



**Finnish Institute of  
Occupational Health**

## **The situation in the PPE sector in light of the revision of the PPE Directive**

11TH EUROPEAN SEMINAR ON PERSONAL  
PROTECTIVE EQUIPMENT

24 – 26 January 2012, SANTA'S HOTEL TUNTURI,  
Saariselkä, Finland

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Occupational Health**

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## ABSTRACT

This seminar report contains papers presented at the 11th EUROPEAN SEMINAR ON PERSONAL PROTECTIVE EQUIPMENT (PPE), held in Saariselkä, Finland, on 24 - 26 January 2012. The primary aim of this seminar was to give up-to-date information regarding the PPE regulations, research results, selection and use of PPE and the state of the art level of PPE. The second aim of the seminar was to bring together European PPE experts dealing with legislation, standardization, selection and use of PPE, testing, certification, research, manufacturing, market surveillance and workplace inspection. Once again, this seminar provided a unique forum for disseminating findings in the PPE field, and gave speakers and participants the opportunity to exchange experiences and participate in debates. Workshops and panel discussions were arranged in order to generate productive discussion among participants. The four workshops were as follows:

- Main topics from the point of view of users
- Main topics from the point of view of authorities and market surveillance
- Main topics from the point of view of Notified Bodies, and
- Main topics from the point of view of manufacturers and dealers.

A summary of the workshops was sent to the European Commission as recommendations for further action.

The FIOH team leader, Helena Mäkinen, opened the seminar with an overview of previous PPE seminars: the first PPE Seminar was held at Levi, Kittilä, in 1992. The keynote speech addressed and focused on the state of the art of the revision of the PPE Directive, and was given by Petra Jackisch from BG BAU on behalf of Michael Thierbach from the EU Commission. Participants attended workshops on issues related to the situation of the revision of the PPE Directive. During the outdoor activity, the FIOH researchers carried out physiological measurements and some of the seminar participants took part in the test drill as test persons. On the final day, the researcher presented the results of these physiological measurements.

At this 2012 seminar, there were 60 registered participants from 12 different European countries. The attendees included authorities, research scientists, engineers, manufacturers, industrial safety professionals and consultants. During this seminar, there was a high level of auroral activity, and some of the participants got to personally experience the magic northern lights!

The seminar was organized by the Finnish Institute of Occupational Health (FIOH) Finland, BG BAU Germany, the Ministry of Social Affairs and Health Finland, and the European Safety Federation (ESF). Dr Helena Mäkinen from FIOH, Eero Korhonen from Safeco, Petra Jackisch from BG BAU and Senior Officer Pirje Lankinen from the Ministry of Social Affairs and Health functioned as seminar chairs.

On behalf of the organization committee, we would like to thank all of the speakers for their time and effort in their abstracts, presentations and full papers for this seminar report. We would like to thank BG BAU for their financial support and we also thank the PPE Seminar Organization Committee for their time and effort for their reviewing and their contributions to the seminar.

The next European Seminar on PPE will be held in 2014, in Finnish Lapland. We look forward to your participation next time!

Helsinki, 2 July 2012

Susanna Mäki  
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# 1 OPENING OF THE SEMINAR

Helena Mäkinen, Finnish Institute of Occupational Health (FIOH), Finland

I have the honour of welcoming you to this, the 11th European Seminar on Personal Protective Equipment. First, I would like to extend the regards of Harri Vainio, the Director General of FIOH. He wishes us a successful seminar.

In the past, we have been presented with a keynote speech from the Commission. Mr Dudás has moved on to other tasks from being responsible for the personal protective equipment (PPE) Directive in the Commission, and Mr. Thierbach, who has replaced him, will continue. Unfortunately, about two weeks ago we received a message from Mr. Fraser. For budgetary reasons, the Commission will not be able to send a speaker to this PPE seminar. The Commission, however, is awaiting our seminar report.

First, let's look back to 1993, when we held the first PPE seminar in Levi, Kittilä, which many of us attended. PPE Directives were applicable, but did not fully come into effect until 1 July 1995.

The aim of the seminar report was to handle problems and recommendations related to the implementation of PPE legislation. During this time, only a few European standards were in effect:

- TC 79 Respiratory protection, 20 EN standards, 18 drafts
- TC 84 Eye protection, 4 EN standards, 3 adopted by TC 85, 9 drafts, 7 in preparation
- TC 158 Head protection, 5 drafts, 10 in preparation
- TC 159 Hearing protection, 5 drafts, 1 in preparation
- TC 160 Protection against falls from a height, 12 EN standards, 3 drafts, 8 in preparation
- TC 161 Foot and leg protection, 4 EN standards, 6 in preparation
- TC 162 Protective clothing including hand and arm protection and lifejackets, 2 EN standards, 47 drafts, 22 in preparation.

And this is where we are now:

- The revision of the PPE Directive is almost ready, one amendment has been published
- The number of EN standards is enormous; about 350 EN, EN ISO or amendment standards and 7 CENELEC standards
- 141 technical sheets for recommendation for use sheets (RfUs), for horizontal coordination
- Several hundred technical sheets for recommendation for use sheets (RfUs), for vertical coordination, most on protective clothing
- About 120 Notified Bodies
- NN-certified products on the market
- EN standards are the basis for ISO standards, in some areas the work is now done in ISO only.

What has been done to achieve these?

- A multitude of EN ISO standards meetings have been arranged in different European countries and all over the world
- A great number of stakeholders have been attended to the EN ISO standards meetings
- Many, many kilometers have been travelled by plane, car, train, etc.
- Thousands of work hours have been used for standardization work
- The standardization work has created a massive carbon footprint.

What makes it worth the effort?

- The use of PPE has shown efficiency
- The example of the Finnish construction industry
- The example of the individual accident situation
- The well-being of workers has increased, for example, after a day at work, musicians and machinery workers' ears don't ring anymore
- The decrease in occupational diseases.

Our challenges:

- Standards are still missing for some types of Personal Protective Equipment (PPE)
- Problems in compatibility and ease of use of PPE
- New types of PPE are being brought onto the market, such as "intelligent PPE", which also cover other directives
- Accreditation of Notified Bodies, NFL regulation
- Better instructions to improve the correct usage of PPE
- All stakeholders should be provided with more information when the risk situations are more complicated
- The economic crisis.

We are going to discuss the situation in the PPE sector from different stakeholders' perspectives, such as end users, manufacturers, authorities and Notified Bodies. I hope that after this seminar we will take a notable step forward, making work and leisure activities safer in situations where PPE is needed.

I wish to thank you, the organizing committee; Petra Jackisch, Karl-Heinz Noetel, Pirje Lankinen, Martti Humpila, Eero Korhonen, Heli Koskinen, and especially Susanna Mäki, for all your hard work in organizing this European Seminar on PPE again. Thank you also BG BAU for your financial support for the seminar.

Finally, it's a great pleasure to welcome you all to the PPE seminar, we hope you will enjoy your stay in Saariselkä, and we wish you a successful seminar! Thank you.



## 2 REVISION OF THE PPE DIRECTIVE

Revision of the PPE Directive: State of play

Michael Thierbach, European Commission

Council Directive 89/686/EEC of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment (the PPE Directive) <sup>1)</sup> has been fully applicable since 1995. It permits the free movement of PPE in Europe while ensuring a high level of protection for users.

The PPE Directive applies to protective equipment that is worn or held by the individual in order to protect him or herself against one or more health and safety hazards. The Directive covers not only equipment for professional use at the workplace but also the growing field of equipment used for leisure or sports activities (PPE for consumer use). The Directive sets out the basic health and safety requirements to ensure that the equipment provides adequate protection against the risk concerned and establishes the conformity assessment procedure to be followed by manufacturers before the PPE is placed on the market. The procedure depends on the severity of the risk concerned. However, most categories of PPE are assessed by independent third-party bodies – Notified Bodies.

The success of the PPE Directive is recognised by all stakeholders. The Directive, (together with its "sister" Directive 89/656/EEC on the use of PPE at the workplace)<sup>1)</sup> has essentially created a European market for PPE and made a major contribution to the improvement of the safety of workers and consumers. The Directive is supported by a body of 275 harmonized standards providing requirements and test methods for each of the main categories of PPE. Under the impulsion of the PPE Directive, European standardization in this field has gained a major advance over all other regions of the world. While they remain voluntary, the harmonized standards are used by almost all PPE manufacturers and their application provides purchasers of PPE with objectively tested information on the level of protection afforded by the equipment, as well as precise instructions for use. Major 'success stories' for the PPE Directive include the European standards for sunglasses, cycling helmets and high visibility clothing.

Nevertheless, there is also a broad consensus that some improvements are needed. These involve no major changes. However, in light of the experience of application of the Directive, certain adjustments to the scope are considered necessary, namely to the application of the conformity assessment procedures and to the basic safety and health requirements. This was why the Commission (DG ENTR) decided in 2008 to revise the PPE Directive. This was also why the PPE Directive was not included in the package of directives to be subject to a pure alignment with the New Legislative Framework (NLF) Decision. However the revision will include a complete alignment with the NLF.

The proposed changes include the following:

- Adjustments to the scope of the Directive in order to achieve greater clarity and legal certainty. Some inconsistencies will be removed. The equipment to be included will improve the protection of users against health and safety risks;
- Adjustment of the conformity assessment procedures with a more consistent list of products subject to the most stringent conformity assessment procedures. Consequently, this range of PPE will be homogeneous and the protection of health and safety against serious risks will be enhanced;
- Clarification of the documentary requirements to help the Member States to better carry out market surveillance. Manufacturers will have a better understanding of their responsibilities with respect to the technical file;
- Minor changes to the basic health and safety requirements will not affect the health and safety of users, since the elements to be deleted have proved to be impracticable.

Additionally, it is proposed to take the opportunity to change the nature of this legal act from a Directive to a Regulation. This will reduce the administrative burden for the Member States and the Commission relating to the implementation into national law and speed up the application of the revised act.

It is expected that the proposal will be adopted by the European Commission by the end of 2012.

## 2.1 References

1. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1989L0686:20031120:EN:PDF>.
2. Council Directive of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace (third individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work).

## 3 SITUATIONS IN THE PPE SECTOR: THE PERSPECTIVE OF THE MANUFACTURERS AND DEALERS.

Guido Van Duren, President, European Safety Federation (ESF), Brussels, Belgium

### 3.1 Introduction

In this paper, the current situation in the PPE sector seen from the point of view of the manufacturers and dealers is reviewed, and it covers the most important issues that manufacturers and/or dealers are dealing with in the market. It also relates to the revision of Directive 89/686 that is pending at the moment.

The needs in the PPE market related to these issues are also highlighted.

### 3.2 Situation in the PPE sector

#### 3.2.1 Harmonization

Manufacturers and dealers are being confronted more and more with dis-harmonization.

Market surveillance authorities do not always have a common understanding and may use different interpretations towards the enforcement of legislation. Moreover, in certain EU countries, there is also a lack of enforcement or a lack of market control.

However, effective market surveillance remains a key factor for ensuring safe PPE and fair competition.

This leads to serious problems that manufacturers and dealers are having to deal with and results in serious barriers to doing business in an efficient way. In addition, this is also punishing in some sense the bigger, serious and compliant actors in the field, since they all have to deal with these various interpretations, whilst on the other had the less serious and/or non-compliant actors seem to get away with deviating from the rules and will continue to do so.

Of course, this also leads to unfair competition, but we should all strive towards a single, uniform European market, where Member States are using one common harmonized approach with the aim to get rid of non-compliant actors.

In addition, at the level of Notified Bodies, there are also quite a lot of instances of uncommon approaches.

For example, some Notified Bodies already apply a validity date on the certifications they issue, whilst others don't. Some apply the Recommendations for Use strictly while others do not.

Hence, the way PPE is tested and/or certified is not always done in the same way, which of course leads to more confusion and more disharmony; but it also poses a serious risk to manufacturers and dealers, since results found between different Notified Bodies will differ, something which market surveillance authorities may not accept.

The same serious dis-harmonization – both at the level of Notified Bodies as well as surveillance authorities – can be experienced in the interpretation of withdrawn or revised standards.

Some will require the use of the latest up-to-date standards (with or without a transitional period), whilst others still allow the use of the old standards.

### 3.2.2 Market misinterpretations

Although improvements in the use of the PPE can be noted, as well as in the actual PPE quality submitted to the market, we still see the wrong PPE products being used too often.

For example, in the EU glove market, a study by Ansell revealed that > 70% of glove users were not using the most efficient PPE for the task and > 50% of the glove wearers didn't know exactly why they were using the gloves they were actually wearing.

This of course may lead to a higher risk and an increase in accidents.

Customers sometimes believe that compliance to an EN standard is good enough, but these only provide the presumption of conformity to the PPE Directive and are only ONE means in the risk assessment exercise.

It must be sufficiently understood that compliance to any standard, or claims made based under lab test conditions, do not necessarily reflect the reality in the field. Results from lab tests or compliance to a standard must be considered as advisory, but field trials are often even more important in the selection process of a PPE.

In addition, care and maintenance is often insufficiently understood, although this is also a very important factor to consider in the life cycle of a PPE. All too often we see PPE not being maintained properly, which again increases the risk of accidents in the field.

### 3.2.3 Economic crisis

The current economic crisis also has an effect on the PPE market.

Manufacturers and dealers will avoid unnecessary costs and burdens and may tend to look at any possibilities to reduce costs in their PPE products. Moreover, the research into more innovative products may be delayed or halted.

It is same thing for the user who will tend to select and use the cheapest possible PPE.

This of course may all have a negative impact on safety in the workplace and could give rise to possible accidents.

### 3.2.4 Complexity of regulations and standards

PPE products not only have to comply with the requirements of the Directive 89/686, but there are also many other regulations that could impact significantly on manufacturers and dealers and which complicate things in the market.

For example, as per REACH regulations, manufacturers and dealers will have to make sure their products also adhere to the requirements of this regulation; i.e. they will have to inform their customers as to the safe use of their PPE if the product includes what are termed Substances of Very High Concern (the list of such substances is revised and amended every six months), and they will have to make sure they do not use any restricted ingredients or ingredients that exceed the limitations as defined under REACH.

As an example, the Medical Device Directive now also allows dual use of certain specific PPE (i.e. protection of the patient at the same time the wearer), which forms an additional complication in the market. Such products will now have to respond to the requirements of the PPE as well as the Medical Device Directive. Both directives have two quite distinct requirements, which also means that two different certification routes will have to be followed and in some instances two different Notified Bodies may need to be used.

Some PPE that is used in food applications will also have to comply to the applicable Food Contact Regulations, which can be very specific and many differ between different EU countries; SMART or intelligent PPE may include some electronic components, which would mean that such equipment may also have to comply to the regulatory requirements applicable to electrical and electronic equipment.

Besides the regulatory requirements, there is also a huge number of EN or international standards that exist and against which PPE needs to be tested. Some EN standards related to certain specific PPE products are now in the process of being switched from EN to ISO standards, which will need to be closely followed up since these will again change the whole landscape for these products.

### 3.2.5 Reliable versus unreliable manufacturers and dealers

A big concern for reliable manufacturers and dealers, who are trying to follow the rules strictly, are the unreliable manufacturers on the market who create unfair competition.

These unreliable manufacturers will try to abuse the system in many different ways, such as making false overstated claims on their products, falsifying certificates or test reports, and so on. They also often certify products based on over specified prototypes whilst the production samples on the market are completely different and are significantly lower in quality.

It is these unreliable manufacturers and dealers that should be targeted by market control.

### 3.3 Situation with the PPE Directive

Since the birth of the PPE Directive and its implementation in the EU market, we have seen a positive impact and improvements in the market. The quality of the PPE used has been improved and has become safer, although we have not necessarily seen a major reduction in the amount of accidents on in the workplace.

Although the CE mark is still considered added-value (both here and in other parts of the world), the perception of the value of this mark is decreasing.

Hence, the current system needs some improvement, and the need to restrengthen the CE mark should be welcomed.

There are currently too many uncertainties and unclear situations related to the product categorization. For example, bulletproof, stab- or cut-resistant vests and gloves are currently Category II products, whilst simple disposable products that protect from chemical splashes are Category III products. This causes some disbelief and confusion in the market.

The revision of the PPE Directive is therefore very much welcomed, but various factors should be taken into account.

First of all, clear rules and interpretations are needed, such as those related to this categorization, but also towards the conformity assessment procedures, the instructions for use, the declarations of conformity, and so on.

Moreover, the costs and burdens for manufacturers and dealers should not be increased unnecessarily, which means that a careful assessment should be made.

To be in line with the New Legislative Framework (Regulation 765/2008 and Decision 768/2008); clarification of the validity of certifications and the definition and responsibilities of the economic operators will definitely be an improvement and will help to prevent non-compliant players from entering the EU market.

### 3.4 Needs and conclusions

In order to avoid confusion at the levels of the manufacturer and dealer, Notified Bodies, market control and in the user's market, there is definitely a need for much improved harmonization.

In addition, continuous education and training at all levels will certainly help the market, whilst at the same time we should aim at simplifying the regulations and standards as much as possible.

As a general rule, we need to strive for transparency and the same rules for everybody.

Every manufacturer and dealer should be treated the same way; it should not always be the bigger players that are being controlled because they usually follow the rules strictly.

There is definitely a need for open communication and to achieve all of this. Notified Bodies, market authorities, the European and national PPE federations and all other stakeholders should aim to work as a team. If this is done in a transparent way, a Common and Single European EU market is possible.

## 4 SITUATIONS IN THE PPE SECTOR: PERSPECTIVE OF THE NOTIFIED BODIES

Karl-Heinz Noetel, BG BAU, Germany

The developments in the PPE sector over more than 20 years since the PPE Directive came into force have generally been seen as positive.

Nevertheless, there are a few areas that have given rise to discussions, and where harmonisation is not fully established. The New Legislative Framework (NLF) and the revision of the PPE Directive are a good opportunity to bring about some clarification. In addition, there are some current developments in the PPE sector that need to be addressed to make sure that there is a harmonised approach in Europe.

The paper will take up some of the issues that are of particular concern to the notified bodies and present a view from the perspective of the Notified Bodies.

### 4.1 Situation of the Notified Bodies

According to the Nando list, there are currently around 105 Notified Bodies in the field of PPE which are active in EC type examination and / or the assessment of quality control procedures for one or more types of PPE.

To harmonize procedures and coordinate the activities of the notified bodies, the European Coordination of Notified Bodies in the Field of PPE was established as early as in 1992. The European Commission supports the Technical Secretariat of the European Coordination of Notified Bodies for PPE. In the Horizontal Committee and in 10 Vertical Groups, the notified bodies discuss questions regarding the implementation of the specifications in the PPE Directive as well as technical issues in the testing and certification of individual types of PPE, respectively. The working results are established in the form of Recommendation for Use sheets.

### 4.2 Accreditation and notification

The notified bodies are notified to the European Commission by their Member States, after these have made sure that the bodies are competent and fulfill the requirements for notified bodies as defined in the PPE Directive. The assessment of the competence of notified bodies is carried out by different bodies at a national level. The process may involve accreditation, sets out conditions for reporting and ensures regular checks. The requirements for notification that result from the process show quite some differences, which make it difficult for the notified bodies to ensure harmonized working procedures at a European level.



Although accreditation is not always necessary, most Member States require accreditation as a basis for notification. However, in some countries the accreditation process and subsequent auditing of notified bodies are much more demanding (in terms of documents to be provided, reporting requirements, etc.) and take much longer than in other countries. Therefore the costs for becoming a Notified Body are considerably higher in some countries than in others.

Obvious differences also exist with regard to sub-contracting tests. Whereas in some countries the use of test results from other test houses are quite restrictive (only a certain number or quality of tests can be sub-contracted; results have to come from accredited test institutes), other notified bodies have much more freedom to have tests carried out as external services.

Another example is the participation of notified bodies in coordination and standardization activities. Some Member States require their notified bodies to be involved in those activities and participate in interlaboratory testing to keep up their competence. Again, this can be quite costly, and should be mandatory in order to be able to harmonize certification.

In order to harmonize accreditation in Europe, the EU has started an initiative through the requirement in the NLF (Regulation 765/2008/EC) to improve cooperation between accreditation bodies in EA. The notified bodies hope that this will harmonize the conditions that are set for their work.

In addition, Decision 768/2008/EC of the NLF provides for the possibility of introducing the requirement for participation in coordination activities in the revision of the PPE Directive, which would strengthen the efforts made in the Coordination of Notified Bodies.

### 4.3 Recommendation for Use sheets (RfU)

Similarly, the revision of the PPE Directive could contribute to clarify the status and further application of the Recommendation for Use sheets prepared in the European Coordination of Notified Bodies. While it is true that Recommendation for Use sheets remain 'recommendations', the EU Commission, after endorsement by the PPE Working Group in the Standing Committee of the EU Commission, publishes the documents on the EU website and expects their application. (1).

In the past, only the horizontal RfU sheets were published on the EU website, but then publication was extended to the Vertical RfU sheets. RfUs from some Vertical Groups are already available at the EU website, but the majority of VGs are still missing, and the RfUs currently published on the website are not really up-to-date; even if the date on the website says September 2011, the actual date of the documents is much older.

Before the Recommendation for Use sheets can be published they need to be confirmed in the VG, approved by the Horizontal Committee and endorsed by the PPE Working Group. In order to speed up the process of preparing and approving the RfU sheets the EU Commission has now introduced a new procedure for endorsement. They will take the RfUs that have been approved by the Horizontal Committee and send them to the members of the PPE Working Group for comments or objections. If no objections are raised, the

documents can proceed for publication. At the moment, a total of 184 RfUs from various Vertical Groups are out for comments by the PPE Working Group until April 2012. The process still takes a lot of time, but there is a clearer time schedule to know when an update of the RfUs on the website can be expected.

In addition to that official publication, the EU Commission recently suggested that the European Coordination of Notified Bodies could also publish those RfUs that have been approved by the Vertical Groups and Horizontal Committee during the time taken by the PPE Working Group for commenting. The Technical Secretariat is checking the options to create a dedicated website for this, bearing in mind that the status of the relevant RfUs must be very clear.

The website could then also be used to make the application of the Recommendation for Use sheets transparent. Although the EU Commission somehow expects the notified bodies to follow the solutions offered by the Recommendation for Use sheets, some notified bodies see them as recommendations which do not have to be followed. Since the Recommendation for Use sheets are intended to harmonize procedures in Europe, the objective should be for the Recommendation for Use sheets to be applied as consistent as possible. Therefore the European Coordination of Notified Bodies proposed a voluntary system for notified bodies to declare that they apply the Recommendation for Use sheets. The list of notified bodies that issue such a declaration could be made available on the website so that authorities, manufacturers, etc. can see that the notified bodies follow the recommendations produced by the European Coordination of Notified Bodies.

## 4.4 Revision of standards

A topic that is not only important for manufacturers but also for the work of the Notified Bodies are the question of the consequences of a revision of standards: Does the publication of a revised standard mean that the old standard can no longer be applied? Will manufacturers have to adapt their entire production to the new standard to follow the state of the art? What is the extent of changes in a standard that would be considered to actually change the state of the art? Who has the power to decide about the quality of changes in a standard? When will EC type examination certificates based on "old" standards have to be withdrawn? How can transitional periods be agreed to adapt products and certificates to the new situation? What is the situation for products that do not follow a standard?

All these questions and more have been under discussion for almost 20 years, but with no clear answer. Market Surveillance authorities have different interpretations on those questions, which frequently cause problems in the market and at customs. Clear answers and a uniform approach are necessary for manufacturers, notified bodies and other stakeholders.

In the light of these discussions, the European Coordination of Notified Bodies introduced a recommendation to limit the validity of new EC type examination certificates to 5 years. The value of a regular check of EC type examination certificates had been discussed for a long time: changes to products can be identified, certificates for products that are no

longer manufactured can be abandoned, and the adaptation of the production to new standards can be ensured. The Recommendation for Use asks for a reassessment of EC type examination certificates after 5 years to make sure that the product still complies with the PPE Directive. The process will not be a complete new EC type examination but a check of the product and the documentation to make sure that there are no changes. The renewal of the certificate will take account of the latest version of the standards related to the product so that the recommendation partly addresses the question of the revision of standards.

The Notified Bodies hope that the revision of the PPE Directive will define uniform procedures that clarify the responsibilities and provide legal certainty for manufacturers, notified bodies and other stakeholders.

## 4.5 Categorization

Categorization of PPE is another area where clear decisions are needed. Although the definition of PPE and the exhaustive lists of products that are category I and III PPE in the PPE Directive 89/686/EC should be clear enough, a lot of discussions centre about the questions whether a product is covered by the PPE Directive or not, and which category should apply. Different views arise, for instance, in borderline cases, for product innovations, and for new applications or functions of a particular product.

Questions about categorization should be discussed at the level of the Member States, i.e. in the PPE Working Group, to ensure a harmonized approach all over Europe. Unfortunately, the decision-taking processes can sometimes take quite a long time. In the meantime, national market surveillance authorities sometimes take different views and thus impose different obligations on manufacturers. Chemical protective clothing is an example of a product where contradictory information was spread by Member States, with serious problems in the market.

