"real world" noise exposure beneath hearing protectors : a scattered international practise

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Abstract

Assessment of occupational noise exposure "beneath" Hearing Protection Devices (HPD) is a topical subject. Standardized methods allow us to calculate the exposure by using the HPD attenuation. HPD attenuation values declared by manufacturers are much higher than "real-world" values. A number of "compensation" methods are proposed to curtail this discrepancy, but these methods and the rules they implement vary significantly from one country to another. The "derating" method reduces declared values by a specific amount, depending on the type of HPD. The "Subject Fit" method uses attenuation values measured on untrained subjects in the laboratory. "Statistical range enlargement" extends the statistical confidence of laboratory test results. Implementation of a compensation method should never represent a global solution combining reasons involving human behaviour (mainly improper wearing of HPD), product quality and differences between laboratory test and industrial workplace conditions. This type of "blind" approach could be considered to endorse insufficient worker training and could impede HPD development progress. "Statistical enlargement" would allow formulation of a short-term answer, which could be easily implemented on an international scale.

1 Noise exposure and hearing protectors

The recent European 2003/10/EC Noise Directive introduces the notion of "limit values", prompting consideration of HPD performance [1]. This new regulation, in force since 2006, has given a new impetus to the issue of HPD influence on noise exposure. Standard EN-ISO 4869-2 [2] includes methods for calculating exposure beneath HPD. The general idea is to deduct HPD attenuation from the ambiant noise exposure;this attenuation is evaluated by laboratory tests based on methodology given in EN 24869-1 [3].

Nowadays, it is commonly accepted that "real-world" attenuation values are lower than "laboratory measured" values. The difference is highly variable, depending on the type of HPD and the industrial workplace conditions. The difference is generally lower for earmuffs than for earplugs. However, an HPD "real-world" attenuation value may be until 20% of the the corresponding laboratory-measured value. There are many reasons for this discrepancy. Most studies dealing with this subject provide global results, which do not allow the problem to be parametrically analysed. Studies, which attempt to perform this analysis, extend our understanding of the problem [4]. It would be mainly importantt to separate the discrepancy parameters between those which deal with the workers' behaviour (how the HPD is worn), the product quality (manufacturing variability, ageing…) and the differences between laboratory test and industrial acoustic conditions [5].

2 "Compensation" methods

Various methods have been proposed to reduce the gap between real-world and laboratory-measured attenuation values. They differ widely, depending on their country of origin. The two main approaches involve "derating" laboratory measured values and modifying laboratory methodology.

"Derating" is a popular method: American authorities proposed a % derating value proportional to the declared attenuation and they now recommend in priority the "Subject Fit" method described below. German health and safety organisations propose an absolute derating value [6]. In general, the difference between declared and real-world attenuation is statistically lower for earmuffs than for earplugs. Derating values often differ in relation to the various types of HPD. In European countries, derating is still the most popular method, but HPD classification and derating values may differ from country to country. In Germany, current derating values areto date 9 dB for earplugs, 5 dB for earmuffs and 3 dB for custom moulded earplugs [6]. A more accurate HPD classification is planned. Switzerland proposes the same values for earmuffs and earplugs, with no special derate for custom moulded earplugs. The United Kingdom calls for 4 dB derating on all types of hearing protector based on workers being trained in wearing them. In Italy, a project is in progress for recommending derating values based on the above American rule: deduct 25% from the declared earmuff value, 50% from the standard earplug value and 30% from the custom-moulded earplug value.

Current recommendations applied in the USA are derived from observing that an improperly worn HPD is a major cause of device efficiency loss. To date, “conventional” laboratory tests have been mainly dedicated to qualifying HPDs themselves as products, excluding the influence of their usage by wearers. Test subjects are in fact trained by the testing technician to ensure proper wearing of the HPD and this is indeed checked prior to taking measurements. The HPD user instructions only are given to test subjects in the new recommendations and they are required to put on the HPD without assistance or checking. This is called the Subject-Fit (SF) method. Numerous studies have revealed that “SF attenuations” are closer to real-world values [7]. This method is now included in American standards [8] and as an ISO technical specification [9]. Some manufacturers print the SF value next to the “conventional” value, but this leads to “double labelling” of the HPD. The SF method is not only applied on a widespread basis in the USA: Australia and New Zealand, for example, have been using it for many years.

