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Discover the standards for “Safe Listening”, past, present and future

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Masahito Kawamori
Lidia Best
Mark Laureyns

Introduction

The “**Make Listening Safe workgroup**” is an initiative of The World Health Organization in the framework of the World Hearing Forum and is committed to **create a world where nobody’s hearing is put in danger due to unsafe listening**.

In this article we focus on **standards for safe listening** in the **industry**, for **personal music players** and for **personal amplifiers**. For each of these three focus areas the World Health Organisation estimates the population at risk:

- Worldwide, 16% of the disabling hearing loss in adults is attributed to **occupational noise**.
- Worldwide 1.1 billion teenagers and young adults are at risk of hearing loss due to the unsafe use of **personal audio devices** and exposure to damaging levels of sound at noisy entertainment venues.
- Worldwide there are 466 million **persons with disabling hearing loss** (6.1% of the world's population).

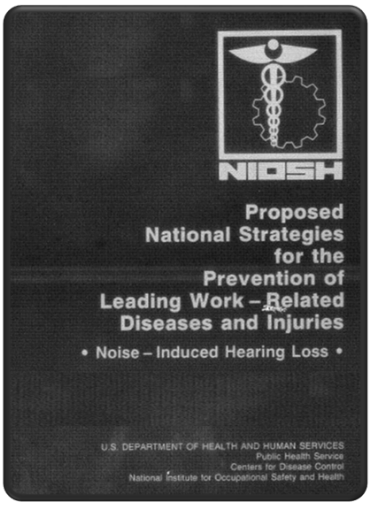
Noise exposure in the industry

The **first known regulation on safe listening**, dates back as far as **the 6th century BC**, when the Greek colony of Sybaris, now Southern Italy, decreed that tinsmiths and potters had to live outside the city because of the noise they made. **The first record on hearing loss caused by industry noise, dates back to 1830** and was made by Fostbroke in 1830, when he discussed the hearing loss noted among blacksmiths. Gloris states that **as late as 1935, audiometric studies on hearing loss due to noise were practically non-existent**.

In **1950 Kryter publishes a monograph "The Effects of Noise on Man", with a specific chapter on "Deafening effects of Noise"** in which he concludes that "continued repeated exposures of extended periods (years) to intense noise from machinery, may result in partial but permanent deafness. The maximum safe intensity at which no deafening effect will occur is probably in the neighborhood of **85 dB above 0,0002 dyne/cm² for critical bands of noise**.

In **1957** in Noise Control a pamphlet "**Guide for Conservation of Hearing in Noise**" is published, this document was developed by the Subcommittee on noise in industry, the committee on conservation of hearing and the American Academy of Ophthalmology and Otolaryngology. In this document, the **Duration and Distribution of Exposure During Workday and Work-Life is mentioned as a key aspect of evaluating the impact of noise on hearing**.

In **1971, the first ISO standard ISO 1999 "Acoustics — Assessment of occupational noise exposure for hearing conservation purposes**" is published. This standard has been reviewed many times and the latest version was reviewed in 2018 and maintained as ISO 1999-2013 "Acoustics — Estimation of noise-induced hearing loss". **Noise exposure level over time is the main criterium** used in this standard and the studies used as reference in the standard have evaluated the impact of exposure level of time on the pure tone audiogram of the participants. This standard takes dB A weighted sound pressure for a nominal 8 h working day as the reference. It is clear from this standard that **the risk of noise induced hearing loss significantly increases from an exposure of 85 dBA Lex8h/day and higher**.



In **1972, the first NIOSH (National Institute for Occupational Safety and Health) guidelines were published**. In the NIOSH guidelines, the concept of daily dose is introduced and a table for **"Combinations of noise exposure levels and durations that no worker exposure shall equal or exceed" is displayed, exposure level 85dBA – 8 hours** // 88 dBA – 4 hours // 91 dBA – 2 hours etc … is presented. This concept is based on the **energy equivalence principle**, when you double the energy, you need to reduce the exposure time by half.

In **2003**, the European Commission publishes the **EU Noise at Work Regulations** (Directive 2003/10/EC), which sets 3 action levels:

- lower exposure action values - **at 80 dB(A) LEX,8h the employer shall make individual hearing protectors available to workers**
- upper exposure action values - **at 85 dB(A) LEX,8h individual hearing protectors shall be used** - the individual hearing protectors shall be so selected as to eliminate the risk to hearing or to reduce the risk to a minimum.
- exposure limit values - **at 87 dB(A) LEX,8h under no circumstances shall the exposure of the worker exceed the exposure limit values**

Safe Listening with personal audio systems

In **2010** the International Technical Commission (ITC) published the first **standard IEC 62368-1 on Audio/video, information and communication technology equipment Part 1: Safety requirements**. In this standard the focus is on the output level of the personal music player, for an output that stays under or equal to 85 dBA, is considered safe. The LAeq,T **acoustic output shall be lower or equal to the relevant RS2 sound output value of 100 dBA.**

Unfortunately, the use of a max output level, has had the unfortunate effect, that more and more compression was used for recorded music files, and although the max output value of 100 dBA (LAeq,T) was not acceded when the personal music player was tested, the exposure level, could easily exceed 85 dBA or more, **which could result in unsafe listening**.

In the **new ITU and WHO standard H.870 "Guidelines for safe listening devices/systems"**, which was published in August **2018**, focus was on evaluating weekly sound-dose exposure, which was based on the EN 50332-3 standard "Sound system equipment: headphones and earphones associated with personal music players - maximum sound pressure level measurement methodology - Part 3: measurement method for sound dose management.

