Noise Exposure Levels from Extended Workshifts

Alberto Behar*

Faculty of Arts, Department of Psychology, Ryerson University, 350 Victoria Street, Toronto, Ontario M5B 2K3, Canada

Abstract: Noise exposure level is the magnitude used to assess the risk of occupational hearing loss. For that reason, its correct measurement and interpretation are of utmost importance. A common practice is to perform the measurement during a representative period of time, generally during an entire workshift, and to assume that the acoustic environment repeats for the rest of the weeks, months, and years. Unfortunately, this assumption is not always accurate. This paper focuses on workshifts of durations other than 8 hours. It presents a novel approach when dealing with seasonal workers and those active for only part of the year.

Keywords: Equivalentlevel, hearing loss, shift duration, exposure duration, seasonal workers.

INTRODUCTION

Workers regularly exposed to noise for extended periods of time are at risk of developing hearing loss of varying severity [1]. Some effects of the loss includepoor speech understanding, poor perception of everyday acoustic signals, and diminished appreciation of music [2]. With the exception of exposure to blast, high-level impulse noise, and extremely high levelsof steady noise, permanent impairment of hearing takes months toyears, or may evenrequiredecades of exposure. This is one of the reasons for the loss to be rarely detected at the beginning, until it is well advanced.

This phenomenon has been known since antiquity, but it was Bernardino Ramazzini (1633 –1714), the Father of Occupational Medicine, who first documented hearing loss as an effect from excessive noise exposure. In his book "De Morbis Artificum Diatriba" (Diseases of Workers) he included a chapter dedicated to this problem among bronze workers in Venice. He states thatall members of that profession were concentrated in a single borough of the city, where they worked and lived. Consequently, the place was extremely loud allday long. Workers typically lost their sense of hearing and became mostly deaf by the end of their lives [3].

Occupational hearing loss has been known through the ages under different names, such as the disease of blacksmiths, coppersmiths, railway workers, weavers, etc. In more modern days, it hasbecome known as the disease of boilersmiths, and even of workers riveting airplane wings, who are also exposed to very high noise levels.[1]

NOISE EXPOSURE LEVEL

The magnitude used to assess the risk of acquiring occupational noise exposure hearing loss is the noise exposure level, *Lex(T)*, expressed in dBA [4, 5]. This value combines the integral of the sound levelsduring the exposure with the duration of the exposure period. This paper aimsto clarify some of the terms involved, focusing mainly onnon-steady noise exposures that change during the workshift in duration or in magnitude.

Presently, the limit fora daily noise exposure is set almost universally at 85 dBA. As such, it is quoted in regulations and jurisdictions in most countries in Europe, America, as well as in Australia.[2]

The basic assumption regarding this limit is that a population exposed to *Lex(8)*=85 dBA, 8 hours a day for 5 days a week (40 hours/week) during the work life of 40 yearswill acquire an acceptable value of occupational noise induced hearing loss.[3] The ISO 1999 standard [9], which is the document used as a basis for those regulations, presents in statistical terms the relationship between noise exposures andthe "noise-induced permanent threshold shift" (NIPTS) in people of various ages. It provides proceduresfor estimating the loss due to noise exposure of a population free from auditory impairment otherthan that due to noise (with allowance for the effects of age).

*Address correspondence to this author at the Faculty of Arts, Department of Psychology, 350 Victoria Street, Toronto, Ontario M5B 2K3, Canada; Tel: +1-647-705-4520; E-mail: albehar31@gmail.com

[1]W. Sydenburg. Personal communication.
[2]There are still some exceptions, such as OSHA, the Province of Quebec and the Federal Government in Canada [6-8].
[3]Acceptable by a local jurisdiction, generally expressed in maximum los at different audiometric frequencies.

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Itcontains detailed tables of the lossesfrom exposures to different noise levels and durations. The losses (i.e., hearing threshold shifts) are calculated for differentaudiometric frequencies. The standardalso containsformulas tocalculate the values contained in the tables.[4]

Several assumptions are used for those calculations. The basic one is that the losses are the result of daily noise exposures, repeated during the 40 years ofthe working life. This impliesthat every day, the hearing organ has 16 hours to rest and heal any damage resulting from the daily 8 hours of work-related exposureto noise. Another assumption is that during that exposure period, there have been noextremely high noise levels. In other words, it is assumedthat there is linearitybetween noise levels and hearing loss. This assumption is onlyvalid below a certain noise level limit.[5]

Another basis for the ISO Standard is the equal energy principle. It assumes that equal energy penetrating the ear causes equal hearing damage. Consequently, the effect of extending the sound exposure duration by two is equivalent to increasing the sound levelby 3 dB.

This statement is translated mathematically as:

$$Lex(T) = Leq(t) + 10log\ t/T, dBA \quad (1)$$

Where:

Lex(T) = is the noise exposure level for the nominal duration of the work shift *T*,in dBA

Leq(t) = is the noise exposure level during a duration of *t* hours, in dBA

T = is the duration of the nominal workday or shift, in hours, and

t = is the actual duration of the exposure, in hours.

Most jurisdictions have adopted 8hours as the nominal duration *T*, so the equation (1) is often seen as:

$$Lex(8) = Leq(t) + 10log\ t/8 \quad (2)$$

The formula (2) is used by jurisdictions when dealing with workshifts durations other than 8 hrs.

As an example, for a person working during 4 hours in an environment where the sound level is= 88 dBA, the noise exposure *Leq(t)* is *Leq(4)* = 88 dBA and the equivalent noise exposure for the workday becomes:

$$Lex(8) = 88 + 10log(4/8) = 85\ dBA$$

NOISE EXPOSURES OTHER THAN 8 HOURS

Workplace situations are highly variable with regard to their noise environments as well as in their durations. For example, there is the case characteristic of employments where noise levels are highly variable during the workday. This is a situation typically found among construction workers whose exposure varies largely because of the environment they are in and the tools they are using. In someinstances, they may be working close to noisy vehicles or machines, while in others noise levels may be comparably low.

