Guide for Risk Assessment
in Small and Medium Enterprises

8 Hazards arising from whole-body and hand-arm vibrations

Identification and Evaluation of Hazards; Taking Measures

issa | INTERNATIONAL SOCIAL SECURITY ASSOCIATION

Section for Electricity
Section for Iron and Metal
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Imprint

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Introduction

This brochure is to meet the demand for risk assessment and exposure reduction in connection with vibration exposure at work and to serve the purpose of implementing, at national level, the Directive "Vibrations" (2002/44/EC) in small and medium-sized enterprises.

The brochure is structured as follows:

1. **Fundamentals**
2. **Risk Assessment**
3. **Annex 1 and 2**

Note:

This brochure serves the purpose of transposing into national law the Framework Directive on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC) and the Individual Directive "Vibrations" (2002/44/EC) enacted under it. All and any relevant provisions transposed into national law shall be complied with (see page 23).

This brochure does not deal with the documentation of risk assessment, as the relevant provisions vary considerably from member state to member state.

In addition to the present brochure, guidelines on the following subjects are being planned or already available:

- **Noise**
- **Chemical hazards**
- **Hazards arising from electricity**
- **Hazards arising from explosions**
- **Hazards arising from machinery and other work equipment**
- **Slipping and falling from a height**
- **Physical strain (e.g. heavy and one-sided work)**
- **Mental workload**

1. Fundamentals

Exposure to vibrations may affect human beings in a variety of ways ranging from mere annoyance to impairment of performance, health hazards and even damage to health.

Vibrations take the form of

- **Hand-arm vibrations**
  during work with vibrating hand-held machinery such as grinders, clipping hammers, rammers, plate vibrators, rock drills, breakers, hammer drills, chain saws etc.
- **Whole-body vibrations**
  on mobile machinery and equipment such as (construction site) lorries, forest machines, graders, wheel or crawler-type loaders, tractors, fork-lift trucks operating on uneven ground, military vehicles.
  They may also occur at stationary workplaces next to heavy machinery, such as control platforms on compressors or punch presses.

The harmful effects of vibrating tools or machines have long since been known but are still frequently underestimated.

1.1 | Protection of safety and health

Vibrations may affect the whole body or parts thereof.

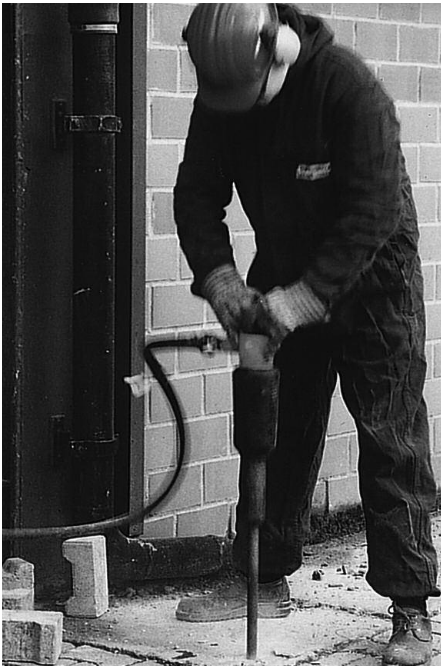
Whole-body vibrations (WBV) are mechanical vibrations transmitted to the body via the buttocks or back in the case of sedentary work, via the feet in the case of work performed while standing or the head and back when working in supine position.

They affect the whole body.

Whole-body vibrations may also occur during leisure time, for instance when going by car or motor bike.

Hand-arm vibrations (HAV) are mechanical vibrations transmitted via the hands and affect only or mainly the hand-arm system.

Hand-arm vibrations are for instance caused by hand-held electrical or pneumatic tools including hedge trimmers and the like.



Vibrations and health

As in the case of sound, a number of parameters and effects on human health are known with regard to mechanical vibrations.

Health hazards depend on the site of impact, the intensity of exposure and daily recurrence of exposure over years.

Avoid such hazards!

The strain to which individuals are exposed depend on

- intensity of vibrations,
- frequency,
- duration of exposure,
- working techniques and
- type of activity.

The way vibrations are experienced by individuals may also be affected by

- their state of health,
- the kind of activity performed and
- the individual's attitude and expectations.

Health hazards occur whenever **strongly felt** vibrations are transmitted

- to the hand-arm system and
- in the case of work performed while standing or sitting, to the whole body.

Hand-arm vibrations

Hand-arm vibrations impair subjective perception, fine motor skills and performance, and may, after years of exposure, cause

- circulation disorders,
- nerve function disorders,
- muscular tissue changes and
- bone and joint damage.

