with no-load is representative of the maximum load)
Long-shaft hedge trimmer	EN 774	Idling and racing Test does not include the cutting process	2, A, I	Cutting bushes and hedges	Emission value likely to represent real use (vibration value with no-load is representative of the maximum load)
Back-pack blower	EN 15503	Idling and full load (load from the fan wheel)	1, A, I	Surface cleaning by means of an intense air-stream	Emission value likely to represent real use
Hand-held blower	in preparation	Idling and full load (load from the fan wheel)	1, A, I	Surface cleaning by means of an intense air-stream	Emission value likely to represent real use
Vacuum cleaner	see blowers	Idling and full load (load from the fan wheel)	1, A, I	Surface cleaning by means of an intense air-stream	Emission value likely to represent real use
Mist blower	in preparation	Idling and full load (load from the fan wheel)	1, A, I	Spraying of fluids	Emission value likely to represent real use
Lawn edger	ISO 11789	Idling and racing	2, A, I	Cutting of roots at the boundaries of grass covered surfaces	Emission value likely to represent real use (vibration value with no-load is representative of the maximum load)
Power pruner	EN ISO 11680 (all parts)	Idling and racing	1, A, I	Tree maintenance	Test does not include the cutting process, vibration value of no-load is representative for maximum load as well

Table G.3 *(continued)*

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Cate-gory of the test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Power broom	see brush cutters	Idling and racing	1, A, I	Cleaning of construction sites	Test does not include the normal working process, vibration value of no-load is representative for maximum load as well
Fruit harvester (flap type)	see brush cutters	Idling and racing	1, A, I	Generation of an intense shaking process applied on bushes for harvesting fruits such as coffee	Test does not include the normal working process, vibration value of no-load is representative for maximum load as well
Olive harvester (hook type)	see brush cutters	Idling and full load (load from shaking an artificial branch)	1, A, I	Generation of an intense shaking process applied on branches for harvesting fruits such as olives	Conditions in the field may vary considerably depending on the working conditions, if daily vibration exposure close to the limit conduct special field analysis
Motor hoe	EN 709	Idling and racing	1, A, I	Soil processing before planting	Test does not include the normal working process, vibration value of no-load is representative for maximum load as well
Hand drill	see hedge trimmer	Racing	2, B, I	Drilling of holes in wood and in the ground	Test does not include the normal working process, vibration value of no-load is representative for maximum load as well
Earth auger	see hedge trimmers	Racing	2, B, I	Drilling of holes in the ground	Test does not include the normal working process, vibration value of no-load is representative for maximum load as well
Cut-off machine (hand-held)	EN ISO 19432	Idling and full load speed (no load applied)	1, A, I	Cutting of stone, asphalt, steel and other solid material	Test does not include the normal working process, vibration value of no-load is generated by a disc with defined unbalance
Cut-off machine (hand-guided)	see cut-off machines (hand-held)	Idling and full load speed (no load applied)	1, A, I	Cutting of stone, asphalt, steel and other solid material	Test does not include the normal working process, vibration value of no-load is generated by a disc with defined unbalance [b]
Track wrenches, impact wrenches	EN ISO 20643			Tightening rail track screws	
Tie tamper	EN ISO 20643			Ramming rail track ballast	

Table G.3 *(continued)*

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition of the test code**	**Cate-gory of the test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Direct fastening tools	CEN ISO/TS 8662-11	Driving a fastener into specified wood every 3 s	3, B, II	Driving fasteners every 3 s [c]	Emission value likely to represent real use

[a] Brush cutter: There are machines which look similar to brush cutters. However, as a cutting means these machines use circular hedge trimmer attachments instead of metal blades or plastic monofilaments. These attachments are not covered by the test procedure of this standard. Due to the alternating movement of the tool and tool-ground-interaction the application of this standard might lead to misleading test results. For these kinds of tools real work vibration emission is significantly higher than declared, see A.3.

[b] For some cut-off machines (hand-guided): There is a significant difference between the declared vibration emission value (declared before 2010) and the vibration value from the work task.

[c] When the time interval t_x between the single driving events is shorter than 3 s use for the vibration exposure estimation an exposure duration T according to the relationship $T = N / 5\,000 \times 4{,}2$ h with N being the number of fasteners driven on that working day. The exact interrelationship is $a_{tx} = a_{t\,3s}\,(3\ \text{s}/t_x)^{0,5}$.

