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BSI Standards Publication

Hand-arm vibration — Guidelines for vibration hazards reduction

Part 2: Management measures at the workplace

National foreword

This Published Document is the UK implementation of CEN/TR 1030-2:2016. It supersedes PD 6585-2:1996 which is withdrawn.

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European foreword

This document (CEN/TR 1030-2:2016) 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 shall not be held responsible for identifying any or all such patent rights.

This document supersedes CR 1030-2:1995.

The present series CR 1030 / CEN/TR 1030 is composed with the following parts:

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

— CEN/TR 1030-2, *Hand-arm vibration — Guidelines for vibration hazards reduction — Part 2: Management measures at the workplace*.

Introduction

The habitual and prolonged use of machinery which transmits vibration to the hand can cause disorders of the upper limbs. European legislation — especially the Physical Agents Directive 2002/44/EC (Vibrations at work) — requires that employers assess and take measures to prevent or reduce workplace risks to the health and safety of their employees. The basic strategy to be adopted is defined in the European legislation including the Directive 2002/44/EC and described in the “Non-binding guide to good practice for implementing Directive 2002/44/EC (Vibrations at work)”, Part I “Guide to good practice on hand-arm vibration”, which is addressed to the European Member States. It covers the following areas of measures:

a) assessment of risks;

b) identification of necessary preventative and/or protective measures;

c) organization for the effective implementation of preventative and protective measures;

d) implementation of an adequate programme of measures to prevent or reduce risks.

This revised Technical Report CEN/TR 1030-2 (first edition was published as CR 1030-2 in 1995) primarily provides additional information and examples to the European “Guide to good practice on hand-arm vibration” (Part I of the Non-binding guide to good practice for implementing Directive 2002/44/EC (Vibrations at work)).

This Technical Report CEN/TR 1030-2 provides additional information for Member States’ health and safety authorities or labour authorities as well as managers, health and safety officers, engineers, planning and purchasing staff and others on further aspects of vibration effect reduction and control, which supports the practical implementation of the requirements of the Physical Agents Directive 2002/44/EC (Vibrations at work). Effective protection against vibration generally requires a combination of measures which can be categorized as technical measures and management measures; see Figure 1.

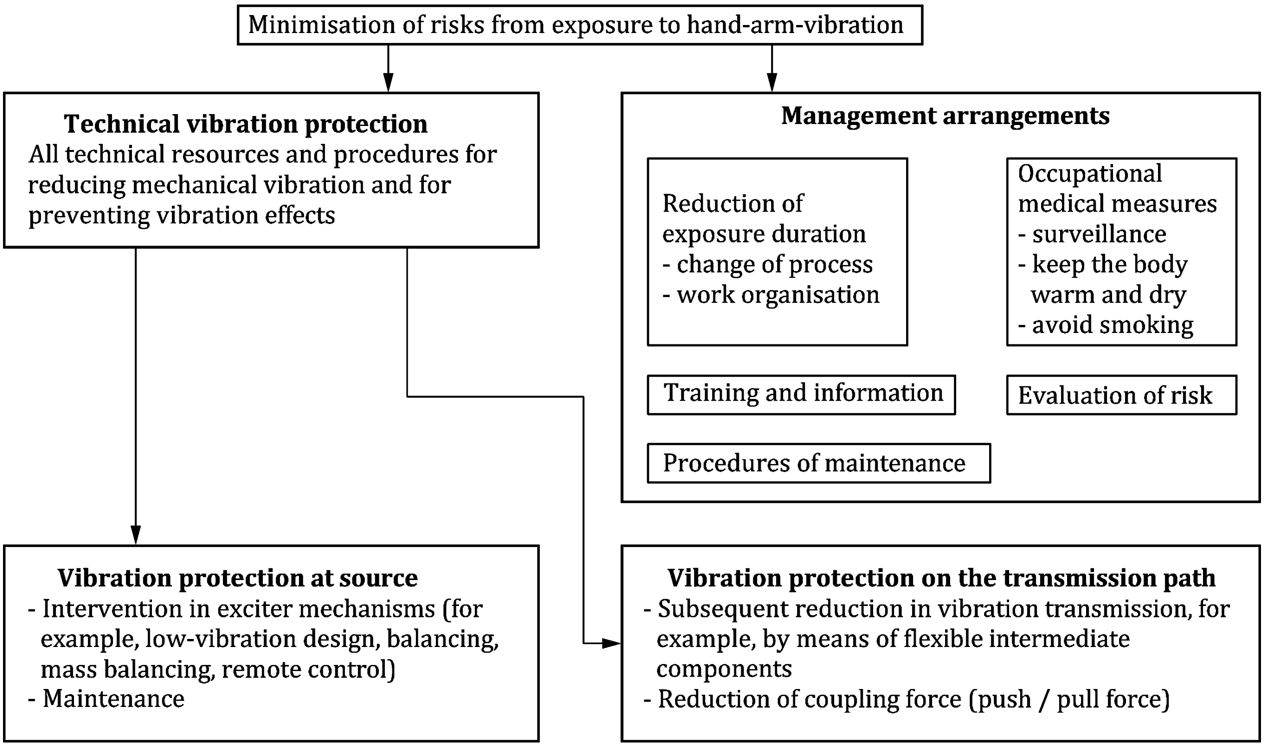


Figure 1 — Minimization of risks from exposure to hand-arm vibration

1 Scope

This Technical Report outlines practicable measures for the reduction and control of health hazards associated with exposure to hand-arm vibration at work. It supplements the European "Guide to good practice on hand-arm vibration" and provides a practical professional aid for Member States' health and safety authorities or labour authorities who write national guidance for managers, health and safety officers, engineers, planning and purchasing staff and others.

This Technical Report covers the following principal aspects:

a) identification of main sources of hand-arm vibration at work;

b) vibration reduction by re-considering task, product, process and design;

c) how to select low-vibration machinery, including vibration reducing features, auxiliary equipment for control of vibration;

d) other issues, e.g. personal protection and its limitation;

e) management measures for the control of hand-arm vibration exposure;

f) health surveillance.

2 Normative references

The following documents, in whole or in part, are 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.

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

EN 12096, *Mechanical vibration - Declaration and verification of vibration emission values*

CEN/TR 15350:2013, *Mechanical vibration - Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery*

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

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

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN ISO 5349-2, ISO 2041 and ISO 5805 apply.

4 Identification of main sources of hand-arm vibration at work

A starting point is to consider the work being carried out, the processes involved and the tools and equipment used. Use of hand-held, hand-guided or hand-fed powered equipment should be managed.

The risk assessment should:

a) identify where there can be a risk from hand-arm vibration;

b) estimate workers' exposures using information on tool vibration and information gathered on patterns and durations of tool use and compare them with the exposure action value and exposure limit value as specified in the Physical Agents Directive 2002/44/EC (Vibrations at work);

c) identify the available risk controls;

d) identify people who can be at particular risk, e.g. young or pregnant workers, those who have had surgery on hands and arms or have known disorders similar to those that can be caused by vibration;

e) if it is likely to help plan and implement controls, make a more detailed assessment of exposure, e.g. including measurement;

f) identify the steps to control and monitor hand-arm vibration risks;

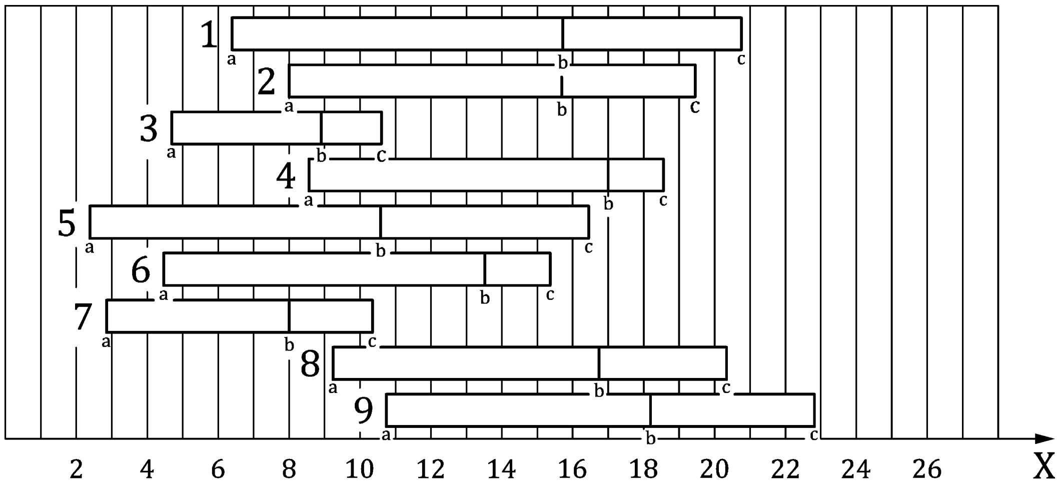
g) record the assessment, the steps that have been taken and their effectiveness;

h) be revised periodically, e.g. if there are changes in the work equipment or if workers report signs or symptoms that can be attributed to vibration injury.

Figure 2 shows sample ranges of vibration magnitudes of some of the most common tools and machines that create the risks. Annex A lists more examples of tools for which the management of vibration exposure is needed.

The values listed in Figure 2 are values from real-world/field measurements at working places with tool applications/conditions at companies according to EN ISO 5349-2 (the values of Figure 2 are not manufacturer data or manufacturer-declared values).

Annex I provides additional information about tool characteristics and work tasks for the tools, listed in Figure 2.



Key

X a_{hv} in m/s²

1 concrete breaker E and P (39)

2 impact drill E (10) - percussive mode

3 core drill E (28)

4 trench rammer C (12)

5 plate compactor C (31)

6 cut-off saw C (19)

7 angle grinder E (12)

8 perforator SDS plus E (32)

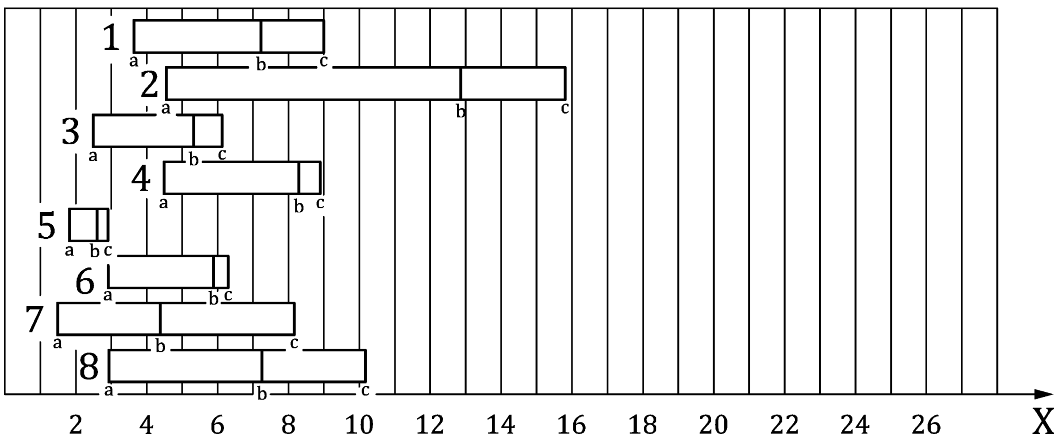
9 perforator SDS max E (40)

a 10th percentile

b 75th percentile

c 90th percentile

a) Machinery used in construction



Key

X a_{hv} in m/s²

1 mower C (18)

2 brush cutter with disc C (12)

3 brush cutter with strimmer C (21)

4 chain saw C (17)

5 pole pruner B (11)

6 pole pruner P (22)

7 leaf blower C (12)

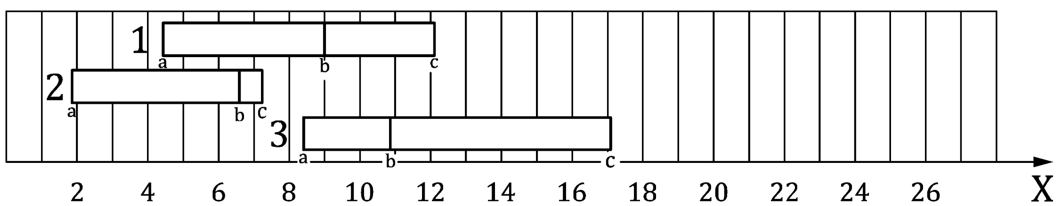
8 hedge cutter C (23)

a 10th percentile

b 75th percentile

c 90th percentile

b) Machinery used in landscaping and gardening



Key

X a_{hv} in m/s²

1 nail gun P (48)

2 tacker P (10)

