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CORRELATION BETWEEN NOISE, VIBRATIONS AND HEALTH PEOPLE

Drugă C, Barbu D, Lache S [1]

[1] Universitatea „TRANSILVANIA" Braşov
Catedra de Mecanică Fină şi Mecatronică,
e-mail: druga@unitbv.ro

Abstract: *The activities industrial development during last decades, leaded to the increasing of the number and power of the noise and vibration sources, having as result a high noise and vibration pollution for many workplaces and extended areas. The scientific researches emphasized the fact that noise and vibration, exceeding certain intensity have negative consequences for the safety and operational characteristics of the installation and technical equipments situated in polluted areas, as well as for the safety and quality of the products.*

Key words: *noise and vibration, health people, hand arm vibration syndrome*

1. Introduction

The activities industrial development during last decades, leaded to the increasing of the number and power of the noise and vibration sources, having as result a high noise and vibration pollution for many workplaces and extended areas (fig.1).

The scientific researches emphasized the fact that noise and vibration, exceeding certain intensity have negative consequences for the safety and operational characteristics of the installation and technical equipments situated in polluted areas, as well as for the safety and quality of the products.

In the same time, clinical researches highlighted on statistical bases the fact that noise and vibration exceeding certain limits have negative medical effects by affecting the health and working capacity of the employees.

Mechanical vibration arises from a wide variety of processes and operations performed in industry, mining and construction, forestry and agriculture, and public utilities.

Fig.1 – ***Some noise and vibration sources***

Noise is typically defined as unwanted or undesirable sound, where sound is characterized by small air pressure fluctuations above and below atmospheric pressure.

The basic parameters of environmental noise that affects human subjective response are: 1- intensity or level, 2- frequency content, and 3- variation with time.

Sound intensity or level is determined by how greatly the sound pressure fluctuates above and below the atmospheric pressure and is expressed on a compressed scale in units of decibels (dB). Using this scale, the range of normally encountered sound can be expressed by values between 0 and 120 dB. On a relative basis, a 3-dB change in sound level generally represents a barely noticeable change outside the laboratory, whereas a 10-dB change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound. The frequency content of noise is related to the tone or pitch of the sound and is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called Hertz [Hz]).

The human ear can detect a wide range of frequencies from about 20 Hz to 17,000 Hz. However, because the sensitivity of human hearing varies with frequency, the *A-weighting* system is commonly used when measuring environmental noise to provide a single number descriptor that correlates with human subjective response.
Sound levels measured using this weighting system are called A-weighted sound levels and are expressed in dB notation as dBA. The *A-weighted* sound level is widely accepted by acousticians as a proper unit for describing environmental noise.

Figure 2 shows typical *A-weighted* sound levels for transit, highway, and other noise sources. As indicated in the figure, most commonly encountered outdoor noise sources generate noise levels within the range of 60 dBA to 90 dBA at 50 feet(1 feet= 30.48 cm).

