Guide to good practice on

Hand-Arm Vibration

Non-binding guide to good practice with a view to implementation of Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations).

Information on how to provide comments on this draft document is given at www.humanvibration.com/EUNIBGUIDE.htm
CONTENTS

Contents ........................................................................................................................................... 2
Forward ............................................................................................................................................. 4
Acknowledgements ...................................................................................................................... 5
Chapter 1 Introduction ..................................................................................................................... 6
Chapter 2 Evaluation of risk ........................................................................................................... 10
  2.1 The basics of risk assessment ................................................................................................. 11
  2.2 Determining exposure duration ......................................................................................... 14
  2.3 Vibration magnitude ............................................................................................................ 16
    2.3.1 Use of manufacturer’s emission data ........................................................................... 16
    2.3.2 Use of other data sources ......................................................................................... 17
    2.3.3 Measurement of vibration magnitude ........................................................................ 18
  2.4 Calculating daily vibration exposures .................................................................................... 20
    2.4.1 Where just one machine is used ............................................................................... 20
    2.4.2 Where more than one machine is used .................................................................... 20
    2.4.3 Uncertainty of daily exposure evaluations .................................................................. 21
Chapter 3 Removing or reducing exposure .................................................................................. 22
  3.1 Developing a control strategy ............................................................................................... 23
  3.2 Risk controls ......................................................................................................................... 24
    3.2.1 Substitution of other working methods ..................................................................... 24
    3.2.2 Equipment selection .................................................................................................. 24
    3.2.3 Purchasing policy ....................................................................................................... 24
    3.2.4 Workstation design .................................................................................................... 26
    3.2.5 Maintenance ............................................................................................................... 26
    3.2.6 Training and information to workers ......................................................................... 27
    3.2.7 Work schedules .......................................................................................................... 28
    3.2.8 Clothing and personal protection ............................................................................. 28
  3.3 Monitoring and reassessment ............................................................................................... 29
    3.3.1 How do I know if my hand-arm vibration controls are working? ............................. 29
    3.3.2 When do I need to repeat the risk assessment? ......................................................... 29
Chapter 4 Health Surveillance ...................................................................................................... 30
  4.1 When is health surveillance required? ................................................................................... 31
  4.2 What techniques are available? ............................................................................................. 32
4.3 What recording is required? .................................................................34
4.4 What to do if injury is identified? ......................................................35

Annex A  Health risks, signs and symptoms........................................36
A.1 Vascular disorders ........................................................................36
A.2 Neurological disorders ..................................................................37
A.3 Carpal-tunnel syndrome ...............................................................37
A.4 Musculoskeletal disorders ..............................................................37

Annex B  What is vibration? .................................................................38
B.1 What is vibration? .........................................................................38
B.2 What is measured? ........................................................................38
B.3 What is frequency and frequency-weighting? ...............................39
B.4 What parameters are used for exposure assessment? ...................39
B.5 What instrumentation should be used? .........................................40

Annex C  Tools for calculating daily exposures ..................................41
C.1 Web-based tools ...........................................................................41
C.2 Daily exposure graph .................................................................41
C.3 Daily exposure nomogram ............................................................41
C.4 Exposure points system ...............................................................41
C.5 Traffic light system .....................................................................42

Annex D  Glossary .................................................................................45

Bibliography ..........................................................................................46

Index ..........................................................................................................48
FORWARD

Directive 2002/44/EC of the European Parliament and of the Council on the exposure of workers to the risks arising from physical agents (vibration) seeks to introduce, at Community level, minimum protection requirements for workers when they are exposed, in the course of their work, to risks arising from vibration.

Directive 2002/44/EC is the most appropriate means of achieving the desired objectives and does not go beyond what is necessary to achieve that purpose. It gives exposure limit values and exposure action values. It also explains employers’ obligations with regard to determining and assessing risks, sets out the measures to be taken to reduce or avoid exposure and explains how to provide information and training for workers. Any employer who intends to carry out work involving risks arising from exposure to vibration must therefore implement a series of protection measures before and during actual operations. Similarly, the Directive requires the Member States to put in place a suitable system for monitoring the health of workers exposed to risks arising from vibration.

Given that evaluating and determining risks arising from exposure to vibration, on the one hand, and implementing protection measures, on the other, can be a complicated matter, it was considered worthwhile to have a non-binding "guide to good practice" which facilitates the appropriate choice and correct use of methods and work equipment, depending on environmental nuisances, the duration of the work and constraints.

This guide on hand-arm vibration, together with its companion guide on whole-body vibration, has been prepared under contract VC/2004/0341 for the European Commission General Direction Employment and Social Affairs. They are intended to cover the methodology used for determining and evaluating risks; dealing with the choice and correct use of work equipment, the optimisation of methods and the implementation of protection measures (technical and/or organisational measures) on the basis of a prior risk analysis. This guide also gives details of the type of training and information to be provided to the workers concerned and proposes effective solutions for the other matters raised in Directive 2002/44/EC.
ACKNOWLEDGEMENTS

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HSE: Health and Safety Executive
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CHAPTER 1 INTRODUCTION

This guide is intended to help employers identify hand-arm vibration hazards, assess exposures and risks and identify measures for safeguarding the health and safety of workers exposed to hand-arm vibration risks.

The guide should be read in conjunction with the Vibration Directive or national legislation that implements the requirements of that Directive.

Workers whose hands are regularly exposed to vibration may suffer from damage to the tissues of hands and arm, which cause the symptoms collectively known as hand-arm vibration syndrome, see Annex A.

Hand-arm vibration risks affect people across many industries and occupations. The risks are greatly increased with use of higher vibration equipment and with prolonged and regular use of the equipment. However, investigations have shown that vibration hazards can be controlled and risks reduced by good management. They have also shown that the costs of such controls need not be high and can usually be offset by the benefits of keeping workers healthy. Additionally, the vibration control measures have, in many cases, led to improved efficiency.

The EU Vibration Directive (Directive 2002/44/EC – see further reading box) sets a daily exposure action value, above which it requires employers to control the hand-arm vibration risks of their workforce and a daily exposure limit value above which employees should not be exposed:

- a daily exposure action value of 2.5 m/s²
- a daily exposure limit value of 5 m/s².

The Vibration Directive places requirements on employers to ensure that risks from hand-arm vibration are eliminated or reduced to a minimum. These responsibilities are summarised in Table 1.