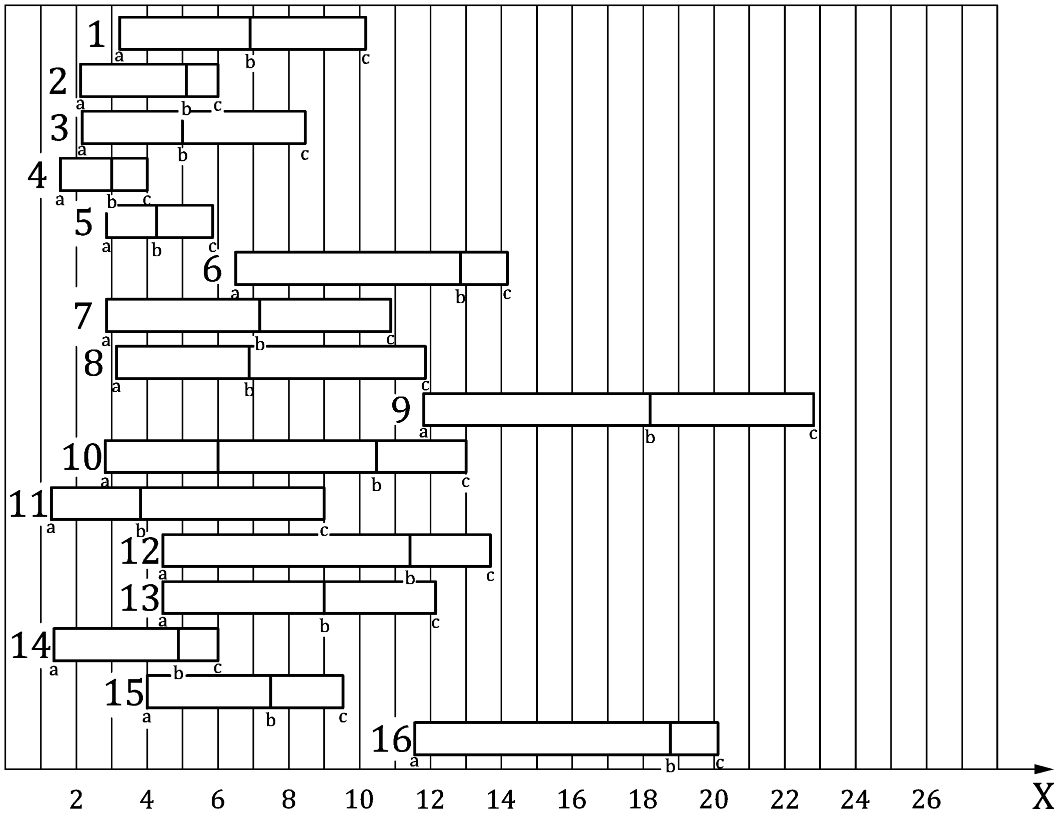
3 jig saw E (9)

a 10th percentile

b 75th percentile

c 90th percentile

c) Machinery used in wood working



Key

X a_{hv} in m/s²

1 angle grinder E and P (106)

2 vertical grinder P (12)

3 straight grinder E and P (28)

4 screwdriver E and P (12)

5 impact wrench B (13)

6 impact wrench P (12)

7 impact wrench P (21)

8 ergo pulse/ratchet wrench E and P (11)

9 needle scalers P no susp. (12)

10 needle scalers P susp. (12)

11 angle sander E and P (12)

12 orbital sander P (73)

13 vibrating sander E and P (20)

14 drill E and P (16)

15 impact drill E (10) - rotatory mode only

16 reciprocating saw E and P (13)

a 10th percentile

b 75th percentile

c 90th percentile

d) Machinery used in metal working

NOTE For each tool family, the energy mode (B: Battery; C: Combustion; E: Electric; P: Pneumatic) and the number of measurements are given.

Figure 2 — Examples of vibration magnitudes for common tools, given as total acceleration values a_{hv} measured along the 3 axes under real conditions (2005 to 2014)

It is important to keep workers and their representatives involved and informed in the assessment of vibration risk. An effective partnership with workers helps to ensure that the information used for the risk assessment is based on realistic assessments of the work being carried out and the time taken to do that work.

The factors that govern a person's daily vibration exposure are:

— the frequency-weighted magnitude (level) of vibration and

— the length of time (duration) the person is exposed to it.

The greater the magnitude or the longer the duration of exposure, the greater is the person's vibration exposure.

It is essential that the various sources of vibration with risks for health and safety and their characteristics are known, exposed employees are identified and a reliable estimate is made of their exposures. In order to do this, it is necessary to know

— the machinery, processes, tools and tasks in use within the company, which are likely to expose employees to vibration;

— who is likely to be exposed sufficiently to vibration to be at risk.

An initial identification of sources of exposure to hand-arm vibration can be made by listing all the vibrating processes, machines and tools used at work which require employees to hold or guide a vibrating handle, control, work-piece or other vibrating surface. A list of the more common machines and processes which expose people at work to hand-arm vibration is given in Annex A.

Furthermore, it is necessary to know

1) the number and location of employees for each of the tasks which expose them to hand-arm vibration;

2) representative vibration values and the likely range in values for each machine, tool, etc. which create the hazard and the vibration exposure of persons at risk;

3) uses of the machines (if any) that are likely to cause increased vibration risk;

4) daily duration and pattern (e.g. tasks and tools) of vibration exposure.

If there is a range of well-maintained modern tools, exposure above the exposure action value is likely for 15 min use of hammer action tools or 1 h of other action tools. It is often possible to select equipment carefully for lower vibration so that it can be used for longer than these periods.

NOTE 1 The exposure action value standardized to an 8 h reference period is 2,5 m/s^2 as defined in Directive 2002/44/EC (Vibrations at work). Some people regularly exposed to this level of vibration will develop symptoms after some years of exposure.

Most older/traditional designs of tool will reach the exposure action value after much shorter durations. Also designs of tool without vibration minimization (state of the art of minimization measures as required by the EU Machinery Directive 2006/42/EC) will reach the exposure action value after much shorter durations.

The daily vibration exposure A(8) represents the contribution of all machines, processes or tools to the daily vibration exposure of the persons who operate or use it. The daily vibration exposure A(8) for a worker carrying out one process or operating one tool can be calculated from a magnitude and exposure time:

$$A(8)=a_{hv}\sqrt{\frac{T}{T_0}} \quad (1)$$

where

a_{hv} is the vibration total value (in m/s^2);

T is the daily duration of exposure to the vibration magnitude a_{hv};

T_0 is the reference duration of 8 h.

Like the vibration magnitude, the daily vibration exposure has units of metres per second squared (m/s2).

Important is the contribution made by each source of vibration to the daily vibration exposure A(8) of a person. If a person is exposed to more than one source of vibration, then partial vibration exposures are calculated from the magnitude and duration for each source. The overall daily vibration exposure can be calculated from the partial vibration exposure values:

$$A(8)=\sqrt{A_1^2(8)+A_2^2(8)+A_3^2(8)+\dots} \quad (2)$$

where

A_1(8), A_2(8), A_1(8), etc. are the partial vibration exposure values for the different vibration sources.

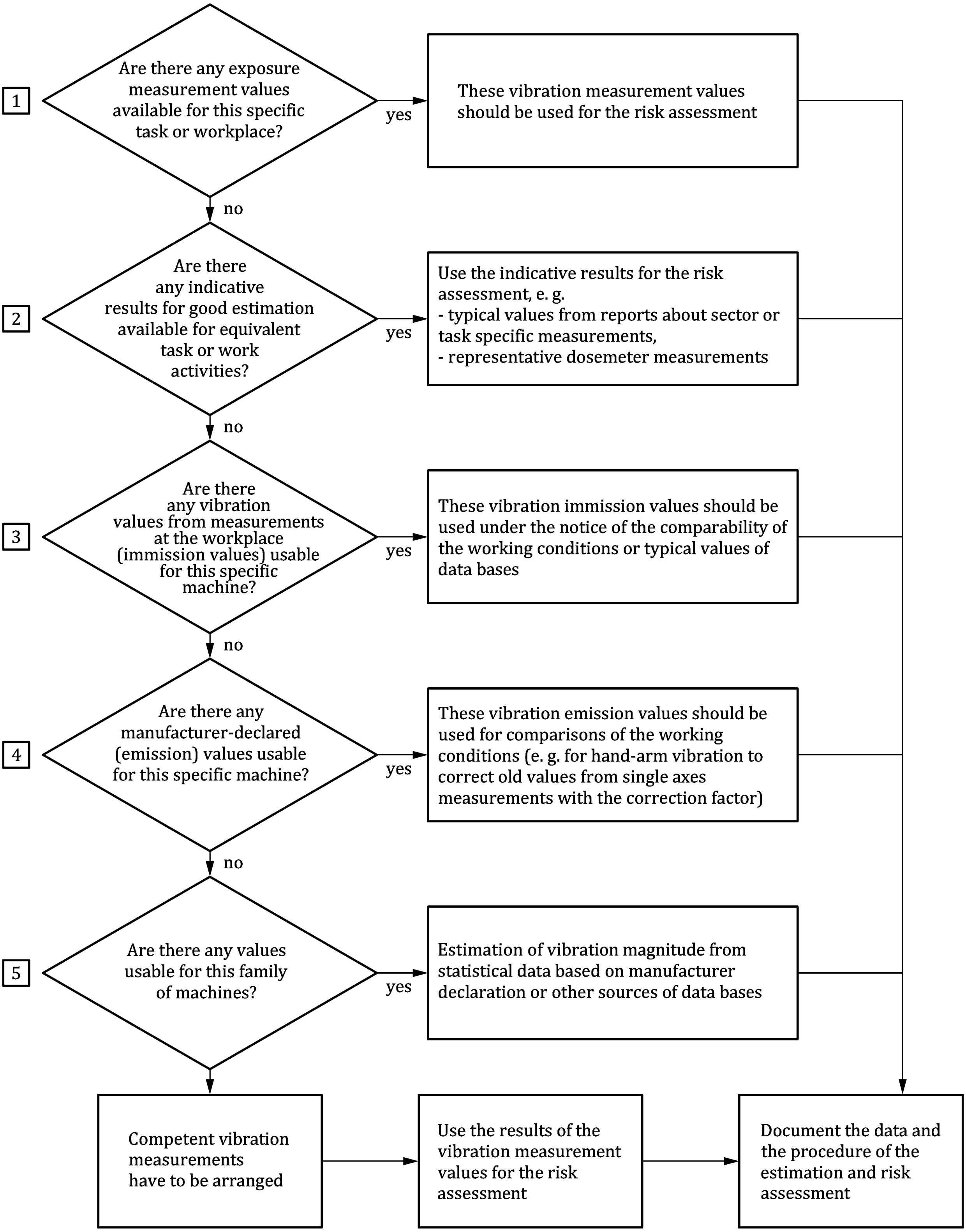
Occasional exposure to vibration is likely to present a different risk than exposure everyday.

Various methods of calculating vibration exposure have already been developed in many Member States, e.g. HSE Guidance (GB), INRS Guidance (FR) or DGUV-IFA/BAuA Guidance (DE), other national guidances and most of these are summarized in the EU Guide [14] (Annex D “Tools for calculating daily exposures”) and in CEN/TR 15350:2013, 3.5 and 7.3.

The values derived in this way show which tools and processes impose the greatest total vibration burden on the workforce and this could be taken into account when deciding priorities for action.

NOTE 2 In many cases it is practicable to make an adequate estimate of vibration exposures using existing data and without making vibration measurements. For example, vibration data provided by machinery suppliers and published in the technical sales literature (according to EU Machinery Directive 2006/42/EC) can be used in many cases. It is recognized that the measurement and assessment of vibration can be complex and can require costly equipment and it is generally necessary to use the service of a competent vibration consultant.

A possible hierarchy (good practice) for the use of different information sources including aspects of uncertainty is shown in Figure 3. Further information on aspects of uncertainty is explained in Annex H.



NOTE In case of different national approaches and data, Figure 3 needs to be modified.

Figure 3 — Good practice to use different information sources including aspects of uncertainty

5 Vibration reduction by task, product and process re-design

5.1 General

Information should be gathered concerning the usage of the various machines, processes and tools, which have been identified as sources of hand-arm vibration hazard, i.e. what they are used for, how they are used and why they are used.

In considering a particular production function or task, the first step is to define its purpose or function in broad terms, i.e. what is to be achieved or done. At this stage the question as to whether or not the function provided by the process is required at all should be reviewed and to do this it is necessary to consider all the factors which created the need for the function or task. Some of these factors might be specified by others, e.g. customer's requirements, an architect's design or a consultant's recommendation. The need to follow specifications should be discussed with the customer, etc. if it reduces exposure to vibration — eliminating the process can reduce the cost of manufacture.

