



DALARNA
UNIVERSITY

**Working papers in transport, tourism, information technology and microdata
analysis**

Implementation of Video Exposure Monitoring In Aluminum Industry

**Ann Hedlund
Ing-Marie Andersson
Gunnar Rosén
Editor: Hasan Fleyeh**

Nr: 2015:12

Working papers in transport, tourism, information technology and microdata analysis
ISSN: 1650-5581

© Authors

Implementation of Video Exposure Monitoring In Aluminum Industry

Ann Hedlund

Ing-Marie Andersson

Gunnar Rosén

Abstract

The aim was to evaluate results and experiences from development of new technology, a training program and implementation of strategies for the use of a video exposure monitoring method, PIMEX.

Starting point of this study is an increased incidence of asthma among workers in the aluminium industry. Exposure peaks of fumes are supposed to play an important role. PIMEX makes it possible to link used work practice, use of control technology, and so forth to peaks. Nine companies participated in the project, which was divided into three parts, development of PIMEX technology, production of training material, and training in use of equipment and related strategies.

The use of the video exposure monitoring method PIMEX offers prerequisites supporting workers participation in safety activities. The experiences from the project reveal the importance of good timing of primary training, technology development, technical support, and follow up training. In spite of a delay of delivery of the new technology, representatives from the participating companies declared that the experiences showed that PIMEX gave an important contribution for effective control of hazards in the companies. Eight out of nine smelters used the PIMEX method as a part of a strategy for control of workers exposure to fumes in potrooms. Possibilities to conduct effective control measures were identified.

This article describes experiences from implementation of a, for this branch, new method supporting workers participation for workplace improvements.

Key words:

PIMEX, peak exposure, aluminium industry, video exposure monitoring, worker participation

Ann Hedlund

Lektor i Arbetsvetenskap, Högskolan Dalarna
e-post: ahd@du.se

Ing-Marie Andersson

Professor i Arbetsvetenskap, Högskolan Dalarna
e-post: ima@du.se

Gunnar Rosén

Professor i Arbetsvetenskap, Högskolan Dalarna
e-post: grs@du.se

Preface

To effectively reduce staff exposure to noise, vibrations and heat radiation AMS (Aluminiumindustriens Miljøsekretariat) decided that the PIMEX method should be adapted and developed for the special needs of all Nordic Aluminium industries. The following report describes the process. It has been a collaboration between Dalarna University, Sweden and the Norwegian Institute of Occupational health (STAMI) and Analytik Jena AG, Germany.

Borlänge in December 2015

Authors

Table of Contents

1 Introduction	7
2 Aim	9
3 Subjects and methods	9
3.1 PIMEX-Technology	10
3.2 Training Material	11
3.3 Implementation and Training	11
3.4 Evaluation	12
4 Results	12
4.1 PIMEX-Technology	12
4.2 Implementation and Training	13
4.2.1 The Industrial Sector	13
4.2.2 Smelters	14
4 Discussion	18
4.1 Challenges	19
4.2 Mistakes	19
4.3 Training	20
5 Conclusion	21
6 References	22

1 Introduction

To protect workers from risks at work, occupational exposure limits (OEL) have been decided upon, especially for air contaminants. The fact that those OELs normally are set as averages for longer time periods, up to 8 hours, implies that occupational exposure assessments preferably are made to show whether the exposure in question complies with the OEL. The variation of exposure over time is however significant, which implies that an average hides important information about health risk factors, and perhaps even more important, information for identification of the reasons behind high exposure.

Primary aluminium is produced by electrolysis of ore, most commonly bauxite (International Aluminium Institute, 2012). The industrial settings are normally constructed from a large amount of such electrolysis cells, in buildings that can be more than 1 000 meter long. These halls are called potrooms. There are many assumed and confirmed health effects of occupational exposure in aluminium smelters. The occurrence of potroom asthma and possibilities to eliminate that has been in focus in this study. One hypothesis from the aluminium industry is that peak exposures leads to more acute changes in lung function, while constant exposure leads to long-term disabilities (Radon *et al.*, 1999). The amount of different hazards in the potrooms implies that workers in the aluminium industry wear a lot of personal protection equipment. The Norwegian Labour Inspection Authority demanded that something was done to reduce the unacceptably high numbers of reported work-related cases of potroom asthma. The authorities and the aluminium industry, together, developed framework directives for potrooms and other parts of the production, based on the vision: “No new cases of potroom asthma in the future”. The development of framework directives was a joint project and volunteer based (Nilssen, 2007). Measurements of exposure to air contaminants in aluminium smelters made with real time monitoring instruments, HAPPA project, (Skaugset *et al.*, 2008) illustrated that the variation typically was huge. The main part of worker exposure to fumes and gases are explained by short peaks. Typically was 90 % of the total exposure dose explained by 6 % of time. It was also concluded that traditional measurement methods kept this information concealed. Andersson and Rosén (1995) have estimated that with GSDs (geometric standard deviation) exceeding 3.0, at least half of the total exposure dose is explained by exposure peaks representing only one-tenth of the time (Andersson and Rosén, 1995).

