ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering

THE INFLUENCE OF LOW FREQUENCY VIBRATIONS AGAINST DRIVERS

Florin CONSTANTIN, Eugenia SECARA
Transilvania University of Brasov

Abstract

The paper presents the influence of low frequency vibrations against drivers. The human body can be associated with a mechanical model which can explain the effects of vibrations against vertebral column subject to successive comprehensions and relaxations. Vibrations are differently perceived depending on the human body position, the variation of vibration in time and their duration, etc. Finally the work presents the conditions that need to be fulfilled to attenuate the influence of vibrations against drivers.

1. THE EFFECTS OF VIBRATIONS AGAINST DRIVERS

The human body appears as a very complex physical and biological system, his properties easily being subject to change because of the exposure to vibrations. When the vibrations exceed certain limits take place mechanical effects materialized in wounds of different human body internal organs. The biological effect is due to the excitation of nervous system, conducting to changes regarding capacity for work because tiredness and reduction of attention appear.

Although the vibrations to which the driver is subject are transmitted vertically, horizontally and transversely as well, the vertically vibrations transmitted through the chair are considered to mostly generate the deterioration of driver's health.

Apart from drivers using suspension equipped motor vehicles, who travel on regular asphalted roads, tractor drivers are subject to 2 up to 4 times higher vibrations while working the fields as well as to 5 up to 7 times higher vibrations while traveling on non-asphalted roads. To explain the mechanical effects of chair vibrations against both human body internal organs and vertebral column a three freedom degrees mechanical model (figure no. 3) is used to substitute the tractor driver: the head, the chest and the pelvis, tied together by flexible organs – muscles, ligaments and cartilages, which provide an elastic hanging. The vertebral column and the internal organs are subject to successive compressions and relaxations. Those undesired movements will determine a side sinking of each inter-vertebral disc and a spinning of the vertebral column, conducting to neuralgia as well as to lasting articular aches. The vibrating movement of the chair is transmitted to the three sealing compound generating a new vibrating movement in each one of them.

The vibrations which are most important for the tractor drivers and are also very dangerous because of their influence on human body are contained within 1 Hz to 30 Hz range. Generally, under 3 Hz range the human body acts like a whole and there appear different intensity symptoms, starting with a slightly discomfort, ending with disgust, puke, sick, cold perspiration and even more severe symptoms that force travel interruption. Low frequency vibrations, contained within 3…30 Hz range, are transmitted all the way up the human body and the tissues and the internal organs act differently to vibrations changes.

Besides frequency, the vibrations action is also determined by the value of acceleration, the vibration transmitting direction through human body, the human body position, the driver's health and the duration of vibrations. The internal abdominal organs,

the osseous system and the muscular system are most affected.

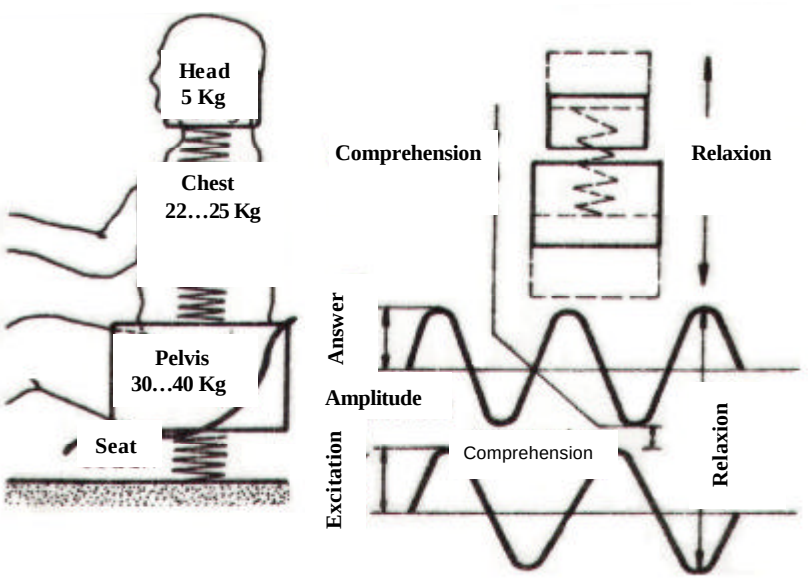


Figure no. 1
Vibrations effects against vertebral column

The driver's sensitivity to vibrations rises to the maximum within 4…8 Hz range. It is within this range that the first resonance appear; the abdomen, the chest and the shoulder articulation are subject to the resonance.