The weekly sound dose should be limited to the equivalent of 80 dBA for 40 hours/week. For the **higher safety level** (for children and/or sensitive users), the weekly sound dose should be limited to the **equivalent of 75 dBA for 40 hours/week**, see table 1 and 2.

dB(A) SPL	Weekly (1,6 Pa²h)
107	4.5 minutes
104	9.5 minutes
101	18,8 minutes
98	37,5 minutes
95	75 minutes
92	2,5 hours
89	5 hours
86	10 hours
83	20 hours
80	40 hours

Tabel 1 - ITU-WHO Weekly safe listening time - energy equivalence principle - standard safety level

dB(A) SPL	Weekly (0,51 Pa²h)
101	6 minutes
98	12 minutes
95	24 minutes
92	48 minutes
89	1 hours 36 minutes
86	3 hours 15 minutes
83	6 hours 24 minutes
80	12 hours 20 minutes
77	25hours
75	40 hours

Tabel 2 - ITU-WHO Weekly safe listening time - energy equivalence principle - higher safety level

ITU and WHO recommend that Personal Audio Systems be equipped with a monitoring function that sets the above exposure as a one-week sound allowance. It is recommended that the display method be designed in an easy-to-understand manner. The device should be able to provide the user with a **suitable method for limiting volume**. This refers to a feature where **a message will be given before or when the user reaches 100% of their weekly sound allowance**. The user will have the option to "continue listening" if they do not wish the device volume to reduce. **If the message is not acknowledged, a default setting will reduce the volume output to below the predetermined level** (based on the mode selected, i.e. 80 dBA or 75 dBA).

Since October 2019, you can find this feature, the weekly dose of sound exposure, in the health app on iPhone. We hope that many smartphone and headphone manufacturers will follow soon.

In **2018 IEC 62368-1** was reviewed and the concept of **weekly sound dose should be limited to the equivalent of 80 dBA for 40 hours/week as a standard safety level** was also added to this standard on Audio/video, information and communication technology equipment Part 1: Safety requirements.

Safe Listening with Personal Amplifiers

In **2015** the joined associations EFHOH (European Federation of Hard of Hearing People) and AEA (European Association of Hearing Aid Professionals) published "**Paper on the potential risk of using "Personal Sound Amplification Products" PSAPs"** in which have analyzed 27 personal amplifier, there were in 2014 commercially available in Europe. All devices had a maximum output level of more than 120 dBSPL, 23 had an output level that exceeded 125 dBSPL and 8 exceeded 130 dBSPL. None of the products had a limiter of the maximum power. Furthermore, for the end-user it is very hard to see the difference between "hearing aids" (produced

with a medical purpose) and “personal amplifiers” which can provide very high and dangerous sound levels. Both EFHOH and AEA called on all relevant stakeholders to ensure that PSAPs are not used when they exceed unsafe sound levels.

This alarming report initiated the ITU standard on personal amplifiers.

In **2017** the Consumer Technology Association, published the **ANSI/CTA standard 2051 on “Personal Sound Amplification Performance Criteria”**. The safety aspects in this standard state that “**The maximum OSPL90 output level shall not exceed 120 dB SPL measured in a 2cc coupler**”. This standard exceeds the safety level set by IEC 62368-1 (The LAeq,T acoustic output shall be lower or equal to the sound output value of 100 dBA) with more than 15 dB if we correct 5 dB for the conversion dBSPL to dBA.

In **2019** ITU published ITU-T H.871, which can be considered a companion standard to H.870, which describes **safety requirements for personal sound amplifiers (PSA)**, including both personal sound amplification products (PSAP) and personal sound amplification apps (PSAA). Personal sound amplifiers are non-medical devices which amplify sounds picked up by a microphone. This device is intended for people with normal hearing and can: have a design physically comparable to a hearing aid, in which case it is called personal sound amplification product (PSAP) or simply be an application on any smartphone or other device, in which case it is called a personal sound amplification application (PSAA). Currently there is no other international standard for PSAs. Thus, this standard is needed to ensure that these devices, which are freely available in the market to anyone, are safe for users and do not further damage users' hearing.

For PSA’s with the capacity to measure weekly dose it is required that **weekly maximum sound dose needs to be less than 80 dBA for 40 hours**. For example, at 89 dBA, the exposure time shall be limited to 5 hours/week. For other exposure levels, a linear intrapolation and extrapolation applies. Measurements taken of the dynamic range of sound should be accounted for

and the reasonably foreseeable use of the products. [ITU-T H.870].

When PSA's do not have the capacity to measure weekly sound dose, **the maximum output of the device needs to be permanently limited to 95 dBA**; a user then is unlikely to use the device at a level higher than 80 dBA since the dynamic range of speech has a crest factor of 12 to 17 dB.

PSA's need to provide adequate warnings in advertisements, user guides and packaging detailing the risks of further damaging the user's hearing as a result of using the device and provide information to users showing how to avoid these risks.

Conclusions:

Since the 6th century BC, regulations for safe listening have been issued. In 1971, the first standard was issued, stating that exposure to sound levels of 85dBA and higher should be avoided to reduce the risk of noise induced hearing loss. In the current standards, the availability of hearing protection at work, for personal music players and personal amplifiers the exposure should be less than 80 dBA for 40 hours. Although only setting a maximum output level is not advisable, since this can result in higher compression in the source music file or in the amplification, for Personal Sound Amplifiers that don't have the capacity to measure weekly dose needs to be permanently limited to 95 dBA.

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