SLOVENSKI STANDARD
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Mehanske vibracije - Vodilo o vplivu vibracij na zdravje človeškega telesa

Mechanical vibration - Guide to the health effects of vibration on the human body

Mechanische Schwingungen - Leitfaden über die Wirkung von Schwingungen auf die Gesundheit des Menschen

Vibrations mécaniques - Guide concernant les effets des vibrations sur la santé du corps humain

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Mechanical vibration - Guide to the health effects of vibration on the human body

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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European foreword

This document (CEN/TR 12349:2023) has been prepared by Technical Committee CEN/TC 231 “Mechanical vibration and shock”, the secretariat of which is held by DIN.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes CR 12349:1996.

The main changes compared to the previous edition are as follows:

- general information about foot transmitted vibration included;
- subclauses on “Prevention” moved to new informative Annex A;
- glossary moved to Annex B;
- editorial revision to comply with CEN Internal Regulations.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

Introduction

This document is an update of the 1st version from 1996 and it provides a short overview of the knowledge of the possible effects of vibration on the human body at work. It is an informative document which presents general background information for the user of the different European Standards on vibration. Information about existing approaches for prevention is provided in the informative Annex A. A glossary with important terms is listed in Annex B.

Mechanical vibration arises from a wide variety of processes and operations performed in industry, craft, forestry and agriculture, and public utilities. Vibrations are mainly caused by powered processes, hand-held and hand-guided tools, workpieces, or by vehicles. Occupational exposure to vibration can lead to health risks including occupational diseases. Exposure to harmful vibration can induce several complaints and health disorders, mainly at the upper limbs and the lower back. A comprehensive knowledge of effects of vibration on the body with risks for safety and health at work is essential to implement appropriate technical, administrative/organisational, personal protective measures and medical preventive measures.

This knowledge forms the basis for the EU Vibration Directive 2002/44/EC, its national implementation at EU Member States and the continuous updating of this regulatory framework by new scientific knowledge including the technical and medical guides to avoid or minimize occupational risks by vibration exposure at work.

1 Scope

The aim of this document is to provide information on the possible adverse health effects caused by exposure to vibration at work. The report addresses manufacturers, companies which introduce machinery on the EU market as well as employers and employees using vibrating machinery in order to improve their understanding of the possible health problems arising from occupational exposure to vibration.

This document is limited to the effects on health and does not cover the potential effects of vibration on comfort, human performance, or vibration perception. Most of the information on whole-body vibration in this document is based upon data available from research on human response to vibration of seated persons. There are only few data on the effects of vibration on persons in standing, reclining or recumbent positions.

The information on both hand-transmitted vibration and whole-body vibration is based upon data from laboratory research on acute effects as well as upon data from epidemiologic field-studies at workplaces.

Additional information can be obtained from the scientific literature.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at https://www.electropedia.org/

4 Hand-transmitted vibration

4.1 General

Powered processes and tools which expose operators' hands to vibration are widespread in several industrial and craft activities. Occupational exposure to hand-transmitted vibration can arise from rotating and percussive hand-held power tools used in the manufacturing industry, craft, quarrying, mining and construction, forestry and agriculture, and public utilities. Exposure to hand-transmitted vibration can also occur from vibrating workpieces held in the hands of the operator, and from hand-held vibrating controls such as motorcycle bars or vehicle steering wheels.

It has been estimated that 1,7 % to 3,6 % of the workers in the European countries are exposed to potentially harmful hand-transmitted vibration.

The term *hand-arm vibration (HAV) syndrome* is commonly used to refer to the complex of peripheral vascular, neurological and musculoskeletal disorders associated with exposure to hand-transmitted vibration. Workers exposed to hand-transmitted vibration can be affected with neurological and/or vascular disorders separately or simultaneously. Excessive exposure to hand-transmitted vibration can include disturbances in finger blood flow, and in neurological and locomotor functions of the hand and arm. Vascular disorders and bone and joints abnormalities caused by hand-transmitted vibration are compensated occupational diseases in several countries. These disorders are also included in a European schedule of recognized occupational diseases.

The vibration related diseases as listed at the European schedule of occupational diseases.

This is the background for the exposure action and limit values given in the EU Directive Vibration connected with corresponding mandatory preventive measures.

4.2 Vascular disorders

Workers exposed to hand-transmitted vibration can complain of episodes of pale or white finger usually triggered by cold exposure. This disorder, due to temporary abolition of blood circulation to the fingers, is called Raynaud's phenomenon (after Maurice Raynaud, a French physician who first described it in 1862). It is believed that vibration can disturb the digital circulation making it more sensitive to the vasoconstrictive action of cold.

To explain cold-induced Raynaud's phenomenon in vibration-exposed workers, some investigators invoke an exaggerated central vasoconstrictor reflex caused by prolonged exposure to harmful vibration, while others tend to emphasize the role of vibration-induced local changes in the digital vessels.

Various synonyms have been used to describe vibration-induced vascular disorders: dead or white finger, Raynaud's phenomenon of occupational origin, traumatic vasospastic disease, and, more recently, vibration-induced white finger (VWF). VWF is a prescribed disease in many countries.

Initially attacks of blanching involve the tips at one or more fingers, but, with continued exposure to vibration, the blanching can extend to the base of the fingers. Sometimes, an attack of blanching is followed by cyanosis, i.e. a bluish discoloration of the affected fingers due to increased extraction of oxygen from the sluggish digital circulation. In the recovery phase, commonly accelerated by warmth or local massage, redness, eventually associated with pain, can appear in the affected fingers as a result of a reactive increase of blood flow in the cutaneous vessels. The blanching attacks are more common in winter than in summer and last from a few minutes to more than one hour. The duration varies with the intensity of the triggering stimuli, the attack is usually ending when the entire body is warmed.

