



ABSTRACTS

Health Effects on Canteen Staff Working in a University Canteen

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Background: Working in a canteen will involve more than one activity e.g. cutting, grinding, washing. These activities may lead to stress and muscle fatigue.

Objective: To analyse health effects in canteen staff working at the university.

Methods: A cross-sectional study was conducted in canteen staff. A questionnaire was used to compare the level of feeling e.g. strength, force, interest before and after work between canteen staff using a subjective judgment scale from 1–10, together with assessing muscles; extensor of the wrist, biceps, triceps at different times by using surface electromyography (EMG). A paired t-test was used to analyse data.

Results: 23 canteen staff participated the project (100%). Canteen staff did not report any significant difference in feeling e.g. freshness, keenness, force or strength that differentiated before work and after work. Extensor of the wrist seems to be the most muscle using part in a canteen activity.

Conclusions: Stress levels related to working in a university canteen are low as muscle fatigue measured by EMG. However, performing repetitive work in a canteen could lead to muscle fatigue or stress so break interval time may be important for preventing muscle fatigue and reducing stress.

Prevalence and Correlates of Noise Induced Hearing Loss among Traffic Policemen in the City of Colombo

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Background and objective: Noise induced hearing loss (NIHL) is a high frequency sensory-neural hearing loss in subjects who are exposed to environmental noise. Traffic policemen are exposed to environmental noise due to the nature of their duty and are susceptible to develop NIHL.

The objective of this study was to determine the prevalence and correlates of NIHL among traffic policemen in the city of Colombo.

Methods: A cross sectional study was carried out among traffic policemen in the city of Colombo. 350 participants were selected by cluster sampling. Pure-tone audiometry test was performed to assess the level of NIHL. Hearing levels of participants were classified using a classification obtained by modifying the Clark's classification. Correlates of NIHL were assessed using an Interviewer Administered Questionnaire (IAQ).

Results: Seventy nine participants (27.5%) had minor NIHL and 39 participants (13.6%) had major NIHL. In bivariate analysis 23 variables showed statistically significant association with mild and major NIHL while multi-variate analysis showed only age had statistically significant association with major NIHL with odds-ratio (OR) of 1.088 and only "duration of work as a policeman" had statistically significant association with any NIHL (major or minor) with OR of 1.007.

Conclusions: Prevalence of NIHL among traffic policemen working in the city of Colombo was 41.1% (95% CI=35.5%–46.9%). A third of those having NIHL had major NIHL.

Traffic policemen should undergo periodic hearing assessment. The police department should explore the feasibility of reducing the number of hours per day spent on the road by traffic policemen.

Occupational and Prostate Cancer Risk

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Objectives: To assess occupation's exposure as risk for prostate cancer.

Methods: A population-based case-control study recruited 237 men with a diagnosis of confirmed prostate Cancer and 237 controls randomly selected from the community between 1/Jan/2009 to 30/December/2012 in Gezira state-Central of Sudan. Thirteen occupations and 8 industries were selected for analyses to estimate the odds ratio between each occupational circumstance and prostate cancer with control for potential confounders.

Results: History of farmer was associated with a highly significant increased the risk for prostate cancer OR (3.711; 95% CI, 2.722–5.058), as was exposure to pesticides was associated with a highly significant increased OR (3.512; 95% CI, 2.611–4.725, P < 0.000).

Agriculture industry were strongly significantly elevated the risk for prostate cancer, as well as miscellaneous services wasn't associated but it had significant affected OR (3.439 and 0.506; respectively, P < 0.000). Farmer and Horticulturalists, mixable workers and Businessmen are relatively high odds ratios; also these are high statistically significant (P < 0.000).

Conclusions: These results suggest positive associated was appeared between some occupations, industries and increased the risk for prostate cancer in Sudan. Furthermore it needs more attention to preventing and curing the agriculture community.

Effects of Carpet and on Human Health and Wellbeing in Health Care Facilities

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Flooring materials may have a broad impact on the health, safety, comfort, and confidence level of patients, visitors, and employees in health care facilities (HCFs). We reviewed scientific research related to the effects of carpet on human health and wellbeing in HCFs, using Google and Pubmed in our literature search. According to the literature, using carpet has some

advantages: certain serious pathogens survive for a shorter time on carpet than on other floor coverings, carpeting transfers less pathogens to hands than vinyl or rubber flooring, noise is reduced, glare is reduced, walking is easier, falls and resultant injuries are less likely, visits by family and friends are longer (increased social support), and carpets encourage a feeling of safety and improved personal psychological and thermal comfort, and produce a more homelike, non-institutional, ambience. The reported disadvantages of carpets are: they are more difficult to keep clean than hard flooring - bacteria returns to pre-cleaning levels fairly quickly, occupant activities such as heavy and fast walking can re-suspend more dust from carpets than from equally loaded hard floors, and it can be difficult for staff to push carts, gurneys and wheelchairs down carpeted hallways - this has been associated with an increased risk of neck, shoulder and lower back pain. In conclusion, both advantages and disadvantages to using carpet in HCFs have been reported. Proper methods of carpet maintenance and cleaning are critical to minimize or prevent the production of aerosols and the dispersal of carpet microorganisms into the air.

Application of Predictive Models for the Assessment of Occupational Exposure during High Temperature Processes

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Analysis of various occupational exposure assessment models (EASE, MEASE, ECETOC TRA, EMKG-Expo-Tool, Stoffenmanager) in terms of possibilities for the application of these models to high temperature processes was performed. Available manuals for selected models, ECHA Guidance documents on occupational exposure estimation, literature data as well as selected models were analyzed. Testing prediction using selected models was carried out. Recommendations on exposure estimation to hazardous chemicals applied in high temperature processes using predictive models were prepared including indication on specific model as applicable for specific process. EASE takes into account process temperature but it is not possible to use this model to PROC 21-27. Stoffenmanager is not designed for estimating exposure to substances released into the air as a result of hot working techniques (with one exception). EASE, ECETOC TRA do not address exposure to process fumes. ECETOC is not applicable for non-mineral solids used at elevated temperature. EMKG-Expo-Tool allow for exposure estimation during processes performed in elevated temperatures only for liquids, MEASE only for solids. Prepared recommendations will facilitate the risk assessment process.

Polish Recommendation for Calcium Oxide and Calcium Hydroxide OELs

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Objective: In 2013 The Group of Experts for Chemical Agents (GECA), worked in NIOM in Poland proposed health based Maximum Admissible Concentrations values (MAC) for calcium oxide and calcium hydroxide.

Method: To calculate the value of the maximum admissible concentration, the results of study on human volunteers exposed to calcium oxide dusts were adopted. The nose was the target organ. Volunteers reported some irritation of the nose when exposed to inhalable dust levels of 5 mg/m³ for 20 minutes and some 'feel' at lower levels of 1 and 2 mg/m³. The 2.5 mg/m³ level can be considered as the LOAEL.

Results: Given the similarities in the action of calcium oxide and calcium hydroxide, which is formed due to the reaction with water of the first the same limit values are proposed. MAC-TWA of 1 mg/m³ and MAC-STEL of 4 mg/m³ are recommended for respirable dust of CaO and Ca(OH)₂. MAC-TWA of 2 mg/m³ and MAC-STEL of 6 mg/m³ were recommended for inhalable dust of CaO and Ca(OH)₂.

Conclusions: Occupational and accidental exposures have shown calcium oxide to be very irritating and corrosive to mucous membranes, eyes, and moist skin. The specified MAC values constitute the guidelines for the polish manufacturer and downstream users to evaluate working conditions. In Poland CaO is manufactured by **Cement Roadstone Holding Group** in Trzuskawica. The total sold production of cement, lime and gypsum in the first three quarters of 2010 amounted to PLN 4468.5 million.

Proposals on Occupational Exposure Limit Values for Chemical in the Workplace in Poland in 2013

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Objective: In 2013 The Group of Experts for Chemical Agents (GECA), worked in NIOM in Poland proposed health based Maximum Admissible Concentrations values (MAC) for 14 new dangerous chemicals in the working environment: acrylamide [79-06-1]; chloro(phenyl)methane [100-44-7]; 4-chloro-3-methylphenol [59-50-7]; chromium(VI); cyclopentane [287-92-3]; titanium dioxide [13463-67-7]; tert-butylethyl ether [637-92-3]; peracetic acid [79-21-0]; n-butyl [123-86-4]; sec-butyl [105-46-4]; isobutyl [110-19-0] and tert-butyl acetate [540-88-5]; lead [7439-92-1]; propano-1,3-sultone [1120-71-4].

Method: The MAC values in Poland have been set as follows: GECA within the Interdepartmental Commission for Maximum Admissible Concentrations for Agents Harmful to Health in the Working Environment performs a critical evaluation of the documentation for the MACs prepared by individual members of the team. The experts prepare health-based documentation for recommended exposure limits along with analytical procedures, recommendations on pre-employment and periodical medical examinations and contraindications to exposure. The experts review all available data and information: experimental animal and human data, structure activity relationship, occupational experience and select most relevant study and dose descriptor. Those proposals are presented during a session of the Commission including representatives of the ministries of health and labor, and representatives of industry and of scientific institutions.

Results: Polish OELs are legally binding administrative norms. To 2013 there are 518 health based MAC values for chemical substances in Poland regulation (Pol. J. of Law No 217/2002, pos. 1833 with amendments).

Conclusions: The specified MAC values constitute the guidelines for the designers of new and updated technologies and products, and the criteria for the evaluation of working conditions.

The Role of Body Mass Index on Fit Testing and Respirator Selection

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Background: Employees in different industries use respiratory protective equipment (RPE) to prevent work-related respiratory illnesses such as silicosis, asbestosis and tuberculosis. The current perception in many South African workplaces is that one size respirator fits all. Workplace control to reduce occupational health hazards can be arranged in order of priority (hierarchy of controls). Elimination of hazards is best while PPE is the least preferable. However, RPE such as respirators is the first to be used while others are being implemented. Elevated body mass index (BMI) has effects upon facial dimensions that may potentially have bearing upon respirator fit (Roberge et al, 2006).

Method: Quantitative respirator fit test was performed on +500 NHLs employees at different laboratories. BMI and respiratory fit testing was done on same employees who were fit tested. With no shoes on, body weight was measured in light clothing with a scale, height was measured using a vertical mounted measuring tape, and BMI (kg/m²) was calculated. Three facial

dimensions (face width, face length and nose bridge) were measured on each participant using callipers.

Results: Obese people were associated with facial dimensions, whereby face width and face length were statistically associated with BMI and an increasing BMI impacted on face width more than face length (Zhuang et al, 2004). Majority of people with small faces failed on the medium size respirator. Wearing a respirator that does not fit can create additional risk.

Reducing Occupational Disease through Effective Exposure Control

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Objectives: To explain the factors which affect the practicality and effectiveness of exposure controls and to explore ways in which effectiveness may be quantified.

Background: Control is arguably the most important part of occupational hygiene. In selecting controls, hygienists and others will use the likely effectiveness of any control items in deciding the most appropriate form of control.

Despite attempts to define effectiveness of control options, control efficiency values can vary enormously, and in some cases exposure can *increase!* There is also confusion of terminology. This together with continued ignorance of key factors means that controls often do not provide adequate control of risk and health of workers continues to be compromised.

Methods: Effective exposure control measures are often a combination of the right design and engineering technology with understanding and motivation to adopt the correct methods of work. Using a number of real life examples we shall examine the interplay of these factors and the crucial elements that determine efficiency in the long term.

We shall discuss the need for a simple measure of efficiency, the information that is currently available, and consider options to refine and improve the concept of 'control efficiency'.

This presentation will illustrate the need for better information to guide industry in the selection and use of control measures in order to reduce exposure and occupational disease. These issues will be explored in more detail in the Workshop on "Quantifying the efficiency of exposure controls".

Case Study: Controlling Exposure to Isoflurane Used in Animal Surgical Procedures in Research & Development

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At three pharmaceutical locations of J&J, there were reports of acute adverse health effects associated with isoflurane in a total of 8 employees. The symptoms reported to Occupational Health were headaches, drowsiness and dizziness, loss of concentration and numbness of the hands. These effects occurred when the anesthetic agent was used in animal surgical procedures in Research & Development facilities. Symptoms were most often associated with exposures in the 10–23 ppm range. Due to these reports, the internal OEL of isoflurane of J&J was reduced from 20 to 2 ppm.

Therefore a new baseline sampling plan was developed to evaluate the exposure level during all identified activities at the different work stations in R&D at the Janssen Site in Beerse, Belgium. All the results were statistically analyzed, evaluated and documented in a standard form. Step by step, solutions were developed, tested and implemented to reduce the exposure level to isoflurane below the new internal OEL. Additional containment controls are implemented, Personal Protective Equipment has been reviewed and additional good work practices identified.

These lessons learned are included in an updated internal procedure and shared with other R&D facilities within J&J and other pharmaceutical companies.

What's the Point? A Young Hygienist's View of the Workplace and our Role as Occupational Hygienists

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"Tell me if it is safe or if it is not safe?" A common question asked when occupational hygienists are confronted with a new situation, sometimes months after the activity has started. Many outsiders to our profession have the view that our role is to define what is safe and what is unsafe, so that they may act when it is the latter. Is the whole point of our profession truly to be asked to come in after a work activity has started and to assess something that has been going on for months, or to even measure it?

At University we are taught that the point of our profession is to protect the health of the workforce. This means that we need to be engaged from the very beginning of the project, before the activity has started to have the greatest impact. Our tertiary education however, focusses on the science, rather than the art of occupational hygiene, yet both are needed in order for us to be effective at our goal.

In order to change the perceptions of those people who engage us to better understand what we do, we need to use both the art and the science of our profession. Rather than using our traditional tools of sampling pumps and dosimeters, this paper will discuss my experiences as a young career professional that I have used to address these issues.

This is the view of our role in the modern workplace in Australia from a young hygienist's perspective.

Leadership and Worker Health in Construction

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Note: This is preliminary and the authors are willing to discuss the detail to establish this as one of the keynote papers

The reputation of the construction for the London 2012 Olympic and Paralympic Games has rested largely on the absence of any fatal accident (and generally an excellent safety record). However, the provision of a world-class occupational health service to 50,000 workers over a 6 year period, subject to independent evaluation in an action-research approach, has helped the UK construction sector to focus on its health programmes as never before.

This paper outlines the structure of the service, explaining how it was modelled and delivered so that it fully integrated with leadership and safety dynamics in a complex and rapidly changing environment. It concludes by demonstrating through an analysed business case that the service was an investment with a positive yield and not an on-cost. The paper will show that an integrated, comprehensive approach to health in construction has occupational hygiene at its heart, holistically matched with clinical and well-being resources and efforts.

The Shipping Industry: a Bermuda Triangle for Occupational Hygiene?

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Objective: To analyse the reasons why the international maritime trading sector has been slow to adopt the principles of occupational hygiene, as applied ashore, to manage health risks on ships.

Methods: Review the structure of the sector: economic, legal, managerial and the sourcing of crews. Consider the implications of working and living aboard and the history of maritime safety and health risk management, where priority has been given to shipping disasters and injury prevention. The health risks of concern have been transmissible infections and medical emergencies arising at sea. The complexities of assessment when working and living environments are co-located and mobile will be addressed, as will the practicality of evaluating exposures remote

from shore and the limited scope for making improvements where the risks are often inherent to the design of the ship.

Results: The impact of the contexts of work at sea on methods of risk assessment and management will be presented, illustrated by examples of practical problems. The feasibility of using the regulatory tools and management cultures in the sector to improve risk management will be considered.

Conclusions: Practical methods for day-to-day risk assessment and quantification are required that can be used at sea, crewmembers have to be trained in their use. This should be reinforced by corporate attitudes and regulatory requirements. Model procedures for risk management during regular and high-risk activities also need to be developed, based on detailed investigations of the levels of risk and the effectiveness of controls.

Task-Based Occupational Exposure Assessment and Particle Number Concentration: Two Important Data Resources to Perform Risk Assessment for Occupational Exposure to Particles

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Environment monitoring has an important role in occupational exposure assessment. However, due to several factors is done with insufficient frequency and normally don't give the necessary information to choose the most adequate safety measures to avoid or control exposure.

Identifying all the tasks developed in each workplace and conducting a task-based exposure assessment help to refine the exposure characterization and reduce assessment errors. A task-based assessment can provide also a better evaluation of exposure variability, instead of assessing personal exposures using continuous 8-hour time weighted average measurements.

Health effects related with exposure to particles have mainly been investigated with mass-measuring instruments or gravimetric analysis. However, more recently, there are some studies that support that size distribution and particle number concentration may have advantages over particle mass concentration for assessing the health effects of airborne particles.

Several exposure assessments were performed in different occupational settings (bakery, grill house, cork industry and horse stable) and were applied these two resources: task-based exposure assessment and particle number concentration by size.

The results showed interesting results: task-based approach applied permitted to identify the tasks with higher exposure to the smaller particles (0.3 µm) in the different occupational settings.

The data obtained allow more concrete and effective risk assessment and the identification of priorities for safety investments.

Chemical Risk Assessment: A Novel Approach for the Hazard Identification of Chemicals Present in Contaminated Sites

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Objectives: The chemical risk assessment in workplaces and the assessment of the chemical risk arising from contamination of soil are made on the basis of the Italian Legislative Decree 81/2008 and Legislative Decree no.152/2006, respectively, by the application of different procedures. In order to harmonize the application of these different procedures, we present a novel approach useful in

identifying whether a soil chemical contaminant is present in the air of a workplace belonging to the polluted site: on or after this decision, the need of the risk assessment of worker's chemical exposure will be clear.

Methods: This identification is based on the application of the risk analysis by vapor intrusion in backward mode. The risk analysis in direct mode is generally performed in order to establish the level of chemical contamination inside indoors ambient due to emission from near polluted site. As an alternative, by the application of the backward mode, we can derive an acceptable concentration in air of a workplace belonging to a polluted site. It is derived by selecting the most conservative value among those identified for carcinogenic and non-carcinogenic effects and by taking into account the exposure parameters typical of a worker, time average exposure time (years), exposure duration (years), exposure frequency (days / year), daily frequency of exposure (hours / day), inhalation rate and the body weight. Above this value we can assume that in a workplace is necessary to proceed with the chemical risk evaluation.

Acetone and Styrene Co-Exposure in Fiberglass-Reinforced Plastic Plant

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Results and conclusions: The styrene air concentration resulted ranging between 4.95 and 157.46 mg/m³ (average 81.16 mg/m³); the sum MA+PGA resulted ranging between 32.08 and 566.65 mg/g creatinine (average 260.63 mg/g creatinine). In this scenario workers also experimented an acetone exposure ranging between 6.93 and 194.37 mg/m³ (average 62.82 mg/m³). The styrene metabolites MA+PGA resulted linear correlated with the air concentration of styrene (R=0.85, N=27), but if we analyze the group of data corresponding to acetone concentrations below 39.02 mg/m³ (N=17) the slope of the corresponding regression curve results higher than that obtained for concentrations in the range 65.68 - 194.37 mg/m³ (N=10).