---

1 Transitional periods apply to the exposure limit value. The transitional periods apply only to the use of machinery supplied prior to 6th July 2007 for a period of 5 years from 6th July 2005 (Member States are entitled to extend this period for a further 4 years for agricultural and forestry machinery).
This guide will help employers comply with the Vibration Directive as it applies to hand-arm vibration. Separate guidance (ref) gives advice on whole-body vibration. The structure for this guide is shown in the flow diagram of Figure 1.

### Further reading:

**Vibration Directive:**


**Framework Directive:**

Table 1 Summary of responsibilities defined by Directive 2002/44/EEC

<table>
<thead>
<tr>
<th>Directive Article</th>
<th>Who</th>
<th>When</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| Article 4        | Employer | Potential risk from hand-arm vibration | **Determination and assessment of risk:**  
  ▪ Use someone who is competent to assess the hand-arm vibration risk.  
  ▪ Be in possession of the risk assessment.  
  ▪ Identify measures required for control of exposure and worker information and training.  
  ▪ Keep the risk assessment up to date.  |
| Article 5        | Employer | Risks from vibration | **Avoiding or reducing exposure:**  
  ▪ Take general actions to eliminate exposures or reduce them to a minimum  |
|                  |          | Exposures above the exposure action value | ▪ Establish and implement programme of measures to eliminate, or reduce to a minimum, exposures to hand-arm vibration risks  |
|                  |          | Exposures above the exposure limit value | ▪ Take immediate action to prevent exposure above the limit value  
  ▪ Identify why exposures limit value has been exceeded  |
|                  |          | Workers at particular risk | ▪ Adapt to requirements of workers at particular risk  |
| Article 6        | Employer | Workers at risk from hand-arm vibration | **Worker information and training:**  
  ▪ For all workers exposed to hand-arm vibration risks.  |
| Article 7        | Employer | Workers at risk from hand-arm vibration | **Worker consultation and participation:**  
  ▪ To consult, in a balanced way and in good time, workers and their representatives on risk assessment, control measures health surveillance and training.  |
| Article 8        | Doctor or suitably qualified person | Where ill health is identified | **Health Surveillance:**  
  ▪ Inform worker of results of health surveillance  
  ▪ Provide information and advice to worker on health surveillance necessary when exposure to hand-arm vibration has finished.  
  ▪ Provide significant findings of health surveillance to employer  |
|                  | Employer | Where ill health is identified | ▪ Review risk assessment  
  ▪ Further eliminate or reduce risks  
  ▪ Review the health status of similarly exposed employees.  |
|                  | Employer | Exposures above the exposure action value | ▪ Employees entitled to appropriate health surveillance  |
Figure 1 Hand-arm vibration diagram
CHAPTER 2 EVALUATION OF RISK

The purpose of the hand-arm vibration risk assessment is to enable you as the employer to make a valid decision about the measures necessary to prevent or adequately control the exposure of workers to hand-arm vibration.

In this chapter we show how you can decide whether you may have a problem with hand-arm vibration exposures in your workplace without the need for measurement or any detailed knowledge of exposure assessment.
2.1 The basics of risk assessment

The risk assessment should:

- identify where there may be a risk from hand-arm vibration;
- estimate employees’ exposures and compare them with the exposure action value and exposure limit value;
- identify the available risk controls;
- identify the steps you plan to take to control and monitor hand-arm vibration risks; and
- record the assessment, the steps that have been taken and their effectiveness.

A starting point is to consider the industry you work in, the processes involved and the tools and equipment used, and ask: “Does your business use hand-held, hand-guided or handfed powered equipment?” If so, you may need to manage exposures to vibration. Some questions to help you decide whether further action is required are shown in Table 2.

Some industries known to have risks from hand-arm vibration are shown in Figure 2, along with some of the tools and machines that create the risks.

The factors that govern a person’s daily vibration exposure are the frequency-weighted magnitude (level) of vibration and the length of time the person is exposed to it. The greater the magnitude or the longer the duration of exposure, the greater will be the person’s vibration exposure.
### Table 2 Some questions to help decide whether further action is needed

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do you use rotary action tools (e.g. grinders, polishers)?</strong></td>
<td>Some rotary action tools can exceed the exposure action value within about half an hour, and you should certainly be taking action if individual employees are using them for more than about 2 hours per day.</td>
</tr>
<tr>
<td><strong>Do you use impact or percussive tools (i.e. hammer-action tools)?</strong></td>
<td>With impact or percussive tools the levels of vibration are likely to be much higher than rotary tools. Some hammer action tools can exceed the exposure action value within a few minutes, and you should certainly be taking action if individual employees are using them for more than about half an hour per day.</td>
</tr>
<tr>
<td><strong>Do the manufacturers or suppliers of your tools warn of a risk from vibration?</strong></td>
<td>If you are using hand-held power tools that may put the users at risk of vibration injury, the manufacturer should warn you about it in the handbook.</td>
</tr>
<tr>
<td><strong>Do any vibrating tools cause tingling or numbness in the hands during or after use?</strong></td>
<td>Tingling or numbness of the hands may be noticeable during or after use of a power tool and is an indicator of hand-arm vibration risk from long-term tool use.</td>
</tr>
<tr>
<td><strong>Have any vibration-exposed employees already reported symptoms of hand-arm vibration syndrome?</strong></td>
<td>Evidence of hand-arm vibration syndrome means that vibration exposures need to be managed. Where symptoms are linked to exposures that are below the action value, it may identify workers who are particularly susceptible to hand-arm vibration risks.</td>
</tr>
</tbody>
</table>
Figure 2 Examples of vibration magnitudes for common tools
2.2 Determining exposure duration

In order to assess the vibration exposure an estimate is required of the time that the tool operators are exposed to the vibration. Experience has shown that this is often overestimated during the risk assessment.

In this chapter we look at what exposure time information is needed and how it can be determined.

Before the daily vibration exposure can be estimated, you need to know the total daily duration of exposure to the vibration from each tool or process being used. You should be careful to count only the time that the employee is actively operating the equipment; a period when an employee has put the equipment down or is holding it but not operating it should not be counted.

The contact time or trigger time is the time that the hands are actually exposed to the vibration from the tool or workpiece. The trigger time is often very much shorter than the overall “time on the job” and is usually over-estimated by operators. The method used for estimating trigger times often depends on whether the tool usage is continuous or intermittent:

Continuous tool operation:

Example: the use of a grinder to remove large amounts of material over several hours.

