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EFFECTS OF EXPOSURE TO VIBRATIONS ON HEALTH

Eugenia SECARĂ

"Transilvania" University of Braşov, eugenia.secara@unitbv.ro

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Abstract

The work presents the values of vibrations which, propagating through chair or legs to the entire body influence the health condition of operators as well as their effects work.

A large variety of procedures, industrial, forestry and farming operations generate mechanic vibrations. Vibrations, induced by mechanical procedures, hand or portable tools, vehicles, can adversely affect the human body. Exposure to vibrations can generate afflictions and health disorders. The simple knowledge of the adverse effects of vibrations on the human body can allow the implementation of administrative, technical and medical prevention measures.

According to estimates given in a number of European states, between 4% and 7% of the operators are exposed to potentially harmful whole body vibrations (WVB). Whole body vibrations are the mechanical vibrations which are transmitted through the chair or legs to the whole body. WVB is a widely known professional factor with possible negative effects on the human health the source of which is found in vehicles (on the ground, in air or water) and, generally speaking, in all vibrating surfaces. High risk groups exposed to vibrations are considered: off road vehicle drivers (for example: farm machinery, forestry machines, earth moving machinery), truck drivers , bus drivers, crane operators, pilots flying helicopters, ship crew members.

WVB are generated in several directions, they vary in time and contain many frequencies and therefore their effects can be very complex. In respect with such complex effect, biological differences between subjects can occur, for example: WVB can cause discomfort or uneasiness, can influence the individual performance capacity and/or can raise a health or safety risk. Generally speaking the low frequency body vibrations (under 0.5 Hz) can cause motion sickness.

Biodynamic an epidemiological research pinpointed at the high risk of health impairment following extended exposure to intense whole body vibrations. The lumbar parts of the back bone with the respective nervous system are especially affected. Exposure over a longer period of time – either during the working hours, or daily for several years – as well as a higher intensity of the vibrations generate larger doses of vibrations which, obviously, increase the risk whereas the rest periods diminish the said risk. The specialty literature demonstrates that the assessment of the effect of vibrations on human health must be performed independently for each axis (Figure 1). Vibration assessment must also be put in relation with the maximum frequency weighted acceleration as determined for any axis of the chair.

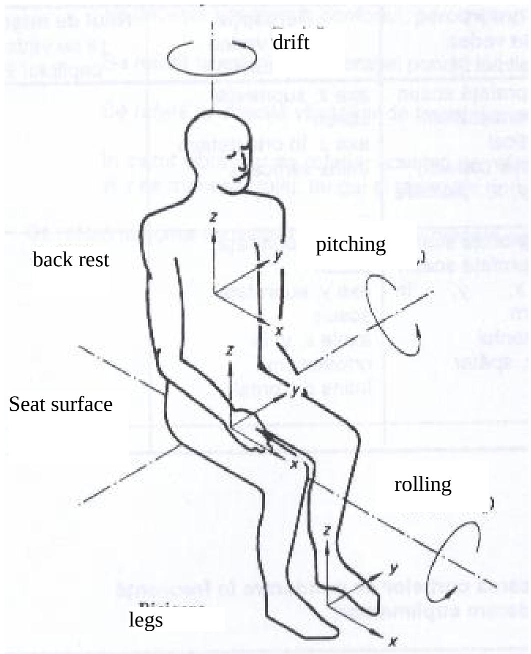

Figure 1 Sitting position

If the vibrations along two or several axes are comparable, vector sum shall be used to determine the health risk.

Figure 2 (presents the so called “attention zone” for health (shadowed zone). This attention zone warns about the potential risks in relation mainly with exposures to vibrations over a period between 4 and 8 hours.

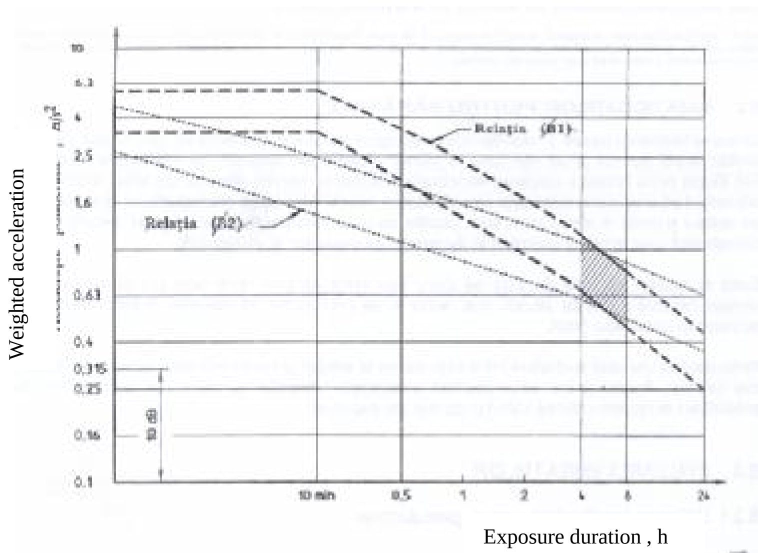

Figure 2 “Attention zone” for health (shadowed zone)

In case of exposures under the zone, the effects on the human health have not been clearly stressed out and/or have not been objectively studied whereas the exposures above the attention zone health risks are probable. One can see in Figure 2 that the attention zone for exposures between 4 and 8 hours is about the same irrespective of the use of relations 1 or 2.

Thus,
(a) two exposures to daily vibrations are equivalent if:

$$a_{w1} \times T_1^{1/2} = a_{w2} \times T_2^{1/2} \quad (1)$$

where:

a_{w1} and a_{w2} are vibration accelerations, expressed as weighted average, square values (rms) for the first and second exposure, respectively.
T_1 and T_2 are the durations of the first and second exposure.