The association for the primary aluminium industry in the Nordic countries, AMS (Aluminiumindustriens Miljøsekretariat) concluded that it, in order to meet the demands from the labour inspection, was necessary to focus on reasons for exposure peaks. The importance of an educationally good method to analyse the job execution was seen as central. Even if

knowledge about risks with exposure and means to control it are well documented, a large number of employees are still exposed to hazards. Transfer of knowledge to the individuals is still often a missing step. The workers motivation to actively take part in workplace improvements is also crucial.

Workers involvement in safety activities are directly related to individual responsibility for such questions, as well as the degree of the workers satisfaction with the physical work environment. Shortages in environmental conditions results in increased safety activities. The individual's involvement in safety activities is influenced by his/her experience of the work group's involvement. Safety communication within the work group, as well as safety standards and goals, and safety management are also of importance for the involvement of the individual. (Cheyne *et al.*, 2002)

Visualization methods that can support increased knowledge and motivation among workers, as well as among supervisors, are therefore important (Rosén, 2002). Video exposure monitoring (VEM) methods, such as PIMEX (PIcture Mix EXposure), provide such possibilities. AMS did therefore decide to finance a project with the aim to implement PIMEX in all member aluminium plants. VEM is an established method for different control and training purposes in occupational hygiene. The PIMEX method means that a person is videoed at his/her workplace, while its exposure to a particular risk factor in their work environment is measured by a real time monitoring instrument. The work environment factor can be chemical or physical, such as an air contaminant or noise, but can also be the effects of exposure such as muscle strain or heart rate. The measurement result is displayed graphically parallel to the video during the video recording or at a later time. With modern technical solutions both the video and measurement data are stored on a laptop computer. By using real time monitoring instruments, that can provide the reading fast, it becomes possible to study in detail how various ways of carrying out a work operation affect the measured stress on the worker (Rosén *et al.*, 2005a).

It is this feature of the PIMEX method that provides excellent opportunities to involve the affected employees in measures to reduce exposure, in a way that clearly increases their motivation to make changes, and it provides opportunities to learn about how the risks can be reduced. Because the method makes it easier to understand the connections between how the work is done and what factors of stress it implies, communication between the occupational hygiene expert and the affected employee is also facilitated. In this way, the employee's knowledge can effectively be turned to good account in the work to reduce exposure to hazards (Rosén *et al.*, 2005a).

To be able to reduce exposure at single plants, one important aspect is that each plant has access to equipment and knowledge to implement the PIMEX method. This corresponds well with the framework directives (Nilssen, 2007). It was also stated in the directives that the workers should be involved in the work, to improve their motivation in this matter. Involvement of workers is very important, according to the assumption that the behaviour when performing the work tasks has a great impact on the variation in exposure (Arbeidstilsynet, 2007). Cooperation between employees, employers and occupational hygiene experts is important for the project to be successful. Likewise, motivation and engagement are important to achieve continuous work environment improvements. The PIMEX method is defined as a Moveit-method (Motivation and engagement supporting workplace improvement tools) (Rosén *et al.*, 2005b). The choice of this method therefore meets a number of the goals agreed about in the framework directives.

2 Aim

The aim of the project was to adapt the technology for the PIMEX method to the needs in the aluminium smelting industry as well as implement the use of the method for control of hazards exposure in this industrial branch. The underlying aim is to minimize the incidences of asthma among affected workers especially in the potrooms in the aluminium industry. The aim was to evaluate results and experiences from development of new technology, a training program and implementation of strategies for the use of a video exposure monitoring method, PIMEX.