The second step is to break the process down into its key elements, processes or stages highlighting those which are the principal contributors to the vibration hazard. There can, of course, be other hazards such as physical strain, dust or noise, which can also need to be dealt with.

This should then be used for a systematic analysis to determine the most cost-effective combination of protective and preventative measures.

The basic methods for reducing occupational exposure to hand-arm vibration are, in order of priority:

a) elimination of hazard by the substitution of alternative non-hazardous processes, machinery or plant, e.g. automated or mechanized processes;

b) reduction of vibration at source by machinery or process substitution e.g. the use of low-vibration equipment, where a) is not reasonably practicable;

Modification of a hand-held tool is not recommended, but its manufacturer may supply consumables or component options that will reduce vibration.

c) reduction of vibration transmission

   1) in the path between the source of vibration and the handles or other vibrating surfaces gripped by employees' hands, e.g. vibrating isolation of handle-bars on pedestrian-controlled equipment,

   2) from handles and other vibrating surfaces onto the hands gripping them, e.g. reducing the required grip or feed force;

d) reduction of exposure duration, e.g. work rotation to reduce the time for which employees are actually in contact with tool handles, machine controls or other vibrating surfaces.

In addition to reduction of vibration exposures it is necessary to have management measures to reduce and manage the remaining risk, e.g. training, maintenance, keeping warm and dry, awareness of circulatory disorders and other factors for vibration injury risk and health surveillance.

These recommendations in line with the EU Directive "Vibration" (2002/44/EC) are developed as a checklist for employers in Annex B.

NOTE The EU Framework Directive and the Physical Agents Directive 2002/44/EC (Vibrations at work) provide a control strategy (including how to prioritize the control activities) which is re-stated in Chapter 3.1 of the "Non-binding guide to good practice for implementing Directive 2002/44/EC (Vibrations at work), Part I "Guide to good practice on hand-arm vibration" (European Communities, 2008).

5.2 Vibration reduction by work task re-design

The risks to the health of persons who are exposed to hand-arm vibration can be reduced by adapting work tasks to the individual.

Work tasks should be designed so that:

a) the values of hand-arm vibration are as low as practicable;

b) the daily period of exposure to hand-transmitted vibration is as short as possible;

c) the working posture is one which imposes the least physical burden on the individual;

d) physical loads, particularly (but not only) those on the hand-arm system, are matched to the capabilities of the individual;

e) grip and feed forces required to control the process are as low as possible;

f) unduly rapid and frequent repetition of finger, hand and/or arm movements are avoided.

In designing the work task, it shall be noted that the greater the forces applied by the hand upon vibrating surface, the greater the vibration passing into the user's hand and arm.

Detailed guidance on machinery design is given in CR 1030-1.

5.3 Vibration reduction measures by product re-design

All involved in the process — customers, designers, production engineers and managers — should take into account certain "essential safety requirements" relating to the potential impact of the product on the health and safety of those who are involved.

In respect of hand-arm transmitted vibration, product designers should evaluate the effect of alternative designs on the manufacturing process in general and the ergonomic requirements of work tasks.

Where appropriate, the advice of production engineers, production managers, and, if necessary, vibration and other specialists should be sought. In particular the aim should be

a) to avoid, or at least minimize, the use of operations and tools which expose workers to hazardous values of vibration, e.g. by engineering (see CR 1030-1) or by auxiliary equipment (see 6.2.3);

b) to facilitate the use of low-vibration tools or processes;

c) to facilitate the optimum ergonomic design of work spaces and tasks.

Practical examples are given in Annex C.

5.4 Vibration reduction by process re-design

Where employees are exposed to hand-arm vibration a thorough periodic review of the production process or task should be carried out and, where reasonably practicable, alternative production methods that eliminate vibration or involve lower-vibration processes substituted for those which create the hazard.

Often ways of improving the process can be found which not only reduce hazardous vibration (and possibly other hazards) but also improve productivity and quality. Practical examples of vibration reduction measures by process design are given in Annex D.

Some of the more obvious possibilities for vibration reduction by use of an alternative process are as follows:

a) Substitution of milling, turning or other machining operations for metal removing processes for powered hand tools, such as portable grinders and pneumatic chisels;

b) use of arc-air and other flame cutting or gouging methods instead of pneumatic chisels or portable grinders for the rough dressings of castings and similar work;

c) use of smooth hydraulic rather than pneumatic, impulsive or riveting techniques;

d) use of laser profiling or water jetting equipment for accurate cutting of components from plate or sheet metal with minimum distortion from heat and little or no need for dressing.

Sometimes the alternative process might not be a complete substitute for processes which expose workers to vibration but nevertheless could reduce substantially the total vibration exposure.

Abrasive, mechanical cleaning or mixed mechanical and chemical cleaning processes such as shot blasting and rumbling can be substituted for grinding and descaling operations. Where the process involves the removal of rust or paint, abrasive or mechanical cleaning is generally more effective and economic than grinding.

Where elimination or substitution is not reasonably practicable, it can nevertheless be possible to re-design the process so as to eliminate many hazardous, manual operations by the greater use of mechanization and remote control or automation.

Care should be taken to ensure that the removal of one hazard does not introduce one that is worse.

6 How to select low-vibration machinery, anti-vibration systems and auxiliary equipment

6.1 Selection of low-vibration machinery

6.1.1 General

It should be ensured that equipment selected or allocated for tasks is suitable and can do the work efficiently. Equipment which is unsuitable or of insufficient capacity is likely to take much longer time to complete the task and expose workers to vibration for longer time than is necessary, resulting in a higher daily vibration exposure dose.

Careful selection of consumables (e.g. abrasives for grinders and sanders) or tool accessories (such as drill bits, chisels and saw blades) can affect vibration exposure. Some manufacturers supply accessories designed to reduce vibration exposure.

To keep up-to-date on the tools, consumables and accessories available it should be regularly checked with

1) equipment supplier,

2) trade association,

3) other industry contacts,

4) trade journals.

When the use of powered hand-held or hand-guided equipment is required and cannot be substituted by other techniques or processes with less risk to safety and health, vibration exposure should be minimized by avoiding machinery or tools with unnecessarily high vibration.

Most types of hand-held or hand-guided machines on the market include examples of low-vibration designs. For some types of machines this is done in a systematic way:

a) breakers,

b) chipping hammers,

c) sanders,

d) lawn mowers,

e) hedge cutters,

f) wrenches,

g) chain saws,

h) needle scalers.

In practice some difficulties continue in choosing a low-vibration machine, such as:

i) status of implementation of latest versions of test codes in the market,

ii) transparency of vibration control measures in sales literature or instruction manuals,

iii) lack of experience and training at procurement departments of users.

Annex E provides examples and further information.

6.1.2 Questions that potential buyers should ask

Before purchasing new machinery or equipment, potential buyers should always ask themselves the following basic question concerning the supplier: Is adequate information (vibration declaration) available about the vibration of that machine family and about the lowest vibration achievable?

NOTE General requirements concerning information for safe use are as important as vibration emission declaration.

According to the EU Machinery Directive 2006/42/EC manufacturers and suppliers of equipment for use at work have a duty to provide adequate information about the equipment they supply and in particular about any conditions necessary to ensure safe use without risk to health.

A simple strategy is

a) to choose a shortlist of machines that can do the job,

b) to consider the vibration information available for the shortlisted machines,

c) to remove from the shortlist any machines with unusually high vibration.

Annex F provides a list of the most important questions with regard to hand-arm vibration that potential buyers should ask suppliers.

6.1.3 Declared vibration values

Declared values can be used, e.g. for

a) comparing vibration emission of competing products,

b) estimating vibration exposures for actual use of products at work (that is, combining the vibration emission with the patterns and durations of operation of the products per working day).

For specific working conditions, a risk assessment based on declared values might not lead to an appropriate result. CEN/TR 15350 addresses some of the problems with using declared values for risk assessment. Even so, estimated exposures should be used with extreme caution.

Values of machine vibration are given by the manufacturer in the vibration declaration. The method and procedure to verify these values are defined in EN 12096.

Instructions shall give the following information concerning vibration transmitted by portable hand-held and hand-guided machinery:

— The vibration total value to which the hand-arm system is subjected, if it exceeds 2,5 m/s^2. Where this value does not exceed 2,5 m/s^2, this shall be mentioned;

— The uncertainty of measurement.

Following EU Machinery Directive (2006/42/EC), Annex I, 1.7.4.3, the information on vibration emission given in the instructions shall be available as well in any commercial documents/sales literature including internet catalogues giving the performance characteristics of the machinery.

NOTE The requirements are listed in EU Machinery Directive (2006/42/EC), Annex I, 1.1.2, 1.5.9, 1.7.2, 1.7.4, 1.7.4.1, 1.7.4.2 (h, k, l, m, r, s), 1.7.4.3, 2.2.1.2: “Sales literature describing the machinery must not contradict the instructions as regards health and safety aspects. Sales literature describing the performance characteristics of machinery must contain the same information on emissions as is contained in the instructions.”

Further information on the relevance of EU Machinery Directive (2006/42/EC) for vibration emission data are available in the “Guide to application of the Machinery Directive 2006/42/EC”.

It is important to distinguish the exposure of persons to vibration from the emission of vibration by machinery. It should be noted that the exposure of workers to vibration is subject to the national provisions implementing Directive 2002/44/EC. That Directive sets daily exposure limit values and action values for hand-arm (and whole-body) vibration.

The daily exposure of persons to vibration cannot be deduced directly from the measurement of vibration emission from machinery because exposure also depends on the duration and conditions of use of the machinery concerned. However, the lower the level of emission of vibration from the machinery, the easier it is for users to comply with the exposure or action limits set by Directive 2002/44/EC. Users thus have an interest in selecting machinery with a low vibration emission for the intended work.

6.2 Selection of anti-vibration systems and auxiliary equipment

6.2.1 Minimizing or avoiding vibration from hand-fed machines

Direct connection between workers’ hands and vibrating surfaces can often be avoided by making use of jig handles and similar aids which incorporate anti-vibration mounts or other means of preventing vibration from reaching the users’ hands.

However, providing effective vibration isolation between the vibrating surfaces of machines or components and the hands of persons at risk can be difficult especially for tools which vibrate at low frequency.

Especially for tools which vibrate at low frequency, such suspension needs more space and requires more efforts for the handling of the workpiece.

6.2.2 Anti-vibration handles

Many tools are nowadays already equipped with anti-vibration handles or suspended casing.

'Anti-vibration' handles can reduce the vibration, but incorrect selection of this type of handle can actually increase the vibration at the hand or reduce the operators ability to control the machine.

So, if manufacturer offer anti-vibration handles, users should ask about the vibration reduction achieved, especially for optional side-handles. It is preferable, to select anti-vibration handles, endorsed by the tool manufacturer, because an incorrect selection of this type of anti-vibration handles can cause increasing vibration and other risks. Therefore suspension handles for pedestrian and hand-guided tools provide generally a very effective vibration reduction.

6.2.3 Auxiliary equipment for the reduction of vibration exposure

There is auxiliary equipment available for the reduction of exposure to vibration, e.g. tensioners, autobalancers, sleeved chisels, etc.

Experiences from measurements and practical application are reported by an HSL project on auxiliary equipment [17].

6.2.4 Use of resilient materials

Wrapping rubber or other resilient materials around vibrating handles can improve comfort but it is unlikely to reduce significantly the vibration at frequencies that contribute most. Unless carefully selected, resilient materials can amplify vibration at some frequencies and actually increase vibration exposure.

An exception of this is the case of chisel sleeves fitted to small stone hammers. It has been measured significant vibration reduction at the chisel hand location when compared with a plain chisel. This necessitates to use a thick resilient material and operators to change their work technique in some circumstance as they can no more alter their grip on the chisel to control the action of the chisel (e.g. a loose grip on the chisel allows it to vibrate, reducing the power into the work piece), see Table B.1, question 12.

6.2.5 Reduction of forces exerted by operators

Reducing the gripping or pushing force exerted through the hand reduces the vibration passing into the user's hand and arm. These forces can be required to support the tool or workpiece, to control or guide the machine, or to achieve high work rates. However, the actual forces applied can be greater than is necessary for efficient work because of incorrect equipment selection, inadequate maintenance, insufficient training or poor workstation design.

These forces can be required in order to

i) support the weight of a tool or workpiece;

ii) control and guide a machine, tool or workpiece;

iii) achieve and maintain high metal removal rates.

The actual forces applied can differ from the minimum values required due to:

1) the incorrect selection of equipment for particular tasks,

2) inadequate maintenance,

3) inadequate operator training,

4) poor workstation design.

