OCCUPATIONAL AND ENVIRONMENTAL NOISE STANDARDS IN SWITZERLAND

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1. INTRODUCTION

From a strictly scientific position, noise is discordant sound resulting from non-periodic vibrations in air. From a public health and welfare point of view and in common usage, noise is defined as unwanted sound or as audible acoustic energy that adversely affects the physiological or psychological well-being of people (1).

Noise is typically characterized by its amplitude or sound pressure level in dB (loudness), frequency in Hz (pitch) and duration (time). Types of noise frequently differentiated in order to evaluate the effects of this nuisance on humans are ongoing noise (which can be steady-state, fluctuating or intermittent) and impulsive noise. Impulsive (or impulse) noise consists of one or more high intensity transient acoustical events such as a gunshot, each of which lasts less than 500 milliseconds (tens of microseconds for a reverberant industrial impact) and has a magnitude (change in sound pressure level) of at least 40 dB within that time (2). Some other factors like the predictability of noise bursts (fixed interval or random) or the degree of personal control over the source of noise are also important in the understanding of the effects of noise on man (3). Common noise sources include transportation vehicles, industrial and construction machinery, building equipment, live or recorded high-volume music, some household appliances, noise from neighbours, etc.

As well as crowding, heat or air pollution, noise is also considered as an environmental stressor and represents, in industrialized countries, the most deeply felt nuisance at home. Noise-induced hearing loss is still to-day one of the most frequent occupational hazards (4). In this paper, the main auditory and non-auditory effects of noise on man will be briefly discussed, and the occupational (aimed at protecting the hearing of the exposed workers) as well as the environmental noise standards (set to protect the population in living situations) presented.

2. EFFECTS OF NOISE ON MAN

Sounds or noises of high intensity can cause hearing impairment among the exposed persons. Two types of injury have been recognized: acoustic trauma and noise-induced hearing loss (NIHL). Short-duration very intense sounds (eg, explosion or blast,

impulse burst such as a gunshot, extremely high levels of steady noise), typically above 140 dB, may provoke immediate, severe and permanent hearing loss, termed "acoustic trauma". In such cases, virtually all the structures of the ear can be damaged, especially the organ of Corti (sensory structure of the cochlea) which may be torn apart. But generally, exposure to occupational noises above 85 dB(A), induces only progressive permanent hearing impairment (NIHL) over periods of months, years or even decades. Moderate exposure may initially cause temporary hearing loss or "TTS" (temporary threshold shift) and repeated exposure to such sounds will gradually provoke permanent NIHL or "PTS" (permanent threshold shift). In this type of injury, cochlear blood flow may be altered, and a few scattered hair cells will be damaged with each exposure. Furthermore, once there are a sufficient number of injured hair cells, the nerve fibers to that region also degenerate. Once destroyed the sensory cells (of the inner ear) are not replaced and the resulting sensorineural hearing loss is not reversible by any presently available medical or surgical treatment. The first audiometric sign of NIHL resulting from broadband noise is usually a loss of sensitivity in the higher frequencies with a characteristic "notch" at around 4000 Hz. If exposure continues, the resulting permanent threshold shifts (PTSs) will increase in magnitude and extend to the lower frequencies (2000, 1000 and even 500 Hz) which are essential to the understanding of speech "speech intelligibility" and also to higher frequencies (8000 Hz). Therefore, an important consequence of NIHL is difficulty in understanding speech, especially in noisy environments. NIHL may be accompanied by tinnitus (ie, ringing in the ears) which is often an additional debilitating condition. NIHL may interfere with daily life, especially in those activities where speech understanding is important, and lead to fatigue, anxiety and stress, also affecting indirectly friendships and family relations.

An important feature about NIHL is that it can be prevented except in rare cases of accidental exposure. The ISO Standard 1999: 1990 allows the evaluation of the mean hearing loss induced by noise (or noise and presbycusis) of a given population in function of Leq (8h) in dB(A) (starting at 75 dB(A)) and the exposure period in years. This cannot be done for a given person among the population in question, because of the great inter-individual variability concerning NIHL as well as presbycusis. Considering sounds that can damage hearing, it is the acoustic energy of the sound reaching the ear, not its source, that is important. There is now general agreement that sounds with levels less than 75 dB(A), even after long exposures, are unlikely to cause permanent hearing loss even at 4000 Hz, and that sounds with levels above 85 dB(A) with 8 hours per day exposure, will produce permanent hearing loss after many years. Therefore, occupational noise standards must be set and appropriate measures taken in order to protect the hearing of the exposed workers. The same protective measures (ie, the wearing of ear protectors) could be taken by any person who might be exposed to non-occupational noises that are likely to damage hearing. Numerous studies, especially in occupational settings, suggest that high intensity noise might be a risk

factor in the genesis of cardiovascular diseases and hypertension (5). However, it does not appear that there is a direct relation between the importance of the hearing losses and the incidence of the mentioned diseases. In Switzerland, work-place noise problems are dealt with by the Swiss National Accident Insurance Fund "SUVA".

