



Non binding guide to good practice for implementing Directive 2002/44/EC (Vibrations at Work)



**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)**

European Commission

Directorate-General for Employment, Social Affairs and Equal Opportunities

Unit F.4

Manuscript completed in August 2007

Neither the European Commission nor any person acting on behalf of the Commission may be held responsible for the use that may be made of the information contained in this publication.



© 1: Health & Safety Laboratory - UK

© 2: FreeFoto.com

© 3: Freephoto1.com

© 4: Health & Safety Laboratory - UK

**Europe Direct is a service to help
you find answers to your questions
about the European Union**

**Freephone number (*):
00 800 6 7 8 9 10 11**

(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed.

A great deal of additional information on the European Union is available on the Internet. It can be accessed through the Europa server (<http://europa.eu>).

© European Communities, 2008

Reproduction is authorised provided the source is acknowledged.

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2008

ISBN 978-92-79-07533-9

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

FOREWORD

To create more jobs has always been an objective of the European Union. This objective was formally adopted by the Council at the Lisbon European Council in March 2000 and it is one of the key elements to enhance the quality of work.

Adoption of legislative measures is part of the commitment to include health and safety of workers at work in the global approach to well-being at work. In this framework, the European Commission combines a variety of instruments to consolidate a real culture of risk prevention.

This guide of good practice is one of those instruments.

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 gives 'exposure limit values' and 'exposure action values'. It also specifies employers' obligations with regard to determining and assessing risks, sets out the measures to be taken to reduce or avoid exposure and details how to provide information and training for workers. Any employer who intends to carry out work involving risks arising from exposure to vibration must implement a series of protection measures before and during the work.

The Directive also requires the Member States of the EU to put in place a suitable system for monitoring the health of workers exposed to risks arising from vibration. The evaluation and assessment of risks arising from exposure to vibration and the implementation of protection measures can be complicated. This non-binding "guide to good practice" will facilitate the assessment of risks from exposure to hand-arm and whole-body vibrations, the identification of controls to eliminate or reduce exposure, and the introduction of systems to prevent the development and progression of injury.

CONTENTS

Acknowledgments	6
PART I GUIDE TO GOOD PRACTICE ON HAND-ARM VIBRATION.....	7
Chapter 1 Introduction.....	11
Chapter 2 Evaluation of risk.....	15
Chapter 3 Removing or reducing exposure.....	23
Chapter 4 Health Surveillance.....	31
Annexes A-H	33
Index	53
PART II GUIDE TO GOOD PRACTICE ON WHOLE-BODY VIBRATION	57
Chapter 1 Introduction.....	61
Chapter 2 Evaluation of risk	65
Chapter 3 Avoiding or reducing exposure.....	75
Chapter 4 Health Surveillance.....	81
Annexes A-H	83
Index	105
DIRECTIVE 2002/44/EC.....	107

ACKNOWLEDGMENTS

This guide is based on the project which has been produced by:

- ISVR: Professor M.J. Griffin & Dr H.V.C. Howarth
Institute of Sound and Vibration Research
University of Southampton, U.K.
- HSL: Mr P. M. Pitts
Health and Safety Laboratory
U.K.
- BGIA: Dr S. Fischer & Mr U. Kaulbars
Berufsgenossenschaftliches Institut für Arbeitsschutz,
Germany.
- INRS: Dr P.M. Donati
Institut National de Recherche et de Sécurité,
France.
- HSE: Mr P.F. Bereton
Health and Safety Executive
U.K.

This team has been selected on the basis of a call for tender issued by the European Commission.

The work has been performed under the supervision of:

Unit "Health, Safety and Hygiene at Work" of Commission's Directorate general Employment, Social Affairs and Equal Opportunities and the Working Party "Vibration" mandated by the Advisory Committee on Safety and Health at Work.¹

Note: The authors of the project for this guide would also like to acknowledge the information generated by two EC-funded Projects, which has been used in preparing this guide:

- VIBRISKS: Risks of Occupational Vibration Exposures,
EC FP5 project no. QLK4-2002-02650.
- VINET: Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures,
EC Biomed II project no. BMH4-CT98-3251.

¹ Council Decision of 22 July 2003 (O.J. C218 of 13.09.2003, page 1)



PART I Guide to good practice on Hand-Arm Vibration

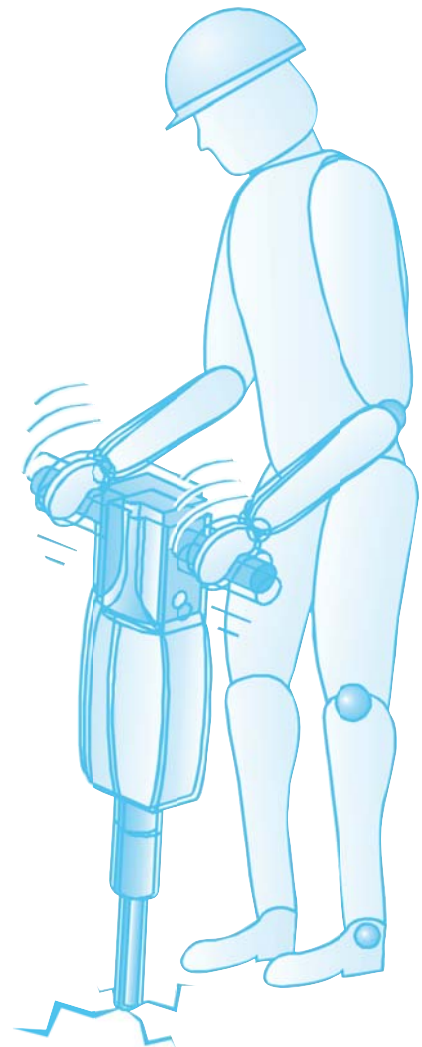


TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION	11
CHAPTER 2 EVALUATION OF RISK.....	15
2.1 THE BASICS OF RISK ASSESSMENT	15
2.2 DETERMINING EXPOSURE DURATION.....	18
2.3 VIBRATION MAGNITUDE.....	19
2.3.1 Use of manufacturer's emission data.....	19
2.3.2 Use of other data sources.....	20
2.3.3 Measurement of vibration magnitude	20
2.4 CALCULATING DAILY VIBRATION EXPOSURES.....	22
2.4.1 Daily Vibration Exposure.....	22
2.4.2 Partial Vibration Exposures.....	22
2.4.3 Uncertainty of daily exposure evaluations	22
CHAPTER 3 REMOVING OR REDUCING EXPOSURE	23
3.1 DEVELOPING A CONTROL STRATEGY.....	23
3.2 CONSULTATION AND PARTICIPATION OF WORKERS.....	24
3.3 RISK CONTROLS	25
3.3.1 Substitution of other working methods.....	25
3.3.2 Equipment selection.....	25
3.3.3 Purchasing policy	25
3.3.4 Workstation design	26
3.3.5 Training and information to workers.....	27
3.3.6 Work schedules.....	27
3.3.7 Collective measures	27
3.3.8 Clothing and personal protection.....	28
3.3.9 Maintenance.....	28

3.4 MONITORING AND REASSESSMENT.....	29
3.4.1 <i>How do I know if my hand-arm vibration controls are working?</i>	29
3.4.2 <i>When do I need to repeat the risk assessment?</i>	29
CHAPTER 4 HEALTH SURVEILLANCE	31
4.1 WHEN IS HEALTH SURVEILLANCE REQUIRED?	31
4.2 WHAT RECORDING IS REQUIRED?	31
4.3 WHAT TO DO IF INJURY IS IDENTIFIED?	31
ANNEX A Summary of responsibilities defined by Directive 2002/44/EC	33
ANNEX B What is vibration?	34
ANNEX C Health risks, signs and symptoms.....	37
ANNEX D Tools for calculating daily exposures.....	38
ANNEX E Worked Examples	43
ANNEX F Health Surveillance techniques	45
ANNEX G Glossary	47
ANNEX H Bibliography.....	48
INDEX	53

CHAPTER 1 INTRODUCTION

EU Directive 2002/44/EC (the 'Vibration Directive') places responsibilities on employers to ensure that risks from hand-arm vibration are eliminated or reduced to a minimum (these responsibilities are summarised in Annex A).

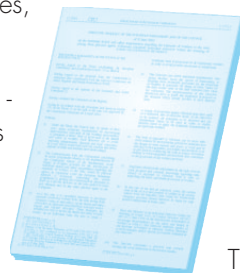
This guide is intended to help employers identify hand-arm vibration hazards, assess exposures and risks and identify measures for safeguarding the health and safety of workers exposed to hand-arm vibration risks.

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

Hand-arm vibration is caused by vibration transmitted into the hand and arms through the palm and fingers (see Annex B). Workers whose hands are regularly exposed to hand-arm vibration may suffer from damage to the tissues of the hands and arms, which cause the symptoms collectively known as hand-arm vibration syndrome, see Annex C.

The risks from hand-arm vibration 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 'Vibration Directive' (Directive 2002/44/EC - see "Further reading" box) sets minimum standards for controlling the risks from hand-arm vibration. The Vibration Directive requires that member states of the European Union implement national legislation to implement the requirements of the Directive by 6th July 2005. National legislation may apply more favourable provisions than those required by the Directive, and should not reduce the protection afforded to workers by any pre-existing national legislation.



The Vibration Directive sets an exposure action value for daily vibration exposure, above which it requires employers to control the hand-arm vibration risks of their workforce and an exposure limit value above which workers must not be exposed²:

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

However, there is some risk of hand-arm vibration injury where exposures are below the exposure action value. The Vibration Directive places responsibilities on employers to ensure that risks from hand-arm vibration are eliminated or reduced to a minimum. These responsibilities are summarised in Annex A.

The Vibration Directive is a daughter Directive of the Framework Directive (Directive 89/391/EEC - see "Further reading" box) as such many of the requirements of the Vibration Directive are derived from, and make specific reference to, the Framework Directive.

This guide will help employers comply with the "Vibration Directive" as it applies to hand-arm vibration. The guide is intended to cover the methodology used for determining and evaluating risks; dealing with the choice and correct use of work equipment,

² Member states are entitled (after consultation with the two sides of industry) to apply transitional periods to the exposure limit value 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). The transitional periods only apply to the use of machinery supplied prior to 6th July 2007 for which (taking into account all available technical or organisational means to control the risk) the exposure limit value cannot be respected.

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. The structure for this guide is shown in the flow diagram of [Figure 1](#).

Further reading:

Vibration Directive:

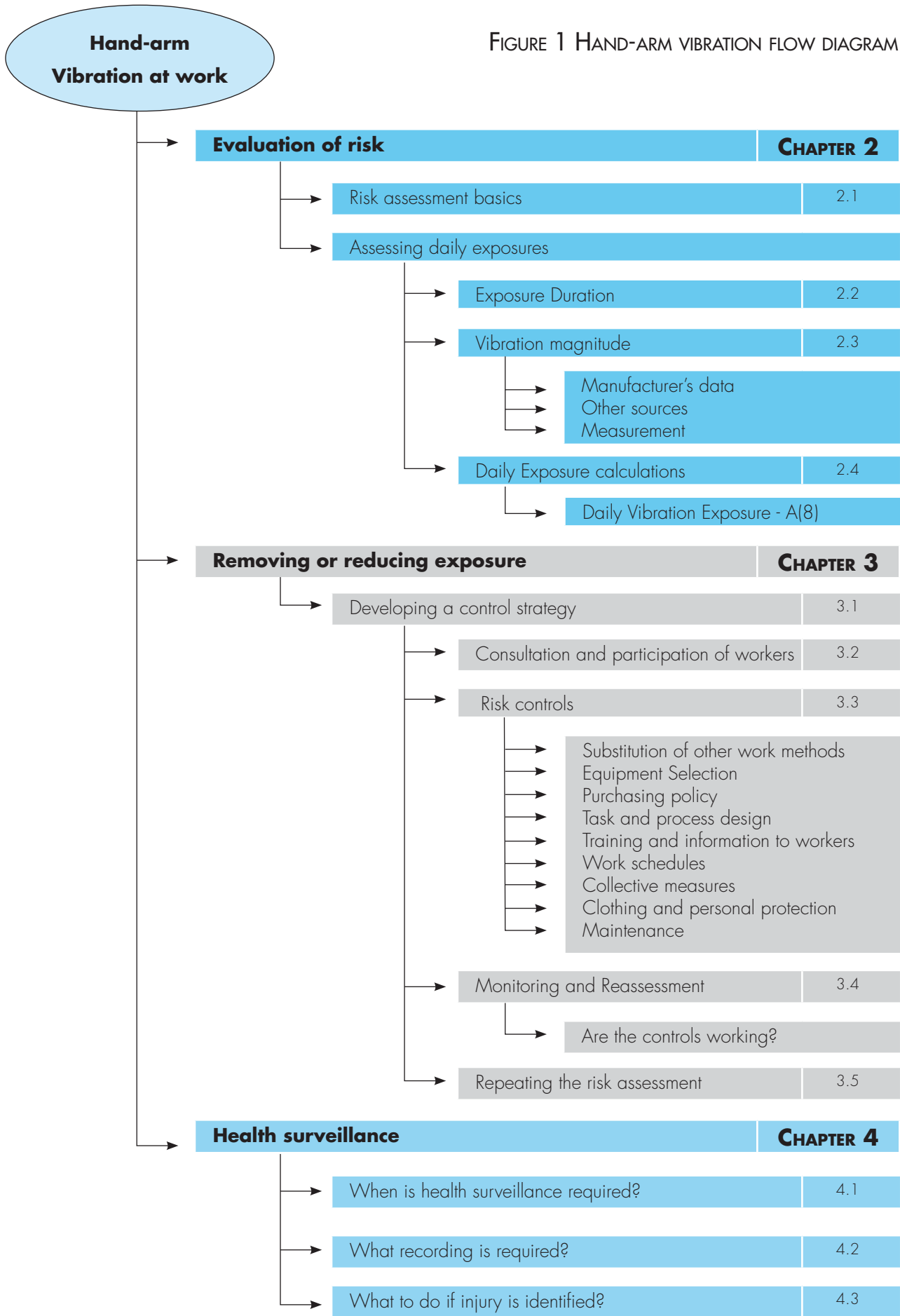
Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002 *on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)*.

(Published in the Official Journal of the European Communities L 177 of 6 July 2002, page 13)

Framework Directive:

Directive 89/391/EEC of the European Parliament and of the Council of 12 June 1989 *on the introduction of measures to encourage improvements in the safety and health of workers at work*.

FIGURE 1 HAND-ARM VIBRATION FLOW 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 risks from 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 workers' 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 work being carried out, the processes involved and the tools and equipment used, and to 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 1](#). [Figure 2](#), shows sample vibration magnitudes of some of the tools and machines that create the risks.

It is important to keep workers and their representatives involved and informed in the assessment of vibration risk. An effective partnership with workers will help to ensure 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 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 1 SOME QUESTIONS TO HELP DECIDE WHETHER FURTHER ACTION IS NEEDED

Do you use rotary action tools (e.g. grinders, polishers)?

Some rotary action tools can exceed the exposure action value within about half an hour and you should certainly be taking action if individual workers are using them for more than about 2 hours per day.

Do you use impact or percussive tools (i.e. hammer-action tools)?

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 workers are using them for more than about half an hour per day.

Do the manufacturers or suppliers of your tools warn of a risk from vibration?

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.

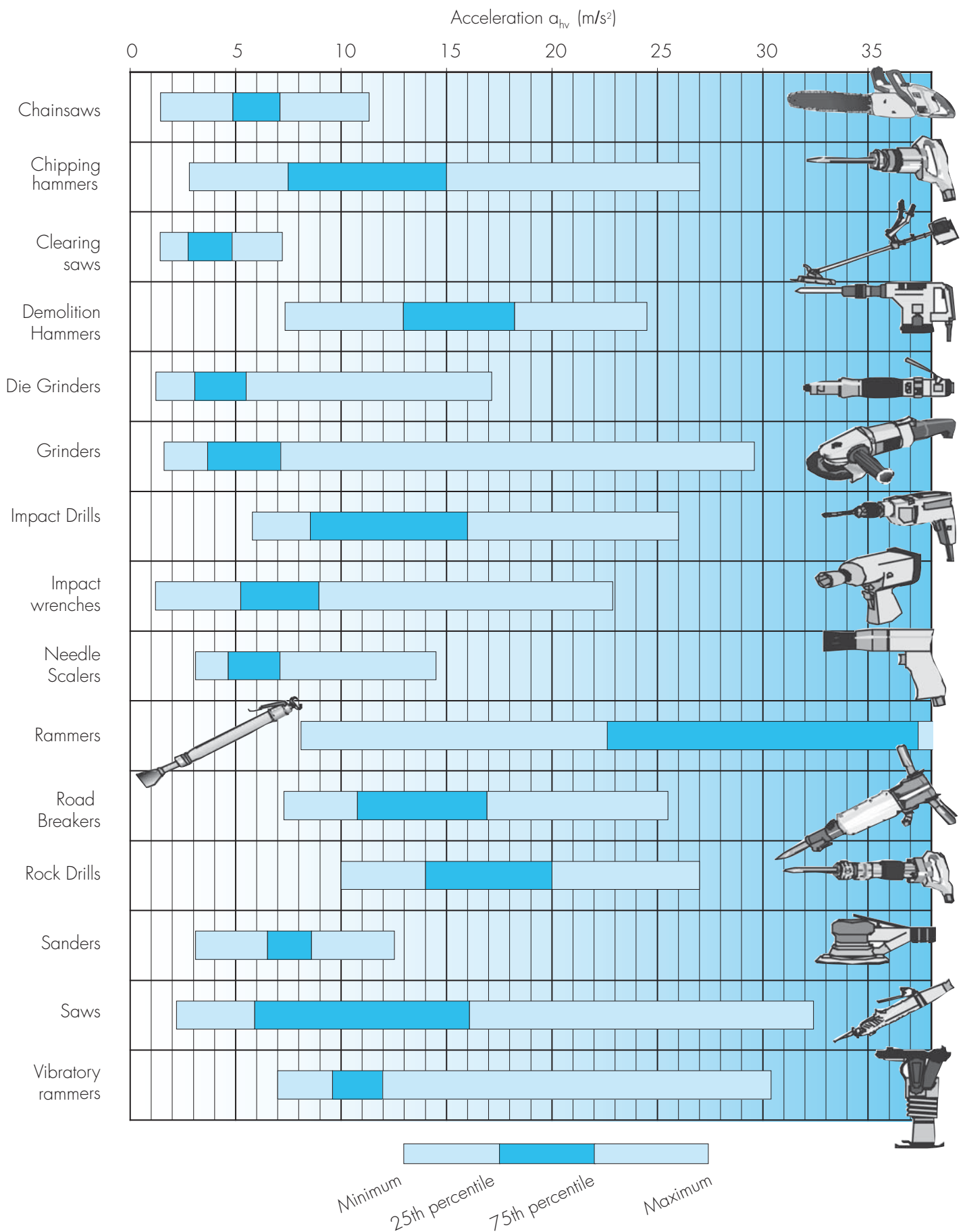
Do any vibrating tools cause tingling or numbness in the hands during or after use?

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.

Have any vibration-exposed workers already reported symptoms of hand-arm vibration syndrome?

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.

FIGURE 2 EXAMPLES OF VIBRATION MAGNITUDES FOR COMMON TOOLS
 Ranges of vibration values for common equipment on the EU market. These data are FOR ILLUSTRATION ONLY.
 For more details see [ANNEX B](#).



2.2 DETERMINING EXPOSURE DURATION

To assess the daily 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.

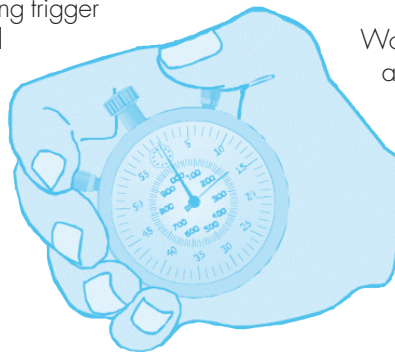
In this chapter we look at what exposure time information is needed and how it can be determined.

Before the daily vibration exposure, $A(8)$, 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 worker is exposed to vibration; a period when a worker 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-nut.

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:

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

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

2.3 VIBRATION MAGNITUDE

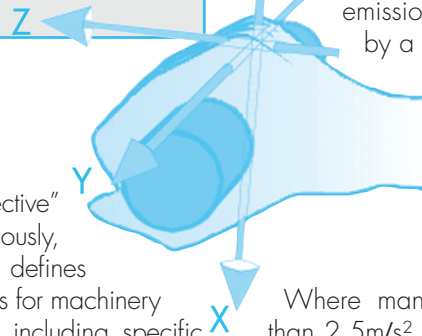
Hand-arm vibration risk is based on the frequency-weighted acceleration total value a_{hv} , given by the root-sum-of-squares of the frequency-weighted acceleration from the three orthogonal axes, x , y and z :

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

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.



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.

Declared emission values allow purchasers to compare machines tested to the same standardised test code. The emission values can show when there are large differences between machines, so that high-vibration tools can be avoided.

Emission data from manufacturers can also 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 15350 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:	x1
Pneumatic tools:	x1.5 to x2
Electric tools:	x1.5 to x2

Where manufacturers declare emission values less than 2.5m/s^2 , then a value of 2.5m/s^2 should be used and multiplied by the appropriate factor.

More information on these multiplication factors is given in CEN/TR 15350. Where there is no better information and a range of multiplying factors is given, the higher value should be used.

Many harmonised European vibration test codes are currently under review. The revised test codes should result in improved emission values that will not be directly comparable with older emission data, but should provide a more accurate guide to the vibration experienced in the workplace.

2.3.1 Use of manufacturer's emission data

The European "Machinery Directive" (Directive 2006/42/EC and, previously, repealed 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

Further reading:

EN 12096:1997 Mechanical vibration — Declaration and verification of vibration emission values

EN ISO 20643:2005 Mechanical vibration — Hand-held and hand-guided machinery. Principles for evaluation of vibration emission

CEN/TR 15350: 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.

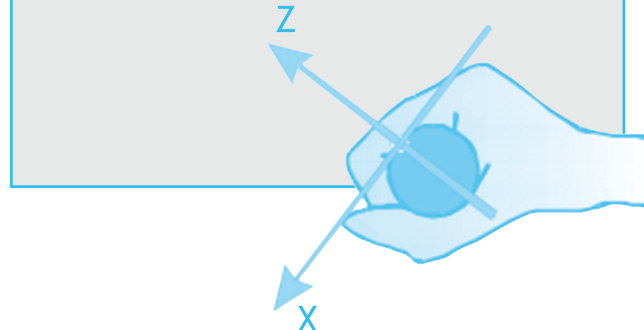
When choosing published vibration information the factors you need to take account of in making your choice include:

- 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.

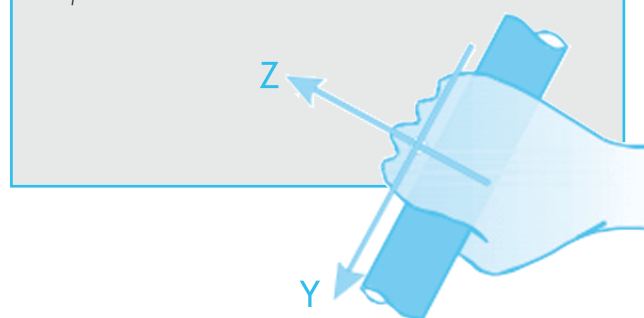
When using published vibration data it is good practice to try to compare data from two or more sources.

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/s^2).

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:

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

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

2.4 CALCULATING DAILY VIBRATION EXPOSURES

A daily vibration exposure assessment 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 D](#) and worked examples of calculating daily vibration exposures are given in [Annex E](#).

2.4.1 Daily Vibration Exposure

The daily vibration exposure, $A(8)$, is calculated from a magnitude and exposure time. Like the vibration magnitude, the daily vibration exposure has units of metres per second squared (m/s^2). Examples of the calculation of daily vibration exposures are given in [Annex E](#)

2.4.2 Partial Vibration Exposures

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 the partial vibration exposures are 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. An example of the calculation of daily vibration exposures is given in [Annex E](#)

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.