3 Subjects and methods

This study is conducted in primary aluminium smelters in Norway, Iceland and Sweden. The project was organized with project management from the Norwegian Institute of Occupational health (STAMI); and with Dalarna University, Sweden (DU) and Analytik Jena AG, Germany as project partners. Except for coordination of the project STAMI was also responsible for knowledge about and selection of measuring equipment, as well as technical development and support. DU was responsible for choice of user interface for PIMEX, knowledge about PIMEX and strategies for its use in production of training material and training in use of the equipment. Development of new hardware as well as of software for PIMEX was made by Analytik Jena. The participating plants in the project have comparable production and thereby the same kind of work environmental problems. Seven of the primary aluminium smelters are located in Norway, one in Iceland and one in Sweden. The number of employees varies between about 200 and 1000 persons. It is warm and often dusty in the potroom, where the electrolysis is conducted, and

trucks and other vehicles are used both indoors and outdoors. Continuously performed tasks are control of the melting process, filling of raw material, sampling of melted alumina, and maintenance of equipment.

This project has methodologically been divided into three parts, development of PIMEX-technology for the specific need in the aluminium industry, production of a training material, and training in use of equipment and related strategies. The project was running during the period 2007-2008. Follow up and evaluation meetings were ongoing until September 2010.

3.1 PIMEX-Technology

Primary production of aluminium implies a process based on electrolysis with extremely high current intensity. This in turn means that the level of electromagnetic fields partly is extremely high. It was therefore not possible to use existing technology for PIMEX. A new technology based on earlier experiences and specific needs has therefore been developed (Rosén *et al.*, 2005a). A specification of demands for the hardware as well as user interface was formulated and used as the input for development of technology and software. Development of a ready system was formed as an interactive process including software and hardware development as well as field testing.

The PIMEX method presupposes that real time monitoring instruments are available for occupational hazards of interest. To make it possible to monitor the workers exposure the instrument need to be relatively small, battery operated, and has a short response time, not longer than a few seconds. One group of air contaminant that might be of interest to study in the aluminium industry is poly-aromatic hydrocarbons. Any instrument suitable for PIMEX is however not available. Studied hazards in this study are described in table 1.

Tabell 1. Used PIMEX equipment and additional technology among aluminium smelters.

Company	PIMEX-equipment	Dust and smoke	Noise	Video editing	Other sensors
A	x	x	x		Heat Stress
B	x	x	x	x	
C	x	x	x	x	
D	x	x	x	x	Light
E	x	x			
F	x				
G	x	x	x		
H	x	x	x	x	
I	x	x	x	x	

3.2 Training Material

It was decided to produce a training material, handbook, based on four chapters: introduction, equipment, sampling and processing. The material was developed step by step and distributed on DVD. It consists of text documents, still pictures, and video sequences. The ambition was to give the user a deep understanding and practical guidance in the PIMEX method. The handbook covers everything from PIMEX-history to detailed instructions on for instance how to prepare a PowerPoint presentation from recorded material.

3.3 Implementation and Training

On all eight aluminium plants in Sweden and Norway a half-day training course was arranged focusing on the basic PIMEX-technology, needed prerequisites and the possibilities the method will imply for the branch. The plants were mostly represented by people working with environmental hygiene, occupational health and safety (OHS), as well as production processes. When a first version of the training material and the specially developed PIMEX-technology was ready, a new one-day course was arranged. The one-day course was arranged at one plant in Norway, with participants from all other plants in Norway. A similar course was arranged at a plant in Island, also including participants from Sweden.

3.4 Evaluation

Half a year after the end of the project, one of the smelters was visited, with the aim to discuss experiences from their implementation. The smelter was selected because the local OHS expert also was a representative of AMS. Based on the discussions with the OHS expert, areas were identified for later phone interviews. Detailed interviews were made, about one year after the project ending, with representatives for all smelters that had started to use the PIMEX equipment. Examples of discussed areas are; used equipment and technology, use of distributed training material, experiences, practical solutions for transportation and measurements, strategies, and examples of use.

During the project and until one and a half year after it was finished a continuous contact has been ongoing with AMS. All participating companies were two years after the project invited to a one-day follow-up meeting. Representatives from all companies attended and they presented their experiences so far. Discussions around the topic were held together with researchers and the branch organization. Those discussions were analysed in order to qualitatively evaluate the benefits from implementation of PIMEX.