The Measurement of Musculoskeletal Overuse Syndrome of Industrial Workers and Prevention Possibilities

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Work-related musculo-skeletal diseases (MSDs) affecting the upper body and limbs have been the more often diagnosed occupational diseases for milkmaids, construction workers, sorters, packers, dressmakers, cooks-confectioners in Estonia during the years 2010–2014.

Therefore, Estonian Government is investing money for the research of preventive and rehabilitation methods of MSDs of working population.

Objectives: The paper is aimed on the methods for testing and measure the effect of physical and balneological therapies on the musculoskeletal overuse syndrome on the example of industrial workers in Estonia.

Methods: The methods include workplace risk evaluation (microclimate measurements), microcirculation of the extremities, including the post-occlusive reactive hyperaemia (PORH) (measured with laser-Doppler perfusion monitoring), muscle functions (Myometric method), personal health status (Work Ability Index, Standardised Nordic questionnaires).

Results: The post reactive hyperaemia (PORH) showed positive reaction on the extremities - the differences between rest and peak flow increased at the end of the heat and balneological therapies. Temperature 42°C is a strong stressor on the microcirculation of extremities, but the individual variability for this reaction is very high. The Myometric measurements showed that the stiffness on the right hand- m. abductor pollicis brevis was 33%, m. abductor pollicis 16% and m.trapezius stiffness 61.1% of the studied group.

Conclusions: PORH is a valuable method for testing the microcirculation reactions. MSD questionnaires, objective methods and environmental measurements are useful to plan prevention and early rehabilitation before the disability appears. Further research is necessary to understand the individual reactions to balneological agents measured by laser-Doppler.

Beer, Tigers and Other Household Items. The Communication of Hazard and Risk

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The public perception, understanding and evaluation of risk is often skewed, based more on gut feel and outrage than on scientific understanding and balance. Contrast the continued concern around childhood vaccinations despite continued confirmation of medical good with the continued prevalence of cigarette smoking despite decades of evidence of harm. Even within our workforces thinking around the exact and separate meanings of "hazard" and "risk" can be muddled and unhelpful.

In order to ensure that our workforce (and others) clearly understand these concepts we need to clearly communicate them.

Many scholarly articles have been written on the communication of risk. This short talk will not add to them!

I will however present three, short, visual communication aids that act as a springboard in training sessions for discussions on hazard vrs risk, the concept of dose, and recognition of chemical hazards.

Suggestions to Improve Occupational Hygiene Activities Based on the Health Problems of Semiconductor Workers

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The aim of this study is to review occupational hygiene activities, including work environment measurement as required by the industrial safety and health laws of Korea, and suggest improvements required to establish an effective exposure surveillance system. The controversial limitations of exposure surveillance examining the work-association of several types of cancers in semiconductor workers were reviewed. The bulk of the exposure surveillance system was found to focus purely on work environment measurements without providing other important exposure surrogates, such as job title, operation, exposure duration, etc. The current work environment measurement system is limited in terms of the efficient assessment of the exposure status of workers due to a lack of exposure information. The introduction of a national standard classification of occupations and job titles into the exposure and health effect surveillance system should be discussed in order to retrospectively assess exposure characteristics.

Occupational Cancer in Construction - Diesel Engine Exhaust Emissions, Painters and Decorators

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The huge burden of occupational cancer in the GB workforce has been highlighted in recent research published in the British Journal of Cancer (2012). This estimated that there were about 13,500 new cancer registrations and 8,000 new cancer deaths for the reference year. The construction industry is a particularly high risk sector. It has the largest burden of occupational cancers amongst the industrial sectors. Over 40% of the occupational cancer deaths and cancer registrations were from the industry.

The research highlighted a number of causes linked to historical exposures over many years. Among these, asbestos and silica were the greatest contributors. However, an unexpectedly high number of cancers were also linked to Diesel Engine Exhaust Emissions (DEEEs) and working as a painter or decorator.

Technology and working practices have changed over the years. Work has been undertaken to better understand and provide evidence of the current exposures to DEEEs and work as a painter. This allows us to more accurately understand what the future burden might be and also how best to intervene and protect workers. This presentation will provide the findings of this work and how HSE, with the industry, plan to act upon this information going forwards.

A Review of Historical Asbestos Exposure to Laboratory Workers

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Introduction: This poster is the third in a series examining the effects of industry on the health and wellbeing of workers and how Occupational Hygiene techniques have played a major role in improving workers' conditions. Asbestos exposure to Laboratory Workers appears to be under represented in the literature.

Aims: To examine the historical exposure of laboratory workers to asbestos. Exposure occurred in three main ways through the use of asbestos, 1) as a filter media in chemical and biological experiments; 2) in glass blowing techniques and 3) in equipment.

Methods: The study was conducted by reviewing historical documents, research papers, and interviews.

Results: The results show how the use of asbestos in laboratory work has been superseded by the use of modern materials, identifies areas where asbestos is still present and where asbestos containing equipment is still in use, for example in laboratory fittings and fixtures that may have been used to store items such as asbestos mats and in older equipment, such as furnaces, particularly those that were custom built.

Conclusion: The use of asbestos in laboratories has now been discontinued, but there is still the risk of exposure to asbestos particularly when laboratories are being refurbished and if maintenance is attempted on old equipment, such as furnaces, which contain asbestos. Because this area has not been given such prominence as asbestos containing materials in construction, there is an increased risk that asbestos surveys may be missed in these areas.

Working with the Industry to Improve Health Risk Management - A Supply Chain Project Approach

CLARE FORSHAW

Health and Safety Executive, Bootle, UK

A project has been running with HSE facilitating key representatives of the construction supply chain to resolve issues identified as barriers to health risk management in the Paving Road and Highways sector.

Work has been progressing through a number of working groups to provide information on good practice along with a range of reasonably practicable measures and interventions to improve worker health.

This project was set up following a series of meetings held with construction industry, suppliers, designers and other interested parties who highlighted the particular areas for the project to concentrate upon. These were;

- To deal with issues around preconstruction communication, procurement and the key role of clients interaction with contractors and designers
- To work towards establishing a 'level playing field' for contractors' in health risk management

- To provide a visual risk matrix approach to aid understanding and good practice in health risk management and identification of guidance materials
- To provide guidance on Exposure Monitoring and Health Surveillance and their roles in health risk management

The project has made good progress based on close working relationships between those with key roles in effecting change for this sector. This has included engaging with key client groups, designer and CDM coordinators and working with them to understand how they can assist contractors and suppliers to embed good practice.

This presentation will report on the progress made with this project and the tools and advice it has produced to date

Lung Function and Systemic Inflammation among Waste Water Workers

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Objectives: As a part of a larger study we will here present the associations between exposure (years of employment) and lung function and systemic inflammation among workers handling waste water at sewage plants and in sewage net systems.

Methods: Workers (n=148) from waste water plants and sewage net system participated in the study. Based on job operations, 30 of these workers were characterized as little or not exposed and served as an internal referent group. Each worker underwent spirometry (SPIRARE 3) to study lung function, and a blood sample was drawn to study markers of systemic inflammation (CRP) measured by a HS-MicroCRP assay.

Results: The predicted FEV₁ % (92.9) and FVC% (95.6) was lower among exposed worker compared to the referents (100.1 and 105.3, respectively) adjusted for body mass index, age and smoking (p<0.05). The median (range) levels of CRP were higher among exposed workers compared to referents (1.2 ng/ml (0.1–19.0) and 0.8 ng/ml (0.1–5.0), respectively) (p<0.01). The level of CRP showed a negative association with predicted FEV₁ for all exposed workers (b = -6.7, p<0.05). Year of employment was associated negatively with the predicted FEV₁/FVC ratio (b=-0.001, p<0.05).

Conclusion: The results indicate that workplace exposure to waste water at sewage plants and network system may possibly affect the lung function and level of systemic inflammation.

Biomarkers of Inflammation and Coagulation in Tunnel Construction Workers

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Objectives: Epidemiological studies have shown increased cardiovascular mortality by increasing particle concentrations in ambient air. The mechanisms are not well understood, but one hypothesis suggests that inhaled particles cause pulmonary inflammation that subsequently can result in systemic inflammation. In this study circulating biomarkers of systemic inflammation, endothelial and platelet activation, coagulability and selected fatty acids were measured.

Methods: Ninety tunnel construction workers (TCW) and 50 referents were examined. All subjects worked 11 consecutive days before they were off work for

nine days. Blood samples were collected immediately before the start (baseline) and at the end of the work period (follow-up).

Results: Mean exposures to particles in the thoracic aerosol fraction and elemental carbon among the TCWs were 604 (range 110–7870) and 51 µg/m³ (range 4–172), respectively. Serum biomarker concentrations did not differ significantly between TCWs and referents at baseline, while referents had significantly higher concentrations of the anti-inflammatory omega-3 fatty acids EPA+DHA. The concentrations of TNF-α, CD40L and P-selectin were statistically significantly lower at follow-up in TCWs, while no significant change was observed among referents. Substantial alterations in the fatty acid concentrations across the work period were observed, particularly in the referents. The EPA+DHA concentrations were significantly lower in the referents at follow-up, but unaltered in the TCWs.

Conclusions: The results indicate, somewhat unexpected, less inflammation and endothelial activation in the TCWs at the end of exposure. The change in the fatty acid profile suggests more unhealthy diet when working at the construction site, particularly among the referents.

Occupational Exposure Limits (OELs): A New Professional Group is Setting OELs

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The Occupational Alliance for Risk Science (OARS) - Workplace Exposure and Environmental Limits (WEEL) group is setting occupational exposure limits (OEL) using volunteers, supported and administered by a non-profit organization. It is a multi-national collaborative initiative with the goal of promoting worker health protection through increased access to high quality occupational exposure limits, enhancements in methods for establishing worker- health exposure guidelines, and education and training in occupational risk assessment methods. Members of this group are IH and toxicology professionals from industry, academia, government and consulting. This new group is taking a comprehensive data-driven approach to setting OELs in which one specific process may not fit all chemicals and their respective data sets. The new group, OARS-WEEL, and their OELs have a positive impact on industry because the OELs being set are for chemicals that are requested by those needing protection from specific chemicals and, for the most part, have not been established by other OEL-setting organizations. This presentation will provide an overview of the organization, the professionals involved, the OEL setting process along with OELs that have been set to date and those chemicals currently being reviewed and how you can request the group to set OELs for your workplace.

Turbulent Eddy Diffusion Models in Exposure Assessment - Determination of the Eddy Diffusion Coefficient

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Objectives: The use of the turbulent eddy diffusion model in exposure assessment is limited because of the need to know the eddy diffusion coefficient, D. Recent studies have hypothesized that this parameter is related to the air changes per hour (ACH) and the room dimensions. The goal of this work is to determine this relationship.

Methods: An exposure chamber (11.9 m³) was constructed with the ability to vary flowrate from 0.5 to 10 ACH. Vapor generation was controlled using a Harvard syringe. Two X-AM 7000 vapor monitors were used with a multiplexer to measure air concentrations of acetone, toluene, and methylene chloride at six locations in the chamber. The eddy diffusion model corrected for wall effects was used to predict concentrations at the same locations. The difference between the measured and predicted concentrations was minimized to determine D. Experiments were conducted at five different values of ACH and three generation rates. The effect of exposure averaging time on the value of D was also studied.

Results: The turbulent diffusion model can predict average exposures in close proximity to emitting sources, as long as the turbulent diffusion coefficient (D) can be estimated. There is a significant positive linear correlation between ACH and the turbulent diffusion coefficient.

Conclusions: The ability to estimate the turbulent diffusion coefficient air change rate and room dimensions can significantly increase the ease of use of this model for occupational exposure assessment.

On the International Harmonization of Exposure Assessment Tools

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The comparison of 11 existing GHS/EU health hazard groupings (R-phrases, H-statements) in Control Band schemes, presented at the BOHS OH2014 in Nottingham, showed methodological differences that could not be explained by science or logic only. Also other fields in chemical workplace air exposure assessment like OELVs, exposure modelling, mixture exposure and compliance testing with multiple tools per field show mutual non-scientific differences leading to different outcome for the same task. As substance hazards are intrinsic properties some of these differences cannot be justified. It was stated that these differences are caused by national or organisational hazard/risk perception sentiments and also on the lack of mutual alignment in the last decades.

Different tools performing the same task with different outcome are confusing for public and experts. It triggers comprehensive debates among scientist, social partners and claim solicitors, and may lead to shopping for best fitting results and in the end to reputation damage for the Occupational Hygiene. So much advantage is to be gained by an international mutual alignment or harmonization of existing exposure assessment tools.

The International Occupational Hygiene Association (IOHA) is probably the best organization to spread this message within the field of workers safety and health, to put pressure on countries and organizations to perform a mutual alignment, to stimulate and to coordinate initiatives and to monitor the developments.

This presentation will give an overview of exposure assessment tools for which harmonization may be necessary and does some recommendations on the role of IOHA.

A French Silica Job-Exposure Matrix: Uses in Occupational Health Surveillance and Research

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Context/objectives: The crystalline silica job-exposure matrix (CS-JEM) was developed under the MATGÉNÉ program and provides an exhaustive and retrospective exposure assessment for all jobs in France.

The aim is to present the uses of this JEM in occupational health surveillance and research.

Methods: The CS-JEM assesses occupational exposure to respirable crystalline silica dust from 1947 to 2007. The exposure indices are: probability, intensity and frequency of exposure.

The CS-JEM was linked to French census data to estimate the prevalence of exposure in 1999 and 2006, and to a representative sample of 10000 subjects with complete occupational history to estimate lifetime exposure prevalence in 2007.

Results: The prevalence of occupational exposure to silica in France was estimated at 4.2% (7.4% among men, 0.3% among women) in 1999 and at 4.2% (7.4% among men, 0.5% among women) in 2006.

Lifetime occupational exposure prevalence was estimated at 7.8% [7.30–8.29] (15.6 % [14.60–16.54] among men, 0.75 % [0.54–0.96] among women). The

CS-JEM was also used to 1) assess silica exposure in epidemiological studies, 2) estimate the fraction of lung cancer attributable to silica exposure, 3) help occupational medical team to identify past exposures. The CS-JEM is freely accessible and available on a dedicated website (<http://www.exppro.fr>).

Conclusion: The multiple applications of the CS-JEM to describe and quantify occupational exposure to silica make it a valuable tool for all the scientific community.

Risk Assessment and Modelling Techniques for Setting Air Change Rates in Laboratories

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Objectives: Historically, laboratory general ventilation systems used fixed and constant rates typically in the range of 4 to 12 air changes per hour (ACH). Newer laboratory ventilation guidelines do not specify ACH, but rather require a risk based approach for specifying dilution ventilation. The paper discusses modelling techniques used in a ventilation re-design project, where the minimum air change rate was lowered from 6 to 2 ACH, while employing a variable ventilation rate controlled by a chemical sensor array.

Methods: Quantitative modelling of average room air concentrations, for both normal and upset conditions, are presented. For spill modelling, this required calculating mass transfer coefficients for each chemical in the inventory, for which engineering equations are discussed.

Results: Results indicated little change in risk if the air change rate was lowered, but prompted new procedures and restrictions on handling and storage of some chemicals. Under both air change rates modelled, some spills would result in air concentrations exceeding short term limits before the new controls would increase air flow rate. Changes to emergency response procedures and personal protective equipment were recommended to the laboratory.

An evaluation of the fixed sensors for a few chemicals indicated that response factors and manufacturer's recommended set points would result in unacceptable high levels before they would trigger an increased airflow, prompting changes to chemical use.

Conclusions: Modern laboratory ventilation systems provide opportunities for increased energy efficiency. However, implementing such systems requires occupational hygiene input to risk assessments to ensure health is adequately protected.

Discomfort and Health Complaints due to Prolonged Standing at Work

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Workers spending substantial work time on their feet are prone to aches and pains on the lower body at the end of the work shift, and prolonged standing is known to cause various health effects. Nonetheless, the extent and severity of health issues related working long hours on the feet have not been closely examined. In this study, we examined how much time people stand while on job duties, and how working on both feet may have affected their health conditions. Workers of various manufacturing and service sectors were recruited in this study. Each study participant was given a self-administered questionnaire to collect personal profile (age, gender, work history, health habit, etc.), daily working hours, time spent standing at work, and self-reported symptoms and chronic diseases. In all, 1,585 self-administered questionnaires were completed. The study participants averaged 36.8 years (s.d. = 9.7) in age, and the average work experience was 8.1 years (s.d. = 6.7). Nearly 70% of study participants reported discomfort or symptoms at the end of the work day. Compared to those who work seated most of the time, people who had to stand at work most of the time were 31 – 38% more likely to suffer from discomfort, and the number of symptoms also increased with hours spent standing. The effects were

more pronounced with women and older age groups. While lifestyle and health conditions were slightly associated with these discomforts, arrangement of work breaks and task timing were more effective in preventing discomfort.

Noise and Noise Exposure of Personnel Aboard Vessels in the Royal Norwegian Navy (RNoN), and Hearing Loss in the RNoN

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Objectives: Describe noise levels and assess personnel's noise exposure aboard vessels in the Royal Norwegian Navy (RNoN). Assess the prevalence of, and predictors of hearing loss (HL) in the RNoN.

Methods: Noise measurements were conducted aboard 14 RNoN vessels. Median noise levels were calculated for each vessel class. The exposure of personnel was assessed by noise dosimeters and with task based (TB) estimates. Personnel aboard RNoN vessels completed a questionnaire on noise exposure and health, followed by pure tone audiometry.

Results: Engine rooms had the highest noise levels (around 100 dB(A)) aboard the vessels. In other locations the coastal corvettes had the highest noise levels ranging from 71.7 to 95.0 dB(A), while the coastguard had the lowest noise levels ranging from 41.5 to 57.8 dB(A). For different job categories TB estimates of 24-hour noise exposure revealed equivalent exposure levels ranging from 76.6 to 79.3 dB(A) aboard the coastal corvettes, while the coastguard had exposure ranging from 47.4 to 67.3 dB(A). Dosimeter measurements indicated higher noise exposure than found by the TB estimates. Prevalence of HL among navy personnel was 31.4%. Years of sailing in the Navy were the strongest predictor of reduced hearing.

Conclusions: All vessels except the coastguard, had locations with noise levels exceeding standard's recommendations. The exposure estimates indicate that personnel are at risk of acquiring adverse health effects from exposure to noise. Prevalence of HL in the RNoN is considerable, and time spent aboard vessels is a predictor for HL.

Identification of Workstations with Potential Exposure to Engineered Nanomaterials within EPINANO Epidemiological Surveillance Program

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Context: EpiNano is a national epidemiological surveillance program which aims at surveying the possible health effects in relation with occupational exposure to carbon nanotubes (NTC) and titanium dioxide (TiO₂) in France. The potentially exposed workstations should be identified during *in situ* industrial hygiene (IH) visits using a standardized non-instrumental tool called "Field technical logbook". Workers assigned to these workstations are eligible to the program.