2.4.3 Uncertainty of daily exposure evaluations

The uncertainty of vibration exposure evaluation is dependent on many factors, see EN ISO 5349-2:2001, including:

- Instrument / calibration uncertainty,
- Accuracy of source data (e.g. manufacturer's emission data),
- Variation of machine operators (e.g. experience, operating technique or physique),
- Ability of the worker to reproduce typical work during measurements,
- Repeatability of the work task,
- Environmental factors (e.g. noise, temperature),
- Variations in the machine (e.g. is there a need for maintenance, has the machine been warmed-up?),
- Wear of inserted components or abrasives (e.g. is the saw-blade sharp, is the abrasive disc worn?)

Where vibration magnitude and exposure time are measured the uncertainties associated with the evaluation of $A(8)$ can mean that the calculated value can be as much as much 20% above the true value to 40% below. 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:

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

CHAPTER 3 REMOVING OR REDUCING EXPOSURE

Your risk assessment will help you plan the measures necessary to prevent or adequately control the exposure of workers to hand-arm vibration.

In this chapter we show how you can develop a control strategy, prioritise your control activities, implement risk controls and monitor the effectiveness of those controls.

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.

You may also need to adapt your controls for workers who are at particular risk of injury, e.g. those workers who are more susceptible to vibration injury and show signs of developing injury at exposures below the exposure action value.

Example: use of partial vibration exposure to rank risks

A steel worker uses two tools, a grinder with an in-use vibration emission of 7 m/s^2 and a chipping hammer with an in-use emission of 16 m/s^2 . The grinder is used for a total of $2\frac{1}{2}$ hours per day, the chipping hammer for 15 minutes:

- Grinder (7 m/s^2 for $2\frac{1}{2}$ hours):

$$A_1(8) = 3.9\text{ m/s}^2$$

- Chipping hammer (16 m/s^2 for 15 minutes):

$$A_2(8) = 2.8\text{ m/s}^2$$

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

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.

The Framework Directive provides the following hierarchy for implementing a programme of preventative measures:

1. avoiding risks;
2. evaluating the risks which cannot be avoided;
3. combating the risks at source;
4. adapting the work to the individual, especially as regards the design of work places, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;
5. adapting to technical progress;
6. replacing the dangerous by the non-dangerous or the less dangerous;
7. developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment;
8. giving collective protective measures priority over individual protective measures;
9. giving appropriate instructions to the workers.

3.2 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 will be quite straightforward, others will require changes to the way in which work is organised. Such changes can only be effectively dealt with in consultation with workplace representatives.

Consultation can result in better control solutions being identified that are well understood by the workers. You will be relying on workers to make the control measures effective. Subject to adequate training and supervision, workers have a duty to make correct use of machinery and to cooperate with the employer to enable them to ensure that their environment and working conditions are safe, such that risks to safety and health are minimised and where possible eliminated. The process of consultation encourages worker involvement and co-operation with control measures and so ensures that controls are more likely to be successfully implemented.

Effective consultation relies on:

- the sharing of relevant information about health and safety measures with workers;
- workers being given the opportunity to express their views and to contribute in a timely fashion to the resolution of health and safety issues;
- the views of workers being valued and taken into account

3.3 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.

3.3.1 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.



3.3.2 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 workers 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 expo-

sure. 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.

3.3.3 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 2006/42/EC repealing Directive 98/37/EC), which requires them to provide information on:

- the vibration emission (as reported in the instruction handbook);
- the uncertainty of measurement.

The supplier may also be able to offer technical support or advice on:

- 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;
- any vibration reduction features.

The new Machinery Directive requires that manufacturers or suppliers of machinery provide the following in the instructions:

“information concerning vibrations transmitted to the hand-arm system:

- *The vibration total value to which the hand-arm system is subjected, if it exceeds 2.5 m/s². Where this value does not exceed 2.5 m/s², this must be mentioned.”*

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 workers’ 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.

3.3.4 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 at 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;
- use of techniques such as bench-felling in forestry, where the chainsaw slides along the log during de-branching, rather than holding the full weight of the saw at all times.

3.3.5 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;
- why and how to report machines in need of maintenance;
- how and when to scrap inserted tools or consumables that contribute to excessive vibration exposures;
- 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.

Workers should also be advised on the impact of non-work activities on the risks to their health. They should be encouraged to stop or cut-down and smoking, which can impair blood circulation. 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 so increase the risk of developing hand-arm vibration injury.

3.3.6 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.

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 few breaks in exposure.

3.3.7 Collective measures

Where several undertakings share a work place, the various employers are required to cooperate in implementing the safety and health provisions. This may mean, for example, one company taking responsibility for purchasing or hiring low-vibration machinery, where the machines are shared amongst many contractors working on a construction site.

3.3.8 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. If you have to work outside, then some machines, such as chainsaws, are available with heated handles to help keep the hands warm.

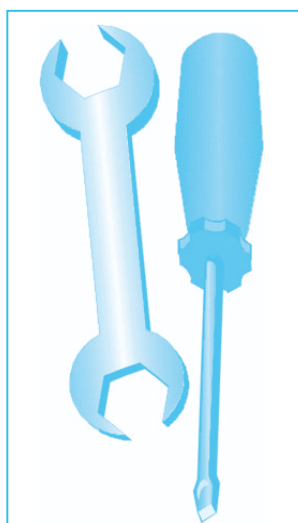
The temperature in an indoor workplace should provide reasonable comfort without the need for special clothing and should normally be at least 16°C. You should avoid machines that might make the hands cold, e.g. steel-bodied machines or pneumatic tools that blow exhaust air over the operator's hands.

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.

3.3.9 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.



3.4 MONITORING AND REASSESSMENT

Management of vibration exposure is an ongoing process. You need to 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.

3.4.1 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 workers are still carrying out the programme of controls you have introduced;
- Talk regularly to managers, supervisors, workers and safety or worker 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 occupational health provider whether the controls appear to be effective or need to be changed.

3.4.2 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 for the detection 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.

Implementation of health surveillance is a clear Member State competence and there are differences in health surveillance practices across the European Union. It is not the intention of this guide to provide definitive guidance on health surveillance. In this chapter we re-state the requirements for health surveillance given in the vibration directive and review some of the assessment techniques available.

Some health surveillance techniques related to hand-arm injury are described in [Annex F](#).

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 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.

4.3 WHAT TO DO IF INJURY IS IDENTIFIED?

Where, as a result of health surveillance, a worker is found to have an identifiable disease or adverse health effect that is considered by a doctor or occupational health-care professional to be the result of exposure to mechanical vibration at work:

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 Summary of responsibilities defined by Directive 2002/44/EC

Table A.1 Summary of responsibilities defined by Directive 2002/44/EC

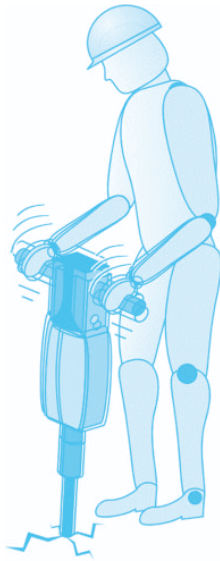
Directive Article	Who	When	Requirement
Article 4	Employer	Potential risk from hand-arm vibration	Determination and assessment of risk: <ul style="list-style-type: none"> ✓ Use someone who is competent to assess the hand-arm vibration risk. ✓ Be in possession of the risk assessment. ✓ Identify measures 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: <ul style="list-style-type: none"> ✓ Take general actions to eliminate exposures or reduce them to a minimum
		Exposures above the exposure action value	<ul style="list-style-type: none"> ✓ 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	<ul style="list-style-type: none"> ✓ Take immediate action to prevent exposure above the limit value ✓ Identify why exposures limit value has been exceeded
		Workers at particular risk	<ul style="list-style-type: none"> ✓ Adapt to requirements of workers at particular risk
Article 6	Employer	Workers at risk from hand-arm vibration	Worker information and training: <ul style="list-style-type: none"> ✓ For all workers exposed to hand-arm vibration risks.
Article 7	Employer	Workers at risk from hand-arm vibration	Worker consultation and participation: <ul style="list-style-type: none"> ✓ 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: <ul style="list-style-type: none"> ✓ Inform worker of results of health surveillance ✓ Provide information and advice to worker regarding any health surveillance which he should undergo following the end of exposure ✓ Provide significant findings of health surveillance to employer
	Employer	Where ill health is identified	<ul style="list-style-type: none"> ✓ Review risk assessment ✓ Further eliminate or reduce risks ✓ Review the health status of similarly exposed workers.
	Employer	Exposures above the exposure action value	<ul style="list-style-type: none"> ✓ Workers entitled to appropriate health surveillance



ANNEX B What is vibration?

B.1 WHAT IS VIBRATION?

Vibrations arise when a body oscillates 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, and this motion is transmitted into the hand and arm.



B.2 WHAT IS MEASURED?

Vibration is defined by its magnitude and frequency. [Figure B.1](#) [Hand-arm vibration](#). 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/s^2). 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](#).

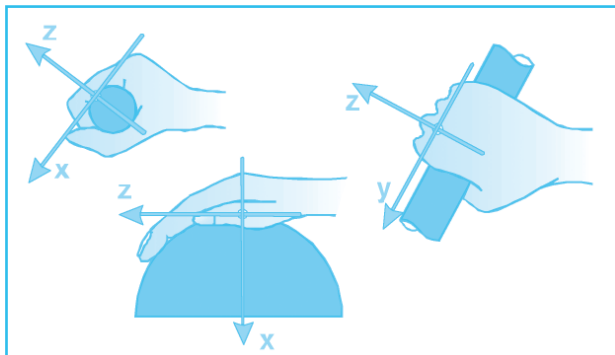


Figure B.2 Axes of hand-arm vibration measurement

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 8 Hz to 1000 Hz. 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-arm vibration, only one frequency-weighting curve is used for all three axes.

B.4 WHAT VIBRATION PARAMETERS ARE USED FOR EXPOSURE ASSESSMENT?

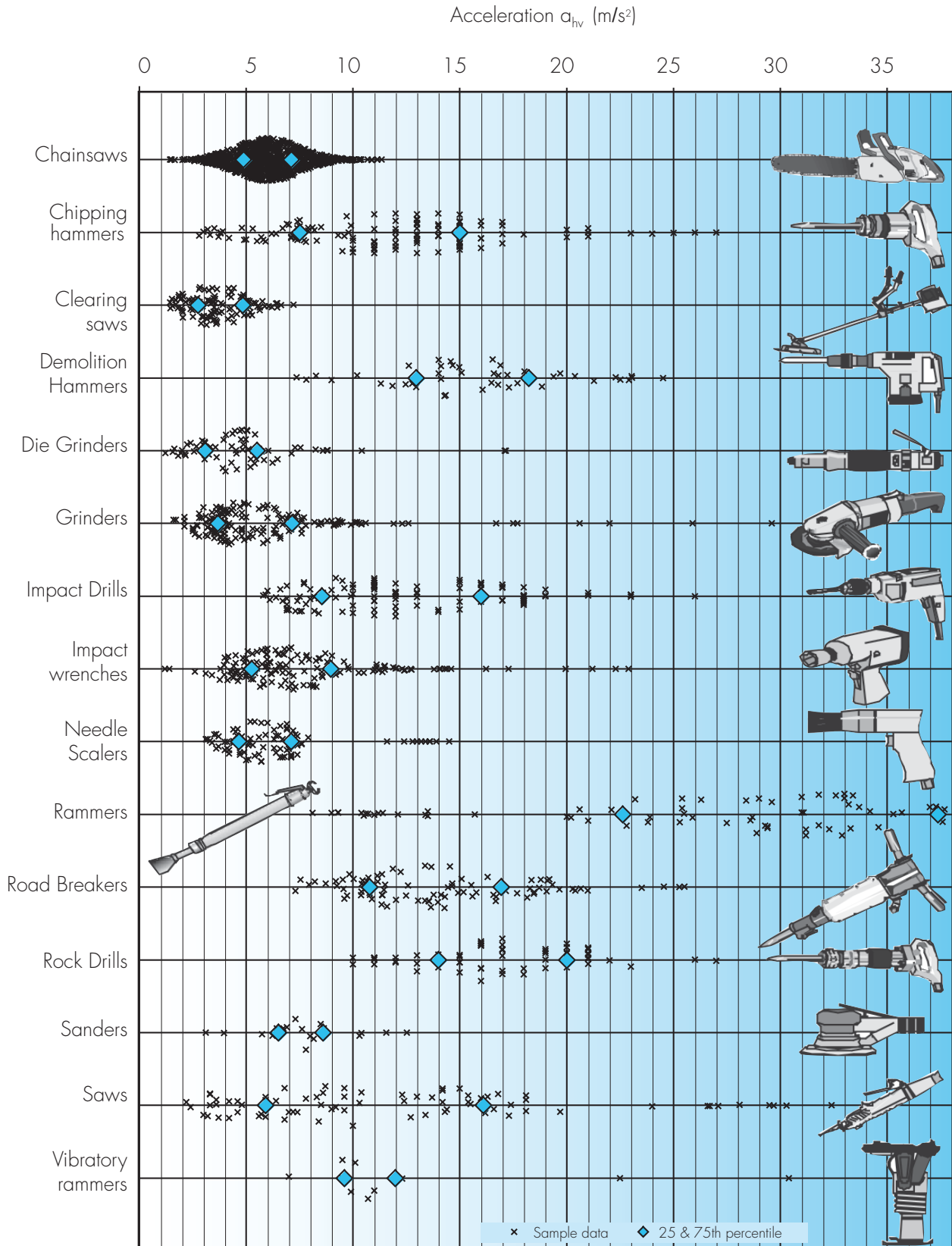
From each vibration axis a frequency-weighted root-mean-square average acceleration is measured. This is referred to as a_{hw} . The value used for assessment of exposure is the vibration total value, which combines the three a_{hw} values for the axes x, y and z, using:

$$a_{hv} = \sqrt{a_{hw,x}^2 + a_{hw,y}^2 + a_{hw,z}^2}$$

Some examples of vibration total values for common hand-held power tools are shown in [Figure B.3](#).

FIGURE B.3 EXAMPLES OF VIBRATION MAGNITUDES FOR COMMON TOOLS

Sample data based on workplace vibration measurements of total vibration values a_{hv} (see Chapter 2.3) by HSL and INRS between 1997 and 2005. These data are for illustration only and may not be representative of machine use in all circumstances. The 25th and 75th percentile points show the vibration magnitude that 25% or 75% of samples are equal to or below



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.

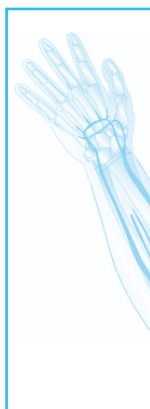
Further reading:

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

ANNEX C Health risks, signs and symptoms

Workers exposed regularly to excessive hand-arm-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.



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).

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

C.1 VASCULAR DISORDERS

Workers exposed to hand-transmitted arm 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.

C.2 NEUROLOGICAL DISORDERS

Workers exposed to hand-transmitted arm 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.

C.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.

C.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 D Tools for calculating daily exposures

D.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>.

<http://www.hvbg.de/d/bia/prs/softwa/kennwertrechner/index.html>

D.2 DAILY EXPOSURE GRAPH

The graph in [Figure D.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.

The green area in [Figure D.1](#) indicates exposures likely to be below the exposure action value. These exposures

must not be assumed to be “safe”. There may be a risk of hand-arm vibration injury for exposures below the exposure action value, and so some exposures within the green area may cause vibration injury in some workers, especially after many years of exposure.

D.3 DAILY EXPOSURE NOMOGRAM

The nomogram in [Figure D.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.

FIGURE D.1 DAILY EXPOSURE GRAPH

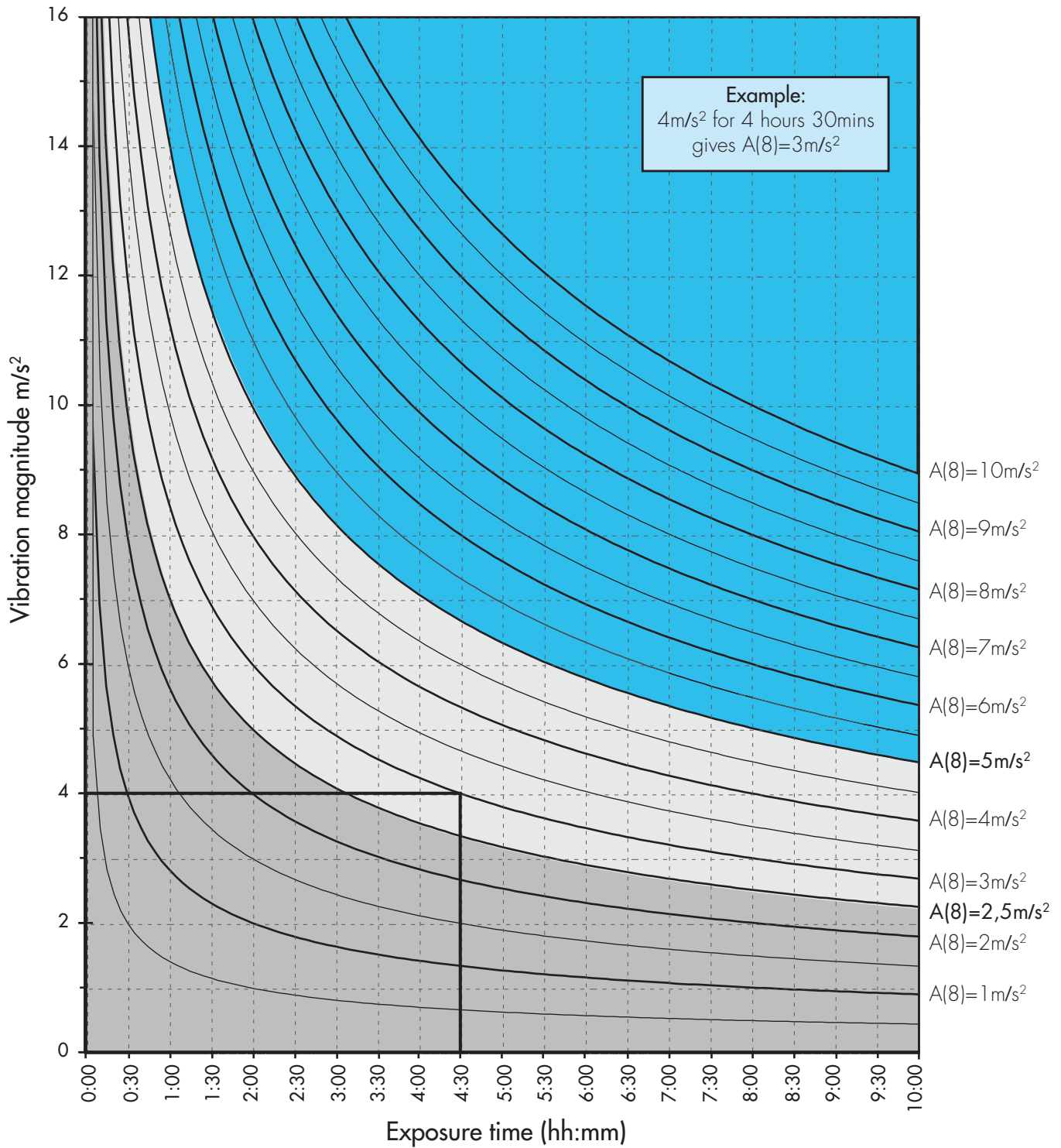
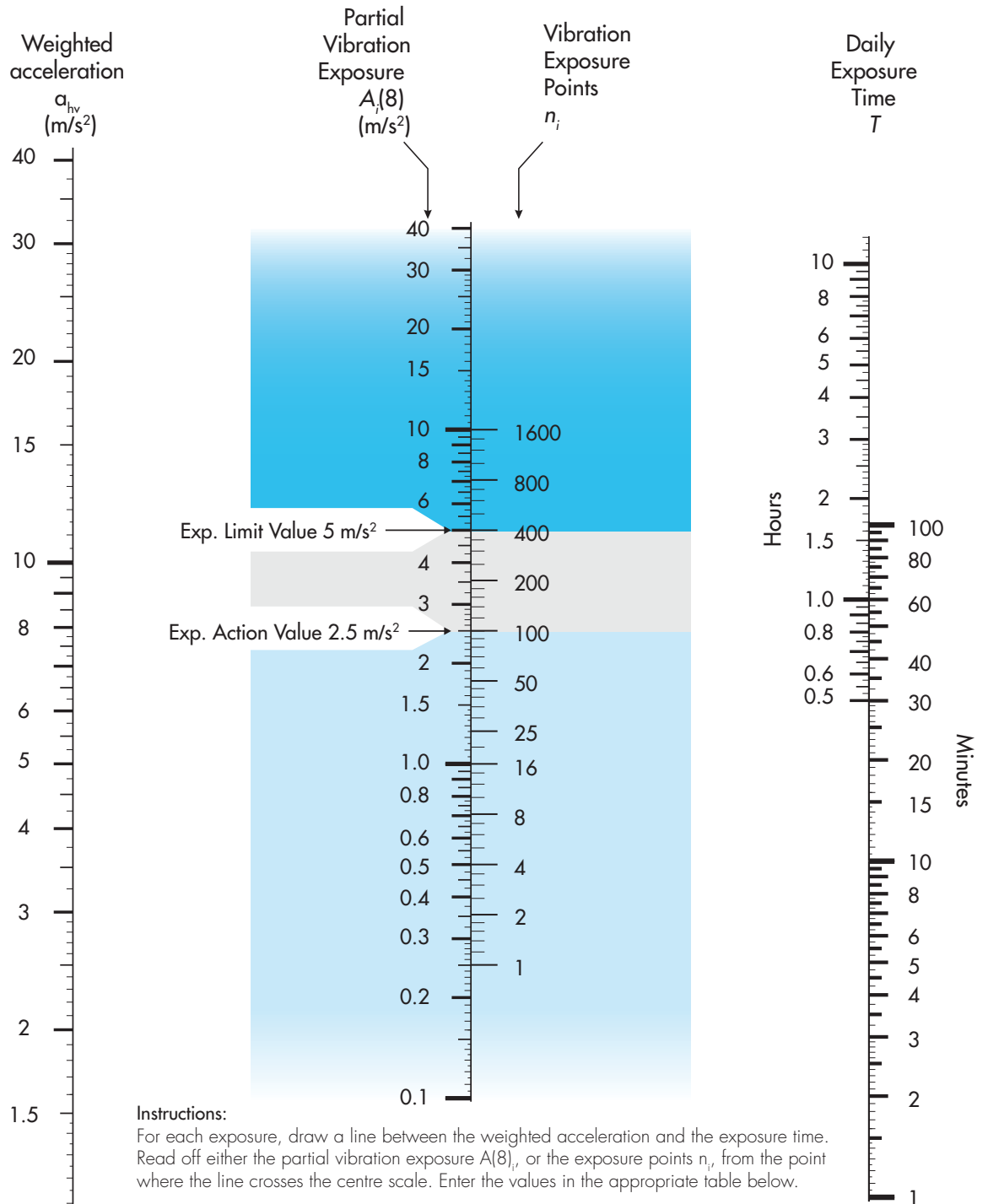


FIGURE D.2 HAND-ARM VIBRATION EXPOSURE NOMOGRAM



Instructions:

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

For $A(8)_i$ values:

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

For n_i values:

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

	$A_i(8)$	$A_i(8)^2$
Exposure 1		
Exposure 2		
Exposure 3		
Exposure 4		
Exposure 5		
$\sum A_i(8)^2 =$		
$A(8) = \sqrt{\sum A_i(8)^2} =$		

	n_i
Exposure 1	
Exposure 2	
Exposure 3	
Exposure 4	
Exposure 5	
$n = \sum n_i =$	
$A(8) =$	

D.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 (PE, 1 h in points per hour) can be obtained from the vibration magnitude a_{hv} in m/s^2 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 ($2.5 m/s^2$) = 100 points;
- exposure limit value ($5 m/s^2$) = 400 points.