NOTE 1 For machines which are not listed in this table and only a single-axis value is declared, a correction factor of at least 1,5 is applied.

NOTE 2 For all machines, declared values below 2,5 m/s^2 are raised to 2,5 m/s^2 before the recommendations in this table are applied.

NOTE 3 The explanation of column 4 is given in Annex D.

G.4 Calculation of the daily vibration exposure

The daily vibration exposure can be determined by using the equivalent vibration total value and the daily exposure duration for the specific machine as described in Clause 7.

EXAMPLE An operator is using a 40 cm^3 chain saw in forestry work. The chain saw has a declared value of 3,5 m/s^2 in accordance with EN ISO 22867. Field studies show that the proportions between idling, rated speed and maximum speed is similar to the time sequences for chain saws stated in Table G.2 and the studies estimate the daily exposure duration to 3 h. This is compared to the typical daily exposure duration in Table G.1 and it indicates that the estimation is reasonable. Determination of the vibration exposure is done using Table 1. The declared value and the estimated exposure duration give a vibration exposure of 74 points. Since no other vibratory machinery is used it is likely that the vibration action value is not exceeded.

Annex H
(informative)

Estimation of the daily vibration exposure for hydraulic machines

H.1 General

The "precise" vibration exposure from the use of hydraulic machines in industrial applications for specific operators on specific days is almost impossible to find. Both the exposure duration and the vibration magnitudes vary within broad ranges from one day to another. It is possible though to make rough exposure estimates using the declared emission values for the machines combined with estimations of the exposure duration. This annex is intended to guide the employer when making this type of rough exposure estimations.

NOTE The machines listed in Table H.1 are referenced in ISO 17066.

H.2 Determination of rough estimates of the likely vibration magnitudes in real use

In this subclause guidance is given regarding the use of information given by the manufacturer either in the form of declared vibration emission values or as additional information.

Start to look for additional information regarding vibration values in real use supplied in the documentation accompanying the machines. If found, check that your application is covered by the values given. The values can then be used directly in an exposure estimation combined with relevant exposure durations.

In cases where no additional vibration information is given, the declared emission values may be used. Note that exposure estimations based of modified declared emission values are only rough estimates. When this estimation shows that the operator is likely to be exposed above the action value the employer can either choose to reduce the exposure by e.g. the use of machines with lower vibration magnitudes or he can make a more sophisticated determination to find if the operator is exposed above the action value or not. It should be noted though that such a determination will require that vibration measurements are made at the workplace. In Table H.1 information for using the declared emission values is given.

It should be noted that EN ISO 8662 is currently under revision and the remarks and restrictions apply only to the editions quoted, and the machine definitions in each part. EN ISO 8662 (EN 28662) series addressed the measurement of single-axis values only. Use Table H.1 to find adequate correction factors.

EN ISO 28927 series replaces EN ISO 8662 series and addresses the measurement of triaxial “vibration total values” which represent the upper quartile of real use vibration. “Vibration total values” according to these standards likely represents real use vibration in general.

Table H.1 — Hydraulic machines: Use of declared vibration data in the vibration exposure estimation

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition in test code**	**Category of test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Chipping hammer	EN 28662-2:1994 A1.1995 A2:2001	Running in steel ball energy absorber	2, B, II 2, B, III or 2, B, II [a]	Fettling Scaling Other applications	Multiply with factor 2
Rotary hammer Rock drill Drill, core drill	EN 28662-3:1994 A1:1995 A2:2001	Drilling into a block of non-reinforced concrete	1, B, II 2, B, II	Hammer drilling Chiselling Core Sampling	Multiply with factor 2
Grinder Cut-off grinder	EN ISO 8662-4:1995	Free running at specified speed with aluminium unbalanced disc	3, B, I	Angle and vertical grinders: grinding or cutting Straight grinders: grinding	Multiply with factor 1,5
Pavement braker Construction hammer	EN 28662-5:1994 A1:1995 A2.2001	Running in steel ball energy absorber	2, B, II	Breaking concrete	Multiply with factor 2
				Breaking asphalt	Multiply with factor 1,5
					Some machines with anti-vibration handles are very sensitive for push force. For such machines, the above values are only valid when the push force used is in accordance with manufacturer's recommendations.
Impact drill	EN ISO 8662-6:1995	Impact drilling	2, B, I	Impact drilling	Multiply with factor 1,5
Impact wrench Impulse tool	EN ISO 8662-7:1997	Running on a standard socket fixed in an artificial loading device	3, B, I	Tightening bolts	Multiply with factor 1,5
Polisher Rotary sander Orbital sander Random orbital sander	EN ISO 8662-8:1997	Polishing or sanding on steel surface in figure-of-eight pattern with fixed feed force, fixed paper grit	2, B, I	Polishing Sanding	Multiply with factor 1,5
Rammer Pole tamper	EN ISO 8662-9:1996	Ramming on foam surface	2, B, I	Ramming	Multiply with factor 1,5
Shears	EN ISO 8662-10:1998	Cutting metal	2, B, II	Cutting metal cables	Multiply with factor 1,5
Saw Circular saw	EN ISO 8662-12:1997	Cutting specified wood or steel	2, B, II	Cutting wood or steel	Multiply with factor 1,5

