

VIBRATIONS TRANSMITTED THROUGH THE HANDS AND THEIR EFFECT ON HUMAN HEALTH

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Abstract

The work presents the possibility of onset of the “vibration disease” or of other categories of diseases already considered as professional and compensated diseases. The groups of operators who can develop a disease due to the tools they use during normal working hours are presented together with the respective afflictions. The work presents the present knowledge of the consequences of handling vibrating machinery, tools and parts.

When a person uses percussion tools, pneumatically, electrically and hydraulically actuated grinding machines, chain saws, etc., high intensity vibrations are transmitted to the hand, arm and shoulders. The vibrations induced in various parts of the human body often represent a source of discomfort possibly of reduced efficiency, and furthermore it was demonstrated that various afflictions affecting blood vessels, nerves, bones, joints, muscles, hand and arm ligaments are connected with the frequent use of vibrating, power tools. As regards vibration amplitude, the frequency spectrum, daily duration or cumulated exposure duration there are no known thresholds for the onset of the diseases.

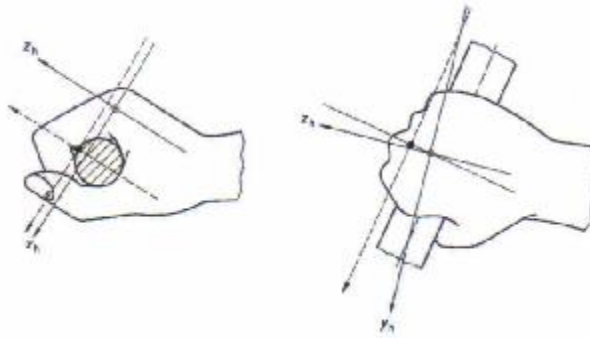
There are multiple factors which influence the effects on the human body of exposure to vibrations transmitted through the hand during the work programs, namely:

- vibration frequency spectrum;
- vibration acceleration value;
- exposure duration over one working day;
- cumulated exposure before the date of measurement;
- direction of vibrations transmitted to the hand;
- work method and operator's deftness;
- age and factors predisposing to diseases or impairing the health of individuals;
- exposure model in time and work method, i.e. the duration and frequency of actual work alternated with rest periods; during the rest period the tool is set aside or kept idling in hand, etc;
- coupling forces, such as the gripping and pushing force exerted by the tool or press operator and the pressure on the tegument;
- the position of hand and arm as well as the position of the body during exposure (angles between hand and wrist, elbow and shoulder);
- type and condition of the vibrating tool, accessories or component parts to be processed;
- zone and location of hand parts exposed to vibrations; (there are factors which specifically affect circulation modification caused by vibrations transmitted through the hand);
- climatic conditions and other factors influencing the temperature of the hand or of the body;
- diseases affecting the circulatory system;
- agents affecting the peripheral circulation such as: nicotine, certain drugs or chemical substances existing at the working place;

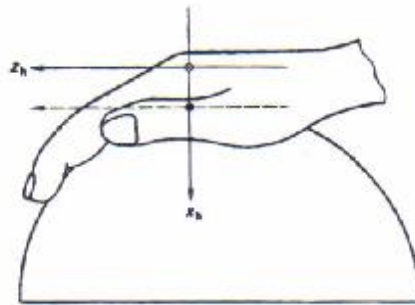
- noise.

To characterize the exposure to vibrations the main value used is the acceleration of the zones in contact with the hand. The connection between the hand and the vibration source generates various biological effects.

The system of coordinates used to measure the vibrations transmitted to the hand are shown in Figure 1 .



(a) Hand grip position (in this position the hand takes a standard position on a cylindrical bar)



(b) Position „open palm” (in this position the hand presses against a sphere)

Figure 1

Exposure of the operator to vibrations transmitted through the hand can occur in the case of portable power tools, rotational or percussion tools used in the manufacturing process of various products, stone extraction, mining, constructions, forestry and agriculture, public utilities, etc. Vibrations transmitted through the hand be can also generated from the processed parts which vibrate and are held in hand by the operator as well as from motorbike hand grips, vehicle steering wheel.

Excessive exposure to vibrations transmitted through the hand can cause alterations of the in-flow of blood to fingertips and of the neurological and motility functions of hand and arm.