In general the number of exposure points, P_E , is defined by:

$$P_E = \left(\frac{a_{hv}}{2.5 m/s^2} \right)^2 \frac{T}{8 \text{ hours}} 100$$

Where a_{hv} is the vibration magnitude in m/s^2 and T is the exposure time in hours.

Alternatively Figure D.3 gives a simple method for looking up the exposure points.

The daily exposure $A(8)$, can be calculated from the exposure point using:

$$A(8) = 2.5 m/s^2 \sqrt{\frac{P_E}{100}}$$

FIGURE D.3 EXPOSURE POINTS TABLE (ROUNDED VALUES).

20	67	200	400	800	1600	2400	3200	4000	4800	6400	8000
19.5	63	190	380	760	1500	2300	3050	3800	4550	6100	7600
19	60	180	360	720	1450	2150	2900	3600	4350	5800	7200
18.5	57	170	340	685	1350	2050	2750	3400	4100	5500	6850
18	54	160	325	650	1300	1950	2600	3250	3900	5200	6500
17.5	51	155	305	615	1250	1850	2450	3050	3700	4900	6150
17	48	145	290	580	1150	1750	2300	2900	3450	4600	5800
16.5	45	135	270	545	1100	1650	2200	2700	3250	4350	5450
16	43	130	255	510	1000	1550	2050	2550	3050	4100	5100
15.5	40	120	240	480	960	1450	1900	2400	2900	3850	4800
15	38	115	225	450	900	1350	1800	2250	2700	3600	4500
14.5	35	105	210	420	840	1250	1700	2100	2500	3350	4200
14	33	98	195	390	785	1200	1550	1950	2350	3150	3900
13.5	30	91	180	365	730	1100	1450	1800	2200	2900	3650
13	28	85	170	340	675	1000	1350	1700	2050	2700	3400
12.5	26	78	155	315	625	940	1250	1550	1900	2500	3150
12	24	72	145	290	575	865	1150	1450	1750	2300	2900
11.5	22	66	130	265	530	795	1050	1300	1600	2100	2650
11	20	61	120	240	485	725	970	1200	1450	1950	2400
10.5	18	55	110	220	440	660	880	1100	1300	1750	2200
10	17	50	100	200	400	600	800	1000	1200	1600	2000
9.5	15	45	90	180	360	540	720	905	1100	1450	1800
9	14	41	81	160	325	485	650	810	970	1300	1600
8.5	12	36	72	145	290	435	580	725	865	1150	1450
8	11	32	64	130	255	385	510	640	770	1000	1300
7.5	9	28	56	115	225	340	450	565	675	900	1150
7	8	25	49	98	195	295	390	490	590	785	980
6.5	7	21	42	85	170	255	340	425	505	675	845
6	6	18	36	72	145	215	290	360	430	575	720
5.5	5	15	30	61	120	180	240	305	365	485	605
5	4	13	25	50	100	150	200	250	300	400	500
4.5	3	10	20	41	81	120	160	205	245	325	405
4	3	8	16	32	64	96	130	160	190	255	320
3.5	2	6	12	25	49	74	98	125	145	195	245
3	2	5	9	18	36	54	72	90	110	145	180
2.5	1	3	6	13	25	38	50	63	75	100	125
	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h

D.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, dependent on the expected in-use vibration magnitude of each machine, one example of this coding scheme is illustrated in [Table D.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.

of each machine. 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](#)).

The use of a ‘green’ machine indicates that exposures are likely to be below the exposure action or limit value. These exposures must not be assumed to be “safe”. There may be a risk of hand-arm vibration injury for exposures

TABLE D.1 EXAMPLE OF COLOUR CODING SCHEME FOR TRAFFIC-LIGHT SYSTEM		
Colour code	Time to reach EAV (2.5m/s ²)	Time to reach ELV (5m/s ²)
Red	Less than 30 mins	Less than 2 hours
Amber	30 minutes to 2 hours	2 to 8 hours
Green	More than 2 hours	More than 8 hours

The success of the traffic light system is dependent on the quality of data used to determine the colour rating

below the exposure action value and other management controls must be used to ensure that workers are trained to understand and operate the system correctly, that the systems are actually correctly used and that workers at risk do not develop symptoms of hand-arm vibration syndrome.

ANNEX E Worked Examples

E.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:

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

This daily exposure of $3m/s^2$ is above the exposure action value but below the exposure limit value.

Example

A fettler uses three tools during a working day:

1. An angle grinder: $4m/s^2$ for 2½ 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: $A_{Grind}(8) = 4 \sqrt{\frac{2,5}{8}} = 2.2 m/s^2$
2. Cutter: $A_{Cut}(8) = 3 \sqrt{\frac{1}{8}} = 1.1 m/s^2$
3. Chipper: $A_{Chip}(8) = 20 \sqrt{\frac{15}{8 \times 60}} = 3.5 m/s^2$

The daily vibration exposure is then:

$$\begin{aligned} A(8) &= \sqrt{A_{Grind}(8)^2 + A_{Cut}(8)^2 + A_{Chip}(8)^2} \\ &= \sqrt{2.2^2 + 1.1^2 + 3.5^2} \\ &= \sqrt{4.8 + 1.2 + 12.3} = \sqrt{18.3} = 4.3 m/s^2 \end{aligned}$$

This daily exposure of $4.3m/s^2$ is above the exposure action value but below the exposure limit value.

E.2 WHERE MORE THAN ONE MACHINE IS USED

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, using:

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

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

E.3 DAILY EXPOSURE: $A(8)$, USING THE EXPOSURE POINTS SYSTEM

(Note: this is the same worked example as Annex E.2 using the exposure points method)

If you have acceleration values in m/s^2 :

- Step 1:** Determine points values for each task or machine, using Figure D.3 to look-up the exposure points based on the acceleration value and the exposure time.
- Step 2:** Add the points per machine to give a total daily points.
- Step 3:** The highest value of the three axis values is the daily vibration exposure in points

Example

A fletcher uses three tools during a working day:

1. An angle grinder: $4m/s^2$ 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

Step 1: The exposure points are, from Figure D.3:

Angle grinder ($2\frac{1}{2}$ hours use)	$4m/s^2$ for 3* hours = 96 points
Angle cutter (1 hours use)	$3m/s^2$ for 1 hour = 18 points
Chipping hammer (15 minutes use)	$20 m/s^2$ for 15 minutes = 200 points

* $2\frac{1}{2}$ hours not shown in Figure D.3, therefore nearest higher value of 3 hours is used.

Step 2: Daily vibration exposure points, for each machine are:

$$96 + 18 + 200 = 314 \text{ points}$$

Step 3: The daily vibration exposure is 314 points, i.e. above the 100 points exposure action value, but below the 400 points exposure limit value.

If you have points-per-hour data:

- Step 1:** Determine points-per-hour values for each machine or operation, from manufacturer's data, other sources, or measurement.
- Step 2:** For each machine or operation, find the daily points for by multiplying the number of points-per-hour by the number of hours use of the machine:
- Step 3:** The sum of the points values for the individual machines or operations is the daily vibration exposure in points.

Example

A fletcher uses three tools during a working day:

1. An angle grinder: $4m/s^2$ 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

Step 1: The points per hour values for the machines are:

Angle grinder	Angle cutter	Chipping hammer
32 points	18 points	800 points

Step 2: The exposure points are then:

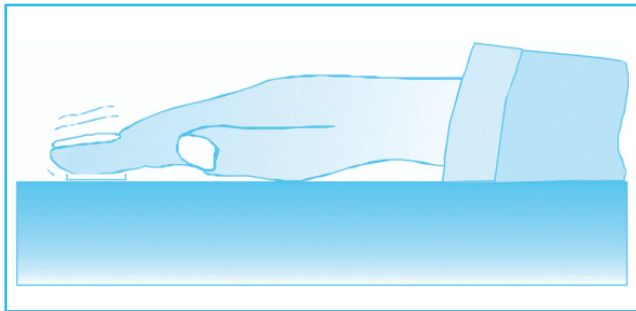
Angle grinder ($2\frac{1}{2}$ hours use)	Angle cutter (1 hours use)	Chipping hammer (15 minutes use)
$32 \times 2.5 = 80$	$18 \times 1 = 18$	$800 \times 0.25 = 200$

Step 3: Daily vibration exposure points, for each machine are:

Step 4: $80 + 18 + 200 = 298$ points

Step 5: The daily vibration exposure is 298 points, i.e. above the 100 points exposure action value, but below the 400 point exposure limit value.

ANNEX F Health Surveillance Techniques



Health surveillance may consist of an evaluation of the case history for a worker in conjunction with a physical examination conducted by a doctor or suitably qualified health-care professional.

Questionnaires for hand-arm vibration health surveillance are available from various sources (e.g. the VIBGUIDE section of: http://www.humanvibration.com/EU/EU_index.htm).

F.1 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-arm 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.

F.2 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

F.3 CLINICAL TESTS

In general, clinical tests do not provide reliable proof of vibration injury, however, they may be helpful to exclude other causes of symptoms similar to those of 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).

F.4 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.

F.5 NEUROLOGICAL INVESTIGATIONS

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

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

F.6 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.

F.7 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 osteoarthritis in the upper limbs is recognised as an occupational disease.

F.8 LABORATORY TESTS

Blood and urine analyses may be necessary in some case to distinguish vibration injury from other vascular or neurological disorders.

Further reading:

ISO 13091-1:2001 Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction — Part 1: Methods of measurement at the fingertips

ISO 14835-1:2005 Mechanical vibration and shock — Cold provocation tests for the assessment of peripheral vascular function — Part 1: Measurement and evaluation of finger skin temperature

ISO 14835-2:2005 Mechanical vibration and shock — Cold provocation tests for the assessment of peripheral vascular function — Part 2: Measurement and evaluation of finger systolic blood pressure

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 8-hour energy equivalent vibration total value for a worker in meters per second squared (m/s^2), including all hand-arm vibration exposures during the day.

Partial vibration exposure, $A_i(8)$

The contribution of operation i to the daily vibration exposure in m/s^2 . The *partial vibration exposure* relates to the daily exposure from an individual tool or process, i (where a worker is only exposed to vibration from 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 $2.5m/s^2$, above which the risks from vibration exposure must be controlled.

Exposure limit value

A value for a workers daily vibration exposure of $5m/s^2$, above which workers should not be exposed.

Exposure time

The duration per day that a worker is exposure to a vibration source.



ANNEX H Bibliography

H.1 EU DIRECTIVES

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)

Directive 89/391/EEC of the European Parliament and of the Council of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work

Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)

Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery (repealed by Directive 2006/42/EC)

Directive 89/686/EEC: Council Directive of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment as amended by Directives 93/68/EEC, 93/95/EEC and 96/58/EC

Council Directive 89/656/EEC of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace (third individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

European Committee for Standardization (1996) Mechanical vibration and shock — Hand-arm vibration — Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand EN ISO 10819:1996

European Committee for Standardization (1997) Mechanical vibration — Declaration and verification of vibration emission values EN 12096:1997

European Committee for Standardization (2005) Mechanical vibration — Hand-held and hand-guided machinery — Principles for evaluation of vibration emission EN ISO 20643:2005

European Committee for Standardisation (1995) Hand-arm vibration — Guidelines for vibration hazards reduction — Part 1: Engineering methods by design of machinery CEN/CR 1030-1:1995

European Committee for Standardisation (1995) Hand-arm vibration — Guidelines for vibration hazards reduction — Part 2: Management measures at the workplace CEN/CR 1030-2:1995

European Committee for Standardisation (2005) Mechanical vibration — Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery CEN/TR 15350: 2005

H.2 STANDARDS

European

European Committee for Standardization (2001) Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements EN ISO 5349-1:2001.

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

International

International Organization for Standardization (2005) Human response to vibration — measuring instrumentation ISO 8041:2005

ISO 13091-1:2001 Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction — Part 1: Methods of measurement at the fingertips

ISO 13091-2:2003 Mechanical vibration — Vibrotactile perception thresholds for the assessment of nerve dysfunction — Part 2: Analysis and interpretation of measurements at the fingertips

ISO 14835-1:2005 Mechanical vibration and shock— Cold provocation tests for the assessment of peripheral vascular function — Part 1: Measurement and evaluation of finger skin temperature

ISO 14835-2:2005 Mechanical vibration and shock — Cold provocation tests for the assessment of peripheral vascular function — Part 2: Measurement and evaluation of finger systolic blood pressure

ISO/TS 15694:2004 Mechanical vibration and shock — Measurement and evaluation of single shocks transmitted from hand-held and hand-guided machines to the hand-arm system

ISO/TR 22521:2005 Portable hand-held forestry machines — Vibration emission values at the handles — Comparative data in 2002

H.3 SCIENTIFIC PUBLICATIONS

Bovenzi M. Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. *International Archives of Occupational and Environmental Health* 1998; 71:509-519.

Bovenzi M. Vibration-induced white finger and cold response of digital arterial vessels in occupational groups with various patterns of exposure to hand-transmitted vibration. *Scandinavian Journal of Work, Environment & Health* 1998; 24:138-144.

Bovenzi M. Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger. *International Archives of Occupational and Environmental Health* 2002; 75:20-28.

Brammer, A.J., Taylor, W., Lundborg, G. (1987) Sensorineural stages of the hand-arm vibration syndrome. *Scandinavian Journal of Work, Environment and Health*, 13, (4), 279-283.

Gemne, G., Pyykko, I., Taylor, W., Pelmeur, P. (1987) The Stockholm Workshop scale for the classification of cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome (revision of the Taylor-Pelmeur scale). *Scandinavian Journal of Work, Environment and Health*, 13, (4), 275-278.

Griffin, M.J. (2004) Minimum health and safety requirements for workers exposed to hand-transmitted vibration and whole-body vibration in the European Union; a review. *Occupational and Environmental Medicine*; 61, 387-397.

Griffin, M.J. (1990, 1996) *Handbook of human vibration*. Published: Academic Press, London, ISBN: 0-12-303040-4.

Griffin, M.J. (1997) Measurement, evaluation, and assessment of occupational exposures to hand-transmitted vibration. *Occupational and Environmental Medicine*, 54, (2), 73-89.

Griffin, M.J. (1998) Evaluating the effectiveness of gloves in reducing the hazards of hand-transmitted vibration. *Occupational and Environmental Medicine*, 55, (5), 340-348.

Griffin, M.J., Bovenzi, M. (2002) The diagnosis of disorders caused by hand-transmitted vibration: Southampton Workshop 2000. *International Archives of Occupational and Environmental Health*, 75, (1-2), 1-5.

Griffin, M.J., Bovenzi, M., Nelson, C.M. (2003) Dose response patterns for vibration-induced white finger. *Journal of Occupational and Environmental Medicine*, 60, 16-26.

Griffin, M.J. & Lindell C.J. (1998) Cold provocation tests for the diagnosis of vibration-induced white finger: Standardisation and repeatability. HSE research report CRR 173/1998.

Kaulbars, U. Hand-arm vibration parameters: from manufacturers and workplace measurements – deviations and causes. VDI-Report No. 1821 (2004), p. 115-124). www.hvbg.de/d/bia/vera/vera2a/human/kaulbars2.pdf. (In German)

LEY F. X. Hand arm vibration bone and joint disorders. INRS, Document pour le médecin du Travail, n°40, 4 term 1989. (In French)

Lindell, C.J. & Griffin, M.J. (1998) Standardised diagnostic methods for assessing components of the hand-arm vibration syndrome. HSE research report CRR 197/1998.

Mason H., Poole K. Clinical testing and management of individuals exposed to hand-transmitted vibration. An evidence review. Faculty of Occupational Medicine of the Royal College of Physicians 2004 ISBN 1 86016 203 7.

Mansfield, N.J. (2004) *Human Response to Vibration* ISBN 0-4152-8239-X

Paddan, G.S. & Griffin, M.J. (1999) Standard tests for the vibration transmissibility of gloves. HSE research report CRR 249/1999.

Paddan, G.S., Haward, B.M., Griffin, M.J., Palmer, K.T. Paddan, G.S. et al. (1999) Hand-transmitted vibration: Evaluation of some common sources of exposure in Great Britain. HSE research report CRR 234/1999.

Palmer, K.T., Coggon, D.N., Bednall, H.E., Kellingray, S.D., Pannett, B., Griffin, M.J., Haward, B. (1999) Palmer, K.T. et al. (1999) Hand-transmitted vibration Occupational exposures and their health effects in Great Britain. HSE research report CRR 232/1999.

Palmer, K.T., Griffin, M.J., Bednall, H., Pannett, B., Coggon, D. (2000) Prevalence and pattern of occupational exposure to hand transmitted vibration in Great Britain: findings from a national survey. *Occupational and Environmental Medicine*, 57, (4), 218-228.

Palmer, K.T., Griffin, M.J., Bendall, H., Pannett, B., Cooper, C., Coggon, D. (2000) The prevalence of sensorineural symptoms attributable to hand-transmitted vibration in Great Britain: a national postal survey. *American Journal of Industrial Medicine*, 38, 99-107.

Palmer, K.T., Griffin, M.J., Syddall, H., Pannett, B., Cooper, C., Coggon, D. (2000) Prevalence of Raynaud's phenomenon in Great Britain and its relation to hand transmitted vibration: a national postal survey. *Occupational and Environmental Medicine*, 57, (7), 448-452.

Palmer, K.T., Griffin, M.J., Syddall, H., Pannett, B., Cooper, C., Coggon, D. (2001) Risk of hand-arm vibration syndrome according to occupation and source of exposure to hand-transmitted vibration: a national survey. *American Journal of Industrial Medicine*, 339, 389-396.

Palmer, K.T., Griffin, M.J., Syddall, H.E., Pannett, B., Cooper, C., Coggon, D. (2001) Exposure to hand-transmitted vibration and pain in the neck and upper limbs. *Occupational Medicine*, 51, (7), 464-467.

Palmer, K.T., Haward, B., Griffin, M.J., Bednall, H., Coggon, D. (2000) Validity of self reported occupational exposure to hand transmitted and whole body vibration. *Occupational and Environmental Medicine*, 57, (4), 237-241.

Rocher O., Lex F. X., Mereau P., Donati P. Bone and joint disorders of elbow when exposed to hand held tool vibration. INRS, Document pour le médecin du Travail, n°56, 4 term, 1993 (in French)

Stayner, R.M. (1996) Grinder characteristics and their effects on hand-arm vibration. HSE research report CRR 115/1996.

Stayner, R.M. (1997) European grinder vibration test code: a critical review. HSE research report CRR 135/1997.

Stayner, R.M. (2003) Isolation and auto-balancing techniques for portable machines. HSE research report RR 078/2003.

Taylor, W. (Editor) (1974) The vibration syndrome. Proceedings of a Conference on the Medical Engineering and Legal Aspects of Hand-Arm Vibration at the University of Dundee, 12-14th July, 1972. Edited: W. Taylor, Published: Academic Press, ISBN 0 12 684760 6.

Taylor, W., Pelmear, P.L. (Editors) (1975) Vibration white finger in industry, (A report, comprising edited versions of papers submitted to the Department of Health and Social Security in December 1973). Published: Academic Press, ISBN 0 12 684550 6.

H.4 GUIDANCE PUBLICATIONS

Bulletin for workers of the institution for statutory accident insurance and prevention in the mining industry (Bergbau-Berufsgenossenschaft) „Human diseases caused by vibrations“. (In German)

Federal Institute for Occupational Safety and Health (FIOOSH) Protection against vibration: a problem or not? (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)). www.baua.de/info/bestell.htm#schrift. (In German)

Federal Institute for Occupational Safety and Health (FIOOSH). Protection against vibration at the workplace (technics 12). (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)). www.baua.de/info/bestell.htm#schrift. (In German)

Federal Institute for Occupational Safety and Health (FIOOSH). Vibration loads in the building industry (technics 23). (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin – BAuA). www.baua.de/info/bestell.htm#schrift. (In German)

Gruber, H.; Mierdel, B. Guidelines for risk assessment. Bochum: VTI Verlag 2003. (In German)

HSE (2005) Hand-arm Vibration - The Control of Vibration at Work Regulations 2005. Guidance on Regulations L140
HSE Books 2005 ISBN 0 7176 6125 3

HSE (2005) Control the risks from hand-arm vibration: Advice for employers on the Control of Vibration at Work Regulations 2005 Leaflet
INDG175 (rev2) HSE Books 2005 ISBN 0 7176 6117 2

HSE (2005) Hand-arm vibration: Advice for workers Pocket card
INDG296 (rev1) HSE Books 2005 ISBN 0 7176 6118 0

HSE (1998) Hard to handle: Hand-arm vibration – managing the risk Video
HSE Books 1998 ISBN 0 7176 1881 1

HSE (2002) Use of contractors: A joint responsibility Leaflet INDG368
HSE Books 2002 10 ISBN 0 7176 2566 4

HSE (1996) Hazards associated with foundry processes: Hand-arm vibration - the current picture
Foundries Information Sheet FNIS8
Web only version available at www.hse.gov.uk/pubns/founindx.htm

HSE (1999) Hazards associated with foundry processes: Hand-arm vibration - assessing the need for action
Foundries Information Sheet FNIS10
Web only version available at www.hse.gov.uk/pubns/founindx.htm

HSE (2002) Hand-arm vibration in foundries: Furnace and ladle relining operations
Foundries Information Sheet FNIS11
Web only version available at www.hse.gov.uk/pubns/founindx.htm

HSE (2002) A purchasing policy for vibration-reduced tools in foundries
Foundries Information Sheet FNIS12
Web only version available at www.hse.gov.uk/pubns/founindx.htm

UK Department of Trade and Industry (1995). Machinery. Guidance notes on UK Regulations. Guidance on the Supply of Machinery (Safety) Regulations 1992 as amended by the Supply of Machinery (Safety) (Amendment) Regulations 1994 URN 95/650

INRS (1991). Smooth impact. Use an anti-vibration concrete breaker. INRS, ED 1346. (In French).

INRS. (2001) The hand in danger. INRS, ED 863. (In French and English)

Centres de Mesure Physique (CMP) and Institut National de Recherche et de Sécurité (INRS). Guide to evaluate vibration at work. Part 2 : Hand arm vibration. Edited by INRS. 2000.

