

A Web App for Avoidance of Hazards Arising from Combinations of Personal Protective Equipment – Measurements on Reduction of Sound Attenuation of Ear Muffs by Goggle Sidepieces

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Summary

Many workplaces require different types of personal protective equipment (PPE) to be used simultaneously, since protection is required at the same time against exposure to multiple hazards and/or for several parts of the body. The items of PPE used must therefore be mutually compatible and must not impair each other in their protective function. Compatibility of devices, being members of different types of PPE, is often not (yet) covered satisfactorily by standards. Due to this deficit there is not any comprehensive and clearly arranged information available on the effects of risks or impairment of serviceability, when PPE are used simultaneously which are not fully compatible.

Relevant information is made accessible to all stakeholders concerned how to detect and avoid risks arising from combinations of PPE by a web app, which will be presented. It is available at: <http://www.dguv.de/webcode/e549573>

This compilation of the observations made may be useful during risk assessments. The issue is more difficult in the case of complex mutual influences, such as the combination of PPE against falls from a height with a respiratory protective device. In such cases, the employer must be able to rely on the expertise of the manufacturers and of the testing and certifying bodies.

A combination of equipment for eye/face protection and hearing protection may significantly reduce the sound attenuation properties of ear muffs, for example owing to thick goggle sidepieces. Measurements revealed that thick goggle sidepieces reduced the sound attenuation significantly. Results of some measurements conducted by the SUVA are presented.

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1. Introduction

Examples of CE-marked sets of PPE on the market have shown that compatibility of PPE items offered within those sets is at least questionable:

Several sets consisting of two or three items of PPE were found where eye protectors and respiratory protective equipment may affect each other in the area of the bridge. Leakage can be

expected to occur either for the eye protector or the respiratory protective equipment or for both of them. For other sets interaction is expected for eye protectors and ear muffs: The ear muffs' attenuation may be decreased significantly by interaction with the ear piece of the goggle's frame.

For a 'Helmet safety set', where an ear muff was attached to an industrial helmet, but the safety goggle required a gap between the cups of the ear muff and the helmet's brim of about 2 or 3 cm for its bulky ear pieces, the adjustment of the ear muff

and/or the helmet is affected; hence the attenuation of the ear muff can be decreased significantly if the ear muff is not able to cover the whole outer ear of a small-sized head or the helmet cannot found a safe fit on the user's head.

For a mesh type face protection together with a hearing protector and a 'quick lock ear muff holder' that holder affects the head band force of the ear muff; the ear muff's attenuation may be decreased or comfort will be derogated by transmuting the ear muff into a bench vice.

An example for more complex design of PPE combinations and more complex interactions is a PPE designed to prevent drowning attached to a PPE against falls from a height.

2. Methods

2.1 Analysis of occurring situations

2.1.1 PPE combined by the employer

The situation most familiar to persons concerned is the following:

Manufacturer A produces PPE A and manufacturer B produces PPE B. The two manufacturers place their PPE on the European market. This part of the process is covered by Directive 89/686/EEC [1], which specifies responsibilities of manufacturers, notified bodies and authorities (e.g. market surveillance).

Within the risk assessment the employer discovers, that more than one item of PPE is required and has to be used simultaneously by the worker for his protection. Among other obligations the employer has to consider PPE compatibility and PPE combinations within the selection of PPE and subsequent within the risk assessment. This part of the process is covered by Directive 89/656/EEC [2], which specifies '*minimum health and safety requirements for the use by workers of personal protective equipment at the workplace*'. In section II of this Directive the employers' obligations are described in detail.

Examples for situations in question are workplaces in corrosion protection, clean-up operations in combustion equipment, mine rescue brigades and building clean-up operations.

2.1.2 PPE combined by the manufacturer

The second situation to be considered is:

Manufacturer C places a set of PPE C and PPE D on the market to be used simultaneously by one user as intended by the manufacturer. Therefore he is responsible for the risk assessment with respect to the compatibility of PPE C and PPE D. This is covered by Directive 89/686/EEC [1].

The employer's risk assessment at the workplace results in the need of a set like that one offered by manufacturer C. The employer can assume that in principle PPE C and PPE D are compatible, because this has to be assured by the manufacturer placing the set of PPE C and PPE D on the market. But all other aspects of the risk assessment specific to the workplace in question have to be considered by the employer (s. 89/656/EEC [2]).

In all cases where PPE items have been integrally combined by the manufacturer or the manufacturer makes available PPE items for simultaneous use as specified in his user information this is covered by Council Directive 89/686/EEC [1]. This Directive requires that the products can be used in complete safety for their intended purpose. To realize this manufacturers and Notified Bodies have to assume their responsibilities.