Observe work during a representative part of the working day and record how much of the time the tool is operating. A stopwatch or video recording can be useful for this.

Intermittent tool operation:

Example: Use of impact wrench to tighten wheel nuts on vehicles.

You may have access to information on the number of operations that occur during the working day (e.g. the number of components completed per day). If an average duration for an operation is estimated by observing the work rate over a sample work period then the total daily duration can be calculated.

For our example of an impact wrench, you may know the number of wheels removed and replaced per day and the number of wheel nuts per wheel, you will also need to know how long it typically takes to remove or replace one wheel.

Work patterns also need careful consideration. For example some workers may only use vibrating tools for certain periods in a day or week. Typical usage patterns should
be established, as these will be an important factor in calculating a person’s likely vibration exposure.

**Further reading:**

<table>
<thead>
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<tbody>
<tr>
<td>CEN/TR xxxx (publication expected 2005) Mechanical vibration — Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery</td>
</tr>
</tbody>
</table>
2.3 Vibration magnitude

Hand-arm vibration risk is based on the frequency-weighted acceleration total value $a_{hv}$, given by the root-sum-of-squares of the frequency-weighted acceleration from the three orthogonal axes, x, y and z:

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

The value is assessed at the point where the vibration enters the hand (see Annex B).

The vibration information you use to do your vibration assessment needs to match as closely as possible the likely vibration emissions of the equipment you plan to use in the way you plan to use it.

In this chapter we look at how vibration can be estimated from manufacturer’s data, other published data sources and from workplace measurement.

2.3.1 Use of manufacturer’s emission data

The European “Machinery Directive” (Directive 98/37/EC) defines essential health and safety requirements for machinery supplied within the European Union, including specific requirements regarding vibration.

Amongst other requirements, the Machinery Directive requires manufacturers, importers and suppliers of machines to provide information on vibration emissions at the hand. This vibration emission information should be given in the information or instructions that accompany the machine.

Manufacturer’s declared vibration emission values are usually obtained according to harmonised European vibration test codes produced by European or International standards bodies, and (from 2005) these are based on EN ISO 20643. Examples are the EN ISO 8662 series for pneumatic and other non-electric tools and the EN 60745 series for electric tools.

Emission data from manufacturers can tell you how much vibration is likely to enter a person’s hands when using a particular power tool. This may be useful to help make an estimate of daily exposure and an assessment of risk.

At present, the vibration test codes tend to under-estimate the vibration of tools when they are being used in the workplace, and are usually based on measurements in a single vibration axis. CEN/TR xxxx (NOTE: expected to be published in 2005) advises that for estimating risk, the manufacturer’s declared emission value should in most cases be multiplied by a factor depending on the type of tool:

- Combustion engine tools: $\times 1$
Pneumatic tools: \times 2

Electric tools: \times 2

Many harmonised European vibration test codes are currently (in 2005) under review and the revised versions should result in emission values that provide a more accurate guide to the vibration experience in the workplace.

**Further reading:**

| EN 12096:1997 Mechanical vibration — Declaration and verification of vibration emission values |
| CEN/TR XXXX: 2005 Mechanical vibration — Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery |

2.3.2 **Use of other data sources**

There are other sources of information on vibration magnitudes, which are often sufficient to allow you to decide whether the exposure action value or the exposure limit value is likely to be exceeded.

Your trade association or equivalent may also have useful vibration data and there are international vibration databases on the Internet, which may meet your needs. This may be suitable for some employers to do an initial vibration risk assessment.

Other sources of vibration data include specialist vibration consultants and government bodies. Some data can also be found in various technical or scientific publications and on the Internet and some data on typical real-use vibration may be available on manufacturer’s web sites. Two European websites that hold manufacturers’ standard vibration emission data along with some values measured in “real use” for a range of machines are:

http://vibration.arbetslivsinstitutet.se/eng/havhome.lasso

http://www.las-bb.de/karla/index_.htm

Ideally you should use vibration information for the equipment (make and model) you plan to use. However, if this is not available you may need to use information relating to similar equipment as a starting point, replacing the data with more accurate values when this becomes available.

When choosing published vibration information the factors you need to take account of in making your choice include:

- the type of equipment (e.g. road breaker),
• the class of equipment (e.g. power or size),
• the power source (e.g. pneumatic, hydraulic, electric or combustion engine)
• any anti-vibration features (e.g. suspended handles),
• the task the equipment was used for when producing the vibration information,
• the speed at which it was operated,
• the type of material on which it was used.

When using published vibration data it is good practice to try to compare data from two or more sources.

<table>
<thead>
<tr>
<th>Further reading:</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Vibration at Work” ISSA1989</td>
</tr>
</tbody>
</table>

### 2.3.3 Measurement of vibration magnitude

In many situations it will not be necessary to measure vibration magnitudes. However, it is important to know when to conduct measurements.

In this chapter we look what how and where vibration is measured and how measurements are reported.

Sometimes it may not be possible to obtain adequate information (from equipment suppliers or other sources) on the vibration produced by a tool or work process. It may then be necessary to make measurements of vibration in the workplace.

Vibration measurement is a difficult and complex task. You may choose to make the measurements in-house, or to employ a specialist consultant. In either case, it is important that whoever makes the measurements has sufficient competence and experience.

### What is measured?

Human exposure to hand-arm vibration should be evaluated using the method defined in European Standard EN ISO 5349-1:2001 and detailed practical guidance on using the method for measurement of vibration at the workplace is given in EN ISO 5349-2:2001.

The vibration magnitude is expressed in terms of the frequency-weighted acceleration of the surface of the tool-handle or workpiece that is in contact with the hand (see Annex B) it is expressed in units of metres per second squared (m/s²).
Making vibration measurements

Measurements should be made to produce vibration values that are representative of the average vibration for a tool or process throughout the operator’s working period. It is therefore important that the operating conditions and measurement periods are selected to achieve this.

Where tools are held in both hands, measurements must be made at both hand positions and the highest value used for determining vibration exposure.

Further reading:

2.4 Calculating daily vibration exposures

A risk assessment is based on the daily vibration exposure of a worker. Daily vibration exposure depends on both the level of vibration and the duration of exposure.

In this chapter we look at how daily vibration exposure is calculated from vibration magnitude information and exposure times.

Some tools for simplifying the calculation of daily exposures and managing exposure times are given in Annex C.