ISSA. Vibration at work. Published by INRS for International section Research of the ISSA, 1989. (available in English, French, German and Spanish)

Kaulbars, U. (1998) Technical protection against hand-arm vibrations. BIA Handbuch, 33. Lfg. XII/98. (In German)

Kaulbars, U. (2001) Anti-vibration-gloves – Positive list. BIA Handbuch, 39. Lfg. VII/2001. (In German)

Neugebauer, G.; Hartung, E. Mechanical vibrations at the workplace. Bochum: VTI Verlag 2002. (In German)

Berufsgenossenschaftlicher Grundsatz. (2005) G46: Belastungen des Muskel- und Skelettsystems. (In German)

Ministère fédéral de l'Emploi et du Travail (Belgique) Vibrations main bras. Stratégie d'évaluation et de prévention des risques. D/1998/1205/70 (In French)

ISPESL La sindrome da vibrazioni mano - braccio. Vibrazioni meccaniche nei luoghi di lavoro : stato della normativa. (In Italian)

H.5 WEB SITES

www.humanvibration.com

General information on human-vibration including links to various human-vibration websites

<http://vibration.arbetslivsinstitutet.se/eng/wbvhome.lasso>

Vibration emission data

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

Vibration emission data

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

Exposure calculator

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

Exposure calculator

<http://www.hvbg.de/d/bia/prs/softwa/kennwertrechner/index.html>

Exposure calculator

INDEX

A	
accelerometers.....	36
anti-vibration gloves.....	28
anti-vibration mounts.....	26,28
average vibration	21
B	
balancers	26
C	
carpel-tunnel syndrome.....	27, 45
case history.....	45
clinical tests.....	45
clothing.....	13, 28
cold provocation tests	45, 46, 49
collective measures.....	27, 63, 77
colour coding.....	42
consultation and participation	24, 33, 63, 76, 83
continuous tool operation	18
control strategy	23, 75
D	
daily vibration exposure.....	22, 31, 44, 47
declared emission value	19
dominant frequency	34
Dupuytren's contracture	37
duration of exposure	15, 18, 22, 37, 66, 65
E	
equipment selection	15, 25, 26, 63, 76, 78
exposure action value	3,20 23, 27, 31, 33, 38, 83,
exposure duration.....	9, 13, 18, 61, 63, 69
exposure limit value	3, 11, 20, 27, 33, 41, 44, 61
exposure points system	41, 91, 96
F	
Framework Directive.....	24, 62
frequency.....	19, 20, 28, 34, 47, 72, 84
frequency-weighted acceleration	9, 20, 70, 71
frequency-weighting	34, 47, 84, 98
G	
grip and push forces	26
H	
hammer-action	16
hand-arm vibration syndrome	16, 37, 42, 45, 49
health records.....	31, 81
health risks	37, 87
health surveillance	27, 29, 31, 33, 63, 83
I	
impact	37, 51
impact wrench.....	18
intermittent tool operation.....	18
L	
laboratory tests.....	46
M	
Machinery Directive	19, 25, 70, 77
magnitude.....	19, 20, 22, 26, 28, 34, 38
maintenance	22, 25, 26, 28, 59, 63, 73, 77, 78
manufacturer	13, 16, 18, 26, 70, 71, 78, 91, 96
manufacturer's emission data.....	22, 70, 73
measurement....	19, 22, 35, 42, 46, 65, 69, 71, 93
measurement of vibration magnitude.....	20, 71
monitoring and reassessment.....	13, 29, 63, 79
muscle strength investigations.....	46
muscular weakness.....	37
musculoskeletal disorders.....	37, 100
N	
neurological disorders.....	37, 47
neurological investigations.....	45



nomogram.....	38, 40, 88, 90
numbness	16, 37
P	
partial vibration exposure	22, 43, 47, 93, 95
partial vibration exposures.....	22, 38, 43, 88
percussive	16, 37
personal protection.....	13, 28
physical examination.....	45, 61, 88
purchasing policy.....	25, 51, 59, 63, 76
Purdue pegboard	45
Q	
qualified physician	45
R	
radiological investigations	46
ranking	23, 75
Raynaud's phenomenon	37, 49, 50
reassessment.....	13, 29, 63, 79
resilient materials	26
risk assessment.....	15, 20, 23, 27, 29, 33, 51, 63
risk controls	23
rotary action tools.....	16
S	
substitution	25, 63, 66
supplier	19, 25, 42, 70, 76, 78
T	
tactile sensitivity	45
tendonitis.....	37
tension chains	26
tingling	16, 37
trade association	20, 25, 71, 76
traffic light system	42
training and information.....	13, 27, 63
training and supervision.....	24, 27
transitional periods.....	11, 61
U	
uncertainty	22, 73
V	
vascular disorders.....	37
vascular investigations	45
vibration	1, 21, 25
vibration controls	30
Vibration Directive	31
vibration directive responsibilities.....	34
vibration emission... ..	19, 23, 25, 41, 51, 70, 76, 98
vibration exposure	21, 22, 25, 31, 37, 40, 44
vibration magnitude	19, 22, 26, 28, 35, 41
vibration perception thresholds.....	45
vibration risk assessment	20
vibration test codes	19, 70
vibration total value.....	34, 46, 98
vibration-induced white finger	37, 49
W	
warm clothing.....	28
web-based calculators.....	38, 88
work patterns.....	27
work schedules	27, 63, 78
workplace representatives	24, 76
workstation design.....	9, 26



PART II Guide to good practice Whole-Body Vibration



TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION	61
CHAPTER 2 EVALUATION OF RISK.....	65
2.1 THE BASICS OF RISK ASSESSMENT	65
2.2 DETERMINING EXPOSURE DURATION.....	69
2.3 DETERMINING VIBRATION MAGNITUDE.....	70
2.3.1 Use of manufacturer's emission data.....	70
2.3.2 Use of other data sources.....	71
2.3.3 Measurement of vibration magnitude	71
2.4 CALCULATING DAILY VIBRATION EXPOSURES.....	73
2.4.1 A(8) and VDV daily exposure evaluation.....	73
2.4.2 Uncertainty of daily exposure evaluations	73
CHAPTER 3 AVOIDING OR REDUCING EXPOSURE.....	75
3.1 DEVELOPING A CONTROL STRATEGY.....	75
3.2 CONSULTATION AND PARTICIPATION OF WORKERS.....	76
3.3 RISK CONTROLS	76
3.3.1 Substitution of other working methods.....	76
3.3.2 Equipment selection.....	76
3.3.3 Purchasing policy	76
3.3.4 Task and process design	77
3.3.5 Collective measures	77
3.3.6 Training and information to workers.....	78
3.3.7 Work schedule	78
3.3.8 Maintenance.....	78
3.3.9 Suspension seats	78

3.4 VIBRATION MONITORING AND REASSESSMENT.....	79
3.4.1 <i>How do I know if my whole-body vibration controls are working?</i>	79
3.4.2 <i>When do I need to repeat the risk assessment?</i>	79
CHAPTER 4 HEALTH SURVEILLANCE	81
4.1 WHEN IS HEALTH SURVEILLANCE REQUIRED?	81
4.2 WHAT RECORDING IS REQUIRED?	81
4.3 WHAT TO DO IF INJURY IS IDENTIFIED?	81
ANNEX A Summary of responsibilities defined by Directive 2002/44/EC	83
ANNEX B What is vibration?	84
ANNEX C Health risks, signs and symptoms.....	87
ANNEX D Tools for calculating daily exposures.....	88
ANNEX E Daily exposure Worked examples	92
ANNEX F Health Surveillance techniques	98
ANNEX G Glossary	99
ANNEX H Bibliography.....	100
INDEX	105

CHAPTER 1 INTRODUCTION

EU Directive 2002/44/EC (the 'Vibration Directive') places responsibilities on employers to ensure that risks from whole-body vibration are eliminated or reduced to a minimum (these responsibilities are summarised in Annex A)

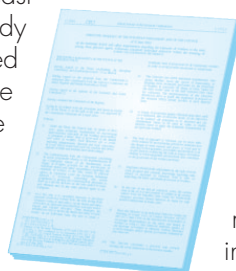
This guide is intended to help employers identify hazards relating to whole-body vibration, assess exposures and risks and identify measures for safeguarding the health and safety of workers exposed to whole-body vibration risks.

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

Whole body vibration is caused by vibration transmitted through the seat or the feet by workplace machines and vehicles (see Annex B). Exposure to high levels of whole-body vibration can present risks to health and safety and are reported to cause or aggravate back injuries (see Annex C). The risks are greatest when the vibration magnitudes are high, the exposure durations long, frequent, and regular, and the vibration includes severe shocks or jolts.

Work that involves exposure to whole-body vibration occurs commonly in off-road work, such as farming, construction and quarrying, but it can occur elsewhere, for example on the road in lorries and trucks, at sea in small fast boats and in the air in some helicopters. Whole-body vibration is not restricted to seated workers such as drivers, but may also be experienced during standing operations such as standing on a concrete crushing machine.

Back injury can be caused by ergonomic factors such as manual handling of the load and restricted or awkward postures. These are factors that may be at least as important as the exposure to whole-body vibration. Back injury can, of course, be caused by activities in or out of work unrelated to use of vehicles. In order to tackle successfully the problem of back injury in drivers and operators of mobile machinery it is important to identify and deal with all possible contributing factors together.



The 'Vibration Directive' (Directive 2002/44/EC - see "Further reading" box) sets minimum standards for controlling the risks from whole-body vibration. The Vibration Directive requires that member states of the European Union implement national legislation to implement the requirements of the Directive by 6th July 2005. National legislation may apply more favourable provisions than those required by the Directive, and should not reduce the protection afforded to workers by any pre-existing national legislation.

The Vibration Directive sets an exposure action value, above which it requires employers to control the whole-body vibration risks of their workforce and an exposure limit value above which workers must not be exposed²:

- a daily exposure action value of 0.5 m/s^2

(or, at the choice of the EC Member State, a vibration dose value of $9.1 \text{ m/s}^{1.75}$);

- a daily exposure limit value of 1.15 m/s^2

(or, at the choice of the EC Member State, a vibration dose value of $21 \text{ m/s}^{1.75}$);

The Vibration Directive places requirements on employers to ensure that risks from whole-body vibration are eliminated or reduced to a minimum. These responsibilities are summarised in Annex A.

² Member states are entitled (after consultation with the two sides of industry) to apply transitional periods to the exposure limit value 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). The transitional periods only apply to the use of machinery supplied prior to 6th July 2007 for which (taking into account all available technical or organisational means to control the risk) the exposure limit value cannot be respected.

The Vibration Directive is a daughter Directive of the Framework Directive (Directive 89/391/EEC - see "Further reading" box) as such many of the requirements of the Vibration Directive are derived from, and make specific reference to, the Framework Directive.

This guide will help employers comply with the Vibration Directive as it applies to whole-body vibration. The guide is 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 the Vibration Directive. The structure for this guide is shown in the flow diagram of [Figure 1](#).

Further reading:

Vibration Directive:

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).

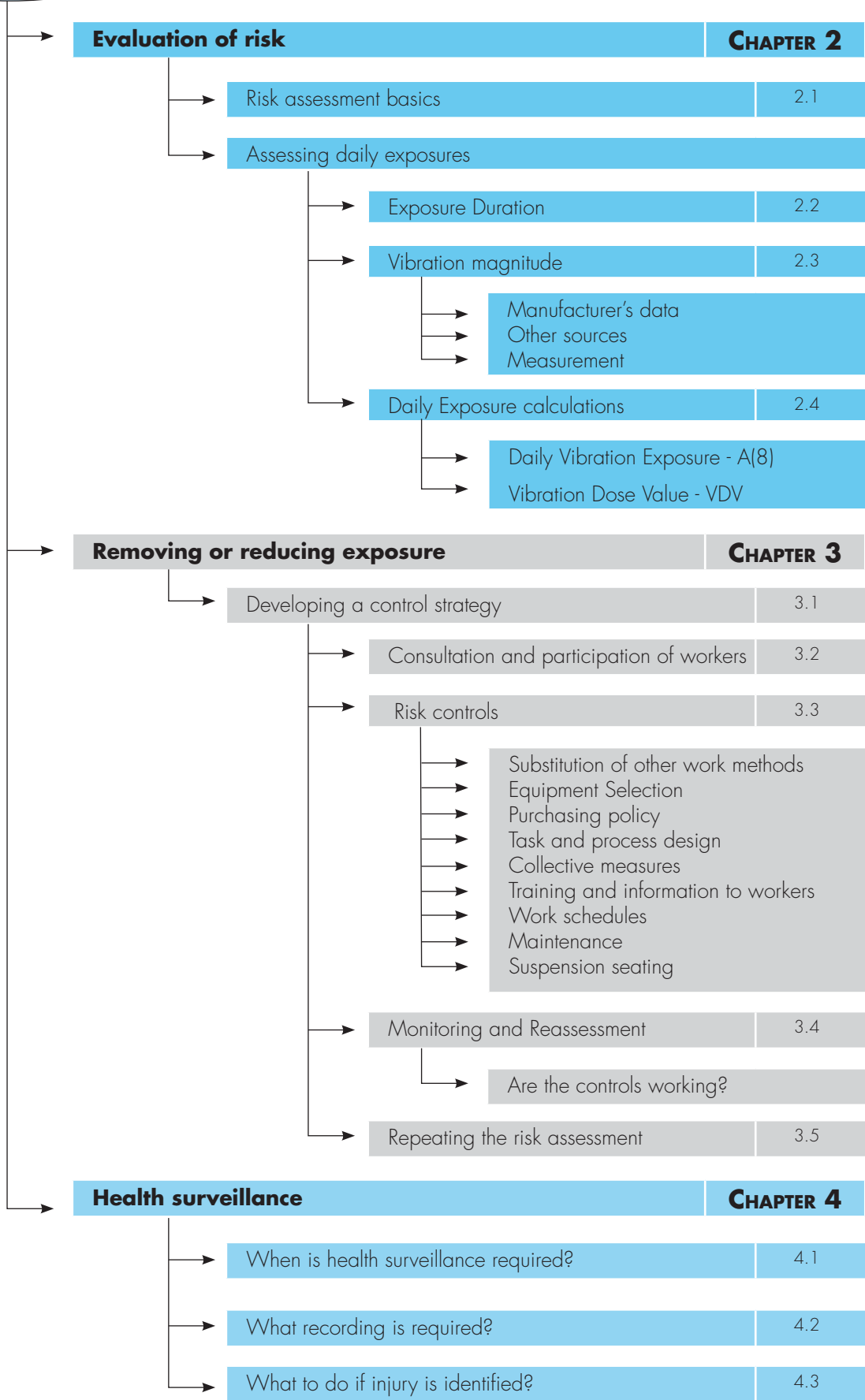
(Published in the Official Journal of the European Communities L 177 of 6 July 2002, page 13)

Framework Directive:

Directive 89/391/EEC of the European parliament and of the Council of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work.

**Whole-body
Vibration at work**

FIGURE 1 WHOLE-BODY VIBRATION FLOW DIAGRAM



CHAPTER 2 EVALUATION OF RISK

The purpose of the whole-body 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 whole-body vibration.

In this chapter we show how you can decide whether you may have a problem with whole-body 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 health or safety risk for which whole-body vibration is either the cause or a contributory factor;
- estimate workers' 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 whole-body vibration risks; and
- record the assessment, the steps that have been taken and their effectiveness.

Along with whole-body vibration, other ergonomic factors may contribute to back pain, these include:

- poor posture while driving/operating plant;
- sitting for long periods without being able to change position;
- poorly placed control operations, which require the driver/operator to stretch or twist;
- poor visibility of the operation, which requires twisting and stretching to get an adequate view;

- manual lifting and carrying of heavy or awkward loads;
- repeatedly climbing into or jumping out of a high or difficult access cab.

All these factors can separately cause back pain. However, the risk will be increased where a person is exposed to one or more of these factors while being exposed to whole-body vibration. For example:

- being exposed to whole-body vibration for long periods without being able to change position;
- being exposed to whole-body vibration while sitting in a stretched or twisted posture (e.g. looking over your shoulder to monitor the operation of attached equipment);
- being exposed to whole-body vibration and then doing work involving manually lifting and carrying heavy loads.

Environmental factors, such as temperature may further increase the risk of back pain or injury.

All these causes must be considered together in your plans to minimise risk of back injury. Regulations and guidance on manual handling of materials should be considered where this is a factor in your workers' work.



A starting point in your risk assessment is to consider the work being carried out, the processes involved and the machinery and equipment used. Some questions to help you decide whether further action is required are shown in Table 1.

All types of vehicle, when in motion, are likely to cause the driver to experience whole-body vibration.

The risks to health increase where people are regularly exposed to high levels of whole-body vibration over a long period. Some vehicles that have been associated with whole-body vibration and ergonomic risks are shown in Figure 2. Remember that whole-body vibration exposure may also arise from non-driving activities, e.g. where workers stand on vibrating platforms.

Further reading:

Manual Handling Directive:

Council Directive 90/269/EEC of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

TABLE 1 QUESTIONS TO HELP DECIDE WHETHER FURTHER ACTION MAY BE NEEDED

Do you drive off-road?

High levels of whole-body vibration are most likely for people who drive vehicles over rough surfaces as part of their job, for example off-road vehicles such as tractors, quad bikes, and dumper trucks.

Do you drive or operate vibrating machinery for a long time every day?

The factors that govern a person's daily vibration exposure are the magnitude (level) of vibration and the length of time the person is exposed to it. The longer the duration of exposure, the greater will be the risk from vibration exposure.

Do you drive vehicles that are not designed for the roadway conditions?

Some industrial vehicles, such as forklift trucks, do not have wheel suspension and are fitted with solid tyres, to provide them with the necessary stability to work safely. Provided they are driven on smooth surfaces whole-body vibration levels should not be high. However, if they are driven on unsuitable surfaces (e.g. a fork-lift truck designed for warehouse use being operated in an external loading yard), they can generate high levels of whole-body vibration.

Do you drive over poorly maintained road surfaces?

Most road vehicles will generate fairly low levels of whole-body vibration provided the road surface is well maintained. Cars, vans and modern designs of suspended-cab lorries are generally unlikely to present a risk from whole-body vibration when used on well-maintained roads. However, vehicles with less effective suspension such as rigid body lorries may cause high levels of whole-body vibration, particularly when they are driven over poor surfaces, or when they are unladen.

Are you exposed to shock (or jolts)?

The greatest risk from vibration exposure is believed to come from exposure to shock vibration. Shock vibration may arise from poor road surfaces, driving too fast for the terrain, or incorrect setup of the seat suspension. Scrapers may generate high levels of shock vibration when driving over difficult ground. Some heavily laden vehicles may transmit shocks and jolts to the driver with hard use of the brakes.

Do you need to adopt poor postures or perform manual handling tasks?

Poor cab layout or poor visibility can result in stretching and twisting, or may confine the driver to a fixed position for long periods. These poor ergonomic environments, either alone or combined with whole-body vibration exposures, can result in back and other musculoskeletal injuries.

Do the manufacturers of the machinery warn of risk from whole-body vibration?

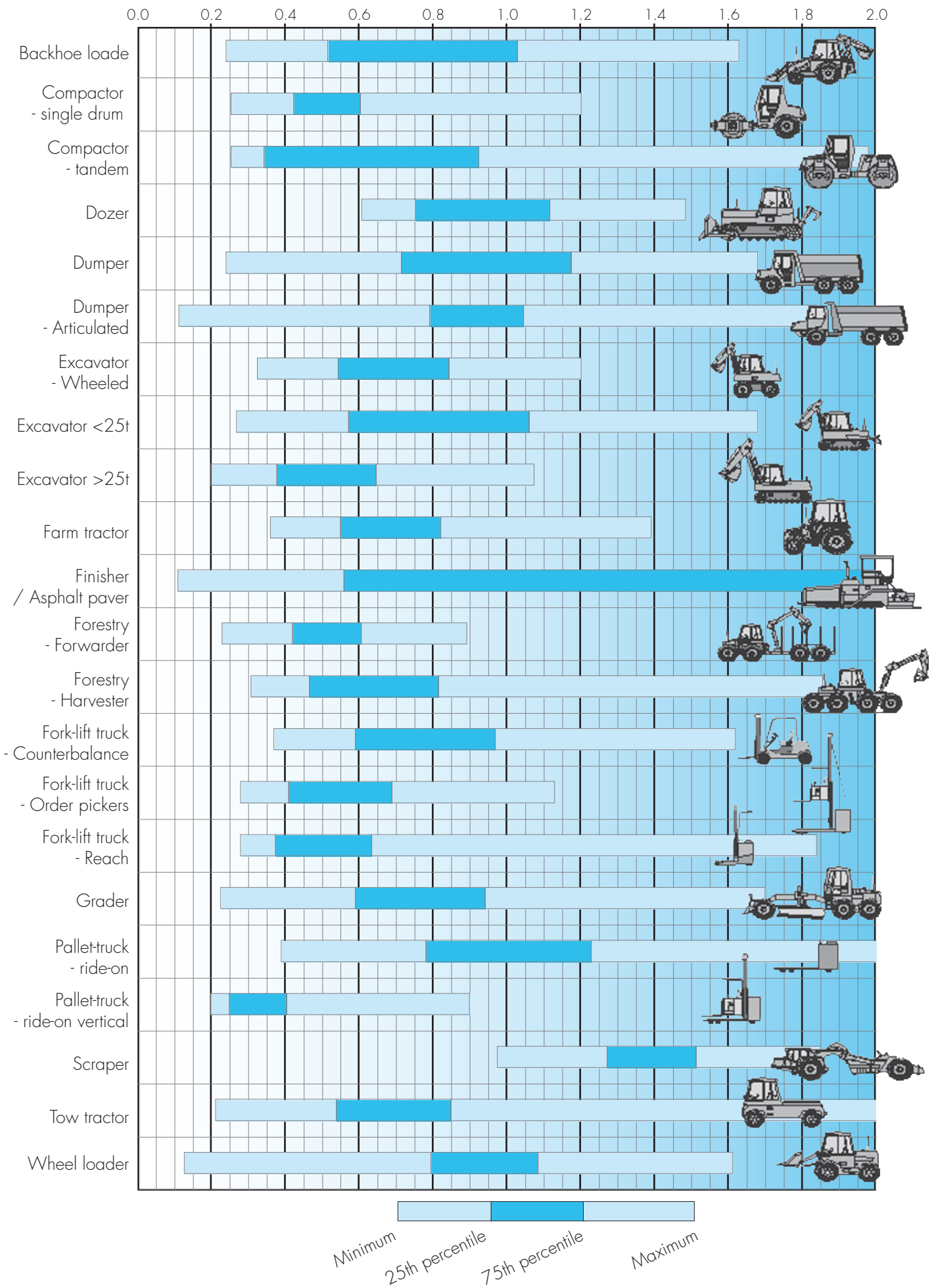
If you are using a machine that may put the users at risk of vibration injury, the manufacturer should warn you about it in the handbook.

Do workers report back disorders?

Evidence of back injury means that ergonomic risks and vibration exposures need to be managed.

FIGURE 2 EXAMPLES OF VIBRATION MAGNITUDES FOR COMMON TOOLS
 Ranges of vibration values for common equipment on the EU market. These data are for illustration only.

For more details see [ANNEX B](#).

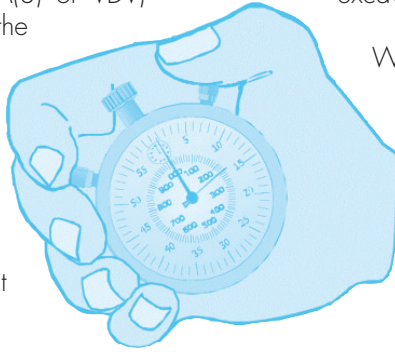


2.2 DETERMINING EXPOSURE DURATION

To assess the daily vibration exposure of workers, we need an estimate of the time machine operators are exposed to the vibration source.

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

Before the daily vibration exposure (A(8) or VDV) can be estimated, you need to know the total daily duration of exposure to the vibration from the vehicles or machines used. You should be careful to use data that is compatible with your vibration magnitude data, for example, if your vibration magnitude data is based on measurements when the machine was working, then count



only the time that the worker is exposed to vibration. Machine or vehicle operators questioned on their typical daily duration of vibration exposure usually state a value containing periods without vibration exposure, e.g. truck loading and waiting times.

Usually, the vibration that occurs when the vehicle is travelling will dominate vibration exposures. However, some exposures are dominated by operations being performed while the vehicle is static, such as excavators and tree harvesters.

Work patterns need careful consideration. For example some workers may only operate machines for certain periods in a day. Typical usage patterns should be established, as these will be an important factor in calculating a person's likely vibration exposure.