Exposure to high-frequency vibrations over years may lead to **circulation disorders** in the fingers: workers may suffer periodic attacks in which the fingers become white and numb (**white finger** or hand-arm vibration syndrome). The condition is also known as vibration-induced vasospastic syndrome.

Intense low-frequency hand-arm vibrations may also cause degenerative changes of the hand bones, finger joints and wrists as well as the elbow and shoulder regions. The condition is painful and may impair mobility.

Joint damage may involve:

- the wrists
- the elbow joints
- the AC (acromioclavicular) joints.

In addition, lunate necrosis and/or fatigue fractures may occur in the region of the carpal bones.

Working in a cold environment increases the risk for these conditions.

Whole-body vibrations may

- impair the senses and may lead to balance disorders, kinetoses or visual disturbances,
- impair fine motor skills or reduce performance,
- cause stomach troubles or
- affect the spine.

Note:

Please note that preventive measures have to be taken in particular with regard to certain groups of persons, e. g. young or older workers, pregnant women.

1.2 | Legal basis

Legislation on preventive measures with regard to vibration exposure is based on the EC Directive “Vibrations“ (2002/44/EC), which defines measures as well as action values and exposure limit values.

These stipulations in combination with standards ISO 2631 and ISO 5349, which contain state-of-the-art findings on the measurement and assessment of vibrations at the workplace, require employers to determine and assess the risks, to duly inform workers and to draw up a programme for the reduction of vibrations.

The objective of the regulations is to define preventive measures for diseases of the musculoskeletal system (e. g. spine, bones, joints) as well as circulation disturbances in the fingers and hands.

Action and exposure limit values “Vibrations“

The daily exposure limit shall be calculated on the basis of a standardised eight-hour reference period A(8). Measurement of accelerations is frequency-weighted and the values determined converted by means of procedures outlined in national standards.

Attention:
In recent years the weighting filters for whole-body vibrations have been adapted to the latest scientific findings so that in some cases new measurements or measurement series may be useful.

The European Directive (2002/44/EC) defines exposure limit and action values as follows:

Hand-arm vibrations

- Exposure limit value A(8) = 5 m/s^2
- Action value A(8) = 2.5 m/s^2

Whole-body vibrations

- Exposure limit value for all directions A(8) = 1.15 m/s^2
- Action value for all directions A(8) = 0.5 m/s^2

Note:
Implementation shall respect country-specific differences (see page 23).

In some cases an individual assessment and evaluation will be necessary.

Depending on the action values/exposure limit values the following steps shall be taken

- Appropriate determination and assessment of risks
- Implementation of technological and organisational measures
- Elaboration and implementation of a programme to reduce vibrations
- Information and instruction of the workers
- Health monitoring
- Provision of additional equipment (e.g. handles)
- Personal protective equipment (e.g. special anti-vibration gloves)

2. Risk Assessment

By an assessment of risks possible exposures can be recognised and reduced at an early stage. The assessment process can be

- activity-related,
- machine-related,
- work-place-related and/or
- performed on an individual basis.

Exposures are to be evaluated on the basis of the degree of severity and the probability of harmful effects.

The most important steps to be taken are:

Step 1: Determination of hazards (i.e. hazards due to vibrations)

Step 2: Estimation and evaluation of risks

Step 3: Reduction of risks and taking measures

Step 1: Determination of hazards

The employer is obliged to assess workplace conditions on the basis of EC-Directive 2002/44/EC as transposed into national law. In the absence of empirical data measurements will have to be performed, which normally require special expert knowledge and expensive measuring devices.

Annex 1 gives detailed information on how to proceed when measurements are performed at workplaces.

In practice complicated measurements of typical vibration exposures can be avoided by resorting to catalogues, data bases (Internet) or to data provided by manufacturers (e. g. instructions for use). In many cases accident insurers or supervisory authorities will supply information on activities or workplaces considered harmful because of vibration exposure (e. g. occupational diseases caused by long-term vibration exposure).

Manufacturers' data

The Machinery Directive 2006/42/EC provides the legal framework for machinery safety to be complied with by machinery manufacturers or providers.

Manufacturers are obliged to provide data on vibrations generated by machinery in the form of measured results under "test conditions".

When evaluating workplaces the data provided by manufacturers will have to be critically checked and, if necessary, recalculated to meet actual working conditions.

Conversion factors for typical machinery (conversion of test-stand conditions to immission values) are being prepared.

These data are helpful for the procurement of low-vibration equipment, in implementing and adhering to state-of-the-art vibration reduction methods and in drawing up a programme to minimise vibrations.

