Prevention of vibration risks in the construction sector

Introduction

Employees in the construction sector are frequently exposed to vibration at work. As well as reducing their performance, vibration also damages their health. Efforts have been made both by legislators and the manufacturers of machinery to cut the risks.

Vibration from using tools and machinery can be a function of the working principles of the machines themselves. It can also be caused by external influences. The main sources of vibration are an unbalanced mass of rotating parts, friction between machine components and bearings, and shocks caused by internal and external forces. Vibration, which is either hand-arm or whole-body, is generally transmitted to the human body through the hands, buttocks, back or feet. It is measured in terms of acceleration (m/s^2).

Hand-arm vibration

On hand-held or manually guided machines, hand-arm vibration is transmitted through the handles or surface of the workpiece, via the palms and the fingers, into the hands and arms. Examples of machines that may cause hand-arm vibration are demolition hammers, drills, hammer drills, angle grinders, chain saws and hand-held circular saws.

The potential health effects of hand-arm vibration

Employees who are regularly exposed to this kind of vibration may suffer from hand-arm vibration syndrome, which causes neurological and motor disorders in the hands and fingers, as well as circulatory disorders in the fingers and disorders of the musculoskeletal system.

Vascular disorders may occur in the form of white finger, which is caused by inadequate circulation. This phenomenon is generally more prevalent in colder seasons. Depending upon the duration and intensity of the exposure to vibration, it may affect only the fingertips or the entire fingers.

Neurological disorders are experienced as tingling and numbness in the fingers, which become increasingly severe with rising exposure. Examples of musculoskeletal disorders related to hand-arm vibration includes wrist tendinitis and tenosynovitis.

Example: A building worker who has worked on construction sites since the age of 14, using drilling and pneumatic hammers three or four days a week for several hours, now suffers from an occupational disease. At the age of 42, the pain in his wrist is so severe that he can no longer work.

Whole-body vibration

Whole-body vibration is caused by machines or vehicles that transmit vibration through the operator's feet, buttocks and back into his or her body. These include excavators, wheel loaders, caterpillars, graders, scrapers, site dumpers, articulated dump trucks, wheeled (motor) scrapers and fork-lift trucks used on uneven terrain.

The potential health effects of whole-body vibration

Employees who are regularly exposed to whole-body vibration may suffer from lower back pain as well as disorders of the sensory functions or fine-motor co-ordination. Factors such as twisting the body in constrained seated postures or exposing the spine to shocks or impact loads while using a vibrating machine place extra strain upon the spine.

Example: A machine operator in Germany, who has driven an excavator and loader every day for some 20 years, has had to give up his job because the pain in his back is so severe. This situation could have been avoided if he had used a modern, well-designed and adjustable seat on his vehicle and limited his exposure; for example, by rotating jobs.

The distribution of vibration-induced disorders in Europe

Apart from mining, quarrying and manufacturing, construction is the sector in Europe most hit by occupational diseases. These include disorders that may be triggered by exposure to vibration. These are recognised as occupational diseases in many Member States of the European Union. A European Occupational Diseases Statistics (EODS) pilot study has shown that between 1995 and 2000 some 23% of 2,539 cases of disorders of the locomotor apparatus of the hand and wrist, which are caused by mechanical vibration, occurred in the construction sector. By comparison, 28% were suffered by employees in manufacturing and 19% in mining.

Some 11% of 2,454 cases of vasoneurosis between 1995 and 2000 occurred in construction, compared to 39% in manufacturing and 37% in mining. Between 2000 and 2003, 1,711 cases of Raynaud's syndrome occurred in the EU, of which 12% affected construction employees. This equates to an incidence rate of 3/100,000 employees in the building industry. In the manufacturing sector the ratio is 2.3/100,000 employees, 3.41/100,000 in mining and 2/100,000 across all economic sectors.

Statutory provisions governing the prevention of vibration

On 25 June 2002, the EU adopted Directive 2002/44/EC covering the protection of employees against vibration. The objective of the directive was to set out minimum provisions to protect employees against hazards arising from the use of vibrating equipment. The directive was to be transposed at national level by 6 July 2005; its requirements were to be at least as strict as those of existing national provisions.