Further reading:

EN 14253, Mechanical vibration — Measurement and calculation of occupational exposure to whole-body vibration with reference to health — Practical guidance

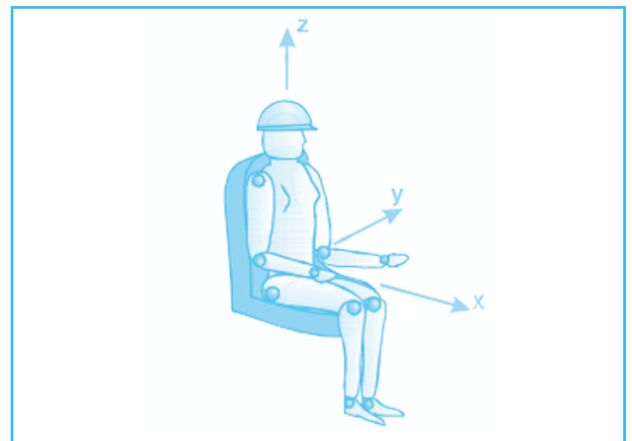
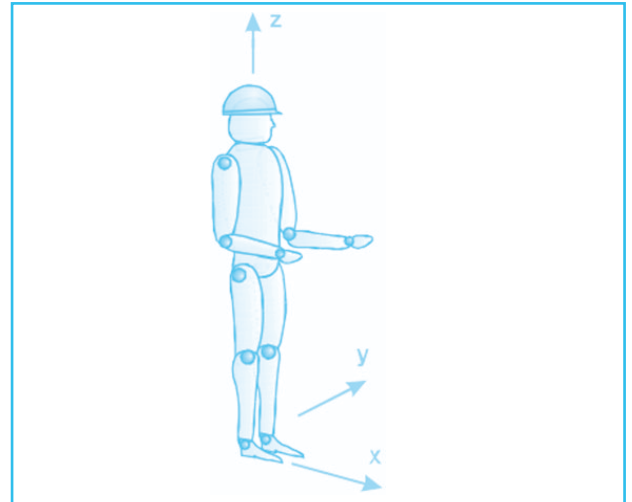
2.3 DETERMINING VIBRATION MAGNITUDE

Whole-body vibration magnitude is the frequency-weighted acceleration value in the highest of three orthogonal axes (1.4_{awx} , 1.4_{awy} or a_{wz}) for a seated or standing worker.

The vibration information you use for your vibration assessment needs to match closely the likely vibration performance of the machine being used (both the machine's specifications and the way the machine is operated).

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

European or international standards bodies. However, very few machine specific standards are currently (in 2005) available and where standards do exist such as for industrial trucks, the differences between directly competing machines are often less than 50%.



2.3.1 Use of manufacturer's emission data

The European Union's "Machinery Directive" (Directive 2006/42/EC and, previously, repealed Directive 98/37/EC) defines essential health and safety requirements for machinery supplied within the EU including specific requirements regarding vibration.

Amongst other requirements, the Machinery Directive requires manufacturers, importers and suppliers of machines to provide information on any risks from vibration, and values for the whole-body vibration emissions of mobile machinery. This vibration emission information should be given in the information or instructions that accompany the machine.

Vibration emission data is usually obtained according to harmonised European vibration test codes produced by

Further reading:

EN 1032:2003 Mechanical vibration — Testing of mobile machinery in order to determine the vibration emission value

EN 12096:1997 Mechanical vibration — Declaration and verification of vibration emission values.

CEN/TR First committee draft Munich (March 2005) — Mechanical vibration - Guideline for the assessment of exposure to whole-body vibration of ride on operated earth-moving machines. Using harmonised data measured by international institutes, organisations and manufacturers.

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 either the exposure action value or the exposure limit values are likely to be exceeded.

Your trade association or equivalent may 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 make an initial vibration exposure assessment.

Other sources of vibration data include specialist vibration consultants, trade associations, manufacturers and government bodies. Some data can also be found in various technical or scientific publications and on the Internet. 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/wbvhome.lasso>

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

Ideally you should use vibration information for the machine (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:

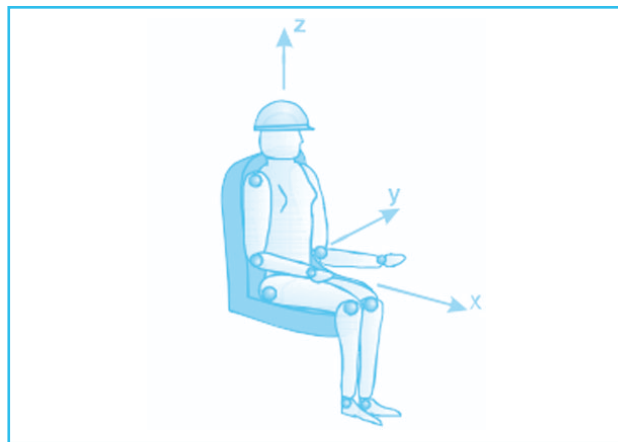
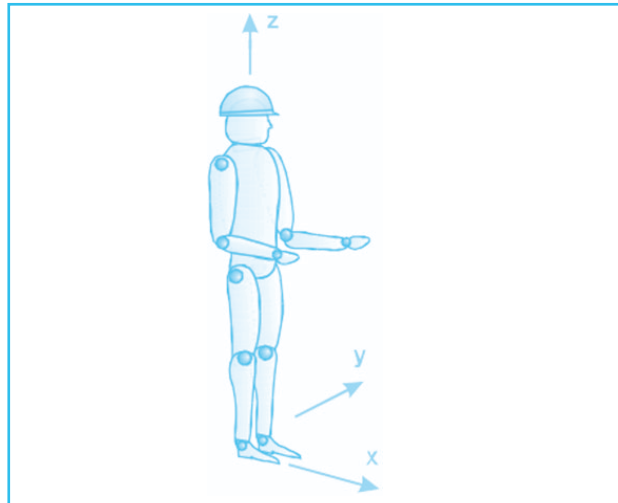
- the type of equipment (e.g. forklift truck),
- the class of equipment (e.g. power or size),
- the power source (e.g. electric or combustion engine),
- any anti-vibration features (e.g. suspension systems, suspended cab, seats),
- the task the vehicle was used for when producing the vibration information,
- the speed it was operated at,
- the type of surface it was run on.

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

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 at what is measured, where vibration is measured and how it is reported.



Manufacturer's data and information from other information sources may give a useful indication of the vibration exposure of machine operator's. However, whole-body vibration exposure is very dependent on the quality of road surfaces, vehicle speeds and other factors such as how the vehicle is operated. Therefore, it may be necessary to confirm your initial exposure assessment by having measurements of vibration magnitudes made.

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

What is measured?

Human exposure to whole-body vibration should be evaluated using the method defined in International Standard ISO 2631 1:1997 and detailed practical guidance on using the method for measurement of vibration at the workplace is given in EN 14253:2003.

The *root-mean-square (r.m.s) vibration magnitude* is expressed in terms of the frequency-weighted acceleration at the seat of a seated person or the feet of a standing person (see Annex B), it is expressed in units of metres per second squared (m/s^2). The r.m.s vibration magnitude represents the average acceleration over a measurement period. It is the highest of three orthogonal axes values ($1.4a_{wx}$, $1.4a_{wy}$ or a_{wz}) that is used for the exposure assessment.

The *vibration dose value* (or VDV) provides an alternative measure of vibration exposure. The VDV was developed as a measure that gives a better indication of the risks from vibrations that include shocks. The units for VDV are *metres per second to the power 1.75* ($m/s^{1.75}$), and unlike the *r.m.s vibration magnitude*, the measured VDV

is cumulative value, i.e. it increases with measurement time. It is therefore important for any measurement of VDV to know the period over which the value was measured. It is the highest of three orthogonal axis values ($1.4VDV_{wx}$, $1.4VDV_{wy}$ or VDV_{wz}) that is used for the exposure assessment.

Making vibration measurements

Measurements should be made to produce vibration values that are representative of the vibration throughout the operator's working period. It is therefore important that the operating conditions and measurement periods are selected to achieve this.

It is recommended that wherever practical, measurements should be made over periods of at least 20 minutes, where shorter measurements are unavoidable they should normally be at least three minutes long and, if possible, they should be repeated to give a total measurement time of more than 20 minutes (see EN 14253 for further advice). Longer measurements, of 2 hours or more are preferable (half or full working day measurements are sometimes possible).

Further reading:

EN 14253, Mechanical vibration — Measurement and calculation of occupational exposure to whole-body vibration with reference to health — Practical guidance

CEN/TR First committee draft Munich (March 2005) — Mechanical vibration - Guideline for the assessment of exposure to whole-body vibration of ride on operated earth-moving machines. Using harmonised data measured by international institutes, organisations and manufacturers.

2.4 CALCULATING DAILY VIBRATION EXPOSURES

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 the exposure times and either the vibration magnitude information or from vibration dose values.

Some tools for simplifying the calculation of daily exposures and managing exposure times are given in [Annex D](#).

Worked examples of how daily vibration exposures and VDV's can be calculated are given [Annex E](#)

2.4.1 A(8) and VDV daily exposure evaluation

Daily exposure to vibration may be assessed using either or both of the two exposure measures:

- (a) Daily vibration exposure, A(8), or
- (b) Vibration dose value, VDV.

Both measures are dependent on a measured vibration value. The A(8) also requires an exposure time. Like vibration magnitude, the daily vibration exposure has units of metres per second squared (m/s^2).

If the VDV is measured over a measurement period that is shorter than the full working day (as it usually will be), then the resulting measurement will need to be scaled up.

Instructions and worked examples showing how to calculate A(8) and VDV exposures are given in Annex E.

2.4.2 Uncertainty of daily exposure evaluations

The uncertainty of vibration exposure evaluation is dependent on many factors, see EN 14253:2003, including:

- Instrument / calibration uncertainty,
- Accuracy of source data (e.g. manufacturer's emission data),
- Variation of machine operators (e.g. experience, driving speeds or styles),
- Ability of the worker to reproduce typical work during measurements,
- Repeatability of the work task,
- Environmental factors (e.g. rain, wind, temperature),
- Variations in the machine and suspension systems (e.g. is there a need for maintenance, has the machine been warmed-up?).

Where vibration magnitude and exposure time are measured the uncertainties associated with the evaluation of A(8) and VDV can mean that the calculated value can be as much as much 20% above the true value to 40% below. 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.

CHAPTER 3 AVOIDING OR REDUCING EXPOSURE



To control exposure we must have a strategy that can effectively deliver reduced exposures to whole-body vibration.

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

3.1 DEVELOPING A CONTROL STRATEGY

A 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 high vibrations and ergonomic risks will help identify methods for reducing or eliminating the risks.

The important stages in this management process are:

- identifying the main sources of vibration;
- identifying the main sources of shock vibration;
- ranking them in terms of their contribution to the exposure;
- 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 whole-body vibration will depend on the practical aspects of your particular processes and on the current levels of exposure.

You may also need to adapt your controls for workers who are at particular risk of injury, e.g. those workers who are more susceptible to vibration injury and show signs of developing injury at exposures below the exposure action value.

The Framework Directive provides the following hierarchy for implementing a programme of preventative measures:

- (a) avoiding risks;
- (b) evaluating the risks which cannot be avoided;
- (c) combating the risks at source;
- (d) adapting the work to the individual, especially as regards the design of work places, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;
- (e) adapting to technical progress;
- (f) replacing the dangerous by the non-dangerous or the less dangerous;
- (g) developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors related to the working environment;
- (h) giving collective protective measures priority over individual protective measures;
- (i) giving appropriate instructions to the workers.

3.2 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.

Lower-back pain may be caused by a combination of factors, including whole-body vibration exposure, so a variety of different solutions may be necessary. Some solutions may be quite straightforward. Other solutions will require modifications to the way in which work is organised. These issues can often only be effectively dealt with in consultation with workplace representatives.

Effective consultation relies on:

- the sharing of relevant information about health and safety measures with workers;
- workers being given the opportunity to express their views and to contribute in a timely fashion to the resolution of health and safety issues;
- the views of workers being valued and taken in to account.

Consultation can result in better control solutions being identified that are well understood by the workers. You will be relying on workers to make the control measures effective. Subject to adequate training and supervision, workers have a duty to make correct use of machinery and to cooperate with the employer to enable them to ensure that their environment and working conditions are safe, such that risks to safety and health are minimised and where possible eliminated. The process of consultation encourages worker involvement and co-operation with control measures and so ensures that controls are more likely to be successfully implemented.

3.3 RISK CONTROLS

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

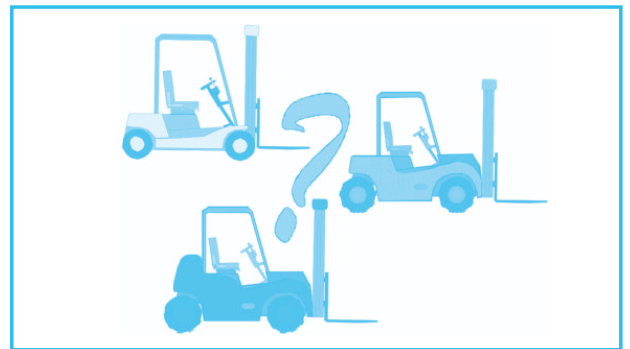
In this chapter we look at the engineering, management and other methods that should be considered when looking for control solutions.

3.3.1 Substitution of other working methods

It may be possible to find alternative work methods that avoid or reduce exposure to vibration, e.g. by transporting materials by conveyor rather than using mobile machinery. To keep up-to-date on the methods available you should check regularly with:

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

3.3.2 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 workers to more vibration for longer than is necessary.

Choose machines with cab layouts and control levers arranged so that the operator is able to maintain a comfortable upright posture and will not need to twist the body excessively, or maintain twisted postures for any length of time.

Selection of tyres can be important; tyres will absorb some effects of uneven ground. However, tyres cannot absorb the vibration from larger lumps and potholes, and soft tyres on undulating ground can amplify a vehicle's vertical motions. Tyres need to be selected so that the vehicle can handle rougher terrain.

3.3.3 Purchasing policy

Make sure your purchasing department has a policy on purchasing suitable equipment that takes into account health and safety issues, including: vibration emission, ergonomic factors, driver vision and your operating requirements.

Anyone supplying machinery for use in Europe must comply with the Machinery Directive (Directive 2006/42/EC repealing Directive 98/37/EC). According to this Directive, machinery must be so designed and constructed that risks resulting from vibrations produced by the machinery are reduced to the lowest level, taking account of technical progress and the availability of means of reducing vibration, in particular at source. This Directive also states that the seat must be designed to reduce vibrations transmitted to the driver to the lowest level that can be reasonably achieved.

The supplier should advise you of any risks presented by the machine, including those from whole-body vibration. The information about vibration should include:

- the vibration emission (as reported in the instruction handbook);
- the uncertainty of measurement.

The supplier may also be able to offer technical support or advice on:

- any circumstances under which the machine can generate whole-body vibration exposures above the exposure action value;
- any circumstances under which the machine can generate whole-body vibration exposures above the exposure limit value;
- any special training (of drivers, maintenance crew, etc.) recommended to control whole-body vibration exposures;
- how to maintain the machine in good condition;
- information showing that the seat provided in the vehicle reduces the vibration exposure to the lowest level that can reasonably be achieved;
- any options that are available that are recommended for control of whole-body vibration in specific applications of the machine.

For mobile machinery, the Machinery Directive requires that manufacturers or suppliers of machinery provide in the instructions:

“information concerning vibrations transmitted by the machinery to the whole-body:

- the highest root mean square value of weighted acceleration to which the whole body is subjected, if it exceeds 0.5 m/s². Where this value does not exceed 0.5 m/s², this must be mentioned.”

3.3.4 Task and process design

Work tasks should be designed so that:

- whole-body vibration exposures are as low as practicable,
- the daily period of exposure to excessive vibration is as short as possible,
- the exposure to severe shocks is avoided and
- the working posture does not increase the risks of back injury.

In many cases, travelling over rough or uneven ground is the main contributor to the vibration exposure. Vibration exposure may be reduced and controlled by:

- minimising the travelling distances,
- limiting the vehicle speeds,
- improving the road surfaces (removing obstacles, filling potholes, levelling surfaces over which vehicles are driven, etc),
- providing a suitable suspended seat which is set correctly for the driver’s weight.

A good posture is vital for minimising the risks of back injury when driving. Posture can be improved by:

- improving the drivers vision from the cab (to minimise twisting of the back and neck),
- relocating machine controls (to minimise repeated stretching),
- providing a seat, that fits all the drivers that will use the vehicle, fits the space available within the cab and is suitable for the task being carried out,
- using seat-belts to maintain the driver in the best position, providing support for the back.

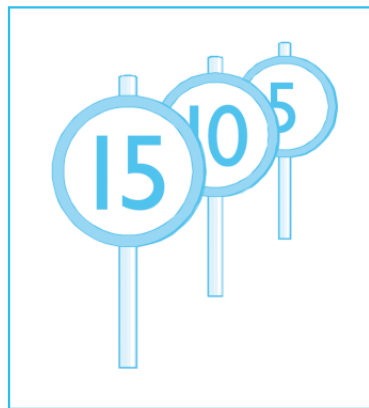
3.3.5 Collective measures

Where several undertakings share a work place, the various employers are required to cooperate in implementing the safety, and health and occupational hygiene provisions. This may mean, for example, ensuring that a road surface is adequately maintained, so that vibration exposure of workers from another company operating at the same location may be controlled.

3.3.6 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 whole-body vibration;
- safe working practices that minimise exposure to vibration;
- why and how to detect and report signs of injury;
- the circumstances in which workers are entitled to health surveillance.



Workers must be trained in driving techniques that minimise vibration exposure. They must be made aware of the effect of driving speed, and if speed limits are imposed, the reasons for imposing them.

Where seat suspension systems are fitted, drivers should be shown how to adjust them for their own weight. They also need to be shown how to set other seat controls (fore-aft position, height, back-rest inclination etc...) to achieve the best posture.

Drivers and maintenance technicians need to be trained to recognise when machine components that affect vibration exposure and posture, such as the seat suspension system, need maintenance or replacing.

Workers should also be advised on the impact of non-work activities on the risks to their health. To reduce the risks of developing lower-back pain workers should be encouraged to maintain their general fitness, and to consider the risks to their backs from non-work activities, for example using poor lifting techniques or adopting poor postures for long periods.

3.3.7 Work schedules

To control the risks from whole-body vibration you may need to limit the time workers are exposed to vibration from some vehicles or machines.

3.3.8 Maintenance

Regular servicing of vehicles, attachments and the roadways they use will help keep vibration magnitudes and shocks down to the a minimum necessary, so:

- maintain road surfaces;
- replace worn parts (including any seat suspension);,
- check and replace defective vibration dampers, bearings and gears;
- tune engines;
- maintain tyres and ensure they are inflated to the correct pressures for the surface and load conditions;
- lubricate seat and other suspension systems.

3.3.9 Suspension seats

The machine supplier should provide information on appropriate seats for their vehicles. Suspension seats are not always appropriate, but the machine manufacturers must provide a seat designed to reduce vibration transmitted to the driver to the lowest level that can reasonably be achieved.

Where suspension seats are provided, it is important that the seat suspension is appropriate for the vehicle. Poor choice of seat suspension systems can easily result in a higher vibration exposure than would be given without the suspension. All seat suspension systems have a range of frequencies that they amplify. If the dominant frequencies of the vehicle vibration fall within this amplification range, the seat suspension will make the driver's vibration exposure worse. ISO EN 7096:2000, ISO EN 5007 and EN 13490:2001 provide performance criteria for earth moving machinery, agricultural

wheeled tractors and industrial trucks respectively that are designed to ensure appropriate performance of seat suspension.



The seat suspension system must also be selected so that, in typical use, it is unlikely to hit its top or bottom end-stops. Striking the end-stops creates shock vibrations, so increasing the risk of back injury.

The seat suspension must be readily accessible and easy to adjust for the operator's weight and body size. Height, fore-aft and backrest adjustments are especially important. The seat cushions should be ergonomically designed.

Further reading:

CEN/TR 15172-1, Whole-body vibration – Guidelines for vibration hazards reduction – Part 1: Engineering methods by design of machinery.

CEN/TR 15172-2, Whole-body vibration – Guidelines for vibration hazards reduction – Part 2: Management measures at the workplace.

3.4 VIBRATION MONITORING AND REASSESSMENT

Management of vibration exposure is an ongoing process, you need to 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.

3.4.1 How do I know if my whole-body vibration controls are working?

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

- Check regularly that workers (including managers and supervisors) are still carrying out the programme of controls you have introduced;
- Talk regularly to all workers, safety personnel and worker representatives about any vibration or postural problems with the vehicles or machines or the way they are 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.

3.4.2 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 vehicles or machinery 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, machine 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 for the detection 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.

Implementation of health surveillance is a clear Member State competence and there are differences in health surveillance practices across the European Union. It is not the intention of this guide to provide definitive guidance on health surveillance. In this chapter we re-state the requirements for health surveillance given in the vibration directive and review some of the assessment techniques available.

Some health surveillance techniques related to whole-body injury are described in [Annex F](#).

4.1 WHEN IS HEALTH SURVEILLANCE REQUIRED ?

Member States shall adopt provisions to ensure the appropriate health surveillance of workers where the whole-body 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 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.

4.3 WHAT TO DO IF INJURY IS IDENTIFIED?

Where, as a result of health surveillance, a worker is found to have an identifiable disease or adverse health effect that is considered by a doctor or occupational health-care professional to be the result of exposure to mechanical vibration at work:

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 whole-body vibration risk assessment,
- Review the measures provided to eliminate or reduce risks from whole-body 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 whole-body 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 Summary of responsibilities defined by Directive 2002/44/EC

Table A.1 Summary of responsibilities defined by Directive 2002/44/EC

Directive Article	Who	When	Requirement
Article 4	Employer	Potential risk from whole-body vibration	Determination and assessment of risk: <ul style="list-style-type: none"> ✓ Use someone who is competent to assess the whole-body 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	Removing or reducing exposure: <ul style="list-style-type: none"> ✓ Take general actions to eliminate risks or reduce them to a minimum
		Exposures above the exposure action value	<ul style="list-style-type: none"> ✓ Establish and implement programme of measures to eliminate, or reduce to a minimum, exposures to whole-body vibration
		Exposures above the exposure limit value	<ul style="list-style-type: none"> ✓ Take immediate action to prevent exposure above the limit value ✓ Identify why the exposure limit value has been exceeded
		Workers at particular risk	<ul style="list-style-type: none"> ✓ Adapt to requirements of workers at particular risk
Article 6	Employer	Workers at risk from whole-body vibration	Worker information and training: <ul style="list-style-type: none"> ✓ For all workers exposed to whole-body vibration risks.
Article 7	Employer	Workers at risk from whole-body vibration	Worker consultation and participation: <ul style="list-style-type: none"> ✓ 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: <ul style="list-style-type: none"> ✓ Inform worker of results of health surveillance ✓ Provide information and advice to worker on health surveillance necessary when exposure to whole-body vibration has finished. ✓ Provide significant findings of health surveillance to employer
	Employer	Where ill-health is identified	<ul style="list-style-type: none"> ✓ Review risk assessment ✓ Further eliminate or reduce risks ✓ Review the health status of similarly exposed workers.
	Employer	Exposures above the exposure action value	<ul style="list-style-type: none"> ✓ Workers entitled to appropriate health surveillance

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 whole-body vibration, it may be the seat of a vehicle or the platform on which a worker is standing that vibrates, and this motion is transmitted into the body of the driver.

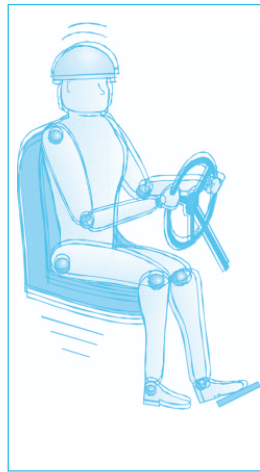


Figure B.1
Whole-body vibration

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 metres), the vibration velocity (in metres per second) or the vibration acceleration (in metres per second per second or m/s^2). However, most vibration transducers produce an output that is related to acceleration (their output is dependent on the force acting on a fixed mass within the transducer and, for a fixed mass, force and acceleration are directly related); so acceleration has traditionally been used to describe vibration.

The vibration transducer measures acceleration in one direction only, so to get a more complete picture of the vibration on a surface, three transducers are needed: one in each axis as illustrated in [Figure B.2](#).

