

Vibrations

Vibration is the oscillatory motion of an elastic environment about a fixed point. Vibration is periodic when it repeats itself. We usually distinguish:

- vibration of equipment (characterizing sources of vibration at a certain operative state);
- vibrations affecting a man;
- monitoring of transmission ways of vibrations.

Effects of Vibration

Effects of vibration manifest themselves both mechanically and psychologically on the body. The overall effect of vibration depends on:

1. The characteristics of the vibration
 1. amplitude;
 2. acceleration;
 3. magnitude;
 4. frequency;
 5. direction.
2. Exposure type
 1. whole-body;
 2. hand transmitted.
3. Factors related to the worker:
 1. exposure duration;
 2. the posture used during exposure;
 3. location of body contacts;
 4. applied forces;
 5. amount of training received with the vibrating tool.

Biological Effects of Vibration

The effect of vibrations on an organism may be general or local. Vibrations with frequencies up to 500 Hz cause mostly general effects such as tiredness and worsening of reactions to outside stimuli after a long-term exposure. These effects occur e.g. when driving a car or a tractor, or flying by plane and may be a factor contributing to transport accidents.

Local Effects of Vibrations

Generally we refer to "whole body vibration" when the vibration affects whole or major portion of body. It may be transmitted through the air (sound) or through a supporting area to whole body - sitting in a chair, standing on vibrating ground. Of the whole body, the spine is the part most sensitive to vibrations when exposed to oscillation in the direction vertical to the spine axis. It has been shown that occupations involving prolonged exposure to whole-body vibration (truck, bus, and tractor drivers) are associated with low back pain.

"Localized vibrations" refer usually to hand/arm vibration and occur when holding a vibrating tool for example pneumatic hammer or chainsaw. Disorders of the hand are collectively known as Hand-Arm Vibration Syndrome (RAVS). The disorder most often associated with vibration exposure to the hand/arm is **Raynaud's Syndrome** (White Finger). It is caused by vibrations transmitted to hands at frequency 20-40 Hz manifested by damage of vessels and nerves, starting in fingers:

- impairment of vessels of the upper extremities occurs at vibrations of frequency above 100Hz;
- after a long-term exposure of upper extremities we can also find changes at the elbow joint.

There are other bone/joint (decalcification, osteoarthritis), neurological (sensory loss), and muscular disorders (muscle atrophy, vibration causes voluntary and involuntary contractions, which contributes to fatigue) associated with vibration, but these disorders generally don't receive as much attention as Raynaud's syndrome.

Sensory Effects of Vibration



Raynaud's phenomenon

Vibrations can also affect sensory processes in man. Vision is affected by whole body vibration, which may lead to motion sickness. Hearing is also adversely affected, however it is difficult to determine how much damage occurs from vibration and how much occurs from the loud noise that typically accompanies vibrating tools. Tactile perception is also affected, and this is sometimes exacerbated by cold air discharged from pneumatic tools.

Measuring and Evaluation

The movement of individual points of the body exposed to vibrations can be described using values of deviation, speed or acceleration. Acceleration levels are weighted according to the frequency of the vibration, since certain frequencies are more detrimental to a person than others. This weighted data are then compared to existing threshold limit values to determine if they are acceptable for certain exposure. In addition we evaluate:

1. time of exposure;
2. type of activity of the exposed person;
3. type of utilization of the building;
4. the grip force of hands on the vibrating object (when measuring vibrations transmitted to the hands);
5. the measuring of vibrations itself is guided by similar rules as noise measuring.

Way of Transmission

The way of vibration transmission is decisive when evaluating damaging effect on man. In principle it is necessary to distinguish the vibrations transmission to the hands, to the whole body, and to the spine and the head. Every object tends to vibrate at a natural frequency that depends on its composition, size, structure, weight and shape. A vibrating tool transfers maximum energy to an object when the tool vibrates at the object's resonant frequency. In resonance, the amplitude of vibrations exceeds that of the source.

The body varies with respect to the resonant frequency. Low frequencies, i.e. frequencies between 0-2 Hz (ships, cranes), are particularly detrimental since most parts of the body move together, but they mostly affect the vestibular system. Middle frequencies of 2-20 Hz (aircrafts, vehicles) mostly affect joints. High frequencies of more than 20 Hz (power tools) mostly affect somatosensory receptors.

Environmental Classification

The evaluation itself is usually divided into three categories according to the environment:

1. Vibrations at working places: the setting up of the highest admissible limit is done in a similar way as for noise.
2. Vibrations in dwellings and other buildings for activities not related to work: the highest admissible level of acceleration of vibrations in building structure is set up as sum total of the basic level of acceleration, of vibrations, and corrections for the utilisation of premises, daytime and character of vibrations.
3. Vibrations of the frequency lower than 1 Hz: the limitation of incidence of kinetosis (motion sickness) should be taken into consideration when setting up admissible values for vibrations with frequency lower than 1 Hz.

Prevention and Protection

Whenever possible, it is always most desirable to use some type of "engineering" solution to reduce exposure. Development of "anti-vibration or reduced vibration" tools and handles, for example a sharpened tool is much more effective than a dull tool. Regular and appropriate tool maintenance is also of great importance. Gloves help to some extent by impeding some vibration. However, with gloves it is often necessary to exert more force than would be exerted without a glove (due partly to the glove material and partly to the reduced tactility). It is important to keep hands warm as workers exposed to the detrimental effects of vibrations must be also protected against cold and dampness (warm working clothing and footwear, gloves with limited transmission of vibrations, heated machine cabins, warming rooms). It is possible to minimize exposure administratively by using job rotation schedule and providing adequate rest, for example, working with certain types of vibrating tools is limited to two hours per work shift. The total time of work in hard working conditions (such as mines) should not exceed 2000 shifts during the work life. It is important to inform the workers about early symptoms and how to avoid factors enhancing the risk of disease caused by vibrations (vasoactive substances such as coffee, or smoking). Provisions concerning compensatory measures (protective aids) and preventive medical examinations are similar to those applied for working in a noisy environment.

Links

Sources

- RAMES, . *Physical Factors of Environment* [lecture for subject Hygiene and Epidemiology, specialization Hygiene and Epidemiology, 1LF Charles University in Prague]. Prague. 2011-04-20.

Bibliography

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