Figure no. 2
Hydro-pulse device

Within 10-12 Hz range the vertebral column is affected. Another resonance domain appears within 20…30 Hz range and it affects the neck, the shoulder and the head, conducting to visual acuity reduction.

The vibrations are differently perceived depending on: the human body position related to the vibrations direction, the variation of vibration in time, the continuity or the discontinuity of vibrations, the duration of vibrations, the frequency and the amplitude of vibrations.

A chair having a non adjusted suspension may conduct both to the decreasing of driver's efficiency and the deterioration of his health. The research can be done using the hydro-pulse device presented in figure no. 2. The hydro-pulse device tests the elastic and cushion qualities of the suspension, aiming to provide the comfort.

The international research extended, aiming to study the driver's physical, physiological and psychological behavior while being subject to vertical vibrations. It was established the existence of a correlation between physical effort due to vibrations and the driver's physiological and psychological behavior.

In figure no. 3 it is presented the influence of the chair suspension on the driver's pulse. The 49 years old driver subject to test faced a 10 mm amplitude harmonic excitation, frequency ranged between 1 Hz to 8 Hz. In the case of non adjusted suspension we can see the rise of the driver's pulse from 63 pulsation/min up to 90 pulsations/min. On the other hand, in the case of adjusted suspension we can see the driver's pulse rises only up to 75 pulsations/min. The retrieving time to the normal pulse is 19 seconds in the case of non adjusted suspension, versus 5 seconds in the case of the suspension adjusted according to driver's weight and work conditions.

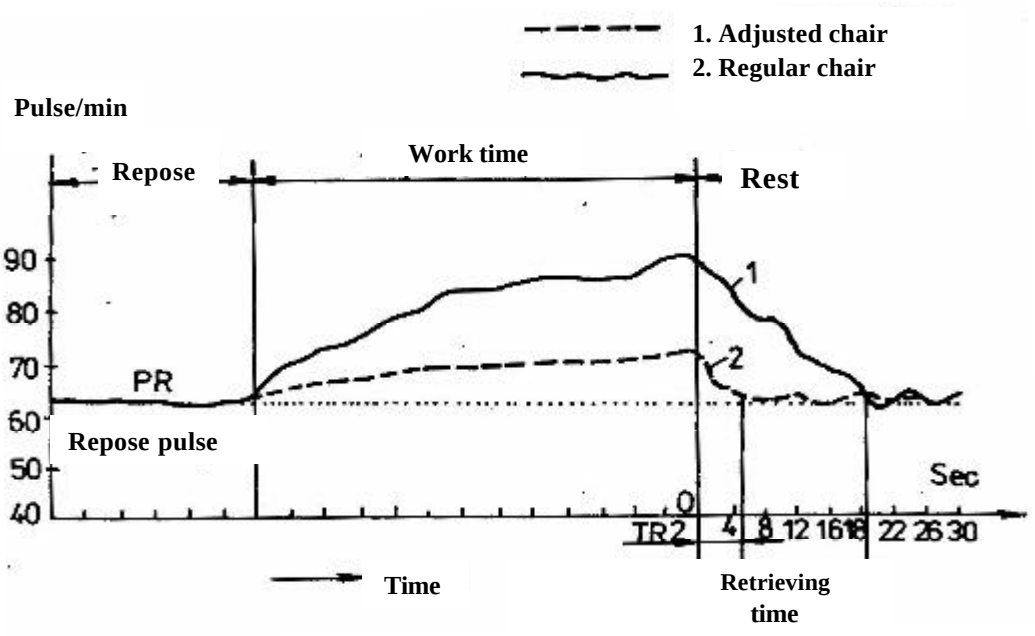


Figure no. 3
The influence of the chair suspension on driver's pulse

In figure no. 4 it is shown the importance of the suspension adjustment according to driver's weight, related to the pulse. We can easily see that a rigid adjustment of the suspension, that is inadequate to a 75 Kg weight, determines a significant rise of the pulse up to 110 pulsation/min.