When Notified Bodies receive a request for EC type examination, they have to respond to the manufacturer. Where the category is not clear, they would normally check whether there are relevant standards that have been prepared with a link to the PPE Directive and contact other notified bodies or the relevant Vertical Group. But still the answer they provide would need confirmation by the PPE Working Group. Therefore it is extremely important for Notified Bodies to get quick and reliable information from the PPE Working Group. The revision of the PPE Directive might help to set up proper procedures for the PPE Working Group to take decisions on categorization issues in an acceptable time frame.

## 4.6 Instructions for use

Instructions for use should provide the users of PPE with all the information they need to use the product correctly and for the right applications. Therefore, the information has to be presented in a clear, understandable and legible way.

For market surveillance authorities, checking the instruction leaflets supplied with the PPE is an important element of market control, and there have recently been a lot of complaints about the way in which instructions are presented. These include aspects like the font size of the print, which sometimes is so small that it is difficult to read the instructions, and instruction leaflets that cover a whole product range, which may make it difficult for users to find the exact information for a specific product.

During the EC type examination, the notified bodies check the content of the instructions for use. However, they normally do not see the final printed version of the instruction leaflet and therefore cannot check font sizes or booklets covering other products.

Another topic in relation to the instructions for use is the question whether all the information to be supplied by the manufacturer has to be available in print. There is general agreement that the instructions for use and product information need to be available to the user without using any tools like notebook computers or I-Pads. However, some information that is required to go into the information supplied by the manufacturer may be more important for the purchasing departments of a company than for the user, such as test results achieved in the EC type examination. Also specific information on installation or inspection requirements for complex PPE like respiratory protective devices or PPE against falls from a height does not necessarily address the end user, but the safety engineer in the company. It may be helpful to split up the information supplied by the manufacturer into basic information that has to be available for the user at the workplace, and some additional information that could be offered separately and in a different format. This would help to keep the size of user instructions down and thus make them easier to read.

## 4.7 Cooperation needs

The above points represent some of the main discussion items for the Notified Bodies with regard to the current situation in the PPE sector and the expectations for the revision of the PPE directive. There are also some other concerns, like the increase in fake certificates and fake products in the PPE market.

All those topics do not only affect the Notified Bodies but all stakeholders in the PPE field. In order to find the best practical solutions for the sector, it is important to include all interested parties in the discussions and benefit from the different experiences. This should not be restricted to the authorities, the manufacturers and the notified bodies, but also cover standardizes and users.

It is important to share experiences, exchange views and discuss current developments to find a common basis to solve the challenges at hand. The PPE seminar offers an excellent opportunity to find common solutions and thus make workplaces safer and healthier.

## 4.8 References

1. [http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/personal-protective-equipment/notified-bodies/index\\_en.htm](http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/personal-protective-equipment/notified-bodies/index_en.htm)

## 5 SITUATIONS IN THE PPE SECTOR: THE PERSPECTIVE OF THE MARKET SURVEILLANCE AUTHORITY

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### 5.1 Abstract

Since the publication of the New Legislative Framework (NLF), there are new rules and tools for market surveillance and accreditation and a framework for making better regulations.

This paper gives an overview of the new obligations and instruments for market surveillance authorities. The challenges that Member States are confronted with are pointed out and a glance of the Belgian implementation of Regulation 765/2008 regarding market surveillance in general, and more specifically in the field of PPE, is given.

The current revision of the PPE Directive gives the opportunity to align the provisions as much as possible with the new common framework that is given by Decision 768/2008 of the NLF. Obligations for importers, distributors and producers will be updated and strengthened so that there will be more compliant PPE on the market. A brief overview of the obligations of the economic operators and the impact on market surveillance is presented.

### 5.2 Introduction

The New Legislative Framework (NLF) was adopted in 2008 and entered into force on 1 January 2010. It is also referred to as the revision or modernization of the New Approach to the marketing of products.

The legal reference texts of this framework are:

- Regulation (EC) 765/2008 of the European Parliament and of the Council of 9 July 2008, setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93.
- Decision 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products, and repealing Council Decision 93/465/EEC.
- Regulation (EC) 764/2008 of the European Parliament and of the Council of 9 July 2008 laying down procedures relating to the application of certain national technical rules to products lawfully marketed in another Member State and repealing Decision No 3052/95/EC.

The presentation at the 11th European PPE Seminar on Personal Protective Equipment focused on 765/2008/EC and 768/2008/EC. These entail a package of new rules and tools for market surveillance and accreditation and a framework for making better regulations.

Regulation (EC) 765/2008 of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products

This regulation 765/2008 aims to reinforce the application and enforcement of internal market legislation. Next to a European policy and framework for accreditation, this regulation lays down obligations for market surveillance. The following obligations are some of the requirements for market surveillance authorities to be found in the regulation:

- Information and communication at EU and national level  
The existence, responsibilities and contact details of national market surveillance authorities must be communicated to other Member States, the European Commission and made available to the public. This also applies to the annual market surveillance programme.  
This favours a better cooperation between authorities and a higher level of transparency. The Belgian market surveillance programme is published on the Internet, including a comprehensive list of contact details.
- Review and self-assessment  
The regulation obliges Member States to periodically review and assess their functioning at least every fourth year. The results thereof should also be made available. The first evaluations should be seen in 2014, since the regulation entered into force in 2010.
- Follow up scientific and technical knowledge concerning safety issues  
Market surveillance needs to keep up with innovations and scientific and technical evolution. For small Member States, it is practically impossible to ensure this follow up for all sectors and all possible safety issues. Sharing knowledge and exchanging information between Member States would also be an opportunity here. Another potential hypothesis is to "buy" knowledge from laboratories and research institutes, or to create some sort of partnerships with industry.
- Cooperation at the EU and national level  
At the European level, Belgian market surveillance authorities support and participate in different joint actions and opportunities for the exchange of information and best practices (e.g. PROSAFE projects, AdCo-groups, ICSMS, RAPEX ...). In many cases there has also been a bilateral cooperation with other Member States when contacting a producer directly didn't have the desired effect ('home authority principle'). At the national level, Belgium has created a specific market surveillance working group within a national interdepartmental commission (IEC) in order to exchange information and best practices and to prepare the national market surveillance programme. All market surveillance authorities, including Customs, are invited to this platform.

With the NLF, market surveillance is a theme as such with high visibility. Obligations for transparency on market surveillance activities will put pressure on less active Member States and force them to participate more.

To make market surveillance more efficient and fight against dangerous products on the market, cooperation and exchange of information (knowledge, best practices, etc) between market surveillance authorities at national and European level are crucial and constitute the key to success!

Decision 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products, and repealing Council Decision 93/465/EEC

This decision reflects a common framework of general principles and reference provisions for the drawing up of Community harmonization legislation. It includes definitions, the application of the CE mark, modules for conformity assessment procedures, (new) obligations for economic operators, obligations for Notified Bodies, and a simplified safeguard procedure. The current revision of the PPE Directive gives us the opportunity to align its provisions with this new common framework.

This means for example that obligations for importers, distributors and producers will be updated and strengthened to have more compliant PPE on the market. More stringent obligations for importers include the verification of the conformity assessment procedure and ensuring that technical documentation is present. In addition, the verification of the presence of markings, documents and user instructions are added to the importer's responsibilities, in addition to indicating his/her name and address on the imported product. With regards to corrective actions, traceability, cooperation with authorities and notifying dangerous, non-compliant products, importers and distributors have a role to play.

Generally, this means that all economic operators have to know 'their' product regulations to fulfil their new obligations and responsibilities. Market surveillance benefits from these new rules because it can shift from "product controls" to "company audits" for importers and distributors, and is more efficient in that way. It is a very interesting approach for Member States with a small number of manufacturers.

Generalizing definitions and conformity assessment procedures for all sectoral regulations will make it more consistent and easier to implement.

Today's best market surveillance practices in the PPE field

A non-exhaustive list of examples of some of today's best practices in market surveillance in the PPE field:

- Market surveillance authorities cooperate in Joint Actions and the Rapid Advice Forum (coordinated by PROSAFE). Recent Joint Actions with regards to PPE are the projects on helmets and high visibility clothing and accessories.



- PPE AdCo (Administrative Cooperation) meetings between market surveillance officers have been organized since the mid-1990s to exchange information, views and interpretations and to discuss relevant issues. These meetings are held twice yearly, usually in parallel with the PPE Expert Working Group.
- Ad hoc bilateral cooperation between market surveillance authorities (directly or via ICSMS) exists in order to assist one another and collaborate according to the 'home authority principle'.
- Exchange of information on dangerous products via the RAPEX system.
- Implementation of the risk assessment tool described in the new RAPEX Guidelines (2010/15/EC).

Unfortunately, nowadays we see that enforcement of product safety regulations can still differ in Member States. "Everyone has their own way of doing things". This is inefficient for the protection of the consumer and for the competitiveness of enterprises, since the market is European.

To facilitate and optimize enforcement and surveillance, there is a need for a standardized approach and procedures at the European level. The implementation of 'standards for market surveillance' would lead to a uniform and effective approach and it would also facilitate the cooperation between Member States. Belgium already has such a system in place which standardizes the determination of measures for economic operators in case of a non-compliant product. This procedure starts from the risk assessment method of the RAPEX Guidelines: the risk category of non-compliant product is determined and, taking into account the principle of proportionality, a standard measure corresponding to the risk category is proposed.

This method could be further optimized and elaborated for use at the European level.

## 6 SITUATIONS IN THE PPE SECTOR: THE PERSPECTIVE OF THE END USERS

Mari Kiurula, Safety Expert, BU Skanska Finland

### 6.1 Introduction

This paper looks into the current situation in the PPE sector, seen from the perspective of the end users. The paper discusses how well some of the PPE in the market meets with the protection needs at construction sites. Practice has also indicated some problems in standards. These issues are also introduced in this paper.

### 6.2 Current conditions

#### 6.2.1 PPE regulations on construction sites

In Finland, by law, it is mandatory to wear a safety helmet, eye protection, safety boots and hi-visibility, reflective clothing at all times when inside a construction site area. Other PPE is worn when needed.

Getting workers to wear PPE has proved to be challenging. That partly results from the fact that the consequences of not abiding by the law have not been significant to the worker. Recently the Finnish construction industry agreed on substantial fines and consequences for anyone who contravenes the safety rules. This is still very new practice and not in effective use yet.

The best methods to encourage the use of PPE are positive ones. The PPE seems to stay on if the workers find them good, useful and comfortable. The best motivation is if they understand that PPE really is good for them – that it really can save their lives or their health. That comes from experience and communicating accident and near-miss cases.

The Finnish Act on Construction Safety was revised in 2009 and took effect on 1 June of the same year. That was when wearing eye protection at all times became compulsory. The effects of this change in Skanska Finland can be seen in Figure 1.

In 2011, every third accident at Skanska involved injuries to the hands or fingers (this includes accidents without absence). 32% of all injuries to hands and fingers could have been prevented with cut-resistant gloves. That is 11% of all accidents. As a result, a decision was made that from the beginning of this year, the wearing of gloves while working has been required on Skanska sites.

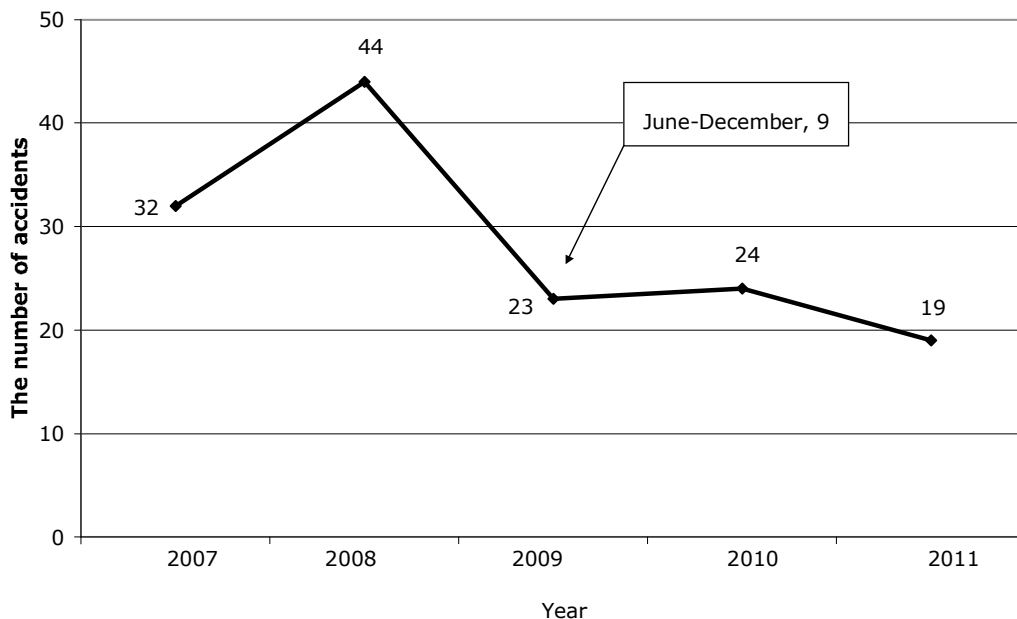


Figure 1: The number of accidents to the eye has reduced. The numbers include cases that needed some kind of treatment but did not lead to absence.

### 6.2.2 Challenges with PPE

Mandatory PPE has resulted in a decreasing accident rate. Demands by the law are the same for everyone, yet the diversity of tasks, weather conditions, working environment and physique of the workers make finding suitable PPE challenging. Some of the biggest development needs are introduced below. Most of the needs come directly from the workers who wear the PPE daily in various conditions.

- In the summer, the temperature under a helmet can get very high. There is a need for an innovation that cools the head in order to be able to wear the helmet.
- The selection of cut-resistant gloves doesn't include a warm model for winter. Wearing two pairs of gloves is not a good solution.
- A toecap is required in safety boots, but those workers that have to be on their knees a lot find that the toe cap hurts their toes.
- Dusty work is also done in the winter and in unheated conditions. Powered and supplied air respiratory systems cannot be worn in temperatures below zero degrees Celsius.

- Eye protectors gets steamed up when doing heavy work, breathing hard and sweating. Steam is also hazardous when one enters a warmer space from the colder outdoors. Steaming eye protection also distracts from work when worn together with a respirator.
- For those who need corrective lenses, eye protection with such lenses is the best solution. Accidents to the eye have occurred because small particles fly in the eye very easily from the large gaps at the side of the lens.
- The Finnish Occupational Safety and Health Administration demands that cut-resistant trousers and boots (along with other appropriate PPE) are worn when using a chain-saw. At the same time we have the requirement of using safety boots with a midsole that prevents penetration. We have not succeeded in finding boots with all of the above.

### 6.2.3 Problems with standards

From the end user's point of view, some problems have arisen concerning the testing of PPE according to standards.

Fall arrest harnesses

Fall arrest harnesses are tested with a 100 kg test weight. A construction worker can weigh well over 100 kg when they have all their tools on them.

Hi-vis material

The standard SFS-EN 471 requires a certain area of the surface of clothing to be of hi-vis material. Small clothes can not be made in class 2, which is used in building construction, or in class 3, which is used in infrastructure construction. This is a particular problem for women. Clothes that are too big are a safety risk and disturb effective work.

Textile midsole against penetration of nails

There have been at least two cases at Skanska Finland where a nail has gone through the sole and into the foot. In collaboration with the manufacturer, we organized a test at the Finnish Institute of Occupational Health.

The standard for testing midsoles against penetration was presumably developed for steel midsoles. That would explain why the test is carried out with a nail of diameter 4,5 mm; it is strong enough to endure the force of 1100 Newtons if required. The most common nails on construction sites are much smaller and sharper, however. We tested metallic and textile midsoles with the thinner nails in cooperation with our supplier. The results show what the accidents prove.

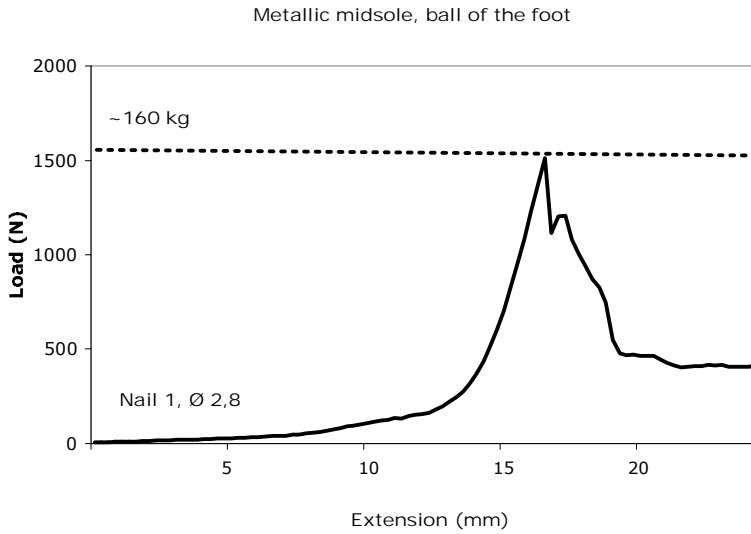


Figure 2. The first test was carried out with a nail of  $\varnothing$  2.8 mm. The metallic midsole passed the test very well. It took about 1600 Newtons for the nail to penetrate.

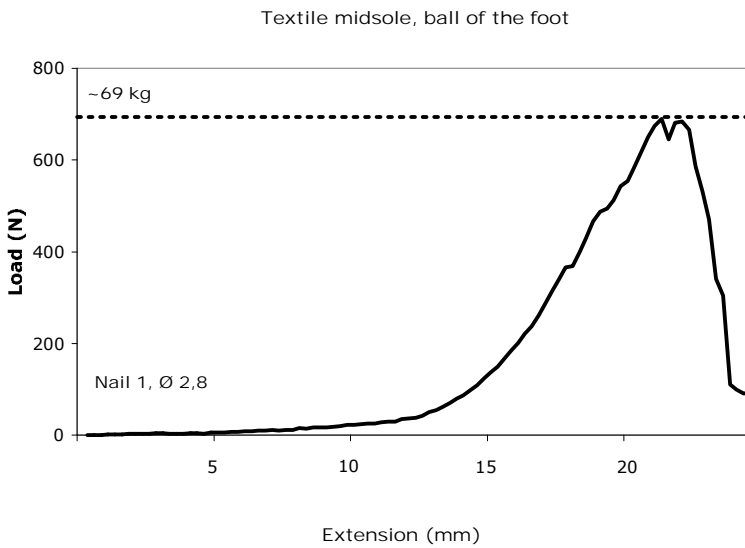


Figure 3. With the same  $\varnothing$  2.8 mm nail it took only 690 Newtons to penetrate the textile midsole.

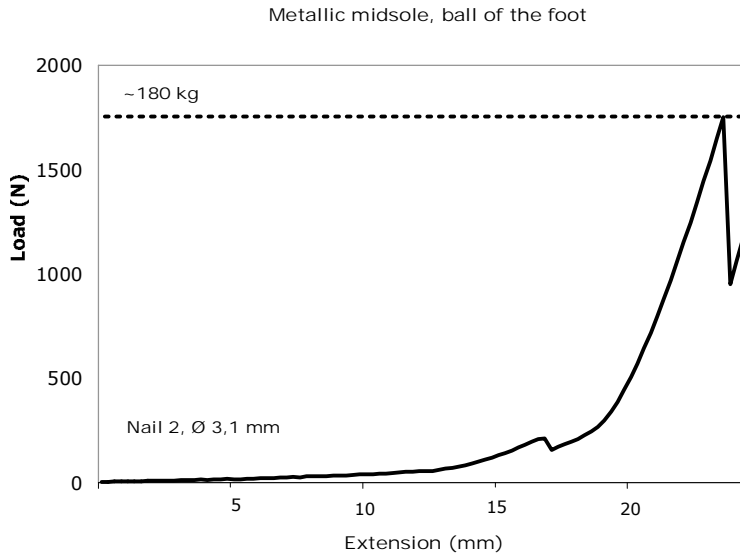


Figure 4. The second test was carried out with a nail of  $\varnothing 3.1$  mm. Again the metallic midsole passed the test excellently.

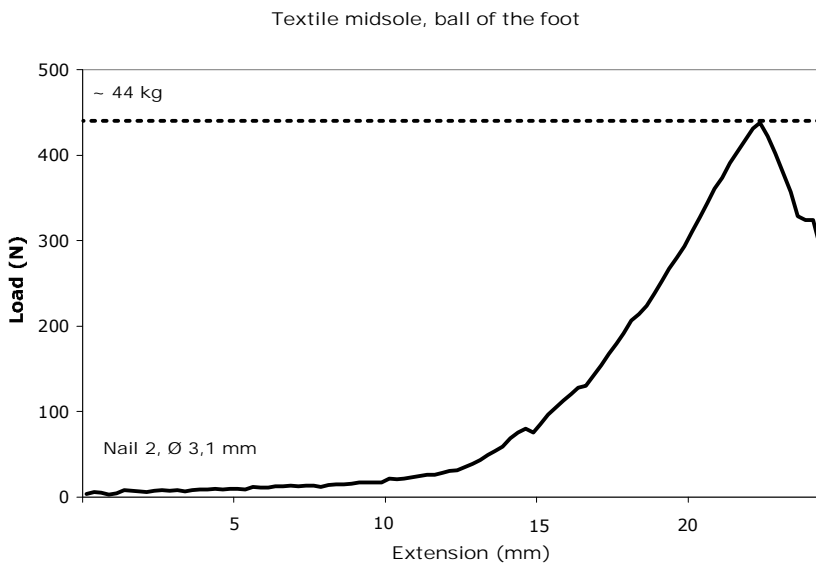


Figure 5. The nail of  $\varnothing 3.1$  mm penetrated the textile midsole with only about 440 Newtons. The thinner nail got a better result because it became blunt easier.

## 6.3 Conclusions

This paper introduced the end user's experiences of using PPE. We communicate and cooperate with the manufacturers and Notified Bodies, making changes and developing PPE to meet our needs. Sometimes the standards of development and manufacturing costs simply fail to meet the needs. The purpose of this presentation and final paper was to highlight these cases in order to deliver the message to quarters that may have the means to influence these matters in a positive way.

## 7 RESULTS FROM THE WORKSHOPS

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Four workshops were organized on the issues discussed in the framework of the revision of the PPE Directive. Although the four workshops focused on different aspects – that is, some main topics from the point of view of users, Notified Bodies, authorities and market surveillance, and manufacturers and dealers – it was the seminar organizers' specific intention to take up those topics in mixed groups made up of all stakeholders. The workshops were designed to give the participants the possibility to understand and discuss the views of the different stakeholders, and to suggest solutions to be considered in the revision of the PPE Directive.

As a basis for the discussions in the workshops, all participants received copies of the introductory presentation to the seminar as provided by Dr Thierbach from the EU Commission, as well as the document of the "draft options", the document that served as the basis for the impact assessment study and the public consultation on the revision of the PPE Directive.

All four workshops were characterized by good and open discussions. The presentation of the results of the workshop sessions showed that a number of topics were discussed in all the groups, with similar discussion results.

The following conclusions and recommendations were agreed by the seminar participants:

### 7.1 Scope and categorization

To avoid long and repeated discussions between authorities, manufacturers and Notified Bodies, clear definitions and criteria are needed in order to establish whether a product is PPE or not, and which category a PPE belongs to.

Long-standing issues like high visibility equipment, high and low temperature equipment and professional or private use of PPE need to be resolved.

The PPE Working Group should have the power to make decisions concerning issues of categorization.

Some of the proposed changes to categories appear to need further discussion, such as PPE to protect against adverse atmospheric conditions, dishwashing and oven gloves, and bulletproof, stab-, needle- and spike-resistant vests or equipment.



The proposed change of category for hearing protectors to become Category III is not considered justified.

## 7.2 Consequences of the revision of standards

Authorities, manufacturers and Notified Bodies need clarity about their responsibilities when a standard has been revised, such as when bringing a product into line with a new standard, updating of certificates, etc.

A revised standard should include an assessment of the significance of changes relating to safety issues.

Time limits of EC-type examination certificates may be one way of making sure that products are re-examined in accordance with revised standards. Procedures for re-evaluation upon expiry of a certificate must not be too burdensome, and they must be the same for all Notified Bodies.

## 7.3 Conformity assessment procedures

An Article 11A option should be retained for manufacturers that have smaller PPE production lines that do not justify full quality assurance systems.

Module H is not a suitable module for the PPE Directive.

## 7.4 New legislative framework

The requirements relating to the obligations of the economic operators and Notified Bodies, and requirements relating to safeguard clauses must be explicit in the PPE Directive.

## 7.5 Operation of Notified Bodies

The requirements that Notified Bodies have to meet in order to be notified by their Member State need to be harmonized, for example with regard to accreditation, subcontracting, auditing, reporting to authorities, etc.

There should be a clear obligation of Notified Bodies to participate in the coordination activities: participation in the Coordination of Notified Bodies, participation in round robin tests, and the application of recommendation for use sheets (RfUs). Those obligations must be explicit in the PPE Directive.