A “third approach” has been adopted in some countries. This is based on statistical results obtained through laboratory testing. Tests on a single HPD give several results, depending mainly on the number of subjects used (16 subjects are required in ISO 4969-1). Statistical parameters, such as mean and standard-deviation, can be derived from the test results. The declared value is then usually quoted after deducting one standard-deviation from the test-derived mean. The outcome of this process is that, statistically, 84% of HPDs tested should have an higher attenuation values than those declared. Subtracting two standard-deviations to the mean of the test measurements (instead of one) widens the statistical confidence of the laboratory-test results to 98%. This “statistical range enlargement” provides individual derating for each HPD based on its statistical performance in laboratory tests. This method is used in the Portuguese regulation, which applies the octave band method to calculate the noise level beneath an HPD [10]. This method is also used in Italy at the present time.

3 What are these methods dealing with ?

Most compensation methods have a “technical” aim, namely how to achieve an HPD attenuation value closer to the “real-world” value. This is an specialist issue of great interest, but the various steps taken in relation to it have unfortunately increased the distance from the real occupational health issue. Prevention and real worker protection concerns should sometimes be recalled [11]. Discussions have ranged from worker exposure to HPD attenuation measurement, dealing with real-world attenuation settings and how to adapt “golden standard” tests! We often find ourselves in the situation, in which we need to find a “ready-made recipe” for converting one column of data (laboratory test results) into another (assumed real-world attenuation).. Addressing the problem from a prevention standpoint, i.e. from the worker’s protection standpoint, we need to ask the questions, “What is the “driving force” behind the rule applied?”, “Does the rule allow appropriate protection of the worker in any situation?”, “To what extent is worker behaviour involved in the solution?” and, “Does the rule allow further progress in terms of prevention means?”.

A first approach from this standpoint would require us to differentiate between which method deals with worker behaviour and which is concerned with the HPD as a product.

As far as the workers behaviour is concerned, “proper use” of an HPD is obviously a prevailing cause in the discrepancy between declared and real-world HPD attenuation [12]. But this should be counteracted by worker training. The European regulation embraces the employer’s responsibility, *“The workers' obligations in the field of safety and health at work shall not affect the principle of* *the responsibility of the employer"*, ([13], article 5). Giving *"appropriate instructions to the workers"* is one of the general principles of prevention ([13], article 6). Necessity of worker training in wearing HPDs is recalled in the European "Noise Directive", *"The employer shall ensure that workers [...] receive information and training relating to risks resulting from exposure to noise concerning, in particular [...] the correct use of hearing protectors"* ([1], article 8). Similarly, choice of the most appropriate HPD and its proper fitting is a clear legal requirement, *"All personal protective equipment must: (a) be appropriate for the risks involved, [...], (b) correspond to existing conditions at the workplace; (c) take account of ergonomic requirements and the worker's state of health; (d) fit the wearer correctly after any necessary adjustment."* ([14], article 4). Requirements of American regulations are entirely congruent. From this perspective, the rule involving "adjustment" of the HPD performance should not compensate for improper wearing of HPDs. From a legal standpoint, proper wearing should be ensured by worker training, which is indeed compulsory. From a prevention standpoint, including the effect of improper wearing in reduced HPD performance could be considered to endorse insufficient training. Why shoud companies train workers, if their lack of training is taken into account in the HPD attenuation? In other respects, a risk would arise if such attenuation would be substituted for the value being measured on trained subjects: training workers would thus lead to their overprotection. Hearing overprotection impedes perception of required signals and communication and this is a cause of risk-increasing hazards.

A different viewpoint comprises considering the HPD purely as a product. In European regulations, HPD tests are conducted within the framework of "market requirements". Each product must comply with essential safety requirements. Laboratory tests must then permit qualification of the product itself, without considering the influence of "improper" use. As far as the "customer" (as opposed to the "user") is concerned, he should be aware of the product's objective qualities to compare their intrinsic performance characteristics. Manufacturer incentive for product quality progress can be prompted by leaving to the product what concerns only product design and manufacturing. Assessment studies of product quality variation could be developed to contribute to standardised requirement creation [15,16]. In other words, such advances could be encouraged only if products of the same type were differentiated. What would encourage a manufacturer to make a "better" product, if the rule of "adjusting" HPD performance were the same for all products of the same type?