Some methods of reducing grip and push forces, and therefore reducing vibration transmission to the hands, are:

a) where heavy workpieces are ground by hand at pedestal grinders, support for the whole workpiece means that the worker needs only to guide it onto the wheel rather than support all the weight. Floor mounted stands (not mounted to the wheel frame) can reduce vibration;

b) tension chains (sometimes called balancers) and manipulators can be used to support vibrating tools such as heavy drills, grinders, nut runners, nailing guns (in some cases) and pneumatic chisels, thus relieving the operator from supporting the tool's weight;

c) changes in the texture and material of a grip surface can allow the operator to use a smaller grip force to hold and control the tool;

d) use of techniques such as bench-felling in forestry where the chainsaw slides along the log during debranching rather than holding the full weight of the saw at all times.

NOTE For further information on forces, see CEN/TR 16391.

6.2.6 Personal protection

Personal protective equipment is a last resort for protection against hazards at work, and should only be considered as a long-term means of control after all other options have been explored.

6.2.6.1 Protection from vibration

Gloves marketed as 'anti-vibration' should carry the CE mark, indicating they have been tested and found to meet the requirements of EN ISO 10819. However, this standard does not provide detailed performance data for gloves; therefore the protection offered by 'anti-vibration' gloves as required by the EU Directive on Personal Protective Equipment at Work (89/686/EEC) shall be separately assessed.

'Anti-vibration' gloves do not provide significant risk reduction at frequencies below 150 Hz (equal to 9 000 r/min). This means that for most powered hand tools, the reduction in frequency-weighted vibration magnitude provided by anti-vibration gloves is negligible. Anti-vibration gloves may provide some vibration risk reduction for tools that operate at high rotational speeds (or produce vibration at high frequencies) and are held with a light grip. However, this risk reduction cannot easily be quantified and so gloves should not normally be relied upon to provide protection from hand-arm-vibration.

6.2.6.2 Protection from cold

Low body temperature increases the risk of finger blanching (White Finger Syndrom) because of the reduced blood circulation. Employees should therefore avoid outdoor working in cold weather if they can. If employees have to work outside, then some machines, such as chain saws, are available with heated handles to help keep the hands warm.

Heated handles should be considered for hand-held or hand-guided machines (e.g. chain saws) whose principal use is outdoors or in other low-temperature environments.

The temperature in an indoor workplace should provide reasonable comfort without the need for special clothing and should normally be at least 16 °C. Machines that might make the hands cold, e.g. steel bodied machines or pneumatic tools that blow exhaust air over the operator's hands, should be avoided.

Employers should provide warm clothing and gloves if there is an increased hand-arm vibration risk due to the cold. Gloves and other clothing should be assessed for good fit and for effectiveness in keeping the hands and body warm and dry in the working environment.

7 Management measures for the control of hand-arm vibration exposure

7.1 Vibration reduction strategy

7.1.1 General

The objective of the vibration reduction strategy is to reduce employees' risk from exposure to vibration to the state-of-the-art of minimization measures.

If the state-of-the-art does not achieve exposure below the exposure action value, a specific programme of minimization measures is required.

In any case, the A(8) daily vibration exposure values shall not exceed the exposure limit values, as required by the EU Directive "Vibration" (2002/44/EC) and its national implementations.

NOTE EU Directive 2002/44/EC, Article 5, No. 3 reads: "In any event, workers shall not be exposed above the exposure limit value. If, despite the measures taken by the employer to comply with this Directive, the exposure limit value is exceeded, the employer shall take immediate action to reduce exposure below the exposure limit value. He shall identify the reasons why the exposure limit value has been exceeded, and shall amend the protection and prevention measures accordingly in order to prevent it being exceeded again."

If the A(8) daily vibration exposure values lie above the action values and below the exposure limit values in the long term, even though all protective measures have been taken, the state-of-the-art shall be reviewed regularly for possible hazard reductions. Such checks are recommended at maximum intervals of two to three years.

The employer can also need to adapt the programme of measures for workers who are at particular risk of injury, e.g. those workers who are more susceptible to vibration injury or already have symptoms of injury. The exposure of these people shall be below the exposure action value.

The measures possible to minimize vibration risk should be ranked (see 7.1.2) taking account of both the need for control and the availability of protective measures. Table B.1 provides guidance.

The programme of technical and/or organizational measures shall be elaborated. It should contain milestones and deadlines in a schedule for the implementation of each selected measure.

The programme of technical and/or organizational measures should name the parties responsible and state the criteria and dates to assist monitoring of the results. It therefore covers all actions to be taken for the avoidance or reduction of vibration hazards at work.

The success of the measures shall be assessed by reliable estimation of the reduction of the vibration exposures, e.g. using manufacturer's data (see CEN/TR 15350) or by measurements performed by skilled personnel.

In order to maximize the success of the programme of technical and/or organizational measures, the employer should involve the workers closely in its implementation.

If the evaluation of the targets' effectiveness reveals that they have not been met, further protective measures shall be included in the programme of technical and/or organizational measures. The identification of the main vibration sources and, if necessary, the risk assessment shall be adjusted in this case.

7.1.2 Vibration source analysis

Analysis of the sources of vibration exposure (e.g. hand-held or hand-guided equipment or hand-fed workpieces) identifies the discrete periods of use of equipment presenting different levels of vibration risks.

Once a list of sources of vibration has been produced, it can be used to identify the nature, scale and duration of the risk for each source of vibration and ranked according to its contribution to the overall vibration exposure.

Once the sources of vibration exposure have been ranked, the next step is to review control measures already in place and to identify possible further protective measures. Table B.1 lists the questions relating to the sources of vibration exposure, and examples of corresponding protective measures. The minimization measures should be checked with regard to:

a) the prospects for reducing the vibration exposure,

b) the prospects for reducing the coupling forces (grip and feed forces),

c) how quickly the minimization measures can be implemented,

d) the kind of minimization measures (technical, organizational),

e) how many people benefit from the minimization measures.

Table B.1 offers an example form for a list of possible protective measures. The answers to the questions will differ according to the working conditions. The list forms the basis for the subsequent steps.

7.1.3 Overview of the most important steps in the management process

The most important steps in the management process are:

a) identifying all the sources of significant vibration;

b) ranking them in terms of their contribution to the risks (exposure, posture, grip, etc.);

c) identifying and evaluating potential risk avoidance or risk reduction measures in terms of practicability and cost;

d) establishing realistic targets, in line with state-of-the-art technology;

e) aiming at achieving exposure below the daily exposure action value;

f) ensuring that the vibration exposure does not exceed the daily exposure limit value for hand-arm vibration (in accordance with EU Directive 2002/44/EC);

g) allocating priorities and establishing a timetabled ‘action programme’;

h) defining management responsibilities and allocating adequate resources;

i) implementing the programme;

j) monitoring progress;

k) evaluating the programme.

7.2 Quality control of manufacturing processes

Good control of process quality not only maintains product quality and production efficiency but also reduces vibration hazards. For example, in the ship building and ship repair industries, vibration exposure can be reduced by establishing good quality control systems which avoid mistakes and subsequent rectification work.

Control of product quality during production can greatly reduce the need for later remedial work. For example, ensuring shuttering for a concrete pour is sealed reduces the need to remove excess concrete later. Ensuring that the dimensions of steel plates are specified and cut accurately can eliminate the need to remove a few millimetres (usually by hand grinding) during final assembly. Ensuring workshop and component cleanliness can prevent contamination of, for example, metal castings and reduces the need to cut out blemishes and make good.

Much exposure to vibration arises from the use of powered hand-tools to repair defects in product quality or to rectify errors in production.

7.3 Maintenance of tools and equipment

Maintaining tools and equipment in optimum condition ensures optimum performance and can contribute to the reduction of vibration exposure.

Vibrating tools and other work equipment which expose workers to hand-arm vibration should be maintained as necessary on a regular basis to help keep vibration magnitudes to a minimum.

The instructions provided by manufacturers or suppliers of equipment should identify suitable maintenance schedules including those concerning maintaining vibration at a minimum.

The employer can need to supplement manufacturers' or suppliers' instructions with additional instructions where the employer's experience of the maintenance of tools or equipment used in their particular applications affects the vibration. The employer should decide which tools need maintenance to prevent increased vibration and should work out an appropriate maintenance interval.

Employers should provide workers with equipment to re-sharpen the working part of their tools (inserted tools such as chisels, chains, etc.) when the tool is supplied. Workers should have a stock of replacement consumables, e.g. sanding discs, polishing discs and grinding wheels.

A scheme of preventative maintenance should also be established for components, attachments and other devices provided to reduce worker vibration exposure, e.g. vibration reducing (suspended) handles, vibration reducing mounts and resilient materials, auto-balancing systems.

Annex G provides a list which indicates a few of the measures that should be taken to maintain tools and equipment correctly.

7.4 Training and information for workers

One of the most important ways to eliminate or reduce vibration injuries is to inform and train the workers of the work equipment on the outcome of the risk assessment. The information and training provided should suit the workplace, work task and the work conditions. It is appropriate to give workers who are more exposed to vibration more information and training than workers exposed to less vibration. New recruits should be provided with relevant information, instructions and training specific to the work tasks he, or she, is expected to carry out. The information should be readily understood taking account of native language and reading ability.

This needs to be repeated periodically to take account of:

1) changes in the work tasks being carried out and

2) changes in machinery, plant or processes.

It is important to inform the workers about:

a) the potential injury arising from the work equipment in use,

b) the exposure limit values and the exposure action values,

c) the results of the vibration risk assessment and any vibration measurements,

d) the control measures being used to eliminate or reduce risks from hand-arm vibration,

e) safe working practices to minimize exposure to mechanical vibration,

f) why and how to detect and report signs of injury,

g) why and how to report machines in need of maintenance,

h) how and when to renew or re-sharpen inserted tools or consumables to prevent unnecessary vibration exposures,

i) the circumstances under which workers are entitled to health surveillance,

j) the limitations of personal protective equipment (e.g. anti-vibration gloves) if provided,

k) the risks and ways in which individuals at risk can contribute to their reduction and control.

Training is required to ensure that workers understand how to follow employers instructions to protect themselves against the development of vibration-related diseases. Employees taking part in a health surveillance scheme usually have a regular opportunity for one-to-one discussion of the vibration hazard and how to reduce the risk of injury.

Workers should also be trained in working techniques, e.g. to help avoid excessive gripping, pushing and guiding forces and to ensure the tools are operated safely and with optimum efficiency. The manufacturer can often give advice of any training requirements, and can also offer training. Furthermore, workers need to be trained to recognize when a machine is in need of maintenance.

In some cases it can be difficult to get workers acceptance of new tools and methods especially where incorrect working practices, which have become deeply ingrained throughout years of use, shall be altered. For example, training workers who use pedestal grinders to avoid the common practice of placing their hands between the work rest and the workpiece during grinding and sometimes during dressing.

Differences in the weight of portable tools and changes in the sensations of vibration experiences often cause users of low-vibration tools to reject them because they feel that they are not doing the job as well as the tools they have become accustomed to. With some tools, the operator’s hands need to be in the correct position to avoid increased vibration exposure. Many vibration-reduced tools, such as breakers with suspended handles, produce high vibration emissions if the operator pushes down too hard while operating the tool (road breakers can also produce high vibration emission if the tool is pulled up while operating, e.g. to remove the pick from a hole).

Workers should be advised on the impact of non-work activities on the risks to their health. They should be informed that smoking impairs blood circulation which in combination with vibration implies larger risk for vibration injuries. Workers should also be aware that the use of power tools for do-it-yourself work in the home or activities such as motorbike riding will add to daily vibration exposures and thereby increase the risk of developing hand-arm vibration injury.

7.5 Consultation and participation of workers

The successful management of risks relies on the support and involvement of workers, and in particular their representatives. Representatives can provide an effective channel of communication with the workforce and assist workers in understanding and using health and safety information.

While some hand-arm vibration control solutions are quite straight forward, others require changes to the way in which work is organized, e.g. job rotation due to necessary limitations of exposure duration (see 7.6). Such changes can only be effectively dealt with in consultation with worker representatives.

NOTE There are different procedures and responsibilities for consultation and participation of workers between Member States concerning the implementation of Directive 2002/44/EC, Article 7 "Consultation and participation of workers and/or of their representatives shall take place in accordance with Article 11 of Directive 89/391/EEC on the matters covered by this Directive".

7.6 Reducing the period of exposure

Where immediate vibration reduction by tool selection and maintenance as reasonably practical methods of vibration reduction have been applied, and vibration remains unacceptably high (at or above exposure action value (good practice/minimization principle) and/or limit value (mandatory due to EC Directive), while further methods of vibration reduction are being developed (product re-design and process re-design), it can be necessary to reduce the exposure of workers to hand-arm vibration by job rotation or other techniques of work organization.