Objectives: This report presents the workstations identified as potentially exposed to NTC or TiO₂ with this logbook during the first visits of the enterprises included in the program.

Method: The logbook includes 3 parts allowing a detailed description of each task, process and surrounding conditions necessary to identify exhaustively workstations with potential direct and indirect exposure. Each visit is conducted jointly by an occupational hygienist and an epidemiologist and lasts one or two days.

Results: Between January and April 2014, ten companies were visited. 53 workstations were observed, among them: 5 using TiO₂, 16 single-walled NTC, 27 multiwalled NTC. The tasks performed were mainly: analysis (8 workstations), weighing (7), synthesis (6), functionalization (5), and transfer (5). The manipulated quantities were usually very small. After analysis of the data gathered in logbook, 30 workstations have been classified as presenting a potential exposure to NTC or TiO₂.

Conclusion: The logbook is useful to identify workstations concerned with exposure to nanomaterials and people potentially exposed to them in different occupational settings. The data collected using this tool will be used for estimating individual workers' exposure index.

Effectiveness of a Multidimensional Intervention among Dutch Construction Workers on Respirable Quartz Exposure: Results from a Cluster Randomized Controlled Trial

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Objectives: We aimed to evaluate the effectiveness of a multidimensional intervention focused on reducing quartz exposure in the Dutch construction industry.

Methods: Within a cluster-RCT, eight participating construction companies were randomly allocated to an intervention or control group. Pre and post-intervention personal respirable quartz exposure measurements (n=282) were taken. Detailed observations and questionnaires were used to gain insight in the use of technical control measures and behavioral (e.g., beliefs, knowledge, social influence) and organizational factors, respectively. Bayesian multilevel analyses were applied to evaluate the effectiveness of the intervention.

Results: Quartz exposure during baseline was highest for concrete drillers, tuck pointers and demolishers (GM respectively 0.20, 0.18 and 0.12 mg/m³), exceeding the Dutch OEL for quartz (0.075 mg/m³) in 80% of the measurements (maximum 1.36 mg/m³). After post-intervention measurements, a significant decrease in exposure over time was observed for demolishers and tuck pointers (p=0.005 and p=0.008, respectively) in the intervention group relative to controls, but not for concrete drillers (p=0.15). During follow-up, 40% of the measurements in the intervention group and 60% in the control group exceeded the OEL for quartz (maximum 0.86 mg/m³).

Conclusion: Overall, intervention effects for three job categories seems present. However, additional analyses indicate that the exact magnitude of the intervention effect is difficult to assess. An overview of our ongoing analyses evaluating the potential contribution of organizational and behavioral factors when increasing the use of technical control measures will be presented during the conference.

Keywords: silica in construction; intervention study; effectiveness

Terpene Hydroperoxides Identified as Occupational Contact Allergens in Masseurs

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Objectives: Occupational contact dermatitis caused by fragrances is rare. Contact allergy to essential oils is occasionally reported among masseurs working with massage oils fragranced with essential oils, i.e. aroma massage. Many fragrance terpenes, occurring in essential oils, can autoxidize to form sensitizing

hydroperoxides. These terpenes are also found in essential oils, and we have detected the same sensitizing hydroperoxides in essential oils, derived from plants. The objective was to investigate the importance of terpene hydroperoxides as contact allergens in four masseurs referred from one workplace, and in two masseur students, all referred for investigation of severe occupational contact dermatitis of the hands.

Methods: Masseurs with suspected occupational contact dermatitis were patch tested with the Swedish baseline series and oxidation mixtures of linalool, limonene, linalyl acetate, geraniol, citronellol and lavender oil. Hydroperoxide content in oxidation mixtures was analysed using LC-MS and LC-UV.

Results: Four out of six showed positive reactions to our preparations of oxidized fragrance terpenes. Only one out of six reacted to any of the fragrance preparations of the baseline series. Three of the four working masseurs showed positive reactions to the oils used at the workplace. One masseur did not show any relevant positive reactions in patch testing.

Conclusion: Contact allergy to hydroperoxides formed in autoxidation of fragrance terpenes can cause severe occupational contact dermatitis. As these allergies were not detected using baseline testing, occupational contact allergy caused by terpene hydroperoxides might be more common than previously thought.

Fit of N95 Filtering-Facepiece and Half-Mask Respirators as Determined by Qualitative Versus Quantitative Fit Tests

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Objectives: The fit of respirators to the users is typically determined by qualitative fit test (QLFT) or quantitative fit test (QNFT) and expressed as a fit factor. However, discrepancy in the results of QLFT and QNFT were often observed. This study investigated the fit of N95 filtering-facepiece respirators (FFRs) and a half mask to identify sources that contributed to the variations in the results of QLFT and QNFT.

Methods: Thirty males and thirty females were measured for 19 facial dimensions relevant to respirator fit. The participants then were tested using QLFT and QNFT for the fit of N95 FFRs of three different facepiece designs and one half mask of plastic facepiece. The principal component analysis (PCA) was performed on the collected anthropometric data to establish a Taiwanese fit-test panel.

Results: Two principal components (PCs) were identified from the PCA analysis, with the significant dimensions identified in PC1 being the face width, minimum frontal breadth, and nose breadth ($r = 0.775-0.817$) and those in PC2 being the face length, nose protrusion, and sellion-subnasale length ($r = 0.423-0.709$). The half mask fitted better (fit factor: 148.6 ± 70.0 ; QNFT) than the N95 FFRs (107.0 ± 74.2). The rate of passage was greater when the fit test was conducted by QNFT (41%) than by QLFT (37%).

Conclusions: False positives may occur in OLFT as a result of the participants being over-sensitive to bitter tastes resembling Bitrex. The results of QLFT should be validated by QNFT on a routine basis.

Nano-Objects Release during Drilling and Sawing of Nanofiller Composites

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Nanofiller polymer composites have been developed in recent years for their superior physical and chemical properties. However, nano-objects might be released from the matrix as free particles during mechanical treatment, potentially resulting in human exposure. The goal of this study was to determine the characteristics of particles released during controlled mechanical treatment of nanocomposites.

The treatment included manual drilling, sawing and automatic drilling. Different types of nanofiller samples were treated in an enclosure which created an isolated and easily controlled environment. Various treatment parameters such as drill diameter and drilling speed were applied. The mean size and number concentration of the generated particles were measured by the DISCmini diffusion size classifier, the particle morphology by SEM.

Pure polyurethane (PU), PU/SiO₂, PU/Carbon black and PU/CNTs (NM-400, JRC) composites were treated with an automatic drilling setup. The net particle release was not significantly changed by nanofillers. A reduced generation of particles was observed for the PU/CNT sample. Larger drill diameter and faster drilling speed produced higher particle concentrations. The released particles appeared as irregular flake-like shapes ranging from 1–20 µm in diameter. Although filler particles were visible on the surface of the dust particles, free nanofillers were rarely observed.

These preliminary tests suggest that the treatment parameters influenced particle release more than adding nanofillers. Most of the released particles seemed to be composite material with nanoparticles remaining contained in the matrix. For hazard assessment of the polymer with filler, it will thus be important to characterize the hazard of such composite particles.

Investigating Airborne Stability of Nanomaterials - Aerosol Generations and Characterizations

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The stability of nanomaterial agglomerates is an important parameter for toxicological studies and for estimating the particle size of airborne nanoparticles. The aim of this study is to develop a system that effectively tests the potential of airborne nanomaterials to deagglomerate into smaller agglomerates or primary particles within a wide range of applied energies.

The aerosolization is achieved by fluidic agitation of nanopowders. Relative humidity can be adjusted to study the humidity dependence of aerosol stability. The pressure change is carefully controlled to ensure different shear forces can be applied onto the particles in a critical orifice. The aerosol is measured by various types of devices for the number concentration, size distribution and morphology.

Seven nanopowders, including TiO₂, ZnO, CeO₂ and SiO₂ (from the JRC Nanomaterials Repository) with diverse surface properties and primary particle size, have been tested under different shear force conditions. After the treatment, the particle size distribution changes from a broad and multiple-peak spectrum to a narrowed and monodispersed distribution. Accordingly, the total particle number generated is elevated. The number fraction of large agglomerates is reduced, while the fraction of nanoscale particles below 100 nm is increased. Under the microscope, the sample collected before treatment demonstrates a number of big agglomerates, while treated sample shows a lower level of agglomeration.

The results suggest that we are able to deagglomerate nanoparticle clusters with different shear forces. However, after reaching the choked flow condition further increases of upstream pressure do not lead to much stronger deagglomeration.

Exposure to Particulate Matter (Pm₁₀) in Indoor Air and Lung Function Test Among Dental Laboratory Technologists and Administration Workers

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Objectives: This cross-sectional comparative study aimed to study the relationship between exposure to PM₁₀, lung function and respiratory symptoms among dental laboratory technologists and administration workers.

Methodology: Sixty subjects were recruited using universal sampling method from one private dental clinic, eight public dental clinic and one dental administration office. Self-constructed questionnaire was used to gather data on socio-demographic, work characteristics and respiratory symptoms among subjects. Area and personal monitoring were conducted to measure PM10 concentrations. For personal PM10 exposure, Personal Aerosol Monitor (TSI SidePak) was attached to the

worker for eight hours within breathing zone by clipping flexible tygon tubing on the lapel and the pump was worn on a belt. Spirometer (COSMED Pony FX) was used in lung function test (LFT) which was performed three times for each subject and the best result was selected.

Results: The median exposure to PM₁₀ recorded among dental technologists is significantly higher 0.09 (IQR 0.07–0.13) µg/m³ compared to the dental administration workers 0.02 (IQR 0.02) µg/m³ ($p < 0.05$). The LFT gave no significant difference between these two groups. Presence of respiratory symptoms depend on the duration of exposure, age and sensitivity of the exposed person. PM readings for both area and personal monitoring exceeded the PEL. Only wheezing ($p = 0.038$) and severe cough ($p = 0.005$) were significantly associated with average PM₁₀ exposure.

Conclusion: There was no significant relationship between exposure to PM₁₀ with LFT. The management have to ensure the prevention and control measures are efficiently implemented and give training to the exposed population.

Satisfaction of Workers toward Indoor Environmental Quality in a Thin-Film-Transistor Liquid-Crystal Display (TFT-LCD) Manufacturing Facility

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Objectives: In optoelectronic industry the fabrication of electronic devices often requires the workers to stay long hours in the clean room. However, the indoor environmental quality (IEQ) between areas of different manufacturing processes in the facility varies significantly, e.g., in the areas of liquid photoresist-coating the yellow light is employed and the emission of volatile organic compounds (VOCs) may be expected. This study evaluated the workers' satisfaction toward the IEQ in a thin-film-transistor (TFT) liquid-crystal display (LCD) manufacturing facility.

Methods: On-site monitoring of IEQ and survey of IEQ satisfaction were conducted during the winter of 2013 in a TFT-LCD manufacturing facility in Taiwan. The IEQ monitoring included the measurement of air temperature, globe temperature, humidity, air speed, noise level, illuminance, VOC and carbon dioxide concentrations. The subjective satisfaction was surveyed using a questionnaire that ranked the workers' perception toward the performance of the facility in noise, illumination, thermal condition, ventilation, and overall IEQ.

Results: A majority of workers were dissatisfied with the overall IEQ, and a trend analysis indicated that noise and poor ventilation were the primary sources of dissatisfaction. The vote of dissatisfaction toward the overall IEQ was significantly correlated to those voted for dissatisfaction with noise, thermal performance, and ventilation ($r = 0.43$ – 0.66). The greatest dissatisfaction was found in ventilation, particularly in association with the presence of odor ($r = 0.63$) and dust (0.60).

Conclusions: To improve the IEQ in this TFT-LCD facility, strategies for reduction of noise and increase in fresh-air ventilation are needed.

Risk Assessment Landscape--Present Practice and Future Visionary Promise

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The overarching purpose of this quick paced presentation is to take a "fresh look" at risk assessment--its global practice today, its visionary promise, and

our profession's input as to direction. Session components include--defining the challenge; describing today's practice and landscape; describing future opportunities; discussing the language of risk; and engaging the audience in dialogue.

"Today's landscape" will address present terminology in use, its varied interpretations, commonalities and differences geographically, how that drives the templates/models developed (target setting vs. compliance driven), and where our professional vulnerabilities and challenges exist.

This will be followed by a future vision segment and the interface between exposure science and toxicology. Automated hazard predictions and recent advances in tools and technologies-- sensor systems, analytic methods, molecular technologies, computational tools and bioinformatics--are providing the potential for more accurate, more comprehensive exposure science data.

The language choices of scientifically developed risk characterizations can determine how well the audience accepts/rejects the risk/benefit duality. While exposures exist everywhere at all times, not all exposures are unacceptable, nor do they always create unacceptable risk. Conclusions about safe/ unsafe are not intrinsic, but are the process of assessing, characterizing and managing risk, often a democratic process renegotiated and changing over time. How to take lessons learned from previous generations and apply them to interpret and manage newly discovered unacceptable risks? This segment will discuss the concepts of risk perception and communication and offer new ways to approach stakeholders.

The final segment will encompass audience interaction with transponders to instantly gauge understanding, needs and professional direction.

Exposure Assessment of Vinyl Chloride Monomer for Workers in Vinylchloride Manufacturing and Using Plants

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Objectives: To assess exposure profile and health effects in 134 workers from four VCM manufacturing/using plants.

Methods: After signing the informed consent, personal air sampling, urinary sampling, and biochemistry examination including liver function and insulin resistance had been conducted, respectively. Personal air sampling had been analyzed by GC/MS to assess personal VCM and EDC exposure levels according to the CLA 2306 methods. Furthermore, urinary sampling had been collected before beginning and after finishing their work. TDGA levels had been analyzed by HPLC/MS/MS. Personal exposure data and time -activity pattern had been collected by questionnaires.

Results: The pre-shift of urinary TDGA levels in high VCM level group are significantly higher than low VCM level group. The airborne VCM concentration is significantly correlated with pre-shift of urinary TDGA levels ($r = 0.614$, $p = 0.002$). After adjusting confounding factor, airborne VCM concentration and pre-shift of urinary TDGA levels were significantly correlated ($R^2 = 0.382$, $p < 0.001$). After excluding the subjects taking medications or vitamins, the levels of insulin and HOMA-IR in high TDGA levels group are both significantly higher than in the low TDGA levels group ($p = 0.011$ and 0.013), but level of adiponectin in high TDGA group is significantly lower than low TDGA group ($p = 0.031$).

Conclusions: Occupational VCM exposure plays an important role in causing insulin resistance and adiponectin indicators abnormalities. Although VCM exposure concentrations were below 1 ppm (2.55 mg/m³) in the most of workers, the carcinogenic risk are still unacceptable ($> 10^{-3}$) in part of VCM plant's workers under VCM and EDC co-exposure.

Estimating Globe Temperature using Meteorological Data for Prediction of Wet-Bulb Globe Temperature and Heat Stress in Outdoor Working Environment

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Objectives: The wet-bulb globe temperature (WBGT) is widely applied in the workplace for management of thermal stress. However, its calculation requires input of globe temperature (t_g), a physical property not typically included in meteorological forecast, and hence its application in the outdoor working environment is limited. This study aimed to explore means of t_g approximation based on meteorological data for application in heat stress evaluation.

Methods: The t_g outdoors in Taichung, Taiwan, was monitored daily with the heat stress-relevant meteorological parameters, including the air temperature (t_a), relative humidity (rh), wind speed, and UVA and UVB irradiance, from September 2013 to August 2014. The global solar irradiation was also monitored between June and August 2014. Algorithms for t_g estimation adopting meteorological parameters of significant correlation were developed by means of multiple linear regression.

Results: The analysis by Pearson's correlation indicated a significant correlation between the t_g and the t_a , rh , and UV and solar irradiance (the absolute $R > 0.46$, $P < 0.05$). However, as the linear regressions revealed, the weights of these meteorological variables in t_g approximation varied by the season. The predictive power was the greatest in the t_g approximation established from the aforementioned parameters using the annual data ($R^2 = 0.97$) and the lowest in the approximation developed using the summer data ($R^2 = 0.89$).

Conclusions: The approximation of t_g based on meteorological data provides an opportunity to evaluate the heat stress in the outdoor workplace, however season-specific approximations are needed to increase its applicability.

Health Risks from Biocides—Preventing Sensitisation to Isothiazolinones by Human Exposure Assessment

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Skin exposure to biocides containing high concentrations of isothiazolinones may cause severe chemical burns and induce sensitization. In the last decade, an increase in the frequency of occupational and consumer contact allergy to isothiazolinones has been observed in the majority of European countries.

Isothiazolinones are heterocyclic organic chemicals containing sulphur that have been used as biocidal chemicals since the 1970s. The substances 5-chloro-2-methyl-4-isothiazolin-3-one (CMI) and 2-methylisothiazol-3(2H)-one (MI) are used as preservatives either as a 3:1 mixture (CMI:MI) or as single substances in a wide range of products such as household cleaning agents, cosmetics and personal care products, indoor paints, and disinfectants. Other isothiazolinones, such as 1,2-benzisothiazol-3-(2H)-one (BIT) and 2-octyl-3(2H)-isothiazolinone (OIT), are also used for preservation of industrial and household products or as biocidal agents (e.g. fungicides).

Knowledge about occupational and consumer exposures to such hazardous chemicals in our environment is essential to understand the risk related to these chemicals. For sensitising substances the exposure assessment has to be based on the body region and amount of application, as well as the application frequency. Further, apart from dermal exposure also inhalation exposure may play a role in sensitisation. Missing data include e.g. the body region exposed, the corresponding body surface area, as well as weight fractions of the ingredients in consumer products, like e.g. paints.

In an innovative approach using a Smartphone-App for the collection of user data and an extensive analytical study, we collected the missing data and used them to model aggregate exposure to isothiazolinones.

Acute Effects of Exposure to Low Levels of Acrolein in Human Volunteers

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Objective: Acrolein is a reactive aldehyde formed during combustion, e.g., in gasoline and diesel engine exhaust, wood burning, tobacco smoking, and cooking. The critical effect is considered to be irritation of the eyes and airways, however, the scarce data available makes it difficult to assess effect levels and thus to set safe exposure limits. The aim of the study was to investigate subtle acute effects of inhaled acrolein.

Method: Nine healthy volunteers of each sex were exposed at six occasions for 2 h at rest to: clean air, 0.05 and 0.1 ppm acrolein with and without 15 ppm ethyl acetate (EA). EA was used to mask the potential influence of odor on symptom ratings. Symptoms related to irritation and central nervous system effects were rated on Visual Analogue Scales. Pulmonary function, nasal swelling, blink- and breath-frequency were measured. Serum amyloid A, C-reactive protein, fibrinogen, factor VIII, von Willebrand factor, Clara cell protein, interleukin-6 (IL-6), and interleukin-8 (IL-8), were analyzed in blood. Cell count, differential cell count, IL-6 and IL-8 were assessed in induced sputum.