2.2 Analysis of resources for assistance in combining PPE

Up to now only a few standards are available for testing of PPE combinations. The structure of technical committees responsible for standardization in Europe (CEN) is a vertical structure, i.e. each committee covers only one type of PPE: PPE against falls from a height, hearing protection, etc. Therefore compatibility of devices, being members of different types of PPE, is often not (yet) covered satisfactorily.

For employers selecting and combining items of PPE valuable information is available, because this is covered by Council Directive 89/656/EEC [2] and the bodies responsible have published guidelines to assist employers. Therefore the analysis carried out to summarize hazards by the use and by interactions of PPE was based on the following sources:

- Commission communication for the implementation of Council Directive 89/656/EEC [3]

- Rules and information of the German Social Accident Insurance DGUV for the use of PPE (www.dguv.de/fb-psa).

The Commission communication for the implementation of Council Directive 89/656/EEC [3] specifies that:

'These additional, not exhaustive specifications in the annex comprise the factors to be taken into account in selection and use of each of the main categories of PPE and the assessment of the risks to be covered by the equipment and the risks arising from the equipment and the risks arising from the use of the equipment.'

3. Hazards by combining PPE

Only known, relevant, existing hazards with regard to combinations of PPE are considered within this analysis [4]. The matrix shown in table I may be completed as soon as new PPE combinations occur on the market or in manufacturers' laboratories.

Where equipment for head protection is combined with equipment for eye and/or face protection, the individual items of PPE must be compatible. Industrial safety helmet accessories for protection of the eyes must satisfy additional requirements, such as those described in EN 166 governing eye protection.

									
Head protection			X	X	X				X
Eye and face protection			X	X	X				X
Hearing protection				X	X			X	
Respiratory protective equipment							X	X	X
Hand protection						X		X	
Foot protection							X		
Protective clothing								X	X
Equipment designed to prevent drowning									X
PPE against falls from a height									

Table I. PPE combinations, for which a decrease of protection level(s) may occur due to interactions, are indicated by the check mark symbol x.

When equipment for head protection or respiratory protective equipment or protective clothing is combined with that for hearing protection, the head band of ear muffs may prove incompatible. For a combination of equipment for head protection and hearing protection, ear muffs attached to the industrial helmet can be used

An abrasive blasting helmet as a combination of head, eye, face protection and respiratory protective equipment must not only supply breathing air, but must also offer protection to eyes, face, neck and shoulders.

When equipment for head protection is combined with PPE against falls from a height, a chin strap is required for the head protection.

When items of equipment for eye and face protection are worn simultaneously, they may be incompatible owing to their dimensions and/or the physique of the user. This may impair the protection against specific hazards.

A combination of equipment for eye/face protection and hearing protection may significantly reduce the sound attenuation properties of ear muffs, for example owing to thick goggle sidepieces. Measurements conducted by the IFA revealed that thick goggle sidepieces reduced the sound attenuation by up to 14 dB. In other words, the exposure to sound pressure was up to 25 times higher.

If ear plugs and ear muffs are worn simultaneously, the sound attenuation action of the combination may be reduced, owing to leakage caused by contact between the ear plugs and the ear muffs

A combination of a full-body protective suit and breathing/respiratory protection apparatus must not only supply the breathing air, but also protect the body of the wearer.

When it is necessary for a respiratory protective device and PPE against drowning to be worn at the same time and the respiratory protective device does not possess defined inherent buoyancy, a lifejacket with an inherent buoyancy of at least 275 N must be worn.

Studies conducted at the IFA into a number of case scenarios have shown that combinations of respiratory protective equipment and PPE against falls from a height are subject to certain serious

constraints in their protective action (www.dguv.de/webcode/dl161910 - in German).

Combination of several items of hand protection may result in a derogation of motor functions of the hand, e.g. at workplaces in nuclear fuel production.

For combinations of hand or foot protection or respiratory protective devices with protective clothing problems may occur because intersections of PPE or PPE items themselves show differing durability. Where for example a combination of chemical protective glove and chemical protective clothing lacks a fixed joint between the glove and the clothing, the skin is unprotected and may be harmed. For such cases, protective clothing with permanently attached protective gloves or with connecting cuffs (glove adapters) between the protective gloves and the chemical protective clothing is recommended.

When protective clothing and PPE against drowning are worn simultaneously and the protective clothing does not possess defined inherent buoyancy, a lifejacket with an inherent buoyancy of at least 275 N must be used.

A combination of PPE against drowning and PPE against falls from a height constitutes a Category III item of PPE. The PPE against falls from a height must not obstruct the automatic inflation of the lifejacket

When different items of PPE against falls from a height are combined, mutual incompatibility may result in serious accidents. This does not appear to constitute a major problem however, since manufacturers, notified bodies and users are aware of the danger.