Reducing exposure duration is less efficient than reducing vibration emission, for example, as given by Formula (1), vibration exposure can be halved by reducing the usage duration by a factor of 4, but the same reduction of vibration exposure could have been achieved by reducing the vibration emission by a factor of 2 according to EN ISO 5349-1.

Make sure that new work patterns are adequately supervised, to ensure that workers do not drift back to the older work patterns. If workers are paid by results, the systems should be designed to avoid intensive working by individual workers with no break in exposure. It is recommended that employers plan work to include frequent and regular breaks from exposure to vibration during the day.

It is recommended that employers plan work to avoid workers being exposed to vibration for long, continuous periods, see EN ISO 5349-1:2001, Table C.1 and Figure C.1.

Measures of work organization (job rotation) can have the disadvantage that although vibration exposure of some workers might be reduced, that of others could increase if total production is not to be adversely affected. Furthermore, careful planning and supervision of the activities of the workers concerned are needed if effective control of vibration exposure is to be achieved by this means.

EXAMPLE

a) Exposure time can be reduced by selecting appropriate tools for a specific task (see further information in Annex E).

b) Some employers, working with machine manufacturers and suppliers, have developed a green/yellow/red "traffic light" system where each tool is clearly marked with a hand-arm vibration colour coding, dependent on the expected in-use vibration magnitude of each machine.

c) Equipment for exposure-time measurement (e.g. human vibration exposure estimator, machine operation timer, human vibration exposure timer, duration indicators), fitted on tools or the hands, can warn operators when the vibration dose is exceeded. For further information, see [21].

NOTE Direct measurement of exposure time is likely to give shorter exposure time values than otherwise estimated. For this reason, it becomes important to have good quality, conservative estimates of vibration magnitudes to avoid under-estimating vibration risk.

8 Health surveillance

Findings from health surveillance provide information if the controls of exposure to hand-arm vibration are working.

If employees report or complain about short-term vibration effects at their hand-arm system (tingling, numbness, etc.) or new or deteriorating cases of Hand-Arm Vibration Syndrome (HAVS) or vibration-related Carpal Tunnel Syndrome (CTS), controls should be reviewed to find out if the programme of controls is being followed as specified, if more can be done to reduce vibration exposure, or if the work can be done using alternative processes involving less exposure to vibration.

NOTE 1 Carpal Tunnel Syndrome (CTS): Epidemiological research in workers has also shown that use of vibrating tools in combination with repetitive movements, forceful gripping or awkward postures can increase the risk of carpal tunnel syndrome.

The employer shall provide health surveillance for these employees who are likely to be regularly exposed above the exposure action value (A(8) = 2,5 m/s2) or the employee has any disorder linked to the exposure to mechanical vibration.

NOTE 2 There are differences between Member States implementations of Directive 2002/44/EC, Article 8 requirements on the kind of health surveillance: most Member States have established procedures that require employers to provide health surveillance.

There are different national lists of occupational diseases related to hand-arm vibration. The EU list of occupational diseases [15] provides an European framework with recommendations for Member States, including occupational diseases caused by vibration exposure.

Health surveillance can detect HAVS, CTS and other recognized occupational diseases at an early stage so that the employer can stop symptoms getting worse and it can indicate where control measures are not effective.

Upon recruitment, employers might use a medical questionnaire to check for symptoms of vibration injury before exposing newly recruited employees to hand-arm vibration. Any indication of susceptibility to vibration diseases should be assessed by suitable occupational health professionals.

In subsequent years of employment (taking into consideration available national requirements on regular surveillance activities including e.g. qualification of occupational health professionals, doctors obligations on data protection):

a) employers can use a basic questionnaire used by a trained responsible person to check whether any selected employee needs to be referred on to a consultation with an occupational health professional;

b) any employee who reports symptoms associated with vibration diseases needs to be referred for a full assessment by a qualified occupational health professional;

c) annual screening by questionnaire (there can be different national requirements for the interval between screenings) keeps the surveillance relatively simple and can be done by a trained medical assistance personal;

d) only a specialist doctor qualified in occupational health can make a diagnosis;

e) employers should or — depending on national requirements — shall arrange a suitable contract with a competent occupational physician or occupational health service provider including:

    i) to check that they have the right qualifications and training,

ii) to make sure that feedback — in line with national different requirements — is provided including notification of fitness for work with hand-arm vibration for each employee under health surveillance,

iii) to obtain anonymized health surveillance results unless groups of employees are too small to get this type of information (depending on national requirements, e.g. for data protection),

iv) to make sure that employers are informed of new or deteriorating cases of HAVS that are being diagnosed.

Several actions follow from health surveillance (taking into consideration available national requirements on regular surveillance activities including e.g. qualification of occupational health professionals, doctors obligations on data protection):

1) monitor to ensure that health surveillance is being carried out properly;

2) keep a non-confidential health record for each employee which shows fitness for work with hand-arm vibration;

3) review risk assessment and controls in the light of feedback from health surveillance;

4) take action to eliminate or reduce exposure for groups of employees with similar symptoms;

5) act on advice to reduce exposure of an employee;

6) if further technical/organizational prevention measures are not available to prevent development of vibration diseases, consider as a last possibility to remove an employee from exposure if not fit for work with hand-arm vibration even in case of exposure lower than the action value (see EN ISO 5349-1:2001, C.2).

Where employees have diseases, health surveillance should be used over a period of months and years

I) to keep the employee informed of control and possible progression of the disease and his, or her, own options to contribute to the prevention,

II) to keep the employer informed about whether the controls (technical or organizational changes of the work process design) taken to stop the progression of the disease have been sufficient,

III) to check that the whole package of assessment, control and health surveillance has prevented the likelihood of occupational disability before retirement.

Annex A
(informative)

Most common machines and processes which expose people to hand-arm vibration: Groups and list of hand-guided machinery

A.1 Tools by industry

A.1.1 Equipment primarily used in construction, stone working, quarrying, mines:

Percussive hammers, combi hammer drills, rock drills, impact drills vibratory compactors, vibratory rammers for soil compaction, vibratory rollers and plates, concrete breakers and rock drills used in mining, quarrying, demolition and road construction, etc.

Rotatory tools such as joint cutters, power cutters, concrete vibro-thickeners, concrete levelling vibro-tables, etc.

A.1.2 Equipment primarily used in metal working:

Powered percussive metal working tools, including chipping hammers, powered hammers for riveting, caulking, hammering, clinching and flanging; hammer swaging, vibratory rammers (pounding machines), needle guns (needle scalers), impact screwdrivers and wrenches, nut runners, etc.

Pedestal grinders, hand-held (angle, vertical straight, die) grinders, flex-driver grinders and polishers, rotary burring tools, orbital sanders, plate shears, drills, etc.

A.1.3 Equipment primarily used in wood working:

Percussive tools such as nailers and tackers, orbital sanders, chain saws, brush cutters (clearing saws), hand-held or hand-fed circular saws, barking machines, alternative tools such as jig saws, etc.

A.1.4 Equipment primarily used in landscaping and gardening:

Agricultural and gardening machines such as mowers, cultivators, power sickle bar mowers, lawn trimmers, clearing saws, brush cutters, chain saws, pruning, leaf and snow blowers, hedge cutters, etc.

A.2 Tools by function

Employees using the tools listed in Table A.1 are exposed to the hazard and thus, potentially, at risk. However, the magnitude of the risks depends on the vibration exposure of the persons concerned, i.e. the intensity of the vibration and the duration for which their hands are exposed to it. Exposure to hand-arm vibration can be expected to vary from person to person depending on the tasks performed and the tools used.

The list is not comprehensive. Regard any tool or machine which caused tingling or numbness in the user's fingers after about 5 min to 10 min operation as suspect and indicator for risk assessment and corresponding protective measures.

Table A.1 — List of tools by function

01 DRILLS 01 Hand drill, pistol drill 02 Straight drill 03 Angle drill 04 Hammer or impact drill 05 Thread cutting machine, core drill 06 Bench drill 07 Taper (work tapes and threads)	**02 CUTTERS** 01 Scabbler, scarifier 02 Plaster cutter 03 Router, spindle moulder, trimmer 04 Milling machine 05 Edge moulder 06 Chain mortising machine
03 HAMMERS 01 Rock drill, jack hammer 02 Rammer, tamper 03 Pneumatic spade 04 Chipping hammer, chisel hammer, caulking hammer 05 Concrete breaker 06 Pick hammer 07 Combination hammer, rotary hammer 08 Stone hammer 09 Hand hammer 10 Forging hammer (drop forge), blacksmith tong, forge tong	**04 FASTENING – FIXING EQUIPMENT** 01 Nail gun 02 Staple gun, tacker
05 PLANES 01 Electric planer 02 Shaper 03 Surface planer, thicknesser (fixed equipment)	**06 NIBBLING EQUIPMENT** 01 Nibbler, sheet metal nibbler cutter tool 02 Nibbling machine (general)
07 MIXING MACHINES 01 Concrete needle injector, internal vibrator 02 Mixer	**08 RIVETING EQUIPMENT** 01 Riveting hammer 02 Bucking bar 03 Blind riveting machine

09 SURFACE CLEANING EQUIPMENT 01 Needle gun, descaling hammer, engraving pen 02 Pressure washer surface cleaner 03 Shotblasting cabinets	**10 SAWS** 01 Chain saw 02 Circular saw, small circular saw 03 Jig saw 04 Plastic saw 05 Band saw 06 Diamond stone saw, cut off saw 07 Duo twin blade saw, twin cutter saw, wall chasing cutter 08 Cutting off machine (abrasive), cross cut / mitre saw 09 Joint cutter concrete / asphalt saw 10 Reciprocating saw 11 Windscreen removal knife, oscillating saw 12 Electric knife
11 POLISHING and GRINDING MACHINES 01 Angle rotary polisher or sander 02 Vertical grinder 03 Angle grinder 04 Bench grinder, pedestal grinder, rebate and edge sander 05 Random orbital sander, orbital sander, palm sander, 06 Straight grinder 07 Radial / vertical rotary sander 08 Dual purpose polisher / sander (angle or orbital) 09 Vibrating sander 10 Polishing / filling machine with reciprocating action 11 Straight sander 12 Die angle 13 Hand band sander, belt sander, linisher 14 Flex-drive hand grinder 15 Swing grinder, pendulum grinder 16 Rail grinder	**12 CUTTING EQUIPMENT** 01 Stump grinder 02 Motorized scythe 03 Pedestrian controlled lawn mower 04 Pedestrian controlled rotary cultivator, rotary hoe 05 Powered edger with rigid cutting 06 Lawn or brush cutter with disc or strimmer 07 Pole mounted pruner, long reach hedge trimmer 08 Hedge cutter (shear), hedge trimmer 09 Pole pruner 10 Bolt cutter, stud cutter 11 Sheet metal shear, reciprocating or edging shear, rotary cutter 12 Cutting-off and crimping power tool

13 SCREWDRIVERS 01 Screwdriver with shut off clutch 02 Screwdriver with slip clutch 03 Impact wrench, impulse nut runner, angle nutrunner 04 Pulse ratchet wrench 05 Power wrench with reaction bar	**14 COMPACTORS** 01 Vibrating plate, compactor, concrete compactor, vibrator, backfill tamper 02 Vibratory tamper, trench rammer 03 Vibratory roller 04 Vibrating beam
15 OTHER PRODUCTS 01 Leaf blower 02 Spray gun 03 Steering wheel	

Annex B (informative)

An example checklist of protective measures against vibration

When the main hazards (the risk spots) are known, in a next step, protective measures are listed regardless whether they have been already taken or not. The questions in Table B.1 are some examples of vibration hazards (loads), together with examples of appropriate protective measures. The measures could be reviewed with regard to the following questions:

a) which mitigation success do they promise (if possible, their effect on the *A*(8) value),

b) how fast can they be implemented,

c) how much work is associated with them,

d) what type of measures (technical, organizational, personal),

e) for how many workers do they improve the hazard situation.

The measures are classified following the ranking of protective measures by the European Directive 2002/44/EC ("t" technical, "o" organizational, "p" personal protective measures).