Checklists for Risk Assessment

Checklists are a useful tool for risk assessment.

Check list:
Hand-arm-vibrations (HAV)

1. Has it been checked whether hand-held or hand-guided machinery and tools that might have harmful effects on the joints can be replaced by other tools?
2. Has it been checked whether high-speed machinery and tools (frequency range 20 to 1000 Hz) that might have harmful effects on the hands can be replaced by other tools?
3. Have measures been taken to prevent the daily vibration exposure (total value related to an eight-hour period) from exceeding the value A(8) = 2.5 m/s^2?
4. Has information on action and exposure limit values been passed on?
5. Are low-vibration machinery and equipment (e.g. sanding disks) being used?
6. Have the grips been fitted with damping or cushioning elements?
7. Have methods to reduce or eliminate excessive vibrations been checked?
8. When procuring new equipment, is sufficient care taken to choose only low-vibration tools (on the basis of the data the manufacturers are obliged to supply)?
9. Are high grip and pressing forces avoided by the use of suitable equipment and tools?
10. Have special anti-vibration gloves been tested (in particular in the case of outdoor work or work in a cold environment) and are they actually used?
11. Are preventive medical checkups offered to workers exposed to extreme vibrations?

Check list:
Whole-body vibrations (WBV)

1. Have measures been taken to avoid the maximum daily vibration exposure (effective value of the frequency-weighted acceleration standardised to an 8-hour period) from exceeding the value A(8) = 0.5 m/s^2?
2. Has information on action and exposure limit values been passed on?
3. Can driving in an unfavourable or twisted body position be avoided?
4. Has care been taken to ensure that road surfaces are smooth and are potholes or other road surface damage prevented?
5. Has it been checked whether work can be organised in a way that permits a reduction of the duration of driving periods (duration of exposure)?
6. When procuring new vehicles, is sufficient care taken to choose only low-vibration vehicles (on the basis of the data the manufacturers are obliged to supply)?
7. Have low-vibration seats been installed, properly adjusted and are they regularly serviced?
8. Are preventive medical checkups being offered to workers exposed to extreme high vibrations?

Step 2:
Estimation and evaluation of risks

Determination of exposure and the A(8) value

Exposures at work can be assessed on the basis of data provided by manufacturers or obtained from the literature or on the basis of measurements.

Parameters are frequency-weighted accelerations in three directions, observation of maximum values and/or vibration total values (vectors). **Annex 2 describes the parameters for exposure assessment.**

Further parameters, e.g. grip forces

Unfavourable working conditions (working postures) and worn-down tools may result in increased exposures.

High grip and pressing forces increase exposures.

Working in a cold environment increases risks.

Use of data from data bases

The Internet already provides a number of data bases which may be used to determine workplace exposure to vibrations (e. g. the data base „KARLA). These data bases mostly supply immission values which considerably differ from those supplied by manufacturers in the form of emission values. EU Practical Guides and vibration parameter calculators are also useful (available on the Internet).

Note:

Never confuse emission data with immission values.

Step 3:
Reduction of risks and taking measures

1. Fundamentals

As stipulated by the Regulation the employer is under the obligation to resort to technological and/or organisational corrective measures whenever action and exposure limit values are exceeded. These measures include, e. g. alternative working processes, selection of suitable tools and materials or the reduction of the duration and intensity of exposure. Priority should be given to reduction measures at the source.

Protective measures should always be taken in the order **S-T-O-P**:

S: Substitution

T: Technological solutions, e. g. low-vibration machinery, tools and vehicles

O: Organisational measures, e.g. limiting intense vibration exposure to certain periods

P: Personal protective measures, e.g. use of anti-vibration gloves to reduce hand-arm vibrations, which are, however, only available and effective in respect of higher-frequency vibration components.

2. Measures against hand-arm vibrations (HAV)

Depending on the intensity and duration of hand-arm vibration exposure the following measures shall be taken:

Daily exposure value A(8) = 2.5 m/s²

- Inform your workers and instruct them as to the risks of vibration exposure

Daily exposure value A(8) > 2.5 m/s²

- Draw up and implement a programme to reduce vibrations
- Offer your workers preventive medical check-ups

Daily exposure value A(8) > 5 m/s²

- Measures have to be taken immediately to avoid such excessive exposures!
- Take care to ensure regular preventive medical check-ups!