Table H.1 *(continued)*

1	2	3	4	5	6
Machine	**Vibration test code**	**Working condition in test code**	**Category of test code**	**Real work task considered**	**Remarks and restrictions when using the declared value for rough estimation of exposure**
Stone working tool	EN ISO 8662-14:1996	Running in steel ball energy absorber	3, B, III or 3, B, II [a]	Chiseling stone	Multiply with factor 2

[a] Depending on the design, category II may be appropriate.

NOTE 1 For machines which are not listed in this table and only a single-axis value is declared, a correction factor of at least 1,5 is applied.

NOTE 2 For all machines, declared values below 2,5 m/s^2 are raised to 2,5 m/s^2 before the recommendations in this table are applied.

NOTE 3 The explanation of column 4 is given in Annex D.

NOTE 4 Values found using the values in the table can only be used when the left hand is never in contact with inserted tools or hand-held workpieces.

H.3 Simplified method for the estimation of the exposure duration

The use of hydraulic machines in industrial applications varies very much from one application to another. It is therefore not possible to give any typical daily exposure duration. Exposure duration should be estimated in every case. To get rough estimates simplified methods can be used.

Since for hydraulic machines the vibration exposure duration is almost equal to the trigger time, one simplified method is: Measurement of the trigger time to wear out one grinding wheel and multiplication with the number of wheels used per day. Identification of the trigger time in line production to produce one unit and multiplication with the number of units produced per day. Some examples are given in H.4.

H.4 Examples

H.4.1 Example 1

A vertical grinder is used to clean castings. The operator is using a 180 mm depressed centre wheel. The declared vibration value given by the manufacturer is 5,2 m/s^2. The value was measured according to EN ISO 8662-4:1995.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Vertical grinder (surface grinding)	5,2 m/s^2	EN ISO 8662-4:1995	1,5	5,2 m/s^2 × 1,5 = 7,8 m/s^2

An investigation showed an exposure duration per day of 2 h based on a wheel-consumption of 10 wheels per week and an average lifetime of a wheel, when used by this operator, of 1 h.

Now the vibration value and the exposure duration are both estimated and the exposure points can calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Formula (2)
Vertical grinder (surface grinding)	7,8 m/s^2	2 h	243
Total vibration exposure points $P_{E\ tot}$			243

The total vibration exposure points are above 100 and far below 400. The 243 points can be recalculated to an *A*(8) value of 3,9 m/s^2 using Formula (3) or Figure 1. The vibration action value is exceeded but the vibration exposure is far below the limit value. This operator is likely exposed between the action and the limit value and an action programme has to be established for him.

H.4.2 Example 2

Let us assume we have the same application as in Example 1. The grinder, however, has a declared vibration value of 1,3 m/s^2.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Angle grinder (surface grinding)	1,3 m/s^2 (use 2,5 m/s^2 according to Note 2 to Table H.1)	EN ISO 8662-4:1995	1,5	2,5 m/s^2 × 1,5 = 3,75 m/s^2, rounded to 3,8 m/s^2

This machine is more powerful and the exposure duration is found to be 1 h 30 min.