Result: The ratings of eye irritation increased significantly during exposure to acrolein in a dose dependent manner with and without co-exposure to EA. Also the blink frequency increased, with the highest effect for 0.1 ppm acrolein without EA. No significant exposure related effects were found for any of the other effect parameters.

Conclusion: The study suggests that short-term exposure to 0.1 ppm acrolein is mildly irritating to the eyes.

A Historical Review of Silicosis and its Relationship to the Work Conditions of Dusty Trades in Hong Kong

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Objectives: To have a review over the change of silicosis among the dusty trades since 1950s up to the present; to examine the major dusty problems and the associated dust levels; to discuss the accomplishment of prevention of silicosis in Hong Kong.

Methods: The review is carried out by literature search for reports, scientific papers and other available information. Many dusty trades like quarrying, construction, quartz milling, jade work, which once had flourished in Hong Kong have been reviewed.

Results: Dust problems were not a concern in society until the establishment of the diagnosis and reporting system for the disease. The major dusty trades locally include the quarrying and mining industry in the last century, and construction too when mechanisation took place in those days for urban development. Construction has become the lead in the 1980s until now. Once the hand dug caisson workers for foundation work were among the highest risk. The silica exposure level was over 100 times the occupational exposure limit set for today. The maximum incidence rate of those skillful workers was 82% in 1996. Some other dusty occupations like quartz milling operators, jade workers, had significant exposure too, but the working population was far less in number, such that the absolute number of cases was smaller.

Conclusion: A downward trend for silicosis was observed. However, the success could not be attributed to any single reason but multi-factorial like the change of work method, banning of hazardous process, and good maintenance of plant and equipment.

Measurement Error near the Limit of Detection and the Estimation of Geometric Statistics in Exposure Groups

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Context: Near the Limit of Detection exposure measurements have a poor relative precision and hence also on a log-transformed scale. We explore the consequences of this lack of precision on the estimation of geometric statistics.

Methods: First we assess quantitatively the uncertainty in LOD estimation and the minimal uncertainty in exposure measurements as a function of the LOD by performing a simulation study of the standard calibration curve-based approach to the determination of the LOD. Second, the effect of this lack of precision on the estimation of the geometric mean and standard deviation is examined using a simulation study based on maximum likelihood estimation. We consider the case of a log-normally distributed measurement data with percentages of non-detects ranging from 10 to 40% and geometric standard deviation between 1.7 and 2.5. To illustrate these results, we present a detailed analysis of a real data set of MEA measurements among hospital cleaners.

Results: The standard deviation of the measurement error is shown to be always greater than LOD/3. The simulations show that the LOD obtained using the standard calibration approach is highly variable and that the measurement error standard deviation can reach 2LOD/3. We found small but systematic median biases for geometric statistics due to measurement error. The analysis of the real example showed that the estimation of the geometric statistics is sensitive to the actual value of the LOD used in the computations.

Conclusion: When a sizeable proportional of subjects is below the LOD, the sensitivity to its value should be explored

Models vs. Measurement. Are We on the Right Track? Current and Future Strategies for Monitoring Exposure

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Piecing together the themes and conclusions of this session's presentations, I ask the question, are we progressing in our understanding of exposure through models and simple practical solutions such as banding, or are we losing the cornerstone of occupational hygiene? The obvious question is that we need both models and measurement to fully understand exposure and design effective and practical control strategies. However, the way in which we answer the question relies on the setting, with different considerations and conclusions for management, compliance, epidemiology and risk assessment applications. Strengths and weaknesses of practical and sophisticated models are contrasted with the strengths, limitations and costs of comprehensive measurement programs. Considering these contrasts, occupational hygienists should adopt selected models for appropriate applications, but need to maintain a robust measurement campaign to fully understand new risks, and trends in exposure and risk.

Building Awareness of Occupational Hygiene

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Objectives: Traditionally the British Occupational Hygiene Society (BOHS) has concentrated on advancing the science and practice of occupational hygiene. Although this remains important, the Society has recognised that if the burden of occupational disease in the United Kingdom is to be reduced it needs to become a more outward looking organisation. In 2011 BOHS launched a strategic plan, developed following an extensive consultation with members and other stakeholders. Two of the key objectives in this plan are to raise awareness of occupational hygiene and to increase the visibility and influence of BOHS.

Methods: As an important part of the strategic plan, in 2015 BOHS will be launching a campaign focusing on occupational lung disease, targeting the Construction Industry. The principle objectives will be to help employers gain a better understanding of occupational lung disease, the main causes and measures they can put in place to control the associated risks, and also emphasise the role that occupational hygienists can play.

Results and Conclusions: As a new endeavour for BOHS, many lessons have been learned during preparation and planning of the campaign. These have included how to set realistic objectives and priorities, work with partners and stakeholders and develop relevant materials. Further lessons will be learned as the project progresses.

The development of the campaign, its objectives and key activities will be described. The lessons learned, difficulties encountered and how they are being addressed, will also be discussed.

Using Checklists and Algorithms to Improve Qualitative Exposure Judgment Accuracy

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Objectives: Exposure judgment accuracy made without the benefit of objective inputs are low, ~ 25%. Since the majority of occupational exposure assessments are qualitative, identifying qualitative inputs that improve judgment accuracy is a critical research need. The objective in this study was to evaluate the influence of a qualitative checklist tool on judgment accuracy.

Methods: A qualitative exposure assessment Checklist tool was developed, incorporating algorithms based on physical and chemical principles and refined empirically, through experience. The tool provides a disciplined approach to applying the algorithms and specific interpretive guidance. The influence of the Checklist tool on exposure judgment accuracy was evaluating in a study involving 39 novice and practicing hygienists. Using a database of 11 exposure scenarios that were developed for the study, hygienists were asked to make exposure judgments before and after training on the Checklist tool. 85 pre-training and 195 post Checklist training judgments were collected and analyzed. Inter rater agreement was evaluated using three different metrics, Cohen's and Fleiss' κ and $G(q,k)$.

Results: Baseline (pre-training) judgment accuracy was low (~ 33%) and practicing hygienists tended to underestimate the true exposure. Judgment accuracy improved significantly ($\chi^2(1) = 25.36, p < .000002$) when judgments were guided by the Checklist and judgment bias was reduced. Inter rater agreement was good to excellent.

Conclusions: Using subjective inputs tends when making exposure judgments that tend to be inaccurate and underestimate the true exposure. Qualitative exposure judgment accuracy improved significantly when judgments were guided by the Checklist tool.

Predicting Silica Exposures in Construction Using Input from Chamber and Field Studies

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Objective: Predicting silica exposures is an important first step in effectively managing and preventing overexposure. Mathematical models are useful for predicting exposures in construction environments but their use has been limited because of the inherent challenges of quantitatively defining model inputs. This study was conducted using chamber and field studies to better characterize these inputs.

Methods: Dry wall sanding was simulated by a professional drywall finisher in an exposure (11.9 m³) chamber under highly controlled conditions. Respirable

dust and crystalline silica (quartz) generation rates were quantified by back-calculating the generation rate from the airborne concentration. Other model parameters, such as the ventilation rate, room dimensions and work practice information were collected in the field, providing high quality model inputs for three models; the well-mixed room, near field far field and turbulent eddy diffusion models. Personal exposure measurements were collected using real time and time weighted (integrated) sampling. Measured and modelled exposure estimates were compared.

Results: Generation rates for respirable dust and respirable silica were derived under highly controlled conditions for pole and hand sanding, respectively in a chamber study simulation. The use of the chamber to better characterize model inputs that are difficult to evaluate in the field was very useful and facilitated the use of several models to predict exposures to respirable dust and respirable silica.

Conclusions: Quantifying those parameters inherently challenging to characterize in the field through chamber studies in combination with field data enhances model parameter estimates and ultimately, model performance.

Does Sex Make a Difference to Exposures in the Welding Trades?

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Objectives: To examine whether differences in urinary exposure markers in male and female welders are sufficiently explained by differences in reported tasks and use of PPE.

Methods: Women across Canada who have started an apprenticeship in welding or electrical trades have been recruited for a cohort study (WHAT-ME) of exposures, health effects and pregnancy outcomes. Women in one province (Alberta) gave urine samples in 2011–12 to help validate exposure questionnaires. In 2013–14 a directly comparable cohort of male welders and electricians (WHAT-MEN) was established in Alberta, completing exposure questionnaires every six months, identical to those used in WHAT-ME. From September 2014 both men and women working in their trade in Alberta are being asked to mail-in a (further) urine sample.

Results: To date 346 female welders (228 in Alberta) and 347 male welders have completed a baseline questionnaire. Although many women are no longer in their trades it is anticipated that, by February 2015, 100 female and 300 male active welders from Alberta will have completed a detailed exposure questionnaire and returned a urine sample. Metal concentrations will be analyzed by sex and reported tasks/practices. The 2011–12 samples from 45 women welders showed manganese concentrations that were markedly higher than both the general population of women and published values for male welders.

Conclusions: As women move into non-traditional trades it is important to understand whether there are factors in their work or biology that result in internal doses that differ from those in men in the same trade.

Exposure Monitoring during Handling of Dimethylfumarat

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In the beginning the Occupational exposure limit (OEL) for Dimethylfumarat has been 360 µg/m³.

The OEL disappeared and an occupational exposure band for dimethylfumarat between 1 and 10 µg/m³ was established. Dimethylfumarat is a very special substance as there is powder as well as gaseous dimethylfumarat in the air. Different pharmaceutical processes has been monitored to gain knowledge about the

exposure. The exposure was between 9 and 11505 µg/m³ in different pharmaceutical process steps. Different measure has been proposed and now are ready for implementing.

Potential Occupational Exposures to Nanomaterials and Associated Protection Measures along Nanotechnology Value Chains in Singapore

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Nanomaterials have enormous economic potential for technical and medical applications due to their new properties acquired on a nanoscale. However, given multiple exposure pathways from the raw material production to the final product and its disposal, it is necessary to develop and implement adequate measures to protect workers from potential exposure along these value chains. Our NANOEXS project aims to identify more efficient and cost-effective strategies to protect workers and to test this approach along nanotechnology value chains in Singapore.

A structured questionnaire is used to survey companies across the nanotechnology industry in Singapore to identify which nanomaterials workers are most likely exposed to, what protective strategies are applied and how effective they are.

From both our initial inventory and the survey (not fully completed yet), titanium dioxide is the predominant nanomaterial in nanotechnology industry of Singapore in term of number of companies manufacturing or using it. Multiple industrial sectors are engaging with nanomaterials, e.g. chemicals, electronics, and automotive industry. A notable number of companies are providing nanomaterial-based services such as applications of disinfection coating. Personal protective equipment (PPE) is more often applied rather than engineering controls and organizational measures. We also propose a conceptual approach, derived from economic value chain concepts, to optimize cost of protective efforts that both fulfil legal requirements and optimise protection of health, expressed in terms of minimized disability-adjusted life years. We are currently testing this approach in the NANOEXS project. This research project is funded and supported by WSH Institute, Singapore (RFP No.: MOMOSDETT13000002).

Performance of Short-Time Water Misting to Wash Out Dust from Air in Construction Sites

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Despite of effective dust controls, high dust levels are common at construction sites. The aim of this study was to reduce fine dust concentrations and limit the dust spreading at construction sites with short-time water misting after dusty work phases. The study included laboratory and field experiments. In the laboratory, the method was applied for typical concentration of dust in controlled environment. Field test were conducted at four renovation sites. Concentrations of PM₁₀ particles were measured in real-time and filter samples of inhalable dust were collected. Concentration decays were compared between the control and wet tests. In the wet tests (misting of 2-4 minutes), the amount of used water by a portable misting device was an average 0.5 L. During the misting, relative humidity increased 38-47% in the laboratory and 15-40% in the field. Surfaces did not wet. Clean air delivery rate by water misting was 21 m³/L of water in the laboratory and 16-188 m³ and in the field experiments, respectively. Misting decreased PM₁₀ concentrations 70-81% in the laboratory and 77-99% in the field tests. Inhalable dust concentrations reduced as an average 35% in the laboratory and 47% in the field. Application of mist in renovation sites reduced inhalable dust concentrations outside the working area as an average 60% in renovation sites. The study indicated that water misting is suitable to improving the clearance of particles from the air. Short-time misting after dusty work tasks is useful to supplement other dust controls.

Determination of Exposure Factors of Consumer Products in Korea

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Objectives: Use patterns of consumer products differ by countries, Korean national database for exposure factors is needed. In this study we determined exposure factors of some consumer products such as cleaning products, infection control products, and personal care products.

Methods: The households were randomly selected from national population database. Field survey staffs visited home and collected consumer product information by questionnaire. Out of 2,500 households, 816 men and 2,517 women completed the questionnaire. Field technicians also visited 100 households twice, investigated use of all consumer products, and measured the amount of use. Information from questionnaire and home visit was compared.

Results: Proportion of user population were higher than 97% for toothpaste and shampoo. Conditioner, body cleanser and face cleanser were used by about 60% of population and were used by certain age groups and gender. Frequency of shampoo use in Korea was 0.97 per day. Dish washing cleanser was mainly used by female. People usually used dish washing cleanser twice per day and 9.3 minutes each time. Most household used chlorinated cleanser but use of specific purpose cleanser was less frequent. Amount of use for consumer products was comparable between questionnaire and home visit, and the ratios of use amount ranged 0.7 to 1.4. The use amounts of chlorinated cleanser were overestimated by questionnaire.

Conclusions: Questionnaire by home visit provided accurate exposure factor of consumer products. In addition, detailed information of consumer product could be collected by field survey staff.

Nanoparticle Exposure Levels at a Research Facility during Handling of TiO₂, ZnO and Carbon Nanotubes

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The use of nanotechnology is increasing explosively along with the number of workers handling engineered nanomaterials (ENMs). The objective of this study was to find out if the workers are exposed to ENMs, when nanomaterials are handled in exhausted enclosures. During the measurements, 1) equipment (tubes, ducts and different parts of the aerosol generator) contaminated with TiO₂, ZnO and carbon nanotube (CNT) ENMs were cleaned inside a glove box using running water and compressed air, and 2) TiO₂ and CNT ENMs were handled (spooned into a beaker, poured from one beaker to another, beakers were shaken) inside a fume hood. Particle number concentration was monitored with CPCs and transmission electron microscopy (TEM) samples were collected inside and outside the fume hoods. The average particle number concentrations inside the enclosures were 3600 and 1100 particles/cm³ during cleaning operations and ENM handling, respectively. The use of compressed air for cleaning increased the concentrations shortly up to 100000 particles/cm³ inside the enclosures. There were mainly TiO₂ particles in TEM samples collected inside the glove box, and hardly any TiO₂ or CNTs were detected during ENM handling. The average particle number concentration outside the enclosures were 2500 and 1000 particles/cm³ during cleaning operations and ENM handling, respectively. These particles were mainly background particles not originating from ENM operations, since only a few single ENMs were detected in TEM samples outside the enclosures. In conclusion, exhausted enclosure and wet methods used for cleaning diminish workers' exposure to ENMs during cleaning and handling operations effectively.

Trichloroamine Measurements in Indoor Swimming Baths in Gothenburg

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Objectives: Trichloroamine is formed when chlorine reacts with nitrogen-containing contaminants in the water. Exposure to trichloroamine can cause irritation in airways, eyes, nose and throat to workers and swimmers. The objective was to

measure trichloroamine in indoor air in five swimming baths in Gothenburg, Sweden.

Methods: All five baths used sodium hypochlorite for water disinfection and sand filters (open or closed) for filtration. Number and type of pools (competition, hot water, children's) varied, however none had bubble pool. Stationary measurements were carried out three times in each swimming bath (morning, afternoon and evening) during winter. Air was pumped for three hours (1 L/min) through a filter impregnated with sodium carbonate and arsenic trioxide. The equipment was placed next to the pools (2–4 samples per bath). Water samples were collected as well as information about temperature, number of swimmers, ventilation etc.

Results: In total, 47 air samples were collected. Levels of trichloroamine varied between 0.02 and 0.34 mg/m³ (median: 0.15 mg/m³) in the five swimming baths. In four out of five baths, levels were higher during afternoon and evening compared with morning. In some of the baths concentrations of combined chlorine in the water were higher during evenings. The ventilation systems used recirculation to varying extent and intake of fresh air was regulated automatically depending on temperature and relative humidity.

Conclusions: Air levels of trichloroamine were generally higher during afternoons and evenings than mornings. In some baths ventilation may not be able to remove air contaminants formed during the day.

Workplace Health Without Borders: Sharing Occupational Health and Hygiene Knowledge around the World

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Objectives: Occupational health professionals are acutely aware of the global dimensions of occupational ill-health - the 2 million of the world's workers who die each year from occupational disease, the additional 160 million who get sick, and the enormous costs of workplace illness, which the ILO estimates to be US \$ 2.8 trillion per year. Workplace Health Without Borders (WHWB) is an international non-governmental organization whose members volunteer their time to help develop capacity and knowledge to prevent occupational disease around the world - especially in areas that lack resources and expertise.

Methods: WHWB's activities include training, mentoring, translating and technical assistance. WHWB is an approved OHTA training provider whose volunteers are developing an OHTA module on silica.

Results and Conclusions: With a profession made up of people who care passionately about worker health, it is no surprise that the WHWB membership is growing. This presentation will share details of the organization's activities and what has been learned about challenges to global occupational health - especially from the WHWB projects involving silica exposure in industries such as brick plants, agate processing and stone crushing. These challenges include the integration of the workplace in the home and community, the involvement of whole families including children in the workplace, and barriers to implementation of control measures due to lack of resources such as water and power.

What Pupils in Vocational Schools Learn about Risk at Work

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Negative health effects because of poor work environment is more common among young workers compared to older. One explanation might be that younger ones have a low awareness of risk, a lack of safety training, and inadequate introductions to the work. A study has been made focusing on the pupils in vocational schools knowledge and experiences about potential work environment risks in their future work.

Questionnaires were distributed to 239 pupils in ten Swedish upper secondary schools' graduating classes in four vocational programs focusing on basic knowledge about health risks at work as well as the work environment legislation. The

programs were the Industrial Technology Program, the Restaurant Management and Food Program, the Transport Program, and the Handicraft Program (in which students specialize in wood). The results from the questionnaires were followed up with focus group discussions.

The results showed that the pupils in general had limited knowledge that employers must, by law, conduct risk analyses and prevent risks. It was common that they mentioned themselves as the main responsible to work safe and was not clear about the employers' duty to arrange for safe work. Pupils in all programs mentioned acute risk as the biggest risk at work. It was concluded that a systematic approach to pupils' training in work environment is lacking. The results indicate a clear gap between what knowledge the pupils are offered and what's intended by laws as well as state-of-the-art in occupational health risk research.

