Strategies for the use of PIMEX and other video exposure monitoring methods.

Final report from sub-project “implementation strategies” within the HERIVIS project

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Abstract

Video exposure monitoring (VEM) is a group of methods used for occupational hygiene studies. The method is based on a combined use of video recordings with measurements taken with real-time monitoring instruments. A commonly used name for VEM is PIMEX. Since PIMEX initially was invented in the mid 1980's have the method been implemented and developed in a number of countries. With the aim to give an updated picture of how VEM methods are used and to investigate needs for further development have a number of workshops been organised in Finland, UK, the Netherlands, Germany and Austria. Field studies have also been made with the aim to study to what extent the PIMEX method can improve workers motivation to actively take part in actions aimed at workplace improvements.

The results from the workshops illustrates clearly that there is an impressive amount of experiences and ideas for the use of VEM within the network of the groups participating in the workshops. The sharing of these experiences between the groups, as well as dissemination of it to wider groups is, however, limited. The field studies made together with a number of welders indicate that their motivation to take part in workplace improvements is improved after the PIMEX intervention. The results are however not totally conclusive and further studies focusing on motivation are called for.

It is recommended that strategies for VEM, for interventions in single workplaces, as well as for exposure categorisation and production of training material are further developed. It is also recommended to conduct a research project with the intention of evaluating the effects of the use of VEM as well as to disseminate knowledge about the potential of VEM to occupational hygiene experts and others who may benefit from its use.

Introduction

The PIMEX (PIcture Mix EXposure) Method was originally invented in 1985 by a research group at the former Swedish Institute of Occupational Health. The basic idea is to combine video recordings with measurements taken with real-time monitoring instruments. The first technical solution that was used by the Swedish group was good enough to illustrate that the method had a clear potential to be an important tool for occupational hygienists, but there was a clear need for development. Therefore, specially-built technology was developed and made available in collaboration with a Swedish company. Publication of the basic idea and findings from the first field tests (Rosén and Lundström, 1987) resulted in other research groups and companies in different countries picking up the idea. Some of them bought equipment from the Swedish company and some developed their own solutions. Parallel to this development, similar ideas were developed at NIOSH in the USA. The name PIMEX (sometimes with the extensions of FINN-PIMEX or PIMEX-PC) has been used in some of the countries that primarily picked up technology and/or ideas from the Swedish group. Other names have been used by others (e.g. CAPTIV, ELVis and DOHEMS). A more general name for the basic idea of combining video recordings with measurements taken with real-time monitoring instruments is "Video Exposure Monitoring", abbreviated to VEM. The development of the idea, technology and strategy for use of VEM was thoroughly presented in a review article by Rosén et.al (2005).

In recent years, new technology based on the VEM idea has been developed to a limited extent. A South African group have adapted the technology for studies and visualisation of illumination in underground work (Butterworth, 2005). A South African company have presented plans for a technology called DOHEMS which is intended for use in mining industry in particular, but probably will be able to be used more generally as well (Badenhorst and van Coller, 2008). A German company, in collaboration with the Norwegian Institute for Occupational Health and the university Högskolan Dalarna in Sweden, have developed new technology for use in the aluminium smelting industry that can be used in the especially problematic environment in these factories (extremely high electromagnetic fields). A continuous further development of the technology developed by the company KOHS in Austria has also taken place during recent years.

Training material based on PIMEX has been widely used, especially as a part of an international program for the elimination of silicosis. The training material includes two CD-ROM disks with a complete set of text and lecturing material, including around 100 video illustrations, mainly using the PIMEX technology to illustrate reasons for and ways to solve dust exposure problems (Riipinen et.al., 2005). This material has been used by ILO, which has organized workshops on the prevention of pneumoconiosis in e.g. India, Chile, Vietnam, Thailand and Indonesia.

Production of different kinds of e-reports (reports delivered on digital media as CD-ROM or similar) has been one line of development for the dissemination of results from single studies based on PIMEX (Andersson et.al., 2005). This method of reporting means that staff and managers in workplaces will have easy access to the results of PIMEX studies f or future use.

In a collaboration project with participating research groups from Finland, Austria and Sweden, a special strategy for use of PIMEX in workplaces has been developed and tested (Rosén, 1999). The main steps in the strategy are to use PIMEX in workplaces where an occupational hazard problem has been identified. Measurements with PIMEX are made on persons that are affected by the exposure and the results are, when possible, discussed directly after the first measurements are finished, usually after a few minutes. The results are then viewed and discussed together with workers and managers, and possibilities for improving the situation are searched for. Possible solutions like changes in work practices, provisional changes in control technology such as ventilation, etc. are tested and immediately evaluated with PIMEX. This process can be continued with new tests and evaluations until a satisfactory result is achieved. Experience shows that it in many situations is possible to drastically reduce exposure to air contaminants with this strategy. The results of all recordings are then analysed and edited to a report which serves as a basis for discussions at a meeting where the persons involved as well as the responsible managers discuss and decide on a plan for future work aimed at improving the work environment.

One key factor for success when investing in technology aimed at improving the work environment is to involve the workers in the development process. Many control measures are dependent on correct use and maintenance for maximal effect. This, in turn, presupposes that the workers are motivated. One typical example is the use of a movable local exhaust aimed at capturing air contaminants from a process, e.g. smoke from welding. For maximum effect the worker must carefully move the exhaust near the source. Experience from practise tells that this is far from always the case, and that this can be explained partly by a lack of motivation to use the available control technology in the most effective way. A concept called Moveit has therefore been developed (Rosén et.al. 2005). Moveit stands for Motivation and Engagement for Hazard Control, and six characteristics have been defined as important for ability to support improved motivation for the individual to take part in workplace improvements. PIMEX has been identified as one such method.

With the intention of further developing technologies as well as strategies for the PIMEX method, the HERIVIS project was initiated and started in 2007. The overall objectives of this project are (KOHS, 2009):

> "Development of an innovative system for a comprehensive analysis and risk assessment of working systems.
> Development of an analysis and controlling tool for the integration of safety and health as a fundamental management task."

The HERIVIS project, which is coordinated by the Austrian company KOHS, is divided into a number of sub projects. One of those is entitled "Implementation strategy". The present report is the final report from this sub-project.

Aim

The aim of the work in this sub-project of the HERIVIS project has been:

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- To collect and summarise experiences concerning implementation strategies for PIMEX, especially from work done in Austria, Germany, the Netherlands, Finland and Sweden.
- To present strategies based on collected information.
- To analyse the qualities of the PIMEX-method as a Moveit-method.
- To conduct intervention studies where the presented strategies for PIMEX are used.
- To evaluate the effects of the interventions on changes in hazardous exposure, as well as changes in motivation for work environment improvements among affected workers and supervisors.