2.4.1 Where just one machine is used

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, using the equation:

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

where $a_{hv}$ is the vibration magnitude (in m/s$^2$), $T$ is the daily duration of exposure to the vibration magnitude $a_{hv}$ and $T_0$ is the reference duration of eight hours. Like vibration magnitude, the daily vibration exposure has units of metres per second squared (m/s$^2$).

Example

A forest worker uses a brush cutter for a total of 4½ hours a day. The vibration on the brush cutter when in use is 4m/s$^2$. The daily exposure $A(8)$ is:

$$A(8) = 4 \sqrt{\frac{4.5}{8}} = 3 \text{ m/s}^2$$

2.4.2 Where more than one machine is used

If a person is exposed to more than one source of vibration (perhaps because they use two or more different tools or processes during the day) then a partial vibration exposure is calculated from the magnitude and duration for each one. The partial vibration values are combined to give the overall daily exposure value, $A(8)$, for that person.

Each partial vibration exposure represents the contribution of a particular source of vibration (tool or process) to the worker’s total daily exposure. Knowledge of the partial exposure values will help you decide on your priorities: the tools or processes with the highest partial vibration exposure values are those that should be given priority for control measures.

The overall daily vibration exposure can be calculated from the partial vibration exposure values, using:
\[ A(8) = \sqrt{A_1(8)^2 + A_2(8)^2 + A_3(8)^2 + \ldots} \]

where \(A_1(8), A_2(8), A_3(8), \ldots\) are the partial vibration exposure values for the different vibration sources.

**Example**

A fettler uses three tools during a working day:

1. An angle grinder: 4 m/s\(^2\) for 2\(\frac{1}{2}\) hours
2. An angle cutter for 3 m/s\(^2\) for 1 hour
3. A chipping hammer 20 m/s\(^2\) for 15 minutes

The partial vibration exposures for the three tasks are:

1. Grinder: \(A_{\text{Grind}}(8) = 4 \sqrt{\frac{2.5}{8}} = 2.2\) m/s\(^2\)
2. Cutter: \(A_{\text{Cut}}(8) = 3 \sqrt{\frac{1}{8}} = 1.1\) m/s\(^2\)
3. Chipper: \(A_{\text{Chip}}(8) = 20 \sqrt{\frac{15}{8 \times 60}} = 3.5\) m/s\(^2\)

The daily vibration exposure is then:

\[
A(8) = \sqrt{A_{\text{Grind}}(8)^2 + A_{\text{Cut}}(8)^2 + A_{\text{Chip}}(8)^2} \\
= \sqrt{2.2^2 + 1.1^2 + 3.5^2} \\
= \sqrt{4.8 + 1.2 + 12.3} = \sqrt{18.3} = 4.3\) m/s\(^2\)

**2.4.3 Uncertainty of daily exposure evaluations**

Where vibration magnitude and exposure time are measured the uncertainties associated with the evaluation of \(A(8)\) can be as much as 20 - 40\%. Where either the exposure time or the vibration magnitude is estimated — e.g. based on information from the worker (exposure time) or manufacturer (magnitude) — then the uncertainty in the evaluation of daily exposure can be much higher.

**Further reading:**

CHAPTER 3 REMOVING OR REDUCING EXPOSURE
3.1 Developing a control strategy

To control risk you must have a strategy that can effectively deliver reduced exposure to hand-arm vibration.

In this chapter we look at the process of developing a control strategy, including how to prioritise your control activities.

Your risk assessment should enable methods for controlling exposure to be identified. While you are assessing the vibration exposures, you should be thinking about the work processes that cause them. Understanding why workers are exposed to vibration will help identify methods for reducing or eliminating them.

The important stages in this management process are:

- identifying the chief sources of vibration,
- ranking them in terms of their contribution to the risk,
- identifying and evaluating potential solutions in terms of practicability and cost,
- establishing targets which can be realistically achieved.
- allocating priorities and establishing an 'action programme';
- defining management responsibilities and allocating adequate resources;
- implementing the programme;
- monitoring progress;
- evaluating the programme.

The approach you take to reduce risks from hand-arm vibration will depend on the practical aspects of your particular processes and on the current levels of exposure.

Example: use of partial vibration exposure to rank risks

A steel worker uses two tools, a grinder with an in-use vibration emission of 7m/s² and a chipping hammer with an in-use emission of 16m/s². The grinder is used for a total of 2½ hours per day, the chipping hammer for 15 minutes:

- Grinder (7 m/s² for 2½ hours): \( A_1(8) = 3.9 \text{ m/s}^2 \)
- Chipping hammer (16 m/s² for 15 minutes): \( A_2(8) = 2.8 \text{ m/s}^2 \)

Total exposure: \( A(8) = 4.8 \text{ m/s}^2 \)

Although the chipping hammer has a greater vibration magnitude than the grinder, the partial exposure values show that the use of the grinder accounts for the greater proportion of the worker’s overall vibration exposure. Therefore, initially, the grinder should be the main focus for risk reduction.
3.2 Risk controls

To control risk you must remove or reduce exposure to hand-arm vibration. It may also be possible to take actions that reduce the likelihood of developing injury. It is likely that effective control will be based on a combination of several methods.

In this chapter we look at the engineering, management and other methods that should be considered when looking for control solutions.

3.2.1 Substitution of other working methods

It may be possible to find alternative work methods that eliminate or reduce exposure to vibration. This may involve mechanisation or automation of tasks, or substitution of alternative work processes. To keep up-to-date on the methods available you should check regularly with:

- your trade association;
- other industry contacts;
- equipment suppliers;
- trade journals.

3.2.2 Equipment selection

You should make sure 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 to complete the task and expose employees to vibration for longer than is necessary.

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 you should check regularly with:

- equipment suppliers;
- your trade association;
- other industry contacts;
- trade journals.

3.2.3 Purchasing policy

Make sure your purchasing department has a policy on purchasing suitable equipment, that takes into account both vibration emission, and your operating requirements.
Power tool manufacturers (and 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. They have duties to reduce risks from vibration to a minimum and to help you with information on managing vibration risks that they have been unable to eliminate by design.