Table B.1 — General guidance for employers on the selection of protective measures

Question	**Explanation**	**Examples of measures** (t = technical, o = organizational, *P* = personal)	**For further information, see Subclause**
1. Can substitute processes be found for work processes involving vibration exposure?	Alternative procedures and methods (substitutes) enable the vibration impact to be eliminated, or at least reduced.	a) Production of burr-free castings, obviating or reducing the need for deburring by grinders or chipping hammers (t) b) Bonded or welded rather than riveted joints (t)	5.4
2. Can vibrating work equipment be replaced by low-vibration machinery or equipment?	The use of machinery or equipment with a modified operating principle or better damping systems can enable the vibration emissions to be substantially reduced (substitution), even if the underlying procedure is essentially the same.	a) Rotary hammers with pneumatic percussion mechanisms generate lower vibration than percussive drilling machines (t) b) Paving breakers with handles with flexible mountings (t)	6.1

Question	**Explanation**	**Examples of measures** (t = technical, o = organizational, *P* = personal)	**For further information, see Subclause**
3. Can low-vibration substitutes be found for tool inserts or consumables?	Careful selection of consumables and tool accessories can have an influence on the vibration exposure. Some manufacturers supply accessories which are designed to reduce vibration.	a) Vibration caused e.g. by drill bits, chisels, saw blades or grinding discs can be reduced by means of special geometry, material properties or precision during manufacture (t) b) The manufacturer's approval needs to be obtained when third-party accessories are used (t)	6.1
4. Can additional equipment be fitted to reduce the vibration exposure of the operator?	Putting the tool in a jig or fitting vibration reducing (suspended) handles or similar equipment can obviate the need for vibrating surfaces to be held, or can reduce the transmission of vibration.	— Only handles approved by the tool manufacturer should be used (t): Vibration reducing (suspended) handles are in principle able to reduce vibration. Use of the wrong type of vibration reducing handles, however, can actually increase the vibration transmitted to the hand in practice.	6.2
5. Are correct work equipment and suitable tool inserts used for the task?	Unexpectedly high vibration can arise when a tool is used outside of its design range. For example, use of a machine which is not sufficiently powerful can result in an exposure time being too long.	— Observe the manufacturer's operating instructions and train employees (o)	7.4
6. Are the conditions under which the work equipment is operated consistent with the manufacturer's information?	For example, if pneumatic work equipment is not operated at the correct operating pressure, unexpectedly high exposure can occur.	a) Create means for checks and adjustments, e.g. by fitting adjustable pressure reducers (t) b) Observe the manufacturer's operating instructions and train employees (o)	7.4, E.1, Annex F
7. Tool inserts or consumables: Can the vibration be reduced by regular checking?	Blunt or worn tool inserts often lead to increased vibration and/or force, or to an extension of the exposure duration.	a) Check and sharpen or replace drill bits, saw blades, discs, etc. (t, o) b) Train employees and observe the manufacturer's operating instructions (o)	7.3, 7.4

Question	**Explanation**	**Examples of measures** (t = technical, o = organizational, *P* = personal)	**For further information, see Subclause**
8. Is the work equipment regularly serviced/ maintained?	The operation and condition of the tools and dampers should be inspected regularly. Unexpectedly high vibration exposure levels are thus avoided.	Regular maintenance and servicing, such as: a) Lubrication of all moving parts in accordance with the manufacturer's recommendations (t) b) Replacement of worn parts (t) c) Checking for out-of-balance and adjusting as necessary (t) d) Inspection of the vibration damping mountings before their effectiveness deteriorates (t) e) Exchange defective spring-mounted handles (t) f) Checking of bearings and transmissions, and replacement of defective components (t)	7.3
9. Can the transmission of vibration be reduced by lowering grip and feed forces (coupling forces)?	If the grip and pull/push forces exerted by the hand are reduced, the vibration transmitted to the user's hand-arm system is also reduced.	a) Avoidance of tasks in which the worker needs to carry the machine weight and exert additional pull/push force, such as overhead work (o) b) Balancers and positioners can be used to carry the weight of vibrating tools such as heavy drills, grinding machines, power screwdrivers, nail guns (in some cases) and pneumatic chisels (t) c) Ergonomic design of the gripping zone helps the user to minimize grip forces to hold and guide the tool (t)	6.2.5

Question	Explanation	Examples of measures (t = technical, o = organizational, *P* = personal)	For further information, see Subclause
10. Is it possible to reduce the effects of other agents or working conditions, that might increase the health risk of vibration exposure?	Employee exposed to vibration can be working in environments that increase the risk of harm from vibration such as cold, damp, exhaust fumes, or working in unfavourable postures (musculoskeletal system) or requiring high force exertion.	a) Relocation of the work away from the damp or cold environment (o) b) Wearing of gloves and warm clothes to protect against the cold (p) c) Machines should be designed to prevent the hands becoming cold, e.g. avoid uncoated steel housings or pneumatic tools that discharge air across the operator's hands (t) d) For work in the open air, machines with heated handles are available, e.g. chain saws (t) e) Provide information for the employees (o)	6.2.6, 7.4
11. Can the duration of exposure be reduced?	Long durations of exposure to moderate or high vibration can result in injury. Short duration of exposure to very high vibration can also result in injury. Tasks should be organized so that workers have minimized duration and repetition of exposure to vibration.	a) Mark machines causing particularly high vibration exposure (t, o) b) Limit the duration of use of machines according to the Directive 2003/10/EC (o) c) Enable job rotation between jobs with higher and lower vibration exposure (o) d) Provide information and training for the employees (o)	7.6
12. Can resilient materials on gripping zones be used to reduce the health risk of vibration exposure?	Covering vibrating handles with rubber or other elastic materials can make them more comfortable and reduce the transmission of cold.	a) Only a minor reduction in vibration can, however, be attained, depending on the vibration frequencies (t) b) If care is not taken in the selection of elastic materials, they can actually increase vibration at certain frequencies and thereby increase the vibration exposure (t)	6.2.4

Question	**Explanation**	**Examples of measures** (t = technical, o = organizational, *P* = personal)	**For further information, see Subclause**
13. Can gloves marketed as 'anti-vibration' make a useful contribution to reduce vibration exposure?	Gloves cannot be relied upon for protection against hand-arm vibration. On tools operating at high rotational speeds (above 9 000 r/min, i.e. 150 Hz) and not held too firmly, gloves marketed as 'anti-vibration' can reduce the vibration hazard to a certain degree. Since this risk reduction cannot easily be quantified reliance should not be placed upon gloves for protection against hand-arm vibration.	— Workers can find gloves marketed as 'anti-vibration' make the holding of vibrating tools or workpieces more comfortable even though the glove cannot be shown to significantly reduce vibration (p)	6.2.6
14. Do the workers have breaks from the vibration exposure?	Breaks from the vibration exposure can reduce circulatory disturbances, relieve the stress on the muscle system, etc.	a) Review the work organization (o) b) Inform workers (o) c) Workers pay attention to their working procedures (o, p)	7.4, 7.6

Annex C (informative)

Vibration reduction measures by modifying the design of the product — Practical examples

C.1 General

In case of existing products whose manufacture exposes employees to potentially hazardous values of hand-arm vibration the product should be carefully examined.

The production process or the product itself can be re-designed or the specification reduced so that the need to use powered hand-tools is reduced or alternative methods can be used which expose employees to lower vibration.

In this annex, some examples are given.

C.2 Metal working

It can be reasonably practicable to make use of adhesive or welded joints in a fabricated product as an alternative to riveted joints and so avoid the use of pneumatic riveting hammers.

The careful design of metal castings (including the selection of the most suitable material) and the casting process can reduce the degree of hand finishing (fettling) required, improve product quality and/or permit the mechanization or automation of the process.

C.3 Construction

Architects could choose finishes for building surfaces which avoid the use of scabbling tools to produce a decorative effect.

Similarly concrete polishing to obtain a marble effect can be mechanically done without operator on flat surface but needs hand-held tools and operators for curve surface. Square columns should be preferred to circular ones.

Building designers could maximize the use of off-site prefabrication which enables components of higher quality to be produced by mechanized methods thus reducing on site cutting and patching to fit using powered hand-tools and makes positive allowances for manufacturing uncertainties by providing gaps and specifying mastic or other appropriate fillers.

Annex D
(informative)

Practical examples of vibration reduction measures by changing the process used to manufacture a product

D.1 Design specification

Quality control should begin with the design specification. For example, designing conduit channels into a concrete cast can eliminate the need to chase out conduit channels using powered hand-tools once the concrete is set.

D.2 Improving productivity

Often ways of improving the process can be found which not only reduce hazardous vibration (and possibly other hazards, e.g. noise) but also improve productivity.

For example, in light and heavy engineering, developments in cutting technology have increased the accuracy of the cuts and reduced the need for re-work prior to final assembly thus greatly reducing exposure to vibration from use of powered hand-tools.

Hand-held flame cutting of plate greatly increased the speed of production but required extensive fettling work to remove burrs and to straighten heat distortion. Chipping hammers and powered hand-held grinders were used to remove the burrs with consequent high exposure to vibration.

The introduction of CNC plasma cutters greatly reduced both the burring and heat distortion but remedial work is still usually required. Vibration exposure has been reduced.

Cutting of sheet and plate metal can be done with high precision and low or zero heat distortion using laser profiling. Many components can be used without remedial work. Vibration exposure has been eliminated for some products.

NOTE 1 Laser profiling can be slow, for example when compared with the productivity of a CNC turret press, especially for components that can be used directly from the press. With plate components, there comes a time where the additional time taken for laser profiling is offset by the laser's elimination or reduction of the time taken to re-work components cut by coarser methods (e.g. flame).

High-pressure CNC controlled water jetting can produce complex components without burring or heat distortion thus thoroughly eliminating the need for fettling using powered hand-tools. However, water jetting can introduce the need to manage high noise and aerosols.

In heavy fabrication (e.g. ship building industry), the need to use chipping hammers and portable grinders to prepare the edges of plates should be minimal. Some use of grinders is inevitable, e.g. to trim incorrectly specified dimensions (especially during prototyping) but overall vibration exposure should be low and manageable by job sharing.

Using magnetic or vacuum clamps and hydraulic devices to align plates eliminates or reduces the need for fairing aids (temporary brackets and stiffeners used to hold the plates together during welding) correspondingly removes or reduces the need to prepare the welds (using chipping hammers and portable grinders) during tacking and cleaning up the surface of the finished product when the fairing aids are removed. Not only has the vibration exposure of workers been reduced but productivity has been considerably increased.

NOTE 2 This approach also resulted in reduced noise exposure.

D.3 Examples at roadway maintenance, demolition of concrete structures, pipelines

There was a time when laying surfaces beneath a made-up roadway required cutting of a trench the entire length of the roadway. This was usually done with powered hand-held road breakers. Mobile road cutting machines and/or trenching machines should be used for cable laying, water and main repairs and similar work. Portable road breakers should only be used where other processes are not suitable.

The use of road drills in the demolition of some reinforced concrete structures can be much reduced, if not eliminated, by the use of hydraulic crushing or nibbling techniques. Large blocks can be fragmented by the use of hydraulic expanding devices inserted into pre-drilled holes.

The use of electronic detectors can be used to locate leaks from buried pipelines more precisely and thereby reducing the need for trenching and increasing productivity. Increased productivity and reduction in vibration exposure can be achieved by using renovation techniques involving scraping out and relining old pipelines *in situ*.

D.4 Examples at foundries, e.g. fettling castings, polishing, automation, auxiliary equipment

D.4.1 General

The amount of fettling required by castings (and hence the vibration exposure of the fettlers) is affected not only by the casting design and material but also by the method of manufacture selected and the skill with which it is carried out. The more precise the method and the higher the quality of the production process the less the need for manual rectification and finishing.

For example, a company manufacturing castings of up to 350 t in a variety of steel alloys, who substituted a moulding process based on the use of cold setting phenolic resins for the traditional green sand method, found that it gave better casting quality (improved dimensional accuracy) and greatly reduced the amount (and cost) of fettling and rectification work.

When fettling castings, for example, it is often more economic as well as less hazardous to rough machine, rather than hand fettle, surfaces which are later to be finished by machining.

D.4.2 Polishing

The polishing of plated components on buffing, linishing and similar machines exposes the hands of workers to vibration but the need for this work can sometimes be reduced by introducing preliminary, chemical, polishing processes.

D.4.3 Automation

The vibration exposure due to the hand grinding of precision components to improve balance could be eliminated by automating the balancing process. This not only improved the working environment but also increased productivity.

Similarly, for some applications (such as the removal of runners and risers from castings, bar cutting, and the cutting of concrete blocks and slabs) manually operated cut-off saws can be replaced by enclosed, remote controlled or semi-automatic models. The advantages of this approach are not only the reduction or elimination of vibration exposure but also reduction of noise and dust and of the physical effort required to perform the work.

Industry and various industrial organizations use robot or highly automated grinders and burring machines for the removal of feeder heads and other fettling operations.

D.4.4 Auxiliary equipment

In the foundry industry the use of manipulators and remote control swing grinders allows more power to be applied during fettling thereby improving productivity. The operator's hands are removed from direct contact with the source of vibration (the grinder) and thereby effectively protected from hazardous vibration, provided the hand-held controls are well isolated from the grinder, e.g. hydraulic remote controls or pendulum arm control incorporating vibration isolation.