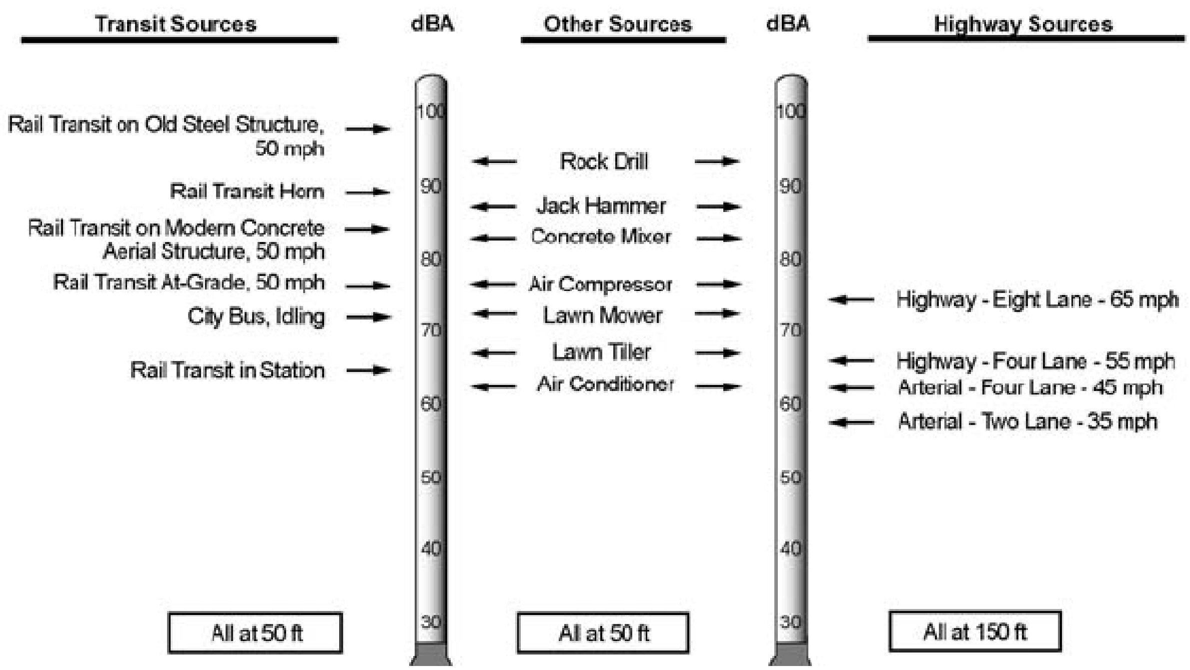

Fig.2 - *Typical A−Weighted Sound Levels (Source: Federal Transit Administration, 2006)*

Because environmental noise fluctuates from moment to moment, it is common practice to condense all of this information into a single number, called the *equivalent sound level (Leq)*. The *Leq* can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period, typically 1 hour or 24 hours. Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the day-*night sound level (Ldn)*.

The *Ldn* is the A-weighted Leq for a 24-hour period with an added 10-dB penalty imposed on noise that occurs during the nighttime hours (between 10:00 PM and 7:00 AM). Many surveys have shown that Ldn is well correlated with human annoyance; therefore, this descriptor is widely used for environmental noise impact assessment of transit systems and airports. Figure 3 provides examples of typical noise environments and criteria in terms of Ldn. While the extremes of Ldn are shown to range from 35 dBA in a wilderness environment to 85 dBA in noisy urban environments, Ldn is generally found to range between 55 dBA and 75 dBA in most communities. As shown in figure 3, this spans the range between an *ideal* residential environment and the threshold for an unacceptable residential environment according to criteria established by several federal agencies.