Environmental noise (transportation noise, building equipment, etc.) or community noise usually does not attain levels which could impair hearing, but will provoke annoyance reactions in the exposed population, as well as sleep disturbance and interference with speech, modification of the task performance, psychological symptoms and also physiological (mainly vegetative) effects. These non-auditory effects of noise, the amplitude of which not only depends on the acoustic parameters but also on the emotional and informative content of the sound stimulus, have been discussed in previous papers (2). Effects of noise on children at school or at home could also be very deleterious and more research is needed to elucidate these effects (6). Usually, environmental noise immission standards are established from social surveys on annoyance and also from sleep disturbance studies. Generally, the percentage of very annoyed people (and the mean annoyance) in residential settings rises with increasing noise levels, but the self-reported (individual) annoyance is much less related to the noise level; this highlights the strong individual differences in response sensitivity to noise. In our country, these issues are treated by the Federal Office of Environment, Forests and Landscape "FOEFL".

3. OCCUPATIONAL NOISE STANDARDS

The SUVA considers that noise is dangerous for the hearing if the equivalent sound level Leq calculated over 40 hours per week (2000 h per year) is higher than 87 dB(A). In such cases, prophylactic measures against hearing impairment (NIHL) must be taken, namely technical measures for noise reduction, obligation to wear appropriate ear protectors and preventive medical examinations. For impulse noise events with peak levels of over 145 dB(A), the limit value is 125 dB(A) SEL (sound exposure level) per hour; this result derives from research conducted by the SUVA in collaboration with the Swiss Federal Institute of Technology in Zurich (7).

In Switzerland, 225'000 workers are exposed to noises which are dangerous for the hearing. The SUVA has six "audiomobiles" for audiometric control of hearing acuity, allowing the examination of 60'000 persons per year. In our country, preventive measures have reduced the percentage of workers exposed to dangerous occupational noises and presenting appreciable hearing impairment from 22% in 1980 to 15% in 1990.

4. ENVIRONMENTAL NOISE STANDARDS

Based on numerous annoyance and sleep disturbance surveys, mainly with regard to transportation noise (ground and air), immission standards Lr have been adopted in Switzerland, according to the general formula:

$$Lr = Leq + K$$

where Leq is the equivalent sound level in dB(A) over a given period (generally day from 06'00 to 22'00 and night from 22'00 to 06'00 o'clock) and K is a correction factor taking into account special situations and the type of noise. For ground traffic noise (road and train) and outdoor noise deriving from industries (and other occupational settings) day and night immission standards are given separately. As far as aircraft noise is concerned, only one set of values (day) have been issued and apply to regional airports and aviation fields. All these noise immission standards Lr (for other kind of noises too) and the way to calculate or measure them are published in the Noise abatement ordinance "OPB" (8) as required by the Federal law related to the protection of the environment "LPE" (9). Three sets of standards are generally indicated regarding noise immission values for each of four different noise sensitive zones (I and II, the most sensitive: rest or relaxation and residential zones; III and IV, the least sensitive: mixed zones including dwellings as well as some moderately noisy enterprises and zones with very noisy enterprises), namely: a) planning values (the lowest, are concerned for example with the delimitation of new building zones); b) maximal immission values (concern existing building zones); and c) "alarm values" (are the highest, and when exceeded, some action like to reduce the noise emissions must be undertaken, or if that is not possible sound insulation of the exposed dwellings must be carried out). The national airports (Geneva - Cointrin, Zürich - Kloten) are not yet included in the OPB and the Noise and Number Index NNI is still used to quantify the exposure to aircraft noise in the communities surrounding these airports. Studies are under way to examine the possibility of switching from NNI to Lr. All these problems related to environmental (or community) noise fall within the competence of the FOEFL in Bern.

5. CONCLUSION

Leq or Leq based indices (Lr) in dB(A) are widely used in Switzerland and in many other countries to establish occupational and environmental noise immission standards aimed to protect respectively the worker and the public from the misdeeds of noise. Although Leq or Lr show some weaknesses, they present the advantage of being relatively easy to handle and are of a wide applicability; their use will probably be maintained or even generalized, as long as no significantly better instruments characterizing human reaction to noise are found. Despite the various legislations and

progress realized in sound reduction or insulation technologies, noise remains a major problem in industrialized countries.

6. REFERENCES

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