Method and material

Workshop

The project group from Dalarna University arranged small workshops in five countries. The workshops were arranged in Finland, the Netherlands, the United Kingdom, Germany and Austria, during the period from April 2008 to February 2009.The participating organisations were the Finnish Institute of Occupational Health, VTT Technical Research Centre of Finland, Health & Safety Laboratory, Arbounie, University Nijmegen, Kooperationsstelle Hamburg, AUVA-Allgemeine Unfallversicherungsanstalt and KOHS-Kviecien Occupational Health Solutions. Early in the project, a contact person in each country was informed of these plans and asked to organize a suitable national group. Several persons with extensive experience in the use of PIMEX in practical field studies aimed at the reduction of hazards were invited to those workshops. The groups were to not exceed ten participants, in order to ensure fruitful discussions. Information about the aim of the workshop and some questions to be answered during the workshop was sent out in advance (see appendix 1). A brief overview of the groups that participated in the workshops is presented in table 1.

Country/ group	Used system	Main strategies	Web page
Austria/AUVA	KOHS PIMEX	Service for customers	www.auva.at/mediaDB/MMDB102660_PIMEX%20-%20Sichtbarmachen%20von%20Gefahren.pdf
Austria/KOHS	KOHS PIMEX	Development and marketing of technology and strategy	www.pimex.at/en/pimex.php
Finland/FIOH	PIMEX-PC	Service for customers	
Finland/VTT	PIMEX-PC	Research and service for customers	
Germany/KH	KOHS PIMEX	Service and production of training material for customers	http://www.pimexservice.de/index.php?option=com_content&task=view&id=12&Itemid=32&lang=english
Great Britain/HSL	ELVis	Service for HSE and external customers and production of training material	www.hsl.gov.uk/news/archive06_news.html#air
The Netherlands/Arbou Unie	PIMEX-PC	Service for customers and production of training material for web pages	http://www.arbounie.nl/PIMEX_Picture_Mix_Exposure.htm?fluxmenu=&searchForWord=pimex
The Netherlands/Univ. Nijmegen	PIMEX-PC	Training of students in occupational hygiene	
Sweden/HDa	PIMEX-PC	Strategy development and production of training material	www.du.se/pimex_en

Table 1. An overview of the groups participating in the workshops.

The workshops lasted half a day. The Swedish project group and the invited persons in each country had discussions about the PIMEX-method, strategies for use and technical aspects. Criteria for Moveit - motivation and engagement by the method - was also discussed (Rosén et.al., 2005). Other topics discussed were the production of training material related to PIMEX, experience from the dissemination of knowledge in occupational hygiene to bigger groups and how to support increased use of PIMEX. Each workshop ended with conclusions about the best strategy for the use of PIMEX in different situations. A summary of the conclusions from the workshops was prepared and circulated among those who participated.

When they were approved, all the minutes from the workshops were published on the project platform at www.pimex.at.

Field Study

The PIMEX Method was used at one company with the aim of measuring its impact on motivation for work environment improvements. It was a Swedish company with more than 50 years of experience in soundproofing. They supply soundproofing products from most application areas, from solutions to simpler noise problems, to deliveries with more complicated problem definitions. Their bywords are quality, expertise and reliability. They had about 40 persons involved in the production process, 23 of them welders. They welded both in black sheet and stainless steel, which were divided into different locations. They used different gas electric welding methods: MIG for welding in black sheet and TIG for welding in stainless steel. Only the premises for black sheet welding were equipped with an exhaust system. Local exhaust hoods at the work sites were to some extent missing, but under construction. The company had quite recently moved in to an older industrial building.

Figure 1. Black sheet welding. The welder is using a helmet with fresh air supply.

For evaluation of the effects of interventions aimed at reducing the welders' exposure to welding fumes, three different methods were used. Firstly, the results of the exposure measurements with PIMEX were analysed by making calculations based on the exposure data recorded before and after single interventions. Secondly, the responsible managers were interviewed some time after the intervention. Thirdly, the workers' motivation to actively take part in activities aimed at reducing hazards and to improve working conditions was monitored before and after the intervention took place.

All welders and their production colleagues in the company were gathered in an initial meeting in which the Swedish project group presented a questionnaire which they were asked to fill in. The questionnaire was aimed at measuring the employees' motivation for work environment improvements. Twenty-one welders and 14 others (control group) participated in the study. When the questionnaires were answered and collected, the PIMEX-method was presented. From this moment the WISP- workplace improvement strategy by PIMEX was mainly followed (Rosén, 1999). The PIMEX technique was explained and some examples were shown to illustrate the link between the video picture, bar and diagram. The employees were also given the opportunity to ask questions. The next step was to inform participants of the date for the two days when it was planned to incorporate PIMEX into production. They were then asked to discuss and prepare work tasks of special interest for the approaching PIMEX measurements in advance.

During the two measuring days, PIMEX measurements were taken, with the participation of seven employees. Each of the individuals was asked to carry a backpack containing an instrument (MiniRAM) for measuring welding fumes. The backpack also contained a telemetric transmission device, which sent the measurement signal to a receiver placed close to the computer used for logging the data. Using a video camera, the employee's various tasks were recorded in conjunction with the measurements. The results were stored in a laptop computer and a video image with the exposure curve was displayed on the screen in real-time (Andersson et al 2005).

During the first sample the worker was asked to carry through the welding work task as it was usually done. The Swedish project group and the employees then looked at and analysed the sampled material together. This also gave other employees the opportunity to follow the results as they were displayed on the computer's screen. What was seen led to discussions about what the causes of fluctuations in exposure and particularly high exposure peaks were in terms of how the work was done.

The next step was to change the work situation with the aim of reducing exposure to welding fumes. Different attempts were carried out until the exposure was reduced as to close to zero as possible without affecting the result of the weld joint. The ideas for testing came from either employees or the project group. Four different work tasks were studied, and they were performed in black sheet or in stainless steel with two different basic welding methods. Steel cutting with lasers was also briefly studied.

After the two days of PIMEX measurements ended at the company, the project group looked through and analysed all the material. Interesting sequences showing high exposure peaks and explanations for these were picked out, as well as sequences explaining how to perform the work tasks to decrease the exposure to welding fumes. Presentation material based on a text document (Microsoft Word) was prepared. A short text described the work tasks and their circumstances. Each part was linked to a PIMEX video showing the result.

A month later the welders were gathering once again at the company. The PIMEX videos prepared from different work situations were shown and discussed. High exposure peaks were explained. The welders and their managers analysed the possibilities and problems with alternative control measures together. The meeting ended with 22 welders filling in the motivation questionnaire a second time. One of the welders participated in the meeting but filled in the questionnaire afterwards. The welder's production colleagues did not participate in the meeting, but filled in the questionnaire afterwards as well.

Two months after the intervention, the manager was interviewed about the value of it, particularly about which decisions were made about specific measures, and to what extent these decisions were influenced by the PIMEX intervention.

Motivation

A specially-developed questionnaire was used to measure the workers' motivation for work environment improvements, described here.