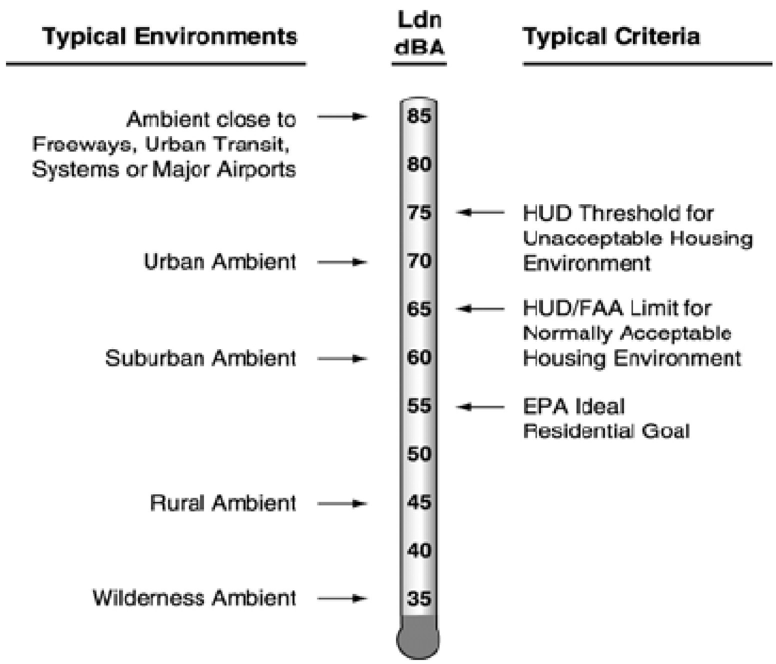

Fig.3 - *Examples of Typical Outdoor Noise Exposure*
(Source: Harris Miller Miller & Hanson Inc., 2006)

Vibration refers to oscillatory motions of solid bodies. A simple vibrating system is represented by a weight suspended on a spring and set into an up and down motion. The vibrating weight is displaced above and below an average position.

Vibration can be:

- ***whole-body vibration (WBV)*** - where the vibration is transmitted to the body as a whole by its supporting surface (i.e. seat or floor);
- ***segmental*** - where the vibration is transmitted to a specific segment of the body such as the hand/arm or foot/leg.

Vibration arises from various mechanical sources with which humans have physical contact. Vibration energy can be passed on to operators from vehicles on rough roads; vibrating tools; vibrating machinery; or vibrating work platforms and may give rise to adverse health effects. It can be transmitted through the feet and legs, the hands and arms but most commonly through the buttocks while seated in a vehicle.

The magnitude of the effect of vibration depends on the severity and length of exposures. The effect of vibration depends on the severity and length of exposures.

2. European legislation

Article 2 of the Directive 2002/44/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration), defines ***hand-arm vibration*** as "*the mechanical vibration that, when transmitted to the human hand-arm system, entails risks to the health and safety of workers, in particular vascular, bone or joint, neurological or muscular disorders*", and ***whole-body vibration*** as "*the mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine*".

According to the 3rd European Survey on Working Conditions, about 23.6% of all workers interviewed during the survey reported being exposed to mechanical vibration in the workplaces of the European Union. Of them, 10.3% were exposed all or almost of the time, 6.5% around ¾ or ½ of the time, and 6.8% around ¼ of the time.

In Europe, craft workers, machine operators, agricultural workers, work force involved in elementary occupations, and armed forces are the occupations with the greatest exposure to vibration from hand tools, machinery, and vehicles.

Exposure to harmful vibration at the workplace can induce several complaints and health disorders, mainly in the upper limbs and the lower back.

3. Standards for whole-body vibration

The Australian Standard *(AS 2670.1 - Evaluation of human exposure to whole-body vibration)* was published in 1990 and was a complete adoption of the now superseded International Standard (ISO 2631 - 1, 1985).

The Australian Standard gives exposure limits for three criteria:

- *Comfort* - concerned with the preservation of comfort ('reduced comfort boundary')
- *Fatigue* - relating to impaired working efficiency due to fatigue (fatigue-decreased proficiency boundary).
- *Health* - preservation of health and safety (exposure limit).

The exposure limit is set at approximately half the level considered to be the threshold of pain (or limit of voluntary tolerance) for healthy human subjects restrained to a vibrating seat. (Such limit levels have been explored for male human subjects in laboratory research.) The exposure limit is 2 times the fatigue-decreased proficiency limit and the reduced comfort boundary is 3.15 times below the fatigue-decreased proficiency boundary. The reduced comfort boundary is set at a level which does not take into account its subjective nature. For example, a luxury car occupant will expect a higher level of comfort than a bulldozer driver.

The Australian Standard provides vibration exposure limits for periods of 1 minute to 24 hours.

The International Standard (*ISO 2631.1 - Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration*) is quite different to the Australian Standard. It incorporates assessment methods for both steady state and shock type vibration. Steady state vibration is assessed using r.m.s. methods while shocks or jolts and jars are assessed using the *Vibration Dose Value- VDV* which is sensitive to high peaks. An alternative method to the VDV for shocks called the *running r.m.s* method is also recommended in the Standard.