TLV Adjustments Forage

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Occupational hygienists are facing an aging workforce. Most exposure limits or exposure scenarios are based on a "normal" workforce consisting of young healthy workers. The workforce is slowly changing, and adjustments in our thinking have to be made in order to handle this new reality. Insufficient research has been carried out on the effects of workplace exposures on older workers. However, there is evidence that reduced pulmonary function, visual acuity, hearing, rates of metabolism, and response to heat can alter an older worker's response to workplace hazards. To compound the problem, there is an increased incidence of chronic illnesses such as heart and kidney diseases, diabetes, and arthritis. This includes the medications required to manage these illnesses which can affect the worker's reaction to workplace risks. Occupational hygiene is not a clerical comparison of exposure levels to occupational exposure limits, or comparing an actual workplace to model workplace scenarios, but the protection of workers through the understanding of workers and workplaces.

Issues and Challenges for Industrial Hygiene Practice in Latinamerica: A Regional Perspective

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Latin America is a region composed for 22 countries with a roughly population of 600 million people and an estimated GDP of \$5,725 billion dollars. The region holds two of the top 15 countries by nominal GDP, Brazil (7) and Mexico (14). From the following years, Latin America has great growth perspectives, which means we will see more multinational companies expanding their activities in the region. This represent a challenge to those companies that will need to comply with local regulations regarding Health & Safety, as well as their own practices in this field.

This presentations will cover the different regulations in place in different countries in Latin America. We will explain what are the main issues that every country faces in the common practice of Industrial Hygiene. Finally, we will discuss the main challenges that we identify to improve the Industrial Hygiene field in Latin America.

Occupational Noise Sources, Exposures and Controls in Small Enterprises in New Zealand

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Objectives: The present paper describes a multiple case study designed to identify, describe and evaluate noise exposures, sources and control strategies used by 33 SEs (employee count less than 20) in "high", "moderate" and "low" risk industry sectors in New Zealand.

Methods: Data collection involved workplace observations, noise assessments, semi-structured interviews, self-administered questionnaires, and reference to

archival data. In addition to sound level measurements in work areas and personal dosimetry, assessments of each SE's conformance to current noise management standards were undertaken.

Results: Area and personal sound level exposures were found to vary considerably within the "high risk" (agriculture, manufacturing and construction; range $L_{Aeq,8hr}$ 80 - 90 dB), "moderate risk" (cafes and restaurants; range $L_{Aeq,8hr}$ 60 - 75 dB) and "low risk" sectors (pre-schools; range $L_{Aeq,8hr}$ 70 - 80 dB). Generally noise sources and paths could be readily identified in the workplaces. The predominant noise control strategy in 90% of the industry sectors was minimisation, specifically the use of personal hearing protection. In most cases, noise management strategies aimed at the noise source and noise paths could have been investigated further by the management of the small business.

Conclusions: The findings suggest that there needs to be significant changes in expectations with respect to noise management practices and solutions for small enterprises in particular. In addition, national strategies on the prevention of NIHL need to be designed from a small business perspective and where noise management interventions are seen as a benefit to the enterprise rather than a cost.

Raising the Level of Occupational Hygiene Expertise in Trinidad & Tobago through OHTA Training

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Golder Associates Inc., Jacksonville, Florida, USA

The Occupational Hygiene Training Association (OHTA) was formed to promote better standards of occupational hygiene practice throughout the world. It has provided training materials and made them freely available for use by students and authorized training providers. The Association also promotes an international qualifications framework so that hygienists can be trained to a consistent, high standard, recognized throughout the world.

This presentation highlights how over a 4 year period a group of students from the Caribbean Island Trinidad and Tobago has gone through the entire Intermediate Level training program in order to obtain their International Certificate of Occupational Hygiene (*iCertOH*). The students had very diverse backgrounds, with varying levels of previous experience and education in Occupational Hygiene.

Challenges encountered in both teaching the courses, including the development of how the course material could be used to address Occupational Hygiene risks in the student's workplaces, as well as addressing cultural matters, are discussed in detail. In addition some successes on how students were able to use what they have learned from the courses at their facilities are highlighted in this presentation. It is really a success story of how a well-developed international training program has been used in raising the level of Occupational Hygiene skill and knowledge in a country that has limited local resources or expertise in this area but with extensive industrial development and known Occupational Health risks.

Exposure Assessment of 1-bromopropane for Golf-club Head Workers

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1-bromopropane is a colorless liquid with irritating odor, and an excellent cleaning solvent for oil, wax, and metals. Animal experiments showed that the exposure to 800 ppm 1-bromopropane would result in a region-specific decrease in cerebral weight, swelling of the preterminal axons in the gracile nucleus of the medulla oblongata, degeneration of peripheral nerves, low nerve conduction velocity. Furthermore, 1-bromopropane would inhibit spermatiation from the testis. The workers exposed to 1-bromopropane complained the symptoms of headache, nausea and vomiting, near-syncope, and mucous membrane irritation. Currently, 1-bromopropane is not regulated for workplace; however, ACGIH suggests a TLV-TWA value of 0.1 ppm. This study aimed to evaluate the exposure level to 1-bromopropane for golf club head workers. A total of 109 samples, including regional and personal sampling, were collected at three different work days. Charcoal tubes (SKC575-00) were used to collect

1-bromopropane with a sampling rate of about 200 mL/min for six hours. The trapped 1-bromopropane was extracted with 2 ml carbon disulfide for 2 hours and determined by a GC-MS (Agilent 6890N-5973N, USA). The average concentration of 1-BP is 2.32 ± 2.74 ppm which is much higher than the ACGIH recommended TLV-TWA. The spatial distribution of 1-bromopropane clearly indicates that the cleaning process is the only and critical source of 1-bromopropane. Our results suggest the workers in the studied plant posed to high health risk owing to 1-bromopropane exposure if no further control measures were applied. Thus, if the cleaning process were well administrated, the exposure can be significantly reduced.

Air concentrations of Particle Mass, Surface Area and Number - Comparison of Exposure Metrics in Some Swedish Industries

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Introduction: In an exposure survey in Swedish mechanical workshops, different aerosol air concentration metrics were determined. The survey was part of a larger study we intended to use various exposure metrics in a dose-response analysis.

Methods: Exposure levels of total dust were determined with open-faced filter cassettes, static sampling of total, inhalable and respirable dust, PM₁₀, PM_{2.5} was performed, and particle number and particle surface area concentrations of fine particles were determined.

Results: The static total dust varied between from 0.016 to 3.8 mg/m³, inhalable dust from 0.01 to 3.2 mg/m³ and respirable dust from 0.016 to 1.1 mg/m³. The average number of fine particles (20 nm–1 µm) in the different environments ranged from 12×10^3 to 130×10^3 p/cc and the corresponding particle surface area between 45 and 3,800 µm²/cc. Correlating exposure and static rig sampling of total dust showed high rank correlation coefficients (Spearman's rho=0.695, p<0.05). Regression analysis of the same samples showed a significant regression coefficient ($\beta=0.276$; p<0.005) with a low explained variance ($r^2=0.11$) and wide confidence limits (CI = 0.090–0.461).

Correlating parallel static sampling gave high rank correlation coefficients for comparing all mass concentrations, including particle surface area. Regression analysis showed significant regression coefficients, but very wide confidence intervals for regression coefficients and prediction intervals.

Discussion: Our findings support the use of mass and particle surface area based measurements from static sampling as a proxy for exposure measures, in particular when ranking will be used for grouping of data in dose-response analysis.

Improving Co-operation between Workplaces and Occupational Health Services in Managing Chemical Risks

MILJA KOPONEN

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Objectives: Several studies show that downstream users of chemicals find workplace risk assessment demanding. Chemicals make no exception. Occupational health professionals also often lack expertise on the issue. Aim of a currently ongoing project is to create common understanding, and better quality workplace risk assessments by applying control banding approach and other features offered by Stoffenmanager® toolkit.

Methods: To encourage and support SMEs, a website and supporting network aimed especially for SMEs has been published, in close cooperation with relevant stakeholders (www.ttl.fi/kemikaalivihi, in Finnish). High profile campaigns for

promoting Stoffenmanager® are going on. A training package consisting of, e.g., basics of exposure and risk assessment for occupational health nurses and physicians is going to be developed and piloted in close cooperation with a major nationwide OH service provider. Understanding and utilising Stoffenmanager® is an essential part of the training.

Results and conclusions: Risk management oriented control banding approach recognizes the natural phenomena of variability and uncertainty, and therefore, forgives small mistakes or ignorance. CB helps to lead the decision-making into right direction, both on company's and OHS's point of view.

In the future, occupational health professionals should be able to interpret the risk assessments done by companies, and take a stand on potential health risks caused by chemicals in more scientifically sound, but practically applicable way. The concept of finding synergisms between the to some extent similar tasks of both companies and OHS's may show an example for assessing other workplace risks as well.

Effectiveness of the NEPSI Good Practice Guide 'Case Studies of Some Applied Good Practices within the European Industrial Minerals Sector'

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Objectives: In order to reduce exposure to dust and quartz, we evaluated the effectiveness of implemented control measures as described in the good practice guide (GPG) of the European Network on Silica (NEPSI) (www.nepsi.eu).

Methods: Five intervention case studies from worksites within the European industrial minerals sector were evaluated. To evaluate the effectiveness of the intervention we estimated pre- and post-intervention mean concentrations of inhalable and respirable dust and quartz.

Results: In the total set of five case studies, 128 measurements were available during pre-intervention (n=64) and post-intervention (n=64) consisting of samples of inhalable dust (n=13); respirable dust (n=64) and respirable quartz (n=51). In three case studies, with exposure data from the IMA Dust Monitoring Project, the reduction in dust and quartz concentrations in bagging workers ranged between 1 and 3 fold. The stationary real-time samples in the fourth case study showed a reduction of dust exposure of a factor 4 for transport/bulk loading workers. In the remaining case study, we found two-fold reduced dust concentrations among the bagging workers, but quartz concentrations slightly increased after the implementation of control measures.

Conclusions: The results of the intervention case studies show clear evidence of effective control measures based on the task sheets described in the NEPSI-GPG. The protection factor is however clearly lower than expected from guidance like COSHH essentials. Based on these results, guidance is being developed to perform better intervention studies in the future in order to reach a higher level of evidence of the effectiveness of the interventions.

Local Exhaust Ventilation Air Recycling and the Exposure to Metal Working Fluids

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Exposure to metalworking fluids (MWFs) is a common problem during the metal shaping operation in the metal products and machinery industry. Exposure can occur by breathing aerosols generated in the machining process, or through skin contact when handling parts, tools, and equipment covered with the fluids.

Typically, modern machining centres have full enclosures which are equipped with local exhaust ventilation (LEV). The air from the LEV unit can be directed outside the factory building or recycled back to the factory hall after filtration. Mist collectors used in the machining centres usually consist of multi-stage particulate filters and they can remove particles efficiently especially if high efficiency particulate filters are used. However, chemical agents present in the gas phase penetrate the filtration unit and increase the airborne contaminant levels inside the factory hall, thus causing increased exposure of the worker.

In this study, we examined the quality of the recycled air of the LEV units installed in the machining centres and compared them with the quality of air inside the factory hall. Air quality measurements included inhalable particulate mass, alkanolamines, volatile organic carbon, formaldehyde and endotoxins. Airborne concentrations are compared with the OELs and Finnish target level values for MWF exposure. Contaminant concentrations of the some measured volatile components were higher in the recycled air than in the general workroom air. They also exceeded the recommended Finnish reference values but not the OELs. Discussion about the profitability of the use of the recycled air will be made.

Establishing Reference Ranges of Elements in Human Lung Samples*

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Objectives: To establish current reference ranges of elements in lung samples from people not occupationally exposed to metals. There are very few published data on the normal level of elements found in lung tissue samples. This makes interpretation of occupational, environmental or accidental exposure difficult.

Methods: Lung tissue was collected from 54 donors undergoing lung-tumour removal surgeries. These samples were excess tissue that would otherwise be discarded after required histopathological tests.

The samples were stored in alcohol, then sectioned using ceramic blades and dried to a constant weight. Three lung samples from each donor were then microwave digested and analysed by ICP-MS for a wide range of elements. Certified reference materials were analysed alongside, where available.

Results: The lung samples were analysed for aluminum, antimony, arsenic, barium, beryllium, boron, bismuth, bromide, cadmium, cerium, cesium, chromium, cobalt, copper, gadolinium, gallium, germanium, gold, hafnium, indium, iron, lead, lithium, mercury, molybdenum, nickel, strontium, thallium, niobium, osmium, palladium, platinum, rhenium, rhodium, rubidium, ruthenium, samarium, selenium, silver, tellurium, thulium, tin titanium, vanadium, tungsten, yttrium, zinc and zirconium. The samples have been analysed and are currently undergoing data analysis to investigate trends in elements between and within the donors.

Conclusions: Reference ranges of these elements in lung samples collected from human donors will be established. These data will greatly enhance the knowledge in the area of metals found in the lungs and will aid in the interpretation of results from pathology and forensic samples where excessive inhalation exposure to metal dust is suspected.

Biological Monitoring: Evidence for Reductions in Exposure and Risk*

JOHN COCKER, KATE JONES

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives: HSL is the leading UK laboratory for biological monitoring. Samples come via HSE's inspectors, hygienists and external occupational health professionals for investigations or routine monitoring. Since 1996 all results have been stored in a database that now has over 750,000 results from >100,000 workers in 6500 companies.

Methods: The database was searched for results for chemicals where we expected over 100 results per substance per year. The results were expressed as the 90th percentile values for each year.

Results: Since 1996, HSL analysed 900 - 2100 lead samples per year (Σ28,720). The 90% value steadily decreased from 54 µg/dl in 1997 to 28 µg/dl in 2014. Reductions were also seen for hexamethylene diisocyanate (1 µmol HDA/mol creatinine in 2005 to 0.6 in 2014, Σ13,450), mercury (24.5 µmol/mol in 1997 to <5 in 2014, Σ9340), benzene (133 µmol/mol in 1997 to <5 in 2014, Σ6581) and methylenedianiline (39 µmol/mol in 1997 to <5 in 2014, Σ4320). A more variable pattern was seen with urinary chromium (Σ12,623), nickel (Σ10,038), cadmium (Σ5,338) and cobalt (Σ4,880) with occasional high values, but all recent 90% values were less than international guidance values.

Conclusions: Most of the samples come without any exposure information. Data may be biased downwards if the samples come only from 'good' workplaces or could be biased high by companies with problems. Gradually reducing levels for lead and HDI show the impact of regulatory action. Current 90% levels for all the substances examined are below guidance values.

Near Real-time Monitoring of Diesel Exhaust Particulate (DEP): Sampling Techniques*

JAMES FORDER

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives: The UK Health & Safety Laboratory (HSL) has had an interest in the measurement of DEP since the 1990's. This began with measuring elemental carbon (EC) in the respirable fraction utilising pumped sampling onto filters with analysis in the laboratory for EC by controlled combustion. Later HSL described a method whereby a filter could be measured immediately after sampling using a reflectance instrument (the Bosch meter) thus enabling routine on-site / end-of-shift monitoring to reduce time lag and facilitate prompt action to maintain controls.

Recent technological developments have produced instruments which combine the pumped sampling and measurement in a wearable device to produce near real time EC personal exposure data. HSL has evaluated the performance of two instruments, the AethLabs MicroAethalometer and the FLIR Airtec.

Methods: The instrument outputs were assessed by comparison with results from concurrent sampling by the reference method of pumped sampling onto filters with analysis by a combustion method. The instruments were tested in a controlled laboratory generated atmosphere and in a variety of workplace environments.

Results and Conclusions: The advantages and limitations of real-time measurement were demonstrated when taken to the workplace.

Novel Application of Instrumentation for the Measurement of Respirable Crystalline Silica (RCS): Sampling Techniques*

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There is a need for occupational hygienists to assess worker exposure to respirable crystalline silica at airborne concentrations lower than current workplace exposure limits (WELs), arising from short term or task specific sampling events. There are also limitations in RCS quantification on air filter samples from low air concentrations ($\leq 0.05 \text{ mg.m}^{-3}$) that are principally due to the relatively high limits of quantification of the X-ray diffraction and Infra-red (IR) techniques and the flow rates of samplers commonly employed ($\sim 2 \text{ l.min}^{-1}$)¹. Recently, the use of high flow rate samplers ($4 - 10 \text{ l.min}^{-1}$) was evaluated for short periods or task specific sampling within the 8-hour reference period^{2,3}. These samplers and pumps are heavy, bulky and may face rejection from workers³. Research is continuing to develop more sensitive analytical techniques which may permit the continued use of existing low flow rate sampling equipment when employed in challenging low air concentration environments. One goal is to develop an ultra-sensitive technique that may enable the evaluation of samples from within respiratory

protective equipment (RPE) to assess their workplace effectiveness. The talk will discuss recent work to evaluate the potential of Raman spectroscopy and cold IR to measure low mass levels of RCS (< 20 µg) for routine or specialist applications.

¹ Stacey P (2007); *J Occup & Env Hyg* 4: D1 - D4

² Stacey P et al (2014); *Ann Occup Hyg* doi:10.1093/annhyg/met075

³ Coggins M et al, ASTM International, DOI: 10.1520/STP156520130141

A New Miniature Sampler for In-mask Leakage Measurement in Workplace Conditions: Sampling Techniques*

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The UK Health and Safety Laboratory has developed a miniature respirable sampler to help gain a better understanding of the exposure of workers to hazardous substances when wearing respiratory protective equipment or helmets with visors in the workplace. This presentation reports results from a multidisciplinary and international study to characterise the performance of the sampler designed to fit within a face filtering particulate (FFP) type 2 or 3 mask. The light weight (4.5 g) miniature sampler (15 mm in length) has an omnidirectional inlet and is designed to collect the respirable fraction using a 90 pores per inch (PPI) polyurethane foam insert. Tests in a calm air chamber show that it meets the respirable convention and has a performance, when challenged with Arizona Road Dust, that is similar to the reference Safety In Mines Respirable Dust Sampler (SIMPEDS), commonly used in Great Britain. Manikin tests show that, when challenged to a sodium chloride aerosol, the sampler has a linear relationship with the photometric measurement traditionally used for inward leakage tests in both ambient and humid conditions. Volunteer tests demonstrated that it does not affect the protection provided by the FFP type mask and that it can fit comfortably within the three FFP 3 type masks tested. The talk will discuss the opportunities and measurement limitations for in-mask sampling in the workplace.

Laboratory Measurement of Gaseous Emissions from Wood Pellets and Wood Chips: Sampling Techniques*

MICHAEL HEMINGWAY, ANDREW SIMPSON

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives: Domestic, commercial and industrial use of wood pellet boilers in the UK is increasing, but this is still a comparatively new industry. There are concerns that the risks associated with wood pellets and wood chips, particularly the factors affecting the emission of carbon monoxide and carbon dioxide, during storage, are not understood; and consequently the health and safety information provided by suppliers to control the risks may be inadequate.

Methodology: Bulk samples of fresh wood pellets and chips were obtained from commercial companies. Carbon monoxide, carbon dioxide, volatile organic compounds (VOCs) and oxygen, together with temperature and humidity, were measured in the headspace of sealed containers packed with the fuels using direct-reading instruments over periods of several weeks.