## 7.6 Market surveillance

Market surveillance should use only accredited test laboratories when re-testing PPE, and should ensure that those are knowledgeable in the current test requirements (including RfUs), that they take part in inter-laboratory testing, and so on.

Databases for EC-type examination certificates could be helpful for market surveillance. However, the creation of a single database for all certificates was not considered practical. It could be sufficient if Notified Bodies made their certificates available on their own websites.

A harmonization of the minimum content of EC-type examination certificates was also requested. This would make it easier to find the relevant information and help solve language problems.

Cooperation with PPE organizations, manufacturers and distributors, Notified Bodies, and other agencies should be strengthened to discuss the need for market surveillance action and to assess products on the market.

## 7.7 User information

It is understood that the current position requires the information supplied by the manufacturer to be provided in a printed format. Taking account of technological development, the use of different formats (CDs, Internet pages, smart phone applications, Radio Frequency Identification (RFID) technology, etc.) should become possible, even if it is in addition to the printed documents for the time being. This would allow manufacturers to add training videos and provide more information without the need for excessive translations.

Long and complex instructions for use are not read by the users. There should be a possibility of having short user information leaflets available with the product, which point out the most important information to the end user. Additional information, such as test results, maintenance, etc. could then be made available in a separate document.

Additional topics were addressed in individual workshops, following the main points suggested for the various stakeholders:

The first group, which focused on the main topics from the point of view of users, also looked at the consequences of the economic crisis on the use of PPE. They were concerned that the selection process, field trials and training in the use of PPE might be affected by the wishes of companies to save money, and they pointed out that more attention should be paid to the usability and wearability of PPE. In addition, they discussed the issue of assigned protection factors for the use of respiratory protective devices.

The second group, focusing on the main topics from the point of view of authorities and market surveillance, discussed the role of customs in market surveillance and suggested that cooperation should be intensified. The number of non-compliant products on the

market could be reduced by educating manufacturers and distributors about the requirements of PPE.

The third group, dealing with the main topics from the point of view of Notified Bodies, took up the item of custom-made products. They thought that these need to be covered in the PPE Directive. Due to the diversity of custom-made products and new product developments, a clear definition of what was custom-made is necessary. Since there are various ways of checking compliance, depending on the way the products are customized, there does not seem to be a uniform solution for conformity assessment.

The fourth group, which looked at the main topics from the point of view of manufacturers, looked at the costs related to conformity assessment and the duration of EC-type examination procedures. To speed up the process, Notified Bodies should define exactly what documents the manufacturers are obliged to provide to the Notified Bodies. Another topic was related to tender procedures, which sometimes follow unrealistic time frames, if certificates are required to be submitted with the tender.

## 8 REALISTIC TRAINING PROGRAMME FOR THE SAFE USE OF CHEMICAL OXYGEN SELF CONTAINED SELF-RESCUERS (SCSR)

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### 8.1 Introduction

Chemical Oxygen Self Contained Self-Rescuers (SCSR) are pieces of Personal Protective Equipment (PPE) which are included in the standard equipment in most of the coal mines around the world, but especially in Spain. This equipment is carried by miners during their working day, for use in the event of emergencies involving absence or deficit of oxygen (fires, explosions). In several accidents in which the use of this equipment was essential, it has been observed that unfamiliarity with the effects of discomfort it produces and the lack of training in its use has led some miners to reject the equipment and take it off, thinking that it was not working properly, with fatal results.

It is for this reason that the National Silicosis Institute of Spain took the necessary action to initiate a continuous programme of training in the use of the equipment. The initial premises of this training were: either use of new devices (high cost), but achieve exactly the same sensations and use difficulties of the real equipment. The Council of the Principality of Asturias Administration funded this research and the developed equipment, which are set out below.



*Figure 1. Miners using SCSR during an emergency.*

## 8.2 Methods

Firstly a simulation station was designed, in which workers could experience the same sensations of discomfort, notably those of heat and dryness of the oxygen that the equipment supplies when in use. The design was presented at the 30th International Conference of Safety in Mines Research Institutes, held in Johannesburg in 2003, and is used in Spain to train coal miners (5,000 miners have been trained up to now).

After doing a lot of training emergency practices were carried out in different coal mines. Despite having received training in the simulation station, when miners had a need to use the SCSR under hostile conditions (emergency practice with smoke, typical mining noises, absence of light), they made a lot of mistakes. Because of this, an important risk for the miners' safety arose again. This led to the development of new self-rescuers for the training, being almost exactly the same as the real ones (the real ones cannot be used to train miners because they only can be used once). In fact, this self-rescuer simulators were made using the casings of real SCSR.

This led to the creation of what has been called training for the use of self-rescuers, which nowadays consist in a brief theoretical introduction, the simulation of sensations with the simulation station and the use of the self-rescuer simulators to practice their opening.

## 8.3 Sensation simulator

SCSR produces an amount of oxygen independently of the surrounding atmosphere, through certain chemical reactions that generate heat and a process that leads to dryness in the respiratory tract. The process also produces water vapour, which increases relative humidity and causes a sensation of suffocation while breathing. These sensations are more or less intense, depending on the user and the model of SCSR.

Similarly, a certain respiratory resistance, and the need to wear nose clips the whole time to prevent air entering the nostrils, are factors that further complicate their use.

If the miner has not previously experienced these sensations, he or she may, in the event of an emergency, attribute them to equipment malfunction and remove the SCSR, as has been documented in real-life incidents.

The station consists of:

- A treadmill belt with adjustable speed and slope.
- A bag with a connected mouthpiece, through which the air is breathed. The humidity and temperature of the air is similar to that produced by SCSR.
- A box with electronic equipment and other elements.
- An air compressor.



*Figure 2. Sensation simulator.*

The basic operation of this station is as follows: a compressor provides a constant flow of dry, filtered air, which is heated by two heating elements in series, into one of which a certain amount of water is introduced, which, by evaporation, produces the degree of humidity required. This airflow, with a controlled temperature and humidity, is conducted to the bag and mouthpiece that simulate the COSR.

The miner carries out the training procedure, controlled by sensors, by walking on a treadmill while breathing in the air provided by the system.

At the same time, the desired respiratory resistance is obtained by automatically adjusting the gradient of the treadmill belt.

The various heating, humidifying, flow control and system management elements are housed in a console equipped with a tactile screen on which the training procedures are operated and controlled, and which show the evolution of the different parameters during the execution of the procedure.

The control programme allows the parameters involved in the process to be varied to create a training procedure that best represents the response of each type of SCSR. During the training procedure, the individual walks on the belt, breathing from the bag and

with the clip in place over his or her nose. The simulator may be programmed to increase the sensations of dryness or humidity, as well as the temperature, as required.

The adverse sensations of heat, dryness and resistance are very similar to those experienced during the use of the real equipment.

Finally, the equipment is fitted with a variety of safety systems to control the maximum temperature and relative humidity, as well as an emergency stop button.



*Figure 3. Detail of the station: Bag for breathing.*



*Figure 4. Detail of the station: Equipment inside the box.*

The next figure shows the training being applied. The training lasts for five minutes, during which time the different sensations that one real SCSR produces are simulated whilst running (it supplies oxygen for an average of 30 minutes).

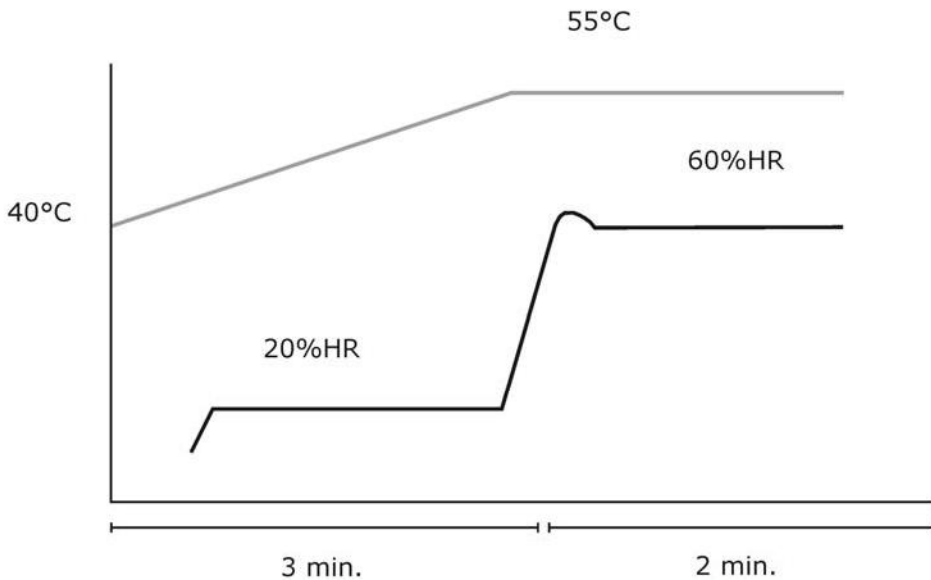


Figure 5. Training being applied.

## 8.4 Training self-rescuers (Dummy SCSR)

Commercially designed training equipment is useful for instructing groups of workers, but there are deficiencies when it comes to individual training that requires the equipment to be opened and donned several times, meaning that it has to be repacked ready for use on each occasion.

Although each self-rescuer has particular characteristics, they maintain some common features that must be worked on in training:

- The need to put the nose clip.
- Adjustment of straps to prevent poor posture during evacuation.
- Good placement of the mouthpiece in the mouth, ensuring the subject only breathes in air supplied from the bag.



Faced with this problem, the National Silicosis Institute developed “dummy” training equipment, adapting each type of SCSR used in the Spanish mining sector, which combines the following characteristics:

- The external appearance, dimensions and weight are the same as those of the real equipment.
- The difficulties in opening, and the peculiarities of each type of SCSR have been faithfully reproduced, but repacking the equipment for future use is now much easier, allowing the worker to reuse the same self-rescue as many times as necessary.
- The mouthpiece is interchangeable, allowing it to be sterilized, and guarantees the conditions of hygiene required when the equipment is in use. By means of an orifice calibrated in the mouthpiece, the user can simulate the swelling of the bag.

In the Spanish mining sector, three different types of SCSR are in use. Thus, it was necessary to develop training equipment for each case.

The next figures show the details of one of the pieces of equipment.



*Figure 6. To enable the equipment for use, it is necessary to pull off the black plate on which the trachea is mounted. Usually, untrained individuals pull directly from the trachea, disabling the equipment.*



*Figure 7. Detail of the assembly.*



*Figure 8. Connecting the mouthpiece (and cap) with the trachea, using mechanized Teflon thread, allowing the nozzle to be changed for each person being trained.*

Two other types of self-rescuers are presented below. During the training procedure, each worker opens and dons the self-rescue simulator as many times as is necessary for him or her to achieve complete familiarity with its use.



*Figure 9. The self-rescue before opening.*



*Figure 10. Detail of the assembly.*



Figure 11. Detail of the assembly.



Figure 12. Detail of the mouthpiece and the nose clip.

## 8.5 The training

The training is carried out in groups, ideally between four and six individuals.

Firstly, the group attends a theoretical session, where a technical professional explains the characteristics of self-rescuers. This part is done with the help of a video to make the session more entertaining. Then, each trainee goes onto the treadmill, where apart from the sensations, the trainer emphasizes to the workers the need to walk if they must use the SCSR and never run. Finally, each trainee opens and dons the self-rescuers several times, in order to ensure their proper use in a possible emergency.



*Figure 13. Room for the theoretical training.*



*Figure 14. Training equipment developed.*

## 8.6 Conclusions

The experience gained by more than 5,000 miners trained in the use of SCSR by the station and training equipment designed by the National Silicosis Institute is very positive. It was also well received by the miners themselves, who demand the same as compulsory before starting to work in a coal mine.

The training can be useful in other industrial sectors, where the risk of lack of oxygen or unbreathable atmosphere may exist.

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## 9 ASSESSMENT OF FILTERS FOR PROTECTION OF THE EYES AGAINST OPTICAL LED RADIATION

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Safe New Technologies, Helsinki, Finland

### 9.1 Introduction

Many traditional light sources have been replaced with high power Light Emitting Diodes (LEDs). LEDs are also used for instance for medical phototherapy treatments and many other new applications. The high radiance of some LED sources may cause a photobiological hazard to the retina of the eye. In addition, the high luminance may cause uncomfortable glare, thus increasing the risk of accidents in specific work tasks, such as during the mounting or servicing of LED equipment.

The aim of the study was to evaluate whether welding filters, sun glare filters and special tinted filters are suitable for reducing glare to a comfortable level and if they give sufficient protection against the blue light radiation when working close to high power LED sources.

### 9.2 Methods

Two LED lights and six filters with different shade numbers were used in the study. The first LED source (LED1) is a floodlight using blue, green and red LEDs arranged as an array of 36 LEDs mounted in a 250 mm x 100 mm enclosure. The second source (LED2) is also a floodlight, but uses white LEDs arranged as an array of 10 x 10 LEDs side by side covering an effective emitting area of 25 mm x 25 mm. The filters were three plastic and three glass welding filters (shade 5, 8 and 10), one sun glare filter (scale number 5-3.1) and an orange tinted plastic filter.

The spectral irradiance of the LED sources was measured with and without the filters in front of the input optics of the measurement equipment at a distance of 0.7 m for LED1 and 0.5 m for LED2.

The measurements were made with a scanning double monochromator equipped with a Teflon diffuser as input optics and a photomultiplier tube as the detector.

The corresponding safe working day exposure time according to standard EN 62471 (Photobiological safety of lamps and lamp systems) and Directive 2006/25/EC was calculated for each measurement. To evaluate which filter is most suitable for comfortable work directly in front of the lights, the luminance was calculated based on the source size, viewing distance and measured illuminance. In addition, a discomfort glare rating was evalu-

ated. In our study a luminance value  $> 2000 \text{ cd/m}^2$  was used for a “high discomfort glare” rating and a value  $> 10000 \text{ cd/m}^2$  was used for a “very high discomfort glare” rating.

### 9.3 Results

The spectral irradiance of LED1 and LED2 without a filter in front of the input optics is shown in figures 1 and 2, and the measurement results for LED1 and LED2 without and with filters are shown in tables 1 and 2.

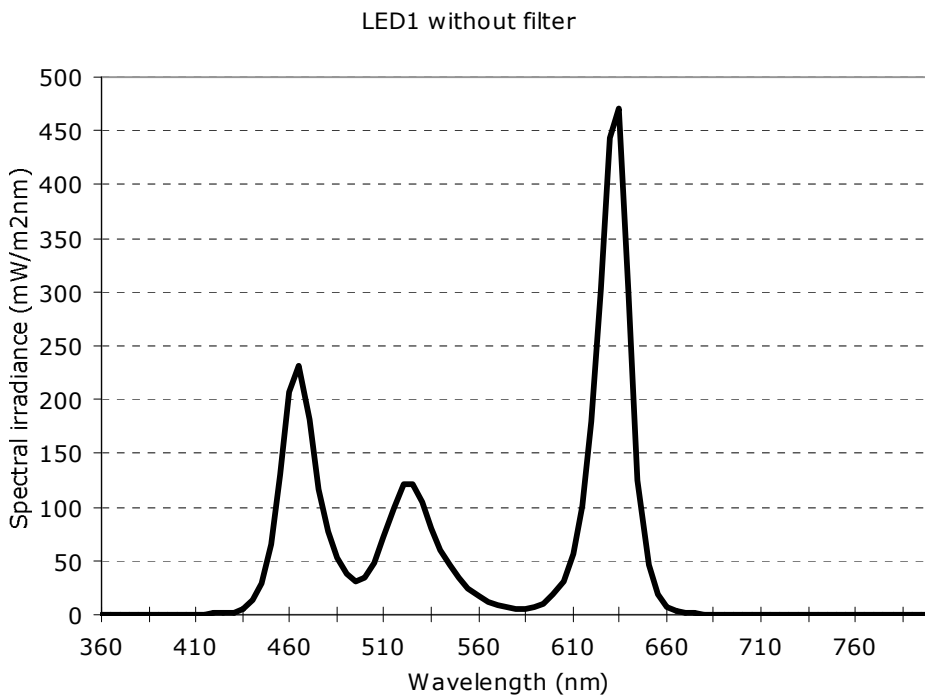


Figure 1. LED1 spectral irradiance without filter at a distance of 0.7 m.



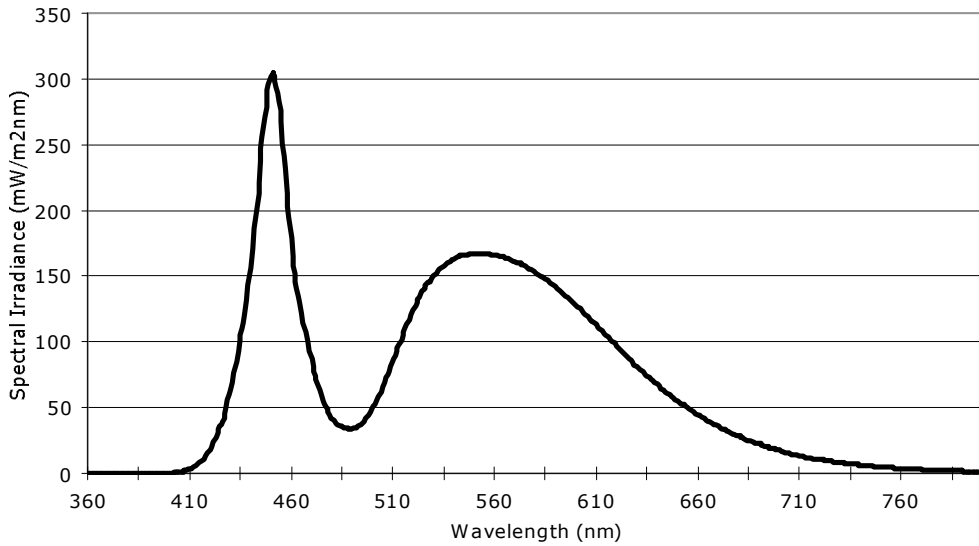


Figure 2. LED2 spectral irradiance without filter at a distance of 0.5 m.

Table 1. LED1 measurement results at a distance of 0.7 m.

Measurement	Luminance (cd/m <sup>2</sup> )	Rating of discomfort glare	Blue light radiance (W/m <sup>2</sup> sr)	Safe daily exposure time
LED1 without filter	230 000	very high	205	1 hrs
Plastic welding filter shade 5	3900	high	0,3	8 hrs
Glass welding filter shade 5	2600	high	1.9	8 hrs
Plastic welding filter shade 8	134	low	0,004	8 hrs
Glass welding filter shade 8	193	low	0.070	8 hrs
Plastic welding filter shade 10	20	low	0.001	8 hrs
Glass welding filter shade 10	26	low	0.008	8 hrs
Plastic orange filter	86 000	very high	0.8	8 hrs
Plastic sun glare filter shade 3.1	33 000	very high	28	8 hrs

Table 2. LED2 measurement results at a distance of 0.5 m.

Measurement	Luminance (cd/m <sup>2</sup> )	Rating of discomfort glare	Blue light radiance (W/m <sup>2</sup> sr)	Safe daily exposure time
LED2 without filter	6 000 000	very high	4 800	3 min
Plastic welding filter shade 5	110 000	very high	5.3	8 hrs
Plastic welding filter shade 8	4 200	high	0.07	8 hrs
Glass welding filter shade 8	6 300	high	1.07	8 hrs
Plastic welding filter shade 10	1 200	low	0.08	8 hrs
Glass welding filter shade 10	1 000	low	0.11	8 hrs
Plastic orange filter	1 800 000	very high	15	8 hrs
Plastic sun glare filter shade 3.1	770 000	very high	548	30 min

Figure 3. Shows the spectral irradiance of LED1 measured through a plastic and a glass welding filter, both with a shade number of 5.

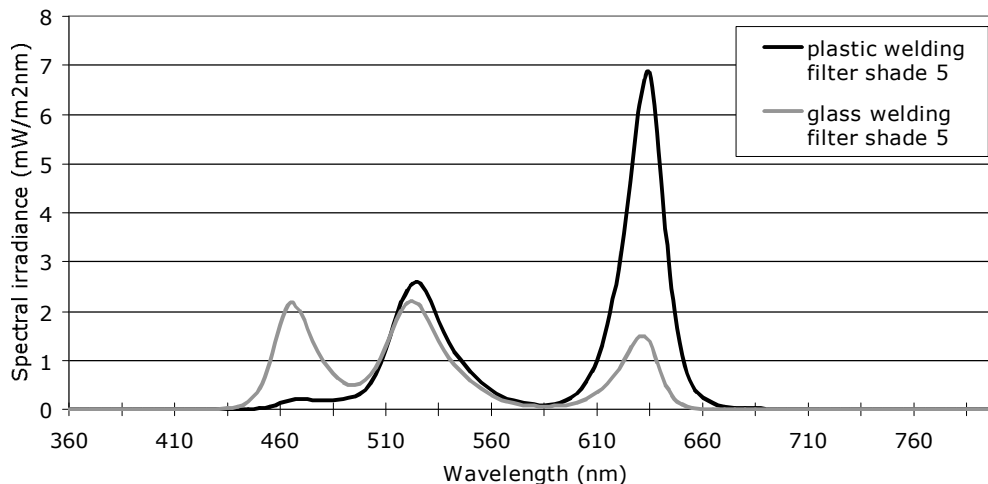


Figure 3. Spectral irradiance of LED1 measured through two welding filters.

The spectral irradiance of source LED2 measured through the orange tinted and the sun glare filter (shade number 3.1) is shown in Figure 4.

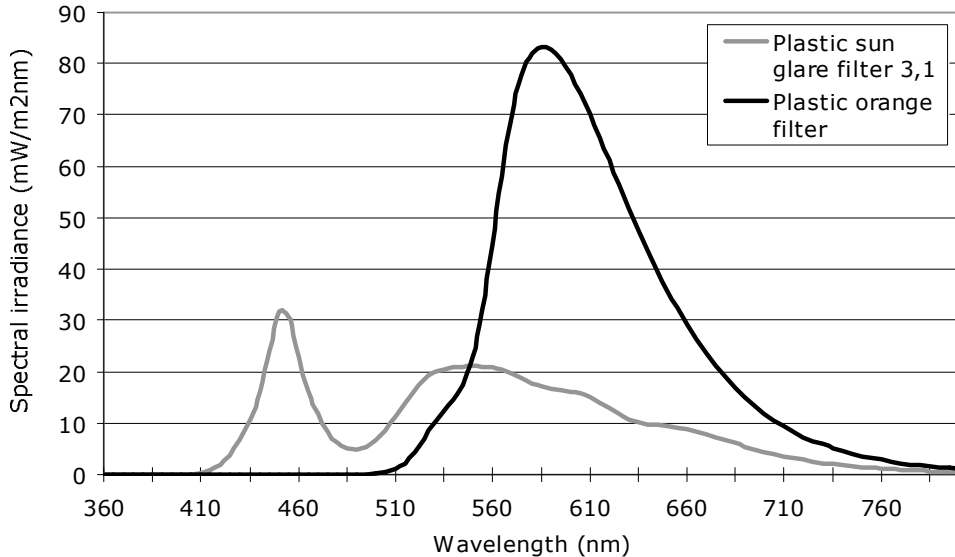


Figure 4. Spectral irradiance of LED2 measured through the orange tinted and sun glare filter using.

## 9.4 Discussion

All welding filters and the orange tinted filter provides sufficient protection to the eyes from blue light hazard.

Due to a low shade number, the sun glare filter does not provide good protection of the eyes for the whole working day from the strong blue light emission peak found in the LED2 source.

Depending on the surrounding illuminance, the work task, the person's age and the type of LED source, the rating of discomfort glare may differ from the evaluation given in tables 1 and 2.

Although the light orange tinted filter gives good protection against blue light hazard, it does not reduce glare to a comfortable level.

If the work task requires good recognition of blue, green and red colours, the measurements showed that a glass welding filter would be more suitable than a plastic welding filter of the same shade number, due to high absorption of blue light in the plastic filter.

Not only the shade number but also the design is important when choosing a suitable eye protector. "Wrap-around" spectacle-type eye protectors are preferable because of the good protection they offer from glare from the sides.

# 10 COLD EXPERIENCES DURING ARCTIC SAFARIS AND A NIGHT IN AN IGLOO

Kirsi Jussila and Sirkka Rissanen, Finnish Institute of Occupational Health, Finland

## 10.1 Introduction

In northern regions, environmental aspects such as snow, low temperatures and darkness can be seen as an attraction. Many tourists in these areas are seeking experiences from winter activities such as snowmobile safaris or even spending a night in an igloo.

Thermal balance depends on three components: ambient conditions, clothing insulation and metabolic heat production. Heat transfer from the body occurs by conduction (contact with a cold surface or liquid), convection (air or water movement), radiation and evaporation of sweat or water, and heat loss by respiration plays a minor role.