Workers' motivation is an important prerequisite for the successful outcome of the intended changes (Rosén et.al, 2005). It is therefore of interest to have a tool that makes it possible to measure the level of motivation and the changes in motivation when investments in control measures or activities of this kind are planned. A questionnaire designed to monitor individuals' own motivation as well as their view of workmates and the organisation's motivation has, therefore, been developed and evaluated. Internal consistency and the test-retest reliability of the domains of the questionnaire have been measured with the conclusion that it is reliable (Hedlund et.al, 2009).

The questionnaire includes 26 questions the workers are asked to answer on a scale of 1 – 6, telling about how important it is for them to take part in improvements and how active they are. Similar questions are also asked about their opinions and views concerning workmates and managers, etc. The outline includes the aspects of safety climate, goals, leadership and participation.

Safety climate refers to the perceptions of policies, procedures, and practices relating to safety in the workplace.

Goals provide guidelines for the work, make planning easier, motivate and inspire employees, and facilitate evaluations.

Leadership, especially the interaction between leader and subordinates, is important for motivation.

Participation and employee involvement are important. Participation in activities in the work environment has been shown to increase motivation.

The questionnaires were filled in twice, before and after the interventions.

The data from the questionnaires were manually transcribed to computer files and the data in the files were double checked against the questionnaires. The workers were asked to write a specific number on the questionnaire on both occasions. Each individual's first and second observations were paired based on these identification numbers. A statistical test was Performed on paired data. The analysis does not include missing data which totaled eight in the material. The answered questionnaires represent a relatively small group and cannot consider to be normally distributed. The Wilcoxon signed-rank test was used to measure different aspects of the worker's motivation to improve the work environment. This is a non-parametric analogue to the paired t-test, and should be used if the distribution of differences between pairs may be non-normally distributed. The absolute values of the differences between observations are ranked from smallest to largest. (Norušis, 2004)

Results

Workshops

The five workshops arranged in Finland, the Netherlands, the United Kingdom, Germany and Austria demonstrated an impressive collected experience and expertise as well as creativity in utilizing video exposure monitoring for different purposes. At the same time, there was a clear potential for development of the strategy as well as the means of using video exposure monitoring. Development of this potential would be clearly facilitated by a strengthened collaboration between the different groups.

The conclusions from the discussions in the workshops have been separated under the following headings: Strategies, Applications, and Motivation for Work Environment Improvements.

Figure 2. Some participants in the HERIVIS workshop in Vienna

Strategies.

Different basic technologies and strategies for the use of video exposure monitoring have been described by Rosén and co-authors (2005). All those were represented by the participants in the workshops. The potential of the method to be used as an important tool for improved communication between the occupational hygiene expert and the exposed workers or their managers was obvious for most of the participants. A number of examples were presented in which the activity with PIMEX raised an interest in discussions about what was studied. Proposals were made about possible reasons for exposure as well as ways to reduce it. The discussion also often leads to relevant questions about the hazards that are studied and this supports important learning among involved persons.

The fact that PIMEX encourages participation does not, however, imply that this is one of the planned strategies for using it. Reasons for this vary. One is that this kind of use isn't sought by or marketed to the users. It is more of a by-product from studies and interventions made for other reasons. Another reason is that the ability to communicate in some workplaces is often made difficult by, for example, noise.

With this more interactive strategy for workplace improvement seen as not so common, and especially not as a part of a defined strategy, four main usage strategies can be identified. One of them is to utilize the advantages of visualization for the analysis and documentation of the exposure situation and to evaluate the effects of control measures. Typically this is ordered by single companies, or in some cases, by a labour inspection. How such studies are financed differs greatly. The group at HSL in UK are mainly doing this at the initiative and order of the Health and Safety Executive. What they order is analysed and processed material ready for presentation. This means the production of Flash videos, PowerPoint presentations or the like, delivered on CD-ROM. Further use of this material is not under the control for HSL. In Finland, the Finnish Institute of Occupational Health (FIOH) offers this as a service for customers. The strategy is often similar to what is described above for HSL, but in these cases the work is often a part of a wider engagement between FIOH and the customer. Additionally, ArboUnie in the Netherlands are offering services for customers similar to this.

In Austria AUVA are offering services for customer with PIMEX. AUVA is the Austrian social insurance organisation for occupational risks, and they offer assistance in all areas related to occupational safety and health. PIMEX service is therefore offered to companies by AUVA with the expense covered by the insurance fee. As in the UK, it is often the labour inspectors that are initiating the studies. It is also common that safety engineers employed by single companies are ordering studies. The reporting is normally in the form of an electronic report on CD-ROM, including a comprehensive documentation and analysis of recorded material. When the report is ready it is delivered to the labour inspector, manager or safety engineer for further use. The Ko-operationsstelle Hamburgs service can be mentioned here, as they are doing visualized evaluations of the effects of the investments made in workplace improvements.

A second strategy is to produce different kinds of material aimed at communicating information about health risks at work and how these risks can be controlled. The visualization of exposure is, of course, very suitable for this purpose. This strategy has been used particularly by ArboUnie in the Netherlands and by the Swedish group. By commission of the Dutch authorities a comprehensive set of PIMEX-based video illustrations has been produced and made public on the Internet (Stoffenmanager, 2009). The general idea behind that work is to support responsible managers and others with documentation about exposure scenarios for various hazards, and how exposure can be reduced. There are more than one hundred examples, covering exposure situations such as the filling of a tank lorry (vapour exposure), the maintenance of helicopters (fuel vapours), work in an artist’s studio (dust), sorting of bulbs (dust), shoe repair (solvents) and diathermia in surgery (smoke). They are all quite short and give essential knowledge for use in practice. The collection and editing of the material has been made in collaboration with occupational hygiene and video experts. The Swedish group at Högskolan Dalarna have produced a number of longer training videos, some of them focusing on particular risk factors in certain branches, like styrene exposure in boat yards or dust control in the woodworking industry. Typically those videos use PIMEX to illustrate especially hazardous situations and how they might be controlled. Such PIMEX videos have been produced by commission of the work environment authorities or industry organisations. Others have been more general, concerning basic principles for control of exposure to air contaminants, and are produced by the Swedish Institute for Working Life for WHO. Those videos were originally distributed as VHS videos but have been transferred to digital format distributed on CD-ROM. Another version of training material, also produced by the Swedish Institute for Working Life for WHO, is a more complete training material distributed on CD-ROM. This material is based on a compendium on dust control, and about one hundred PIMEX illustrations are linked to the text where appropriate. This material also includes lecturing material and instructions for lecturers and is produced to be read through a web browser, making it easy to transfer it to the Internet. This has not been done, however.

Different kinds of PIMEX based training materials are being produced in the UK and Germany as well. Interactive training material illustrating control of soldering fumes made by HSL is one example, and another is a set of videos produced in Germany for the construction industry, illustrating good examples of exhaust solutions for stone cutting.