The International Standard is generally more stringent than the Australian Standard and recommends much reduced exposure times for many vehicle operators.

4. Effects of noise and vibration on the human body

Prolonged exposure to *hand-transmitted vibration -HTV* from powered processes or tools is associated with an increased occurrence of symptoms and signs of disorders in the vascular, neurological and osteoarticular systems of the upper limbs.
The complex of these disorders is called *hand-arm vibration syndrome*. The *vascular component* of the HAV syndrome is represented by a secondary form of Raynaud's phenomenon known as vibration induced white finger (fig.4); the *neurological component* is characterised by a peripheral, diffusely distributed neuropathy with predominant sensory impairment; the *osteo-articular component* includes degenerative changes in the bones and joints of the upper extremities, mainly in the wrists and elbows. An increased risk for upper limb muscle and tendon disorders, as well as for nerve trunk entrapment syndromes, has also been reported in workers who use hand-held vibrating tools.

The vascular and oste-oarticular disorders caused by HTV are included in a European schedule of recognised occupational diseases. It is estimated that 1.7 to 5.8% of the workers in the European Countries, U.S. and Canada are exposed to potentially harmful HTV.

Neurological discorders: there is epidemiologic evidence for a greater occurrence of digital tingling and numbness, deterioration of finger tactile perception, and loss of manipulative dexterity in occupational groups using vibrating tools than in control groups not exposed to HTV. In epidemiologic surveys of vibration-exposed workers, the prevalence of peripheral sensorineural disorders was found to vary from a few percent to more than 80% [source: CEN TR 12349-1996].

Neuro-physiological studies have suggested that sensory disturbances in the hands of vibration-exposed workers are likely due to vibration-induced impairment to various skin mechanoreceptors (Meissner's corpuscles, Pacinian corpuscles, Merkel cell neurite complexes, Ruffini endings) and their afferent nerve fibres. Electron microscopic studies of human finger biopsy specimens suggest that hand transmitted vibration can provoke perineural fibrosis, demyelination, axonal degeneration and nerve fibre loss

Bone and joint disorders: Vibration-induced bone and joint disorders are a controversial matter. Various authors consider that disorders of bones and joints in the upper extremities of workers using hand-held vibrating tools are not specific in character and similar to those due to the ageing process and to heavy manual work. Early radiological investigations had revealed a high prevalence of bone vacuoles and cysts in the hands and wrists of vibration-exposed workers, but more recent studies have shown no significant increase with respect to control groups made up of manual workers. An increased risk for wrist osteo-arthrosis and elbow arthrosis and osteophytosis has been reported in coal miners, road construction workers and metal-working operators exposed to shocks and low frequency vibration (<50 Hz) of high magnitude from percussive tools (pick, riveting and chisel hammers, vibrating compressors).
An excess prevalence of Kienbock's disease (lunate malacia) and pseudo-arthrosis of the scaphoid bone in the wrist has also been reported by a few investigators. On the contrary, there is little evidence for 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 machines. It is thought that, in addition to vibration, joint overload due to heavy physical effort, awkward postures, and other biomechanical factors can account for the higher occurrence of skeletal injuries found in the upper limbs of users of percussive tools. A constitutional susceptibility might also play a role in the etio-pathogenesis of premature wrist and elbow osteo-arthrosis. At present, there are no

epidemiologic studies that may suggest, even tentatively, an exposure-response relation for bone and joint disorders in vibration-exposed workers.

Vascular disorders:vibration-induced white finger (VWF) is recognised as an occupational disease in many industrialised countries. Epidemiologic studies have pointed out that the prevalence of VWF is very wide, from 0-5% in workers using vibratory tools in geographical areas with a warm climate to 80-100% in the past among workers exposed to high vibration magnitudes in northern Countries.

Fig. 4- ***White-fringer syndrome***

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