Insufficient thermal insulation of winter clothing will lead to cooling of the body during low activity levels, whereas too much thermal insulation will result in sweating during physically demanding tasks. It has been shown that sweating reduces thermal insulation and that a dramatic fall in cooling efficiency occurs when moisture is absorbed from the skin before it evaporates (Chen et al., 2003; Havenith et al., 2009). Wind also decreases the thermal insulation of cold protective clothing through convection (Anttonen and Hiltunen, 2003; Havenith et al., 1990). Previous studies have shown that adjustment of optimum thermal protection according to physical activity in the cold is often challenging for inexperienced foreign tourists (Jussila et al., 2010).

To provide an enjoyable and secure holiday for tourists and at the same time a safe and healthy working environment for guides in cold conditions, it is important to control thermal protection according to environmental effects and physical activity. This study is part of a project called Protection and Safety of Tourists and Tourism Workers, which was set up to develop the safety and protection of tourists and tourism workers in extreme conditions and activities in Finland. A multidisciplinary network at the national level was developed, including research institutes, universities, vocational schools, tourism companies, clothing manufacturers and consultants of occupational safety to increase awareness and safety (Jussila, 2010).

## 10.2 Objective

The study aimed to evaluate cold experiences, the level of thermal protection during an Arctic safari and a night in an igloo of both tourists and guides in cold climates.

## 10.3 Material and methods

Measurements were performed during the Arctic snowmobile safari and the night in an igloo in Muonio, Northern Finland, in February 2010.

### 10.3.1 Test subjects

The tests were carried out with four voluntary test subjects: three tourists (two females and one male) and one female guide (age 43, height 1.54 m, weight 58 kg). The tourist subjects were part of the research group (age  $34.3 \pm 13.6$  years, height  $1.7 \pm 0.1$  m, weight  $65.3 \pm 21.5$  kg).

### 10.3.2 Clothing and equipment

In the igloo test, the subjects wore long-sleeved shirts and long-legged pants, hats, thin gloves and woollen socks. The test subjects slept in sleeping bags manufactured by Halti (Ultra<sup>25</sup>L, size: 90 x 235 cm, weight: 2.3 kg, thermal insulation 1.01 m<sup>2</sup>K/W).

For the Arctic safari test, the subjects were allowed to choose their own clothing, which was enquired about by questionnaire.

### 10.3.3 Measurements

Core temperatures of test subjects were measured by telemetric thermo capsule (Jonah<sup>TM</sup> Temperature Capsule, Mini Mitter, USA). Skin temperatures were measured at seven sites (cheek, chest, upper back, upper arm, hand, thigh, foot) by thermistors (NTC DC95, Digi-Key, USA). Heat flow was measured at five sites on the body (upper arm, chest, upper back, thigh, calf) by heat flux transducers (Model Ha13-18-10-P, Thermometrics Co, USA). Thermistors and heat flux transducers were fixed onto the skin with flexible tape. Data was saved at one-minute intervals by the dataloggers (Smart Reader, ACR Systems, Canada).

Total heat flow (HF, W/m<sup>2</sup>) was calculated as a weighted average of local heat flow values. Thermal insulation values ( $I_{cl}$ , m<sup>2</sup>K/W) of clothing were calculated using skin ( $T_{sk}$ ) and ambient ( $T_a$ ) temperatures and heat flow (HF) according to the formula:  $I_{cl} = (T_{sk} - T_a)/(HF)$ .

Relative humidity and temperature between the underwear layer and the outermost clothing layer were measured using a sensor OM-CP-Microtemp (Omega, Canada). Thermal sensation was enquired after according to ISO 10551 Standard (1995).

#### 10.3.4 Test conditions

Two female test subjects spent a night in an igloo from 11 p.m. till 7 a.m., eight hours in total. The test subjects slept in sleeping bags on reindeer skin and an ice bed (Figure 1).



*Figure 1. Sleeping facilities in the igloo, mean temperature inside  $-7.2\text{ }^{\circ}\text{C}$  (standard deviation  $0.7\text{ }^{\circ}\text{C}$ ).*

Two test subjects (female and male) and the female guide participated in the Arctic snowmobile safari. The snowmobile safari started at 10 a.m. with a clothing pick-up from the clothing and equipment storage and continued with safety instructions outdoors. Driving the snowmobiles started at 11 a.m. and ended at 6.15 p.m. During the day lunch was offered by the guide.

Ambient temperatures were measured throughout the night and the safari by placing a portable weather station (iButton, Thermocron) near the igloo and the starting place of the safari and taking readings every ten minutes. Ambient temperatures during the snowmobile safari varied between  $-31$  and  $-19^{\circ}\text{C}$ . The average temperature in the igloo at night was  $-7.2\text{ }^{\circ}\text{C}$  (standard deviation was  $0.7\text{ }^{\circ}\text{C}$ ). The ambient temperatures are presented in Figure 2.

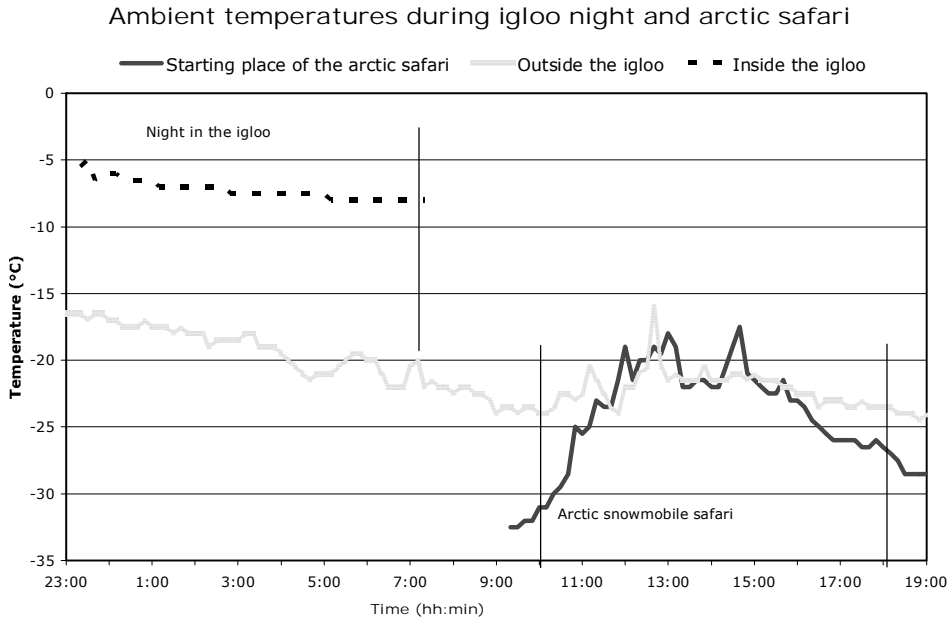


Figure 2. Ambient temperatures inside and outside the igloo and during the Arctic snowmobile safari.

## 10.4 Results and discussion

### 10.4.1 The night in the igloo

During the night, core temperatures decreased to 36.2-36.8 °C. This indicates that the stage of deep sleep could be attained.

After an initial drop,  $T_{sk}$  and local skin temperatures reached thermoneutral level (Figure 3 and Figure 4). The overall thermal sensation was “slightly warm” and “slightly cool” in the morning.

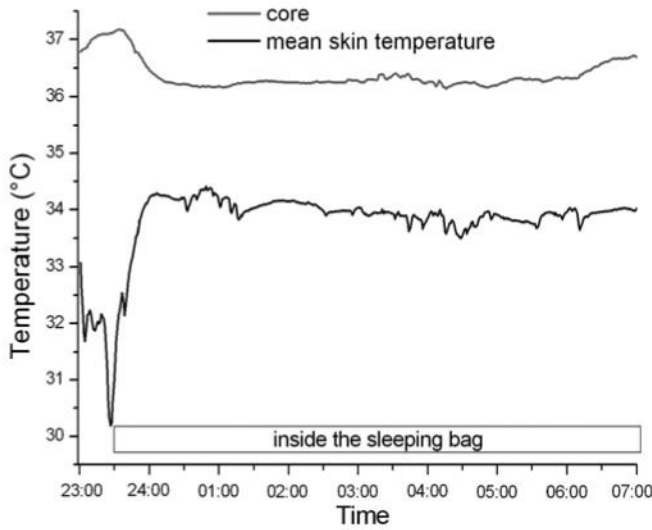


Figure 3. Core and mean skin temperatures, during the night in the igloo. One subject.

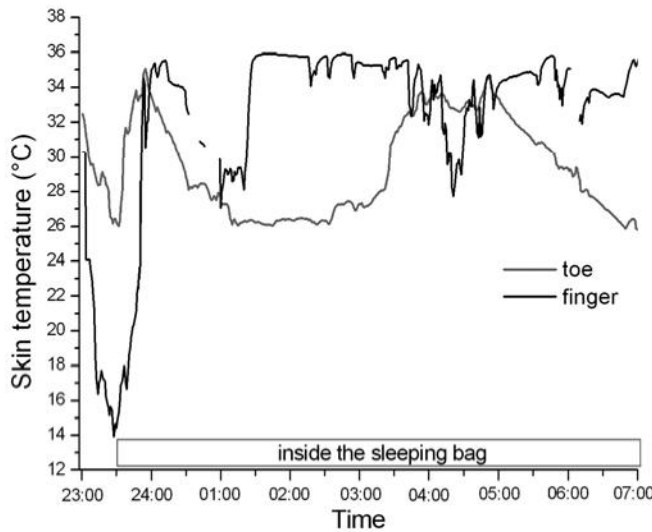


Figure 4. Temperatures of toe and finger during the night in the igloo. One subject.



### 10.4.2 The Arctic snowmobile safari

Results showed that on average the tourists were wearing one layer of clothing more than the guide (Figure 4). The tourists wore their own underwear, middle and outermost layers and thermal overalls (0.388 - 0.620 m<sup>2</sup>K/W). In total the tourists had five to six layers of clothing on the upper body and four layers on the lower body. The guide wore long-sleeved and -legged underwear, two middle shirts and one pair of trousers, and a thermal outermost layer (0.310 - 0.465 m<sup>2</sup>K/W). In total the guide had four layers of clothing on the upper body and three layers on the lower body. The test subjects' feet were protected by three layers of socks and winter shoes, and hands by thin gloves and thermal mittens.

The guide's undershirt was moist during heavier physical activity when one snowmobile had to be removed from deep snow (Figure 5 and Figure 6), but dried before the lunch break (relative humidity < 40%). The effect of sweating and wind speed caused by driving decreased thermal insulation by about 30%. The tourists' clothing was only moist during dressing and equipment pick-up from the storage, but stayed dry during the safari. The wind decreased thermal insulation by about 26-38%. Previous studies have shown that a wind speed of 4 m/s decreases thermal insulation by 20 to 40% (Anttonen and Hiltunen, 2003; Havenith et al., 1990).

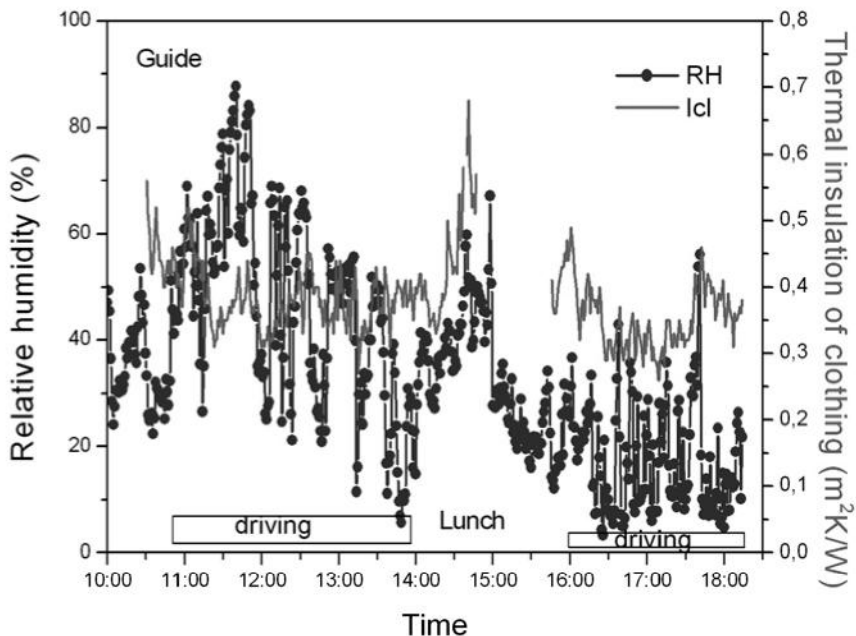


Figure 5. Thermal insulation and relative humidity between under and middle layers of the clothing worn by the guide during the Arctic snowmobile safari.

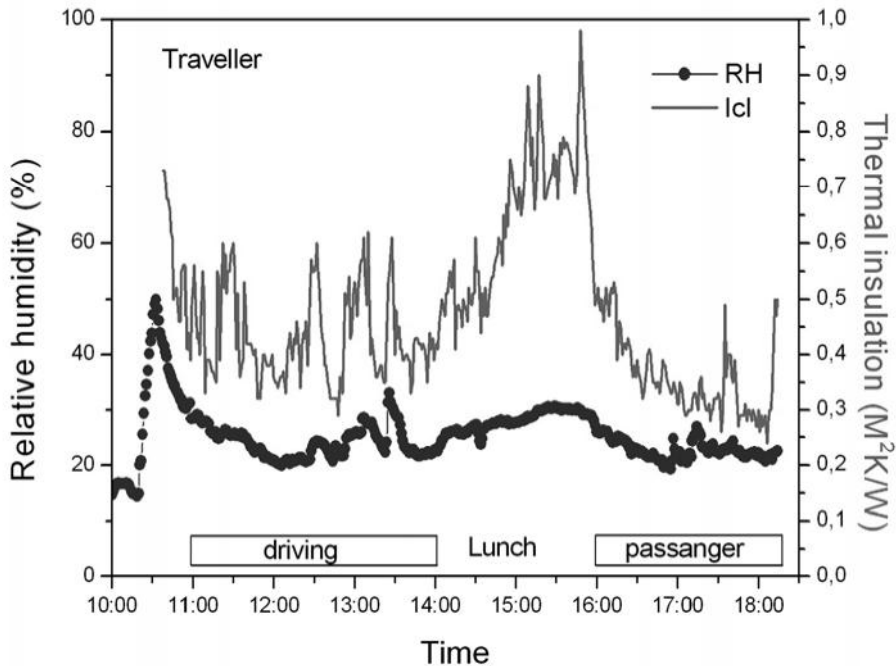


Figure 6. Thermal insulation and relative humidity between under and middle layers of the clothing worn by the tourist during the Arctic snowmobile safari.

Mean skin temperature ( $T_{sk}$ ) of the guide was lower than that of the tourists during the safari (Figure 7 and Figure 8), but extremity skin temperatures were higher. General thermal sensations of the guide varied from “slightly cool” to “warm”. In the end of the safari the guide felt “cold” sensation on the face. When the tourists were driving the snowmobile general thermal sensations varied from “neutral” to “warm” and when sitting as passenger “slightly cool” to “neutral”. The coldest sensations were experienced in fingers and toes.

The heart rate of the guide varied between 90 and 180 beats/min and the average heart rate was 130 beats/min. According to this, the work of the guide can be considered heavy. When driving the snowmobile, the heart rate of the tourists were  $116 \pm 15$  and  $105 \pm 10$  beats/min, and when being a passenger  $89 \pm 13$  and  $105 \pm 9$  beats/min.

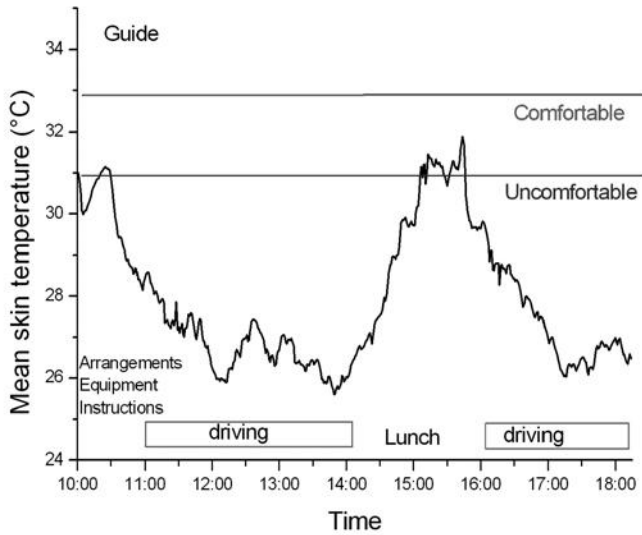


Figure 7. Mean skin temperature of the guide during the snowmobile safari (55 km).

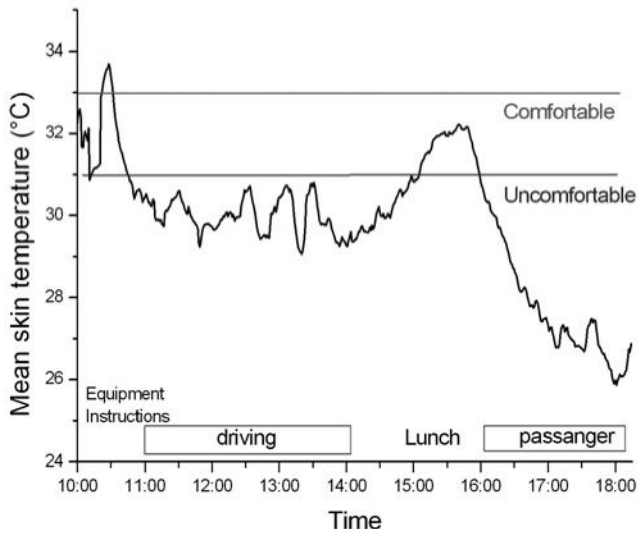


Figure 8. Mean skin temperature of the tourist during the snowmobile safari (55 km).

## 10.5 Conclusions

During the night in the igloo, core and skin temperatures were at a safe level and the stage of deep sleep could be attained. According to the results, sleeping in the igloo is safe for a healthy person with adequate thermal protection from clothing. It was recommended that hands and feet were protected with additional pairs of gloves and socks before going to sleep in the igloo.

The guides are acclimatized to the cold and they, as experienced outdoor workers, are able to adjust the thermal insulation according to physical activity and ambient conditions. However, tourists are less well adapted to the cold. Thus the guide can cope with less clothing than tourists. Sweating during gear pick-up in a warm storage room before the safari should be avoided. Tourists should pay particular attention to protecting their feet and hands from the cold.

## 10.6 Acknowledgements

This research was carried out as part of a project called Protection and Safety of Tourists and Tourism Workers, which was financially supported by the European Union (European Social Fund), for which the authors wish to express their thanks.

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# 11 AN ASSESSMENT OF RESPIRATORY PROTECTIVE EQUIPMENT PROGRAMMES IN UK INDUSTRY

N. Vaughan and N. Bell, Health and Safety Laboratory, UK

This presentation describes the findings from a qualitative study examining respiratory protective device (RPD) programmes across UK industry. Managerial decision-making was the focal point for this research, given that decisions about RPD programmes rest with management. This cross-sector, exploratory study set out to address research on: what current RPD selection and use looks like; how this compares with 'good practice'; and what factors influence the choice and implementation of RPD programmes.

A multidisciplinary team conducted on-site observations and management/staff interviews to gain an understanding of the levels of practical and theoretical competence and control of respiratory risks at each site. Considerable variation was found in the various companies visited. Four groupings of companies were derived:

- Learners - were in the very early stages of development of their RPD programmes and still had some way to go before both competence and control are established.
- Developers - had developed competence, but were failing on the implementation side of their programme.
- Fortuitous - lacked competence, but despite shortcomings in the management system, were in control of respiratory risks.
- Proficient - meaning that management were considered to have at least an acceptable level of RPD competence and controls did appear to be working.

Even "proficient" companies had room for improvement in the management and execution of their RPD programmes. The work identified priority areas for addressing the various shortcomings of these different groupings, primarily associated with improved training at all levels, supervision of RPD use, and maintenance of RPD.

This work was funded by the UK Health and Safety Executive (HSE). Its findings, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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## 12 PEROSH PROJECT - WORKPLACE FIT FACTOR FOR RESPIRATORS

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*European Project (PEROSH) - Determination of Workplace Protection Factors (WPF) for Respiratory Protective Devices*

For Respiratory Protective Devices (RPD) to be correctly selected they must be adequate for the type and level of contaminant and suitable for the environment, the task and the wearer. Adequacy is often assessed based on the protection factor that has been assigned to specific types and classes of RPD – the Assigned Protection Factor (APF). These APFs, set by various regulatory authorities or standards institutes, were based, where possible, on data obtained from workplace protection factor (WPF) studies. However, these studies followed different protocols. Additionally, due to the lack of workplace data available, professional judgement played a part. This resulted in a large variance in APFs.

While the CEN standards have helped to open up trade and provide a harmonized European performance baseline for RPD, the selection and deployment of RPD across Europe (and wider) still has one major barrier to harmonization – the variance in the APFs. This is further compounded when the US market and their APFs are brought into the equation. This discord between APFs can often result in RPD users having to locally implement a more complex, and therefore costly, RPD programme when RPD is used by companies that operate across borders.

One of the goals of this project undertaken through the Partnership for European Research in Occupational Safety and Health, PEROSH, is to carry out WPF studies to obtain a measure of the real performance of RPD in the workplace to provide data for a much needed review of current APFs.

With the global economy in mind, RPD standardization was transferred from CEN to ISO under the governance of ISO/TC94/SC15. As part of the suite of new ISO RPD standards, a new selection, use and maintenance standard is under development. One very important subject that the ISO committee responsible for this standard had to tackle was the variance in the APFs across the globe. Without a harmonized system for the development of APFs, the committee came up with a new approach for assigning a 'protection factor' to RPD. The new approach was to look at the current Nominal Protection Factors (NPF) for various RPD types and classes and how they relate to their respective current assigned protection factors. EU and US APFs and NPFs were reviewed. Because these new 'Protec-

tion Levels' were derived from a comparison of existing protection factors and not from any new workplace data, the ISO committee acknowledged that the proposed protection levels need to be validated via workplace studies.

Although not the primary focus of the PEROSH project, the outcomes of this project will help ISO in their work.

This presentation will provide an update on the PEROSH WPF project, outlining the project aims and objectives; discuss the problems resulting from the discord between APFs, the workplace protection factor study phase and the need for additional partners to assist in the delivery of the project.

Any opinions and/or conclusions expressed are those of the authors alone and do not necessarily reflect the policy of the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung or the Health and Safety Executive.

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## 13 INTERACTIONS BY DIFFERENT TYPES OF PPE WORN SIMULTANEOUSLY

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### 13.1 Introduction

In many workplaces, different types of PPE have to be worn simultaneously, because protection against one or more health and safety hazards is required or simultaneous protection of adjacent parts of the body against combined risks is needed. In such workplaces where the presence of risks makes it necessary for a worker to simultaneously wear more than one item of personal protective equipment, such equipment must be compatible and continue to be effective against the risk or risks in question.

Examples of CE-marked sets of PPE on the market show that compatibility of PPE items offered within those sets are at least questionable.

Several sets consisting of two or three items of PPE were found where eye protection and respiratory protective equipment may affect each other in the area of the bridge of the nose. Leakage can be expected to occur either from the eye protector or the respiratory protective equipment or from 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 is 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 user cannot find a safe fit for the helmet on his or her head.

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

An example of a 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.

In practice, the question "Who is responsible for the assessment of PPE compatibility, when more than one item of PPE has to be used?" occurs in particular when sets of PPE items are offered on the European market either as complete sets in one package or in several packages but are foreseen by the manufacturer(s) to be used simultaneously as specified in their user information.

## 13.2 Methods

### 13.2.1 Analysis of occurring situations

#### 13.2.1.1 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 the responsibilities of the manufacturers, Notified Bodies and authorities (e.g. market surveillance).

As part of 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 or her protection. Among other obligations the employer has to consider PPE compatibility and PPE combinations within the selection of PPE and subsequently 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 concerned with corrosion protection, clean-up operations in combustion equipment, mine rescue brigades and building clean-up operations.

#### 13.2.1.2 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. Therefore they are 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 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)).

### 13.2.2 Overview of the Council Directive's specifications

Based on the Council Directive 89/686/EEC (1) specifications to be found in

- Article 1, 2. PPE definition (a), PPE combination
- Article 10, 4. (b) "Examination of the model"
- Annex II, "BASIC HEALTH AND SAFETY REQUIREMENTS", Clause 1.2.1. "Absence of risks and other 'inherent' nuisance factors"

- Annex II, Clause 1.3.3. "Compatibility of different classes or types of PPE designed for simultaneous use".

The following summary is provided:

In all cases where PPE items have been integrally combined by the manufacturer, or the manufacturer makes PPE items available for simultaneous use as specified in their 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.

### 13.2.3 Analysis of resources for manufacturers and Notified Bodies' assistance

Up to now, only a few standards have been available for the 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, and so on. Therefore, compatibility of devices, being members of different types of PPE, is often not (yet) covered satisfactorily. Therefore, a report published by KAN back in 2002 specified recommendations concerning the standardization (4), with particular importance attributed to coordination and cooperation between the working groups and committees concerned.