Results: The emissions of gases from wood pellets followed a similar pattern to that found in other studies: the carbon dioxide concentration steadily increased to 15000 ppm, the carbon monoxide concentration increased beyond 1042 ppm, the oxygen concentration fell to 0.1%, and the VOC concentration increased to 47 ppm. Relative humidity was ~42%.

Wood chips behaved differently to pellets, e.g. carbon dioxide emissions are higher while carbon monoxide emissions are lower; and some differences were observed between dried wood chip emissions and those from undried wood chip. Relative humidity was ~90%.

Conclusions: Both wood pellet and wood chip biofuels can produce dangerous atmospheres when stored in an unventilated enclosed space. Both fuels can produce carbon monoxide and carbon dioxide and significantly deplete the air of oxygen.

Practical Application of Real Time Monitors: Sampling Techniques*

PETER BALDWIN, HELEN BEATTIE, RUSSELL ATKINSON

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives: The objective of this presentation is to illustrate how real time direct reading monitors can provide valuable information on long term, short term and peak exposures to various gases in a wide variety of workplaces.

Methods: Various monitors, fitted with a variety of detectors, were used to assess exposure potential and associated controls in three situations: ammonia at a maggot farm, decomposition gases at a composting site, and carbon dioxide during dry ice blasting.

Measurements were taken for up to a week using personal or static monitoring.

Results: At the maggot farm, measurements indicated that high the short term exposures occur when feeding maggots. A risk of build-up of gases in the storage and mincing areas was also found.

At the composting site, peaks of exposure from gases during particular hours were found, indicating specific activities which give rise to greater exposure.

Results for dry ice blasting found low carbon dioxide levels and minimal oxygen depletion, confirming that this process can be conducted safely providing suitable controls and working procedures are in place.

Conclusion: The results provided useful information of levels of gases within ongoing processes over periods of time, and valuable insight into processes where little information was previously available.

Compliance Auditing: Exposure Control*

PETER BALDWIN, CHRIS KEEN

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives: The objective of this presentation is to examine various audit approaches to multi-site or multinational business.

Methods: The UK Health & Safety Laboratory has performed numerous occupational hygiene audits and these have taken the form of postal questionnaires and onsite audits. Some of these have been with multi-site and multinational organisations. The advantages and disadvantages of the approaches will be discussed.

Results: Postal questionnaires were used to gain information from multiple companies at minimal cost. The questionnaire design should ensure questions cross-reference each other. Questionnaires rely on a competent person to complete them. Consistency can be improved using multiple-choice answers, with descriptors for each answer.

Multinational audits have been undertaken using site visits to examine the risk management system of companies. These have been used to:

- Improve health and safety standards;
- Examine compliance with high level health and safety policies;
- Promulgate good health and safety practises.

The standards audited against should be clear and be based on good occupational hygiene practise.

Conclusion: Auditing can drive improvements in individual companies. A multi-choice answering regime can indicate to companies where improvements maybe needed.

Multinational audits can ensure a standard approach is applied. Their effectiveness can be hindered by communication issues, and requirements of national legal systems.

Urinary Pesticide Metabolite Concentrations in UK Adults and Children Living near Agricultural Land: Agriculture

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In the UK, the use of pesticides is regulated to protect human health and the environment. Our study aimed to assess exposure to pesticides for residents living within 100m from the edge of agricultural land during the spraying season and assess whether the exposure models used for regulatory risk assessment (RRA) produce sufficiently conservative estimates.

Farms that sprayed their agricultural crops with relevant pesticides, and had residential areas within 100m of these fields were recruited and provided spray event information. Consenting residents (adults and children) provided urine samples and accompanying activity diaries during the spraying season and for a limited period out with the spray season. Selected urine samples (collected 1–2 days after a relevant spray event and ≤ 3 within and 3 outwith spray season backgrounds) were analysed to determine the pesticide metabolite levels. Spray information was used to predict pesticide exposure using RRA methods. A simple pharmacokinetic model was then used to predict the urinary metabolite levels obtained using the RRA procedures with the residents' pesticide metabolite levels.

133 adults and 26 children provided at least one spray event sample during the spraying season, with a total of 582 spray event and 1503 background samples being analysed. A draft publication is complete but results are not in the public domain until disseminated to participants; this will happen in Autumn 2014. Based on our findings, we will report on whether the exposure models used for the UK regulatory risk assessment are acceptable.

Long Latency Health Risks in Foundries*

JOAN COOKE

Health & Safety Laboratory, Buxton, Derbyshire, UK

Objectives:

- Reduce long latency health risks in foundries; improve substance control and identify good controls practice.
- Develop one or more marker substances by which to assess the progress of the industry in tackling long latency health issues aided by full statistical analysis.
- Identify benchmarks and standards of control that are technically achievable and reasonable practicable to implement.

Methods: The project targeted 15 of approximately 150 different exposure risk scenarios within the industry. We estimate that approximately 15,000 workers (75% of total workforce) are potentially exposed to these scenarios. Comprehensive occupational hygiene surveys were carried out at each site, comprising exposure monitoring (air and biological) exposure control assessments. Site feedback was in the form of an extensive report which also included practical recommendations.

Results: Some significant exposures were noted for inhalable ferrous foundry particulate (FFP), RCS and toxic metals. Straightforward improvements could have been made to work practices and engineering controls at all sites visited. Deficiencies to RPE and LEV management programmes were also identified.

Conclusions: Foundries involved have been positive about the project and some have implemented exposure control recommendations. The trade association is receptive to bringing about practical improvements to reduce the

incidence of ill health. Benchmarks and standards of control that are reasonably practicable to implement have been identified that will be used in HSE guidance. The findings show all foundry workers to be at risk of exposure to LLHR substances.

Storage of Wood Pellet and Wood Chip Fuel and Carbon Monoxide Generation*

ANDREW SIMPSON

Health & Safety Laboratory, Buxton, Derbyshire, UK

Aims: The use of wood pellet and chip boilers in the UK is increasing but is still a comparatively new activity. Elsewhere fatalities have been reported, caused by carbon monoxide poisoning following entry into fuel storage areas. The aim of this work was to obtain information on how these fuels are being stored in the UK.

Methods: Site visits were made to six small scale boiler systems and one large scale pellet store, to assess storage practice, risk management systems and controls, user knowledge, and potential for exposure.

Findings: Potentially dangerous atmospheres of carbon monoxide and/or carbon dioxide, with depleted levels of oxygen may be generated in wood pellet and chip stores.

Knowledge of the hazards associated with these fuels was limited at the smaller sites, but greater at the large pellet store.

There has been limited risk communication between companies supplying and maintaining boilers, those manufacturing and supplying fuel, and users.

Risk is controlled by restricting access to the stores with locked entries; some stores have warning signs and carbon monoxide alarms. Nevertheless stores are accessed for inspection and unplanned maintenance.

Unplanned ventilation within store rooms may also be reducing the build-up of dangerous atmospheres.

Dangerous atmospheres in fuel stores may also arise from poorly vented boiler combustion gases.

The Environmental Impact and Associated Occupational Risk of using High or Ultra High Pressure Water Jetting as an Abrasive Technology for Fixed Bulk Storage Tank Cleaning Operations

KATY WELCH

Occhnet Ltd, Carmarthen, Carmarthenshire, UK

Objectives: A study was undertaken to identify the possible environmental and occupational health risks associated with high or ultrahigh pressure water jetting as an abrasive technology for fixed bulk storage tank cleaning operations.

Methodology: A review of relevant legislation and codes of practice provided a reference for assessing the risk to the environment and occupational health from the activities. Noise, particulate and heavy metal emissions were measured during high pressure water jetting activities.

Results: It was found that the environmental impact from particulate and heavy metals was not significant, but the noise emissions were likely to be regarded as a nuisance. Occupational risk from exposure to particulate and heavy metals was not significant however the occupational exposure to noise would be likely to lead to hearing damage without the use of noise abatement or hearing protection.

Conclusions: Improvements to the observed water jetting methodology were identified to reduce the emission of particulate, heavy metals and noise, thereby reducing risk.

Hydrogen Sulphide Release from Cattle Slurry and Additional Risks Associated with Gypsum Addition: Agriculture*

BRIAN CROOK, IAN SMITH, GILLIAN FROST

Health & Safety Laboratory, Buxton, Derbyshire, UK

Cattle slurry storage systems generate gases including hydrogen sulphide gas (H₂S). H₂S is toxic and can be lethal, at high concentrations potentially causing respiratory arrest within seconds. Incidents in slurry stores are sometimes compounded by multiple fatalities where one person collapses then another as they go to rescue the first.

H₂S is generated by the bacteria naturally present in cattle slurry, therefore farmers need to be aware of the conditions influencing its release. Gypsum powder (calcium sulphate) may be used as a liquid absorbent in cattle bedding, but if gets into slurry it could be metabolised by the slurry bacteria and increase the generation of H₂S. This potential was investigated.

Representative batches of cattle slurry and cattle bedding without gypsum were collected. Slurry or moistened bedding was sealed in large plastic tubs, leaving a head space. Using a real-time analyser, H₂S levels in the head spaces were measured before and after the slurry or bedding was stirred, and with and without the addition of gypsum powder. Without stirring, H₂S was undetectable. After stirring, concentrations rapidly increased to levels that would potentially be fatal. Adding gypsum led to a more than five-fold increase in the concentrations released compared to when no gypsum was added.

In summary, potentially dangerous levels of H₂S can be released from cattle slurry and gypsum powder in slurry increases that potential. Farmers therefore need to take additional precautions when handling this material and working in confined spaces.

The PIPAH Study: Self-reported Exposures and Ill Health among Pesticide Users: Agriculture*

DAVID FOX, ANNE-HELEN HARDING

Health & Safety Laboratory, Buxton, Derbyshire, UK

This presentation is an overview of early findings from the Prospective Investigation of Pesticide Applicators' Health Study (PIPAH). PIPAH is a prospective cohort study of the long-term work related health of over 5000 men and women who apply pesticides as part of their normal work activities. The PIPAH study has collected detailed baseline data on the use of specific types of pesticide, methods of application, use of PPE and pesticide related activities such as mixing concentrate and equipment maintenance. Baseline self-reported health data has also been collected on a wide range of health conditions.

This presentation will summarise the PIPAH Study baseline data concerning self-reported factors which may affect exposure to pesticides, including use of PPE when using specific pesticides. Baseline data concerning the self-reported use of sun protection measures will also be reported. The results of statistical analyses of associations between years spent using particular types of pesticide and a variety of health outcomes will be examined.

Conclusions will focus on the implications of whether detected associations between pesticide use and adverse health outcomes are affected by the use of PPE.

Lung Cancer Mortality in a Cohort of Amosite Asbestos Workers: Asbestos*

ANNE-HELEN HARDING¹, ANDREW DARNTON²

¹Health & Safety Laboratory, Buxton, Derbyshire, UK, ²Health & Safety Executive, Bootle, Merseyside, UK

Objectives: To investigate the risk of lung cancer mortality in a cohort of amosite asbestos workers.

Methods: The study analysed lung cancer mortality in a cohort of workers employed between 1947 and 1978 at a site near London producing amosite asbestos board. The individuals included in the study are members of both the

Medical Research Council's (MRC's) cohort of asbestos workers at that site and the Health & Safety Executive's (HSE's) Asbestos Workers Survey. Mortality to the end of June 2014 was analysed. In the first instance, exposure to amosite was assessed using the semi-quantitative estimate of exposure developed for the MRC study¹. The hygiene data collected at the site by Her Majesty's Factory Inspectorate during the 1970s were then modelled in combination with the MRC estimates in order to provide a quantitative estimate of cumulative exposure throughout the period. The risk of lung cancer mortality associated with increasing levels of cumulative exposure, adjusted for age and smoking status, were estimated in a Poisson regression analysis.

Results: 748 workers who appeared in both the MRC and HSE cohorts were included in the analysis. There was a clear increasing risk of lung cancer mortality with increasing cumulative exposure to amosite.

Conclusion: This is one of the few cohorts of asbestos workers exposed almost exclusively to amosite asbestos. The results from this study provide an important contribution to the body of evidence relating to the risks associated with working with amosite.

¹ Acheson et al (Int J Epidemiol, 1984)

Managing Occupational Hygiene in a Multinational Company

DANNY MARTLAND, DAVID GLENNON

BAE Systems, Lancashire, UK

Objective: BAE Systems is Britain's largest manufacturing company with a mature safety, health and environmental (SHE) management system where line management have accountability and responsibility for the day to day SHE management. They are supported by a team of trained safety specialists within each business unit with occupational hygienists based at some manufacturing sites.

SHE professionals are able to recognise an Occupational Hygiene problem, engage consultants and to partially understand the language they use. This together with the small numbers of Occupational Hygienists means that Occupational Hygiene issues are dealt with in a reactive rather than proactive manner.

Method: BAE Systems in partnership with HSE Occupational Hygiene specialists are developing an Occupational Hygiene strategy for incorporation into the organisation's overall SHE strategy. This will help to inform both BAE Systems and the HSE's thinking on the strategic direction of health management in the workplace.

Results and Conclusions: BAE Systems have already started the journey by raising occupational hygiene awareness and enhancing the skills of their SHE professionals. Key safety advisors are now trained to conduct noise and vibration assessments and a detailed suite of COSHH assessments and specific training materials have been developed for the most hazardous substances used within the organisation. In addition occupational hygiene and the wider occupational wellbeing agenda are being moulded into an overall health management offering.

The story to date will be described at the time of the conference.

The NIEHS GuLF STUDY: Estimation of Workers' Exposures through the Inhalation Route on Four Rig Vessels during the Deepwater Horizon Oil Spill Cleanup

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Objectives: After the Deepwater Horizon explosion, four rig vessels (Enterprise, DD2, DD3, and Q4000) were brought within two miles of the wellhead to mitigate the leak, collect and flare oil and gas, and drill relief wells. The objective of

this paper is to characterize inhalation exposure on these vessels for various exposure groups (EGs) to total hydrocarbons (THCs), benzene, toluene, ethylbenzene, and xylene.

Methods: Descriptive statistics were calculated from measurements for ~65 EGs across vessels based on job titles and tasks with four time periods. Since many of the data were below the limit of detection, Bayesian methods were developed to estimate the arithmetic mean (AM), geometric mean, and geometric standard deviation.

Results: From April 20 to May 14, the AM for THCs on the Enterprise and DD3 were 3.2 and 5.2 ppm, respectively. The AMs from May 15-July 15, when dispersant was used to reduce oil-related air concentrations, were ~1 ppm for DD2 and DD3, with higher values for Q4000 (3.1 ppm) and Enterprise (5.6 ppm). After top-capping, the AMs were reduced on all ships (0.3–0.6 ppm). After bottom capping (>August 10), exposures increased on the Q4000 (AM=1.3 ppm), decreased on the Enterprise (0.1 ppm) and did not change significantly on the DD2 and DD3. The vessel capping the well and the vessel burning waste oil and gas had significant differences from the vessels drilling the relief wells.

Conclusions: Differences were found by vessel and time period that likely reflected oil weathering and differences in job and vessel activities.

Transfer of Plasticizers from Consumer Products to Indoor Dust and Air

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Background: In Western societies, people spend most of their time indoors where they are surrounded by a variety of products that contain semi-volatile organic compounds (SVOCs), e.g. plasticizers in plastic products. Plasticizers are slowly released from the initial products and distributed in the environment. This leads to increased human exposure to plasticizers via different exposure pathways including inhalation of contaminated air and non-dietary ingestion of dust.

Aim: In a small-scale field study, the transfer of common plasticizers, such as phthalates and adipates from consumer products to indoor air and settled dust is investigated.

Methods: Eight deuterium labelled plasticizers were synthesized and introduced into artificial consumer products that were used in different use scenarios with several emission processes (e.g. evaporation, direct transfer to dust etc.). Each product contained two different plasticizers that differed in physico-chemical properties. The products were installed in five apartments for the duration of twelve weeks. During the study indoor air and dust samples were collected regularly using different sampling techniques such as wiping and vacuum cleaning. Extraction and clean-up procedures were adjusted to the target compounds and matrix components. Finally, the samples were quantified by GC-MS.

Discussion: As expected the vapor pressure is a major determinant for the substance distribution into either dust or air. Another major influencing factor is the ventilation rate of the room. Concentration in settled dust depends on the substance emission process and the distance to the source of the chemical.

Balancing Efficacy with Effectiveness, Efficiency and Safety: Evaluation of Hard Surface Disinfectants in Health Care

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With the increasing focus on preventing infections in the health care environment, there has been mounting pressure to use more toxic chemicals and physical agents to combat pathogen transmission. Selecting a particular method for cleaning and disinfecting patient rooms should take into account how those methods are employed and therefore what methods are needed to prevent harmful exposure. Efficacy of hard surface disinfectants takes into account only the lethality of the disinfectant to particular organisms under laboratory conditions. Effectiveness measures whether the disinfectant works under field conditions. Efficiency is concerned with cost-effectiveness. Selection of an ideal surface disinfectant needs to

consider these factors as well as the safety and health impacts to the people who apply them and consideration of the environmental impacts of any waste generated in the process. This presentation will review the disinfectant claims, processes and impacts of three surface disinfection techniques that are registered in the USA against *Clostridium difficile*: germicidal wipes impregnated with bleach, improved hydrogen peroxide/peroxyacetic acid solution, and elemental silver/glycerol/ethanol and hydrogen peroxide/peroxyacetic acid two-part solution.

Experimental Approaches to Understand Real-world Nanomaterials

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Objectives: Nanomaterials are promising for a series of technical and medical applications. They start to be used in industrial applications. It is thus important to understand their real-world behaviour and properties and how they are related to health effects. We therefore aimed to develop a series of interlinked systems to test the toxicity of real-world airborne nanomaterials.

Methods: We created an aerosolisation system for nano-powders and nano-dispersions commonly sold for industrial and medical applications. We modified their properties in airborne phase by coating them with low volatile organic compounds (LVOCs). We tested them with chemical assays, optical sensing, electron microscopic imaging techniques, cellular toxicity assays, and human inhalation experiments. We also tested the cell and human exposure system using incidentally created nanoparticles (TIG welding fume).

Results: Our system allowed stable generation of airborne particles from powders and dispersions over a very wide range of concentrations. Coating nanoparticles with various LVOCs altered their reactivity, as demonstrated by chemical fluorescence assay and optical sensing. The air liquid interface cell exposure system allows long exposure periods of time. It allows detecting the presence of reactive oxygen species at relatively low concentrations. Also the system to expose humans was successfully tested in the laboratory setting and the ongoing field study suggests that the system can be used also for real-world exposure studies of humans.

Conclusions: Our experimental approach allows testing the chemico-physical properties and also the toxicity of airborne nanomaterials that originate from commonly used industrial and medical nano-products in real-world situations.

Exposure to Wood Dust, Endotoxins and Terpenes in Norwegian Sawmills

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Objectives: To characterize the occupational exposure to wood dust, endotoxin and terpenes in Norwegian sawmills.