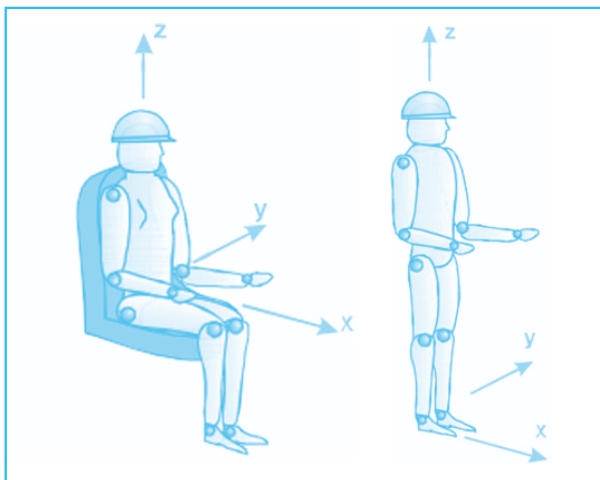


Figure B.2 Vibration measurement axes

B.3 WHAT IS FREQUENCY AND FREQUENCY WEIGHTING?

Frequency represents 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 whole-body vibration, the frequencies thought to be important range from 0.5Hz to 80Hz. However, because the risk of damage 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 whole-body vibration, two different frequency weightings are used. One weighting (the *Wd weighting*) applies to the two lateral axes: x and y, and another (the *Wk weighting*) applies to the vertical, z-axis vibration.

When considering the risks to health from whole-body vibration an additional multiplying factor must be applied to the frequency weighted vibration values. For the two lateral axes (x and y) the acceleration values are multiplied by 1.4. For the vertical, z-axis vibration the factor is 1.0.

B.4 WHAT VIBRATION PARAMETERS ARE USED FOR EXPOSURE ASSESSMENT?

The vibration directive allows for two vibration assessment methods:

- the daily 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/s^2 ; and
- the vibration dose value (VDV) is a cumulative dose, based on the 4th root-mean-quad of the acceleration signal with units of $m/s^{1.75}$.

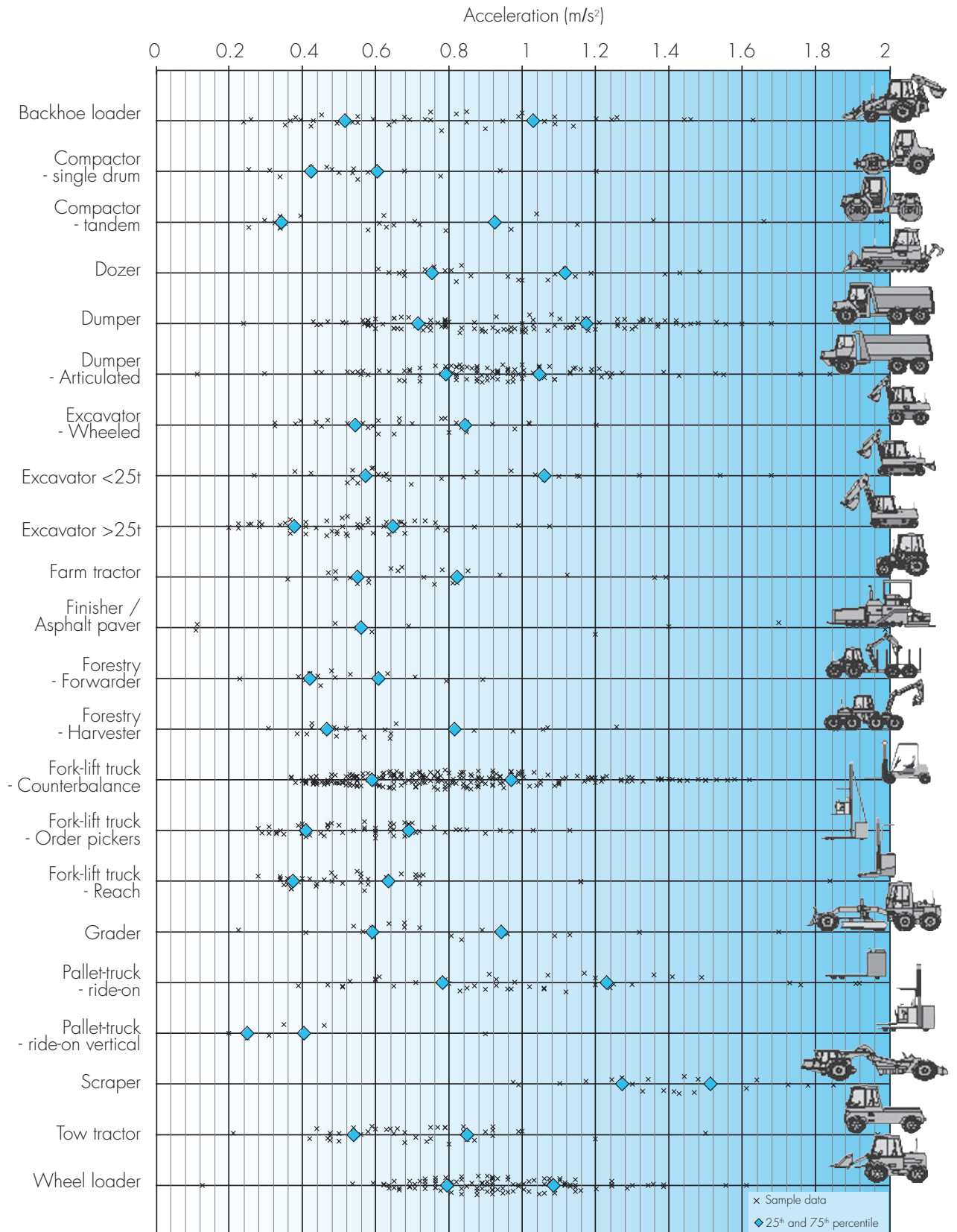
Both parameters $A(8)$ and VDV are defined in ISO 2631-1:1997.

Some examples of vibration magnitudes for common hand-held power tools are shown in [Figure B.3](#).

FIGURE B.3 EXAMPLES OF VIBRATION MAGNITUDES FOR COMMON MACHINES

Sample data based on workplace vibration measurements of highest axis vibration values by INRS INRS (with the assistance of CRAM and Prevencem), HSL and RMS Vibration Test Laboratory between 1997 and 2005. These data are for illustration only and may not be representative of machine use in all circumstances

The 25th and 75th percentile points show the vibration magnitude that 25% or 75% of samples are equal to or below





B.5 WHAT INSTRUMENTATION SHOULD BE USED?

Whole-body vibration measuring equipment should comply with the ISO 8041:2005 specifications for whole-body vibration measuring instruments.

Further reading:

CEN/TR 15172-1, Whole-body vibration – Guidelines for vibration hazards reduction – Part 1: Engineering methods by design of machinery.

CEN/TR 15172-2, Whole-body vibration – Guidelines for vibration hazards reduction – Part 2: Management measures at the workplace.

ANNEX C Health risks, signs and symptoms

C.1 EFFECTS OF WHOLE-BODY VIBRATION ON THE HUMAN BODY

The transmission of vibration to the body is dependent on body posture. The effects of vibration are therefore complex. Exposure to whole-body vibration causes motions and forces within the human body that may:

- cause discomfort,
- adversely affect performance.
- aggravate pre-existing back injuries and
- present a health and safety risk.

Low-frequency vibration of the body can cause motion sickness.

Epidemiological studies of long-term exposure to whole-body vibration have shown evidence for an elevated risk to health, mainly in the lumbar spine but also in the neck and shoulder. Some studies have reported evidence of effects on the digestive system, the female reproductive organs and the peripheral veins.

C.2 LOWER-BACK PAIN AND BACK, SHOULDER OR NECK DISORDERS

The results of epidemiological studies show a higher prevalence rate of low-back pain, herniated disc and early degeneration of the spine in whole-body vibration exposed groups. Increased duration of vibration exposure and increased intensity are assumed to increase the risk, while periods of rest reduce the risk. Many drivers complain also about disorders in the neck-shoulder although epidemiological researches are inconclusive on this effect.

Low-back pain and back, shoulder or neck disorders are not specific to vibration exposures. There are many confounding factors such as working posture, anthropometric characteristics, muscle tone, physical workload, and individual susceptibility (age, pre-existing disorders, muscle force, etc.).



Driving of mobile machines does not only involve exposure to whole-body vibration but also to several other factors that put strains on the back, shoulder or neck. The most important being:

- prolonged sitting in constrained postures,
- prolonged sitting in poor postures,
- frequent twisting of the spine
- needing to adopt twisted head postures,
- frequent lifting and material handling (e. g. drivers of delivery trucks),
- traumatic injuries,
- unexpected movements,
- unfavourable climatic conditions and
- stress.

In some countries and under certain conditions, lumbar disorders occurring in workers exposed to whole-body vibration are considered to be an occupational disease.

C.3 OTHER DISORDERS

The question of whether whole-body vibration exposure might lead to digestive or circulatory disorders or adverse affects on the reproductive system remains open. In some cases an increased prevalence of gastro-intestinal complaints, peptic ulcer and gastritis have been reported in drivers of vibrating vehicles. Whole-body vibration seems to be a factor that in combination with the long-term sitting posture of drivers contributes to the occurrence of varicose veins and haemorrhoids. Some studies have reported evidence of effects on the digestive system, the female reproductive organs and the peripheral veins. One study showed a greater than expected incidence of stillbirth among women exposed to vibration in the transport sector.



ANNEX D Tools for calculating daily exposures

D.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/wbvcalculator.lasso>

D.2 DAILY EXPOSURE GRAPH

The graph in [Figure D.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 $(k_{aw})_{max}$ and exposure time lines meet (the factor k is either 1.4 for the x- and y-axes or 1.0 for the z-axis i.e. vertical direction).

The green area in [Figure D.1](#) indicates exposures likely to be below the exposure action value. These exposures

must not be assumed to be "safe". There may be a risk of whole-body vibration injury for exposures below the exposure action value, and so some exposures within the green area may cause vibration injury in some workers, especially after many years of exposure.

D.3 DAILY EXPOSURE NOMOGRAM

The nomogram in [Figure D.2](#) provides a simple alternative method of obtaining daily vibration exposures, without using the equations:

- On the left hand line find the point corresponding to the vibration magnitude (use the left scale for x- and y-axis values; the right scale for z-axis values).
- Draw a line from the point on the left hand line (representing the vibration magnitude) to a point on the right hand line (representing the exposure time);

Read off the partial exposures where the line crosses the central scale.

FIGURE D.1 DAILY EXPOSURE GRAPH

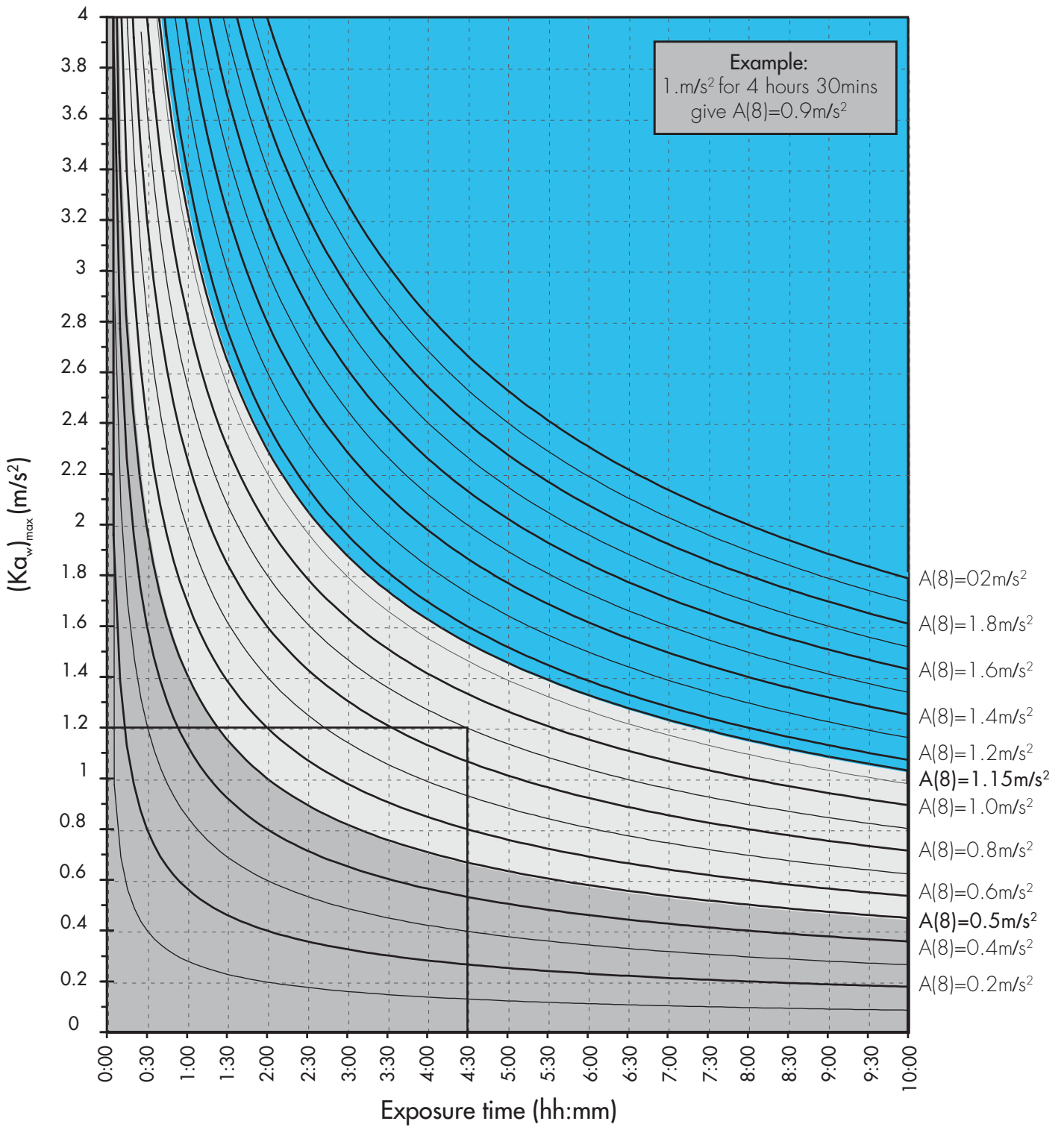
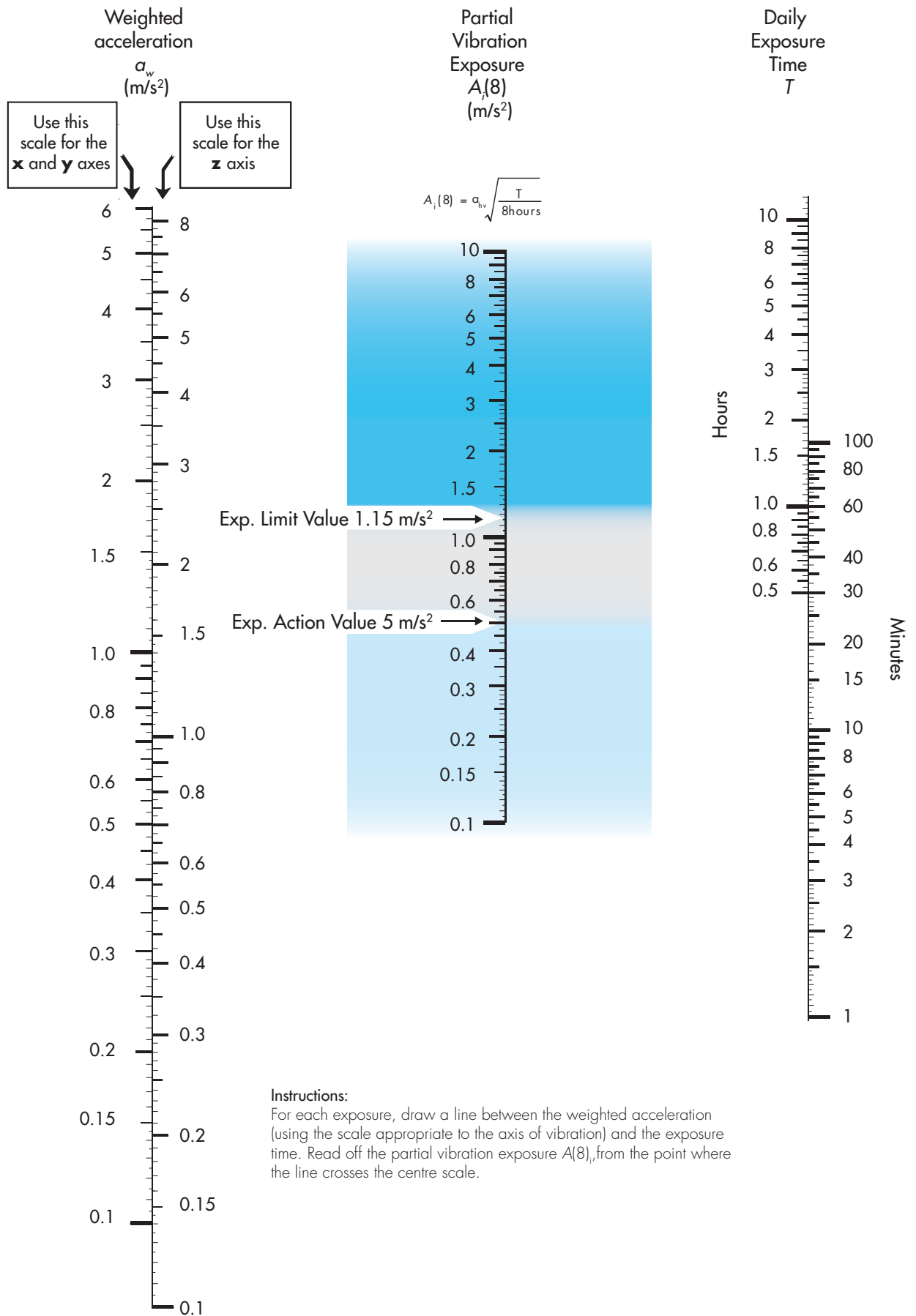


FIGURE D.2 NOMOGRAM FOR A(8) VALUES



D.4 EXPOSURE POINTS SYSTEM

Whole-body vibration exposure management can be simplified by using an exposure “points” system. For any vehicle or machine operated, the number of exposure points accumulated in an hour ($P_{E,1h}$ in points per hour) can be obtained from the vibration magnitude a_w in m/s^2 and the factor k (either 1.4 for x- and y-axes or 1.0 for the z-axis) using:

$$P_{E,1h} = 50(k a_w)^2$$

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 ($0.5 m/s^2$) = 100 points;
- exposure limit value ($1.15 m/s^2$) = 529 points.

In general the number of exposure points, P_E , is defined by:

$$P_E = \left(\frac{k a_w}{0.5 m/s^2} \right)^2 \frac{T}{8 \text{ hours}} 100$$

Where a_w is the vibration magnitude in m/s^2 , T is the exposure time in hours and k is the multiplying factor of either 1.4 for x- and y-axes or 1.0 for the z-axis.

Alternatively Figure D.3 gives a simple method for looking up the exposure points

The daily exposure $A(8)$, can be calculated from the exposure point using:

$$A(8) = 0.5 m/s^2 \sqrt{\frac{P_E}{100}}$$

FIGURE D.3 EXPOSURE POINTS TABLE (ROUNDED VALUES).

Acceleration x k (m/s ²)	2	50	100	200	400	600	800	1000	1200	1600	2000	2400
	1.9	45	90	180	360	540	720	905	1100	1450	1800	2150
	1.8	41	81	160	325	485	650	810	970	1300	1600	1950
	1.7	36	72	145	290	435	580	725	865	1150	1450	1750
	1.6	32	64	130	255	385	510	640	770	1000	1300	1550
	1.5	28	56	115	225	340	450	565	675	900	1150	1350
	1.4	25	49	98	195	295	390	490	590	785	980	1200
	1.3	21	42	85	170	255	340	425	505	675	845	1000
	1.2	18	36	72	145	215	290	360	430	575	720	865
	1.1	15	30	61	120	180	240	305	365	485	605	725
	1	13	25	50	100	150	200	250	300	400	500	600
	0.9	10	20	41	81	120	160	205	245	325	405	485
	0.8	8	16	32	64	96	130	160	190	255	320	385
	0.7	6	12	25	49	74	98	125	145	195	245	295
0.6	5	9	18	36	54	72	90	110	145	180	215	
0.5	3	6	13	25	38	50	63	75	100	125	150	
0.4	2	4	8	16	24	32	40	48	64	80	96	
0.3	1	2	5	9	14	18	23	27	36	45	54	
0.2	1	1	2	4	6	8	10	12	16	20	24	
	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	
Daily Exposure time												



ANNEX E Daily exposure Worked examples

E.1 DAILY EXPOSURE: $A(8)$, WHERE THERE IS JUST ONE TASK

Step 1: Determine the three frequency weighted r.m.s acceleration values a_{wx} , a_{wy} and a_{wz} , from manufacturer's data, other sources, or measurement.

Step 2: Find the daily exposures in the three directions, x, y and z from:

$$A_x(8) = 1.4a_{wx} \sqrt{\frac{T_{exp}}{T_0}}$$

$$A_y(8) = 1.4a_{wy} \sqrt{\frac{T_{exp}}{T_0}}$$

$$A_z(8) = a_{wz} \sqrt{\frac{T_{exp}}{T_0}}$$

- ✓ T_{exp} is the daily duration of exposure to the vibration and
- ✓ T_0 is the reference duration of eight hours.

Step 3: The highest value of $A_x(8)$, $A_y(8)$ and $A_z(8)$ is the daily vibration exposure.

Example

A tree harvester driver operates the vehicle for 6½ hours a day.

Step 1: The vibration values on the seat are:

- x-axis: 0.2 m/s²
- y-axis: 0.4 m/s²
- z-axis: 0.25 m/s²

Step 2: The x, y and z axis daily exposures are then:

$$A_x(8) = 1.4 \times 0.2 \sqrt{\frac{6.5}{8}} = 0.25 \text{ m/s}^2$$

$$A_y(8) = 1.4 \times 0.4 \sqrt{\frac{6.5}{8}} = 0.5 \text{ m/s}^2$$

$$A_z(8) = 0.25 \sqrt{\frac{6.5}{8}} = 0.23 \text{ m/s}^2$$

Step 3: Daily vibration exposure, $A(8)$ is the highest of these values. In this case it is the y-axis: 0.5 m/s² (i.e. at the exposure action value)

E.2 DAILY EXPOSURE: $A(8)$, WHERE THERE IS MORE THAN ONE TASK

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

Step 1: Determine the three frequency weighted r.m.s acceleration values a_{wx} , a_{wy} and a_{wz} , for each task or vehicle, from manufacturer's data, other sources, or measurement.

Step 2: For each vehicle or task, find the partial daily exposures in the three directions, x, y and z using:

$$A_{x,i}(8) = 1.4a_{wx} \sqrt{\frac{T_{exp}}{T_0}}$$

$$A_{y,i}(8) = 1.4a_{wy} \sqrt{\frac{T_{exp}}{T_0}}$$

$$A_{z,i}(8) = a_{wz} \sqrt{\frac{T_{exp}}{T_0}}$$

Where

- ✓ T_{exp} is the daily duration of exposure to the vibration and
- ✓ T_0 is the reference duration of eight hours.

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

Step 3: For each axis (i), the overall daily vibration exposure can be calculated from the partial vibration exposure values, using:

$$A_i(8) = \sqrt{A_{i1}(8)^2 + A_{i2}(8)^2 + A_{i3}(8)^2 + \dots}$$

where $A_{i1}(8)$, $A_{i2}(8)$, $A_{i3}(8)$, etc. are the partial vibration exposure values for the different vibration sources.

Step 4: The highest value of $A_x(8)$, $A_y(8)$ and $A_z(8)$ is the daily vibration exposure.

Example

A delivery driver spends 1 hour loading his lorry using a small forklift truck, followed by 6 hours driving the delivery lorry each day.