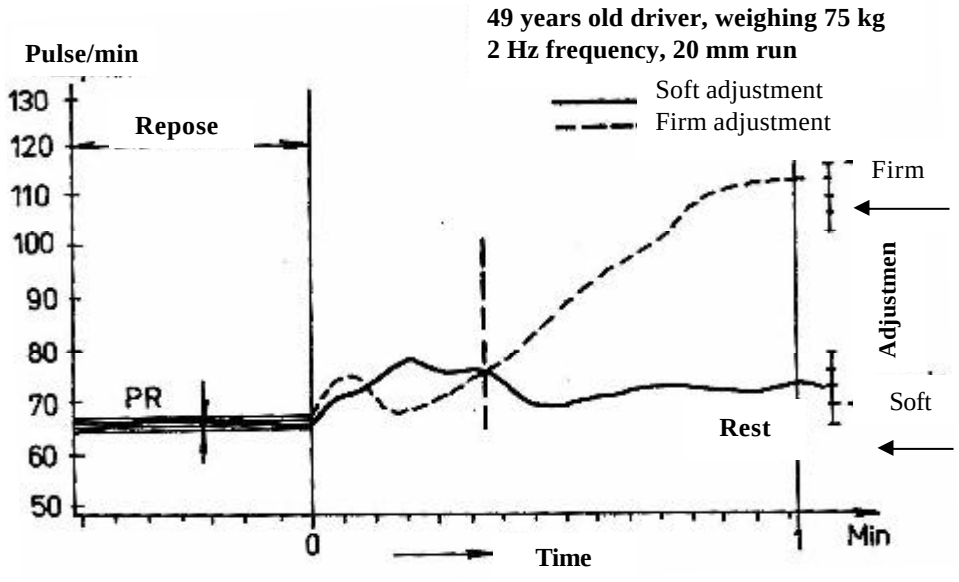


Figure no. 4
Suspension adjustment according to driver's weight

In figure no. 5, using a soft adjustment of the suspension, we can see the rise of the pulse in the case of a 49 years old driver, weighing 85 Kg, subject to different frequency vibrations ranged between 1 Hz to 7 Hz.

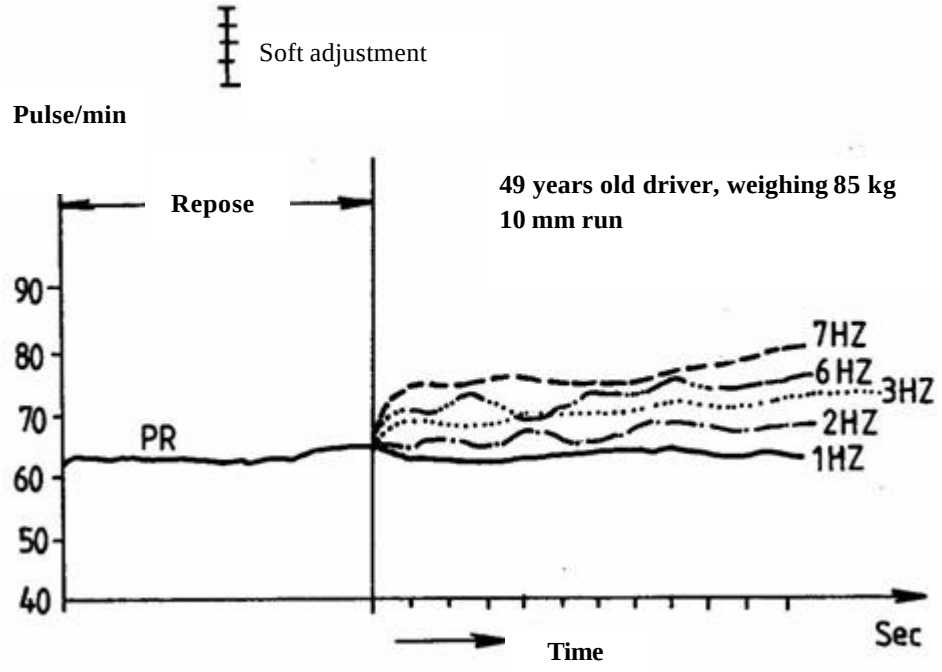


Figure no. 5
Pulse variation in the case of a soft adjustment of the suspension

The international research showed that an inadequate suspension determines a higher consumption of calories within the driver's body.