This "prevention" and "legal" analysis fits in with the families of discrepancy parameters shown above and the difference made between "human factors" and "product performance" parameters. To be consistent with this classification, we should now consider the third parameter family, which deals with the laboratory test representativeness. This family falls within the effective scope of the difference between real-world and laboratory-measured HPD attenuations. Improvements in the laboratory method could be made in three ways. Firstly, keeping the current subjective method: this would allow us to consider the full human hearing mechanism and progress could be made by adapting it to the real-world conditions. Use of high-level noise sources and/or combining noise sources of in different frequency ranges for testing purposes represent methods, which have already been studied. Secondly, develop objective tests: these can sometimes give results close to HPD real-world attenuations [17]. For the multiple reasons given above, "real world" HPD use will provide separate results for every situation and this is why it will invariably be useful to develop new methods, which allow "on-site" personal tests [18].

Whilst necessary, performance of these actions requires time and extensive research and discussion is essential. But the topicality of the subject calls for a "short-term" answer. How can companies achieve a relevant evaluation of worker exposure behind an HPD?

4 A short-term proposal

A short-term proposal can be made by examining existing compensation methods in the light of the above analysis. A quick answer is needed in view of the regulation requirements. Implementation of the proposal would then have to be based on reference texts (e.g. standards), which have already been approved and are assumed not to change often. Proposal effectiveness would require possible international agreement not requiring excessively long discussion. The regulation being common to European Union countries , it would be a pity to remain in a situation, in which a worker would be "well protected" in one workplace and "bad protected" in another. The above analysis allows us to summarise the advantages and drawbacks of the various compensation methods.

"Derating" is simple and allows immediate implementation. But this method does not differentiate clearly between human and product factors and it does not take into account product quality dispersion. Global derating factors do not permit differentiation between various HPDs of the same type and they induce a risk of overprotection with "good", properly used HPDs. Furthermore, they could impede product development progress. Implementation of this method would require an international agreement on HPD-type classification and derating values.

The "Subject-Fit" method allows us to differentiate between HPDs of the same type. It does not require a harmonised HPD classification and derating in different countries. The main risk is that it could "endorse" lack f worker training. Furthermore, it does not take into account product quality dispersion. In the short term, this method would require official European approval of the corresponding standard.

"Statistical enlargement" allows us to differentiate between HPDs of the same type. This method is more suitable for product qualification and can possibly be used immediately. It does not require harmonised HPD classification and derating in different countries and it only requires agreement on the number of standard-deviations to be deducted. On the other hand, the method is complex for a non-specialist. Being dedicated to trained workers, it needs to be applied in conjunction with a strong incentive for worker training

This summary highlights the advantages of the "statistical enlargement" method, which does not contravene prevention principles (no endorsement of insufficient training) and it would not impede HPD developments (individual derating allowed). At the same time, its implementation could be immediate because it is based on results of standards currently approved in Europe.

This method would only need to decide of the statistical interval to take into account, i.e. the number of standard deviations to subtract to the attenuations mean. A number of 2 seems relevant : it is already used in a European regulation (Portugal), it covers a 98 % statistical range, and would not lead to excessive deratings. The main disadvantage of this method is that it is difficult to understand and to implement for a non-specialist. Its choice would then need to develop helping tools to make it easy to use.

The human factors should not be forgotten, and the use of this method should go with a strong incentive to workers training in HPD wearing. In the transient periods when the trainings wouldn't have yet be given to workers, a specific additional compensation could be used. This transient compensation should be of immediate and simple use. We know that the wearing has less effects on some HPD kinds than others : the derating method could then be relevant for this purpose.

5 Conclusion

The attenuation of Hearing Protection Devices must now be taken into account to evaluate the workers noise exposure. In a short term, an answer must be given to companies who ask how to deal with the problem of the difference between the "real world" HPD attenuation and the attenuation values declared at the moment. Enlarging the statistical range of the attenuation obtained in actual laboratory tests could be a quick answer, allowing to keep a difference between "bad" and "good" HPD whichever is their kind. It is urgent to think about an international agreement to ensure the same workers protection rules throughout the European Union. This rule would provide a short term solution, but it should go along with a medium term action aiming at working out the problem according to its three different faces which are the use of HPD by workers, the HPD products quality, and the HPD acoustical tests.

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