If vibration exposure continues, the blanching attacks become more frequent and can occur all year around. In rare advanced cases, repeated and severe finger blanching attacks can lead to trophic changes (ulceration or gangrene) in the skin of the fingertips. During the attack the affected workers 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. In occupational medicine various staging systems for the classification of VWF have been developed. A grading scale proposed at the Stockholm Workshop 86 is reported in Table 1. This scale is also included in EN ISO 5349-1:2001, Annex B.

Table 1 — The Stockholm Workshop scale for staging cold-induced Raynaud's phenomenon in the hand-arm vibration syndrome

Stage	Grade	Symptoms
0	—	No attacks
1_v	Mild	Occasional attacks affecting only the tips of one or more fingers
2_v	Moderate	Occasional attacks affecting distal and middle (rarely also proximal) phalanges of one or more fingers
3_v	Severe	Frequent attacks affecting all phalanges of most fingers
4_v	Very severe	As in stage 3, with trophic skin changes in the fingertips
Key: v vascular component		

Several laboratory tests are used to diagnose white finger objectively. Most of these tests are based on cold provocation and the measurement of finger skin temperature or digital blood flow and pressure before, during and after cooling of the fingers and hands (see ISO 14835-1 and ISO 14835-2).

Epidemiologic studies have demonstrated that the prevalence of VWF varies widely, from 0 % to 100 %. It appears that the probability and severity of white finger symptoms is influenced by several factors such as

- the characteristics of vibration exposure (frequency, magnitude, direction, impulsiveness, duration),
- 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 (susceptibility, diseases and agents, e.g. smoking and certain medicines, affecting the peripheral circulation).

Thus, there is a complex relationship between vibration exposure and the development of white finger symptoms. Epidemiologic studies have shown that the occurrence of VWF increases with increasing duration of vibration exposure. There is some evidence that the cumulative exposure before the appearance of finger blanching is approximately inversely proportional to the magnitude of the vibration exposure (i.e. if the vibration magnitudes are doubled, a halving of the years of exposure is necessary to produce the same effect).

Since the late 1970s a decrease in the incidence of VWF has been reported among active forestry workers in both Europe and Japan after the introduction of anti-vibration chain saws and administrative measures curtailing the saw usage time together with endeavours to reduce exposure to other harmful work environment (e.g. cold, and physical stress). Recovery from VWF has also been reported among retired forestry workers. Similar findings are not yet available for tools of other type.

4.3 Neurological disorders

Workers exposed to hand-transmitted vibration can 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 can exhibit a reduction in the normal sense of touch and temperature as well as an impairment of manual dexterity at the clinical examination. As an effect of hand-transmitted vibration, also a reduction of the vibration sensitivity of the skin of the fingertips can be found. Epidemiologic surveys of vibration-exposed workers show that the prevalence of peripheral neurological disorders varies from a few percent to more than 80 %, and that sensory loss affects users of a wide range of tool type. It seems that sensorineural disturbances can develop independently of other vibration-induced disorders, probably reflecting different pathological mechanisms.

A classification for the neurological component of the HAV syndrome was proposed at the Stockholm Workshop 86, consisting of three stages according to the symptoms complained and the results of clinical neurological examination and psychophysical testing methods such as tactile discrimination, vibrotactile perception, and precision manipulation (see Table 2). This scale is also included in EN ISO 5349-1:2001, Annex B.

Table 2 — Sensorineural stages of the hand-arm vibration syndrome according to the Stockholm Workshop scale

Stage	Signs and symptoms
0_{SN}	Exposed to vibration but no symptoms
1_{SN}	Intermittent numbness, with or without tingling
2_{SN}	Intermittent or persistent numbness, reduced sensory perception
3_{SN}	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity
Key: SN sensorineural component	

Vibration-exposed workers can sometimes show signs and symptoms of entrapment neuropathies, such as carpal tunnel syndrome (CTS), a disorder due to compression of the median nerve as it passes through an anatomical tunnel in the wrist. CTS seems to be a common disorder in some occupational groups using vibrating tools such as rock-drillers, platers and forestry workers. It is believed that ergonomic stressors acting on the hand and wrist (repetitive movements, forceful gripping, awkward postures), in combination with vibration can cause CTS in workers handling vibrating tools. CTS is acknowledged by most of the EU Member States as occupational disease.

4.4 Musculoskeletal disorders

4.4.1 Skeletal – bone and joint disorders

Vibration-induced bone and joint disorders are a controversial matter:

a) Early radiological investigations revealed a high prevalence of bone vacuoles and cysts in the hands and wrists of vibration-exposed workers, other studies have shown no significant increase with respect to manual workers not exposed to vibration.

b) Excess occurrence of wrist and elbow osteoarthrosis as well as ossifications at the sites of tendon insertion, mostly at the elbow, have been found in miners, road construction workers and metal-working operators exposed to shock and low-frequency vibration (<50 Hz) of high magnitude from pneumatic percussive tools.

c) An excess prevalence of Kienböck's disease (lunate malacia) and pseudoarthrosis of the scaphoid bone in the wrist has also been reported by a few investigators.

An increased prevalence of degenerative bone and joint disorders in the upper limbs of workers exposed to mid- or high-frequency vibration arising from chain saws or grinding operation. Heavy physical effort, forceful gripping and various biomechanical factors can also account for the higher occurrence of skeletal injuries found in workers operating percussive tools. Local pain, swelling, and joint stiffness and deformities can be associated with radiological findings of bone and joint degeneration.

In some countries (e.g. France, Germany, Italy), bone and joint disorders occurring in workers using hand-held vibrating tools are considered to be an occupational disease and the affected workers are compensated.