In cases where the employer selects and combines 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 interactions of PPE with the aim of assisting manufacturers and Notified Bodies 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/psa](http://www.dguv.de/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."

## 13.3 Results

### 13.3.1 Risks possibly covered by PPE

Only known, relevant, existing hazards with regard to PPE are considered within the analysis that has been realized. Those hazards are described in the literature mentioned above. The matrix in Figure 1 may be completed as soon as new PPE or new PPE combinations arrive on the market or in manufacturers' laboratories. The black check mark symbols X indicate the risks to be covered by the PPE as specified in the Commission communication (3) and the red check mark symbols X present the completion of the matrix as found in the Rules of the German Social Accident Insurance (DGUV) for the use of PPE.

"Biological hazards" and "ignition of an explosive atmosphere" had to be added to the Commission communication's list of hazards (3). More details are not presented here, because the matrix shown in Figure 1 should only be an aid to becoming as aware as possible of the risks to be covered by a PPE in question. The focus of this paper is on the hazards brought about by combining PPE.

Nevertheless, some check mark symbols might be disputable for the reader. Therefore, a brief explanation is given for some of them:

- A mechanical hazard indicated for the respiratory protective equipment occurs if blasting material is used.
- Thermal hazards are mentioned in relation to respiratory protective devices for self-rescue.
- The risk of non-visibility may occur if a PPE designed to prevent drowning is not well equipped with retroreflective areas.

Possibly risk and protection	Head protection	Eye and face protection	Hearing protection	Respiratory protective equipment	Hand protection	Foot protection	Protective clothing	PPE designed to prevent drownin	Equipment for protection against falls from a height
Mechanical hazards	X	X		X	X	X	X		X
Electrical hazards	X				X	X	X		
Thermal hazards	X			X	X	X	X		
Non-visibility	X?						X	X	
Specific hazards*		X			X		X		
Thermal/mechanical hazards	X	X	X	X	X	X	X		
Cold	X	X			X	X	X		
Chemical hazards		X		X	X	X	X		
Biological hazards		X		X	X	X	X		
Radiation hazards		X		X	X	X	X		
Noise			X				X		
Effects of dangerous substances in inhaled air				X					
Lack of oxygen in inhaled air				X					
Vibration					X				
Contamination					X		X		
General hazards**					X		X		
Humidity						X	X		
Drowning								X	
Impact									X
Ignition of an explosive atmosphere				X		X	X		

Figure 1: Matrix of risks possibly covered by PPE

\* Stress arising from use; puncturing by low-power foreign bodies

\*\* Contact; use-related stress.

## 13.4 Hazards of combining PPE

Only known, relevant, existing hazards with regard to combinations of PPE are considered within this analysis. The matrix shown in Figure 2 may be completed as soon as new PPE combinations occur on the market or in manufacturers' laboratories.

For combinations of head and eye/face protection, PPE has to be compatible and accessories for industrial helmets to protect the eyes must also fulfil EN 166 "Eye protection".

If head protection or respiratory protective equipment or protective clothing and hearing protection are combined, the head band of an ear muff may be not compatible. For the combination of head and hearing protection, a helmet-mounted ear muff or ear plugs may be used instead.

An abrasive-blasting respirator as a combination of head, eye or face protection and respiratory protective equipment must not only provide respiratory air, it must also protect the user's head, eyes, face, cervix and shoulders.

For the combination of head protection and PPE against falls from a height, a chin strap is required for head protection.

If eye and face protection is worn simultaneously, they may not be compatible because of their dimensions and/or the user's build. This may impair the protection against specific hazards.

A combination of eye/face protection and hearing protection may decrease the attenuation of sound by an ear muff due to bulky ear pieces connected to the goggle's frame. Measurements carried out by IFA resulted in a decrease of sound attenuation of up to 14 dB, i.e. the exposure sound pressure will be increased by 25 times.

A combination of ear plugs and ear muffs may result in decreased attenuation because of leakage from ear plugs generated by contact with the ear muff's cups.

A breathing protective suit as a combination of respiratory protective equipment and protective clothing must not only provide respiratory air but also protect the body of the user.

If respiratory protective equipment is combined with equipment designed to prevent drowning, and if there is no defined self-flotation of the respiratory protective equipment, life vests with a minimum flotation ( $\geq 275$  N) are required.

Studies carried out by IFA revealed that several severe restrictions of the protective functions occurred if respiratory protective equipment and PPE against falls from a height are combined, and several fall scenarios were investigated. For more information, please visit the website at [www.dguv.de/ifa/de/fac/psa\\_kombinationen/index.jsp](http://www.dguv.de/ifa/de/fac/psa_kombinationen/index.jsp).

Combination of several items of hand protection may result in a derogation of motor functions of the hand, e.g. in 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 present differing durability.

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

Figure 2: PPE combinations, for which a decrease of protection level(s) may occur due to interactions, are indicated by the check mark symbol X.

A combination of protective clothing and equipment designed to prevent drowning requires life vests with a minimum flotation ( $\geq 275$  n) in case there is no defined self-flotation in the protective clothing.

In case equipment designed to prevent drowning is combined with a PPE against falls from a height, the formed total PPE is then a Category III product. The PPE against falls from a height is not allowed to hinder the inflation of the life vest.

If components of PPE against falls from a height are combined which are not compatible, severe accidents could occur. But this appears to not be a problem because manufacturers, Notified Bodies and users are well aware of this. However, combinations of guided type fall arresters with rigid anchor lines, where each component is produced by a separate manufacturer and/or the two products are tested by two Notified Bodies, may comprise the conformity with Directive 89/686/EEC (1). In this case, contractual relationships between the three or four bodies have to be established in order to fulfil all requirements of 89/686/EEC (1).

Investigations have shown that 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.

#### 13.4.1 Design levels required to combine PPE

In principle, two design levels required to combine PPE can be identified:

- Level 1: The manufacturer (distributor) needs knowledge like that available to employers for the selection of PPE to be worn simultaneously (e.g. combinations of head, eye, face, hearing protection).
- Level 2: To design the product, the manufacturer has to consider knowledge and experience in requirements for specific PPE combinations – such as PPE designed to prevent drowning and PPE against falls from a height. Those requirements are often not (yet) covered by standards and/or may depend very much on the performance of the specific product.

#### 13.4.2 How many certificates does the manufacturer need?

If the PPE components/items are to be connected/disconnected by the user and they are placed on the market separately, the manufacturer(s) may need two certificates. Examples are face shields attached to helmets, helmet-mounted ear muffs and PPE designed to prevent drowning attached to PPE against falls from a height.

In case the PPE components/items are inseparably connected, only one certificate is required. An example is an abrasive-blasting respirator, which in addition fulfils the requirements for industrial safety helmets.



## 13.5 Discussion – PPE compatibility – perspective of those involved

Manufacturers should collect knowledge and experience required for the combination of PPE under their responsibility and consider all relevant aspects and the risk assessment with respect to the compatibility of the PPE combined. They should bring about and support the development of test procedures in standardization as fairly as possible.

Manufacturers have to make sure that the products (including units constituted by several devices) placed on the market provide protection as claimed when selected and used accurately, i.e. according to 89/656/EEC (2) and the manufacturers' user information.

Notified Bodies should develop test procedures where products/prototypes already exist, but standards are not (yet) available. They should use the coordination of Notified Bodies to establish reliable test procedures which provide reproducible and comparable results, and they should establish the cooperation of the Vertical Groups concerned. In addition, they should inform the technical standardization committees concerned when standards need to be revised or developed.

Within the examination of the PPE model, the Notified Body should verify that it has been produced in accordance with the manufacturer's technical file and that it can be used in complete safety for its intended purpose.

When more than one Notified Body and/or more than one manufacturer are involved in the certification(s) of a PPE combination, the responsibilities of those Notified Bodies and those manufacturer(s) should be clarified.

Standards cannot cover all possible PPE combinations and thus the standards should only specify requirements for PPE combinations in widespread use. Manufacturers and Notified Bodies have to carefully consider interactions between the devices integrally combined by the manufacturer. This is often very difficult because harmonized standards for PPE are elaborated by technical committees responsible for one type of PPE only. Therefore, the compatibility of devices, being members of different types of PPE, is often not (yet) covered satisfactorily. It is necessary to strive for more intense cooperation and coordination between the various areas of PPE standardization in order to identify common PPE combinations and carry out standardization, with the involvement of the committees concerned.

Market surveillance should also collect knowledge concerning the PPE combinations required. It should take care of critical areas of the market, e.g. manufacturers with low levels of knowledge about PPE compatibility (such as inexperienced distributors or importers) or where no contractual agreement between the manufacturer of the PPE and the manufacturer of an interchangeable component has been established and problems occurred. Cooperation of the market surveillance bodies concerned should be established.

## 13.6 References

1. Council Directive 89/686/EEC of 21 December 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. Standardization in the field of personal protective equipment, KAN Report 12, 2nd, updated edition, 01/2002, K.H. Noetel et al. ([www.kan.de](http://www.kan.de)).

## 14 DEVELOPMENT OF GUIDANCE ON THE CONTROL OF THERMAL AND PHYSIOLOGICAL RISKS FOR WEARERS OF AIRFED SUITS

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Airfed suits are used for protection from radioactive particulate contamination. The nuclear industry and the UK Office for Nuclear Regulation (ONR) identified the need for clear guidance on the non-radiological aspects of their use, especially the management of ergonomic and physiological issues, including thermal stress. A major collaborative project was run by the Health and Safety Laboratory for ONR and nuclear industry stakeholders to gather evidence and information, and create ONR guidance.

The balance between engineering and behavioural safety issues for airfed suits is different for operational and decommissioning activities. The information gathering concentrated on decommissioning, but also took account of its differences with operational activities. Within decommissioning, the balance between engineering and behavioural aspects for airfed suits also changes according to the different aspects and tasks being considered.

Managing airfed suit operations safely and efficiently involves complex interactions between people, PPE and work systems. The information gathered confirmed that the safety of operations using airfed suits will depend on a unified approach which includes these different factors in a single strategy. Detailed implementation of this strategy can be adjusted according to specific tasks and hazards.

The ONR guidance, scheduled for publication at the end of January 2012, follows this approach, describing the key principles that need to be considered when managing the ergonomic and physiological risks from airfed suits, and how these can be tailored to different applications. The guidance has potential for application to other industrial situations that require the use of airfed suits.

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# 15 LIFE CYCLE DATA OF PPE WITH RFID SENSORS – NEW RESEARCH RESULTS

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*Keywords: AutoID, RFID, sensors, PPE, occupational health and safety*

## 15.1 Abstract

The aim of this research project is to develop new, innovative solutions for improving the occupational health and safety at workplaces using automation technologies such as Radio Frequency Identification (RFID) and sensor technology. Personal Protective Equipment (PPE) is the key tool for protecting the safety and health of individuals at workplaces. Thus, it is important to assure the appropriateness of PPE in fulfilling its primary characteristics. In this research, a tool is being developed to capture the life cycle data of PPE. Here, life cycle data refers to the information about PPE's functional and operational capability that can be identified using sensors and RFID technology. Initial tests were performed on safety helmets equipped with an RFID sensor kit. In these experiments, the effect of falling objects on the helmet in the laboratory was studied. With the aid of an acceleration sensor, which was fixed to the inside of the helmets, vibration and acceleration values could be automatically recorded and evaluated. In the next examinations, the material integrity of the helmet will be measured after being hit several times by heavy objects. Moreover, in order to examine the resistance of RFID components integrated in safety shoes on everyday work situations, including environmental exposure, it was necessary to integrate the RFID tags during the PPE production phase which was carried out in cooperation with a German safety shoe manufacturer. In this field study, 240 transponders were integrated into 60 pairs of safety shoes. These safety shoes have now been used for six months under real construction conditions, and have shown positive results. Furthermore, as a new direction for PPE life cycle data, safety and working platform nets will be examined with RFID technology with the aim of optimizing the process of safety nets inspection and its documentation. Here, RFID transponders will be applied to act as an identification label and a seal for the test meshes which make the information available to the users both centrally and locally. This means that life cycle data can be documented in a way that has not been done before. In conclusion, with having the life cycle data to hand, it can be decided whether the PPE functionality remains intact or if it has exceeded its useful life, or whether any external influences have destroyed its functionality. This information will consequently promote personnel health and safety at work.

## 15.2 Motivation for research

Official statistics of reportable work and commute-related accidents in Germany, which have been reported to the respective insurance carriers, are not detailed enough. Although they estimate absolute numbers, they do not comment on the background of those accidents that are fatal. A new study "Fatal accidents 2001-2010" by the German Federal Institute for Occupational Safety and Health (BAuA) aims to discover key areas to prevent further accidents. Proper use of appropriate personal protective equipment (PPE) is listed among the crucial factors to help the prevention of fatal and serious accidents at work. In the ten years under investigation, up to 328 people who had been involved in accidents (11.7%) would not have lost their lives if PPE had been stipulated or provided, and when available, it was used and then it remained intact. (Source: [http://www.baua.de/de/Informationen-fuer-die-Praxis/Statistiken/Unfaelle/toedliche-Arbeitsunfaelle/pdf/Unfaelle.pdf;jsessionid=B49DE13CF1368A6B33708FE045AF49B9.1\\_cid253?\\_\\_blob=publicationFile&v=8.](http://www.baua.de/de/Informationen-fuer-die-Praxis/Statistiken/Unfaelle/toedliche-Arbeitsunfaelle/pdf/Unfaelle.pdf;jsessionid=B49DE13CF1368A6B33708FE045AF49B9.1_cid253?__blob=publicationFile&v=8.))

Accidents cause personal suffering. Health problems experienced by workers lead to operational and economic losses. About EUR 1.57 billion would have been saved if downtimes were reduced by just half a day annually. The various items of PPE provide a large contribution to the prevention of occupational accidents. However, the PPE's time and usage-related performance characteristics are of great importance.

The KAN Report 39, (Time-dependent performance characteristics of personal protective equipment (PPE) and their inclusion in standards), from 09/2007 noted: "It is generally difficult to include the time and usage-dependent features in standards by merely setting the product design requirements. Because of numerous possible combinations of factors, such as the type and duration of use, external influences (e.g. UV radiation or climatic conditions) and the intensity of the effects on the PPE, the prediction of possible impacts is not fully possible. "The research project "Life cycle data acquisition of personal protective equipment with auto-ID systems" addresses these issues.

## 15.3 Preliminary works

The Chair of Construction Management & Economics at the Bergische University of Wuppertal, Germany, has dealt with the innovation potential of RFID technology (Radio Frequency Identification) in occupational safety and health for many years now within the research project "Safety Technology with RFID". This inter-disciplinary research project in the areas of work safety, safety management, process control and information and communication technology was funded by the German Social Accident Insurance (DGUV). In this project, an RFID (UHF) control gate was developed to improve the occupational safety and health at workplaces across all industries. In the laboratory phase, several tests were performed with transponders, readers and antennae.

Due to the radio transmission of the stored data on transponders to the reading device, different arrangements of antennae and transponders were examined in order to achieve optimal reading results. The function of various transponders depends on the type of substrate. This interactivity between the carrier objects and the transponder made the detailed transponder tests inevitable. Apart from hardware modification, the module of “application-oriented development” includes the software development for the PPE control gate.

The special focus thereby lies in developing a cross-industry and internationally applicable solution which also considers data protection issues. The system is developed as an application server, with the ability to manage the software and databases via the Internet or an extranet. The advantages of this system architecture are the easy integration of software into existing data processing systems, and the possibility of remote administration. In this way the development goal is implemented, creating a low-cost software solution for small and medium-sized businesses. Moreover, the possibility of remote maintenance of the system offers ideal conditions for the use of RFID systems at the production sites.

By completion of the development and laboratory phase, the cross-industry applications of the developed RFID (UHF) control gate was experimented as part of a testing phase. These tests were performed on a construction site and at an automotive industry plant. In summary, it can be noted that RFID technology offers great potential for the sustainable improvement of occupational safety and health. There is also great potential here with respect to product liability law.

Based on the current research project, this means that the gate will not only be able to identify whether all required personal protective equipment (PPE) is worn, but it also shows the qualitative state of each PPE item. The completeness control of the required PPE in combination with the PPE’s degree of wear for each person provides a comprehensive safety inspection of equipment, which is subject to daily updates.



Figure 1: System functionality.

## 15.4 Methods, objectives and scope

### 15.4.1 Identification of PPE's time-dependent performance characteristics

Based on the KAN Report 39 and intensive discussions with experts such as PPE manufacturers and users, the first step towards the feasibility study of automatic detection of life cycle data was taken using the following safety objects:

- Safety helmet
- Respiratory protection device
- Welding mask
- Hearing protection device
- Safety shoes
- Fall protection device.

#### Safety helmet

The lifespan and the resulting protection effect of a helmet are mainly determined by the following factors: UV radiation from the sun and possible damages from external mechanical influences. To detect the effect of the sun's radiation, UV indicators are already in use. This red UV indicator is integrated into the helmet shell and is exposed to sunlight. Through the gradual change of the indicator's colour, the effects of UV radiation on the helmet material are observable. When the red indicator turns completely white, the helmet has lost its full protective effect and should be replaced. Practice has shown that the indicator is often covered with a label and thus it loses its warning effect. The automatic detection of the helmet status (e.g. by video image analysis) is almost impossible, even with objects that have not been manipulated. Similar studies for the detection of traffic signs, for example, have shown that a clear recognition of objects by means of colour analysis is very difficult. Here, in order to detect those mentioned factors automatically, the UV and shock sensors are examined.

#### Respiratory protection

The maintenance cycles for the respiratory devices are generally set at predefined intervals of three, six and nine months, depending on the load time. The maintenance, however, should be performed depending on the usage frequency and environmental factors. Another important aspect to consider is the working conditions of the user. Factors such as temperature and humidity, which the user is exposed to due to being under a breathing hood or in a protective suit, can afford additional information relating to maximum usage time of the PPE.

### Welding mask

Welding masks with a Speedglas filter offer users the advantage of a visor that is darkened only during welding. In this way, there is no need to pull the visor up and down. In order to ensure the proper functioning of this mechanism, a light sensor should be integrated inside the mask. Additional temperature monitoring in the mask is designed to provide information about the working condition of users and in case of overload it can suggest break times.

### Safety shoes

Safety shoes are designed to protect the operator from injuries that may be caused by falling objects, for example. With the use of sensors, the loss of function of safety shoes can be identified at an early stage and therefore be replaced.

### Fall protection

Safety belts are exposed during their service time to various external forces which can have an impact on their operational capability. Sensors that can detect pressure and tensile values provide an indication of the PPE status. Here, the test conditions prescribed by the DIN should be considered in the test series with sensor-RFID tags.

## 15.4.2 Identification of the appropriate Auto-ID systems

The identification of the appropriate Auto-ID systems is based on the previous studies carried out by the authors. According to this, RFID technology is the most appropriate means for recording time-dependent PPE performance characteristics. The RFID technology allows for the ability to automatically identify people or objects. With this technology, the data can be transferred in a contactless manner, without a line of sight between the tag attached to the object (RFID transponders) and a detection unit (RFID reader).

## 15.4.3 Identification of suitable AutoID system components

RFID tags can also be combined with intelligent sensors which are able to detect physical quantities such as pressure, temperature, vibration and moisture. The RFID technology's ability to transmit energy and information wirelessly opens up new possibilities for capturing life cycle data of PPE items. The functional principle of related experiments is described in Section 6 (see also Section 5).



#### 15.4.4 Assessment of the market conditions and documentation of results

Based on the findings from sections 4.1 to 4.3, and the analysis of manufacturing processes of PPE producers and also within the market assessment, the requirements catalogues are to be created for manufacturers of sensor-RFID systems and PPE producers. In these catalogues, the constraints of using RFID sensor transponders and the definition of limit values for the use of PPE objects should be described respectively.

### 15.5 Description of technology

From the expert interviews and extensive market research, it is concluded that sensor-RFID applications, especially those which monitor temperature and humidity by active RFID technology, already exist on the market. However, due to the high prices of active RFID technology and the lack of adaptability to integrate it into existing research results, active RFID technology is not pursued in the further investigation.

However, there are already some solutions for integrating passive and semi-active HF and UHF RFID technology with sensors. Here, essentially temperature and humidity sensors are used for monitoring cold chains. Enquiries by Auto-ID and sensor manufacturers and system integrators have shown that transponders integrated with different sensors (e.g. UV and vibration sensors) are currently available with no additional development effort and costs. Another problem is the different data transmission standards for the available transponders. Depending on the sensor transponders, it may be necessary to use different readers.

A solution to this problem is what is known as the Development Kit (DVK). After extensive market research, the RFID sensor kit, model DVK90129/EVB90129 from ProximaRF, was chosen because of its extensive features, availability and low price. The DPRK has a transponder board, a USB-RFID reader and a software control module

The transponder can simultaneously connect to four different sensors. Furthermore, the sensor transponders can be operated in passive or semi-active mode. To test the feasibility of the automatic detection of various PPE status (influencing factors described in Section 4.1), for example at an RFID-based PPE control gate or an RFID-assisted maintenance unit, various sensors were chosen to detect the following influences:

- UV radiation: UV sensor
- Effects of vibration/acceleration: Acceleration sensor
- Temperature effects: Temperature sensor
- Effects of operating time: Flow meter/operating hours counter
- Noise pollution: Noise sensor
- Stress due to bending: Yet to be determined
- Damages occur on puncture-resistant sole: Yet to be determined

- Pressure and tensile load: Pressure-tensile sensor.

## 15.6 Experimental set-up and results

### 15.6.1 Detection of shock effect on safety helmet

Initial trials by the RFID sensor kit were performed according to DIN EN 397 (test procedures for industrial protection helmets) at the Institute of Occupational Safety test laboratory of the German Social Accident Insurance (IFA). In these experiments, the effects of falling objects on a safety helmet were examined. By fitting an acceleration sensor in the interior of the safety helmet, vibration and acceleration values could be automatically recorded and evaluated (see Figure 2).

However, it was found that there is no direct correlation between the detected values and the condition of the helmet. The acceleration curve for the initial impact of the heavy ball on the helmet did not differ significantly between the third and fifth collision.

A significant difference was observed only after the helmet was visibly damaged.

At this point, further investigations are needed to evaluate the sensor data with regard to the operational capability of safety helmets. Therefore, the second test series at IFA is now in the planning phase aiming at discovering the above-mentioned relationships. The approach here is to examine integrity loss in the helmet, i.e. a breakdown of the material upon impacts with heavy objects. In order to predict such a failure, a significant acceleration curve should be observed by a critical strike, followed by a subsequent impact. Then the helmet would fail completely. Here, in collaboration with a renowned manufacturer of RFID components, an RFID sensor data logger system was developed to optimally adapt to the requirements of the new experimental set-up. These tests will be carried out shortly.

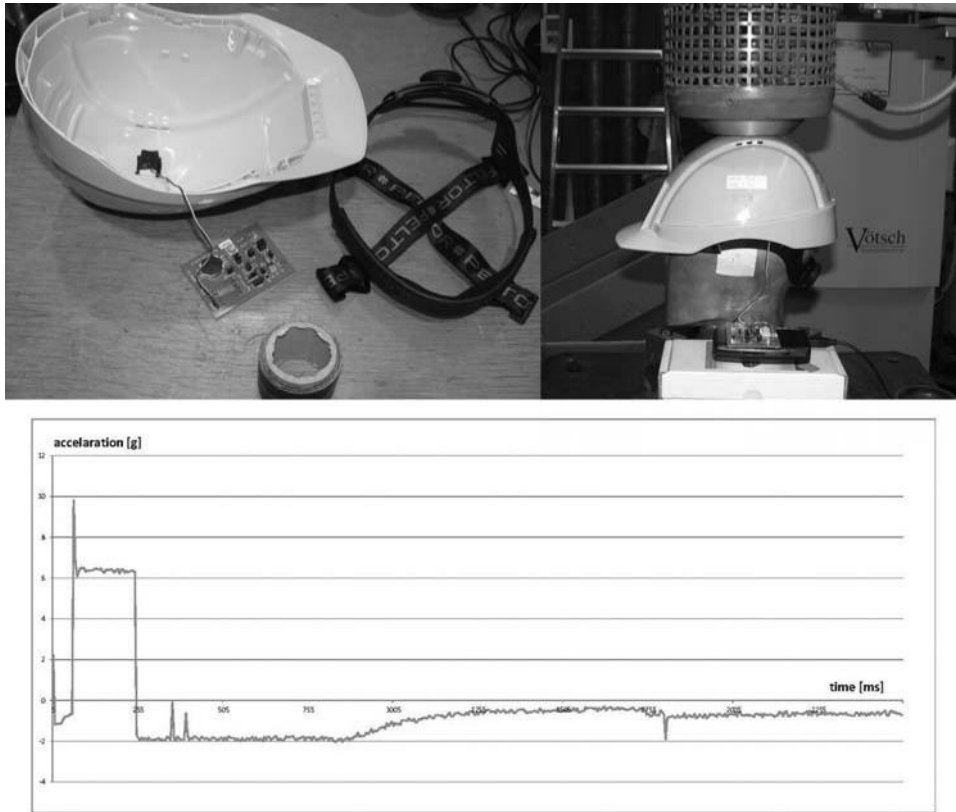


Figure 2: Laboratory test of helmets.