Methods: Full shift personal sampling of monoterpenes (n=85) and sesquiterpenes (n=22), thoracic and inhalable wood dust (n=349 and n=41, respectively) and endotoxins (n=224 and n=29, respectively) were performed two consecutive days summer and winter in 11 Norwegian sawmills (n=162 workers). The geometric mean (GM) exposure and geometric standard deviation (GSD) were calculated. Data were analyzed by mixed regression modeling with STATA-SE-13.

Results: The GM (GSD) exposure for monoterpenes was 500 µg/m³ (7.5) of α-pinene, 110 µg/m³ (6.5) of β-pinene, 110 µg/m³ (8.0) of 3-carene, 31 µg/m³ (4.7) of p-cymene, and 75 µg/m³ (6.0) of limonene. The exposure to α-longipinene was 1.4 µg/m³ (5.4) and the sum of all sesquiterpenes was 31 µg/m³ (5.5). The thoracic dust exposure was 0.09 mg/m³ (2.9), whereas the inhalable dust exposure was 0.7 mg/m³

(2.6). The thoracic endotoxin exposure was 1.4 EU/m³ (2.9), and the inhalable endotoxin exposure was 13 EU/m³ (3.4). Higher levels of sesquiterpenes were observed in the saw department compared with the planing department ($p < 0.02$). The variance components for thoracic dust exposure was 0.12 (between-company), 0.22 (between-worker) and 0.51 (within-worker), and 0.09, 0.23 and 0.57, respectively, for the thoracic endotoxin exposure. Work in different departments explained 28% and 23% of total variances of thoracic wood dust and endotoxin exposure, respectively.

Conclusion: The overall exposure levels were low, but the differences observed between departments may have different impacts on health outcome, and will be subject for further study.

Bayesian Modelling of Biometrologic Censored Measurements for the Determination of Biological Limit Values

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Context: Biological Limit Values are often determined from the atmospheric reference values in modelling biological data obtained on a number of exposed subjects based on measurements of atmospheric exposure. However, often a large number of measurements are below the limit of quantification (LOQ).

Generally, models applied to this type of data are so-called mixed linear regression models, with main subject random effect, by which the biological log-transformed data (Y) are modelled as a function of the log-transformed exposure data (X). While standard "tobit"-type models can treat censored data Y, no method is available for X-censored data that are usually simply suppressed.

Method: The aim of this work is to propose and validate a statistical method taking into account exposure measurements under the LOQ, based on a Bayesian approach, modelling simultaneously distributions X and Y.

This method is validated by a simulation study in which between 20 and 50% of the measurements are censored.

We apply this method to a real exposure data set containing 268 measures of urinary chromium (61% < LOQ) and air (24% < LOQ) in 76 subjects exposed to electrolytic plating.

Results: Preliminary but incomplete simulation results do not seem to show a clear advantage of taking into account the censored X-values.

Conclusion: The proposed method allows the use of biological exposure measures below the LOQ that would otherwise have been excluded.

Ammonia and Hydrogen Sulfide Monitoring during Manure Handling Processes at Livestock Farms

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Objective: Ammonia and hydrogen sulfide are major hazardous gases generated during aerobic/anaerobic bacterial decomposition of livestock manure. The aims of this study were to evaluate and characterize ammonia and hydrogen sulfide emissions from commercial livestock farms.

Methods: A total of five commercial swine farms and five poultry farms were surveyed. A real-time multi gas monitor was used for monitoring ammonia, hydrogen sulfide. Other environmental conditions such as temperature and relative humidity (RH) were also measured simultaneously during manure handling processes. Feeding related information such as raising scale, number of animals, ventilation type and manure storage duration were also surveyed.

Results: The ammonia concentrations were significantly higher at the swine composting facilities (GM range; 9.5~ 43.2 ppm) than poultry manure handling facilities (2.6~35.9 ppm). High concentrations of hydrogen sulfide were identified during manure agitation and mixing process at the swine manure storage facilities (6.9~19.5 ppm). At the poultry manure handling facilities, the ammonia was higher during manure handling processes (2.6~ 57.9 ppm) than swine manure handling facilities (5.9~43.2 ppm) and very low hydrogen sulfide concentrations (0~3.4 ppm) were detected. Several factors such as temperature, RH, facility size, manure storage duration and number of animals were associated with gas concentrations.

Conclusions: High concentrations of hazardous gases were generated during manure handling processes and associated factors were identified. The suitable strategies for monitoring in livestock workplaces should be established to protect workers and animals from the sudden accidents caused by gas inhalation.

What if There is No OELV or DNEL?

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Objective: More than 6.500 substances with a harmonized EU health-hazard classification (CLP) don't have an OELV or DNEL. In order to derive a rationale for Kick-off levels for non-OELV substances with limited health hazard classification, the relationship between OELVs and EU-CLP H-statements is used.

Method: Based on the OELV-distribution per health hazard group of Control Banding approaches, 10%-tiles are derived for vapours and dusts: "Kick-off levels". The Control Banding scheme with the most robust OEL-distribution is used to establish the Kick-off levels.

Results: The OELV-distributions in the hazard groups of the investigated CB-schemes show in some cases to have a log-Normal distributional fit between the 10 and 90%-tile. Therefore we defined the Kick-off levels as the lower unbiased population 10%-tile of the OEL-distribution per health-hazard group from the Control Banding scheme, which have the best OELV-distribution. Different CB-schemes for exposure to vapours and to dusts are selected.

Conclusions: Kick-off levels for exposure to vapours and dusts are derived for substances without an OELV, but with harmonized H3#-sentences in the European Union (CLP). The scheme can also be used for substances with non-harmonized CLP/GHS-classifications.

With the concept of the Kick-off levels, the number of substances with an OELV is greatly increased.

Kick-off levels are conservative by nature. Therefore the Kick-off levels can be used as a starting point for exposure assessment and control. If compliance with the Kick-off level can be met technically and/or economically, than further animal experimental and/or epidemiological research is not necessary in the specific situation.

Identification of Biological Markers in Nasal Lavage Fluid in Individuals with Work Related Upper Airways Symptoms Associated to Moldy and Damp Buildings

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Objectives: Upper airway symptoms are a common problem reported by individuals with prolonged stay in damp and moldy buildings. In this study we used a combined approach of questionnaire, biological monitoring and investigation of the buildings to try to find objective markers for health problems coupled with damp and moldy buildings.

Methods: Nasal lavage fluid was collected from 15 subjects working at 2 different buildings, suspected to have indoor problems, and 10 matched controls from another building. At each building an indoor investigation was performed by a consultant. The participants were also asked to answer a health questionnaire.

Results: The health questionnaire concerning perceived daily symptoms showed that a majority of the subjects working in buildings with suspected indoor problems reported daily upper airway symptoms. In both buildings, compounds that was coupled with degradation of building material where found. In one of the buildings a distinct odor was noted and mould spores were found. The protein composition in the nasal lavage fluid was analyzed with multivariate statistic. This analysis found that the 3 groups had distinct differences in the protein composition and could be separated from each other.

Conclusion: This combined approach can be a useful method when identifying buildings with suspected indoor problems, also giving the possibility to have objective markers for health problems. The results from the protein profiling also indicate that the approach might be used to identify the main cause of the health problems.

On the Validation of Control Banding Schemes

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Objective: A large number of Control Banding schemes (CB), developed by many organisations from different countries, claim to help Small and Medium Enterprises (SME's). SME's are quite often assumed not to be capable of performing OELV compliance testing to work safely with dangerous substances. These CB's differ in many aspects, raising the question which scheme protects workers the best.

Methods: The grouping of Health Hazard Identifiers (HHI) like EU R-phrases or GHS/CLP H3#-statements in CB schemes is examined theoretically, is compared mutually on consistency and is compared with the standard they are replacing: the OELV.

Results: Seven R-phrases and five H-statement hazard groupings schemes are identified. They differ mutually in:

- having 3 to 5 hazard groups;
- having different numbers of HHI's enrolled in hazard groups;
- the way HHI's are allocated over the hazard groups.

Hazard grouping lacks a scientific, theoretical framework and is based on and biased by institutional and/or national professional judgment and risk perception. The range of OELV distribution per HHI category and per physical state varies from two to five orders of magnitude. Within all CB schemes the OELV distributions overlap to a large extend, but the overlap differs between the schemes.

Conclusions: The validation of hazard grouping seems limited. They all show unexplained and undesired differences in enrolling and allocating HHI's in hazard groups. This undermines the credibility of CB in general. An international evaluation and harmonization of Control Banding is recommended.

Quantitative Levels of Exposure to Diesel Exhaust in the Contemporary Mining Industry

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Working in mining is characterised by high exposures to diesel exhaust (classified as a human carcinogen), due to the wide use of heavy equipment. Previous studies suggest the need for stringent occupational standards which remain absent in most countries. We estimated quantitative levels of exposure to diesel exhaust in a contemporary mining industry.

Diesel exhaust exposure has been monitored by measuring elemental carbon (EC) among Western Australian miners since 2003. Measurements and details of exposure circumstances were recorded in a government-held database. Mining occupations were classified into similar exposure groups: 3 surface and 5 underground exposure groups. Mixed-effects models were used to estimate EC levels for exposure groups and specific occupations within each group. Models also included measurement year (median 2010), sampling duration and mineral mined (gold, nickel, iron, base metal, other).

Personal measurements (n=7,181) of EC concentration in the breathing zone were collected from workers at 108 mine sites. 136 different occupations were monitored. Based on the mixed-models, mean exposure level for surface exposure groups in 2010 was estimated as 15 ug/m³ EC. Estimates of mean EC levels for underground exposure groups ranged from 24 to 44 ug/m³. The highest level for specific occupations was estimated for underground diesel loader operators: 60 ug/m³ EC for an 8-hour shift.

Levels of exposure to diesel exhaust in Western Australian mines are in line with previous reports of EC exposure in mining. The derived quantitative exposure estimates will be applied to study the risk of lung cancer among diesel exhaust exposed miners.

Bunkering of Water - a Health Hazard?

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Objective: Existing quality control of bunkering water is not sufficient to ensure healthy drinking water on board.

Regular control of drinking water delivered from bunkering plants focuses on monitoring intestinal bacteria, thus ensuring that freshwater on board is not contaminated with faecal flora.

We recently identified *Legionella pneumophila* (*Lp*) together with free-living amoebae (FLA) on board Norwegian Naval vessels. Genotyping of the bacteria demonstrated that the contamination was limited to a few strains which were found over several years, indicating that the *Lp* survived and reproduced on board. This is possible by coexistence of FLA, which acts as housekeeping organisms that feed the *Lp*; in fact, *Lp* depends on them for reproduction and this again results in increased pathogenicity. The amoebae also protect *Lp* against disinfectants.

As a result, *Lp* on board grow and survive, and are difficult to eliminate. Prevention should therefore focus on the source of contamination. The above-mentioned study showed that the *Lp* genotype found on board was also present in the vessels' bunkering plant.

How to eliminate contamination?

Even though the detection methods for *Lp* are very sensitive, we need to be aware that extremely small amounts of bacteria are sufficient to contaminate the water system. Thus, focus must be placed on hygienic barriers. The design of such barriers must take into account both the bacteria and their housekeepers.

Since *Lp* is a freshwater bacterium, an alternative strategy could be to produce freshwater from seawater on board, by reverse osmosis or EVA.

The Production of Antibodies to the Benzene Biomarkers PMA and the Development of Test Kits for Cost-Effective Laboratory Analysis and On-Site Benzene Exposure Screening

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Objectives: Benzene is an important industrial chemical, a ubiquitous environmental pollutant and a known human carcinogen. S-phenylmercapturic acid (S-PMA) is a urinary metabolite of benzene and a specific and sensitive biomarker of benzene exposure. The determination of urinary S-PMA has allowed the introduction of benzene biomonitoring programmes. However, traditional

methods for the determination of S-PMA tend to be laborious, expensive and have a slow turnaround time. The production of antibodies to S-PMA and the development of immunoassays will overcome these limitations.

Methods and Results: The production of an antisera specific for S-PMA has allowed the development and validation of an ELISA and the manufacture of a benzene biomonitoring test kit. Test kits have been used to detect elevated levels of S-PMA in the urine of workers exposed to benzene. Occupational samples determined by ELISA and GC-MS were in good agreement ($R = 0.9$, range 0-1130ng/ml, $n=39$) confirming the validity of the approach.

S-PMA antibody is also allowing the development of a "point of care test" (POCT) for benzene biomonitoring. The POCT is now being optimised which will enable cheap and immediate on-site testing. A POCT will provide "real-time" sample analysis to health professionals and immediate reassurance to workers involved in potentially hazardous tasks.

Conclusion: The production of antibodies to S-PMA and the development of new immunoassays formats are enabling test kit developments that facilitate the provision of both routine laboratory testing and on-site screening. These developments will increase the utility of benzene biomonitoring and improve the protection of workers health.

The Production of Antibodies and the Development and Characterisation of Novel Immunoassays for Polycyclic Aromatic Hydrocarbon (PAH) Biomonitoring

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Objective: Complex mixtures of PAHs are produced during the incomplete burning of organic materials. Common PAH sources include vehicle exhaust, tobacco smoke and waste incineration. The most significant end-point of PAH exposure is cancer. Pyrene is a common component of PAH exposures and metabolism of pyrene leads to the excretion of 1-hydroxypyrene glucuronide (1-OHPyrG) in urine. Measurement of 1-OHPyrG has been used to assess occupational exposure to PAHs. The production of an antibody to 1-OHPyrG will allow the development of novel PAH biomonitoring tests, facilitating the introduction of routine screening and helping to safeguard workers health.

Methods & Results: A sheep antiserum has been raised to 1-OHPyrG and a urinary ELISA developed. The ELISA has been used to detect elevated levels of 1-OHPyrG in the urine of workers exposed to PAHs. Samples determined by ELISA and HPLC-fluorescence were in good agreement (correlation = 0.9, range 0-1140nM, $n=16$). Test specificity was confirmed in binding studies with structurally similar metabolites. Further optimisation and an extended trial is underway.

Conclusions: The development of an ELISA for 1-OHPyrG will allow the production of a cost-effective PAH biomonitoring test kit. A test kit will increase the accessibility of biomonitoring and facilitate the introduction of routine screening programmes. Alternative assay formats will now be investigated. The development of a "point of care" test will enable on-site testing, allow employers to demonstrate the immediate impact of good working practice and help increase the utility of biomonitoring.

A Study of Exposure to Thoracic- and Respirable Aerosol among Surface Rock Drillers

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Background: Surface rock drillers are exposed to a variety of exposures like diesel exhaust and α -quartz but information on exposure levels is limited. Workers assume that aerosols and gases generated outdoors rapidly disperse in the outside air, however, aerosols from drilling and blasting may be a significant source of exposure to α -quartz and other agents among drillers as well as other operators working in the vicinity of the drill.

Objectives: To characterize the occupational exposure to thoracic and respirable aerosol among surface drillers, and to identify determinants of exposure.

Methods: Full shift personal air samples of thoracic- ($n=41$) and respirable aerosol ($n=40$) were collected in two seasons using GK2.69 and Higgins-Dewell cyclones, respectively. The geometric mean (GM) exposure and geometric standard deviation (GSD) were calculated. Data were analyzed by mixed regression modelling using SAS.

Results: Overall the GM (GSD) exposure for the thoracic- and respirable aerosol fraction was 0.37 (5.5) and 0.19 (4.2) mg/m³, respectively. Statistical differences of air concentrations by type of drill rig were observed for both contaminants ($p < 0.01$). Workers using a rig with fixed control panel were exposed to the highest GM (GSD) levels of thoracic- and respirable aerosol (2.36 (1.8) and 1.0 (2.5) mg/m³, respectively), whereas use of a closed cab reduced the GM exposure with 98 and 95%, respectively.

Conclusions: Type of drill rig is an important determinant of aerosol exposure. Use of closed cabs seems to be the single most important control measure for lowering exposures.

Fabrication of Single Walled Carbon Nanotube (SWNT) Sorbent for Volatile Organic Compounds (VOCs) Sampling

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Objectives: To compare fabrication methods of single-walled carbon nanotube (SWNT) buckypaper by quantifying adsorption efficiencies for use in volatile organic compound (VOC) passive samplers.

Methods: Arc discharge SWNTs in sodium dodecyl sulfate solution was fabricated into a buckypaper with or without a cleaning process. 200 mL of the SWNT solution was suspended in 400 mL of acetone, vacuum-filtered through a polytetrafluoroethylene membrane filter, and buckypaper was obtained by delaminating the layer of SWNTs from the filter (not-cleaned). A cleaning process was added to the above fabrication process. After SWNT solution was vacuum-filtered, SWNTs on the filter were cleaned with 250 mL of deionized water and 50 mL of acetone (acetone-cleaned). As another cleaning process, methanol was used to suspend and clean SWNTs (methanol-cleaned). The fabricated buckypapers were investigated for adsorption efficiency in terms of surface area, pore size, and toluene adsorption isotherm at 23 °C.

Results: Not cleaned buckypapers had 45 m²/g Brunauer, Emmett and Teller (BET) surface area (SA) with 15 nm average pore width while acetone-cleaned buckypapers and methanol-cleaned buckypapers exhibited 217 and 348 m²/g BET SAs with 9 and 8 nm average pore widths, respectively. The adsorption capacities were 54 and 64 mg (toluene)/g (buckypaper) for acetone- and methanol-cleaned buckypapers, respectively (data for not-cleaned buckypaper is not included because of considerably lower SA).

Conclusions: The cleaning process increased BET SA and decreased the average pore size. Adsorption capacity increased with increasing SA of buckypapers. Methanol-cleaned buckypapers were the most adsorptive, hinting for further investigation in desorption efficiency for the application to VOC passive samplers.

Measurement of the Potential Exposure to Isocyanates during Spray Painting Using Dry Air Sampling Device

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Objectives: Monitoring of isocyanates in the workplace environment is important as these reactive compounds are capable of inducing respiratory disorders like "occupational asthma". Monomer and oligomer isocyanates often occur together in product formulations, such as coatings, paints and foam insulations. Analyzing the monomer and oligomer isocyanates in a single method provides

the most efficient solution for determining the concentrations present during potential exposures.

Methods: In this field study, dry air sampling devices were used to assess the exposure to isocyanates during spray paint coating. The dry air sampler allowed sensitive and reliable detection of multiple isocyanates including monomers and oligomers. Low detection limits were obtained by the analysis of urea derivatives of isocyanates by LC-MS-MS.

Results: Quantitative analysis of the isocyanates was possible by using the available deuterated internal standards. The quantitative results indicated that HDI-isocyanurate and IPDI-isocyanurate were present at the highest concentration in the air during the spraying process. The total isocyanate concentration found in this study expressed as total NCO will be presented.

Conclusions: The use of the dry sampling device allowed quantitative analysis of total isocyanates as well as detection and identification of the individual isocyanate species. Monomers and polymers of isophorone diisocyanate (IPDI), and 1,6-hexamethylene diisocyanate (HDI) were detected. HDI polymeric species included HDI-Isocyanurate, HDI-Uretidone and HDI-Biuret. The IPDI polymeric form IPDI-Isocyanurate was also present.