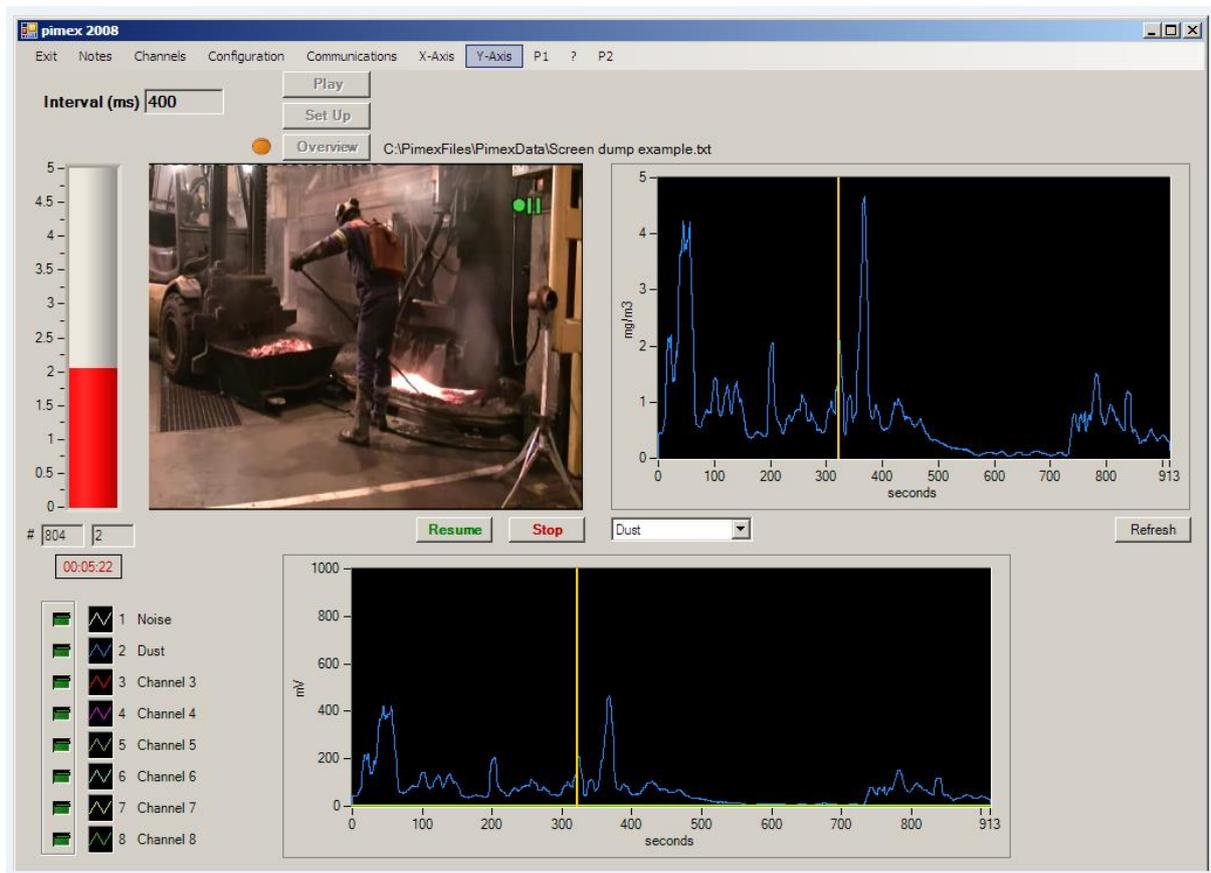
4 Results

4.1 PIMEX-Technology

The biggest challenge in the development of the technology was to handle the extremely high electromagnetic field level. A pilot study revealed that the monitoring instruments of interest were possible to use without any disturbances. The only problems noted were associated to the video camera and the laptop computer. Since it was the mechanical parts in the camera and in the computer that caused the problems, a camera and a laptop with flash memory storage were tested and found to be the solution. A new telemetry solution for up to four channels was designed based on standard technology.

The development of software for PIMEX resulted in a version, which contrary to the earlier Swedish version, combines the software for recording and replay (Rosén *et al.*, 2005a). The user interface (see figure 1) includes graphical presentation of data, for one monitored exposure factor momentarily projected as a vertical bar and synchronized to the video. Data for the same factor are also displayed in a line graph beside the video window. Up to four monitoring instruments can be used simultaneously and a line graph showing the results from all used channels is also displayed under the video frame. The software makes it possible to choose which exposure factor

that will be displayed beside the video window, to adjust axes for the graphical presentation and to display data in absolute values (as mg/m³ or ppm) by incorporating a calibration factor.



4.2 Implementation and Training

The results of how the industrial sector has succeeded in their efforts to reduce occupational exposure is described and analysed at two different levels. The first level is the industrial sector; in this case the group of primary aluminium smelters in the Nordic countries which are associated to AMS. The second level is the plant; here each aluminium smelter.