### 15.6.2 Capturing operating times and airflow rates of a respiratory device

To capture the amount of supplied air and the resulting operating time of a respirator, an air flow sensor is connected to the RFID sensor kit and integrated into the supply air tube. In this way, by automatic aggregation of the operating times, coupled with the measured amount of air flow, the maintenance cycles and filter operating times can be optimized (see Figure 3).

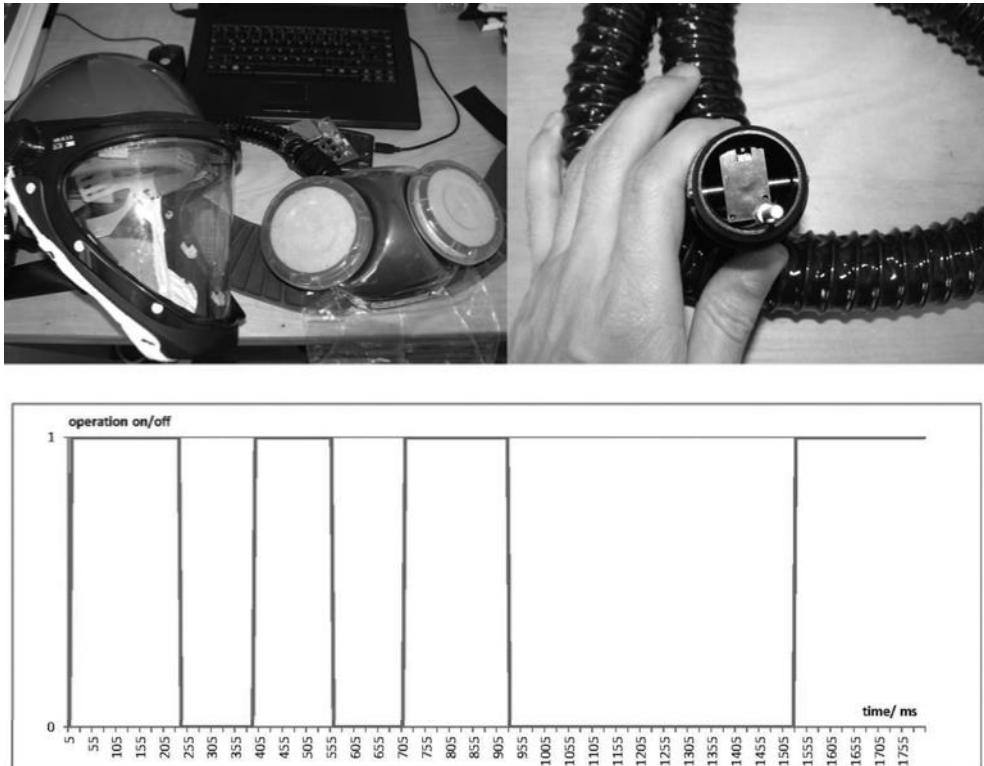


Figure 3: Laboratory test of respiratory protection device.

### 15.6.3 Capturing the light-load and switching times of the Speedglas filter

The tests to demonstrate the proper functioning of the Speedglas filter are performed in the laboratory of the Department of Electrical Engineering at the Bergische University of Wuppertal. Here, with the help of a welding device (type "Lorch V"), the electric arcs on a test specimen were generated. These investigations basically show that the verification of switching times and light-load at different levels of protection is possible (see Figure 4).

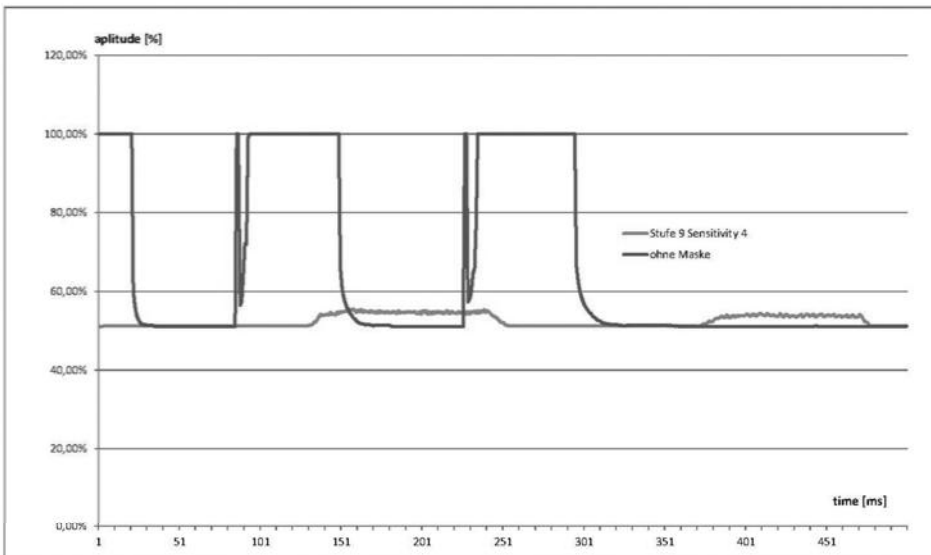
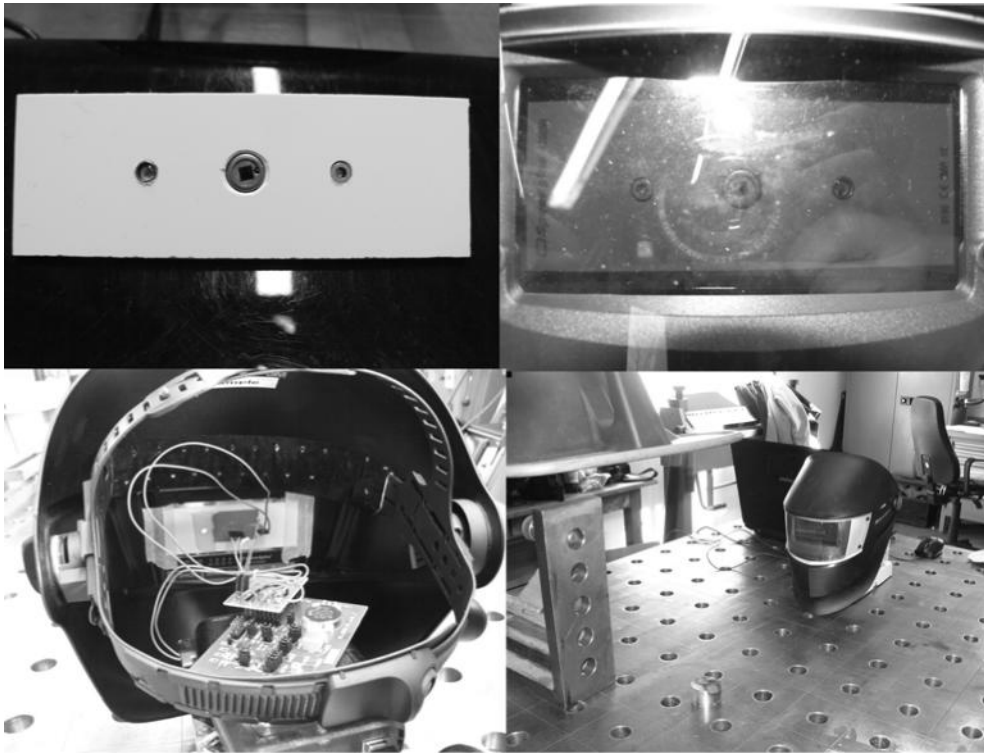


Figure 4: Laboratory test of welding mask.

## 15.6.4 Labelling safety shoes with RFID transponders

The integration of RFID components during the production phase is not only of great importance when collecting the life cycle data, but also for controlling their resistance to the external influences they are exposed to during the working day. To investigate these two aspects, in cooperation with a German safety shoe manufacturer, a field study has been designed and is currently ongoing. Here, a total of 240 transponders within the production phase were integrated into 60 safety shoes. These shoes are now being used for four months under the real conditions of a construction site. The initial results of this field study have proved to be comprehensively positive. Interim findings have shown that so far none of the integrated transponders are damaged (see Figure 5).



*Figure 5: Field study with safety shoes equipped with RFID.*

## 15.7 Future plans

### 15.7.1 RFID sensor technology

The laboratory tests with safety helmets will be intensified based on the new combination of RFID and sensor technology (see 6.1). Through the comprehensive adaptation of the data logger, it is hoped that more differentiated statements about critical impacts on the safety helmet will be obtained. The new system operates at a sampling rate of up to 400Hz, which is double that used in the previous system (DVK90129/EVB90129). This allows for obtaining more sensitive and accurate data. In addition, the data enclosure is more robust and its mounting into the helmet shell is optimized. In the forthcoming tests,

two data loggers are to be placed simultaneously in the helmet in order to investigate the effect of the data logger position in the helmet. Furthermore, two different helmet models will be tested and compared. They are also subject to tests after artificial ageing according to DIN EN 397.

### 15.7.2 Safety and working platform nets

In addition to the RFID sensor applications, the detection of life cycle data is to be experimented with, using safety and working platform nets. The safety nets normally have a life span of one year. This could be extended to a further 12 months, at which point the safety net's attached test meshes are also examined. This test is performed by an authorized body according to DIN EN 1263-1.

The net auditing is documented by attaching an inspection sticker to the safety net. The information includes the date of the audit, the next five test dates and the net identification number. To date, this data has not been stored centrally or by the net manufacturers or renters. A continuous life cycle data acquisition of safety nets is therefore not guaranteed by this procedure. Consequently, this will result in random and incomplete audits of safety nets, which is only possible by visual controlling the net's inspection stickers. However, higher-lying areas or inaccessible safety nets can only be tested with great effort, for example with the use of lifts.

Here, the specific purpose of collecting the safety nets' life cycle of data is to improve the inspection processes and their documentation using RFID technology. Therefore, the safety net identification label, the test mesh seal and the inspection sticker after each audit will be extended and placed on RFID tags. This information can be later accessed centrally or locally. By doing this, the documentation of safety net life cycle data can be optimized and performed without visual contact.

## 15.8 Conclusion

In various research projects, the idea of combining PPE objects and their owner's information with RFID tags has been implemented successfully. In addition, by capturing the life cycle and process data, the controlling and inspection of an individual's PPE and documenting the results, work accidents can be prevented, human lives can be saved and personnel logistics processes will be optimized.

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## 16 EXPERIMENTAL EXPERIENCES OF WINTER ACTIVITIES

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### 16.1 Introduction

Winter tourism is a huge business which involves a large number of people all around the world. The number of recorded nights spent by foreign visitors at accommodation in Finnish Lapland was about 35,000 in January 2011. In Northern Lapland the air temperature averages about  $-15^{\circ}\text{C}$  in January. Most tourists come to northern resorts from countries where the environment is warmer and snow more or less non-existent. Coldness is therefore a new experience for many of them. Moreover, special winter clothing may be unfamiliar and the knowledge relating to what to wear and how to dress for each winter activity might be insufficient. Experienced guides are acclimatized to cold and they know what to wear in each different circumstance. Therefore, their thermal responses may differ from those of tourists as shown in our previous study (Jussila and Rissanen 2012). The aim of this experiment was to investigate how people who are not adapted to the cold experience the winter environment during snowshoe walking.

### 16.2 Material and methods

Five male volunteers from five different countries participated in the study. Their mean ( $\pm$  SD) age was  $49.6 \pm 4.6$  years, height  $180.6 \pm 9.9$  cm and weight  $79.2 \pm 11.6$  kg.

The volunteers took part in snowshoe walking in a forest. The ambient temperature was  $-15^{\circ}\text{C}$  (iButton, Thermocron) and wind varied between 1.5 to 3.8 m/s. The duration and length of the walks were 55 min and 1.4 km, respectively. Mean walking velocity was 1.4 km/h (max 3.9 km/h) measured by GPS (FRWD Sport Performance Recorder, Oulu, Finland).

Three out of five volunteers wore their own long-sleeved and long-legged underwear. All had middle layer trousers and one or two middle layers on their upper body. One or two pairs of socks and gloves or mittens were worn. Four wore thermal coveralls and boots provided by the safari organizer and one had his own winter jacket and boots.

Core temperature ( $T_{\text{core}}$ ) was measured using an ingestible temperature capsule (Jonah™ Temperature Capsule, Mini Mitter Company, Inc., A Respironics, Inc. Company, Bend, OR, USA) and was monitored by data logger (VitalSense® physiological monitor, Mini Mitter Company, Inc., A Respironics, Inc. Company, Bend, OR, USA) at one-minute intervals. Skin temperature was measured from the forehead, cheek, chest, upper back, lower back, lower arm, hand, finger, thigh, calf, instep and toe using thermistors (NTC

DC95; Digi-key Corp., Thief River Falls, MN, USA) taped over the skin with flexible tape (Fixomull stretch, BSN Medical GmbH & Co, Hamburg, Germany). Skin temperature was continuously recorded and saved into a data logger (SmartReaderPlus8, ACR Systems Inc., Surrey, BC, Canada) at one-minute intervals. Heat flow was measured at five sites: upper arm, chest, upper back, abdomen and thigh using heat flux transducers (Model Ha13-18-10-P, Thermo-netics Co, USA) and saved into the data logger (SmartReader-Plus7, ACR Systems Inc., Surrey, BC, Canada) at one-minute intervals. Relative humidity and temperature between underwear and middle-layer shirts was measured using a temperature and humidity data logger (OM-CP-MicroRHTemp, Omega, Canada). Heart rate was recorded by heart rate monitors (Polar S610iTM; Polar Electro Oy, Kempele, Finland and Suunto T6, Suunto, Vantaa, Finland) and saved at one-minute intervals. Thermal sensation was determined using a seven-point standardized scale (ISO 10551, 1995). The rate of perceived exertion (RPE) was determined using Borg's scale (6 - 20) (Borg 1998).

Mean skin temperature ( $T_{sk}$ ) and mean heat flow ( $HF_{skin}$ ,  $W/m^2$ ) was calculated by weighing the representative area (Hardy and Dubois, 1938). Thermal insulation of the clothing ( $I_{cl}$ ) was calculated using the equation  $I_{cl}$  ( $m^2K/W$ ) =  $(T_{sk} - T_a)/(HF_{skin})$ , where  $T_a$  is ambient temperature.

## 16.3 Results and discussion

Snowshoe walking was moderate to hard physical exercise in the snowy forest with up and down hill periods. Mean heart rate was  $120 \pm 18$  beats/min but occasionally higher bouts (more than 150 beats / min) also occurred.

Measured thermal insulation of the clothing averaged  $0.30 \pm 0.04$  at the beginning, and decreased to  $0.25 \pm 0.05$   $m^2K/W$  during the walk. According to IREQ (ISO 11079, 2007) thermal insulation of the clothing should be 0.326 - 0.372  $m^2K/W$  for a low to moderate metabolic rate (140  $W/m^2$ ), 0.263 - 0.310 for moderate (165  $W/m^2$ ) and 0.248 - 0.295  $m^2K/W$  for a moderate to high metabolic rate (175  $W/m^2$ ) in the studied weather conditions. The lower value should provide slightly cool and higher neutral thermal sensation. In the present study the average thermal insulation of the clothing was appropriate for the moderate activity level. Wind, activity and moisture in the clothing reduced the  $I_{cl}$  during the walk.

Due to the physical activity, deep body temperature increased during the snowshoe walk (Figure 1). At the end it was recorded at  $38.3 \pm 0.25^\circ C$ . Mean skin temperature varied between 28 and  $33^\circ C$  (Figure 2). The decrement of  $T_{sk}$  was on an average  $1.65 \pm 1.1^\circ C/h$ . The decrement was mainly caused by the decrease in local skin temperatures on the legs, hand and forehead. Some of the volunteers wore jeans or suit trousers as middle layer trousers (under the coverall) and thus local thermal insulation might have been too low for lower extremities.

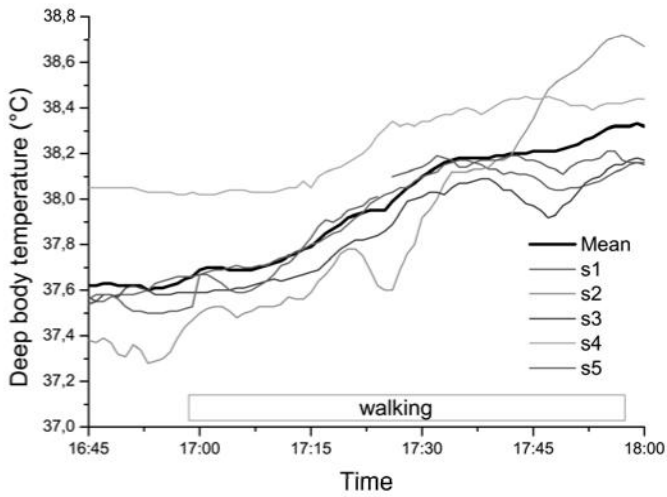


Figure 1. Deep body temperature during the snowshoe walk. Individual and mean values.

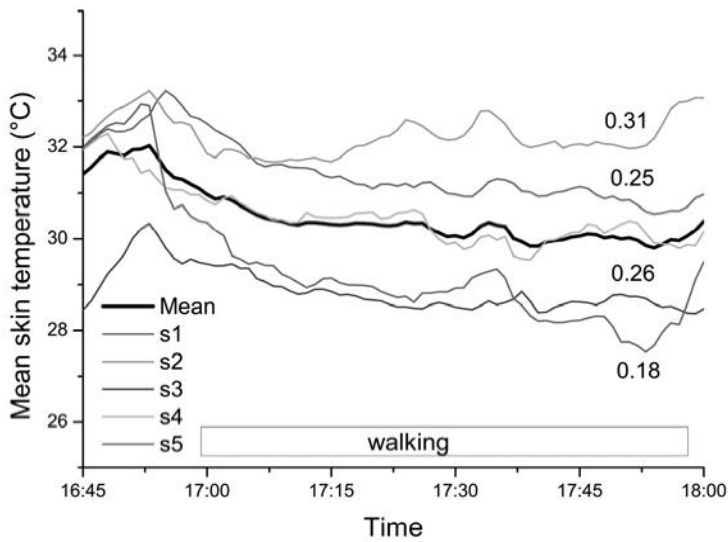


Figure 2. Mean skin temperature during the snowshoe walk. Individual and mean values. Individual values of total Icl ( $m^2K/W$ ) in the end of the walk are added for volunteers s1, s2, s3 and s5.

Finger and toe skin temperatures varied between the individuals, especially at the beginning of the walk (Figures 3 and 4). Volunteer s5 had the lowest finger and toe temperatures. The start of heat production resulted in an increase in finger and toe skin temperatures.

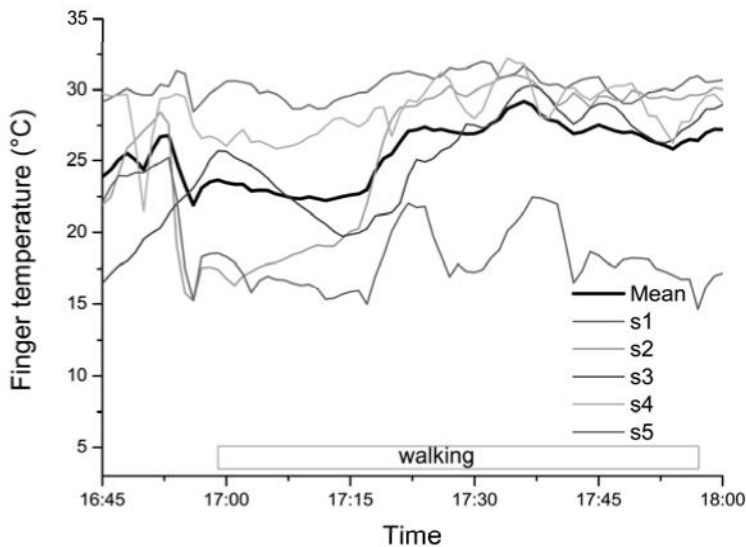


Figure 3. Finger skin temperature during the snowshoe walk. Individual and mean values.

The material and types of shoes or gloves used may have affected the low finger and toe temperatures and thermal sensation. Those who wore thermal mittens had warmer fingers than those who wore gloves. Faces felt cold because of wind and cold air. A hood or balaclava offers good protection for the face.

Mean relative humidity between the underwear and middle layer was on average 29 and 55% at the beginning and the end of the exercise, respectively (Figure 5). A significant variation is seen between the individuals (20 to 90%). Moisture in the clothing decreases its thermal insulation. During longer activity periods, high moisture inside the clothing may increase the cooling of the individual. Clothing feels dry if relative humidity is less than 40%.

The overall thermal sensation at the beginning was "neutral" - "slightly cool" and in the middle and at the end "neutral" - "warm/hot". Fingers were "neutral" or "warm" at the end. The thermal sensation of toes depended on the shoes being either "cold" or "neutral/warm". Wind and cold affected the thermal sensation on the face and was rated "slightly cold/cold". RPE was "somewhat hard" - "hard". Skin felt "slightly moist" for all the volunteers.

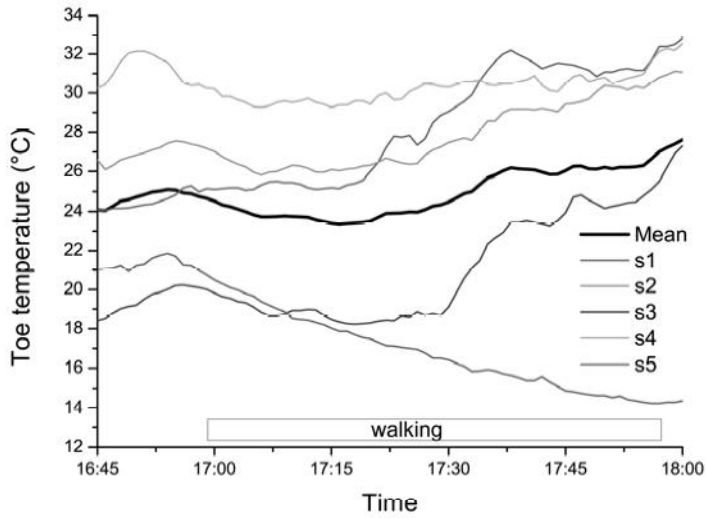


Figure 4. Toe skin temperature during the snowshoe walk. Individual and mean values.

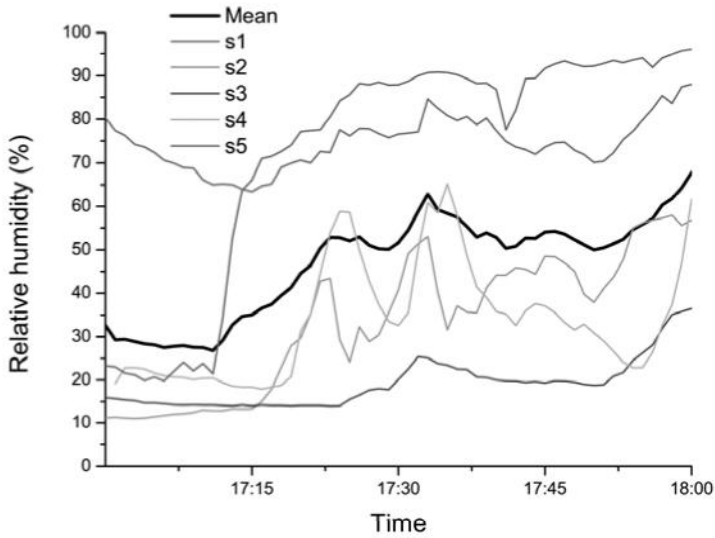


Figure 5. Relative humidity between underwear shirt and middle layer shorts during the snowshoe walk. Individual and mean values.

## 16.4 Conclusions

In conclusion, snowshoe walking is a physically moderate to hard exercise experience in snowy and hilly forest terrain. The measured thermal insulation of the clothing worn was in accordance with the activity level and ambient temperature. However, guidance is needed in terms of what kind of clothing materials and hand and foot protection is appropriate during physical activities in cold winter conditions.

## 16.5 Acknowledgements

The authors would like to offer warm thanks to the volunteers who participated in this study. We gratefully acknowledge the seminar organizers for arranging the snowshoe experience. The study is part of the EU-funded (European Social Fund) project called Protection and Safety of Tourists and Tourism Workers.