Step 1: The vibration values on the seat are:

Forklift truck	Delivery lorry
✓ x-axis: 0.5 m/s ²	✓ x-axis: 0.2 m/s ²
✓ y-axis: 0.3 m/s ²	✓ y-axis: 0.3 m/s ²
✓ z-axis: 0.9 m/s ²	✓ z-axis: 0.3 m/s ²

Step 2: The x, y and z axis daily exposures are then:

Forklift truck
$A_{x, \text{forklift}}(8) = 1.4 \times 0.5 \sqrt{\frac{1}{8}} = 0.25 \text{ m/s}^2$
$A_{y, \text{forklift}}(8) = 1.4 \times 0.3 \sqrt{\frac{1}{8}} = 0.15 \text{ m/s}^2$
$A_{z, \text{forklift}}(8) = 0.9 \sqrt{\frac{1}{8}} = 0.32 \text{ m/s}^2$
Delivery lorry
$A_{x, \text{lorry}}(8) = 1.4 \times 0.2 \sqrt{\frac{6}{8}} = 0.24 \text{ m/s}^2$
$A_{y, \text{lorry}}(8) = 1.4 \times 0.3 \sqrt{\frac{6}{8}} = 0.36 \text{ m/s}^2$
$A_{z, \text{lorry}}(8) = 0.3 \sqrt{\frac{6}{8}} = 0.26 \text{ m/s}^2$

Step 3: Daily vibration exposure, for each axis are:

$$A_x(8) = \sqrt{0.25^2 + 0.24^2} = 0.3 \text{ m/s}^2$$

$$A_y(8) = \sqrt{0.15^2 + 0.36^2} = 0.4 \text{ m/s}^2$$

$$A_z(8) = \sqrt{0.32^2 + 0.26^2} = 0.4 \text{ m/s}^2$$

Step 4: The driver's daily whole-body vibration exposure is the highest axis $A(8)$ value, in this case the value for the y or z-axes: 0.4 m/s², i.e. just below the exposure action value.

E.3 DAILY EXPOSURE: VDV, WHERE THERE IS JUST ONE TASK

Step 1: Determine the three frequency weighted VDV, VDV_x , VDV_y and VDV_z .
(Note – VDV data less widely reported than r.m.s data and is not required to be reported by manufacturers, so VDV values are likely to come from measured rather than published data).

Step 2: Find the daily exposures in the three directions, x, y and z from:

$$VDV_{exp,x,i} = 1.4 \times VDV_x \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

$$VDV_{exp,y,i} = 1.4 \times VDV_y \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

$$VDV_{exp,z,i} = VDV_z \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

Where

- ✓ T_{meas} is the measurement period, and
- ✓ T_{exp} is the daily duration of exposure to the vibration.

Step 3: The highest value of $VDV_{exp,x}$, $VDV_{exp,y}$ and $VDV_{exp,z}$ is the daily VDV.

Example

A tree harvester driver operates the vehicle for 6½ hours a day.

Step 1: The VDVs measured on the seat during a 2 hour measurement period are::

✓ x-axis: 3 m/s^{1.75}

✓ y-axis: 5 m/s^{1.75}

✓ z-axis: 4 m/s^{1.75}

Step 2: The x, y and z axis VDV exposures are then:

$$VDV_{exp,x} = 1.4 \times 3 \left(\frac{6.5}{2} \right)^{1/4} = 5.6 \text{ m/s}^{1.75}$$

$$VDV_{exp,y} = 1.4 \times 5 \left(\frac{6.5}{2} \right)^{1/4} = 9.4 \text{ m/s}^{1.75}$$

$$VDV_{exp,z} = 4 \left(\frac{6.5}{2} \right)^{1/4} = 5.4 \text{ m/s}^{1.75}$$

Step 3: Daily VDV is the highest of these values. In this case, the y-axis: 9.4 m/s^{1.75} i.e. just above the VDV exposure action value.

E.4 DAILY EXPOSURE: VDV, WHERE THERE IS MORE THAN ONE TASK

If a person is exposed to more than one source of vibration (perhaps because they use two or more different machines or activities during the day) then a partial VDV is calculated from the magnitude and duration for each axis and for each exposure. The partial VDVs are combined to give the overall daily VDV for that person, for each axis. The daily VDV is then the highest of the three single axis values.

Step 1: Determine the three frequency weighted VDVs VDV_x , VDV_y and VDV_z , for each task or vehicle.

Step 2: Find the partial VDVs in the three directions, x, y and z from:

$$VDV_{exp,x} = 1.4 \times VDV_x \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

$$VDV_{exp,y} = 1.4 \times VDV_y \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

$$VDV_{exp,z} = VDV_z \left(\frac{T_{exp}}{T_{meas}} \right)^{1/4}$$

✓ T_{meas} is the measurement period, and

✓ T_{exp} is the daily duration of exposure to the vibration.

Step 3: For each axis (i), the overall daily VDV can be calculated from the partial vibration exposure values, using:

$$VDV_i = (VDV_{i1}^4 + VDV_{i2}^4 + VDV_{i3}^4 + K)^{1/4}$$

where VDV_{i1} , VDV_{i2} , VDV_{i3} , etc. are the partial vibration exposure values for the different vibration sources.

Step 4: The highest value of VDV_x , VDV_y and VDV_z is the daily VDV.

Example

A delivery driver spends 1 hour loading his lorry using a small forklift truck, followed by 6 hours driving the delivery lorry each day.

Step 1: The vibration values on the seat, measured for 1 hour on the forklift and 4 hours on the delivery truck, are:

Forklift truck	Delivery lorry
✓ x-axis: 6 m/s ^{1.75}	✓ x-axis: 4 m/s ^{1.75}
✓ y-axis: 4 m/s ^{1.75}	✓ y-axis: 5 m/s ^{1.75}
✓ z-axis: 12 m/s ^{1.75}	✓ z-axis: 6 m/s ^{1.75}

Step 2: The x, y and z axis partial VDVs are then:

Forklift truck
$VDV_{exp,x,flr} = 1.4 \times 6 \left(\frac{1}{1} \right)^{1/4} = 8 \text{ m/s}^{1.75}$
$VDV_{exp,y,flr} = 1.4 \times 4 \left(\frac{1}{1} \right)^{1/4} = 6 \text{ m/s}^{1.75}$
$VDV_{exp,z,flr} = 12 \left(\frac{1}{1} \right)^{1/4} = 12 \text{ m/s}^{1.75}$
Delivery lorry
$VDV_{exp,x,lorry} = 1.4 \times 4 \left(\frac{6}{4} \right)^{1/4} = 6 \text{ m/s}^{1.75}$
$VDV_{exp,y,lorry} = 1.4 \times 5 \left(\frac{6}{4} \right)^{1/4} = 8 \text{ m/s}^{1.75}$
$VDV_{exp,z,lorry} = 6 \left(\frac{6}{4} \right)^{1/4} = 7 \text{ m/s}^{1.75}$

Step 3: Daily vibration exposure, for each axis are:

$$VDV_x = (8^4 + 6^4)^{1/4} = 9 \text{ m/s}^{1.75}$$

$$VDV_y = (6^4 + 8^4)^{1/4} = 9 \text{ m/s}^{1.75}$$

$$VDV_z = (12^4 + 7^4)^{1/4} = 12 \text{ m/s}^{1.75}$$

Step 4: The driver's daily whole-body vibration exposure is the highest axis VDV, in this case the value for the z-axis: 12 m/s^{1.75} i.e. between the VDV exposure action and exposure limit values.

E.5 DAILY EXPOSURE: A(8), USING THE EXPOSURE POINTS SYSTEM

(Note: this is the same worked example as Annex E.2 using the exposure points method)

If you have acceleration values in m/s²:

- Step 1:** Determine points values for each task or vehicle, using [Figure D.3](#) to look-up the exposure points based on the acceleration value, k-factor and the exposure time.
- Step 2:** For each axis add the points per machine to give a total daily points per axis.
- Step 3:** The highest value of the three axis values is the daily vibration exposure in points

Example

A delivery driver spends 1 hour loading his lorry using a small forklift truck, followed by 6 hours driving the delivery lorry each day.

- Step 1:** The x, y and z axis daily exposures are:

Forklift truck

- ✓ x-axis: $0.5 \times 1.4 = 0.7$
- ✓ y-axis: $0.3 \times 1.4 = 0.42$
- ✓ z-axis: 0.9

Points after 1 hours use (from Figure D.3)

- ✓ 0.7 m/s² for 1 hour = 25 points
- ✓ 0.5* m/s² for 1 hour = 13 points
- ✓ 0.9 m/s² for 1 hour = 41 points

* 0.42 m/s² is not shown in Figure D.3, therefore nearest higher value of 0.5 m/s² is used

Delivery lorry

- ✓ x-axis: $0.2 \times 1.4 = 0.28$
- ✓ y-axis: $0.3 \times 1.4 = 0.42$
- ✓ z-axis: 0.3

Points after 6 hours use (from Figure D.3)

- ✓ 0.3* m/s² for 6 hours = 27 points
- ✓ 0.5* m/s² for 6 hours = 75 points
- ✓ 0.3 m/s² for 6 hours = 27 points

* the exact vibration values are not shown in Figure D.3, therefore nearest higher values are used.

- Step 2:** Daily vibration exposure points, for each axis are:

$$\begin{aligned} \text{x-axis} &= 25 + 27 = 52 \text{ points} \\ \text{y-axis} &= 13 + 75 = 88 \text{ points} \\ \text{z-axis} &= 41 + 27 = 68 \text{ points} \end{aligned}$$

- Step 3:** The driver's daily whole-body vibration exposure is the highest axis points value, in this case the value for the y-axis: 83 points, i.e. below the 100 point exposure action value.

If you have points-per-hour data:

- Step 1:** Determine points-per-hour values for each task or vehicle, from manufacturer's data, other sources, or measurement.
- Step 2:** For each vehicle or task, find the daily points for by multiplying the number of points-per-hour by the number of hours use of the machine.
- Step 3:** For each axis add the points per machine to give a total daily points per axis.
- Step 4:** The highest value of the three axis values is the daily vibration exposure in points.

Example

A delivery driver spends 1 hour loading his lorry using a small forklift truck, followed by 6 hours driving the delivery lorry each day.

- Step 1:** The points per hour values on the seat are:

Forklift truck	Delivery lorry
✓ x-axis: 25	✓ x-axis: 4
✓ y-axis: 9	✓ y-axis: 9
✓ z-axis: 41	✓ z-axis: 5

Notes:

- ✓ The k factors are included in the points per hour values (see [Annex D.4](#)).
- ✓ The points per hour values have been rounded up to the nearest whole number.

Step 2: The x, y and z axis daily exposure points are then:

Forklift truck (1 hour use)	Delivery lorry (6 hours use)
✓ x-axis: $25 \times 1 = 25$	✓ x-axis: $4 \times 6 = 24$
✓ y-axis: $9 \times 1 = 9$	✓ y-axis: $9 \times 6 = 54$
✓ z-axis: $41 \times 1 = 41$	✓ z-axis: $5 \times 6 = 30$

Step 3: Daily vibration exposure points, for each axis are:

$$\text{x-axis} = 25 + 24 = 49 \text{ points}$$

$$\text{y-axis} = 9 + 54 = 63 \text{ points}$$

$$\text{z-axis} = 41 + 30 = 71 \text{ points}$$

Step 4: The driver's daily whole-body vibration exposure is the highest axis points value, in this case the value for the z-axis: 71 points, i.e. below the 100 point exposure action value

ANNEX F Health Surveillance Techniques

Health surveillance may consist of an evaluation of the case history for a worker in conjunction with a physical examination conducted by a doctor or suitably qualified health-care professional.

Questionnaires for whole-body vibration health surveillance are available from various sources (e.g. the VIBGUIDE section of: http://www.humanvibration.com/EU/EU_index.htm).

The case history

The case history should focus on:

- family history;
- social history, including smoking habit and alcohol consumption and involvement in physical activities;
- work history, including past and current occupations with exposure to whole-body vibration, working posture, lifting tasks and other work-related back stressors; and

- personal health history.

The physical examination

The physical examination might include:

- examination of the back function and evaluation of the effects on pain of forward and lateral flexion and extension;
- straight leg raising test;
- peripheral neurological examination (knee and Achilles tendon reflexes and the sensitivity in leg and foot);
- signs of muscle weakness (extension quadriceps, flexion/extension big toe/foot);
- back endurance test;
- Waddell's signs of non-organic pain.

Whole-body vibration

The mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine.

Vibration emission

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

Frequency-weighting

A filter applied to vibration measurements to mimic the frequency dependence of the risk of damage to the body. Two weightings are used for whole-body vibration:

- W_d for vibration in both the fore-aft (x) and side-to-side (y) axes, and
- W_k for the vertical (z) axis.

Daily vibration exposure, $A(8)$

The 8-hour energy equivalent vibration total value for a worker in meters per second

squared (m/s^2), including all whole-body vibration exposures during the day.

Vibration dose value, VDV

"A cumulative dose, based on the fourth root of the fourth power of the acceleration signal. VDV has units of $m/s^{1.75}$.

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 either a workers daily vibration exposure, $A(8)$ of $0.5m/s^2$, or a workers daily VDV of $9.1m/s^{1.75}$, above which the risks from vibration exposure must be controlled.

Exposure limit value

A value for either a workers daily vibration exposure, $A(8)$ of $1.15m/s^2$, or a workers daily VDV of $21m/s^{1.75}$, above which workers should not be exposed.³

Exposure time

The duration per day that a worker is exposure to a vibration source.

³ Member States have a choice of using either $A(8)$ or VDV for the exposure action and limit values



ANNEX H Bibliography

H.1 EU DIRECTIVES

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)

Directive 89/391/EEC of the European parliament and of the Council of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work

Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)

Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery (repealed by Directive 2006/42/EC)

Council Directive 90/269/EEC of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

H.2 STANDARDS

European Standards

European Committee for Standardization (1997) Mechanical vibration - Declaration and verification of vibration emission values. EN 12096:1997.

European Committee for Standardization (2001) Mechanical vibration - Industrial trucks - Laboratory evaluation and specification of operator seat vibration. EN 13490:2001.

European Committee for Standardization (2001) Safety of industrial trucks — Test methods for measuring vibration. EN 13059:2001.

European Committee for Standardization (2003) Mechanical vibration — Measurement and calculation of occupational exposure to whole-body vibration with reference to health — Practical guidance. EN 14253:2003.

European Committee for Standardization (2003) Mechanical vibration — Testing of mobile machinery in order to determine the vibration emission value. EN 1032:2003.

European Committee for Standardization Mechanical vibration. Guideline for the assessment of exposure to whole-body vibration of ride on operated earth-moving machines. Using harmonised data measured by international institutes, organisations and manufacturers. CEN/TR First committee draft Munich (March 2005).

European Committee for Standardization. Whole-body vibration — Guidelines for vibration hazards reduction — Part 1: Engineering methods by design of machinery. CEN/TR 15172-1:2005

European Committee for Standardization. Whole-body vibration — Guidelines for vibration hazards reduction - Part 2: Management measures at the workplace. CEN/TR 15172-2:2005

International Organization for Standardization Mechanical vibration (1992) Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements. EN ISO 10326-1:1992

International

International Organization for Standardization (1997) Guide to the evaluation of human exposure to whole-body mechanical vibration and shock. ISO 2631-1:1997.

International Organization for Standardization (2000) Earth moving machinery - laboratory evaluation of operator seat vibration. EN ISO 7096:2000.

International Organization for Standardization (2003) Agricultural wheeled tractors - Operator's seat — Laboratory measurement of transmitted vibration ISO 5007:2003

International Organization for Standardization (2005) Human response to vibration — measuring instrumentation. ISO 8041:2005.

International Organization for Standardization (2001) Mechanical vibration - Laboratory method for evaluating vehicle seat vibration — Part 2: Application to railway vehicles. ISO 10326-2:2001.

National

British Standards Institution (1987) Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock. British Standard, BS 6841.

Dachverband der Ingenieure (2002) Human exposure to mechanical vibrations — Whole-body vibration. VDI 2057-1:2002. In German.

Dachverband der Ingenieure (2005) Protective measures against vibration effects on man. VDI 3831:2005. In German.

H.3 SCIENTIFIC PUBLICATIONS

Bovenzi M & and Betta A. (1994) Low back disorders in agricultural tractor drivers exposed to whole body vibration and postural stress. *Applied Ergonomics* 25. 231-240.

Bovenzi M & and Hulshof CTJ. (1999) An updated review of epidemiologic studies on the relationship between exposure to whole body vibration and low back pain (1986-1997). *Int Arch Occup Environ Health*. 72: 351-365.

Bovenzi M, Pinto I, Stacchini N. Low back pain in port machinery operators. *Journal of Sound and Vibration* 2002; 253(1):3-20.

Bovenzi M & and Zadini (1992) A. Self reported low back symptoms in urban bus drivers exposed to whole body vibration. *Spine*, vol 17, no 9. 1048-1058.

Donati P. Survey of technical preventative measures to reduce whole body vibration effects when designing mobile machinery. *Journal of Sound and vibration* (2002) 253(1), 169-183.

Dupuis H. (1994) Medical and occupational preconditions for vibration-induced spinal disorders: occupational disease no. 2110 in Germany. *Int Arch Occup Environ Health*. 66: 303-308.

Dupuis, H. Diseases due to whole-body vibration. In: *Manual of Occupational Medicine: Occupational physiology, occupational pathology, prevention*. Konietzko, Dupuis. Landsberg a.L.: ercomed-Verl.-Ges., Loose-leaf-edt. Chap. IV-3.5. (In German)

Griffin, M.J. (1990, 1996) *Handbook of human vibration*. Published: Academic Press, London, ISBN: 0-12-303040-4.

Griffin, M.J. (1998) A comparison of standardized methods for predicting the hazards of whole-body

vibration and repeated shocks. *Journal of Sound and Vibration*, 215, (4), 883-914.

Griffin, M.J. (2004) Minimum health and safety requirements for workers exposed to hand-transmitted vibration and whole-body vibration in the European Union; a review. *Occupational and Environmental Medicine*; 61, 387-397.

Hartung, E.; Heckert, Ch.; Fischer, S.; Kaulbars, U. Load by mechanical vibration . Konietzko, Dupuis, Letzel (Hrsg.): *Manual of Occupational Medicine*, Ecomed Landsberg, Chap. II-3.1, 1-16 (33. Completion 8/08). (In German)

Homberg, F; Bauer, M. Neue (2004) VDI-Richtlinie 2057:2002 – „Former measuring values can be used further on“ VDI-Report No. 1821, S. 239-250. (In German)

HSE Contract Research Report 333/2001 Whole body vibration and shock: A literature review. Stayner RM.

Kjellberg, A., Wikstrom, B.O. & Landstrom, U. (1994) Injuries and other adverse effects of occupational exposure to whole body vibration. A review for criteria document *Arbete och halsa vetenskaplig skriftserie* 41. 1-80.

Mansfield, N.J. (2004) *Human Response to Vibration* ISBN 0-4152-8239-X

National Institute of Occupational Safety and Health (NIOSH) (1997) *Musculoskeletal disorders and workplace factors. A critical review of epidemiological evidence for work related musculoskeletal disorders of the neck upper extremity and low back*.

National Institute of Occupational Safety and Health (NIOSH), Bernard, B.P. (Editor) (1997) *Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related disorders of the neck, upper extremities, and, low back*. U.S. Department of Health and Human Services, National Institute of Occupational Safety and Health, DHHS (NIOSH) Publication No. 97-141.

Paddan, G.S., Haward, B.M., Griffin, M.J., Palmer, K.T. (1999) *Whole-body vibration: Evaluation of some common sources of exposure in Great Britain*. Health and Safety Executive Contract Research Report 235/1999, HSE Books, ISBN: 0-7176-2481-1.

Palmer, K.T., Coggon, D.N., Bendall, H.E., Pannett, B., Griffin, M.J., Haward, B. (1999) *Whole-body vibration: occupational exposures and their health effects in Great Britain*. Health and Safety Executive Contract Research Report 233/1999, HSE Books, ISBN: 0-7176-2477-3.

Palmer, K.T., Griffin, M.J., Bednall, H., Pannett, B., Coggon, D. (2000) *Prevalence and pattern of occupational exposure to whole body vibration in Great*



Britain: findings from a national survey. *Occupational and Environmental Medicine*, 57, (4), 229-236.

Palmer, K.T., Haward, B., Griffin, M.J., Bednall, H., Coggon, D. (2000) Validity of self reported occupational exposure to hand transmitted and whole body vibration. *Occupational and Environmental Medicine*, 57, (4), 237-241.

Rossegger R. and Rossegger S. (1960) Health effects of tractor driving. *J Agric. Engineering Research* 5. 241-275.

Sandover J. (1998a) The fatigue approach to vibration and health: is it a practical and viable way of predicting the effects on people? *Journal of Sound & Vibration* 215(4) 688-721.

Sandover J. (1998b) High acceleration events: An introduction and review of expert opinion. *Journal of Sound & Vibration* 215 (4) 927-945.

Scarlett A.J, Price J.S, Semple D.A, Stayner R.M (2005) Whole-body vibration on agricultural vehicles: evaluation of emission and estimated exposure levels HSE Books, 2005. (Research report RR321) ISBN 0717629708

Schwarze, S.; Notbohm, G.; Hartung, F.; Dupuis, H. (1999) Epidemiological Study -Whole body vibration. Joint research project on behalf of the HVBG, Bonn. (In German)

Seidel, H. & Heide, R. (1986) Long term effects of whole body vibration - a critical survey of the literature. *Int. Arch. Occupational Environmental Health* 58. 1-26.

Troup, J.D.G. (1988) Clinical effects of shock and vibration on the spine. *Clinical Biomechanics* 3 227-231.

H.4 GUIDANCE PUBLICATIONS

HSE (2005) Whole-body vibration – Control of Vibration at Work Regulations 2005. Guidance on Regulations L141 HSE Books 2005 ISBN 0 7176 6126 1

HSE (2005) Control back-pain risks from whole-body vibration: Advice for employers on the Control of Vibration at Work Regulations 2005 INDG242(rev1) HSE Books 2005 ISBN 0 7176 6119 9

HSE (2005) Drive away bad backs: Advice for mobile machine operators and drivers INDG404 HSE Books 2005 ISBN 7176 6120 2

Bongers et al (1990) and Boshuizen et al (1990 a,b) in: Bongers PM, Boshuizen HC. Back Disorders and Whole body vibration at Work.

Gruber, H.; Mierdel, B. Guidelines for risk assessment. Bochum: VTI Verlag 2003.

Hartung, E Dupuis, H. Christ, E. Noise and vibration at the workplace: The measurement booklet for the practitioner. Edited bei Institute of Applied Work Science (Institut für angewandte Arbeitswissenschaft e.V.), Adaptation and Editorial: Wilfried Brokmann. 2nd run. Cologne, Wirtschaftsverlag Bachem, 1995. (In German).

INRS. (1992) Driving smoothly. How to adjust your suspension seat. Lift truck and seat manufacturers. Edition INRS, ED1372. (In French)

INRS. (1993) Driving smoothly. Choosing and maintaining suspension seats for fork-lift trucks. Edition INRS, ED1373. (In French)

INRS. (1998) Driving smoothly. A suspension seat to ease your back. Farmers. Edition INRS, ED 1493. (In English and French)

INRS. (1998) Driving smoothly. Help your customers to stay fit. Distributors of farm machinery seat. Edition INRS, ED 1494. (In English and French)

INRS. (1998) Driving smoothly. Selection and replacement of tractor and farm machinery seats. Farm inspectors. Edition INRS, ED 1492. (In English and French)

INRS. The spine in danger. Edition INRS, ED 864, 2001. (In English and French)

Ministère fédéral de l'Emploi et du Travail (Belgique) Vibrations corps total. Stratégie d'évaluation et de prévention des risques. D/1998/1205/72 (In French)

Centres de Mesure Physique (CMP) and Institut National de Recherche et de Sécurité (INRS). Guide to evaluate vibration at work. Part 1 : Whole body vibration transmitted by mobile machines. Edited by INRS. 1998 and Part 3 : Whole body vibration transmitted by fixed machinery. Edited by INRS. 2004. (In French)

Saint Eve P., Donati P. Prevention of spine disorders at the driving place of fork lift trucks. Document pour le médecin du travail n°54, 2nd term 1993 (In French).