Now the vibration value and the exposure duration are estimated and the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Formula (2)
Angle grinder	3,8 m/s^2	1,5 h	45
Total vibration exposure points $P_{E\ tot}$			45

The total vibration exposure points are below 100. This can be recalculated to an *A*(8) value of 1,7 m/s^2 using Formula (3) or Figure 1. This rough estimate shows that this operator is probably not exposed to vibration above the action value.

H.4.3 Example 3

Take the values from the grinding operation in Example 2. This time, the operator is also using a chipping hammer with a declared value of 10 m/s^2.

Machine	Declared single-axis vibration value (from instruction handbook)	Standard used	Factor to be used	Vibration value $a_{hv,eq}$ for rough estimation
Angle grinder (surface grinding)	1,3 m/s^2 (use 2,5 m/s^2 according to Note 2 to Table H.1)	EN ISO 8662-4:1995	1,5	2,5 m/s^2 × 1,5 = 3,75 m/s^2, rounded to 3,8 m/s^2
Chipping hammer (fettling)	10 m/s^2	EN 28662-2:1994	2	10 m/s^2 × 2 = 20 m/s^2

The operator is cleaning 30 pieces per shift and the chipping time was found to be 1 min per piece. The exposure duration is then 30 min per day.

Now the vibration values and the exposure durations are estimated and the exposure points can be calculated according to 7.3.

	$a_{hv,eq}$	T	P_E from Table 1 or Formula (2)
Angle grinder	3,8 m/s^2	1,5 h	45
Chipping hammer	20 m/s^2	0,5 h	400
Total vibration exposure points $P_{E\ tot}$			445

The total vibration exposure points are well above 400. This can be recalculated to an *A*(8) value of 5,3 m/s^2 using Formula (3) or Figure 1. This operator is exposed above the limit value, so that the employer shall reduce the daily vibration exposure for the operator.

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NOTE Some of the standards might already be withdrawn.

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[2] EN 709, *Agricultural and forestry machinery — Pedestrian controlled tractors with mounted rotary cultivators, motor hoes, motor hoes with drive wheel(s) — Safety*

[3] EN 774, *Garden equipment — Hand held, integrally powered hedge trimmers — Safety*

[4] EN 786, *Garden equipment — Electrically powered walk-behind and hand-held lawn trimmers and lawn edge trimmers — Mechanical safety*

[5] EN 836, *Garden equipment — Powered lawnmowers — Safety*

[6] CR 1030-1, *Hand-arm vibration — Guidelines for vibration hazards reduction — Part 1: Engineering methods by design of machinery*

[7] CR 1030-2, *Hand-arm vibration — Guidelines for vibration hazards reduction — Part 2: Management measures at the workplace*

[8] EN 12096, *Mechanical vibration — Declaration and verification of vibration emission values*

[9] EN 12733, *Agricultural and forestry machinery — Pedestrian controlled motor mowers — Safety*

[10] EN 14910, *Garden equipment — Walk-behind combustion engine powered trimmers — Safety*

[11] EN 15503, *Garden equipment — Garden blowers, vacuums and blower/vacuums — Safety*

[12] EN 50144 (all parts), *Safety of hand-held electric motor operated tools*

[13] EN 60335 (all parts), *Household and similar electrical appliances — Safety (IEC 60335)*

[14] EN 60745 (all parts), *Hand-held motor-operated electric tools — Safety (IEC 60745)*

[15] EN ISO 10517, *Powered hand-held hedge trimmers — Safety (ISO 10517)*

[16] EN ISO 11680 (all parts), *Machinery for forestry — Safety requirements and testing for pole-mounted powered pruners (ISO 11680)*

[17] EN ISO 19432, *Building construction machinery and equipment — Portable, hand-held, internal combustion engine driven cut-off machines — Safety requirements (ISO 19432)*

[18] EN ISO 20643, *Mechanical vibration — Hand-held and hand-guided machinery — Principles for evaluation of vibration emission (ISO 20643)*

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[23] ISO 18651-1, *Building construction machinery and equipment — Internal vibrators for concrete — Part 1: Terminology and commercial specifications*

[24] ISO 18652, *Building construction machinery and equipment — External vibrators for concrete*

[25] ISO 19433, *Building construction machinery and equipment — Pedestrian-controlled vibratory plates — Terminology and commercial specifications*

[26] ISO 19452, *Building construction machinery and equipment — Pedestrian-controlled vibratory (percussion) rammers — Terminology and commercial specifications*

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