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Technical Bulletin

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Attenuation Characteristics with the Combined Use of 3M™ PELTOR™ Earmuffs and 3M™ Protective Eyewear

Description

Occupational noise exposure and noise induced hearing loss (NIHL) are significant workplace problems globally. Up to one third of the workforce in Europe is exposed to high levels of workplace noise at least 25% of the time.[1] Estimates for the United States report "about 25% of all workers have been exposed to hazardous noise, with 14% (22 million) exposed in the last year."[2] Hearing loss caused by hazardous noise is common, reportedly affecting an estimated 5% of the population worldwide.[3] In addition to the physical health effects, NIHL is also associated with stress and isolation resulting in mental, social, and socioeconomic impacts at both the individual and societal level.[3] There is no cure or pharmacological treatment for NIHL. To help prevent NIHL, reducing exposure to hazardous noise is imperative.

Hearing protection devices (HPDs) play an important role in a hearing conservation program by reducing an individual's noise exposure. HPDs must fit properly, provide adequate protection and be comfortable enough to use throughout the work shift. Many work activities require the combined use of hearing protection and other personal protective equipment (PPE). Earmuffs are commonly used together with protective eyewear introducing potential interference between the temples of the eyewear and seal of the earmuff cushions. This may result in reduced sound attenuation. Compatibility of earmuffs with protective eyewear is essential to ensure proper fit, form and function of the combined PPE.

Introduction

This study examines the change in attenuation when various styles of 3M™ Protective Eyewear (eyewear) are worn in combination with various 3M™ PELTOR™ Earmuffs (X Series and Optime™ models). 3M earmuff models included both headband (A) and helmet mounted (P3E) models. Attenuation was assessed by measuring the Personal Attenuation Rating (PAR) using the 3M™ E-A-Rfit™ Dual-Ear Validation System for study participants while wearing various PPE combinations.

Methodology

Thirty volunteers were recruited to undergo hearing protector fit testing to quantify the attenuation value, measured by PAR, while wearing 3M™ Protective Eyewear with 3M™ PELTOR™ Earmuffs. This study was conducted in the United States with each volunteer completing an informed consent, a screening tool to confirm study inclusion criteria were met, and five anthropometric measurements to assess head and face sizes to ensure the subject panel represented a wide range of sizes. The hearing protector fit-test session immediately followed, lasting approximately 60 minutes for each subject. Each volunteer was fit tested with 42 combinations of earmuffs with and without protective eyewear, using a randomized test order. Volunteers were verbally instructed on proper donning/doffing techniques for the PPE prior to the fit test.

The six earmuff models used in the study are representative of the broad 3M product line. This selection was based on their similarities in materials, construction and specifications (see Table 1). The P3E helmet-mounted earmuffs were tested on 3M™ SecureFit™ Safety Helmet X5000 Series. Additional lab testing, prior to this study, determined this safety helmet also represents the 3M™ SecureFit™ Hard Hat H-700 Series and 3M™ Safety Helmet G3000 Series. Using ANOVA with a Tukey multiple comparisons procedure showed, with 95% confidence, the PAR values from these helmets/hard hats were not statistically significantly different. Therefore, the 3M™ SecureFit™ Safety Helmet X5000 Series served as the representative head protection product for the study.

The selected protective eyewear models represent the majority of 3M™ Protective Eyewear. Additional testing prior to the study showed that six models represented the core protective eyewear product line (see Table 1). Using ANOVA with a Tukey multiple

[1] World Health Organization. World Report on Hearing. 2021.
[2] National Institute for Occupational Safety and Health (NIOSH). Overall Statistics - All U.S. Industries. Retrieved from the internet, November 2024: https://www.cdc.gov/niosh/noise/surveillance/overall.html
[3] Natarajan, N., Batts, S. and Stankovic, K.M. Noise-Induced Hearing Loss. Journal of Clinical Medicine, 2023, 12, 2347.

comparisons procedure showed, with 95% confidence, the PAR values from these six protective eyewear models did not show statistically significant differences from the others in the same grouping.

The 3M™ E-A-Rfit™ Dual-Ear Validation System, used in this study, is an objective method for individual fit testing of HPDs. The attenuation measurement for the 3M system is presented as a Personal Attenuation Rating (PAR_{84} or "PAR"), which is the attenuation achieved by an HPD user based on the selected hearing protector and personal fit. PAR_{84} represents the protection performance across the percentage of situations in which the desired degree of protection is achieved or exceeded, where a situation is defined as a unique combination of protector, wearer, and noise spectrum. For example, PAR_{84} indicates that individuals across different fits should be able to achieve or exceed the resulting PAR value 84% of the time.