4.2.1 The Industrial Sector

Necessary hardware and software, for use of PIMEX, have been distributed to all aluminium smelters which are members in AMS. The training material has been distributed as well, and two courses have been arranged. One year after all companies have participated in courses and received the PIMEX-equipment five out of nine smelters have started real use. The other four have been forced to delay the start because of the economic recession starting 2008. For example was it not possible for some of the smelters to invest in necessary measuring instruments during

this period. During 2010 all smelters except one have been using the equipment. All of them have started the measurements by using a light scattering instrument for particles. Six of them have also started to use noise meters. Other instruments used are for measuring heat stress, vibration and light.

4.2.2 Smelters

The nine smelters' OHS departments have all more or less experienced a "technological threshold", which they needed to pass before being able to start. After solving the initial technical problems, they were however able to focus on practicing the method and to use it with available instruments in the factories. Most of them used same kind of laptop computer and dust monitoring instrument, as recommended by the project leader of the PIMEX implementation project. The use of the same type of laptop was important for solving unexpected technical problems. The amount of personnel resources involved in using PIMEX differed among the smelters. Especially one smelter pointed out the necessity that one person alone can handle the equipment.

The strategy used for PIMEX measurements has varied among the users. In one company supervisors have, at different departments, ordered measurements with PIMEX from the OHS group when they saw work tasks calling for a risk analysis. One experience so far was that they found the results more useful compared to written reports from traditional exposure measurements. In other companies the use of PIMEX was already more or less integrated in the general work environment management system.

At three of the companies a strategy for use was developed as a part of a risk assessment program. One company divided the program into three steps. Step 1: The risk is identified. Step 2: What are suitable means for control, suitable work routines, process technologies and other factors explaining a clear variation in exposure? Step 3: Use of PIMEX to answer the questions in step 2. To quantify the risk, it is also important to use established (full shift) exposure assessment methods for comparisons with OEL. Therefore, an identified risk always results in a PIMEX study when this method is suitable. The occupational hygienist plans and carries out the study in consultation with affected workers, safety representatives and supervisors. The analysis of the results is, if possible, made by the same group directly after measurements. The conclusions from the analysis are formed so that it can be put into the action plan, which is a part of the general work environment management system.

The strategies in different companies include one or more of the following parts; mapping of different processes, direct interventions at the work place, development of emission control technology, importance of work practice, basis for management decisions. Some companies

mention an intention to produce training material in the future. For one smelter the use of PIMEX was seen as a project, not as a part of the basic work environment management system. On the agenda is also to utilize PIMEX for training of newly employed staff as a part of the already existing program. Other plans for development imply the use of different instruments for other factors of interest and to utilize the possibility to use more than one instrument simultaneously with PIMEX. The possibility to study two workers at the same time is also of big interest.

Different types of practical solutions for storing and transportation of the equipment out to workplaces have been arranged by the users. All have arranged with some kind of backpack for the worker to store the monitoring instrument and the transmitter in, during ongoing measurements. Some have used a special holder for the laptop and a receiver making it possible to carry and handle it while following the worker when he/she moved around. Also the video camera was carried by the same person and this arrangement resulted in a very flexible arrangement, which also made it easy for one person to do the measurements. In one of the companies they also arranged with a special three wheel bicycle with the computer on a luggage carrier and the video camera on a tripod fixed to the bicycle. (Figure 2)



A steady backpack, to be carried by the studied worker, for the monitoring instrument and the transmitter is necessary. Because of strict rules on use of inflammable material in this industrial branch, a specially manufactured backpack, e.g. in leather, must be used. An example from one factory is showed in figure 3.



It is important to always keep the equipment's batteries charged so that eventually needed acute measurements are possible. Another experience is that the workers always have been willing and interested to carry the monitoring backpack.

The degree of implementation varies a lot between the smelters. Some of them have just started while others have covered many work operations. The smelter with the most advanced implementation has a clearly developed strategy based on the Work Environment Risk

Assessment (WERA). The action plan was available on intranet, for everyone in the company, with traditional colour marking for how severe the risk was. Work tasks that have been identified in the high risk group (red category) have been prioritised for PIMEX studies. The recorded material has been shown and discussed together with workers and supervisors involved in the studied work task. Actions have been taken to improve the work environment, and work tasks in the high risk group have been reduced. One such example is how the worker preferably is placed in relation to air currents and dust source during service work at the cells in order to reduce the exposure of dust and smoke. Another example is a modified enclosure at the cell in order to reduce smoke emissions. PIMEX helped to point out critical points for emissions and to evaluate effects of control measures. The company has also done direct changes in their safety instructions. The next step is to link produced PIMEX videos to the description of the risk, where the method has been used, available on intranet. So far, PIMEX-videos have been used as training material for groups of workers.