Council Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work is of great importance in the control of vibration risks. It defines general principles on the prevention and elimination of occupational risks, the informing, consultation and participation of workers and their representatives and general guidelines for the implementation of those principles. General employers' and workers' obligations are covered in this directive, which can be applied directly to the prevention of vibration risks in the construction sector.

Content of the EU vibration directive

Employers are now obliged to identify and assess hazards relating to vibration exposure. The vibration directive contains provisions concerning exposure action and exposure limit values. Violation of these values obliges the employer to launch technical, organisational and personal protective measures in accordance with current good practice. Employees must be informed of any risk identification and assessment, and of subsequent protective measures taken. They have to also receive corresponding instruction. Employees exposed to vibration must receive health checks.

Exposure action and exposure limit values

Daily exposure action and exposure limit values are defined for vibration hazards. These values are standardised against a reference duration of eight hours. For hand-arm vibration, the exposure action value is 2.5 m/s^2 and the exposure limit value 5.0 m/s^2. For whole-body vibration, the daily exposure action value, standardised for an eight-hour period, is 0.5 m/s^2 or 9.1 $m/s^{1.75}$, the daily exposure limit value 1.15 m/s^2 or 21 $m/s^{1.75}$.

Obligations on the construction site

The employer is obliged to conduct a risk identification and assessment study at workplaces where vibration is a hazard. The results must be documented. Should the exposure action values be exceeded, the employer must take measures to reduce vibration. The following must be considered in the process: alternative work procedures; suitable work equipment; personal protective and supplementary equipment; maintenance programmes for equipment and systems; workplace design; information on the proper use of vibrating machines; limiting the duration of exposure; appropriate shift schedules with breaks; and suitable clothing for protection against cold and damp.

Under no circumstances should the exposure limit value be exceeded. But, if it is exceeded, the employer is obliged to take immediate measures to reduce exposure below the limit value.

Employees at risk of exposure to vibration must be informed of the results of the risk assessment and be instructed in the use of the protective measures subsequently provided. Should the exposure action limit be exceeded, employees are entitled to an occupational medical examination. The purpose of the examination is the prevention and early diagnosis of vibration-induced health disorders.

For work on temporary or mobile construction sites, Council Directive 92/57/EEC defines the obligations of the client, project supervisor, employer and of the coordinators for safety and health matters, during the project preparation and execution stages. The client or project supervisor must put in place a safety and health plan before setting up on the site.

The prevention of vibration risks must be taken into account by the project supervisor from the start of the project preparation stage when the various stages of work are planned. The safety and health coordinators must draw up a safety and health plan taking into account the activities on the site, including specific measures to prevent the risks associated with vibration.

During the project execution stage, in particular, the safety and health coordinators must check that working procedures are being implemented correctly and ensure that the general principles of prevention and safety are followed.

Duration of exposure

The degree of exposure can be determined by measurement or by an estimate based on the manufacturer's data, and by observation of the working procedures concerned. The duration of exposure should include only the time during which the employee is in contact with the vibrating surface. Interruptions and breaks should not be included in exposure times. Manufacturers are obliged to declare whole-body vibration values exceeding 0.5 m/s^2 and hand-arm vibration values exceeding 2.5 m/s^2 in the user instructions.

Should an assessment of the exposure to hand-arm vibration consider the manufacturer's values, the standardised conditions under which they are measured must be compared to those actually arising under working conditions on site. Should these conditions differ, or should the vibration not be measured on the handle or the axis of measurement not correspond to the axis of the maximum vibration value, the manufacturer's value should be doubled as a precaution. Vibration values relevant to the conditions in the specific application may be requested from the manufacturer.

The KARLA catalogue of representative noise and vibration data at the workplace (www.las-bb.de/karla in German) may serve as an aid for estimating exposure to hand-arm and whole-body vibration. Further support for estimating exposure and calculators for hand-arm and whole-body vibration can be found at www.hse.gov.uk in English. Parameter calculators in German can be found on the BGIA's web pages at www.hvbg.de and at www.bg-metall.de/index.php?id=180

Reduction of whole-body vibration

When new machines are bought, models with appropriate performance should be selected. Preference should be given to machines with the lowest vibration emissions for a given performance.