Table 1 presents the tested products and the corresponding models they represent. This allows results from 42 tested combinations to be extended to 160 possible combinations of 3M products. Note: Availability of these PPE products may vary depending on region.

Table 1: PPE Test and Representative Models

Category	Test Model	Additional Models Represented by Test Model
Protective Eyewear	SF400	SF100, SF200, SF300, SF400X, SF600, Virtua
	Solus 2000	Virtua AP
	SF500	SF3700
	Solus 1000	Privo
	Solus CCS	Virtua CCS
	SF3700 with readers	N/A
Earmuffs	X1A	H510A, H510B, H510F, H6A, H6B, H6F, X2A
	X4A	X4B
	X5A	X5B
	H520P3E	H9P3E, X2P3E/P5E, X3P3E/P5E
	X4P3E	X4P5E
	X5P3E	X5P5E
Head Protection	X5000 Safety Helmet	SFH-700 Series Hard Hat, SFH-700T Series Hard Hat, G3000 Series Safety Helmet, G3501 Series Safety Helmet, X5500 Series Safety Helmet

Results

With the various combinations of earmuffs and protective eyewear, approximately 1300 PAR values were collected in total across all participants. Comparisons were made between PAR values of the earmuff alone condition and the corresponding earmuff plus eyewear condition. The overall results showed a decrease in PAR ranging from 2 dB to 9 dB, depending on the product combinations, design of the protective eyewear and individual fit. For ease of application, the loss of attenuation was categorized into three groups: a) PAR decrease of 3 dB or less; 2) PAR decrease 4 – 6 dB; 3) PAR decrease 7 – 9 dB. The PPE combinations and the resultant decrease in PAR are shown in Table 2 by these groups.

All earmuff/eyewear combinations revealed a decrease in PAR when compared to earmuff alone. No combinations revealed a decrease in PAR greater than 9 dB. Of the 160 possible combinations, 76, or 47.5% resulted in a loss of 3 dB or less; 60 combinations, or 37.5% resulted in a loss of 4 – 6 dB; and 24 combinations, or 15% resulted in a loss of 7 – 9 dB.

The amount of PAR change as a function of eyewear model indicates that most 3M™ SecureFit™ Protective Eyewear (SF100, SF200. SF300, SF400, SF400X, SF600) with 3M™ PELTOR™ earmuffs showed a smaller loss of attenuation (2-3 dB) than other 3M™ PELTOR™ Earmuff/3M™ Protective Eyewear combinations. This minimal loss may be explained by the special design of the 3M™ SecureFit™ Protective Eyewear products, featuring 3M Pressure Diffusion Temple Technology. The flexible, flat temple design minimizes interference with the earmuff cushion seal.

3M™ Solus Protective Eyewear CCS Series and 3M™ Virtua Protective Eyewear CCS Series experienced a loss of PAR of 4 – 6 dB. These eyewear products feature a cord control system (CCS) that helps to keep eyewear and earplugs attached, untangled, and ready to use. The earplug cord can also be used as a lanyard when not in use. The loss of PAR is likely greater than the SecureFit eyewear due to the differences in size, shape and flexibility of the temples.

The greatest change in PAR occurred with earmuff and eyewear combinations that included Solus CCS and Virtua CCS with most earmuff models, and the SF3700 with readers in combination with all earmuff models.

Table 2: Decrease in PAR for combinations of earmuffs worn together with protective eyewear compared to earmuff alone

3M™ Protective Eyewear	3M™ PELTOR™ Earmuffs (X Series and Optime)									
	X1A X2A	H510A H510B H510F	H6A H6B H6F	X4A X4B	X5A X5B	H520P3E[a]	H9P3E[a]	X2P3E[a] X2P5E[a] X3P3E[a] X3P5E[a]	X4P3E[a] X4P5E[a]	X5P3E[a] X5P5E[a]
SF100	•	•	•	•	•	•	•	•	•	•
SF200	•	•	•	•	•	•	•	•	•	•
SF300	•	•	•	•	•	•	•	•	•	•
SF400	•	•	•	•	•	•	•	•	•	•
SF400X	•	•	•	•	•	•	•	•	•	•
SF600	•	•	•	•	•	•	•	•	•	•
Virtua	•	•	•	•	•	•	•	•	•	•
Solus 2000	•	•	•	••	••	••	••	••	••	••
Virtua AP	•	•	•	••	••	••	••	••	••	••
SF500	••	••	••	••	••	••	••	••	••	••
SF3700	••	••	••	••	••	••	••	••	••	••
Solus 1000	••	••	••	••	••	••	••	••	••	••
Privo	••	••	••	••	••	••	••	••	••	••
Solus CCS	••	••	••	•••	•••	•••	•••	•••	•••	•••
Virtua CCS	••	••	••	•••	•••	•••	•••	•••	•••	•••
SF3700 w/readers[b]	•••	•••	•••	•••	•••	•••	•••	•••	•••	•••

Key[c]	
•	PAR loss of 3 dB or less
••	PAR loss of 4 – 6 dB
•••	PAR loss of 7 – 9 dB

[a] Tested on 3M™ SecureFit™ Safety Helmet X5000 Series. This helmet also represents 3M™ SecureFit™ Safety Helmet X5500 Series, 3M™ SecureFit™ Hard Hat H-700/H-700T Series and 3M™ Safety Helmet G3000/G3501 Series.