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# 17 USING HYBRID FANCY YARNS IN TECHNICAL TEXTILE PRODUCTS PROTECTING AGAINST EMF

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## 17.1 Introduction

Different pieces of equipment can function as the source of an artificial electromagnetic field (EMF) of significant intensity values. Artificial sources of EMF can be used in radio communication, industry, medicine and science. Not only does occupational exposure to EMF depend on the construction of the equipment generating the EMF but also on the nature of activities resulting from the need to use the piece of equipment. Individuals performing temporary activities connected with the servicing, inspecting or repair of a piece of equipment may be working in the surroundings of the EMF source, e.g. an oven, bonding heater or capacitive welders for plastics, or aerial systems. Typical field intensity values for capacitive welder stands are: 20 - 1700 V/m and 0.04 - 14 A/m. A significant problem of great exposure to EMF concerns work carried out on masts used in multi-function structures such as radio and telecommunications broadcasting centres. Basic work during which exposure to EMF can be observed includes maintenance of mast construction, pull-offs, wiring systems, replacement of lights, and maintenance of aerial systems, mainly cable terminals and power dividers. When work on aerial systems is carried out on masts, special conditions of exposure to EMF exist and the exposure can be excessive or even unacceptable. These conditions are primarily found in working conditions where work is carried out on masts – at high altitudes above the ground (even up to 300 m), with strong air movements, temperatures lower than the temperature at the ground level, proximity of a number of primary sources with different field characteristics. They are also found on platforms under or above aerials (where workers walk) and barriers. The above-mentioned special and dangerous working conditions require the use of personal protection against EMF. The equipment must ensure functional comfort and freedom of movement, it should be flexible, resistant to tearing and allow for heat energy exchange and sweat absorption. Such a complicated structure of personal protection equipment against EMF results from the need to meet the most significant requirement – human safety in areas with strong EMF near the source, as a result of which the requirement of working comfort is not fully met.

Energy will be transferred to a material (e.g. biological) object present in the EMF zone. The energy can react with living organisms through the following physical mechanisms:

- 1) Induction of electric charge (static electricity) on surfaces (including the body surface or individual tissues),
- 2) Induction of an electric current inside the object,

- 3) Induction of dipoles and irreversible impact on dipoles (orienting them according to the field direction).

Protection against EMF can be of a collective or personal type. Collective protection methods include shielding sources of EMF from areas of human presence with the use of screens made of reflective materials as well as metal meshes and walls. Personal protection includes protective hooded overalls made of textile fabrics or non-wovens incorporating embedded metal meshes with good electric conduction. Directive 2004/40/EC (1) allows for performing work in zones with very strong EMF with intensities exceeding the admissible values if a person working in the zone uses personal protection with appropriate effectiveness. There are a few types of PPE (Personal Protection Equipment) available on the market that do not satisfy the above-mentioned requirements sufficiently. Coated composite materials (fibrous) with a smooth electro-conductive thread (forming a special Faraday cage) are most commonly used. They are effective against the electric component of EMF but do not attenuate the magnetic component. Shielding is currently used to protect humans against EMF. Shielding is provided by plastics with conductive material admixtures – prepared samples include textile materials of a textile fabric type with every fourth thread in the warp made of a conductive fibre and a textile fabric of an electro-conductive non-woven type: stitched in one direction with polyester silk, in another direction with polyester silk and then finished and needle-stitched with electro-conductive non-woven: 2 mm and 3.5 mm thick. The results of attenuation effectiveness tests on fabrics based on electro-conductive non-wovens depended on the number of used non-woven layers and the angle of their arrangement. A number of findings from EMF shielding with products made of metal-coated or chemically modified fibres have been reported recently:

A Das, V K Kothari, A Kothari, A Kumar & S Tuli (2) and R Perumalraj, B S Dasaradan (3) carried out research on protection against EMF using a fabric containing copper filaments in 2009.

Swiss Shield (4) offers textile products that reduce the electric component within the frequency range up to 10 MHz from the order of 80 dB and the magnetic component up to 50 dB (Figure 1).

The research into EMF attenuation with shields made of amorphous metals and non-wovens modified with metallic copper were carried out in the Central Institute for Labour Protection in Warsaw (the electric component attenuation within the frequency range 0.8-3 GHz was 25-40 dB for a barrier material and 20-35 dB for protective clothes) (5).

None of the studies were concerned with an innovative solution of using hybrid fancy yarns with the effect of an electro-conductive solenoid on a ferromagnetic core in protective clothing. Based on literature review it can be concluded that so far magnetic component attenuation has not been ensured by textile personal protection against EMF within high frequency ranges, i.e. above 100MHz. There are few documented records from research on the magnetic component attenuation with textile personal protection against EMF – only Swiss Shield offers thick, multi-layer textile products attenuating the magnetic component up to 50 dB for frequency values below 10 MHz.



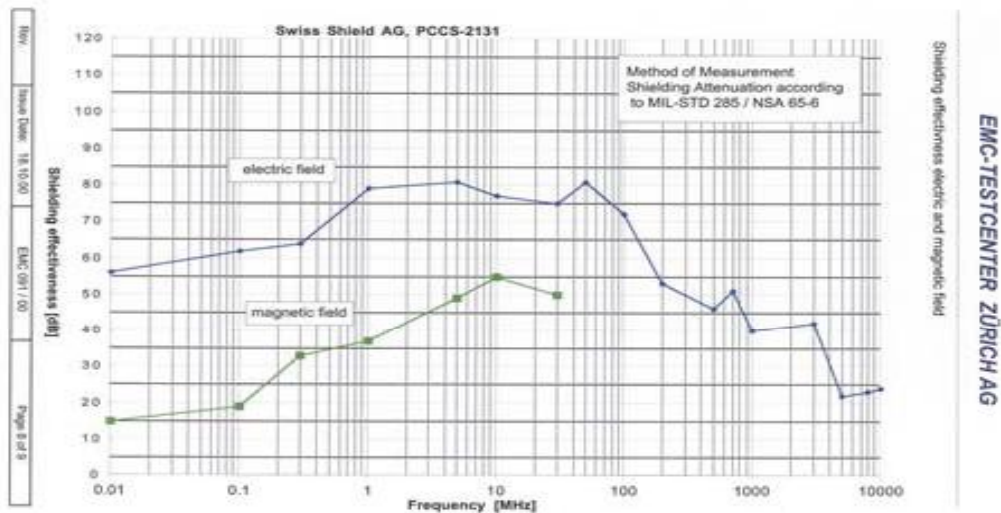


Figure 1: Shielding effectiveness of textile fabrics manufactured by Swiss Shield (4).

## 17.2 Methods

Using electro-conductive threads as component threads in a fancy yarn, we create a hybrid multi-component thread. An analogy was observed between a bunch yarn construction (Figure 2 and Figure 3) and a system of solenoids connected in series on a ferromagnetic core (Figure 4). A bunch yarn consists of three components: core thread, special effect thread (wrapped on the core yarn) and binding thread. The special effect thread forms local roller-shaped thickenings on the core thread, created as a result of a local wrapping of effect yarn on the core component of fancy yarn. It is called a bunch yarn since the basic effect is created as a long roller-bunch in the form of a winding. It is possible to obtain this result when the movement and speed of the effect yarn is temporarily different from the core, and it affects the yarn feeding speed in the twisting zone.

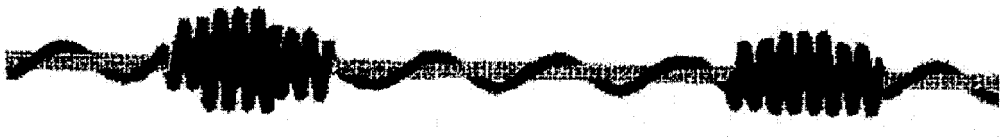


Figure 2. Bunch yarn construction.

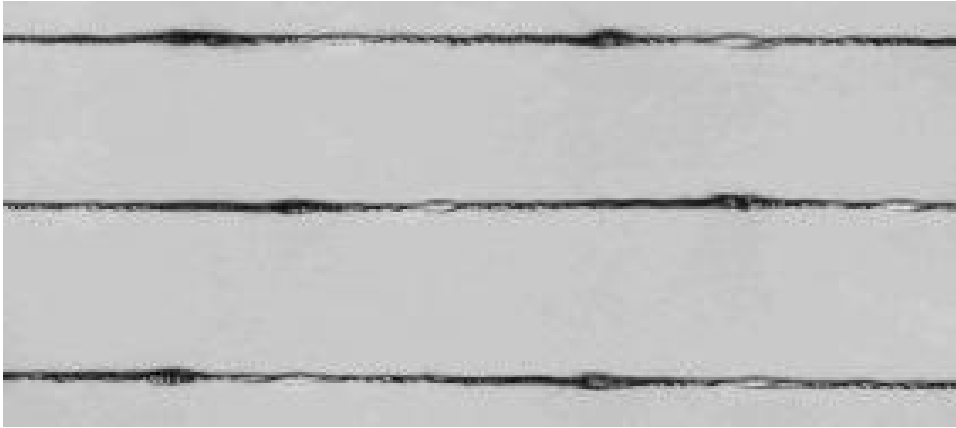


Figure 3. Fancy bunch yarn.

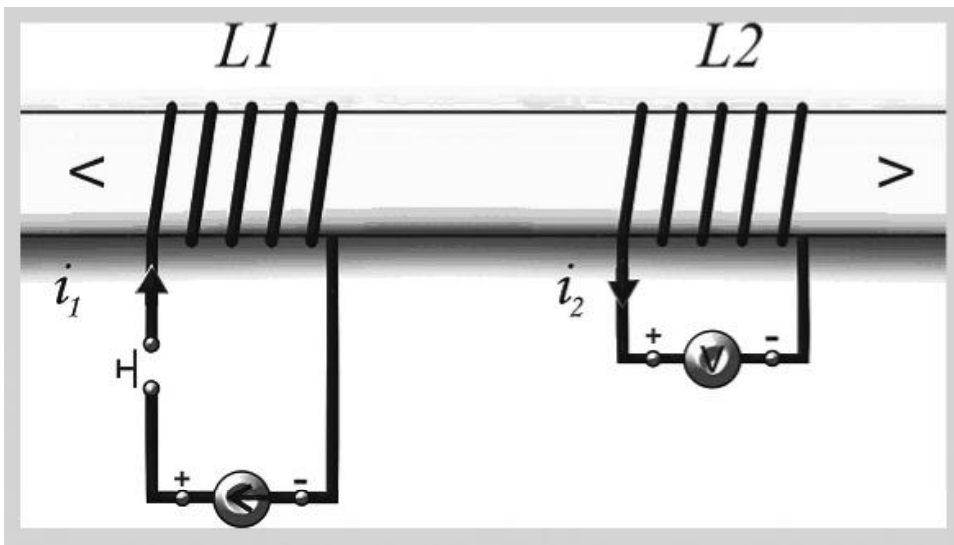


Figure 4. Solenoid systems connected in series in an electric circuit.

The unique character of the suggested solution consists of finding an analogy between the construction of a three-component bunch fancy yarn and a system of solenoids connected in series. The use of electro-conductive threads as componential threads will allow for the creation of a system of solenoids (copper) on a ferromagnetic core (steel thread) with binding thread (stabilising effects on the core-synthetic thread). In this way, a hybrid

fancy bunch thread with ferromagnetic and conductive properties, which will be introduced as one of many wefts on a shuttle weaving loom, will be created. An extreme solution to this problem (the best one, and that which was used in these experiments) is a long conductive solenoid (copper yarn) on a ferromagnetic core. The use of a shuttle weaving loom will allow for the continuous introduction of the above-mentioned hybrid thread as a weft in a protective textile fabric (Figure 5) and thus create a closed electric circuit with solenoids connected in series on a ferromagnetic core (with no need to cut off the edge of cloth, in the case of other loom use).

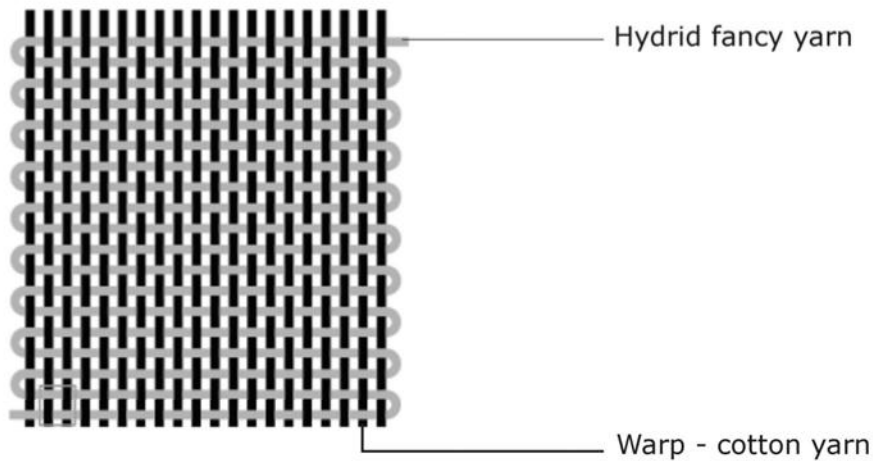


Figure 5: Plain weave produced on a shuttle loom (weft not cut).

It is an innovative solution used for attenuating EMF by individual attenuating textile fabrics with a greater functional comfort as a result of using textile fabrics with different components and types of weaving. Moreover, according to Maxwell's law, it is possible to attenuate the magnetic component of EMF in such a circuit, which is only effectively possible in the current state of technology as a result of using thick lead or steel plates that definitely do not provide comfort of use as personal protection against EMF.

## 17.3 Results

Table 1: List of test results on electric component shielding effectiveness [dB].

Frequencies Hz	Sample A dB	Sample A dB	Sample B dB	Sample B dB
30	51.2	42.0	43.7	43.8
50	50.8	41.6	43.4	44.2
100	50.4	41.3	43.0	44.2
300	50.0	40.9	42.5	44.4
500	49.8	40.8	42.4	44.8
1k	49.7	40.7	42.3	46.9
3k	47.6	40.4	41.5	41.3
5k	47.6	40.3	41.4	41.2
10k	47.3	40.1	41.3	41.0
20k	47.1	40.1	41.1	41.0
30k	46.8	40.5	41.3	41.3
50k	39.8	37.4	38.0	37.7
1M	37.6	36.8	32.6	> 40
5M	37.5	> 40	> 40	> 40
50M	29.2	25.5	18.0	25.0
100M	28.7	26.3	20.4	24.1

Table 2: List of test results on magnetic component shielding effectiveness [dB].

Frequencies MHz	Sample A dB	Sample A1 dB	Sample B dB	Sample B1 dB
100	15	0	1	1
200	7	4	4	5
500	6	2	4	7

## 17.4 Discussion

The measured results of tests (MR) on the electric K(E) and magnetic K(H) [(V/m)/(V/m)] field attenuation multiple ratio as well as electric field shielding effectiveness SE(E) of four samples of textile fabrics are presented in tables 1 and 2. All those results that prove greater shielding effectiveness against EMF in textile fabrics with hybrid yarns based on a ferromagnetic core wrapped by a conductive thread in a solenoid form against textile fabrics based on the same percentage of ferromagnetic and conductive threads (including the conductive thread crimp), but laid in parallel to one another (without the solenoid effect), (i.e. made in the way the problem of personal protection against EMF is solved globally), are marked in yellow. No attenuation of the magnetic component was discovered for the frequency band range from 30 Hz to 100 MHz. This is probably due to the fact that the samples that include the EMF attenuating elements were only arranged in the weft direction, since the practice EM fields could be polarized along the warp or the weft of the fabric or even in three-dimensional textile structures (not only in two dimensional plain fabrics, as in the experiment). These trials, based on the idea of fancy hybrid yarns (conductive solenoids on ferromagnetic core), are the first to prove the correctness of this idea. Only in the case of type B sample (solenoids made of Swiss Shield yarn on Bekinox VN 12/2x275/175S type core (steel)) was the magnetic component attenuation observed for high frequency band ranges above 100 MHz. It should be noted that Swiss Shield states [4] that the protective textile fabric they manufacture attenuates the magnetic component only within a frequency band range of up to 50 kHz (but they do not give any information on the textile fabric structure, including the number of layers used).

The attenuation ratio was determined based on the obtained results of electric and magnetic field measurements (or magnetic induction) without a sample (E0, H0, B0) and repeated with a sample (E1, H1, B1) for some specific field parameters. Shielding effectiveness was determined for samples whose field attenuation ratio was greater than 10.

The expanded measurement uncertainty range at the reliance level of 95% and for the expansion coefficient  $k=2$  for each measuring point was marked in the diagrams.

An assessment of whether the presented solution is sufficient to protect an employee against the impact of an electromagnetic field at each work site requires a detailed analysis of the existing exposure levels and an evaluation of whether the exposure will be sufficiently limited after the barrier has been introduced to satisfy the requirements of OHS regulations. If new materials are used in PPE to protect against EMFs, particularly using a system of conductive electric coils on a ferromagnetic core, it is important to consider interference from the following fields: 1) electromagnetic field with a variable source, 2) secondary electromagnetic field with an opposite direction, induced by an electric system of solenoids on a ferromagnetic core, and 3) electromagnetic field induced as a result of to-and-fro motion and/ or rotating motion of an electric system of solenoids on a ferromagnetic core against the source field created as a result of work done in a danger zone.

If it is necessary to limit an employee's exposure to the danger zone fields, to be able to reduce the exposure level at least to the level of the danger zone fields the field attenuation ratio by the barrier material should be at least 5-10 times (13-20 dB). Fabrics with better parameters have a wider range of potential functional uses, which is particularly true for type A fabric (ferromagnetic core and a system of infinitely long copper solenoids).

The electric field shielding properties of all tested textile fabric samples: A, A1, B, B1 allow for their use to limit the exposure to the electric field. Moreover, type A sample has a much higher capacity for electric component attenuation than the shielding effectiveness of sample A1. Only sample B indicated a magnetic component attenuation within the frequency range over 100MHz i.e. within high frequencies that so far had not been attenuated by personal protection equipment made of textile fabrics.

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## 17.6 Funding acknowledgements

This work was supported by the Polish Government Project ; “Using Hybrid Yarns with the Effect of Solenoids in Technical Textiles as a New Method of Shielding Effect Against of Electromagnetic Fields”; No: O N508 004234 between 2007 and 2011.

## 18 FUTURE TRENDS IN PPE

Michiel Scheffer, Noéton, the Netherlands

### 18.1 Background to the Prometei project -Prometei gives a long-term perspective on PPE

Prometei is an initiative that builds on the Lead Market Initiative on Personal Protective Equipment (PPE) of the European Union. This initiative was one of the action points of the PPE Conference held in Hengelo on 1-2 December 2008; it was set up to foster synergies in research and development in PPE and to develop an end user innovation agenda. It was politically supported by EURATEX, ESF and ETSA and funded by the participating organizations. The Prometei process brought together the whole value chain of PPE, from end users to trade organizations, suppliers and research centres in order to identify key social trends relevant to personal protective equipment, provide guidance for further developments and to generate a more precise strategic research agenda for PPE. The research agenda was recently presented at a PPE Conference organized by the Finnish Institute for Occupational Health in Saariselka, Finland on 24 – 26 January 2012.

The initiative came to being through meetings during 2010 in Frankfurt, Paris and Ghent, focusing on global trends and scenarios and technological and market issues. Furthermore, with the support of an extensive literature study on existing PPE research as well as end user surveys and interviews; a road map has been prepared which addresses scenarios up to 2020, including the trends, risks and challenges of PPE. Rounding up with conclusions for both industrial participants and policy makers, the Prometei road map provides guidelines for the future needs of the industry.

### 18.2 Contextualizing PPE

PPE is defined by the European Commission as: "(...) any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazard". It is often narrowed to the protection of workers, but it addresses all individuals, hence also sport practitioners. A first boundary is that technically PPE excludes military equipment which is subject to specific regulations. It is clothing for which the primary objective is to protect the wearer against production processes or people (e.g. in the food industry or in medical services). Conceptually, the difference between these categories is gradual rather than principled. The Prometei Group advice is that all protective equipment should be integrated under one single conceptual and legal framework.

A second boundary is between PPE and other measures to provide health and safety in the workplace, such as safety of equipment and safe working procedures. PPE is considered: "the last resort after other methods of protection have been considered". In prac-



tice, this shall be sometimes the case, but in many instances PPE is a frequent or even constant factor of protection.

The Prometei Group advocates the consideration of PPE as a theme of equal standing in relation to production technologies, the work environment and organizational measures.

#### Box 1. Fire and rescue services

Data from the Netherlands on the cost and effectiveness of fire services show a doubling of costs, associated with an increase in material damage, whereas the number of casualties (both victims and fire fighters) has remained stable. The dominant strategy of fire fighting incidences turns out to be less and less effective. The scenario to increase effectiveness by ensuring better performance of fire fighters may be defeated (in terms of cost/benefit) by more focus on prevention, by smarter buildings and informing the wider public rather than arming the fire fighters. This has consequences for personal protective equipment and it means that less robust equipment is needed for most staff and additional modules need only be added for staff involved in escalation.

A third boundary exists between the different components of PPE and work tools. There are different components for head protection (including ear and eye protection), and body protection (such as that provided by suits, gloves and shoes). In addition, harnesses and ropes provide protection. Other work tools and communication devices are not considered PPE, although they can be connected or integrated and may contribute to the overall protection.

Prometei recommends taking a holistic view by assessing all components with an end user scenario. Special interest is afforded to communication devices, which have been developed up to now in soldier modernization programmes.

In terms of management philosophy, PPE can be approached from a “must have” perspective by which a set of risks are assumed and equipment is purchased accordingly. This approach focuses on the material aspects of PPE such as those covered by norms and standards. The advantage of this approach is the low workload for HSE executives and the ease of buying off-the-shelf products. SMEs will often use this approach.

This means that the need to approach PPE remains within a proper risk assessment exercise. This is most needed when risks are neither classic nor clearly covered by norms and standards. It is thus required to carry out a risk inventory and evaluation prior to engaging in a PPE selection process. This method is called SUCAM (Selection, Use, Care and Maintenance) of PPE. It involves a higher workload for HSE staff prior to and during procurement, but also a better selection and acceptance of PPE and a lower liability in case of accidents. The workload could be reduced by developing voluntary sectoral guidelines. These should not replace risk assessments at a company level, but they could ease and speed up the process.

## 18.3 Scenarios up to 2020

Five scenarios up to 2020 were identified by the Prometei Initiative for ten end user profiles, based on global trends for the decade. It starts with the globalization of production and the specialization of industrial work with increased automation of industrial processes, the growth of semi-industrial work such as utilities, building, maintenance and repair and product-oriented services. Moreover, globalization leads to a shift in manufacturing to regions with a younger labour reserve and energy intensive industries are shifting to sources of energy. In intermediate industries, such as chemicals and other processing industries, further mechanization and automation is to be expected.

### Box 2. Global shift

Industry, particularly that related to energy and mining, is shifting from developed regions to more demanding environments. This demands appropriate equipment but also the logistics to maintain and wash equipment on-site. In addition in heavy duty sectors, the workforce is often multinational, especially in the Middle East. This demands multilingual information about good use of PPE but also information (for workers with poor literacy skills) available in pictograms or through digital means. It is important to develop applications for smart phones with guidance on how to use PPE.

Secondly, the global ageing of the population is a multifaceted trend impacting on the demographics of workers as well as the provision of health services and the rise of a leisure economy. Ageing is a global development, affecting all countries except regions in Asia and Africa. Life expectancy is rising, while the number of children per capita is declining. The third scenario, global mobility, was seen in terms of migration, labour mobility and a global rise in tourism. A growing concern is the increase in low intensity risk pervasiveness, such as pandemics and zoonoses (animal diseases transmittable to humans).

A fourth scenario is the rise in global individualism and networking. Individualism means that work is increasingly one of the facets of life. This implies that on one hand the quality of PPE is a vector of personal dignity, and on the other hand work should be carried out in conditions that do not affect personal life.

### Box 3. Global warming

Global warming makes specific issues relating to PPE more urgent. Protection against the cold and liquids (including rain) is an important protective driver. This often comes about at the expense of comfort, as heat and moisture build-up in clothing but even more in footwear and gloves. Global warming points to the importance of developing equipment that removes heat and transpiration more effectively, and offers more reflection of light and UV. Cities will experience more effects known as "urban heat islands". Inside buildings air conditioning systems change the climate in which people work.

## 18.4 Sustainable materials

The manufacturing of PPE uses a lot of materials, since it concerns around 10% of all clothing and technical textiles, hence in total some 4 million tonnes worldwide. It is also an important user of plastics in head protection, although this is not quantified. The PPE sector is an important user of polyester, polyamide, polyethylene and other polymers derived from fossil resources. More technical demands also lead to the addition of materials such as aramides, flour-based membranes and finishes (eg. Goretex) or phosphates, which are all derived from fossil sources.

Since the segment is less fashion-sensitive and in many parts less demanding than it is for technical textiles, it is an appropriate arena to develop and test alternative materials such as biopolymers (e.g. for disposable materials) and to assess the reintroduction of alternative natural fibres such as linen and hemp. It is also relevant for certain properties to develop bio-based finishes. Work has been implemented to develop bio-based flame retardants and breathable repellent materials. Materials mimicking nature, such as lotus leaf concepts, are relevant. Plant extracts can be the basis for comfort-enabling properties, e.g. in the lining of gloves and shoes. These may help to reduce temperatures, the development of sweat and repress bacterial activity related to heat and sweat.