Also, the oxygen consumption, measured in l/min, may rise up to 1 l/min during work (test) in the case of non adjusted suspension, compared to 0.5 l/min consumption in the case of adjusted suspension (figure no. 6).

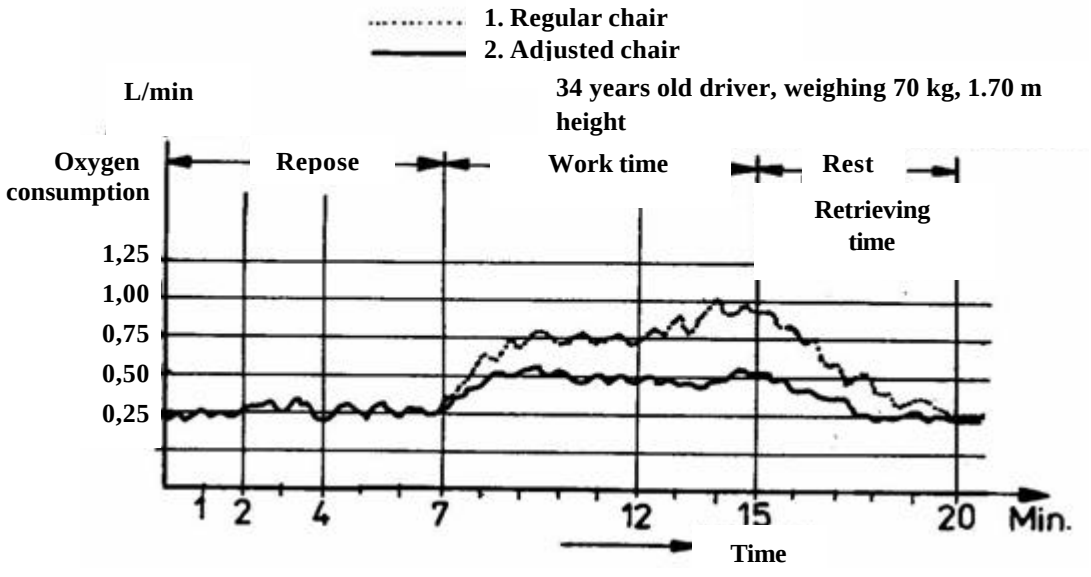


Figure no. 6
Oxygen consumption in the case of non adjusted suspension and in the case of adjusted suspension

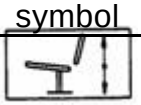
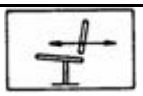
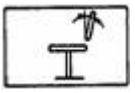
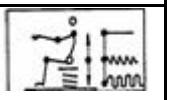
2. MEASURES AIMING TO ATTENUATE THE INFLUENCE OF VIBRATIONS AGAINST DRIVERS

Motor vehicles producers and designers are more and more interested in building ergonomic chairs able to offer proper conditions for drivers. They aim "to humanize" the working environment by designing the chair in a manner which does not jeopardize the driver's life in any circumstances. As well, designing the chair aims to reduce the driver's tiredness and to protect the human body's capacities to recover during rest time.

There are certain conditions that need to be fulfilled to attenuate the influence of vibrations against drivers:

a) The devices attached to driver's chair must offer the possibility to adjust the chair's suspension both vertically and horizontally depending on driver's weight and travel conditions. The back of the chair and the seat must also be adjustable, as it is shown in table no. 1.