Anyone supplying power tools for use in Europe must comply with the Machinery Directive (Directive 98/37/EC). The supplier should also offer technical support where required, including advice on:

- the vibration emission (as reported in the instruction handbook);
- how the emission value has been obtained;
- any vibration reduction features, and
- any circumstances under which the equipment can generate hand-arm vibration exposures above the exposure action value;
- any circumstances under which the equipment can generate hand-arm vibration exposures above the exposure limit value;
- any applications of the equipment that are believed to increase the risk of hand-arm vibration injury;
- how to use the equipment safely and any training requirements for this,
- any training (to operators, maintenance staff etc.) recommended to control hand-arm vibration exposures;
- how to use the equipment for specific tasks,
- the need for any personal protective equipment when operating the machinery.
- how to maintain the tool in good condition;

When selecting tools, you should also consider ergonomic factors and other hazards such as:

- tool weight,
- handle design and comfort,
- grip forces,
- ease of use and handling
- cold from grip surfaces or from exhaust air on pneumatic tools
- noise and
- dust.

Manufacturers or suppliers may be willing to loan sample tools on trial. Make use of this opportunity and take account of employees’ opinions based on practical trials. The efficiency of the tool is 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 that are too powerful for the job could result in exposure to unnecessarily high vibration magnitudes.
3.2.4 Workstation design

Jigs and anti-vibration handles

Jigs and similar aids incorporating anti-vibration mounts can help avoid the need to hold vibrating surfaces.

'Anti-vibration' handles may reduce the vibration, but incorrect selection of this type of handle may actually increase the vibration at the hand, so only use handles that are endorsed by the tool manufacturer.

Resilient materials

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

Grip and push forces

Reducing the gripping or pushing forces exerted through the hand reduces the vibration passing into the user's hand and arm. These forces may 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.

Some methods of reducing grip and push forces are:

- where heavy workpieces are ground by hand at pedestal grinders, support for the whole piece will mean that the worker needs only to guide it onto the wheel, rather than support all the weight;
- 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;
- changes in the texture and material of a grip surface may allow the operator to use a smaller grip force to hold and control the tool.

3.2.5 Maintenance

Regular servicing of power tools and other work equipment will often help keep vibration magnitudes down to the minimum necessary, so:

- keep cutting tools sharp;
- dress grinding wheels correctly by following the manufacturer’s recommendations;
- lubricate any moving parts in accordance with manufacturer’s recommendations
• replace worn parts;
• carry out necessary balance checks and corrections;
• replace anti-vibration mounts and suspended handles before they deteriorate. (look for deterioration or the cracking, swelling and softening, or hardening, of rubber mounts);
• check and replace defective vibration dampers, bearings and gears;
• sharpen chainsaw teeth and keeping the correct chain tension;
• tune engines.

3.2.6 Training and information to workers

It is important that you provide operators and supervisors with information on:

• the potential injury arising from the work equipment in use;
• the exposure limit values and the exposure action values;
• the results of the vibration risk assessment and any vibration measurements;
• the control measures being used to eliminate or reduce risks from hand-arm vibration;
• safe working practices to minimise exposure to mechanical vibration;
• why and how to detect and report signs of injury;
• the circumstances in which workers are entitled to health surveillance.

You will be relying on the operators of vibrating tools and processes to make your control measures effective. You should consult with the workers and their representatives when implementing control measures. Workers have a duty to cooperate when you take action to comply with European health and safety directives.

Workers should be trained in working techniques, for example to help avoid excessive gripping, pushing and guiding forces and to ensure the tools are operated safely and with optimum efficiency. They will also need to be trained to recognise when a machine is in need of maintenance.

With some tools, the operator’s hands must 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 whilst operating, e.g. to remove the pick from a hole)

The manufacturer should advise you of any training requirements, and may offer training for operators. Workers can also be encouraged to rest the tool as much as possible on the material being worked (or in the case of hand-held workpieces, on any support provided) and to hold it with a light but safe grip.

Training and supervision will be required to ensure that workers are protecting themselves against the development of vibration-related disease. They should be encouraged to report any symptoms that may be associated with vibration or the use of power tools, etc. If they are taking part in a health surveillance scheme then this
may provide a regular opportunity for one-to-one discussion of the vibration hazard and how to reduce the risk of injury.

3.2.7 Work schedules

To control the risks from hand-arm vibration you may need to limit the time workers are exposed to vibration from some tools or processes. It is recommended that you plan work to avoid workers being exposed to vibration for long, continuous periods.

3.2.8 Clothing and 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.

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 10819:1997. However, this standard does not provide detailed performance data for gloves, therefore you must separately assess the protection offered by anti-vibration gloves, as required by the Personal Protective Equipment at Work Directive 1992.

Anti-vibration gloves do not provide significant risk reduction at frequencies below 150Hz (9000 revs per minute). 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 vibrations 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.

Protection from cold

Low body temperature increases the risk of finger blanching because of the reduced blood circulation. You should therefore avoid outdoor working in cold weather if you can. The temperature in an indoor workplace should provide reasonable comfort without the need for special clothing and should normally be at least 16°C. You should avoid machines that might make the hands cold, e.g. steel-bodied machines or pneumatic tools that blow exhaust air over the operator’s hands.

You 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.
3.3 Monitoring and reassessment

Management of vibration exposure is an ongoing process, you need ensure that the control systems are being used and that they are giving the expected results.

In this chapter we look at how to monitor the vibration controls and when to repeat the risk assessment.

3.3.1 How do I know if my hand-arm vibration controls are working?

You will need to review your hand-arm vibration controls periodically to ensure they are still relevant and effective. You should:

- Check regularly that managers and employees are still carrying out the programme of controls you have introduced;
- Talk regularly to managers, supervisors, employees and safety or employee representatives about whether there are any vibration problems with the equipment or the way it is being used;
- Check the results of health surveillance and discuss with the health service provider whether the controls appear to be effective or need to be changed.

3.3.2 When do I need to repeat the risk assessment?

You will need to reassess risks from vibration, and how you control them, whenever there are changes in the workplace that may affect the level of exposure, such as:

- the introduction of different machinery or processes
- changes in the work pattern or working methods
- changes in the number of hours worked with the vibrating equipment
- the introduction of new vibration control measures.

You will also need to reassess the risks if there is evidence (e.g. from health surveillance) that your existing controls are not effective.

The extent of the reassessment will depend on the nature of the changes and the number of people affected by them. A change in hours or work patterns may require a recalculation of the daily exposure for the people affected, but will not necessarily alter the vibration magnitudes. The introduction of new machinery or processes may require a full reassessment.