A third strategy is the use of PIMEX as a research tool. This strategy is used especially by VTT in Finland. One example is studies of how static electricity is built up under different conditions. PIMEX can be seen here as complementary to other data collection methods, offering stored and detailed background information on what can be seen in the studied situation. Similar to that strategy is the development of effective control technology for the reduction or elimination of emissions and exposure to hazards. It is important to verify theoretical calculations with measurements, especially if the presence of a person is affecting how the air contaminant is transported from the source to the breathing zone of the worker. One example of this is the development of a low- impulse inlet air unit for control of styrene exposure in the polyester plastic industry (Andersson et.al., 1991).

A fourth strategy is represented by the German group in Hamburg with their colleagues in the Netherlands and Hungary. In a project called Visualisation of the Exposure of Cyclists to Traffic on Roads, VECTOR (VECTOR, 2009) have they utilized PIMEX for the visualization of bicyclists' exposure to air contaminants from traffic. The basic idea is to collect and present material that can be used in a public debate aimed at better conditions for cyclists. The target group for this strategy is typically local authorities, city planners, traffic or environmental departments and journalists. For the German group, this is one example of using PIMEX with the intention of getting a message out to the public. Similar studies in which the monitoring equipment was transported on a bicycle or in a baby carriage have also been made by HSL in UK with the same intention: to visualize bicyclists' or babies' exposure to vehicle exhaust.

Applications

The various research and development groups that participated in the workshops represent a comprehensive number of applications and utilization of video exposure monitoring. The more than 100 PIMEX videos available on the Internet have been used by seventeen trade unions in the Netherlands. This material has also been used as training material in different courses for practitioners. The Radboud University of Nijmegen is using the PIMEX technology within their courses focusing on occupational hygiene and health. PIMEX is then used in the laboratories as well as in field studies.

The Finnish Institute of Occupational Health have focused on offering this service to their customers as a part of their services aimed at the reduction of hazards in individual companies. Examples of such services have included air contaminant exposure in laboratories and car painting as well as ozone and nitrous oxide (in medical surgery).

The German group have made applications that have been carried through or are planned together with national organisations such as the Institute fur Gefarstoff-Forshung der Bergbau- Berufsgenossenshaft, Gefahrstoff-Informationssystem der Berufsgenossenschaft der Bauwirtschaftz and Die Steinbruchs-Berufsgenossenschaft. Applications cover hazardous substances such as solvents, dust, fine and ultrafine particles, noise, vibration and heat radiation, light, air quality in workplaces (temperature, humidity) as well as physiological data like heart rate, body temperature and breathing rate.

In addition to numerous applications dealing with air contaminants like flour dust in bakeries and smoke and dust exposure in steel works, the Austrian groups have also used PIMEX for studies of heat radiation, pulse rate, air humidity and air temperature.

The group in the UK have mainly focused on air contaminant studies. The poultry and pharmaceutical industries are two examples, but the group have also used their technology for visualisation of the exposure of bicyclists and children in baby carriages to engine exhaust in cities.

In recent years the Swedish group have mainly focused on the applications of PIMEX in the aluminium smelting industry (Rosén and Andersson, 2008). The main reason for this branch to implement the method is that asthma caused by workers exposure to dust, smoke and gases is seen as a problem. Due to technical reasons (extremely high electromagnetic fields) it has been necessary to develop a new technology based on earlier Swedish versions. The project also includes the training of occupational hygiene staff in the use of PIMEX.

Motivation for work environment improvements.

One of the main topics of discussion was whether PIMEX can be seen and is used as a method that can improve affected workers' motivation to actively take part in activities aimed at improving their own and their workmates workplaces. There was a clear consensus that the use of PIMEX, in most cases, raises curiosity and discussions around what is seen on the PIMEX-computer, both while the recording is in process and if the result is replayed directly afterwards. The participants in the workshops gave numerous examples of how the monitored worker, as well as workmates and supervisors, brainstormed explanations for the observed exposure peaks as well as suggestions for possible changes in ways of doing the work in order to reduce exposure. These observations have, however, not resulted in any used strategy for utilization of this opportunity. Some different reasons for this were discussed. One is that the physical situation at the workplaces sometimes makes it impossible to arrange for discussions around what is observed. It may be that it is too noisy, or that the conditions require so much personal protective equipment that it makes communication impossible. In such cases it is, of course, possible to move to a nearby location for discussions, but this was normally not done. Another possible reason for not utilizing this opportunity to involve the staff in problem-solving is cultural. The question was raised as to whether there are different traditions for discussions between workers, managers and external experts in the countries represented. The discussions indicated that this may be the case.

Before the workshops, a detailed description about the Moveit concept was distributed to all participants (see appendix 1). The intention was to discuss to what extent VEM/PIMEX fulfils the different Moveit properties, and how the strategy and the technology may be developed to better fulfil those properties. Since experiences from this application of the method were limited, is it difficult to make any clear conclusions. However, in general there was a clear consensus that the "Interactivity" and "Change competence" properties of Moveit were fully fulfilled, and that the "Work environment knowledge" and "Room for action" properties were partly fulfilled. With regard to the "Systematism" and "Integration possibilities" properties, it may be concluded that it is, to some extent, possible to fulfil specific demands, if there is a wish to do so.

Field study

PIMEX measurements

The field study in the welding workshop involved 26 PIMEX recordings in all and the active participation of seven of the welders. All other welders, as well as a manager, took part by watching the results while measurements were ongoing and by discussing the results immediately afterwards. The discussions led to proposals for possible changes in control technology and work practices that were possible to test on the spot. One example of a possible control measure that emerged and was possible to test was whether the welding helmet with fresh air supply that was used was effective, and to what extent an exhaust tube integrated to the welding pistol might be an attractive solution. The question of the effectiveness of the welding helmet was easy to test by placing the sampling probe both inside and outside the helmet during measurements and recordings. The question of exhaust integrated to the welding pistol was somewhat trickier. There was no such equipment available, but the idea to use an ordinary vacuum cleaner to test the principles emerged. The nozzle of the vacuum cleaner was simply attached to the welding pistol with tape so as to avoid disturbing the work too much. This made it possible to obtain preliminary data from this type of control measure. This also gave reasons to discuss the advantages and disadvantages of helmets supplied with fresh air and movable local exhaust tubes near the work station.

The primary results from the measurements are summarized in table 2.

Welder no	**Welding method**	**Work**	**Local exhaust**	**Fresh air helmet**	**Average exposure (relative)**
1	MIG	Use of "welding tractor", black plate	No	No	33.2
2	MIG	Use of "welding tractor", black plate	No	No	208.9
2	MIG	Use of "welding tractor", black plate	No	Yes	9.8
2	MIG	Use of "welding tractor", black plate	Yes	No	6.8
3	MIG	Welding on partly painted black plate	No	Yes	3.9
3	MIG	Welding on partly painted black plate	No	No	36.9
4	MIG	Welding on partly painted black plate	No	No	86.7
5	MIG	Use of "welding tractor", black plate	No	No	97.7
5	MIG	Use of "welding tractor", black plate	Yes	No	2.2
6	MIG flux cord wire	Welding in stainless steel	No	No	33.1
6	MIG flux cord wire	Welding in stainless steel	Yes	No	3.6

Table 2. An overview of studied work situations and results of interventions made.