3. Measures against **whole-body vibrations** (WBV)

In the case of whole-body vibrations the following measures shall be taken:

Daily exposure value A(8) = 0.5 m/s²

- Inform your workers and instruct them as to the risks of vibration exposure

Daily exposure value A(8) > 0.5 m/s²

- Draw up and implement a programme to reduce vibrations
- Offer your workers preventive medical check-ups

Daily exposure value A(8) > 0.8 m/s² and 1.15 m/s²), respectively*

- Measures have to be taken immediately to avoid such excessive exposures!
- Take care to ensure regular preventive medical check-ups!

4. Measures to be taken at source

In order to reduce exposure at the workplace, the generation, transmission and impact of vibrations have to be avoided. The most important protective measures are those which effect a reduction of vibrations at source.

These **primary measures** reduce all other harmful effects regardless of the place and time of their occurrence and other action mechanisms.

Reduction of hand-arm vibrations *(HAV)*

A few practical examples will illustrate how HAV can be reduced on tools and machinery:

- Reduction of the coupling intensity (e.g. reduction of grip force)
- Use of compression riveters or recoil-reduced rivet hammers for the production of riveted joints
- Use of torque screwdrivers instead of impact wrenches when assembling bolted connections
- Use of drill hammers rather than widely used impact drills in plumbing jobs
- Use of low-vibration paving breakers in road construction and mining
- Use of chipping hammers in stone and steel working with low-vibration handle sleeves for chisel guides
- Use of power chainsaws with low-vibration handles in forestry
- Exclusive use of sharp tools and correction of unbalances at regular intervals
- Use of adhesives instead of riveting
- Design of foundry moulds requiring little cleaning effort
- Use of multiple screwdrivers

Generally speaking, preference should be given to low-vibration technologies.

*) Note: See national regulations

Grip vibrations of hand-held machines should be kept at a minimum by the manufacturer by appropriate design measures.

Further advantages of low-vibration machinery are reduced ***wear and tear*** and lower ***noise*** generation. In most cases, their products will show greater dimensional stability and precision.

Reduction of whole-body vibrations *(WBV)*

Road irregularities, e.g. on unsurfaced tracks, construction sites, factory access roads, driveways etc. should be reduced or eliminated. Road ramps, bumps and potholes should be repaired. In the case of ***rail*** vehicles (cranes etc.), rail joints that might induce vibrations should be eliminated by welding or levelled, and construction site roads should be levelled at regular intervals.

Depending on operating conditions and vehicle types preference should be given to ***spring-mounted driver's seats or cabs***. This might require consultation with experts, who will, if necessary, perform vibration measurements.

The ***seat suspension travel*** should be reasonably limited in order not to unduly change the distance between the driver, the steering wheel, controls and pedals. Rubber cushions should be mounted at the upper and lower ends of the suspension travel to ***avoid intensive shocks***!

The driver's seat can also contribute to vibration damping: The spring damping system of the seat substructure should be designed so as to keep the vibrations passed on to the driver at a minimum.

The springing must be adjustable – and actually adjusted! – to different ***body weights***.

Drivers are particularly exposed to whole-body vibrations. ***Vehicle design, road conditions and driving speed*** are important factors influencing vibration exposure, and the seat as the element of transmission from the vehicle to the driver. This means that vibration reduction can be effected through appropriate action in all these areas.

Technological measures to reduce vibrations include:

- elastic coupling of loading devices such as shovels and lifting arms of wheel-loaders or agricultural machinery mounted on the rear of tractors,
- hydraulic axle suspension with level adjustment,
- cushioned driver's cabs and
- installation of driver's seats with adjustable damping.

In the case of ***fork lift trucks*** the chassis is not spring-suspended for technical reasons, so that the vehicle is only cushioned by the tyres. Accordingly, choice of the right type of tyres is of particular importance. Solid tyres transmit vibrations directly without damping them. For this reason tyres with integrated air chambers are being increasingly used.

For all types of vehicles vibration reduction largely depends on the right choice and adjustment of the seat. The spring damping system of the seat substructure should be designed so as to keep the vibrations passed on to the driver at a minimum. In no case should the frequency of the seat be the same as the excitation frequency, otherwise the vibrations would be increased. For this reason the seat must be ***adjustable to*** the driver's ***body weight***.

Only **tested seats** should be used in vehicles, and the cushioning, damping and upholstery of vehicle seats must be regularly serviced.

Alongside the most effective primary measures applied at the source of vibrations, ***secondary measures*** may also help reduce vibration transmission and propagation and in this way reduce vibration exposure effectively.

In stationary machines the transmission of vibrations to the human being can be reduced by appropriate vibration insulation of the machine or the workplace as a whole. Vibration insulation serves to reduce the transmission of machine forces to the supporting structures (e. g. floors and ceilings). For this purpose machines are mounted on an oscillating foundation which, in turn, sits on insulating materials.