This is also the case of maintenance workers, whose exposures are similarly highly variable during the workshift, changing in exposure duration and sound levels. This can be either because of workers switching on and off noisy machines or because they are moving from anoisy location (e.g., shop floor) to another that is not noisy at all (e.g., management office). For those cases, noise exposure measurement during only one day may not be representative and detailed work analyses and partial noise exposure measurements become necessary. Only by doing so one can arrive toa meaningful value of the *Lex*(8).

Differentare the situations where daily activities are performed during periods other than8 hrs./day. They can be classified in three groups. The first situationistheso called “extended workday” when the daily exposure regularly exceeds 8 hours. This caseis not at all unusual nowadays. Workers on extended workday schedules perform their duties for fewer than five days a week. When the traditional thirty-six to forty-hour workweek is squeezed into three or four days, the number of days worked in a row is decreased and the number of consecutive non-working days is increased. So, in the long run (e.g., over a month), the total of hours worked is the same as if the daily number of hours is 8.

[4]Those tables and data are of statistical nature and shall not be used for predicting hearing losses of individuals.

[5]This is the reason for many jurisdictions to limit the allowable peak noise level (in most cases to 140 dBC).

In this case it is necessary to calculate the partial, weekly, daily, or hourly noise exposure and combine all exposure as per the following equation (3):

$$Leq,t,Tot = 10\ log\ [(1/T_{Tot})\ \Sigma T_i\ 10\text{^}L_{eq,i}/10] \quad (3)$$

Where:

Leq,t,Tot is the noise exposure of the entire period (generally 40 hrs.).

TTot is the total duration of the exposure in hours

Ti is the duration of the i^{th}exposure in hours, and

Leq,i is the value *Leq,t* from the i^{th}period

The situation of seasonal workers constitutes another case to be examined. Those are persons that are exposed to noise for a part of a calendar year. Examples are migrant workers, some construction workers and also musicians from orchestras. In these cases, *T* should be taken as the nominal workyear = 2000 hours. Accordingly, *t* is equal to the number of hours actually worked during the year.

One useful example is the case of the musicians from a ballet company [10]. By their contract, they were active (for rehearsals and performances) for approximately350 hours a year.

In this case the equation (1) becomes:

$$Lex(8) = Lex(t) + 10log*(350/2000) = Lex(t) - 7.7\ dBA.$$

In other words, the measured *Lex(t)* has to be reduced by 7.7 dBA to obtain the equivalent noise exposure level for the normalized 2000 hrs./year period.

There is yet another situation where the exposure is steady during the 24-hr. workday. An exampleis the case for some operators of towboats. Even if their workday only lasts 8 hours a day, in some situations, they have to stay overnight on the boat that is operating. That implies that they remain in an environment dominated by the engine noises that penetrate the entire vessel, including the sleeping quarters, for 24 hours a day. Fishermen in offshore and some deep-sea vessels may also be in this category. The calculation of the noise exposure in those cases is done likewise as in the previous situation.[6]

SUMMARY

Noise exposure level measurement and assessment are the main tools to ascertain the risk of hearing loss in a given workplace. Today, with the advancement of the technology, there are excellent measurement devices that are becoming more powerful and user friendly. However, the complexity and the very nature of workplace noises makes is difficult to define measurement parameters, such as how many workers to test, for how long and how often. This paper attempts to provide some guidance for health and safety professionals involved in the task of assessing risk in the workplace by defining the strategy to be used outside of the classical 8-hour workday.

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REFERENCES

[1] Lie A, *et al.* Occupational noise exposure and hearing: a systematic review. Arch Environ Occup Health 2016; 89(3): 351-372. Availablefrom: https://link.springer.com/content/pdf/10.1007/s00420-015-1083-5.pdf DOI 10.1007/s00420-015-1083-5.

[2] Wikipedia. Hearing loss. https://en.wikipedia.org/wiki/Hearing_loss(accessed May 3, 2021).

[3] Werner AF, *et al.* El ruido y la audición. Buenos Aires, Argentina: AD-HOC 1990; pp. 17-18.

[4] Canadian Standard Association (CSA). Measurement of Noise Exposure (Standard No. CSA Z107.56-13). Ottawa, Canada: CSA; 2013.

[5] International Organization for Standardization (ISO). Acoustics—determination of occupational noise exposure—engineering method (Standard No. ISO 9612:2009). Geneva, Switzerland: ISO; 2009.

[6] Canadian Centre for Occupational Safety and Health (CCOHS). Noise - Occupational Exposure Limits in Canada. CCOHS; 2021 [cited 2021 May15]: Available from: https://www.ccohs.ca/oshanswers/phys_agents/exposure_can.html

[7] Occupational Safety and Health Administratio (OSHA). Occupational noise exposure (Standard No. OSHA 1910.95). Washington, DC, USA: OSHA; 2008.

[6]As a matter of prevention and for workers safety it is strongly recommended that periodic audiometric tests be performed to detect early hearing losses.

[8] Safe Work Australia. Noise. https://www.safeworkaustralia.gov.au/noise#too-much-noise-a-definition. 2020.TRALIA2008/ (accessed May 15, 2021).

[9] International Organization for Standardization (ISO). Acoustics - Estimation of Noise-Induced Hearing Loss (Standard No. ISO 1999:2013). Geneva, Switzerland: ISO; 2013.

[10] Qian CL, Behar A, Wong W. Noise exposure of musicians of a ballet orchestra. Noise and Health 2011; 13(50): 59. https://doi.org/10.4103/1463-1741.74000

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