ISSA. (1989) Vibration at work. Published by INRS for International section Research of the ISSA. (In English, French, German and Spanish)

Protection against vibration: a problem or not? Leaflet of the Federal Institute for Occupational Safety and Health (FIOSH) (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)).

Dupuis, H. Diseases due to whole-body vibration. In: Manual of Occupational Medicine: Occupational physiology, occupational pathology, prevention.

Konietzko, Dupuis. Landsberg a.L.: ercomed-Verl.-Ges., Loose-leaf-ed. Chap. IV-3.5. (In German)

Hartung, E.; Heckert, Ch.; Fischer, S.; Kaulbars, U. Load by mechanical vibration. Knietzko, Dupuis, Letzel (Hrsg.): Manual of occupational medicine, ecomed Landsberg, Chap. II-3.1., 1-16 (33. completion 8/08). (In German)

Homborg, F; Bauer, M. New VDI-Directive 2057:2002 – Former measuring values can be used further on. VDI-Berichte Nr. 1821 (2004), S. 239-250.

Federal Institute for Occupational Safety and Health (FIOOSH) Protection against vibrations at the workplace (Technics 12). (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin).

Federal Institute for Occupational Safety and Health (FIOOSH) Load of vibration in the building industry (technics 23). Serial "technics" of the (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin).

Neugebauer, G.; Hartung, E. Mechanical vibrations at the workplace. Bochum: VTI Verlag 2002.

Schwarze, S.; Notbohm, G.; Hartung, F.; Dupuis, H. Epidemiological Study - Whole body vibration. Interconnecting research project on behalf of the HVBG, Bonn 1999.

ISPESL. La colonna vertebrale in pericolo. Vibrazioni meccaniche nei luoghi di lavoro : stato della normativa. (In Italian)

H.5 WEB SITES

www.humanvibration.com

General information on human-vibration including links to various human-vibration websites

<http://vibration.arbetslivsinstitutet.se/eng/wbvhome.lasso>

Vibration emission data

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

Vibration emission data

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

Exposure calculator

<http://vibration.arbetslivsinstitutet.se/eng/wbvcalculator.lasso>

Exposure calculator

INDEX

A	
A(8).....	69
acceleration	77
C	
case history.....	98
collective measures	77
constrained postures.....	87
consultation and participation	24, 33, 63, 76, 83
control strategy	23, 75
D	
daily exposure action value	11
daily exposure limit value	11, 61
daily exposure: A(8).....	43, 92
daily exposure: VDV	94
daily vibration exposure.....	11, 45, 69
daily vibration exposure, A(8).....	18, 22, 77
displacement	34, 84
drivers	61, 77
driving techniques.....	78
E	
ergonomic factors.....	37, 76
exposure action value	15, 20, 43
exposure duration	19, 63
exposure points system	41, 91, 96
F	
Framework Directive.....	24, 62
frequency.....	19, 20, 28, 34, 47, 72, 84
frequency weighting.....	84
frequency-weighted acceleration	19, 20, 70, 71
H	
health records.....	31, 81
health surveillance	79, 98
I	
importers	19, 70
L	
lower-back pain	76, 78
M	
machinery.....	25, 79
Machinery Directive.....	19, 25, 70, 77
magnitude.....	15, 79
maintenance.....	22, 25, 26, 28, 59, 63, 73, 77, 78
manual handling	66
Manual Handling Directive.....	66
manufacturers	16, 77
material handling	87
measurements	35, 42, 47, 69
N	
neck	77
nomogram	38, 40, 88, 90
O	
off-road	61, 66
physical examination.....	61, 98
poor postures.....	78
posture	61, 67, 76, 87
purchasing policy.....	25, 51, 59, 63, 76
Q	
qualified physician.....	45
R	
risk assessment.....	15, 20, 23, 27, 29, 33, 51, 63
root-mean-square (r.m.s)	72
rough ground.....	65



S

seat suspension	67, 79
selection	25, 76
shocks or jolts	61
shoulder	65
substitution	25, 63, 66
supplier	19, 25, 42, 70, 76, 78
suspension seats.....	78

T

task and process design	13, 63
training and information.....	13, 27, 63
transitional periods.....	11, 61
twisting.....	65

U

uncertainty	22, 73
-------------------	--------

V

VDV	95
velocity.....	24, 84
vibration controls	29, 79
Vibration Directive	11, 31
vibration dose value.....	61, 63
vibration dose value, VDV	73, 98
vibration emission.....	19, 47
vibration injury.....	11, 16
vibration magnitude	79
vibration risk assessment	31, 65

W

Wd weighting	84
Wk weighting.....	84
work patterns.....	18, 79
work schedules	27, 63, 78
workplace representatives	24, 76

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)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 137(2) thereof,

Having regard to the proposal from the Commission ⁽¹⁾, submitted after consultation with the Advisory Committee on Safety, Hygiene and Health Protection at Work,

Having regard to the opinion of the Economic and Social Committee ⁽²⁾,

Having consulted the Committee of the Regions,

Acting in accordance with the procedure laid down in Article 251 of the Treaty ⁽³⁾, in the light of the joint text approved by the Conciliation Committee on 8 April 2002,

Whereas:

1. Under the Treaty the Council may, by means of directives, adopt minimum requirements for encouraging improvements, especially in the working environment, to guarantee a better level of protection of the health and safety of workers. Such directives are to avoid imposing administrative, financial and legal constraints in a way which would hold back the creation and development of small and medium-sized undertakings.
2. The communication from the Commission concerning its action programme relating to the implementation of the Community Charter of the Fundamental Social Rights of Workers provides for the introduction of

minimum health and safety requirements regarding the exposure of workers to the risks caused by physical agents. In September 1990 the European Parliament adopted a resolution concerning this action programme ⁽⁴⁾, inviting the Commission in particular to draw up a specific directive on the risks caused by noise and vibration and by any other physical agent at the workplace.

3. As a first step, it is considered necessary to introduce measures protecting workers from the risks arising from vibrations owing to their effects on the health and safety of workers, in particular muscular/bone structure, neurological and vascular disorders. These measures are intended not only to ensure the health and safety of each worker on an individual basis, but also to create a minimum basis of protection for all Community workers in order to avoid possible distortions of competition.
4. This Directive lays down minimum requirements, thus giving Member States the option of maintaining or adopting more favourable provisions for the protection of workers, in particular the fixing of lower values for the daily action value or the daily exposure limit value for vibrations. The implementation of this Directive should not serve to justify any regression in relation to the situation which already prevails in each Member State.
5. A system of protection against vibration must limit itself to a definition, free of excessive detail, of the objectives to be attained, the principles to be observed and the fundamental values to be used, in order to enable Member States to apply the minimum requirements in an equivalent manner.

¹ OJ C 77, 18.3.1993, p. 12.

OJ C 230, 19.8.1994, p. 3.

² OJ C 249, 13.9.1993, p. 28.

³ Opinion of the European Parliament of 20 April 1994 (OJ C 128, 9.5.1994, p. 146) confirmed on 16 September 1999 (OJ C 54, 25.2.2000, p. 75), Council Common Position of 25 June 2001 (OJ C 301, 26.10.2001, p. 1) and Decision of the European Parliament of 23 October 2001 (not yet published in the Official Journal). Decision of the European Parliament of 25 April 2002 and Council Decision of 21 May 2002.

⁴ OJ C 260, 15.10.1990, p. 167. (5) OJ L 183, 29.6.1989, p. 1.

6. The level of exposure to vibration can be more effectively reduced by incorporating preventive measures into the design of work stations and places of work and by selecting work equipment, procedures and methods so as to give priority to reducing the risks at source. Provisions relating to work equipment and methods thus contribute to the protection of the workers involved.
7. Employers should make adjustments in the light of technical progress and scientific knowledge regarding risks related to exposure to vibration, with a view to improving the safety and health protection of workers.
8. In the case of sea and air transport, given the current state of the art it is not possible to comply in all circumstances with the exposure limit values for whole-body vibration; provision should therefore be made for duly justified exemptions in some cases.
9. Since this Directive is an individual Directive within the meaning of Article 16(1) of Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work⁵, that Directive therefore applies to the exposure of workers to vibration, without prejudice to more stringent and/or specific provisions contained in this Directive.
10. This Directive constitutes a practical step towards creating the social dimension of the internal market.
11. The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission⁽¹⁾,

HAVE ADOPTED THIS DIRECTIVE:

SECTION I

GENERAL PROVISIONS

Article 1

Aim and scope

1. This Directive, which is the 16th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC, lays down minimum requirements for the protection of workers from risks to their health

and safety arising or likely to arise from exposure to mechanical vibration.

2. The requirements of this Directive shall apply to activities in which workers are or are likely to be exposed to risks from mechanical vibration during their work.
3. Directive 89/391/EEC shall apply fully to the whole area referred to in paragraph 1, without prejudice to more stringent and/or more specific provisions contained in this Directive.

Article 2

Definitions

For the purposes of this Directive, the following terms shall mean:

- (a) '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;
- (b) 'whole-body vibration': the mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine.

Article 3

Exposure limit values and action values

1. For hand-arm vibration:
 - (a) the daily exposure limit value standardised to an eight-hour reference period shall be 5 m/s²;
 - (b) the daily exposure action value standardised to an eight-hour reference period shall be 2,5 m/s².

Workers' exposure to hand-arm vibration shall be assessed or measured on the basis of the provisions of Point 1 of Part A of the Annex.

2. For whole-body vibration:
 - (a) the daily exposure limit value standardised to an eight-hour reference period shall be 1,15 m/s² or,

⁵ OJ L 183, 29.6.1989, p. 1.

¹ (1) OJ L 184, 17.7.1999, p. 23.

- at the choice of the Member State concerned, a vibration dose value of 21 m/s^{1,75};
- (b) the daily exposure action value standardised to an eighthour reference period shall be 0,5 m/s² or, at the choice of the Member State concerned, a vibration dose value of 9,1 m/s^{1,75}.

Workers' exposure to whole-body vibration shall be assessed or measured on the basis of the provisions of Point 1 of Part B of the Annex.

SECTION II

OBLIGATION OF EMPLOYERS

Article 4

Determination and assessment of risks

1. In carrying out the obligations laid down in Article 6(3) and Article 9(1) of Directive 89/391/EEC, the employer shall assess and, if necessary, measure the levels of mechanical vibration to which workers are exposed. Measurement shall be carried out in accordance with Point 2 of Part A or Point 2 of Part B of the Annex to this Directive, as appropriate.
2. The level of exposure to mechanical vibration may be assessed by means of observation of specific working practices and reference to relevant information on the probable magnitude of the vibration corresponding to the equipment or the types of equipment used in the particular conditions of use, including such information provided by the manufacturer of the equipment. That operation shall be distinguished from measurement, which requires the use of specific apparatus and appropriate methodology.
3. The assessment and measurement referred to in paragraph 1 shall be planned and carried out by competent services at suitable intervals, taking particular account of the provisions of Article 7 of Directive 89/391/EEC concerning the necessary competent services or persons. The data obtained from the assessment and/or measurement of the level of exposure to mechanical vibration shall be preserved in a suitable form so as to permit consultation at a later stage.
4. Pursuant to Article 6(3) of Directive 89/391/EEC, the employer shall give particular attention, when carrying out the risk assessment, to the following:
 - (a) the level, type and duration of exposure, including any exposure to intermittent vibration or repeated shocks;

- (b) the exposure limit values and the exposure action values laid down in Article 3 of this Directive;
 - (c) any effects concerning the health and safety of workers at particularly sensitive risk;
 - (d) any indirect effects on worker safety resulting from interactions between mechanical vibration and the workplace or other work equipment;
 - (e) information provided by the manufacturers of work equipment in accordance with the relevant Community Directives;
 - (f) the existence of replacement equipment designed to reduce the levels of exposure to mechanical vibration;
 - (g) the extension of exposure to whole-body vibration beyond normal working hours under the employer's responsibility;
 - (h) specific working conditions such as low temperatures;
 - (i) appropriate information obtained from health surveillance, including published information, as far as possible.
5. The employer shall be in possession of an assessment of the risk in accordance with Article 9(1)(a) of Directive 89/391/EEC and shall identify which measures must be taken in accordance with Articles 5 and 6 of this Directive. The risk assessment shall be recorded on a suitable medium, according to national law and practice; it may include a justification by the employer that the nature and extent of the risks related to mechanical vibration make a further detailed risk assessment unnecessary. The risk assessment shall be kept up-to-date on a regular basis, particularly if there have been significant changes which could render it out-of-date, or when the results of health surveillance show it to be necessary.

Article 5

Provisions aimed at avoiding or reducing exposure

1. Taking account of technical progress and of the availability of measures to control the risk at source, the risks arising from exposure to mechanical vibration shall be eliminated at their source or reduced to a minimum.

The reduction of such risks shall be based on the general principles of prevention set out in Article 6(2) of Directive 89/391/EEC.

2. On the basis of the risk assessment referred to in Article 4, once the exposure action values laid down in Article 3(1)(b) and (2)(b) are exceeded, the employer shall establish and implement a programme of technical and/or organisational measures intended to reduce to a minimum exposure to mechanical vibration and the attendant risks, taking into account in particular:
 - (a) other working methods that require less exposure to mechanical vibration;
 - (b) the choice of appropriate work equipment of appropriate ergonomic design and, taking account of the work to be done, producing the least possible vibration;
 - (c) the provision of auxiliary equipment that reduces the risk of injuries caused by vibration, such as seats that effectively reduce whole-body vibration and handles which reduce the vibration transmitted to the hand-arm system;
 - (d) appropriate maintenance programmes for work equipment, the workplace and workplace systems;
 - (e) the design and layout of workplaces and work stations;
 - (f) adequate information and training to instruct workers to use work equipment correctly and safely in order to reduce their exposure to mechanical vibration to a minimum;
 - (g) limitation of the duration and intensity of the exposure;
 - (h) appropriate work schedules with adequate rest periods;
 - (i) the provision of clothing to protect exposed workers from cold and damp.
3. 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.
4. Pursuant to Article 15 of Directive 89/391/EEC, the employer shall adapt the measures referred to in this Article to the requirements of workers at particular risk.

Article 6

Worker information and training

Without prejudice to Articles 10 and 12 of Directive 89/391/EEC, the employer shall ensure that workers who are exposed to the risks from mechanical vibration at work and/or their representatives receive information and training relating to the outcome of the risk assessment provided for in Article 4(1) of this Directive, concerning in particular:

- (a) the measures taken to implement this Directive in order to eliminate or reduce to a minimum the risks from mechanical vibration;
- (b) the exposure limit values and the exposure action values;
- (c) the results of the assessment and measurement of the mechanical vibration carried out in accordance with Article 4 of this Directive and the potential injury arising from the work equipment in use;
- (d) why and how to detect and report signs of injury;
- (e) the circumstances in which workers are entitled to health surveillance;
- (f) safe working practices to minimise exposure to mechanical vibration.

Article 7

Consultation and participation of workers

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.

SECTION III

MISCELLANEOUS PROVISIONS

Article 8

Health surveillance

1. Without prejudice to Article 14 of Directive 89/391/EEC, Member States shall adopt provisions to ensure the appropriate health surveillance of workers with reference to the

outcome of the risk assessment provided for in Article 4(1) of this Directive where it indicates a risk to their health. Those provisions, including the requirements specified for health records and their availability, shall be introduced in accordance with national laws and/or practice.

Health surveillance, the results of which are taken into account in the application of preventive measures at a specific workplace, shall be intended to prevent and diagnose rapidly any disorder linked with exposure to mechanical vibration. Such surveillance shall be appropriate 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 exposed to mechanical vibration in excess of the values stated in Article 3(1)(b) and (2)(b) shall be entitled to appropriate health surveillance.

2. Member States shall establish arrangements to ensure that, for each worker who undergoes health surveillance in accordance with paragraph 1, 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 his request, have access to the health records relating to him personally.

3. Where, as a result of health surveillance, a worker is found to have 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 mechanical vibration at work:

- (a) the worker shall be informed by the doctor or other suitably qualified person of the result which relates to him personally. He shall, in particular, receive information and advice regarding any health surveillance which he should undergo following the end of exposure;

- (b) the employer shall be informed of any significant findings from the health surveillance, taking into account any medical confidentiality.

(c) the employer shall:

- review the risk assessment carried out pursuant to Article 4,
- review the measures provided for to eliminate or reduce risks pursuant to Article 5,
- 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 risk in accordance with Article 5, 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.

Article 9

Transitional periods

With regard to implementation of the obligations laid down in Article 5(3), Member States, after consultation of the two sides of industry in accordance with national legislation or practice, shall be entitled to make use of a maximum transitional period of five years from 6 July 2005 where work equipment is used which was given to workers before 6 July 2007 and which does not permit the exposure limit values to be respected, taking into account the latest technical advances and/or the organisational measures taken. With regard to equipment used in the agriculture and forestry sectors, Member States shall be entitled to extend the maximum transitional period by up to four years.

Article 10

Derogations

1. In compliance with the general principles of health and safety protection for workers, Member States may, in the case of sea and air transport, derogate from Article 5(3) in duly justified circumstances with respect to whole-body vibration where, given the

state of the art and the specific characteristics of workplaces, it is not possible to comply with the exposure limit value despite the technical and/or organisation measures taken.

2. In a case where the exposure of a worker to mechanical vibration is usually below the exposure action values given in Article 3(1)(b) and (2)(b) but varies markedly from time to time and may occasionally exceed the exposure limit value, Member States may also grant derogations from Article 5(3). However, the exposure value averaged over 40 hours must be less than the exposure limit value and there must be evidence to show that the risks from the pattern of exposure to the work are lower than those from exposure at the exposure limit value.
3. The derogations referred to in paragraphs 1 and 2 shall be granted by Member States after consultation of the two sides of industry in accordance with national laws and practice. Such derogations must be accompanied by conditions which guarantee, taking into account the special circumstances, that the resulting risks are reduced to a minimum and that the workers concerned are subject to increased health surveillance. Such derogations shall be reviewed every four years and withdrawn as soon as the justifying circumstances no longer obtain.
4. Every four years Member States shall forward to the Commission a list of derogations as referred to in paragraphs 1 and 2, indicating the exact reasons and circumstances which made them decide to grant the derogations.

Article 11

Technical amendments

Amendments to the Annex of a strictly technical nature in line with:

- (a) the adoption of Directives in the field of technical harmonisation and standardisation with regard to the design, building, manufacture or construction of work equipment and/or workplaces;
- (b) technical progress, changes in the most appropriate harmonised European standards or specifications and new findings concerning mechanical vibration; shall be adopted in accordance with the regulatory procedure laid down in Article 12(2).

Article 12

Committee

1. The Commission shall be assisted by the Committee referred to in Article 17(2) of Directive 89/391/EEC.
2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period referred to in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its rules of procedure.

SECTION IV

FINAL PROVISIONS

Article 13

Reports

Every five years Member States shall provide a report to the Commission on the practical implementation of this Directive, indicating the points of view of the two sides of industry. It shall contain a description of best practice for preventing vibrations with a harmful effect on health and of other forms of work organisation, together with the action taken by the Member States to impart knowledge of such best practice.

On the basis of those reports, the Commission shall carry out an overall assessment of the implementation of the Directive, including implementation in the light of research and scientific information, and shall inform the European Parliament, the Council, the Economic and Social Committee and the Advisory Committee on Safety, Hygiene and Health Protection at Work thereof and, if necessary, propose amendments.

Article 14

Transposition

1. The Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive no later than 6 July 2005. They shall forthwith inform the Commission thereof. They shall also include a list, giving detailed

reasons, of the transitional arrangements which the Member States have adopted in accordance with Article 9.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by Member States.

2. Member States shall communicate the provisions of national law which they adopt or have already adopted in the field covered by this Directive to the Commission.

Article 15

Entry into force

This Directive shall enter into force on the day of its publication in the Official Journal of the European Communities.

Article 16

Addressees

This Directive is addressed to the Member States.

Done at Luxembourg, 25 June 2002.

For the European
Parliament
The President
P. COX

For the Council
The President
J. MATAS I PALOU

ANNEX

A. HAND-ARM VIBRATION

1. Assessment of exposure

The assessment of the level of exposure to hand-arm vibration is based on the calculation of the daily exposure value normalised to an eight-hour reference period $A(8)$, expressed as the square root of the sum of the squares (rms) (total value) of the frequency-weighted acceleration values, determined on the orthogonal axes a_{hwz} , a_{hwz} as defined in Chapters 4 and 5 and Annex A to ISO standard 5349-1(2001).

The assessment of the level of exposure may be carried out on the basis of an estimate based on information provided by the manufacturers concerning the level of emission from the work equipment used, and based on the observation of specific work practices or on measurement.

2. Measurement

When measurement is employed in accordance with Article 4(1):

(a) the methods used may include sampling, which must be representative of the personal exposure of a worker to the mechanical vibration in question; the methods and apparatus used must be adapted to the particular characteristics of the mechanical vibration to be measured, to ambient factors and to the characteristics of the measuring apparatus, in accordance with ISO standard 5349-2(2001);

(b) in the case of devices which need to be held with both hands, measurements must be made on each hand. The exposure is determined by reference to the higher value of the two; information for the other hand shall also be given.

3. Interference

Article 4(4)(d) will apply, in particular where the mechanical vibration interferes with the proper handling of controls or reading of indicators.

4. Indirect risks

Article 4(4)(d) will apply in particular when the mechanical vibration interferes with the stability of structures or the security of joints.

5. Individual protectors

Personal protective equipment against hand-arm vibration may contribute to the programme of measures referred to in Article 5(2).

B. WHOLE-BODY VIBRATION

1. Assessment of exposure

The assessment of the level of exposure to vibration is based on the calculation of daily exposure $A(8)$ expressed as equivalent continuous acceleration over an eight-hour period, calculated as the highest (rms) value, or the highest vibration dose value (VDV) of the frequency-

weighted accelerations, determined on three orthogonal axes ($1,4a_{wx}, 1,4a_{wy}, a_{wz}$ for a seated or standing worker) in accordance with Chapters 5, 6 and 7, Annex A and Annex B to ISO standard 2631-1 (1997).

The assessment of the level of exposure may be carried out on the basis of an estimate based on information provided by the manufacturers concerning the level of emission from the work equipment used, and based on observation of specific work practices or on measurement.

In the case of maritime shipping, Member States may consider only vibrations of a frequency exceeding 1 Hz.

2. Measurement

When measurement is employed in accordance with Article 4(1), the methods used may include sampling, which must be representative of the personal exposure of a worker to the mechanical vibration in question. The methods used must be adapted to the particular characteristics of the mechanical vibration to be

measured, to ambient factors and to the characteristics of the measuring apparatus.

3. Interference

Article 4(4)(d) will apply, in particular where the mechanical vibration interferes with the proper handling of controls or reading of indicators.

4. Indirect risks

Article 4(4)(d) will apply, in particular when the mechanical vibration interferes with the stability of structures or the security of joints.

5. Extension of exposure

Article 4(4)(g) will apply, in particular where, owing to the nature of the activity, a worker benefits from the use of rest facilities supervised by the employer; exposure to whole-body vibration in those facilities must be reduced to a level compatible with their purpose and conditions of use, except in cases of 'force majeure'.

How to obtain EU publications

Our priced publications are available from the EU Bookshop (<http://bookshop.europa.eu>), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

Are you interested in the **publications** of the Directorate-General for Employment, Social Affairs and Equal Opportunities?

If so, you can download them at

http://ec.europa.eu/employment_social/emplweb/publications/index_en.cfm

or take out a free online subscription at

http://ec.europa.eu/employment_social/sagapLink/dspSubscribe.do?lang=en

ESmail is the electronic newsletter
from the Directorate-General for Employment,
Social Affairs and Equal Opportunities.

You can subscribe to it online at

http://ec.europa.eu/employment_social/emplweb/news/esmail_en.cfm

http://ec.europa.eu/employment_social/index_en.html



Publications Office

Publications.europa.eu

ISBN 978-92-79-07533-9



9 789279 075339