Investigations have shown that for example the interaction of PPE against falls from a height with other PPE devices integrally combined (e.g. head protection, respiratory protective equipment) can be very complex and may require investigations of a large variety of fall scenarios.

4. Attenuation of hearing protectors when used with goggles

A combination of equipment for eye/face protection and hearing protection may significantly reduce the sound attenuation properties of ear muffs, for example owing to goggle sidepieces causing leakage between head and hearing protector.

4.1. Measurements

Measurements were performed in Suva's semi-anechoic room in Lucerne, using an acoustic test fixture GRAS 45CB according to ANSI S12.42, specially conceived for hearing protector measurements.



Figure 1. Acoustic Test Fixture GRAS 45CB

A 3-dimensional sound field was generated using 8 loudspeakers (EV S-200, EV Sx-80, RCF), placed around and above the artificial test fixture. These loudspeakers radiated non-correlated pink noise from independent noise sources, in order to avoid any local interference effects. As an example for eye protection, Suva's safety glasses Type 100 (figure 2) were used, but experiments with other safety glasses gave very similar results.



Figure 2. Safety glasses used for these tests

Figure 3 shows the typical spectral insertion loss from 63 Hz to 8 kHz with and without goggles. The leakage at the sidepieces of the goggles reduces the attenuation (insertion loss) at lower and at very high frequencies. The attenuation in the frequency range from 1000 Hz to 6000 Hz, where the human ear is most sensitive, remains almost unchanged.

The negative attenuation (amplification) observed at very low frequencies around 100 Hz may be due to a resonance effect.

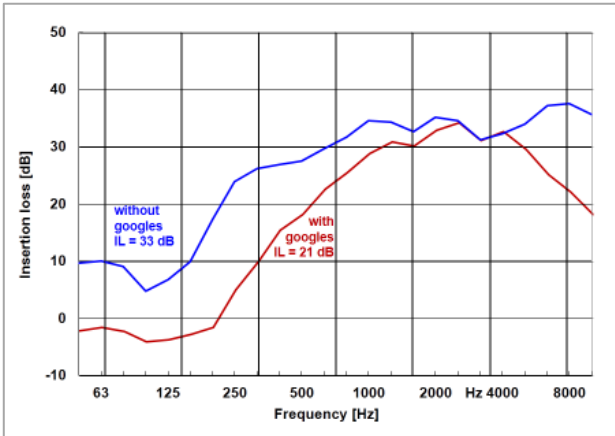


Figure 3. Typical insertion loss with/without goggles

The A-weighted insertion loss was calculated as the difference of A-weighted sound pressure levels with and without hearing protector for a flat spectrum (pink noise) without taking into account any standard deviation. Therefore the insertion loss reported here is higher than the SNR value of these hearing protectors.

Table II. shows the results for 4 different hearing protectors with and without simultaneous use of goggles.

The typical reduction of A-weighted insertion loss due to leakage is 10 to 12 dB.

Hearing protection device	IL without goggles dB(A)	IL with goggles dB(A)	Difference IL, dB
HPD A	31	19	-12
HPD B	33	22	-11
HPD C	33	21	-12
HPD D	26	16	-10

Table II. Insertion loss (IL) with and without goggles.

5. Conclusions

Relevant information is made accessible to all stakeholders concerned how to detect and avoid risks arising from combinations of PPE: <http://www.dguv.de/webcode/e549573>. Practitioners in German construction trade asked for information accessible and useful for mobile devices such as smartphones. Therefore we provided the information on combinations of PPE via a web application to be used on-site by mobile devices: <http://ppecombinations.ifa.dguv.de/>.

Measurements conducted by the SUVA revealed that thick goggle sidepieces reduced the sound attenuation significantly. The typical reduction of A-weighted insertion loss due to leakage is 10 to 12 dB.

References

[1] Council Directive 89/686/EEC of 21December 1989 on the approximation of the laws of the Member States relating to personal protective equipment, Official Journal L 399, 30/12/1989, p. 18

[2] Council Directive 89/656/EEC of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace, Official Journal L 393, 30/12/1989 P. 0018 – 0028

[3] Commission communication for the implementation of Council Directive 89/656/EEC of 30 November 1989, concerning the assessment of the safety aspects of personal protective equipment with a view to the choice and use thereof; Official Journal of the European Communities, NO C 328/3, 20.12.1989

[4] M. Liedtke: Interactions by different types of PPE worn simultaneously. 11th European Seminar on Personal Protective Equipment, 24.-26. January 2012, Saariselkä/Finland. Seminar Report "The situation in the PPE sector in light of the revision of the PPE Directive". p. 60-69. Publisher: Mäki, S.; Mäkinen, H. Finnish Institute of Occupational Health, Helsinki 2012. ISBN: 978-952-261-179-6