It is estimated that 1.7% - 3.6% of the operators in the European Union and USA are exposed to vibrations transmitted through the hand which are potentially harmful. The term „hand-arm vibration syndrome” (HAV) is applied to the complex or peripheral vascular and neurological disorders and in connection with afflictions of the muscles and skeleton associated with exposure to vibrations transmitted through the hand. There are countries

where vascular disorders and deformation of bones and joints caused by vibrations transmitted through the hand are considered compensated professional diseases.

Operators exposed to vibrations transmitted through the hand in cold temperature suffer from the Raynaud phenomenon caused by temporary stop of blood circulation in the fingers with the result in a discoloration of the fingers (pale fingers). To explain the phenomenon some researchers have assumed an exaggerated central vasoconstricting reflex determined by prolonged exposure to vibrations whereas others tend to stress the effect local modifications induced by vibrations have on the finger vessels. To describe these vascular disorders induced by vibrations several synonyms were used from among which the accepted one was VWF – vibration induced white fingers. Initially, the whitening attack occurs at the tip of one or several fingers but if the exposure to vibrations continues the whitening extends to cover the entire region to the base of the fingers. Sometimes, due to the progressive lack of oxygen input caused by poor circulation the affected fingers turn blue and become cyanotic. Accelerated recovery, usually by local massage or heating, result in the fingers turning slightly red and the individual may sometime feel stings and/or pain (as a result of reactive blood inflow in the skin vessels). These whitening attacks are more frequent in winter than in summer and can last from several minutes to 1 hour or more. The duration of the attack depends on the intensity of the stimuli and on the severity of the vascular spasm, usually ending when the whole body is warmed up. If exposure to vibrations continues, the finger whitening attacks become more and more frequent and eventually they can be present throughout an entire year. Repeated and sever finger whitening attacks seldom lead to trophic changes (ulcerations or gangrene) in the tegument of the finger tips. Afflicted operators can suffer total loss of tactile sensitivity and deftness during the attacks impacting individual performance accordingly.

The participants in the Stockholm Seminar (1986) have devised an assessment system to classify VWF and Raynaud phenomenon which has already been adopted at international scale (Table 1).

Table 1

No.	Vascular component		
	Stage	Level	Description
1	-	-	Zero attacks
2	1v	Weak	Occasional attacks interesting only the tips of one or several fingers
3	2v	Moderate	Occasional attacks interesting distal and median phalanx (seldom also the proximal phalanx) of one or several fingers.
4	3v	Severe	Frequent attacks interesting all phalanxes of the majority of fingers
5	4v	Very severe	Same as 3 above but with dystrophic modifications of fingertips.

Figure 2 shows the case of daily exposure to vibrations A(8) which are believed to cause finger whitening in 10% of the exposed subjects. The values are given for total average exposure (throughout the entire life) of groups from 1 year up to 8 years (Table 2)

Table 2

Dy years	1	2	4	8
A(8)	26	14	7	3.7

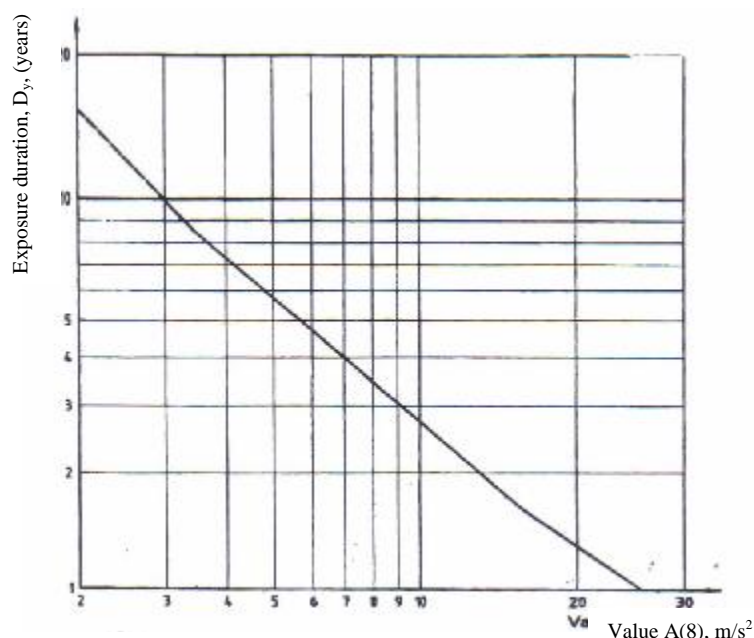


Figure 2 – Exposure to vibrations for a 10% predetermined prevalence of vibration induced white fingers in a group of exposed individuals

The values in Table 2 and Figure 2 have been obtained by studying several groups of operators exposed to values of tool vibrations up to 30 m/s² for 25 years.