In addition, the machine must be ***isolated from all parts of the building or other machines*** by elastic connections such as pipe clamps, hoses, textile connections, flexible boots or elastic pipe compensators to prevent transmission of vibrations which may also be propagated in the form of structure-borne sound.

In the case of heavy machines (e. g. eccentric presses) the oscillation foundation can be replaced by a load-distributing steel plate mounted on ***vibration insulators***. In this way construction costs for the foundation can be saved and the location of the machines can be changed at will.

Low-vibration machines are ***less noisy*** and more wear-resistant and their products will show greater dimensional stability.

5. Technological and organisational measures

Vibration hazards can also be diminished by reducing exposure times through ***changes in work organisation***. Work should be organised in such a way as to keep the ***daily exposure period*** below the recommended level so that they remain below the critical daily dose.

6. Personal protection

It may be pointed out that the protection of human beings from mechanical vibrations can be achieved by an appropriate posture and by keeping grip and pressing forces as low as possible. This form of behaviour can be highly effective, but requires considerable time for training and presupposes constant self-observation.

High-frequency vibration exposures (e. g. when working with grinding machines) can be reduced by ***anti-vibration gloves***. Such gloves, however, require the worker to apply more grip force to guide the hand tool with precision. On account of the large amplitude of low-frequency vibrations such as occur in the operation of breakers, vibration reduction by means of anti-vibration gloves is not particularly effective.

Laboratory tests have shown that vibrations may even be increased when such gloves with air-filled damping cushions on the palms are used. It is therefore advisable to check the data on the damping properties provided by the manufacturer (Look for the CE symbol).

Cold hands should be avoided during exposure to vibrations, e. g. by means of gloves or through warming-up periods.

7. Vibration reduction programme

Following the transposition of the EC directives into national legislation employers have to adopt state-of-the-art protection measures to exclude vibration hazards or reduce them to a minimum. In so doing, vibrations must be prevented or reduced as far as possible at source. Technological measures to reduce vibrations take priority over organisational ones.

The reduction programme aims at determining exposures, analysing their causes and defining appropriate measures.

Steps to be taken

- Determination of vibration exposures
- Vibration reduction programme
- Determination of vibration exposure values
- Comparison with action and exposure limit values
- Cause analysis
- Comparison with state-of-the-art technology
- Choice of appropriate measures
- Drawing up a vibration reduction programme with list of priorities and timetable

*7.1 **Hand-arm vibration** (HAV) **reduction programme***

If the action value A(8) = 2.5 m/s^2 for hand-arm vibrations is exceeded the employer has to prepare and implement a programme of technological and organisational measures for the reduction of vibration exposures.

The following steps are recommended:

Step 1:
Determination of vibration exposures (HAV)

- Can relevant information be obtained from manufacturers?
- Are data available in data bases?
- Can comparable job descriptions yield useful information?
- Are there any data for the equipment in question available in the literature (data bases) and do the conditions of use in the enterprise correspond to those prevailing when the measurements were made?
- Are any daily exposure values known or can they be calculated from vibration intensity data and individual exposure times?
- Is there any need for additional measurements?

Step 2:
Comparison with action and exposure limit values (HAV)

- Is the action value for hand-arm vibrations lower than A(8) = 2.5 m/s^2?
- Is the measured value higher than the action value and lower than the exposure limit value?
- Is the exposure limit value of A(8) = 5 m/s^2 exceeded?

Step 3:
Determination of the main sources of vibrations (HAV)

- Are there any particularly important sources of vibration, i. e. individual jobs that cause particularly intensive vibrations (e.g. work with breakers)?
- Do certain tools or pieces of equipment cause more intensive vibrations than others?
- Do they require high grip and pressing forces?
- Are certain jobs performed in unfavourable body postures (e.g. hands held at unphysiological angles)?
- Are there any other environmental factors to be taken into consideration such as working in a cold environment?

Step 4:
Cause analysis (HAV)

- What are the causes of the high vibration values?
- Is the equipment old and possibly worn down (e.g. defective gear mechanisms)?
- Are the tools used blunt or worn down?
- Are there no adequate decoupling or cushioning systems?
- Is the equipment serviced at regular intervals?
- Does the job require high grip and pressing forces?