It is good practice to review your risk assessment and work practices at regular intervals, even if nothing obvious has changed. There may be new technology, tool designs or ways of working in your industry that would allow you to reduce risks further.
CHAPTER 4 HEALTH SURVEILLANCE

Health surveillance is about putting in place systematic, regular and appropriate procedures to detect early signs of work-related ill health, and acting on the results. The aims are primarily to safeguard the health of workers (including identifying and protecting individuals at increased risk), but also to check the long-term effectiveness of control measures.

It is impossible to provide definitive guidance on health surveillance in this guide, due to differences in health surveillance practices across the European Union. In this chapter we re-state the requirements for health surveillance given in the vibration directive and review some of the assessment techniques available.
4.1 When is health surveillance required?

Member States shall adopt provisions to ensure the appropriate health surveillance of workers where the hand-arm vibration risk assessment indicates a risk to their health. The provision of health surveillance, including the requirements specified for health records and their availability, shall be introduced in accordance with national laws and/or practice.

Employers should provide appropriate health surveillance where the risk assessment indicates a risk to workers’ health. Health surveillance should be instituted for workers who are at risk from vibration injury, where:

- the exposure of workers to vibration is such that a link can be established between that exposure and an identifiable illness or harmful effects on health,
- it is probable that the illness or the effects occur in a worker’s particular working conditions, and
- there are tested techniques for the detection of the illness or the harmful effects on health.

In any event, workers whose daily vibration exposure exceeds the daily exposure action value are entitled to appropriate health surveillance.
4.2 What techniques are available?

Health surveillance should consist of an evaluation of the case history for a worker in conjunction with a physical examination conducted by a qualified physician. Additional clinical tests and investigations may be appropriate in some cases.

Questionnaires for hand-arm vibration health surveillance are available from various sources (e.g. www.humanvibration.com/EU/VINET).

The case history

The case history should focus on:

- family history,
- social history, including smoking habit and alcohol consumption,
- work history, including past and current occupations with exposure to hand-transmitted vibration, previous jobs with exposure to neurotoxic or angiotoxic agents and any leisure activities involving the use of vibrating tools or machines,
- personal health history.

The physical examination

A physical examination should look in detail at the peripheral vascular, neurological, and musculoskeletal systems, and should be performed by a qualified physician

Clinical tests

In general, clinical tests do not provide reliable proof of vibration injury, however, they may be helpful to support a diagnosis hand-arm vibration syndrome or to monitor progression of injury.

Tests for the peripheral vascular system include the Lewis-Prusik test, the Allen test, and the Adson test.

Tests for the peripheral nervous system include the evaluation of manual dexterity (e.g. coin recognition and pick up), the Roos test, the Phalen’s test and the Tinel’s sign (for carpal tunnel compression).
Vascular investigations

The vascular assessment of the hand-arm vibration syndrome is mainly based on cold provocation tests: assessing changes in finger colour, recording recovery times of finger skin temperature, and measuring finger systolic blood pressure. Other non-invasive diagnostic tests, such as Doppler recording of arm and finger blood-flow and pressure, may also be useful.

Neurological investigations

The neurological assessment of the hand-arm vibration syndrome includes several tests:

- Vibration perception thresholds
- Tactile sensitivity (gap detection)
- Thermal perception thresholds
- Nerve conduction velocities in the upper and lower limbs.
- Electromyography.
- Fingertip dexterity (Purdue pegboard).

Muscle strength investigations

The evaluation of muscle force in the hand can be performed by means of a dynamometer to measure grip strength and a pinch gauge to measure pinch strengths.

Radiological investigations

X-rays of the shoulders, elbows, wrists and hands for a radiological diagnosis of bone and joint disorders are usually required in those countries in which vibration-induced osteoartropathy in the upper limbs is recognised as an occupational disease.

Laboratory tests

Blood and urine analyses may be necessary in some case to distinguish vibration injury from other vascular or neurological disorders.
4.3 What recording is required?

Member States shall establish arrangements to ensure that, for each worker who undergoes health surveillance individual health records are made and kept up-to-date. Health records shall contain a summary of the results of the health surveillance carried out. They shall be kept in a suitable form so as to permit any consultation at a later date, taking into account any confidentiality.

Copies of the appropriate records shall be supplied to the competent authority on request. The individual worker shall, at their request, have access to the health records relating to them personally.
4.4 What to do if injury is identified?

The health surveillance, may identify a worker with an identifiable disease or adverse health effect which is considered by a doctor or occupational health-care professional to be the result of exposure to hand-arm vibration at work. Where such a worker is identified then information must be provided to the worker and the employer; the employer must take action to prevent further injury.

**Information for the worker**

The worker shall be informed, by the doctor or other suitably qualified person, of the results of their own personal health surveillance. In particular, workers shall be given information and advice regarding any health surveillance that they should undergo following the end of exposure.

**Information for the employer**

The employer shall be informed of any significant findings from the health surveillance, taking into account any medical confidentiality.

**Employer actions**

- Review the hand-arm vibration risk assessment,
- Review the measures provided to eliminate or reduce risks from hand-arm vibration exposure,
- Take into account the advice of the occupational healthcare professional or other suitably qualified person or the competent authority in implementing any measures required to eliminate or reduce risks from hand-arm vibration exposure, including the possibility of assigning the worker to alternative work where there is no risk of further exposure, and
- Arrange continued health surveillance and provide for a review of the health status of any other worker who has been similarly exposed. In such cases, the competent doctor or occupational health care professional or the competent authority may propose that exposed persons undergo a medical examination.
ANNEX A HEALTH RISKS, SIGNS AND SYMPTOMS

Workers exposed regularly to excessive hand-transmitted vibration may suffer in the long term with disturbances to finger blood flow and to the neurological and locomotor functions of the hand and arm. The term *hand-arm vibration syndrome* is used to refer to these complex disorders.

Hand-arm vibration syndrome has an impact on social and family life. Periodic attacks of impaired blood circulation will take place not only at work, but also during activities such as car washing or watching outdoor sports. Everyday tasks, for example managing small buttons on clothes may become difficult.

Vascular disorders, neurological disorders and bone and joints abnormalities caused by hand-transmitted vibration are recognized occupational diseases in several European countries.

### A.1 Vascular disorders

Workers exposed to hand-transmitted vibration may complain of episodes of whitening (blanching) of the fingers, usually triggered by cold exposure. This symptom is caused by temporary closing down of blood circulation to the fingers.

Various terms have been used to describe vibration-induced vascular disorders:

- dead or white finger,
- Raynaud’s phenomenon of occupational origin,
- vibration-induced white finger.