[b] 3M™ SecureFit™ Protective Eyewear 3700 Series was tested with standard reading glasses, intended to be representative of prescription eyewear. Results will likely change depending on the temple thickness and design of the prescription eyeglasses.

[c] The results in the table cannot be subtracted from labelled attenuation values such as Noise Reduction Rating (NRR) and Single Number Rating (SNR).

Discussion

Historically, research has shown that interference with the seal of the earmuff cushion results in a loss of attenuation.[4] [5] [6] [7] [8] Knowing how much attenuation loss is experienced when earmuffs are worn together with protective eyewear, can help users to select products that are compatible with each other, and to determine if the attenuation of combined products are adequately protecting the user. This study validates the importance of conducting personal hearing protector fit testing while using earmuffs in combination with protective eyewear. For example, when a wearer needs an option for over-the-glass eye protection, consider the 3M™ SecureFit™ Protective Eyewear 3700 Series and conduct the fit test while the user is wearing his/her prescription eyeglasses. Identifying the change in PAR while the user is wearing the chosen combination of gear, will help to determine if the user will be adequately protected in a given noise environment.

The study supports that when selecting products, there will be minimal loss in attenuation for combinations using thin, flexible temples, such as the 3M™ SecureFit™ models, however combining earmuffs with prescription eyeglasses showed a loss of 7-9 dB. The extra thickness of the temples breaking the acoustic seal of the earmuff cushion causes a bigger reduction in attenuation. These results will likely change depending on the temple thickness and design of the prescription eyeglasses. The PAR decrease is a metric that helps users select product combinations with an effort to minimize the attenuation loss. Additionally, a determination should be made regarding the overall effect of the attenuation loss and how it impacts the user's protected exposure. The practicality of changes in PAR should be assessed to identify users who may be at risk of under protection when using an earmuff combined with eyewear. The key is to determine if the user meets the targeted level of protected exposure while using the PPE combination. Table 2 provides guidance as to which combinations may have less impact on overall attenuation.

The PAR value can be directly subtracted from the A-weighted noise exposure of the worker. It is recommended to conduct the fit test while the user is wearing both earmuffs and eyewear and then subtract the PAR from the user's workplace noise exposure. If the PAR is sufficient, the result will be less than the targeted exposure limit. If the PAR is insufficient, then additional options should be tried to obtain more attenuation. If fit testing is not available, the values in Table 2 can be used to estimate the loss of attenuation.

Note that PAR is separate and distinct from hearing protector labeled attenuation values, such as Noise Reduction Rating (NRR) and Single Number Rating (SNR). The results of Table 2 do not apply to these single number labeled values, that is, the changes in Table 2 cannot be subtracted from labeled NRR, SNR or other labeled values to predict how the labeled value would change.

Wearing the proper protective eyewear for a given eye hazard is as important as the earmuff selection for attenuation purposes. While this study focussed on the change in attenuation, there was no specific assessment on the fit of the eyewear. In real-world applications, fit testing of both the hearing protection and eyewear are recommended.

Conclusions

This study shows that eyewear, worn under earmuffs, decreases the personal attenuation rating of the user, the range of decrease depends on the product style, features, and personal fit. It reveals the importance of conducting hearing protector fit testing, specifically when combinations of earmuffs and eyewear are required. During the fit test, ensure the adjacent PPE or apparel items are in place. Other benefits of fit testing, such as individual training, immediate feedback to the worker, identifying potential PPE compatibility issues, and providing accurate attenuation results, have also been identified in other studies.[9] [10] [11] The decrease in PAR values seen in this study, can help direct the health and safety professional when selecting product combinations to minimize earmuff attenuation loss. As well, these findings can help when estimating the practical impacts of attenuation loss for a given noise environment.

This compatibility testing has been conducted to show the viability of these combinations and the overall attenuation loss across 3M Protective Eyewear and 3M PELTOR Earmuffs. These data can be used as a reference point to aid in selection of 3M protective eyewear and 3M earmuff combinations. Selecting the right PPE for the hazard, task, and work environment is critical. Selecting PPE that works well together without compromising fit, comfort, or protection is essential.

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