Step 5:
Comparison with state-of-the-art technology (HAV)

- Is the equipment up to current standards?
- Is there more modern equipment that would result in lower vibration exposures?
- Are there any attachments available that would reduce the vibrations transmitted to the operators?
- Are there any handles or ergonomical handle designs (e.g. spring-loaded handles) that would improve working conditions?
- Are the grips decoupled from the machine casing and/or is it possible to correct unbalances?
- Is it possible to use grips with cushioning such as rubber sleeves?
- Are low-vibration tools such as special sanding discs used?
- Can process alterations result in reducing exposures?
- Is it possible to reduce the extent of manual work with vibrating equipment?

Step 6:
Selection of suitable measures (HAV)

- What measure would be capable of reducing vibrations most effectively?
- Can it be implemented?

- If this is impossible, what measure would be second best?
- Can this measure be implemented?
- How many workers would benefit from these reduction measures?
- Would certain jobs or groups of workers be excluded from these benefits?
- Will it be necessary to inform and/or train workers specifically for the implementation of these measures?

Step 7:
Prognosis (HAV)

- What is the expected effect of the reduction measures?
- Will the measures result in values lower than the action value?
- Will the measures result in values lower than the exposure limit value?
- Will it be necessary to resort to additional measures side by side with the measure in question?
- Will it be necessary to take further measures?

Step 8:
Drawing up the programme with a list of priorities and timetable (HAV)

- What steps have to be taken?
- How much time will it take to implement the individual measures?
- When can the first interim results be expected?
- Who is responsible for which implementation step?
- By what deadline ought all measures to be implemented?
- Is it possible to use anti-vibration gloves in addition to the implemented measures?

Step 9:
Checking the results (HAV)

- Have the measures been implemented correctly?
- What degree of vibration reduction has been achieved?
- Has the predicted reduction been achieved?
- Are the values achieved below the exposure limit value?
- Are the values achieved below the action value?
- Will it be necessary to make further improvements?
- Are subsequent measurements required for checking?
- Would additional vibration reduction measures make sense or be necessary?

7.2 Whole-body vibration (WBV) *reduction programme*

Following the transposition of the EC directives into national legislation employers have to adopt state-of-the-art protection measures to exclude vibration hazards or reduce them to a minimum. In so doing, vibrations must be prevented or reduced as far as possible at source. Technological measures to reduce vibrations take priority over organisational ones.

If the action value A(8) = 0.5 m/s^2 for whole-body vibrations is exceeded the employer has to prepare and implement a programme of technological and organisational measures for the reduction of vibration exposures.

The following steps are recommended:

Step 1:
Determination of vibration exposures (WBV)

- Can relevant information be obtained from manufacturers?
- Are data available in data bases?
- Can comparable job descriptions yield useful information?
- Are there any data for the equipment in question available in the literature (data bases) and do the conditions of use in the enterprise correspond to those prevailing when the measure-ments were made?
- Are any daily exposure values known or can they be calculated from vibration intensity data and individual exposure times?
- Is there any need for additional measurements?

Step 2:
Comparison with action and exposure limit values (WBV)

- Is the measured value for WBV lower than the action value?
- Is the measured value higher than the action value and lower than the exposure limit value?
- Is the exposure limit value exceeded?

Step 3:
Determination of the main sources of vibrations (WBV)

- Are there any particularly important sources of vibration, i.e. individual jobs that cause particularly intensive vibrations (e.g. high percentage of driving on cobblestone pavements, bumpy roads etc.)?
- Do certain machines or vehicles cause more intensive vibrations than others?
- Where are vibrations fairly low?

Step 4:
Cause analysis (WBV)

- What are the causes of the high vibration values?
- Are the roads bumpy?
- Are there any kerbs, potholes etc. that have to be negotiated by the vehicle?
- Are the seats equipped with appropriate cushioning or damping systems?
- Are the seats adjusted to the drivers' individual body weights?
- Are the vehicles serviced at regular intervals?
- Can driving times be reduced?

Step 5:
Comparison with state-of-the-art technology (WBV)

- Are the vehicles and equipment up to current standards?
- Are there any more modern vehicles or equipment that would result in lower vibration exposures?
- Are there any attachments available that would reduce the vibrations transmitted to the operators?
- Are there any seats that would reduce vibrations more effectively than the current ones?
- Can road conditions be improved by appropriate repairs?

Step 6:
Selection of suitable measures (WBV)

- What measure would be capable of reducing vibrations most effectively?
- Can it be implemented?
- If this is impossible, what measure would be second best?
- Can this measure be implemented?
- How many workers would benefit from these reduction measures?
- Would certain jobs or groups of workers be excluded from these benefits?
- Will it be necessary to inform and/or train workers specifically for the implementation of these measures?