Stings and numbness in fingers and hands are other symptoms which the operators exposed to vibration transmitted through hands state. These symptoms can affect the work capacity and daily routine when the exposure to vibrations is prolonged. Clinical investigations performed on human subjects indicated a reduction of the normal tactile sense. Diminished sensitivity of the fingertip tegument is another effect of vibrations transmitted through the hand. Following epidemiological surveillance of operators exposed to vibrations it was ascertained that the incidence of peripheral neurological disorders features a wide range from a couple of percentages up to over 80% of the subjects. It was assumed that the sensorial neurological disorders can appear independent from other vibration caused afflictions probably reflecting different pathological mechanisms. A classification of the neurological component of HVAS was proposed at the Stockholm seminar in 1986. This classification (Table 3) counts three stages corresponding to the symptoms (as revealed by the clinical neurological investigation) and it corresponds to psychological and physical tests such as: tactile differentiation, vibrotactile perception, precision maneuvering.

Table 3

	SENSORIAL COMPONENT	
	Stage	Description
1	0 _{SN}	Exposure to vibrations but no symptoms
2	1 _{SN}	Intermittent numbness with or without stings
3	2 _{SN}	Intermittent or persistent numbness, reduced sensorial perception
4	3 _{SN}	Intermittent or persistent numbness, reduced tactile differentiation and/or diminished maneuvering deftness

Operators using vibrating power tools such as rock perforators, metal work, forestry

tools can accuse neuropathy symptoms such as carpal tunnel syndrome. It is presently believed that this syndrome is generated by ergonomic stress factors acting on the hand and hand wrist (repetitive actions, strong grips, improper position) which overlap on the respective tool induced vibrations.

Operators exposed to such vibrations were found with high prevalence of vacuoles and bone cysts at the level of hand and wrist.

Other groups of operators such as miners, road constructors, metal industry workers who are exposed to shocks and low frequency vibrations (under 50 Hz) or to high value vibrations caused by pneumatic power tools have been found with osteoarthritis of wrist and elbow and with ossification of the elbow tendon insertion point.

Some researchers have ascertained that the Kiekenböck disease as well as the pseudoarthritis of the wrist bones. High physical effort, strong grips, various other biomechanical factors explain the skeleton alterations and lesions in operators working with percussion tools. Radiological investigations indicated bone and joint degeneration. In countries like France, Germany, Italy bone and joint afflictions of operators using vibrating tools are considered professional diseases (they are characterized by local pain, inflammation, rigidity and deformation of the wrist).

It was ascertained that exposure to vibrations leads to diminished hand grip force. In some cases muscle fatigue can result in incapacitation. The possible etiological factors of these symptoms (weakening of muscle force, painful hands and arms, muscle weakening) can be direct, mechanic lesion or deterioration of the peripheral nerves.

The specialized literature treats as uncertain the occurrence of certain afflictions such as tendonitis, tenosynovitis, Dupuytren contraction, and finds generating causes rather in ergonomic stressing factors of manual work than in exposure to vibrations.

Some studies demonstrated that operators affected by VWF (vibration induced white fingers) are also suffering from loss of hearing capacity irrespective of age. This impairment of the hearing capacity was attributed to the deterioration of the blood circulation in the internal ear vessels due to vibration induced vasoconstriction.

Russian and Japanese researchers have identified other negative effects of vibrations which involve the endocrine and the central nervous systems of operators exposed to vibrations. Thus, the "vibration disease" includes symptoms connected with the brain cortical centers (such as: persistent fatigue, headaches, irritability, sleep disorders, impotence, and electroencephalographic abnormalities).

Research work is still underway in order to discover all symptoms and diseases caused by exposure of humans to vibrations transmitted through hands and also to allow identification of measures aiming at reducing vibrations and their harmful effects.

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