Table no. 1

Specific adjustments of the chair						
Adjustment name		Moment of adjustment	Adjustment method	Adjustment type	Adjustment value	Adjustment symbol
Weight adjustment	Vertically	Rest	Hand or foot adjustment*	Continuous	± 60 mm (0 – 120)	
	Horizontally, longitudinal	Rest	Hand adjustment	Gradual	± 75 mm (0-150)	
Angular adjustment	Back inclination	Rest	Hand adjustment	Continuous or gradual	5-15°	
	Seat inclination	Rest	Hand adjustment	Continuous or gradual	5-12°	
Suspension adjustment	Depending on driver's weight	Rest	Hand or foot adjustment*	Continuous	60-1200 N	
	Depending on road type	During travel	Hand or foot adjustment*	Continuous or gradual	-	

*In the case of pneumatic or hydro-pneumatic suspensions

b) The shape and the dimensions of the chair are very important as it concerns the reduction of physiological stress that the driver is exposed to. Driving comfortably is much influenced by both the seat and the back of the chair, and therefore they need to closely reproduce the shapes of the human body. The concave shape of the seat and of the back of the chair may improve the comfort. The chair's shape must provide the allocation of pressure along isobaric curves as uniformly assigned on the seat and on the back of the chair as possible. The international researches have led to building a chair equipped with a pneumatic back, designed to improve the comfort in the lumbar region. The pneumatic lumbar back is specially designed so that it can be adapted to different anthropometric dimensions of drivers, to different weights and to individual shapes of the vertebral column. The pneumatic lumbar back of the chair allows the human body to naturally and comfortably move.

In figure no. 7 driver's positions A and B are wrong, because the back of the chair does not provide a uniform allocation of the pressure on inter-vertebral discs. Position C is the correct one, because the pneumatic lumbar back provides the disposal of the vertebral column along a naturally curve and also a favorable pressure distribution on inter-vertebral discs.

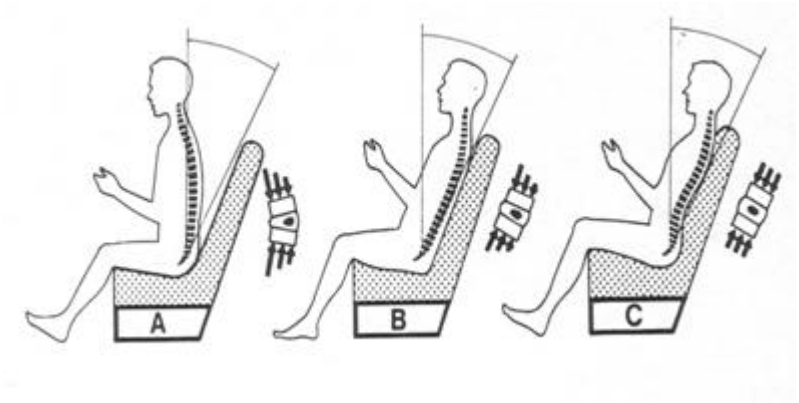


Figure no. 7
Pneumatic lumbar back of the chair

c) Endowing the chair with a pneumatic or hydro-pneumatic suspension determines the attenuation of the vibrations effects against human body up to 30%-40

d) The chair's own resonance frequency must be ranged between 1,5 Hz...3 Hz. It is to be avoided 4 Hz...8 Hz vibrations range, as the sensibility of the human body to vertical vibrations is the highest within that range.

Bibliografy

1. Constantin, Fl., Secara, E., "Posibilitati de atenuare a vibratiilor scaunului tractoarelor pe roti în vederea asigurarii securitatii tractoristului", Universitatea Tehnica a Moldovei, Conferinta Stiintifica Internationala "Tehnologii moderne, calitate, restructurare" TMCR 2003, Buletinul Stiintific vol. 3, pag. 53-56
2. Depuis, H., Steeger, D., "The Pneumatic Lumbar Region Support by Isringhauser", The Johannes-Gutenberg University, Mainz, RFG,
3. Dorling, E., "Arbeitsphysiologische Analyse eines"
4. *** "Effets des vibrations des basses fréquences sur l'homme", Extrait de l'edition INRS no. 598, France, 1987
5. *** "Human Body Vibration", Technical Review no. 1/1982, Brüel&Kjaer