Step 7:
Prognosis (WBV)

- What is the expected effect of the reduction measures?
- Will the measures result in values lower than the action value?
- Will the measures result in values lower than the exposure limit value?
- Will it be necessary to resort to additional measures side by side with the measure in question?
- Will it be necessary to take further measures?

Step 8:
Drawing up the programme with a list of priorities and timetable (WBV)

- What steps have to be taken?
- How much time will it take to implement the individual measures?
- When can the first interim results be expected?
- Who is responsible for which implementation step?
- By what deadline ought all measures to be implemented?

Step 9:
Checking the results (WBV)

- Have the measures been implemented correctly?
- What degree of vibration reduction has been achieved?
- Has the predicted reduction been achieved?
- Are the values achieved below the exposure limit value?
- Are the values achieved below the action value?
- Will it be necessary to make further improvements?
- Are subsequent measurements required for checking?
- Would additional vibration reduction measures make sense or be necessary?

Annex 1

Implementation of workplace measurements

Measurements are made in three dimensions, i.e. along the axes x, y and z.

In the case of hand-arm vibrations, the values obtained are then used to calculate the vibration total value (vector), while for whole-body vibrations the individual directions are assessed separately.

Hand-arm measurements are particularly complex, especially since measurements have to be made on both handles.

Assessment is based on frequency-weighted accelerations and the daily exposure value A(8). Considerable importance attaches to workplace analysis and a representative record of activities (and parts thereof) undertaken in the course of the workday.

Performance of measurements (HAV)

Hand-arm measurements are performed at the handle of the hand-held or hand-guided tool.

For the purpose of measuring a specially designed triaxial accelerometer is clamped to the handle or glued to it.

Hand-arm vibrations are evaluated on the basis of the vibration total value of the frequency-weighted accelerations in all three directions of vibration, which constitutes the vector sum of the values measured in the three directions. It is essential to perform the measurement in the course of an operating sequence typical of the workplace under consideration.

Performance of Measurements (WBV)

Whole-boy vibration measurements are, for instance, performed on the driver's seat of the vehicle under investigation. The triaxial accelerometer pad is attached to the seat by means of an adhesive tape. Care should be taken to orientate the accelerometer pad correctly (x = chest to back, y = shoulder to shoulder, z = along the spine) and to adjust the seat setting to the driver's actual weight. The duration of measurement depends on the usual distance of travel in the course of the daily

Fig. 1: Measuring HAV

Fig. 2: Measuring WBV

operation of the vehicle and/or the type of activity in question and its “repetitiveness”, but should in no case be less than 15 minutes. Measurements should be performed in the course of normal operations so that they are representative of the activity under consideration. All three acceleration values are recorded in the three directions indicated above.

Whole-body vibrations are evaluated on the basis of the highest effective value of the frequency-weighted accelerations in the three directions of measurement. Please note that the horizontal acceleration values have first to be multiplied by a correction factor of 1.4. Since the exposure limit values are different for the vertical and horizontal directions, the measurements have to be assessed separately.

x-axis	$a_w = 1.4\ a_{wx}$
y-axis	$a_w = 1.4\ a_{wy}$
z-axis	$a_w = 1.0\ a_{wz}$

The data are then used to calculate the daily vibration exposure value, taking into account the actual duration of effective exposure.

Exposure parameter calculators

A number of exposure parameter calculators are available on the Internet. They are helpful for calculating averages and presenting the results graphically, e. g. in the form of the “traffic-light rating system“, where the green area stands for results below the action value and the red area for results that exceed the exposure limit value.

Evaluations and graphic presentations may also take the form of exposure points, but the final result is not affected by the method of presentation chosen.

Exposure parameter calculators are available from Ministries, supervisory authorities and equipment manufacturers.

Note:

In part, the red areas show differences, since the transposition of the European Directive “Vibrations“ into national legislations has not been effected in a uniform way, for instance in respect of the stipulations regarding the z-direction in the case of whole-body vibrations.