D.5 Equipment primarily used in construction

The analysis of why water or gas mains leak can identify ways in which the incidence of leaks could, in the long term, be reduced by the replacement of old pipes and fittings. The analysis can, for example, identify road construction and pipe installation practices as factors which contribute to the development of leaks (and to difficulties in repair or replacement) and show that it might be practicable to reduce these effects by improvements in both these areas.

Examination of the key elements is likely to show that the traditional method used to locate leaks is very inaccurate and that several holes are excavated in the wrong place before the site of the leak is precisely located. Here modern electronic leak detection techniques can reduce considerably the exposure to vibration resulting from the use of traditional methods.

Mounted or remote controlled breakers are practicable in most cases. Mobile circular road saws or high-pressure water jets offer other possibilities.

The use of reduced-vibration breakers for work that still needs to be done by hand to excavate access to the source of the leak reduces the vibration exposure of persons carrying out this work but other ways of achieving this end could be considered.

Similarly when the repair has been completed and the excavation backfilled, low-vibration methods for restoring the surface hardness, texture and profile should be identified and evaluated in terms of all relevant task requirements.

On completion of the processes of analysis and evaluation, a revised process/procedure for the task of stopping leaks should have been established which represents the best practicable means for the reduction of hand-arm vibration exposure previously associated with that task.

Annex E
(informative)

Vibration reduction by selection of machinery or equipment

E.1 Information to be provided by manufacturers

Equipment marketed in Europe shall have been designed to minimize risks from vibration (Machinery Directive 2006/42/EC, Annex I, 1.5.9). Minimizing risk from vibration can sometimes be compromised by other requirements for effective equipment, e.g. increasing the mass usually reduces vibration but high mass can present other risks for the equipment user. Where risks from vibration remain despite action to minimize the vibration risk, information about the risk and its control should be available from the manufacturer and supplier.

All equipment with hand-arm vibration emissions at the grip points that exceed 2,5 m/s^2 during normal intended use of the equipment should be supplied with information on the vibration emission likely during normal use and the uncertainty in the measurement of that vibration. This information should be reported in both the handbook and in any documents reporting technical performance parameters for the equipment.

E.2 Declaration of vibration emissions and test-codes

By declaration of the vibration emission it becomes possible to compare the vibration emission of equipment by comparing vibration emissions reported according to the same specified harmonized vibration test code, e.g. the EN 60745 series for electric powered hand-tools or the EN ISO 28927- series for pneumatic powered hand-tools. Harmonized vibration test codes published since 2009 (and some published earlier) usually provide a reasonable guide to vibration risk. If the test code does not provide a good guide to vibration risk, supplementary data should be reported to make the risk clear. The vibration emission is considered adequate to indicate likely risks if it is representative of the 75th percentile of the vibration emissions for normal intended use of the equipment.

Vibration test codes are usually written for a small range of similar tools. A general test code can be used when a tool-specific test code does not exist. Using the harmonized test code provides a presumption of conformity with the requirement to report the vibration emission. Data should not be compared when they are obtained from different test codes or even different dates of the same test code.

If manufacturers do not report to harmonized test codes, they are required to provide information on the test conditions used for their declaration. Further information is given in Annex F.

E.3 Using manufacturers emission values

Guidance on using vibration emission data published by manufacturers is given in CEN/TR 15350. Manufacturers' declared emission values according to harmonized test codes are not intended to substitute high-precision data for specific applications at workplaces (vibration emission is usually highly variable due to person, process and technique amongst other variables) but is usually sufficient to decide if a tool is unusually high, unusually low, or about the same when compared with the vibration emissions of competing models.

E.4 Example data measured at workplaces

Published data from measurements at workplaces, see e.g. Figure 2, provide an indication of the vibration magnitude that can be expected at the workplace.

These data are based on many tool models and the range of applications of those tools by many users using many techniques.

The range of vibration magnitudes in Figure 2 is partly due to variations in the use of the tools, but also due to the range in the vibration emissions of the tools themselves.

NOTE The data shown in Figure 2 can be helpful as part of the risk assessment, which is regulated at European level by the EC Directive 2002/44/EC.

E.5 Examples

E.5.1 Vibration-reduced stone chisel with anti-vibration sleeves

A vibration reducing chisel sleeve successfully reduced stone hammer vibration when compared with the plain chisel on stone or granite by up to 64 %, see [17]. End users also benefit from improved thermal and ergonomic comfort.

The use of vibration reducing chisel sleeves can require operators to modify their working techniques in some circumstances.

E.5.2 Vibration reduction by reducing exposure time with more effective tools

For the work of drilling in stone and concrete, the vibration exposure, the amount of force required and the exposure time were reduced keeping the same drilling performance by the development of new impact mechanisms. The development took place from the impact drill with a ratchet impact mechanism towards rotary hammer with electro pneumatic percussion. In recent times, the diamond core drilling is used for this application, too.

The effect of vibration reduction by reducing the drilling time is shown, e.g. by comparing the penetration for a rotary hammer compared to an impact drill. For a bore diameter of 12 mm and a depth of 80 mm, the rotary hammer requires 11 s and the impact drill 69 s, i.e. the rotary hammer leads to approximately 6 times lower exposure duration, see [20].

Annex F
(informative)

Getting information from manufacturers and suppliers — Important questions that potential buyers should ask potential suppliers with regard to hand-arm vibration

F.1General information

Machine manufacturers, importers, suppliers and tool hire firms should be able to help you select the most suitable and safest tools for your particular needs. They should provide useful information and advice about tool vibration, selection and management. Machine manufacturers have duties to reduce risks from vibration and they need to control risks from vibration. This is done in three steps:

i) reduce vibration at source, e.g. by choosing the appropriate technology during design and construction of machinery;

ii) reduce vibration by protective measures, e.g. by introducing anti-vibration technology or by preventing the user holding or using the machine in an inappropriate way;

iii) provide information about the residual risks from vibration emission which could not be avoided with step 1 and step 2.

It is common for significant residual vibration risks to remain, even if the vibration has been minimized through step 1 and step 2. The Machinery Directive 2006/42/EC requires manufacturers to provide information that allows employers to manage the remaining risks from vibration emission.

The information included, regarding vibration, in the instruction manual and sales literature (including electronic documents) describing performance characteristics of the machinery shall be as follows:

a) Where declaration of vibration emission is required:

   1) the declared vibration emission value of the machinery with the uncertainty,

   2) identification of the applied operating mode (usually by dated reference to the type-C standard including any part number),

   3) identification of the measurement method (usually by dated reference to the relevant type-B standard including any part number,

   4) a description of the operating conditions upon which the determination of these values is based and the measurement methods used. This information is usually provided by giving reference to a harmonized vibration test code (including the date),

   5) if, for any reason, the declared emission value does not adequately warn of risks, give supplementary information on the likely range of vibration in the foreseeable use of the machine, sufficient to allow the user to manage the risk (e.g a warning that a reaction bar used with a riveting hammer is likely to emit a greater level of vibration than the riveting hammer itself);

NOTE Figure F.1 shows an example how the data can be presented.

b) if applicable, give information of the selection of accessories (e.g. inserted tools) that are suitable for the task;

c) give information on any particular training required for the operator;

d) if applicable, explain the uses of the machine for which it is, and is not, suitable;

e) if applicable, give warnings about misuse of the machine (e.g. holding a power tool in a wrong position) that will increase risks from vibration;

f) if applicable, give information on ways to minimize vibration risk by

   1) limiting the operation modes of the machine,

   2) controlling the method of operation,

   3) using auxiliary equipment, such as a balancer or tensioner to support the weight of the hand-held tool and reduce the operator's force,

   4) limiting the duration of operation;

g) if applicable, give information on other factors that affect the risk of vibration-related injury or disease (e.g. ergonomic factors);

h) if applicable, give information on the correct adjustment and maintenance of the machine and accessories used with it;

i) if applicable, make recommendations regarding the maximum daily time for which an individual should operate the machine.

Machine model number, operating conditions and other identifying information **Type 990, Model 12-UH, 0,6 MPa**	
Declared vibration emission value in accordance with EN 12096**:**	
Measured vibration emission value *a*	8,0 m/s^2
Uncertainty *K*	2,3 m/s^2
Values determined according to EN ISO 28927-2:2009.	

a) Specific vibration test code exists

Machine model number, operating conditions and other identifying information **Type 991, Model 14-UF, 0,6 MPa**	
Declared vibration emission value in accordance with EN 12096**:**	
Measured vibration emission value *a*	3,4 m/s^2
Uncertainty *K*	1,7 m/s^2
Specification for the used operating mode: Values determined when the machine was used to remove welding sparks using standard inserted tool Z.	

b) No specific vibration test code exists

Figure F.1 — Examples of vibration emission declarations

F.2 Important questions to consider in the buying process

When choosing between potentially suitable new tools and equipment, buyers should ask for information regarding the vibration emission. Table F.1 contains some of the more important questions that should be asked.

Table F.1 — Questions in the buying process of machines

Question	Explanation
Vibration level	
What are the most suitable machines for the job [describe the job]?	It is important to make sure the machine you are intending to purchase is good for the job in terms of power, weight, performance, etc.
Is the vibration test code up to date?	Standards are revised regularly. The test codes can change from time to time and the measured value can be different from edition to edition
Is the declared vibration emission representative of the workplace vibration?	The vibration emission value determined by the test code often under-represents work place vibration
What is the likely range of vibration?	Vibration usually varies by several meters per second squared according to who is using it and what the workers are doing with it
What operations cause vibration at the top of the range? Which are these and how can they be avoided?	Some operations can cause high vibration levels, e.g. fitting a grinder with a brush
Are there any extra technical options which can be purchased in order to minimize the vibration level?	An auto-balancer system which can be purchased, or a jig the machine can be used with.
User information	
How should the equipment be used for a specific task?	
Ergonomics and training	
Other factors than vibration influence the workers who use the power tools. These factors in combination with vibration often increase the risk of vibration injury. Therefore, additional questions should be asked about the tool.	
What is the tool weight?	If a hand-held tool is difficult to handle, it should be supported by a suspension system
Is the handle design comfortable?	The handle should comfortably fit the hand when wearing gloves if this is normal
Are the necessary grip forces acceptable?	A light grip force helps reduce the transmission of vibration into the hand. High torque can be compensated by
Ease of use and handling?	

Question	Explanation
Cold from grip surfaces or from exhaust air on pneumatic tools?	Cold grip surfaces reduce blood flow
What is the noise?	Noise can affect blood flow
Are there any training requirements in order to use the equipment safely?	The technique of using, e.g. a breaker to nibble away from the edge of a concrete block has much lower vibration exposure than working from the middle
Is there any possibility to borrow the equipment on trial and use it in the real environment to see how it performs?	Manufacturers or suppliers can be willing to loan sample tools on trial. Make use of this opportunity and take account of workers opinions based on practical trials. This is an important step in choosing the correct tool
How efficient is the machine?	Comparison between time and efficiency. For example, a highly efficient high-vibration machine can result in a lower vibration exposure than a less efficient lower-vibration machine (which should be proved) [a]
Consumables (discs, drills, bits, etc.)	
Do the reported vibration values depend on a specific consumable? If so, what is it? And how long will it last?	The consumable (e.g. grinding wheel) can cause a large change in the vibration emission
Maintenance program	
What maintenance should be performed to keep the equipment or tool in good condition?	The vibration emissions of some tool types are highly dependent upon proper maintenance
Personal protective equipment	
Is there any need for personal protective equipment when operating the equipment?	Yes, to keep the hands warm and dry
Extra risk/other information	
Are there any applications of the equipment which are believed to increase the risk of hand-arm vibration injury?	The manufacturer needs to warn of residual risks which can cause vibration which is higher than the declared values

[a] The efficiency of the tool is very important. A tool that takes a long time to do the job will not be popular and could result in a higher vibration exposure than an efficient tool with a greater vibration magnitude. However, tools which are too powerful for the job could result in exposure to unnecessarily high vibration magnitudes.

Annex G (informative)

Practical maintenance measures that should be taken to reduce vibration exposure

G.1 General

This annex provides examples which indicate a few of the measures that should be taken to maintain tools and equipment correctly.

G.2 Machines/power tools

The balance of hand-held grinders should be checked prior to use and each time a wheel is fitted (and before issue from stores). Automatic balancer systems should be checked to ensure that they are working correctly, e.g. an oil leak can block the free motion of the counter-balancing balls.

Moving parts should be regularly lubricated and replaced before wear causes an excessive increase in vibration values. The conditions of bearings and gears should be regularly checked and replaced if defective.