(b) there are studies indicating the time dependence according to the following relation:

$$a_{w1} \times T_1^{1/4} = a_{w2} \times T_2^{1/4} \quad (2)$$

To characterize the exposure to vibrations, the frequency weighted acceleration over a duration of 8 hours can be measured or calculated by means of the relation:

$$a_W = \left[\frac{1}{T} \int_0^T a_W^2(t)dt \right]^{1/2} \quad (3)$$

Where:
Aw(t) is the weighted acceleration (translational or rotational) during the 8 hours, expressed in m/s^2 or rad/s^2
T is the measuring duration in seconds.

When the exposure to vibrations consists of several exposure periods of different values and durations, the equivalent value of the vibrations corresponding to the total exposure durations can be evaluated with one of the following relations:

$$a_{w,e} = [\Sigma a^2_{wi} \times Ti / \Sigma T_i]^{1/2} \quad (4)$$

Where:
$a_{w,e}$ is the equivalent value of vibrations (acceleration r.m.s.), expressed in m/s^2
a_{wi} represents the vibration value (acceleration r.m.s. expressed in m/s^2) over the exposure duration T_i

$$a_{w,e} = [\Sigma a^4_{wi} \times T_i / \Sigma T_i]^{1/4} \quad (5)$$

Some studies use the estimated vibration dose value eVDV calculated as follows:

$$eVDV = 1.4\, a_w \times T^{1/4} \quad (6)$$

where:
a_w is the frequency weighted acceleration r.m.s.;
T is the exposure duration, expressed in seconds.

A prolonged exposure to professional WBV is associated with disorders in the lumbar region. Epidemiologic studies have indicated increased lumbar pains, herniated disk and an early degradation of the back bone (deforming spondylosis, inter-vertebral osteochondritis, deforming arthrosis). There is a tendency of increased risks proportional with the level exposure intensity. It was also ascertained that a transient exposure to vertical WBV (of the shock type) can be of a high risk nature. Although there are several hypotheses on the action mechanisms of vibrations the hypothesis that mechanical overload due to vibrations leads to a early deformation of the lumbar region of the backbone. An ongoing exposure to vibrations over a long enough period of time or at peak values, without sufficient recovery can have a direct mechanic effect, namely loss of the forces due to fatigue and alteration of disk irrigation. The data in the specialized literature demonstrate that a sitting position for a long period of time in combination with exposure to WVB 9as is the case of motor vehicles) can increase the risk of serious damage to the back bone.

Although various studies signaled also other disorders in the human body submitted to WBV, conclusions are far from being drawn, determinations still being outstanding. From among these disorders we need to mention those of the back neck and shoulders, the digestive, circulatory disorders and the impact on the reproduction capability and on the hearing of humans.

The relation between the value (amplitude)of vibrations and the human comfort depends on multiple factors. It can be considered that certain vibrations can cause unacceptable discomfort in certain cases but can be and tolerance to uneasiness in other cases. Comfort and tolerance to uneasiness are different in the case of transport vehicles as compared to buildings (dwellings or business). Reactions of passengers to different total, global values of vibrations can be different depending on the expectancy of the passengers as to the duration of the drive, activities which they would rather do during the ride (e.g.: reading, writing or eating, etc.) as well as other many factors 9noise, temperature, etc.). However, approximations and data of the possible reactions to various total, global vibration values have been brought force in relation with the public transport. (Table 1).

Table 1

No.	Total global values of vibrations	Comfort level
1	Under 0.315 m/s^2	No discomfort
2	0.315 m/s^2 ÷ 0.63 m/s^2	Little discomfort
3	0.5 m/s^2 ÷ 1 m/s^2	Uncomfortably enough
4	0.8 m/s^2 ÷ 1.6 m/s^2	Uncomfortable
5	1.25 m/s^2 ÷ 2.5 m/s^2	Very uncomfortable
6	Over 2 m/s^2	Extremely uncomfortable

As regards the capacity to perceive vibrations there is a substantial variability between individuals. The median average threshold for the perception is of approximately o.o15 m/s^2. Fifty percent of the healthy individuals, van detect, if attentive, a vibration of this peak value. The perception threshold slightly diminishes with the increase of vibration duration up to one second to drop very little with the increase of the duration of vibrations. Although the perception threshold does not drop continuously with the increase of the duration of vibrations, the sensation caused by vibrations with above threshold vibrations can continue to increase.

The low frequency oscillations generate motion sickness. It has been ascertained that women are more predisposed to motion sickness than men and that the occurrence of symptoms diminishes with age. Motion sickness has a lesser intensity to motions between 0.1 Hz and 1 Hz.

Deterioration of the cognitive activity as well as of main task performance can be occur at vibration intensity sufficiently large in a range of at least 10 octaves. Furthermore, the deterioration of attention or of thinking capability occurs if during the execution of a task over a couple of hours a motion of a sufficiently high amplitude is under way. Once present, the deterioration can aggravate with time. Exceptions from this can occur when:

- the human body accommodates to the motion;
- other factors or events intervene contributing to increasing the interest in the task at hand or which can facilitate the task.

Certain physiological effects caused by oscillating motion (such as, for instance, fatigue, unstable position, motion sickness, loss of motivation) o not disappear altogether when the causing motion stops but they can persist in time (minutes up to hours, even days in the most severe cases). This is the reason why the motivation of executing a task by a person remains disturbed after the ship gets to the shore, or after the plane lands if the voyage was difficult.

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