Annex 2

Parameters for Exposure Assessment

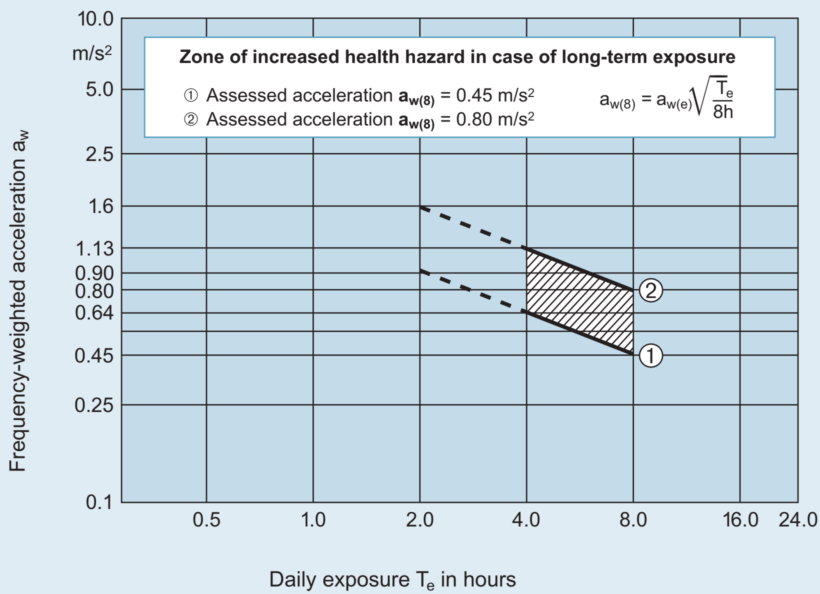
Assessment of whole-body vibrations (WBV)

Whole-body vibrations are assessed on the basis of the highest effective value for the frequency-weighted accelerations in the direction of the axes x, y, and z (1.4 a_{wx}, 1.4 a_{wy}, a_{wz} – z-axis acceleration = along the spine).

Details can be gleaned from ISO 2631. Practical guidance and parameter calculators will be found on the Internet.

Fig. 3 shows the frequency-weighted acceleration plotted against daily exposures.

Fig. 3: Frequency-weighted acceleration plotted against daily exposures (Source: ISO 2631/VDI-Richtlinie 2057-1)

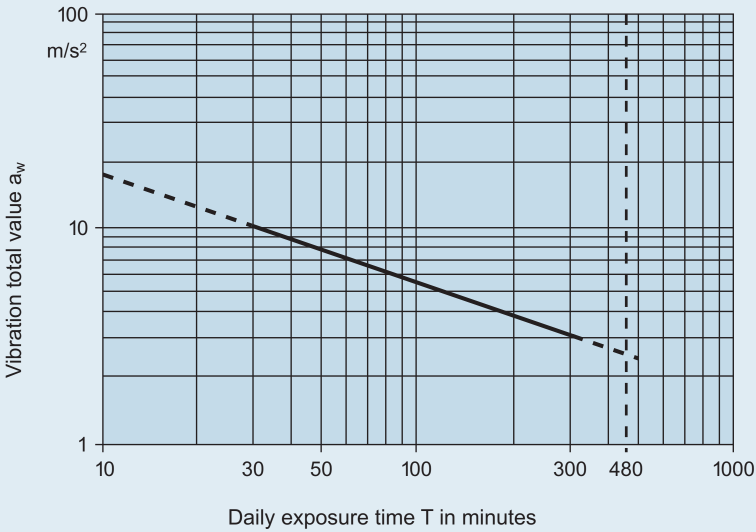


Assessment of hand-arm vibrations (HAV)

Hand-arm vibrations are assessed on the basis of the vibration total value for the frequency-weighted accelerations of all three directions of vibration and the vector calculated from these data, vibration total value ahv. Details will be found in ISO 5349. Practical guidance and exposure parameter calculators are available on the Internet.

Fig. 4 shows the vibration total value plotted against daily exposure.

Fig. 4: Vibration total value plotted against daily exposure (Source: ISO 5349/VDI-Richtlinie 2057-2)



Note: The curve shown represents a daily exposure of $a_{hv(8)}$ of 2.5m/s² for the purpose of prevention.

General

The Directive "Vibrations“ (2002/44/EC) may be transposed into national legislation such as regulations etc. and adapted to individual condition prevailing in the member countries. This means that already existing rules, procedures, limit values and targets may remain in force.

Accordingly, the above-mentioned Directive contains various different parameters such as frequency-weighted acceleration A(8) and a vibration dose value (V).

It is therefore possible to keep existing prevention values already in force, e.g. values for whole-body vibrations that focus in particular on vibrations in the z-direction.

The following ISSA International Sections on Prevention elaborated the brochure. They are also available for further information:

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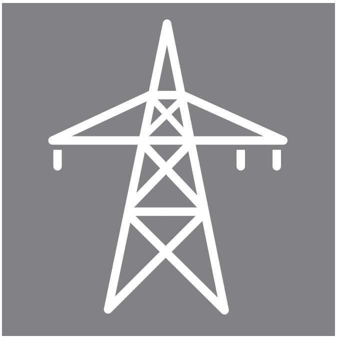

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