The results are, of course, too limited to provide a basis for general conclusions, but this is not the main intention for PIMEX measurements made with this strategy. The intention is to involve the exposed persons in learning more about their own situation and workplace, and to involve them in the evaluation of different possible control measures.

Figure 3. Discussions around the results immediately after monitoring.

Welder 1 and 2 were doing basically the same work but the results indicate that Welder 2 is far more exposed to welding fumes. It is a well-known fact that two persons doing the same work can be quite differently exposed depending on the work practice used. This observation inspired discussions between the involved workers as well as possible explanations, such as the fact that Welder 2 was leaning over the machine more during work. Similar, but less significant differences were observed when Welders 3 and 4 did similar work. This case also yielded discussion about the causes of the differences. See figure 4.

When Welder 2 was using the fresh air welding helmet, his exposure was reduced drastically (95%). This gave reasons to discuss the fact that a correctly-used helmet of this type gives very good protection for the welder, but that the emission to the workroom and workmates is still the same if no emission control is used. The fact that this kind of helmet was seen as more clumsy and heavier than an ordinary one was also discussed. See Figure 5.

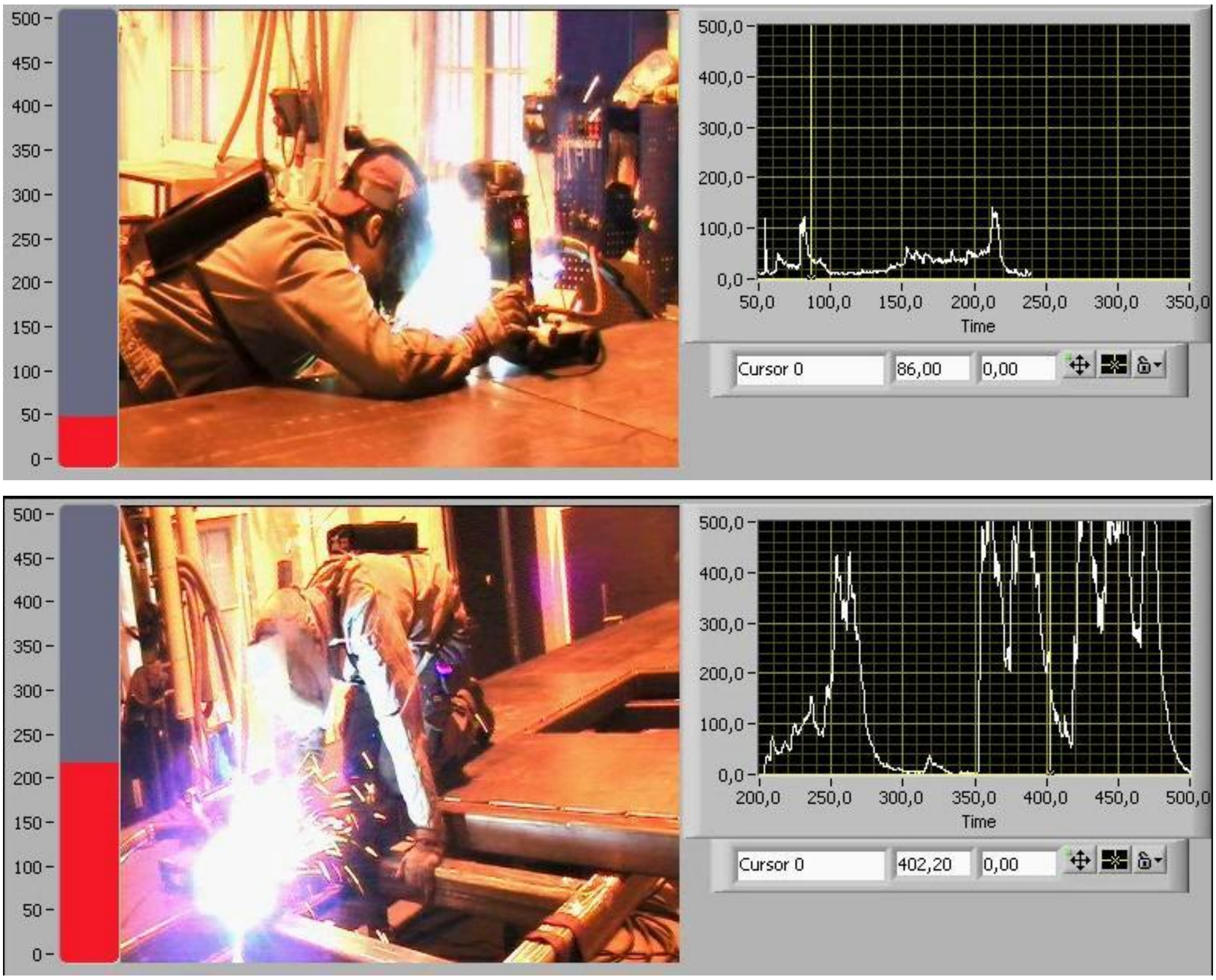

Figure 4. Screen dumps from PIMEX recordings comparing exposure to welding smoke (relative values) during welding with a “welding tractor”. Both welders are doing the same work.

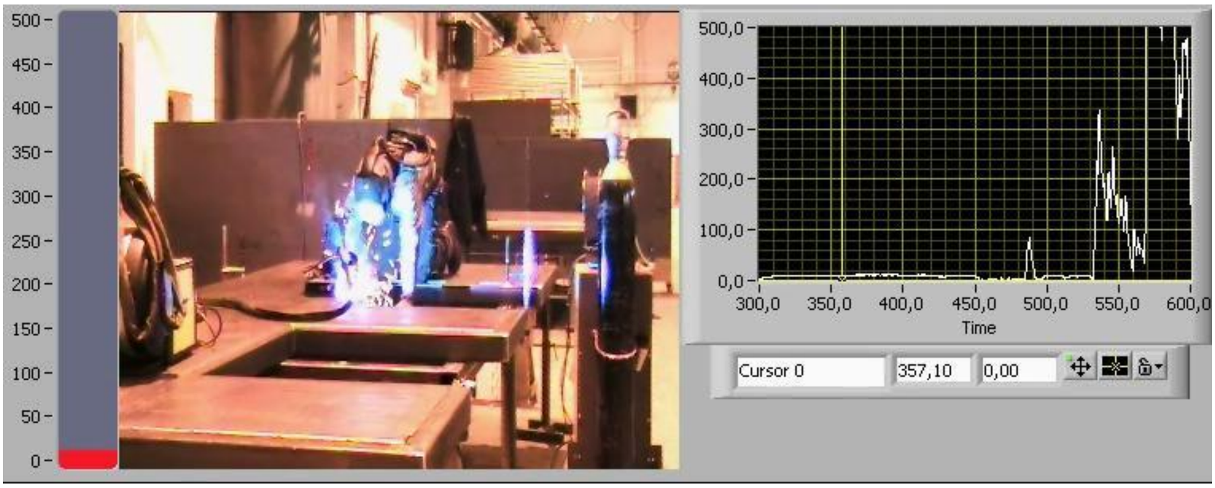

Figure 5. Screen dump from PIMEX recordings comparing exposure to welding smoke (relative values) during welding with a “welding tractor”. The welder is using a fresh air helmet until 530 s (in graph window).