PIMEX has commonly been used to train workers to understand the importance of best practice to perform critical work tasks. So far, work behaviour has been in focus to higher extent than identification of technical solutions. At one smelter the OHS expert has carried the PIMEX-equipment while transporting himself on a three wheeled bicycle around in the large production hall. This means using PIMEX helps to identify areas in the hall, where not expected problems can be identified. One such example is that it was obvious that the use of compressed air to clean work clothes contaminated the air in the workers near surrounding.

One of the smelters started by letting temporarily engaged students do a large number of measurements. Totally more than 100 measurements were done in five different areas. The idea was to collect practical experiences, and let OHS experts analyse the PIMEX-videos afterwards. One example that can illustrate the quantitative effect on exposure to fumes is marking of anodes just after they were picked out from the cells for service. The work was normally done so that the worker stepped up on the still warm anode and marked it. The PIMEX recording illustrated clearly how the smoke concentration around the worker was raised from a background concentration of 2 mg/m^3 up to around 15 mg/m^3 when the worker was standing on the anode. The exposure during this work was to about 80% explained by warm fumes passing the worker on its way up. This exposure was eliminated by changing the work routine so that marking was made from a vehicle. Observations of the PIMEX video was also an eye opener for other risks linked to the work, especially risks for accidents.

Shifting of minor equipment in the electrolytic cell lasting 15 minutes implies exposure to fumes. Fifty per cent of the total exposure dose was explained by peaks lasting 12% of time. During

shovelling slag from the melted metal surface lasting 7.5 minutes, was 50% of total exposure explained by 22 % of time. The difference between the two examples is explained by high background concentration in the latter example.

One main advantage is the possibility to visualise non-visible hazards. The representatives of the companies which have used the system also expressed the positive experiences as it gave possibilities to identify peak exposure, identify how peak exposure can be reduced, involve all in problem solving, demonstrate best work practice, motivate staff to use the best work praxis based on a common view, conduct training based on produced material, more easily convince management on decisions about investments, and document and evaluate effects of control measures. One of the users pointed out difficulties for workers to manipulate results from measurements as an important advantage. The smelters in Norway expressed that the technical support from the national institute of occupational health was of great importance to solve initial technical problems.

There are some negative aspects observed; the expenses for the equipment, that the equipment not was delivered as a complete ready to use package, problems related to the extremely high electromagnetic fields, the size of the equipment to be carried by the worker, and the fact that only instruments with analogue signal output could be used. The use of PIMEX was seen as time consuming and resulted in more measurements since it did not replace traditional measurements. One OHS expert also expressed the wish to arrange possibilities to operate it without any assisting person. Two companies missed an instruction manual. A representative from AMS concluded that the negative aspects of using PIMEX are few in relation to its advantages.

4 Discussion

This paper is presenting experiences and results from an extensive project with the overarching goal to eliminate the occurrence of asthma among workers in the aluminium smelting industry. Nine smelters in Norway, Sweden and Island, as well as the association for the primary aluminium industry in the Nordic countries (AMS) have participated. The point of departure was that the occurrence of asthma depended on the workers exposure to air contaminants and that it was essential to gain more knowledge about the big variation in workers exposure during the work day. A framework directive was voluntary created by the industry and the Norwegian Labour Inspection Authority based on the vision: “No new cases of potroom asthma in the future” (Arbeidstilsynet, 2012). This fact played an important role for the decision to start the project.

4.1 Challenges

This decision, made by AMS, implied a number of challenges. Therefore AMS decided to collaborate with the Norwegian Institute of Occupational Health (STAMI) to find solutions. The first challenge was that they did not find any directly usable technical solution for PIMEX. One main reason was that the level of the static magnetic field in the main part of the aluminium production is extremely high. Common computers and video cameras were for that reason not usable. A pilot study including meeting on some of the smelters clarified what was needed to be done to implement PIMEX. Those meetings included basic information about the possibilities with the method, and also about the demands as the companies representatives dealing with occupational health and safety (OHS) saw it from their point of view. An important part of the pilot study was also to test an available technology for PIMEX (PIMEX-PC developed in Sweden) with the intention to make clear how the technical challenges could be solved best. Based on the conclusions, it was decided to develop a new technology adapted to the special conditions (magnetic field) that were present. The development of the new technology was also guided by the opinions and expectations from the representatives of the companies that participated in the pilot study. Their wish was to have a user friendly, and as far as possible plug-and-play ready system, with the possibilities to study the most relevant air contaminants. A need to arrange for training, when the equipment was ready, was also obvious.