The quality of roadway surfaces is an important factor in the reduction of vibration. Where possible on construction sites, uneven surfaces should be smoothed.

Suspension seats

The machines should be equipped with suspension seats, which must be adjusted to the driver's weight, to reduce vibration to a minimum. This seat suspension system must be easily accessible and adjustable.

Not every suspension seat is suitable for each and every machine. Information on suitable seats should therefore be obtained from the manufacturer before a seat is installed. A poor choice of seat may even increase vibration.

All seats are associated with a particular range of frequencies, which they amplify. Should the inherent frequencies of the vehicle lie within this range, the result is detrimental to the vibration exposure. Standards EN ISO 7096:2000, EN ISO 5007 and EN 13490:2001 contain vibration characteristics for earthmoving machines, agricultural tractors and industrial trucks.

Reduction of hand-arm vibration

Replacing the current work procedure with an alternative that generates lower vibration should always be examined. Equipment should always be suitable for the task concerned and of adequate performance if the duration of exposure for the employee is to be kept as low as possible.

Anti-vibration handles

One possibility for reducing hand-arm vibration lies in the use of vibration-reducing padded handles. Such handles are decoupled as far as possible from the source of vibration, i.e. the machine. Depending upon the manufacturer of the machine, the decoupling mechanism may take the form of springs, dampers, or systems that balance the vibration. Where handles are retro-fitted, it is crucial that the manufacturer's information is followed because incorrect handles may even increase vibration.

Autobalancers

Some machines, such as angle grinders, are equipped with autobalancers, which compensate for unbalanced masses. This is achieved by loose steel balls arranged within a container on the rotating shaft. Should an imbalance arise, the balls automatically align to counteract it and, to some extent, cancel it out. Vibration can also be reduced by using anti-vibration handles.

Mass balancing

Jigsaws and reciprocating saws are available on the market that employ the principle of mass balancing and thus run very smoothly, therefore also generating low vibration.

Suitable tool attachments

The selection of suitable tool attachments also has an influence upon vibration exposure. Attention should be paid to the concentricity and possible unbalanced masses of grinding wheels. Blunt saw blades should be replaced or sharpened in good time. The material and geometry of drill bits may influence the reduction of vibration.

Reduction of grip and feed forces

If the grip and feed forces acting upon the hand while using the machine are reduced, so too is the vibration exposure. Means should therefore be considered for modifying work processes so that contact between the employee and the vibrating machine is reduced or prevented. This may, for example, be achieved by the use of stands or stays during drilling in ceilings and walls. Remote-control trench compactors are available for civil engineering use. Users of these compactors are not exposed to vibration at all.

Anti-vibration gloves

Anti-vibration gloves may lessen high-frequency vibration. Wearing gloves may, however, also increase the grip forces and thus to some degree negate the protective action. A list of approved anti-vibration gloves can be purchased, for example, from the BG Institute for Occupational Safety (BGIA) at www.bgia-handbuchdigital.de/450110.

Legislation, standards and references

Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (16th individual directive within the meaning of Article 16(1) of Directive 89/391/EEC).

Directive 98/37/EC on the approximation of the laws of the Member States relating to machinery.

Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites.

Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work.

Existing standards such as ISO and CEN standards give detailed technical information on the organisation of workplaces and equipment to prevent fatigue and disorders related to vibration.

ISO 2631:2001 Mechanical vibration and shock – evaluation of human exposure to whole-body vibration.

ISO 5349:1986 Mechanical vibration – guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration.

EN 14253:2003 Mechanical vibration – measurement and calculation of occupational exposure to whole-body vibration with reference to health – practical guidance.

ISO 5805:1997 Mechanical vibration and shock – human exposure – vocabulary.

prEN ISO 20643 Hand-transmitted vibration from hand-held or hand-guided machinery – measurement of vibration at the grip surface (ISO/DIS 20643:2002).

ISO 8662:1988 Hand-held portable power tools – measurement of vibrations at the handle.

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Health and Safety Executive: 'Drive away bad backs – advice for mobile machine operators and drivers', pocket card INDG404, HSE Books, Sudbury, 06/2005.

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