When the same welder used the very provisionally-arranged exhaust on the welding pistol instead of the fresh air helmet (figure 6) his exposure was reduced even more relative to the situation without any exposure control. Similar differences (98% and 89% reduction) were observed when Welders 5 and 6 compared exposure with and without this exhaust on the welding pistol. See figure 7. These observations gave cause to discuss whether welding tools equipped with an integrated exhaust should be one alternative for investments aimed at improving work environments. Some of the welders had experience using such equipment, and told the others that this experience was mainly positive.

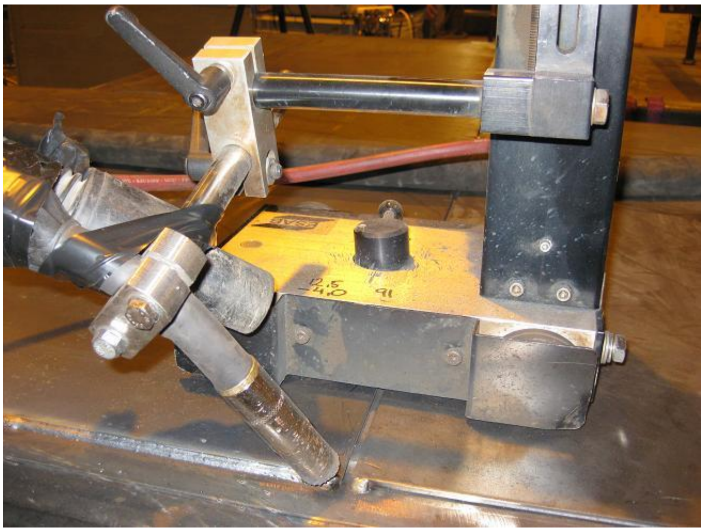

Figure 6. The welding tractor with a provisionally arranged exhaust on the welding pistol.

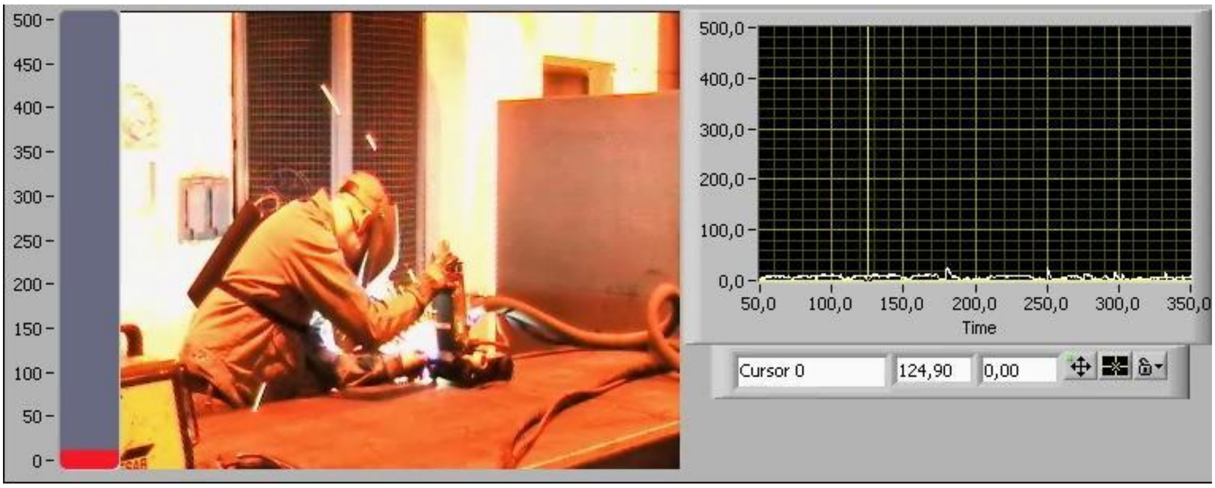

Figure 7. Screen dump from PIMEX recordings comparing exposure to welding smoke (relative values) during welding with a “welding tractor”. The welder is using a provisionally arranged exhaust on the welding pistol.

Welder 6 was welding in stainless steel, and the fact that his exposure was lower measured with an instrument indicating the amount of particles in the air doesn’t say anything about the toxicity of the smoke. This gave cause to discuss the fact that this smoke is more dangerous because it contains chromium and nickel and it can be more dangerous even if the measured value is smaller. A comparison was also made for this welder with and without the use of an exhaust on the welding pistol. See Figure 8.