PPE also has an important footprint in terms of maintenance. However, most energy and water use in PPE is connected to washing. Extending the life span of PPE can be enabled by a better tracking and tracing of PPE. This could be done by adding tracers to PPE, RFID tags or end-of-life or end-of-service indicators. The University of Wuppertal has, through the research of Prof. Helmus, achieved a breakthrough in applying RFID tags in footwear, helmets and clothing in PPE. This helps to monitor incidents and to trace the use and maintenance of PPE.

Making materials stain-repellent has an important impact on reducing maintenance frequency and intensity. However, more efficient maintenance can be obtained by alternative business models in which design, manufacturing management and maintenance are contracted out as one package.

## 18.5 Customization

The customization of PPE is an important trend. Bad fit is one factor in the reduced acceptance of head and foot protection. It is a trend with four elements.

1. More end user-oriented design processes, taking into account diversity in end users, the global factory scenario.
2. More customization in fit, since deficient fit is a major detractor in the acceptance of PPE.
3. More personal management systems of PPE with possibilities for managing personal PPE budgets and maintenance, among other things.

4. More functional and aesthetic differentiation in response to the needs and identity of workers, especially with regard to workers with specific conditions and for self-employed workers or small companies.

## 18.6 Challenges for footwear

Foot protection comes in various materials that protect the wearer from influences from the environment and vice versa. Not only is the protection of the foot important; footwear should also support the activities of the wearer. Metal insoles and toe-caps are now impeding flexibility and are a source of heat build-up. Alternatives in cross-plied fabrics are still inconclusive and need improving, especially when it comes to protection against puncture by sharp objects and cooling. Improved management of the climate, a reduction in bacterial activity and a better understanding of the relation between friction, climate and bacterial activity is required. Research done on sport surfaces (e.g. artificial grass) in relation to sports shoes could be leveraged to work shoes.

In order to balance protection and comfort, adaptive materials need to be developed. This is mainly in relation to breathability and the removal of heat and moisture. Silver is now used to reduce bacterial activity, but more sustainable alternatives are needed. Also of relevance is the developing and application of phase-changing materials and controlled release materials to improve comfort. This should be assessed very closely in terms of how the fit of protective boots influences the entire performance of the PPE. Therefore it is suggested that socks should be customized, as well as the boots the socks are worn in.

The Prometei Initiative concluded that compatibility and modularity between different elements of equipment should be better examined, especially at critical interfaces such as mouth-ear, ear-head, foot-body and body-hands. The integration of tools into PPE is also of importance and the connections between PPE and the environment plays a role if people from different professions work in one operational arena. Furthermore, PPE should be interoperable with the tools in use and the conditions of the environment. It is possible that some functions could be supplied with a de-/activation sensor, which guides interaction with different other devices. An application of this mechanism could be in the forest industry, for example.

Industries and purchasers focus too much on specific parts or elements of PPE, whereas there should be more attention to concept design. An integrated view of the whole concept of PPE needs to be shown in standards and be well organized within large public procurements. User-oriented design starts with the involvement of the user. In communities of practice, issues in design or application can be discussed in the form of an online forum or by using social media and networks.

Offering the user of PPE additional information can support the user's performance in a positive way, but it also brings about the danger of overloading the user with information. Therefore, the data supplied by the PPE should be action-oriented and needs-based to ensure situational awareness. Data that helps the user of PPE in specific situations to identify his or her location (where am I?) and the location of the danger (where is the danger?) would be useful in some situations but not in all. The research carried out by Profes-

sor Helmus at the University of Wuppertal has demonstrated that RFID tags have been successfully positioned in footwear and offer information on the location and possible incidents (e.g. falling). Clearly, where time is scarce – such as in an emergency situation – the speed of the data calculation and its transfer is crucial. The organization of an information infrastructure is important. Another element is to integrate energy production for smart devices. One solution is to integrate a piezoelectric element into the sole of a shoe that converts movement into electricity. This can feed smart systems or, more simply, heating functions.

Foot protection is an area that is not yet sufficiently addressed by research. This is regrettable, since foot protection seems to be a mature segment, whereas innovation could do a lot to develop new product concepts. Since shoes fulfil several functions, the areas of improvement and new developments seem to be extensive. A common road map with sports shoes should be explored.

## 18.7 References

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## 19 NEEDS FOR NEW STANDARDISATION AREAS

Helena Mäkinen, Finnish Institute of Occupational Health (FIOH), Finland

### 19.1 Introduction

During the last ten years, a great deal of development work has been carried out to add intelligence or smartness to personal protective equipment (PPE). In the PPE Sector Forum workshop in November 2011, Dr Lieva Langenhove from Ghent University evaluated that over 500 million euro has been invested in approximately a hundred EU research and development projects in the area of smart fabrics.

In 2008 the European Commission launched the Lead Market Initiative in the field of protective textiles to strengthen European Industry competitiveness in the protective textiles sector (1, 2).

Standardisation is one objective of this initiative. In the 7th FP there was specific call for projects concerning intelligent PPE on THEME 4 NMP - Nanosciences, Nanotechnologies, Materials and New Production Technologies, and standardization was also to be included in the project plans. The i-Protect ([www.i-proptect.pl](http://www.i-proptect.pl)) is one of the seven ongoing projects in this specific call. Other projects are:

- Prospie co-ordinated by TNO, Hollanti  
([www.prospie.eu](http://www.prospie.eu))
- Safe@Sea co-ordinated by Sintef, Noway  
(<http://www.safeatsea-project.eu/impact.html>)
- Safeprotex co-ordinated by Etaireia Technologikis Anaptixis kl Ostoufantourgias Endysis Kai Inon A E from Creece  
(<http://lib.bioinfo.pl/projects/view/12136>)
- Profitex co-ordinated by Aachen University, Germany  
(<https://www.project-profitex.eu/>)
- Posyslaser co-ordinated by Laser Zentrum Hannover, Germany  
(<http://www.prosyslaser.eu/>)
- NOBUG co-ordinated by Ghent University, Belgium  
(<http://www.no-bug.info/content/about>)

Full title of i-Protect is "Intelligent PPE system for personnel in high-risk and complex environments". This four years project started October 2009. Project Coordinator is Piotr Pietrowski, Central Institute for Labour Protection – National Research Institute, POLAND. There are 17 partners in the project from seven European countries.

The objectives of the project are:

- Incorporate into underwear physiological sensors based on optical fibres
- Embed environmental sensors into construction of PPE elements (e.g. clothing)
- Develop communication network, internal – between all electronic modules and external - Between end user and Rescue Coordination Centre
- Develop new materials and nanomodifications enhancing protective parameters and functionality of PPE
- Adapt to users' needs by ergonomic design and usability test of new PPE prototypes by end users
- To formulate strategies for standardisation/legislation concerning new aspects of the proposed PPE system
- To formulate guidelines for developing pre-normative documents for newly elaborated PPE systems for having reference used in EC type assessment process.

## 19.2 Present standard situation for intelligent PPE

Technical Committee CEN/TC 248 "Textiles and textile products" has prepared technical report CEN/TR 16298 "Textiles and textile products - Smart textiles - Definitions, categorisation, applications and standardization needs" (3). According to this report product standards for intelligent PPE systems should cover at least the following aspects:

1. A verification of the claimed performances as a basic PPE and as an intelligent PPE system
2. The innocuousness of the product in its interaction with the human body or with the environment of the product
3. The durability of product properties, in particular with relation to repeated cleaning, heat and fire resistance, resistance to other environmental hazards
4. Product information needed for safe use and maintenance of the product
5. Environmental aspects.

The assessment of the product properties intelligent or not should be done under conditions which are representative for the intended use and the methods use should be relevant, repeatable, reproducible and available on the market. This makes the work demanding and challenging.

## 19.3 Proposal for the strategy concerning standardisation of intelligent PPE

The first step in laying down the essential health and safety requirements of the PPE Directive is to go through all its basic requirements and determine what they mean in the case of intelligent PPE. Table 1 shows some examples.

Table 1. Example of the needs analysis for new requirements/test methods of intelligent PPE based on the PPE directive.

Draft, page 3 (22)	How to show that the requirement is fulfilled	Need for new requirement/test method	Link to other directives
1. Design principles 1.1.1. Ergonomics			
PPE must be designed and manufactured so that in the foreseeable conditions of use for which it is intended, the user can perform the risk-related activity normally, whilst enjoying appropriate protection of the highest possible level.	Accepted practical performance test.	Requirements and test method for ergonomics (physiological, optical, cognitive).	
1.1.2. Levels and classes of protection 1.1.2.1. Highest level of protection possible			
The optimum level of protection to be taken into account in the design is that beyond which the constraints imposed by the wearing of PPE would prevent its effective use during the period of exposure to the risk, or normal performance of the activity.	Levels of protection in the corresponding PPEs, protective clothing, respiratory protection, practical performance.	See the existing corresponding standards and requirements and test methods for ergonomics, analyse the need for further standardization.	
1.1.2.2. Classes of protection appropriate to different levels of risk			
Where differing foreseeable conditions of use are such that several levels of the same risk can be distinguished, appropriate classes of protection must be taken into account in the design of the PPE.	Hazards according to risk assessment and levels of protection in the corresponding PPEs, especially protective clothing, respiratory protection.	See the existing corresponding standards; add requirement and test methods for protection against hazards where protection requirement is missing.	Atex Directive



Intelligent PPE is a product that often includes sensors for measuring the user or the environment and electronics for communication and display. This means that at the same time the standardisation need must be linked to the essential requirements of other relevant directives e.g. ATEX, EMC. In intelligent products different types of techniques are combined. Then different forms of applications should be able to communicate with each other. The standards should ensure the compatibility starting from the basic standard that must be met for the PPE type in question that must be met.

The classification of the features that must be taken into account in standards regarding an i-Protect type (5) of product are as follows:

- 1) Features for measuring environmental risk factors (temperature, gas, oxygen level, electromagnetic hazard etc. combined with the existing measuring standards in the area) Features showing wearer position or activity
- 2) Features for measuring human body parameters (body temperature, heart rate, EGG, EMG, EEG, bio impedance etc.)
- 3) Features for indicating changes in protection performance (e.g. end-of-service-life)
- 4) Communication network and display to monitor the measured data. Here the cognitive requirements of human beings must be taken into account, e.g. performance in the field of neuroergonomics
- 5) Features of usability of PPE systems for multifunctional purposes.

In the CEN/TR 16298 mentioned innocuousness of the product in its interaction with the human body and environment, and also the durability of product properties could be included to the existing standards PPE standards.

Co-operation is essential between different projects, with different Technical Committees, and also with other standardisation bodies, especially with CENELEC. So far the PPE Sector Forum has organised one work shop, which was held in November 2011 for the different 7th FP projects. The workshop concluded that the link between researchers and standardisers should be intensified, people should know more about each other, and that the Sector Forum can be a tool to enhance this link.

## 19.4 References

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[http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/files/pt\\_taskforce\\_report\\_en.pdf](http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative/files/pt_taskforce_report_en.pdf)

2. Final Evaluation of the Lead Market Initiative Final Report July 2011.  
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# 20 NEW CONCEPTS OF TRAINING AND E-LEARNING FOR PPE ADVISORS, BUYERS, OCCUPATIONAL HEALTHCARE EXPERTS AND END USERS

Heli Koskinen, Finnish Institute of Occupational Health (FIOH), Finland

## 20.1 Introduction

Exposure situations at work can be complex, and they require good understanding of how to select all the necessary personal protective equipment (PPE). There might be a need for different types of PPE, and one has to know how to combine the PPE safely so it does not interfere with each other's functions. In addition, sometimes there is an interaction between different exposures and this has to be recognized and dealt with. Work places have an urgent need for experts who can select, use and maintain PPE correctly. These experts can be well-trained personnel, or companies can use external experts. The work safety directive and legislation (1, 2) provides that services acquired by workplaces shall be qualified.

The problems in the selection of PPE has brought about a need to train PPE advisors in Finland. The training programme established in 2000 has educated 250 PPE advisors up to now. However, changes in standards and complicated exposure situations at work require more from employers, buyers, labour protection personnel, occupational health care experts and even end users.

To this end, and to reach the persons involved, a new e-learning training programme has been implemented by the Finnish Institute of Occupational Health in cooperation with the Finnish Safety Federation (STYL). The training has been extended to everyone dealing with PPE selection and usage, and this has been done by using module-based e-learning.

## 20.2 Training programme essentials

The training consists of a number of different modules: one basic module on risk assessment and work safety, and different modules for each PPE group (Table 1). The course uses the Moodle (Modular Object-Oriented Dynamic Learning Environment) environment which is a widely-used free source e-learning software platform. Students have a one-month period to study and complete the private study assignments for each module in their own time, and there is a tutor for the course. There is material available on the Internet and a study book is provided (3).

Table 1. The different modules of the training, asterisk denotes the existing modules

Basic module	Optional modules
Basics of work safety and risk assessment	Respiratory protection*
	Eye and face protection
	Hearing protection*
	Hand protection
	Foot protection*
	Protective clothing
	Fall protection (lecture course)
	Head protection

Students can comment and communicate virtually through the conversation area in Moodle, as well as on a personal basis. When there are problems in the assignments, the system, or the material, the tutor can help. Alternatively, if there is real problem at work, students can ask questions in the forum, and the tutor, if he or she is unable to answer the question him/herself, will convey the question to the relevant PPE specialist, and participants can thus have updated information relating to their problems.

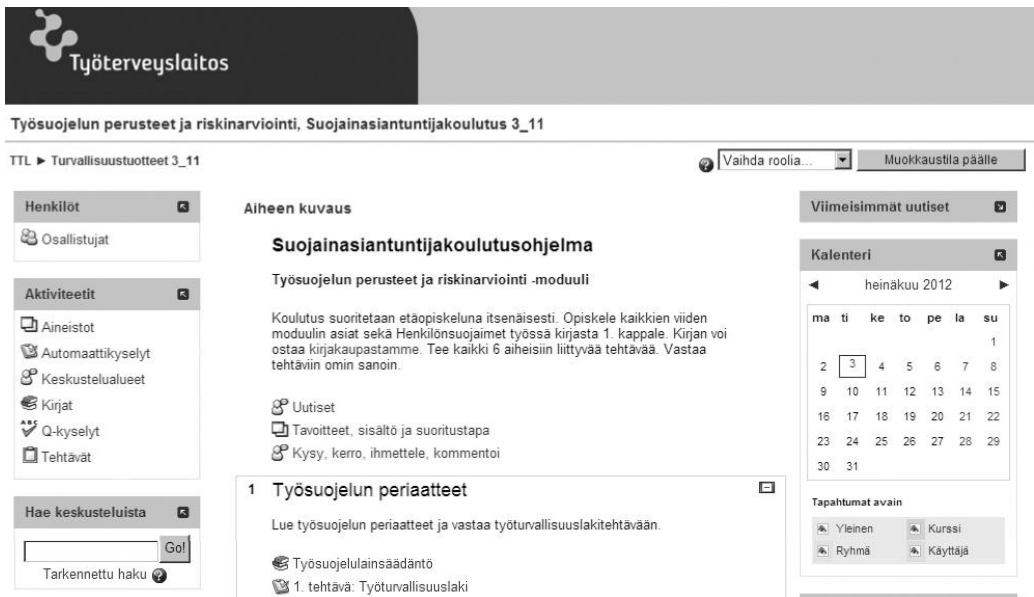
The material has been divided into sections, and at the end of each section there is a home assignment that is graded pass/fail. Corrections can also be required. Every module has a final exam that can be taken at local FIOH institutes (in six towns and cities). The learner passes the module if both the exam and the home assignments are passed. When at least one of the PPE modules and the basic module has been passed, the card (Figure 1) showing the qualification and a diploma is provided to the learner. The card is valid for five years.

Each PPE module gives information on the selection, usage and maintenance, and legislation concerning that particular PPE. The structure enables the modules to be updated much more quickly than books.



Figure 1. The card is a sign of competence.

The basic module deals with risk assessment and work safety from the PPE perspective in particular, including PPE legislation and practices (Figure 2).



**Työsuojelun perusteet ja riskinarviointi, Suojainasiantuntijakoulutus 3\_11**

TTL ▶ Turvallisuustuotteet 3\_11

Vaihda roolia... Muokkaa tilia päälle

**Henkilöt**

- Osallistujat

**Aktiviteetit**

- Aineistot
- Automaattikyselyt
- Keskustelualueet
- Kirjat
- Q-kyselyt
- Tehtävät

**Hae keskusteluista**

Go!

Tarkennettu haku

**Aiheen kuvaus**

**Suojainasiantuntijakoulutusohjelma**

**Työsuojelun perusteet ja riskinarviointi -moduuli**

Koulutus suoritetaan etäopiskeluna itsenäisesti. Opiskele kaikkien viiden moduulin asiat sekä Henkilönsuojaimet työssä kirjasta 1. kappale. Kirjan voi ostaa kirjakaupastamme. Tee kaikki 6 aiheisiin liittyvää tehtävää. Vastaa tehtäviin omin sanoin.

- Uutiset
- Tavoitteet, sisältö ja suoritustapa
- Kysy, kerro, ihmettele, kommentoi

**1 Työsuojelun periaatteet**

Lue työsuojelun periaatteet ja vastaa työturvallisuuslakitehtävään.

- Työsuojelulainsäädäntö
- 1. tehtävä: Työturvallisuuslaki

**Viimeisimmät uutiset**

**Kalenteri**

heinäkuu 2012

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2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

**Tapahtumat avain**

- Yleinen
- Kurssi
- Ryhmä
- Käyttäjä

Figure 2. The main view of the basic module in Moodle.

Chemical and physical risk factors are presented, and there is an opportunity to go more deeply into example situations at the workplace and evaluate the dangers and do the risk assessment as private study assignments. Naturally, it is continuously emphasized that

PPE is the last resort i.e. that the PPE is for residual risk only, to be used only after all other possible technical and organizational measures have been taken to reduce the exposure.

For example, the hearing protector module contains the following sections: effects of noise and estimation of hearing loss, noise control and risk assessment, measurement of noise, hearing protector legislation, and selection, usage and maintenance. As in the basic module, the primary role of technical measures in noise control is stressed. The noise measurement section merely states the basic principles of measurement, and aims to provide the understanding that the measurement is not always simple, and when to use professionals to carry out the measurements.

## 20.3 Experiences of the training

Feedback on the training has been mainly positive. The participants can study the modules at their own pace, and between tasks at work. Absence from work is minimal: leave is only required for the exam and the modules can be accessed wherever there is an Internet connection. Only those students who prefer traditional, lecture-based courses have been less satisfied. For the tutors, the challenges lie in updating and developing the course, and giving proper constructive criticism and advice to the students.

Training also serves as a connection to workplaces. Some of the participants are from workplaces themselves, and they can present their learning at their workplace as part of the private study assignments.

As part of this training we also bring in experts who can identify the problems in PPE usage and select appropriate PPE for use. As a consequence, the usage rates and the efficient use of PPE will increase.

It is the safety of the workers that we are primarily concerned with. PPE does not help if it is used incorrectly or if it is wrongly selected. The wrong selection of PPE can at worst lead to fatalities. This responsibility must be recognized during the selection process and must be taken seriously.

## 20.4 References

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## 21 PROGRAMME OF THE SEMINAR

Tuesday, 24 January 2012

9.00 – 9.30 Registration

Issues relating to the revision of the PPE directive

Introduction lectures: Overview of the situation

*Chairman, Helena Mäkinen*

9.30 – 9.50 Opening of the seminar

*Helena Mäkinen, FIOH, Finland*

9.50 - 10.10 Situation on the review of the PPE Directive

*Petra Jackisch, BG BAU, Germany,  
on behalf of Michael Thierbach, EU Commission*

10.10 - 11.40 Situations in the PPE sector perspective of the:

- Manufacturers and dealers, *Guido Van Duren, ESF, Belgium*
- Notified Bodies, *Karl-Heinz Noetel, BG BAU, Germany*
- Market surveillance authority, *Maries Merken, ADCO, Belgium*
- End users, *Mari Kiurula, Skanska, Finland*

11.40 - 12.00 Break

12.00 - 12.30 Discussion

12.30 - 14.00 Lunch break

Workshops

*Chairman, Eero Korhonen*

14.00 - 14.30 Introductions of workshops

14.30 - 16.00 Workshops on issues discussed in the framework of the revision of the PPE Directive:

1) Main topics from the point of view of users

*Chair Karl-Heinz Noetel, BG BAU, Germany*

2) Main topics from the point of view of authorities and market surveillance

*Chair Pirje Lankinen, Ministry of Social affairs and Health, Finland*

3) Main topics from the point of view of Notified Bodies

*Petra Jackisch, BG BAU, Germany*

4) Main topics from the point of view of manufacturers and dealers

*Chair Martti Humppila, STYL, Finland*

16.00 - 16.30 Coffee break

16.30 - 17.30 Workshops continue

19.00 - 22.00 Get-together



Wednesday, 25 January 2012

#### Reports of the workshops

*Chairman, Eero Korhonen*

- 9.00 - 10.20    1) Main topics from the point of view of users  
*Karl-Heinz Noetel, BG BAU, Germany*  
2) Main topics from the point of view of authorities and market surveillance  
*Pirje Lankinen, Ministry of Social affairs and Health, Finland*  
3) Main topics from the point of view of Notified Bodies  
*Petra Jackisch, BG BAU, Germany*  
4) Main topics the point of view of manufacturers and dealers  
*Martti Humppila, STYL, Finland*

10.20 - 11.00    Panel discussions: Results of the workshops

11.00 - 11.20    Break

#### Poster session about on-going studies on PPE

*Chairman, Petra Jackisch*

- 11.20 - 11.40    Cancelled- Realistic training programme for the safe use of chemical oxygen self-rescuers (DVD)  
*Javier Madera Garcia, National Silicosis Institute, Spain*
- 11.40 - 11.50    Assessments of filters for protection of the eyes against optical LED radiation  
*Patrick von Nandelstadh, FIOH, Finland*
- 11.50- 12.00    Cold experiences during arctic safaris and igloo night - The protection and safety of tourists and tourism workers  
*Kirsi Jussila, Sirkka Rissanen, FIOH, Finland*
- 12.00 - 14.00    Lunch break

#### Presentations, focusing on various PPE aspects

*Chairman, Petra Jackisch*

- 14.00 - 14.20    An assessment of respiratory protective equipment programmes in UK industry  
*Nick Vaughan, Health and Safety Laboratory (HSL), UK*
- 14.20 - 14.40    PEROSH project - Workplace fit factor for respirators  
*Mike Clayton, Health and Safety Laboratory (HSL), UK*  
*Peter Paszkiewicz, Institute for Occupational Safety and Health (IFA), Germany*
- 14.40 - 15.00    Interactions by different types of PPE worn simultaneously  
*Martin Liedtke, Institute for Occupational Safety and Health (IFA), Germany*

Wednesday, 25 January 2012

- 15.00 - 15.20 Development of guidance on the control of thermal and physiological risks for wearers of air fed suits  
*Nick Vaughan, Health and Safety Laboratory (HSL), UK*
- 15.20 - 15.40 Life cycle data of PPE with RFID sensoric – new research results  
*Helmus Manfred, the University of Wuppertal, Germany*
- 15.40 - 16.10 Coffee break
- 16.30 - 18.00 Outdoor activity
- 19.00 - 23.00 Seminar dinner

Thursday, 26 January 2012

Continuation of the presentations

*Chairman, Pirje Lankinen*

- 9.00 - 9.20 Experimental experiences of winter activities  
*Sirkka Rissanen, Kirsi Jussila, FIOH, Finland*
- 9.20 - 9.40 Using hybrid fancy yarns in textile technical products protecting against EMF  
*Katarzyna Grabowska, Technical University of Lodz, Poland*
- 9.40 - 10.00 Future trends in PPE  
*Michiel Scheffer, Noéton, Netherland*
- 10.00 - 10.20 Needs for standardization of intelligent PPE  
*Helena Mäkinen, FIOH, Finland*
- 10.20 - 10.40 New concepts of training and e-learning for PPE advisors, buyers, occupational health care experts and end users  
*Heli Koskinen, FIOH, Finland*
- 11.00 Summing up of the seminar and closing

## 22 LIST OF PARTICIPANTS

Name	Organisation	Country
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This seminar report contains papers presented at the 11th EUROPEAN SEMINAR ON PERSONAL PROTECTIVE EQUIPMENT (PPE), held in Saariselkä, Finland, on 24 - 26 January 2012. The primary aim of this seminar was to give up-to-date information regarding the PPE regulations, research results, selection and use of PPE and the state of the art level of PPE. The second aim of the seminar was to bring together European PPE experts dealing with legislation, standardization, selection and use of PPE, testing, certification, research, manufacturing, market surveillance and workplace inspection. Once again, this seminar provided a unique forum for disseminating findings in the PPE field, and gave speakers and participants the opportunity to exchange experiences and participate in debates. Workshops and panel discussions were arranged in order to generate productive discussion among participants.

The seminar was organized by the Finnish Institute of Occupational Health (FIOH) Finland, BG BAU Germany, the Ministry of Social Affairs and Health Finland, and the European Safety Federation (ESF).

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