Vibration reducing mounts and resilient materials and vibration reducing (suspended) handles should be monitored for deterioration and replaced before the vibration emission is significantly increased.

Deterioration of rubber mounts, in the form of cracking, swelling (such as is caused by oil contamination), softening and conversely hardening can sometimes be detected by visual examination and simple tests but, in general, manufacturers' advice should be sought.

Internal combustion engines should be kept well-tuned with correct spark plug and carburetor settings.

G.3 Tool consumables

Cutting tools should be regularly sharpened. For example, in the case of percussive tools, the chisels should be kept sharp to work efficiently. The saw teeth of chain saws should be kept sharp with even spacing and profiles. Chain tension should be correct to avoid hammering (and wear) of the chain on the guide bar.

Grinding wheels for pedestal grinders should be regularly and correctly dressed by using a suitable procedure recommended by the manufacturer which ensures the wheel is concentric (with minimum unbalance) and has a correct profile. Properly dressed wheels reduce the vibration exposure of workers and can increase metal removal rates and therefore reduce production costs.

Annex H
(informative)

Reliable definition of action and exposure limit values — Consideration of the precision of definition

Data on vibration emission or vibration exposure obtained from manufacturers or from databases are associated with an uncertainty of measurement. For example, differences between products, users and measurement procedures result in measured values differing by various degrees. In order to prevent the risk to health from being under-estimated, an estimation of the workplace exposure, i.e. daily exposure value $A(8)$, should at least consider the uncertainty of the values upon which it is based. Uncertainty caused by the estimation itself or by deviations in operating conditions is higher by an order of magnitude.

Three cases are distinguished in Table H.1:

a) Vibration measurements

Vibration measurements performed by competent test bodies employing instruments compliant with EN ISO 8041.

b) Emission values stated by manufacturers

The lower limit of the estimation deviation is derived from manufacturers' data on the extended uncertainty K in addition to data on the emission values for the frequency-weighted mean acceleration a (approximately 90 % of the measured values lie below $a + K$).

Method:

1) Where a value is stated for K, an estimated acceleration based upon the value a shall be increased by K.

2) Where no value is stated for K, K can be taken from Table H.2.

c) Databases of exposure values

Where present in databases, considerations of uncertainty should be observed appropriately.

In addition, procedure b) can be applied in the same way, since the deviation for exposure values is at least equal to the error of an emission measurement. The values for a then constitute exposure values.

Table H.1 — Source and quality of acquired data on vibration emission or vibration exposure

Case	Source and quality of the acquired data	Remarks about uncertainty
a)	**Vibration measurements** performed by competent test bodies employing instruments compliant with EN ISO 8041	— Non-representative random samples can lead to systematic errors — Estimation of uncertainty including consideration of ISO/IEC Guide 98-3
b)	**Manufacturer's data on emission values** Mean value determined for the same product by one test body, on several identical products and with several users	— Product and laboratory scatter — Deviations caused by differences in operating conditions between real-case and test conditions
c)	**Databases of exposure values**	
	1) Specific data on the uncertainty available 2) No specific data on the uncertainty available (databases, summaries)	— Uncertainties as in b) — Systematic deviation can be caused by products not being comparable

Table H.2 — Determining the extended uncertainty *K* for estimation based upon the emission and exposure values in the absence of other data

Basis for estimation (hand-arm vibration emission or exposure value *a*)	**Extended uncertainty *K***
$2{,}5\ m/s^2 < a \leq 5{,}0\ m/s^2$	0,5 a
$a > 5{,}0\ m/s^2$	0,4 a

Annex I
(informative)

Additional information about tool characteristics and work tasks for the tools listed in Figure 2

NOTE The values listed in Figure 2 are values from real-world/field measurements at workplaces with tool applications/conditions at companies according to EN ISO 5349-2 (the values of Figure 2 are not manufacturer data/declared values).

Tables I.1 to I.4 list the tool characteristics and work tasks for different tool families.

Table I.1 — Tools used in construction work

Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Concrete breaker (03.05)	Breaking concrete, tarmac, stone	Pneumatic/ electric	25 to 30	(1 000 to 1 600) strokes/min	
Hammer or impact drill (01.04)	Drilling concrete	Electric	1,7 to 2,9	(0,6 to 1,6) kW	
Thread cutting machine, core drill (01.05)	Drilling stone with hole saw	Electric	2,4	(1 to 1,7) kW	
Vibratory tamper, trench rammer (14.02)	Compacting stone	Internal combustion	60 to 80	(2 to 4,5) kW	
Vibrating plate, compactor, concrete compactor, vibrator, backfill tamper (14.01)	Compacting on aggregate, sand, asphalt	Internal combustion	60 to 400	(2,5 to 4) kW	
Diamond stone saw, cut-off saw (10.06)	Cutting flagstone, reinforced concrete	Internal combustion	9,5 to 10	(3 to 4) kW	

Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Angle grinder (11.03)	Stone working, smoothing stone, cutting paving	Electric	1 to 7,5	(0,7 to 2,4) kW	
Combination hammer, rotary hammer (03.07)	Drilling holes in stone, concrete	Electric	2 to 7	(3 100 to 5 400) strokes/min	
Combination hammer, rotary hammer (03.07)	Drilling holes in stone, concrete	Electric	5,5 to 12	(1 000 to 3 000) strokes/min	

Table I.2 — Tools used in landscaping and gardening

Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Pedestrian controlled lawn mower (12.03)	Grass cutting, cutting verges	Internal combustion	15 to 120	(2,8 to 4,5) kW	
Lawn or brush cutter with disc or strimmer (12.06)	Brush cutting	Internal combustion	8 to 10	(0,5 to 3) kW	
Lawn or brush cutter with disc or strimmer (12.06)	Brush or grass cutting	Internal combustion	5 to 10	(0,5 to 3) kW	
Chain saw (10.01)	Branch or tree cutting	Internal combustion	2 to 6	(1,5 to 3) kW	
Pole pruner (12.09)	Branch or grape cutting	Battery	0,8 to 2,2	(0,15 to 0,5) kW	
		Pneumatic	0,5 to 2,2		
Leaf blower (15.01)	Leaf or grass blowing	Internal combustion	4 to 10,5	(0,8 to 2,6) kW	
Hedge cutter (shear), hedge trimmer (12.08)	Conifer or shrub trimming	Internal combustion	4 to 7	(0,7 to 1) kW	

Table I.3 — Tools used in wood working

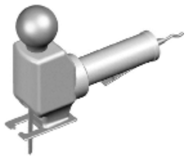
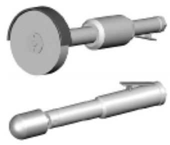
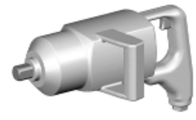
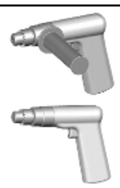
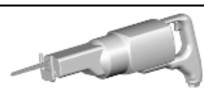
Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Nail gun (04.01)	Wood nailing, pallet repairing, top deck clenching	Pneumatic	1 to 8	Nail length: (35 to 150) mm	
Staple gun, tacker (04.02)	Upholstering, pallet repairing, wood stapling	Pneumatic	0,5 to 2,5	Staple length: (8 to 50) mm	
Jig saw (10.03)	Wood or perspex glass cutting, cutting circles	Electric	2,5 to 3	Material thickness: (10 to 28) mm	

Table I.4 — Tools used in metal working

Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Angle grinder (11.03)	Grinding out spot welds, cutting steel, dressing weld, smoothing metal edges, rail sanding, finishing metal casting, fettling cast iron	Pneumatic/ electric	1 to 8	(0,3 to 4,5) kW	
Vertical grinder (11.02)	Fettling, finishing metal casting	Pneumatic	1 to 8	(0,4 to 3) kW	
Straight grinder (11.06)	Finishing metal casting, fettling, dressing weld	Pneumatic/ electric	0,5 to 4,5	(0,3 to 3) kW	
Screwdriver with shut-off clutch/ Screwdriver with slip clutch (13.01, 13.02)	Screw running	Pneumatic/ electric	0,3 to 0,8	(2 to 35) Nm	
Impact wrench, impulse nut runner, angle nutrunner (13.03)	Undoing or tightening bolts	Battery	0,9 to 3,5	(60 to 1 050) Nm	

Tool type (Reference, see Table A.1)	**Task and materials**	**Power source**	**Declared mass** kg	**Additional characteristics**	**Tool schema**
Impact wrench, impulse nut runner, angle nutrunner (13.03)	Undoing or tightening bolts	Pneumatic	0,9 to 3,6	(50 to 1 100) Nm	
Impact wrench, impulse nut runner, angle nutrunner (13.03)	Removal and fitting of wheel vehicle	Pneumatic	3,5 to 10	(400 to 2 500) Nm	
Pulse ratchet wrench (13.04)	Undoing or tightening bolts	Pneumatic/ electric	1 to 10,5	(50 to 1 000) Nm	
Needle gun, descaling hammer, engraving pen (09.01)	Scaling painting, removal of sand and glue, chisel scaling, surface preparation, roughing out, chiseling stone	Pneumatic	1,5 to 4,3	(1 000 to 5 000) strokes/min	
Needle gun, descaling hammer, engraving pen (09.01)					
Angle rotary polisher or sander (11.01)	Preparing or polishing body work, sanding car bonnet	Pneumatic/ electric	0,5 to 3,3	(0,2 to 1,2) kW	
Random orbital sander, orbital sander, palm sander (11.05)	Finishing metal work, preparing body work, reinforced plastic, plastic moulding for paint	Pneumatic	0,7 to 2,4	(0,1 to 0,8) kW	
Vibrating sander (11.09)		Pneumatic/ electric	1,0 to 2,8	(0,1 to 0,3) kW	
Hand drill, pistol drill (01.01)	Drilling	Pneumatic/ electric	0,5 to 1,0	0,3 kW	
Hammer or impact drill (01.04)	Drilling metal	Electric	2,3 to 4,5	(0,7 to 1,4) kW	
Reciprocating saw (10.10)	Cutting nails, vehicle body	Pneumatic/ electric	0,5 to 4,6	(0,3 to 1,5) kW	

Bibliography

[1] CEN/TR 16391, *Mechanical vibration and shock - Hand-transmitted vibration - Influence of coupling forces at the hand-machine interface on exposure evaluation*

[2] CR 12349, *Mechanical vibration — Guidelines to health effects of vibration on the human body*

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

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

[5] EN ISO 10819, *Mechanical vibration and shock - Hand-arm vibration - Measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand (ISO 10819)*

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

[7] EN ISO 28927 (all parts), *Hand-held portable power tools — Test methods for evaluation of vibration emission*

[8] EN ISO 28927-2:2009, *Hand-held portable power tools - Test methods for evaluation of vibration emission - Part 2: Wrenches, nutrunners and screwdrivers (ISO 28927-2:2009)*

[9] ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

[10] Directive 89/686/EEC on *Personal Protective Equipment (PPE)*

[11] Directive 2002/44/EC of the European parliament and of the Council of 25 June 2002 on *the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration)* (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

[12] Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on *the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)* (Seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

[13] Directive 2006/42/EC of the European Parliament and the Council of 17 May 2006 on *machinery* and amending directive 95/16/EC

[14] Guide E.U. *Non-binding guide to good practice for implementing Directive 2002/44/EC (Vibrations at work)*. EU Commission, 2008

[15] *Commission Recommendation of 19 September 2003 concerning the European Schedule of Occupational Diseases (2003/670/EC)*. European Commission. Official Journal n° L 238, 25.09.2003, p. 28–34

[16] *Guide to application of the Machinery Directive 2006/42/EC*. European Commission, Second Edition, 2010

[17] Report H.S.E. RR990 *Retrofit anti-vibration devices: A study of their effectiveness and influence on hand-arm vibration exposure.* HSE, 2013, www.hse.gov.uk/research/rrhtm/rr990.htm

[18] *Noise and vibration in the working environment*. Occupational Safety and Health Series No. 33, Geneva, International Labour Office (ILO)

[19] Griffin, M.J. *Handbook of Human Vibration*. Academic Press Ltd, London, 1990

[20] Kaulbars, U. *Schutz vor Hand-Arm-Vibration durch Substituieren und Isolieren — Praxisbeispiele zur Technischen Regel*. Technische Sicherheit 1 (2011) Nr. 6, p. 47–53

[21] Pitts, P.M., Kaulbars, U. *Consideration of standardisation requirements for "vibration dosemeters"*. VDI-Tagung Humanschwingungen, 2013, Dresden. VDI-Berichte Nr. 2190, p. 25–34, VDI-Verlag, Düsseldorf 2013, www.dguv.de/medien/ifa/de/pub/grl/pdf/2013_150.pdf

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