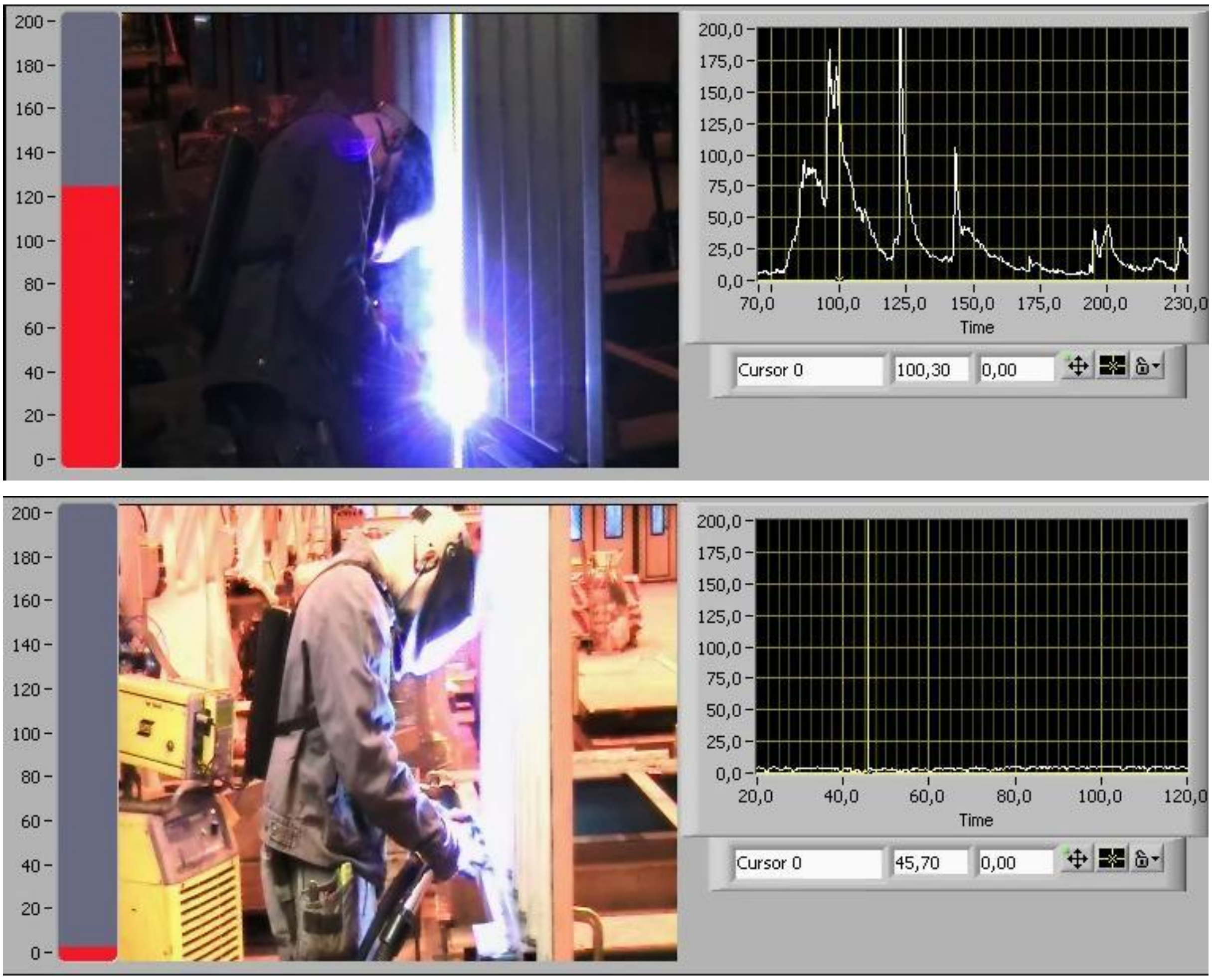

Figure 8. Screen dumps from PIMEX recordings comparing exposure to welding smoke (relative values) during welding in stainless steel. First picture without exhaust on welding pistol. Second with.

Measurements of motivation for workplace improvements.

The newly-developed questionnaire was tested for the first time in this workplace with the aim of discovering whether the involved workers' motivation to take an active part in workplace improvements changed as a result of this kind of intervention. In all, 21 of the welders in the company filled in the questionnaire one week before and one month after the PIMEX measurements. A control group with 14 other persons working in the factory did the same.

For one of the questions, "*To what degree would you say that you are involved in work environment improvements?*", the answer significantly increased in the welding group. Ten out of the 21 welders gave higher scores after the implementation whilst two gave lower scores (nine unchanged). In the control group there were no significant changes. Also, the answers to the question "*To what degree would you say that efforts to improve the work environment are appreciated?*", the average answer increased clearly, but not significantly (11 higher, 4 lower scores). For three questions the average answers were clearly but not significantly lowered. Those questions were: "*How important to you is having enough resources (time, financial) set aside for making changes to the work environment?*" (3 higher, 9 lower), "*How important to you is having opportunities to influence changes in the work environment?*" (4 higher, 10 lower) and "*To what degree would you say that you take responsibility for improving the work environment?*" (4 higher, 8 lower). For the rest of the 26 questions the changes in answers was less significant and are not reported here. The answers given by the welders in filling in the questionnaire before and after the PIMEX intervention give a few clear indications. They see their involvement in the improvements as clear and they see efforts to improve as more appreciated. The interpretation of the results showing lower scores after the intervention is not obvious.

Interview with manager

Two months after the intervention, an interview was done with the production manager about his experiences of the intervention and its results. He said that there were some decisions made with the aim of reducing the welders' exposure to welding fumes. The most important was that they asked for proposals from two companies for exhaust in the welding pistol. It was clear that one of the solutions would be chosen. It was also decided that they would make changes in the factory hall where welding in stainless steel took place. The goal was to arrange for effective control of emissions for all welders, and that the helmet with fresh air supply not be used. The manager also said that the PIMEX intervention and the conclusions from that produced important input for decisions. The welders have asked about which changes will be made as a result of the intervention.

Discussion

The workshops that were carried out as an important part of this sub-project in HERIVIS have made it very clear that within the different research and service groups there is an impressive total knowledge base and experience with the use of video exposure monitoring (VEM) methods like PIMEX. This knowledge is, however, sparsely spread out among the groups and a limited number of collaborating partners, and the communication between groups in different countries can be improved. Therefore, one of the main conclusions is that there is a lot to gain from better communication and exchange of experiences.

One of the main topics for the workshops was about how much the method's built-in potential to improve workers' motivation to participate in workplace improvements is used and developed. This quality of VEM is seen as especially strong if the method is used as a tool for communication between the specialist in the work in question (the exposed worker or group of workers), the production and safety specialist (often a manager) and the expert in occupational hygiene (the VEM expert). This way of utilizing VEM presupposes that the technology is used in single workplaces for a limited time period in such a way that it makes possible meaningful communication between the partners about the findings, as well as time for testing upcoming ideas for changes that might reduce the hazardous exposure in question. There was a clear agreement about the fact that this way of using VEM can help the exposed workers to reduce their exposure by increased understanding of the link between how work is done and how available control measures are utilized in the most effective way. Sometimes the necessary preconditions for effective reduction of the exposure are not available; however, in the field study described here the findings made an important contribution to the decision to invest in one type of control measure.

There are different reasons for not directly organising the use of VEM according to this strategy. One is that this strategy calls for extensive resources that it makes it difficult to market it to customers. Even if it is often possible to markedly reduce exposure to hazards without big investments by using VEM, is it difficult to convince the customer that this will be the case in a specific company. It is also the case that the key question for many companies when they are buying service from occupational hygiene experts is whether they are in compliance with occupational limit values or not. Another reason for not working according to this strategy is the fact that the technology used or disturbances in the workplace make it impossible to carry out discussions (with workmates and others) on the spot during or directly after the measurements. It may be too noisy, or impossible to talk for other reasons. A solution is to move to another place or to meet later when it is possible to discuss the results. This time lag between the monitoring and the opportunity to test ideas is, however, seen as crucial for keeping up the pace of the communication and testing of solutions. A third reason that was discussed was that there might be cultural differences and varying experiences between different countries with regard to arranging for a discussion based on equality. In the workshops there were also varying experiences about how permissible it is to record the working process on video. A fourth possible reason for limited interest among some workers to actively take part in actions to reduce exposure is the fact that they are sometimes economically compensated if they have a "dirty job". The authors believe, based on experiences from different studies, that this strategy for using VEM can be cost-effective in many cases, but it seems that there are several obstacles that need to be removed. There is also an urgent need to collect data that can strengthen the arguments for this strategy, especially for potential customers.