4.2 Mistakes

The results and experiences presented in this paper, some years after the start of the first pilot project, can be summarised as in many ways successful, but with conclusions about crucial steps when a method like PIMEX is widely implemented. It is clear that the companies, after gaining experiences from the use of PIMEX, saw and expressed all the positive qualities that are associated with the method. The way to this was however not as easy and straight as planned and wished.

One important lesson to be learned from the project is that a complicated technology, in this case PIMEX, must be tested and ready before the next steps in an implementation plan. When representatives for OHS from the companies were invited to demonstrations and training the equipment was far from plug-and-play ready. This created scepticism about the method among some of the participants and gave the impression that the use of PIMEX is very complicated. There was a clear risk this would overshadow all the potential possibilities and that might for

some of the participating companies have contributed to a lowered priority for the forthcoming steps in the project.

The expectations from the OHS-staff at the companies to have a plug-and-play ready system were not totally realistic. Consequently, some of them experienced different kinds of problems when they had the technology delivered. Some had problems with installation of software and some with the communication between different parts of hardware. Some of the problems were depending on the fact that not every person reads the manual before testing, but also that must be taken into account. Other problems were however linked to the technology. This resulted in a bigger need for support than expected to overcome the initial problems. A lesson learned from that was that the full PIMEX system should have been put together and tested before delivery to the companies. That would have saved time, not only at the companies but also for the project group, in this case STAMI.

4.3 Training

Timing of training activities for the OHS-staff and distribution of training material to them is essential. The courses that were arranged were scheduled too early. Therefore, many of the participants did not have the possibility to relate the messages in the courses to own experiences and possibilities to practice. Access to a comprehensive training material was therefore not so useful and when they later on were ready to start, there was a big risk that the messages from the courses as well as from the training material were forgotten.

Sharing of experiences between users with similar background and goals is extremely valuable. This was obvious when the PIMEX users together with the central project group gathered for a training day three years after the project start. The need for learning and sharing of experiences was illustrated by the fact that representatives from all companies came. Those who were in the face of starting their use had a lot to learn from those who were more experienced, and those with experiences learned from each other from discussions of strategies and so forth.

As described above, the progress of the project was somewhat slower than expected. A contributing disturbance causing this was the fact that the deep international economic crisis started mainly at the same time as the PIMEX implementation project. This crisis caused huge problems for this branch, and changes in priorities in the companies of course affected this work. This fact was only to accept, but it is important to understand that it, in different ways, contributed to slow down the progress.

In spite of the different obstacles, the companies have demonstrated and declared that implementation of PIMEX give advantages that clearly counterbalance the efforts for learning

and the investments in technology. The advantages that were described by the OHS-staff from the companies were the same as have been described before by other users (Rosén *et al.*, 2005a; McGlothlin, 2005). One quality, which was especially appreciated, was the possibility to visualize non visible hazards. Even if the smoke in general often can be seen in the potrooms in the aluminium smelters, there is no chance to see in what places or when the concentrations are e.g. 20 or maybe 100 times the average and therefore strongly contributes to the health risk. That such peaks in exposure occur can be determined by using real time monitoring instruments with a data logger. The combination and synchronisation with video, as PIMEX offers, add a lot of information and give all the possibilities to link peaks to episodes explaining the peaks. The possibility to involve workers in problem solving by discussing findings together with them offers a base for workers who are more motivated to be engaged in preventive work (Andersson *et al.*, 2000; Rosén, 1999).

The factors in the structural model of employees attitudes to safety (Cheyne *et al.*, 2002) are in different degree included as a result of the implementation of the PIMEX method among the smelters. The framework directives between seven Norwegian smelters and the authority are a safety plan to improve the work environment with the aim to eliminate new cases of potroom asthma. In the agreement is it specially pointed out that worker participation is essential. Since the workers have to wear personal protection equipment depending on the risk for asthma they are not satisfied with the physical work environment. The smelters aim to implement the PIMEX method were to incorporate it in their management system. The results show that three smelters already use the PIMEX method as a part of their risk assessment program. These basic facts indicate that different prerequisites for workers involvement in safety activities are in place. Different examples of the workers involvement in safety activities were described from the smelters. For example were workers involved in direct interventions, as well as analysis of results from measurements and discussions concerning improvements. The analysis and discussions are conducted in groups were both workers, safety representatives and supervisors are participating. As a next step, some companies plans to produce training material in the future as a way to communicate safety issues.