Initially attacks of blanching involve the tips of one or more fingers, but, with continued exposure to vibration, the blanching can extend to the base of the fingers. As the blood flow returns to the fingers (this is commonly initiated by warmth or local massage) the fingers turn red, and are often painful. The blanching attacks are more common in winter than in summer. The duration varies with the intensity of the vibration stimuli from a few minutes to more than one hour.

If vibration exposure continues, the blanching attacks become more frequent affecting more of the fingers. The attacks may occur all year around with quite small reductions of temperature. During a blanching attack the affected worker can experience a complete loss of touch sensation and manipulative dexterity, which can interfere with work activity increasing the risk for acute injuries due to accidents.

Epidemiological studies have demonstrated that the probability and severity of blanching is influenced by the characteristics of vibration exposure and duration of exposure, the type of tool and work process, the environmental conditions (temperature, air flow, humidity, noise), some biodynamic and ergonomic factors (grip force, push force, arm position), and various individual characteristics.
(individual susceptibility, diseases and agents such as smoking and certain medicines that affect peripheral circulation).

A.2 Neurological disorders

Workers exposed to hand-transmitted vibration may experience tingling and numbness in their fingers and hands. If vibration exposure continues, these symptoms tend to worsen and can interfere with work capacity and life activities. Vibration-exposed workers may exhibit a reduction in the normal sense of touch and temperature as well as an impairment of manual dexterity.

A.3 Carpal-tunnel syndrome

Epidemiological research in workers has also shown that use of vibrating tools in combination with repetitive movements, forceful gripping, awkward postures may increase the risk of carpal tunnel syndrome.

A.4 Musculoskeletal disorders

Workers with prolonged exposure to vibration may complain of muscular weakness, pain in the hands and arms, and diminished muscle strength. These disorders seem to be related to ergonomic stress factors arising from heavy manual work.

Excess occurrence of wrist and elbow osteoarthritis as well as hardening of soft tissue (ossification) at the sites of tendon attachment, mostly at the elbow, have been found in miners, road construction workers and metal-working operators of percussive tools.

Other work-related disorders have been reported in vibration-exposed workers, such as inflammation of tendons (tendonitis) and their sheaths in the upper limbs, and Dupuytren's contracture, a disease of the fascial tissues of the palm of the hand.
ANNEX B WHAT IS VIBRATION?

B.1 What is vibration?

Vibrations arise when a body moves back and forth due to external and internal forces [Figure B.1]. In the case of hand-arm vibration, the handle of a machine or the surface of a work piece vibrates rapidly back and forth, and this motion is transmitted into the hand and arm.

![Figure B.1 Oscillation of the hand while sawing wood](image)

B.2 What is measured?

Vibration is defined by its magnitude and frequency. The magnitude of vibration could be expressed as the vibration displacement (in meters), the vibration velocity (in meters per second) or the vibration acceleration (in meters per second per second or m/s²). Most vibration transducers produce an output that is related to acceleration; so acceleration has traditionally been used to describe vibration.

To get a complete picture of the vibration on a surface, vibration must be measured in three axes, as illustrated in Figure B.2.
Figure B.2 Vibration measurement axes

B.3 What is frequency and frequency-weighting?

Frequency is the number of times per second the vibrating body moves back and forth. It is expressed as a value in cycles per second, more usually known as hertz (abbreviated to Hz). For rotating tools the dominant frequency is usually determined by the speed at which the tool rotates (usually expressed as the number of revolutions per minute or rpm; dividing the rpm by 60 gives the frequency in Hz).

For hand-arm vibration, the frequencies thought to be important range from about 8Hz to 1000Hz. However, because the risk of damage to the hand is not equal at all frequencies a frequency-weighting is used to represent the likelihood of damage from the different frequencies. As a result, the weighted acceleration decreases when the frequency increases. For hand-transmitted vibration, only one frequency-weighting curve is used for all three measuring.

B.4 What parameters are used for exposure assessment?

From each vibration axis a frequency-weighted root-mean-square average acceleration is measured. This is referred to as $a_{hw}$. The value used for assessment of exposure is the vibration total value, which combines the three $a_{hw}$ values for the axes x, y and z, using:

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$
B.5 What instrumentation should be used?

Hand-arm vibration measuring equipment should comply with the EN ISO 8041:2005 specifications for hand-arm vibration measuring instruments. It is important that accelerometers (vibration transducers) are carefully selected. The vibration on hand-held and hand-guided machines can be very high and can easily overload unsuitable transducers. Fixing transducers to the machine handles requires mounting systems that are rigid, lightweight and compact. Further information and guidance on transducer selection and mounting methods can be found in EN ISO 5349-2:2001.

Further reading:

ANNEX C TOOLS FOR CALCULATING DAILY EXPOSURES

C.1 Web-based tools

Some web-based calculators are available that simplify the process of doing daily vibration exposure calculations, e.g.:

www.hse.gov.uk/vibration/calculator.htm

http://vibration.arbetslivsinstitutet.se/eng/havcalculator.lasso.

C.2 Daily exposure graph

The graph in Figure C.1 gives a simple alternative method for looking up daily exposures or partial vibration exposures without the need for a calculator.

Simply look on the graph for the A(8) line at or just above where your vibration magnitude value and exposure time lines meet.

C.3 Daily exposure nomogram

The nomogram in Figure C.2 provides a simple alternative method of obtaining daily vibration exposures, without using the equations. For each tool or process:

1. Draw a line from a point on the left hand scale (representing the vibration magnitude) to a point on the right hand scale (representing the exposure time);
2. Read off the partial exposures where the lines cross the central scale;
3. Square each partial vibration exposure value;
4. Add the squared values together;
5. Take the square root of the result to give the overall A(8) daily vibration exposure value.

C.4 Exposure points system

Hand-arm vibration exposure management can be simplified by using an exposure “points” system. For any tool or process, the number of exposure points accumulated in an hour \( P_{E,1h} \) can be obtained from the vibration magnitude \( a_{hv} \) using:

\[
P_{E,1h} = 2a_{hv}^2
\]

Exposure points are simply added together, so you can set a maximum number of exposure points for any person in one day.

The exposure scores corresponding to the exposure action and limit values are:

- exposure action value (2.5 m/s²) = 100 points;
- exposure limit value (5 m/s²) = 400 points.
C.5  Traffic light system

Some employers, working with machine manufacturers and suppliers, have developed a green / amber/ red “traffic light” system, where each tool is clearly marked with a hand-arm vibration colour coding, illustrated in Table C.1.