A more commonly-used strategy for VEM is close to the one described above, but more clearly focused on giving facts about the exposure characteristics in specific workplaces. Those facts then form an important base for decisions about investments in technology aimed at reducing exposure. The results are then very often given as some type of electronic report, often delivered on a CD-ROM. Such reports summarise the conclusions made by the VEM experts and include edited recordings from the studied situations. Such material may, of course, be very useful not only as a documentation of the results, but also as an important base for teaching new or existing staff about health risks at work. The important difference between those two strategies is that the potential for improving workers' motivation with VEM is not utilized directly during the study, and they are, therefore, not as involved in decision-making to the same extent. Such involvement is seen as crucial for making the most efficient investments (Rosén et.al, 2005).

The strategy of producing more general training material based on VEM recordings has been utilized in the Netherlands, Germany, the UK and Sweden. This strategy is, of course, very far from the strategy focusing on the involvement of workers, but it has great potential for transferring visualized knowledge to big groups. Several good examples are: the more than one hundred examples on good and bad work practices and technology that have been made available on internet in the Netherlands (Stoffenmanager, 2009); similar productions for branch organisations in Germany; and a number of training videos and CD-ROM-based materials from Sweden. Such productions can now also be distributed and made easily accessible to big groups via Internet.

The field that was a part of this sub-project in HERIVIS was designed for the collection of important experiences from the use of VEM, based on interaction. The strategy was clearly to establish an open communication between the welders, the supervisors and the VEM group. This was made in advance by providing information about the plans and, especially, asking the workers which work tasks they would like to prioritise in the study. It was also possible to discuss and communicate about the findings during the study. The potential to drastically reduce their exposure to welding fumes was clear for them, and many of the welders became markedly interested and active in the discussions. The statement made by the members of the VEM group that the workers' exposure often can be reduced by more than 90% just by making small changes was illustrated at different workplaces. The very simple test made with a vacuum cleaner to demonstrate the possibility of an exhaust on the welding pistol, as well as comparisons with alternative solutions, was important. The interview with the manager after the intervention made it clear that it provided important input for decisions. The measurements of the welders' and the control groups' motivation for workplace improvements, before and after the intervention, indicated that the welders were affected and that they have improved their motivation to some extent. The measurements were made with a questionnaire newly-developed for this purpose, and the picture is not totally clear. Further research testing and analysing the link between interventions like this, workers' motivation to take part in workplace improvements and the ultimate goal, reduced health risks, is called for.

The example of the vacuum cleaner used as a local exhaust illustrates very well how the built-in potential for simple experiments can be immediately evaluated. The workers' and the occupational hygienists' inventiveness are hereby given a tool for development.

Conclusions and recommendations

The results from the workshops illustrates clearly that there is an impressive amount of experiences and ideas for the use of VEM within the network of the groups participating in the workshops. The sharing of these experiences between the groups, as well as dissemination of it to wider groups is, however, limited.

The use of VEM according to different strategies is, without hesitation, successful in most cases. There is, however, a need for studies that can further demonstrate that the observed effects are significant. The monitoring of workers' motivation for taking part in workplace improvements is one example.

Based on those conclusions it is therefore recommended that the collaboration between different groups of researchers, as well as practitioners that are using and/or developing VEM, be strengthened with the intention to:

- Further develop the strategies for VEM, for interventions in single workplaces, as well as for exposure categorisation and production of training material.
- Conduct a research project with the intention of evaluating the effects of the use of VEM.
- Disseminate knowledge about the potential of VEM to occupational hygiene experts and others who may benefit from its use.

These proposed actions depend on national or international funding, and a first step is, therefore, to form a group of partners to take the initiative to take these proposals further.

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Appendix 1

HERIVIS Health Risk Visualisation System

Background material for workshops. Subproject "Implementation Strategies"

Topics to be discussed during the workshop

Three topics related to the Moveit-properties of VEM/PIMEX

1. To what extent do VEM/PIMEX fulfil the different Moveit properties (For details, see below)?
2. How can the strategy for using VEM/PIMEX be improved to better fulfil those properties?
3. How can the VEM/PIMEX technology be improved to better fulfil those properties?

One topic related to VEM/PIMEX for production of training material.

1. How is VEM/PIMEX utilised in the best way for the dissemination of knowledge in occupational hygiene to bigger groups? Experiences?

We would also like to discuss what can be done to support increased use of VEM/PIMEX and other urgent questions linked to the method and the strategy.

Moveit properties

The Moveit strategy has been presented in an earlier paper (see separate document). In attempting to identify the methods best capable of supporting the creation of motivation and engagement for work environment management, we have identified six separate properties which we consider especially important. In further work a number of aspects for each Moveit property have been identified to facilitate an estimate of the methods. A method can be estimated by deciding which aspects are supported during the use of each method.

Interactivity can be estimated from the type of participation the method support employees/involved to have:

- By feedback, i.e. that the result is given account to
- By participation to accomplish estimations of work environment factors
- By participation in analysis
- By participation in measures

Participation can be carried through at different levels. The principle is, the more participation levels the better the estimation of the methods properties for interactivity. This will also lead to better motivation power. It is also important to take into consideration that participation in measures provides a "better" form of participation than only rough feedback.

Change competence can be estimated from the type of participation the method support employees/involved to have in the alteration work:

- By participating in the analysis
- By performing tasks
- By trying solutions
- By evaluating

The same principle is applied, the more participation levels supported by the method, the better the positive estimation and motivation power.

Work environment knowledge can be estimated from the type of participation the method support employees/involved to have in the knowledge gained around work environment conditions:

- By participation in a measurement/the use of a checklist
- By participation in the work to find the basis for measures
- By interaction with a participating alteration leader or method expert
- By interaction with a participating work environment expert

The same principle is applied, the more participation levels supported by the method, the better the estimation of the properties and motivation power.

Room for action can be divided into, on one hand *Feedback*, on the other *How the individual can influence the work environment*.
Feedback can be estimated from what time interval the method imply that the result is given back to employee/involved

- Immediately (i.e. using direct reading instruments)
- Within an hour
- Within a day
- After one day

The principle is that a method with quick feedback gives bigger opportunities of finding alternative work practices and /or routines to decrease the work environment risk immediately. This is also considered a contribution to an increasing motivation to work environment work.

How the individual can influence the work environment can be estimated from how the method treats:

- Effects of the individuals' behaviour (i.e. the work environment factor can easily be influenced by changed work practice)
- Surrounding factors can easily be influenced
- Surrounding factors that can hardly be influenced

The principle is, the more easily the individual can influence the work environment factor, the higher the estimate of the property room of action and of the method's motivation power.

Systematism can be estimated by whether the method gives or contributes to the creation of:

- Flowchart (i.e. gives a description of causally connection for factors in the work environment)
- Basis for how different method steps shall be carried through
- Steps toward making an action plan

The principle is that a distinct guiding and a concrete final product, i.e. an action plan, gives a higher estimate of the property.

Integration possibilities can be estimated by whether the application of the method implies:

- Demands on regular measurements/controls

- A work practice in agreement with SAM (systematic work environment management)
- A work practice in agreement with the workplace quality system
- A work practice in agreement with the workplace production and /or economical operating systems

The principle is, the more these aspects are supported by the method, the higher the estimation of the method’s integration possibilities.