5 Conclusion

The use of the video exposure monitoring method PIMEX offers prerequisites supporting workers participation in safety activities. It has also been shown that workers have participated in some of the conducted measurements and analysis.

The experiences declared by OHS-staff after the implementation of the PIMEX method at the aluminium smelters can be summarised as follows; it is an effective and useful method that offers many possibilities, but for the users there is a threshold that must be passed. This threshold was especially high in this case since there was a need to develop new technology adapted for this industry. Based on the experiences from the project it can be recommended that, if a group of industries decides to introduce video exposure monitoring, it should be made in four steps. The first step is: Organize a project group which has knowledge about and experiences from the use of PIMEX. The project group must be ready to offer technical support as well as training for participating companies. The second step is: Introduce the OHS staff and other involved (e.g. safety representatives) in every company in general about the qualities that PIMEX offers and discuss special needs and expectations. The third step is: Put together, prepare and test the PIMEX system before delivery to each company. The delivery should be accompanied by a short primary training as well as necessary manuals and training material. How to get support must be clear and planned for. The fourth step is: Offer follow up training when the OHS staffs have had time to collect experiences. To combine this with a meeting between users with the intention to share experiences is especially useful.

6 References

Andersson, I-M., Heinonen, K., Karjalainen, J., Leisser, H., Novak, H., Pääkkönen, R., Riipinen, H., Rosén, G. and Säämänen, A. (2000). "Workplace improvement strategy by PIMEX-WISP", 4th International Scientific Conference of the International Occupational Hygiene Association, Cairns, Australia, 10-14 July page 43.

Andersson, I-M. and Rosén, G. (1995). "Detailed Work Analysis for Control of Exposure to Airborne Contaminants in the Workplace", *Appl. Occup. Environ. Hyg.* 10, 537-544.

Arbeidstilsynet (2007). "Prevention of potroom asthma in the Norwegian aluminium industry. Framework directives for work in the potrooms", Arbeidstilsynet, Norway ref no 2004/15263. English translation Aug 15, 2007.

Arbeidstilsynet. (2012). "Drastisk reduksjon av hallastma", Available at: <http://www.arbeidstilsynet.no/arbeidervernartikkel.html?tid=97730> (accessed 15 December 2015) (in Norwegian)

Cheyne, A., Oliver, A., Tomás, J.M. and Cox, S. (2002) "The architecture of employee attitudes to safety in the manufacturing sector", *Personnel Review*, 31, 6, 649-670.

International Aluminium Institute (2012). "Production", Available at: <http://www.world-aluminium.org/statistics/> (accessed 15 December 2015)

McGlothlin, J.D. (2005). "Occupational Exposure Visualization Comes of Age", *Ann. occup. Hyg.*, 49,197–199.

Nilssen, O.A. (2007). "Prevention of Potroom Asthma in The Norwegian Aluminium Industry. Framework Directives for Work in The Potrooms." Arbeidstilsynet, Trondheim, Norway

Radon, K., Nowak, D., Heinrich-Ramm, R. and Szadkowski, D. (1999). "Respiratory health and flouride exposure in different parts of the modern primary aluminium industry", *Int Arch Occup Environ Health*, 72, 297-303.

Rosén, G. (1999). "Workplace improvement strategy by PIMEX. WISP", Final report to the European Commission, SAFE project No 97 202356 05F05, National Institute for Working Life, Sweden.

Rosén, G. (2002). "Seeing is believing", Invited editorial. *Annals of Occupational Hygiene*, 46, 3-4.

Rosén, G., Andersson, I-M., Walsh, P.T., Clark, R.D.R., Säämänen, A., Heinonen, K., Riipinen, H. and Pääkkönen, R. (2005). "A review of video exposure monitoring as an occupational hygiene tool", *Ann. Occup. Hyg.*, 49, 201-217.

Rosén, G., Andersson, I-M. and Åteg, M. (2005). "Moveit. Improved Motivation and Engagement for Hazard Control", Proceedings of IOHA Conference in Pillanesberg

Skaugset, NP., Notø, H., Jordbekken, L., Seberg, E., Ellingsen, D. and Thomassen, Y. (2008) "Eksponeeringskartlegging ved norske aluminiumverk – Samlerapport for prosjektet: "Kartlegging av yrkeseksponering av betydning for utvikling av hallastma ved produksjon av primæraluminium" (HAPPA)", STAMI-rapport Årg. 9, nr.9, STAMI, Oslo



**HÖGSKOLAN
DALARNA**

Högskolan Dalarna, 791 88 Falun. Telefon 023-778000. www.du.se