Workers are given training in the colour-coding scheme so that they can select vibration tools at a glance and know how long they can use the tool.

**Table C.1 Example of colour coding scheme for traffic-light system**

<table>
<thead>
<tr>
<th>Colour code</th>
<th>In use vibration magnitude</th>
<th>Time to reach EAV (2.5m/s²)</th>
<th>Time to reach EAV (5m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>0 to 5 m/s²</td>
<td>More than 2 hours</td>
<td>More than 8 hours</td>
</tr>
<tr>
<td>Amber</td>
<td>5 to 10 m/s²</td>
<td>30 minutes to 2 hours</td>
<td>2 to 8 hours</td>
</tr>
<tr>
<td>Red</td>
<td>&gt;10</td>
<td>Less than 30 mins</td>
<td>Less than 2 hours</td>
</tr>
</tbody>
</table>

The traffic light scheme may be based on measurements or manufacturer’s declaration of vibration emission. If the vibration emission value is used, it should be multiplied by a factor of between 1 and 2, to account for uncertainty in the results from the standardised emission tests (see Chapter 2.3.1).
**Figure C.1 Daily exposure graph**

Example:
4m/s² for 4 hours 30mins gives \( A(8) = 3 \text{m/s}^2 \).
Instructions:

For each exposure, draw a line between the weighted acceleration and the exposure time. Read off either the partial vibration exposure $A(8)$, or the exposure points $n$, from the point where the line crosses the centre scale. Enter the values in the appropriate table below.

For $A(8)$ values:

Square and add the $A(8)$ values
Square-root the result to give the daily vibration exposure $A(8)$.

For $n$ values:

Add the score values to give a total daily points, $n$
Use the centre scale to convert the $n$ value to $A(8)$

Figure C.2 hand-arm vibration exposure nomogram
ANNEX D GLOSSARY

Hand-arm vibration  The mechanical vibration that, when transmitted to the human hand-arm system, entails risks to the health and safety of workers, in particular vascular, bone or joint, neurological or muscular disorders.

Declared vibration emission  The vibration value provided by machine manufacturers to indicate the vibration likely to occur on their machines. The declared vibration emission value should be obtained using a standardised test code, and has to be included in the machine’s instructions.

Frequency-weighting .... A correction applied to vibration measurements (often using a filter) to allow for the assumed frequency dependence of the risk of damage to the body. The $W_h$ weighting (defined in EN ISO 5349-1:2001) is used for hand-arm vibration.

Daily vibration exposure, $A(8)$  The continuous equivalent acceleration, normalised to an 8 hour day, the $A(8)$ value is based on root-mean-square averaging of the acceleration signal and has units of m/s².

Partial vibration exposure, $A_i(8)$  The continuous equivalent acceleration for a specific tool or process, normalised to an 8 hour day (where a worker is only exposed to vibration form one tool or process then the daily vibration exposure is equal to the partial vibration exposure).

Health surveillance........ A programme of health checks on workers to identify early effects of injury resulting from work activities.

Exposure action value ... A value for a workers daily vibration exposure of 2.5m/s², above which the risks from vibration exposure must be controlled.

Exposure limit value ..... A value for a workers daily vibration exposure of 5m/s², above which employees should not be exposed.
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INDEX

A
accelerometers ..................................40
anti-vibration gloves ..........................28
Anti-vibration gloves ..........................28
anti-vibration mounts ..........................26
average vibration ...............................19

B
balancers ..........................................26

C
Carpel-tunnel syndrome .......................37
case history .......................................32
Clinical tests .....................................32
Clothing .............................................28
cold provocation tests .........................33
colour coding ......................................42
Continuous tool operation .....................14
controlling exposure ................................23

daily vibration exposures .....................41
declared emission value .......................16
dominant frequency .............................39
Dupuytren's contracture .......................37
duration of exposure ............................11

E
Equipment selection .............................24
exposure action value ..........................6, 41
exposure duration ..................................14
exposure limit value .............................6, 41
Exposure points .....................................41

F
Framework Directive ...........................7
frequency ...........................................39
frequency-weighted acceleration ...........19
frequency-weighting .............................39

G
Grip and push forces ............................26

H
hammer-action ...................................12
hand-arm vibration syndrome ..............6, 36
health records .....................................34
Health Surveillance ...............................30

I
impact .................................................12
impact wrench .....................................14
Intermittent tool operation .....................14

L
Laboratory tests .....................................33

M
Machinery Directive .............................25
magnitude ..........................................11
maintenance ........................................25
Maintenance .........................................26
manufacturer .......................................25, 27
manufacturer’s emission data ...............16
Measurement of vibration magnitude .........18
monitoring and reassessment .................29
Muscle strength investigations ..............33
muscular weakness ...............................37
Musculoskeletal disorders ......................37

N
Neurological disorders ........................37
Neurological investigations .................33
nomogram ............................................41
numbness ...........................................12

P
partial vibration exposure ....................20, 21
percussive ..........................................12
personal protection ................................28
personal protective equipment ..............25
physical examination ............................32
Purchasing policy .................................24
Purdue pegboard ...................................33

R
Radiological investigations ...................33
ranking ...............................................23
Raynaud's phenomenon .......................36
reassessment .......................................29
resilient materials ...............................26
risk assessment .....................................11
rotary action tools ...............................12

S
Substitution .........................................24
supplier .............................................. 25

T
Tactile sensitivity .................................. 33
tendonitis ........................................... 37
tension chains ...................................... 26
tingling .............................................. 12
trade association ............................. 17, 24
Traffic light system ......................... 42
training .............................................. 25
Training and information to workers 27
training and supervision ...................... 27
Transitional periods ............................ 6

U
Uncertainty ......................................... 21

V
Vascular disorders ................................ 36
Vascular investigations ....................... 33
vibration controls .............................. 29
Vibration Directive ............................. 7
vibration emission .............................. 25, 42
vibration exposure ............................. 20, 23
vibration magnitude .......................... 20
Vibration perception thresholds ............ 33
vibration reduction features ............... 25
vibration risk assessment ................... 35
vibration test codes .......................... 16
vibration total value ......................... 39
vibration-induced white finger ............ 36

W
warm clothing .................................... 28
Work patterns .................................... 14
Work schedules ................................. 28
Workstation design ............................ 26