Models vs. Measurement. Are We on the Right Track? The Art of Occupational Exposure Modelling

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As the (European) occupational hygiene community would not be able to collect sufficient number of exposure measurements to perform accurate exposure assessments for all relevant scenarios, reliable and accurate models were considered to be critical. The REACH Implementation Project (RIP) 3.2 therefore proposed a tiered approach, needed to facilitate risk assessment for all foreseen exposure scenarios. In the first tier of this approach, relatively simple exposure models are used to efficiently assess workers' exposure, and the precautionary principle is adopted to provide a conservative exposure estimate. In a second tier, more advanced modelling approaches are needed to produce more realistic exposure estimates. In the third tier, the exposure estimate will be based on a comprehensive exposure survey. As the existing modelling approaches were not sufficient, REACH created new modelling approaches to developed accurate exposure estimates.

I will introduce two models for estimating inhalation exposure used within the REACH process. The first model, the Stoffenmanager, was initially developed as a control banding tool to assist small and medium sized enterprises to prioritize their chemical exposures for health risk assessment. In 2008, the relative scores of the Stoffenmanager model were calibrated with exposure measurements. Since then Stoffenmanager provides exposure estimates in mg/m³. The second model, the Advanced REACH Tool (ART), is a higher tier exposure assessment model and includes a Bayesian approach, that makes full use of mechanistically modelled exposure estimates and any relevant measurements of exposure.

Models vs. Measurement. Are We on the Right Track? What Did We Collect over the Years? Experiences with Collecting and Analysing Measurement Data

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Collecting exposure measurement data can be a challenge, but experiences with the EXASRUB, the SYNERGY project and the European Asphalt Workers study have shown that large amounts of (individual) measurement data are around and can be amalgamated into large exposure databases. Especially large country-wide exposure databases like MEGA (DE), COLCHIC (FR), NEDB (UK) and EXPO (NO) contain large collections of exposure measurements of specific agents collected from a wide variety of industries over long periods of time (several decades). It has been shown that meaningful estimates of country/industry/job and time period specific personal exposure levels can be derived that can be successfully applied in occupational epidemiological analyses of quantitative exposure -

response curves, resulting, for instance, in evidence-based occupational exposure limits. Dealing with the varying quality of the data from different sources often collected for other purposes (compliance, inspections, surveillance, epidemiology, etc.) can however be a real challenge especially when auxiliary information necessary to judge representativeness of the measured concentrations is only partially available. Prospective industry-wide exposure monitoring programmes like the IMA-Dust Monitoring Project are extremely rare, but offer the unique opportunity to yield measurement data that can be used to show compliance/non-compliance, allow surveillance at company and industry level. Given the systematically collection (standardized dust monitoring protocol) of exposure data the project will yield valid and precise exposure estimated for future epidemiological studies.

Models vs. Measurement. Are We on the Right Track? Large Exposure Measurement Databases: Experiences from CAREX Canada

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Objectives: CAREX Canada is a surveillance system that estimated the number of workers exposed to carcinogens in Canada. Central to this work was the creation of a national exposure database (Canadian Workplace Exposure Database, CWED). The objective of this talk is to discuss implications of deteriorating exposure data collection for Canada's workplaces.

Methods: The CWED was designed to support the creation of CAREX estimates, but also includes exposure monitoring from non-carcinogenic agents. It was amalgamated from several regulatory bodies' databases from various Canadian provinces via a survey of data availability conducted in 2009. In this survey, each potential data holder was asked about data availability, time period of data collection, and current practices. All data holders were invited to contribute their data to the CWED.

Results: The CWED currently contains ~500,000 samples from the 1970s to early 2000s. This data was used to create estimates of exposure prevalence for >40 carcinogens, and for half of these, exposure levels are available. Of concern is the deregulation of data collection and storage in Canada; the number of samples drops off precipitously in the early 90s. All but one province rely on varying models of industry responsibility for sampling coupled with compliance review, and the centralization of data is no longer performed in a way that offers continued supplementation of the CWED.

Conclusions: The lack of current exposure data impacts the ability to accurately estimate exposure to occupational carcinogens. In addition, chronically under-sampled industries (agriculture, construction) limit the potential use of modelling solutions.

Models vs. Measurement. Are we on the Right Track? The Promise and Limitations of Occupational Exposure Banding

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Chemicals are being introduced into commerce at a rate which significantly outpaces the development of authoritative Occupational Exposure Limits (OELs). The NIOSH Occupational Exposure Banding process uses available toxicological data to create a range of concentrations or an Occupational Exposure Band (OEB), to control chemical exposures. The objective of this paper is to examine 1) the NIOSH Occupational Exposure Banding process 2) review the tier 1 and tier 2 validation results.

Methods: To validate Tier 1 process, OELs for approximately 800 chemicals were compared to derived occupational exposure bands (OEBs). To validate the tier 2 process, approximately 115 chemicals from the EPA IRIS database, the TLV "Under Study" List, the MAK list of "Substances for which no MAK value can be established at present", and Health Canada and compared the banding results from multiple users for seven health endpoints.

Results: The tier 1 validation results illustrated that the exposure concentrations for powder and dust concentrations needed adjustment. In the tier 2 validation, health endpoints irritation and sensitization commonly caused discrepancies in the final bands selected by users. Other discrepancies were caused by judgment calls with qualitative data, or using unique data sources other than those specified in the NIOSH process manual.

Conclusions: The built-in flexibility of the process allowed users to incorporate specialized knowledge about the chemical, when necessary. OEBs can be performed by industrial hygienists and toxicologists to provide useful risk management guidance.

Reduction of Indoor NO₂ in an Air Pollution Hot Spot Area

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Objectives: The study was set up to indicate how outdoor environmental pollution of NO₂ propagates into an office environment in one of the most heavily air polluted areas in Norway. The objective was to compare the effect of combo filters (active carbon + particle filters) with conventional particle filters in the ventilation system of the office building.

Methods: The measurements took place in January to March (2014), when the highest concentration of air pollution is expected due to vehicle traffic, heating and climatic conditions. Two Teledyne API 200E direct reading instruments for measurement of NO₂ were deployed outdoors close to the air inlet and inside an office building, respectively. Hourly mean values of NO₂ were used.

Results: In the study period the outdoor NO₂-concentration at the air inlet varied between 1 and 154 µg/m³, and 10 days had values exceeding the national recommendation (100 µg/m³, 1 hour). There was no apparent difference between outdoors and indoor concentrations of NO₂ when conventional particle filters were used. However, the combo filter reduced NO₂-concentrations by 45–80% compared to outdoor concentrations, and no indoor readings were above 100 µg/m³.

Conclusions: Significant reductions in indoor concentration of NO₂ were obtained when active carbon filters were used in the air supply system. The efficiency of these filters at even higher outdoor air pollution levels, more representative for the conditions in recent years (300–400 µg/m³ NO₂), remains to be elucidated.

Bioaccessibility of Lead in Airborne Particulates from Car Battery Repair Work

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The bioaccessibility of lead in air particulate matter from two car battery repair workshop sites in Kumasi (Ghana) was measured (64 full shift personal aerosol samples). An artificial lung lining fluid simulant (Hatch solution) was applied for leaching the bioaccessible fraction in half of the samples, the other half was leached with synthetic gastric juice. At both locations, the Pb solubility (median) in gastric juice (89 % and 92 %) is substantially higher than in Hatch solution (4.9 % and 5.6 %). The high solubility of Pb in Gastric juice may be related to the presence of Pb oxides. The low bioaccessibility of Pb in Hatch solution is in good

agreement with previous work on mine tailings, urban aerosol, car exhaust, welding fumes and indoor dust. The high bioaccessibility of Pb in the gastrointestinal tract underpins the importance of improving the personal hygienic behavior at the workplace. It is recommended that air monitoring of Pb should include the extrathoracic aerosol fraction using inhalable aerosol samplers, as particles of this size fraction are most likely transferred to the gastrointestinal tract in addition to the non-lung-soluble particles transported from the lung by mucociliary and phagocytosis clearance.

Application of SEM-EDX with Filters and TEM with Metal Grid for Nanoparticle Exposure Assessment

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Objectives: For nanoparticle exposure assessment, both on-line monitoring and off-line monitoring have been used. Electron microscope analysis with off-line sampling has been used for qualitative and semi-quantitative analysis. This study aims to discuss the advantage and disadvantage of SEM with filter samples and TEM with metal grid samples at various nano handling worksites. Also, application of EDX (Energy Dispersive X-ray Spectroscopy) will be discussed.

Methods: Various nano handling worksites were surveyed with PC, PVC, MCE, PTFE filters for SEM analysis and copper TEM grid for TEM analysis. FE-SEM and TEM were used to investigate nanoparticles on the filter or grid. Composition analysis was performed using EDX.

Results: For SEM analysis, PC filter was proved to be appropriate because of getting better images of nanoparticles. Also, samples on PC filters could be used to measure mass, EDX analysis and wet chemical analysis. For TEM grid, selection of grid material is important. There might be interference for qualitative analysis when grid material was the same with the nanoparticles. TEM could define the crystalline structure such as silica, asbestos.

Conclusions: Both SEM, TEM could be a good supportive method to overcome the weakness of real-time monitor for nanoparticle exposure assessment. Advantage of SEM is getting 3D image and relative easiness. Advantage of TEM analysis is to define crystalline structure of some nanoparticles.

Acknowledgement: This study was supported by the Korean Occupational Safety and Health Agency (No. 2013-OSHRI-597), National Research Foundation of Korea (NRF) BK 21 plus project(No. 5280-20140100) and National Institute of Environmental Research (NIER).

Characteristics of Elemental Carbon (EC) and Organic Carbon (OC) Exposure of Municipal Waste Collectors

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Objective: The objective of this study is to characterize waste collectors' exposure to EC and organic carbon (OC).

Methods: A total of 59 municipal waste collectors were chosen to assess EC and OC exposure during a full workday of waste collection. Airborne OC and EC from the breathing zone were collected on pre-fired quartz filters equipped within PM_{2.5} samplers and quantified using the thermal optical reflectance method recommended by the National Institute for Occupational Safety and Health (NIOSH analytical method # 5040).

Results: The EC exposure ($N=36$, 6.2 ± 6.5 ug/m³) of the collectors was found to be significantly higher than that of drivers ($N=23$, 3.1 ± 1.9 ug/m³) ($p=0.0324$). A significant difference in OC exposure levels between collectors (53.9 ± 29.3 ug/m³) and drivers (46.2 ± 28.6 ug/m³) was not found. The average EC exposure level of workers who used collection vehicles less than five years old ($N=11$, 2.9 ± 1.9 ug/m³) was far lower than that measured for collection vehicles over five years old ($N=48$, 5.5 ± 5.8 ug/m³). Both the EC/OC rate (%) from collectors and that from collection vehicles over five years old were significantly higher than that from drivers ($p=0.0469$) and collection vehicles less than five years old ($p=0.0344$).

Conclusion: Workers who collect household waste using collection vehicles older than five years were found to be exposed to higher EC levels.

Characterization of Occupational Exposures to Solar Ultraviolet in France

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Introduction: Occupational exposure to ultraviolet (UV) is associated with an increased risk of skin cancers. The objective was to evaluate occupational UV exposure in France to improve the identification and prevention of occupational skin cancer.

Method: The exposure assessment was carried out in several stages. A telephone survey of the general population, an estimate of the ambient irradiance based on the geo-location of residence, the patterns of exposure collected during the survey and simulations using the SimUVEx tool to calculate the exposure ratio (ER) by anatomical site. This has allowed estimating anatomical erythral doses for seven occupations (farmer, construction worker, child minder, gardener, delivery driver, road worker, market gardener).

Results: Professionals potentially most exposed to solar UV are gardeners / landscapers (median daily dose = 1.19 SED), construction workers (1.13 SED), farmers (0.95 SED) and workers in the culture and art (0.92 SED). Factors significantly associated with high potential exposures are: gender (men vs women: 0.88 vs. 0.62 SED), phototype (IV vs. I: 0.89 vs. 0.70 SED) and meals eaten outside (always vs. never: 1.04 vs. 0.75 SED).

Discussion: Anatomical doses are consistent with the risk classification of occupations. The most affected anatomical site is the neck for both chronic and acute episodes. Daily dose above 15 SED on the most exposed area is common, suggesting frequent sunburns.

Conclusion: The results highlight the need to target prevention messages to outdoor workers. Estimates of dose and calculation tools developed can be used to improve the recognition of occupational skin cancers

A Strategy for Creating a Healthy and Safe Learning Environment as a Part of Company Positive Safety Culture

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Objective: The study proposes a model for a safety culture with focuses on organizational learning, which enables to exchange tacit and explicit safety knowledge. This article concerns organizational safety culture and the structure or architecture of employees' and employers' attitudes and perceptions to safety as part of that culture, as well as the ability to learn, which also should mean changes in worker's behaviour.

Methods: The study assesses senior managers and employees' perceptions of the current safety culture and learning possibilities in Estonian SMEs from different branches of industry, using two different questionnaires on a sample of 463 senior managers and 1757 employees. A qualitative approach includes eight case studies, semi-structured interviews with senior managers, focus group interviews with employees and on-site observations.

Results: The data reveal key issues in safety culture and learning possibilities in industrial SME. A statistical analysis of safety culture questionnaires shows many organizations with an outstanding safety culture and positive perceptions and attitudes. However, qualitative data indicate some important safety flaws and drawing attention to contextual variables in the development of safety management systems and improving the learning possibilities.

Conclusions: The study evaluates safety programmes in SMEs in order to highlight the social and cultural character of learning in organizations, and thus attribute the role of safety culture in safety knowledge exchange. The paper presents an innovative conceptual model for the improvement of safety culture. The authors emphasise the importance of implementing organizational structures, which allow for managers and employees to interact, to learn from safety practice and experience.

The Influence of Ship Movements on the Energy Expenditure of Fishermen. A Study during a North Sea Voyage in Calm Weather

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Objective: Former studies of professional fishing activities has indicated that movements of a ship, in itself, may increase the energy expenditure in addition to the traditional work carried out by fishermen. We have studied the effects of exposure to the ship's movement during calm weather by examining the crude relation between the ship's movement and the energy expenditure of the fishermen, thus ignoring the various tasks undertaken on board.

Methods: Four fishermen on two contemporary steel trawlers were recruited and participated during the whole study. Activities and health conditions were recorded once an hour in four days. Estimation of energy expenditure were done with a body monitoring system (SenseWear Pro 3) carried as an armband placed on the right upper arm. Measurements of sea movements were obtained by a gyroscope placed in the vessels wheelhouse during fishing expeditions in the North Sea off the coast of Bergen. The data were analysed by linear regression.

Results: The exposure monitored in calm weather conditions was small for all measurements of heeling and pitch being less than 10° for both vessels. However, the fishermen's energy expenditure was influenced by these minor sea motions. Trends were seen in the individual graphs with increasing energy expenditure at higher exposures.

Conclusion: Our data suggests that even the heel and pitch in calm weather have an impact on the fishermen by increasing their energy consumption. This study has demonstrated the feasibility of the applied methods that should be repeated with larger samples and in rough weather.

A New Bayesian Toolkit for the Estimation of Occupational Exposure Levels Compared to Exposure Limits

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Objectives: Strategies to interpret exposure measurement data have evolved into a framework based on a lognormal distribution. Most currently available tools and approaches are based on traditional frequentist statistical procedures, which

have been unable to satisfactorily address several methodological challenges. Bayesian methods, which combine prior information with that in the current data set to derive overall inferences, have been proposed but some important extensions remain to be developed, programmed and made more widely available.

Methods: We developed a web-based tool aimed at answering the following types of inferential questions: Is a group compliant with the OEL? Are individuals within this group likely to experience higher risk than the group average? What effect does an intervention have on the underlying exposure distribution? These questions were solved numerically using Bayesian models that integrate the treatment of left-censored data with multiple censoring points.

Results: The Web-based tool is available at www.expostats.ca. In the Bayesian models, variance components are estimated through a hierarchical model with individual workers as the grouping variable, and censoring is treated via multiple imputation by declaring the observations missing from a truncated part of the underlying exposure distribution. The models are estimated using the JAGS Gibbs sampler called through the R statistical package, both installed on a Linux machine with the Shiny Web Server.

Discussion: Future developments include translating current routines into pure internet language code to facilitate its diffusion to the industrial hygiene community and extensive comparison with their frequentist counterparts.

Investigate the Permeation Behaviors of 1-Bromopropane through Chemical Protective Gloves

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Objectives: Metal cleaning technology is an important procedure in various manufacture industries. 1-Bromopropane has been applied as the cleaning agents since the ozone-depletion substances (ODSs) such as, CFC-113 and methyl chloroform, were banned. Workers' hands might expose to 1-bromopropane without appropriate protection. Exposure of 1-bromopropane has been suspected in related with the peripheral neuropathy. The aim of this research was to investigate permeation behaviors of 4 commercial chemical protective gloves while challenged by 1-bromopropane.

Methods: The permeation tests were conducted based on the ASTM F739-12 standard method at 27°C, controlling by water bath system. The permeation sample was collected every 15 minutes. The test durations were 2 hours for natural rubber latex (NRL) gloves, nitrile gloves, butyl rubber gloves and 4 hours for silver shield® gloves. Each permeation test was performed triplicate. The 1-bromopropane was quantified by gas chromatography with a FID detector (GC-FID).

Results: The NRL gloves, nitrile gloves and butyl gloves were broke through by 1-bromopropane with 15 minutes. The maximum permeation masses were 4869.63 mg for NRL glove, 5136.07 mg for nitrile glove, 3490.56 mg for butyl glove; the maximum permeation rates were 8.28 mg/cm²/min for NRL glove, 8.73 mg/cm²/min for nitrile glove, 5.94 mg/cm²/min for butyl glove. No breakthrough was detected for Silver shield® within the 4-hour tests.

Conclusions: NRL gloves, nitrile gloves, and butyl gloves should not be wore by workers to prevent skin contact of 1-bromopropane as their quick breakthrough. The silver shield® gloves were recommended for handling the cleaning agents containing 1-bromopropane.

Validation of the ATs (American Thoracic Society) Respiratory Questionnaire for Lung Function Assessment among an Occupational Group of Textile Workers

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Introduction: The objective of this study was to determine the correlation of spirometric lung pattern with respiratory symptoms and to validate the American Thoracic Society (ATS-DLD-78A) respiratory questionnaire for lung function assessment among textile workers in Karachi, Pakistan.

Methods: A cross-sectional survey conducted in 2009–2010 which included 372 workers from 15 textile mills in Karachi. Data was collected through the ATS-DLD-78A respiratory questionnaire and lung function was assessed by using a portable spirometer.

Results: A general trend of decrease in lung function (predicted FVC, FEV1 and FEV1/FVC ratio) was observed among participants who had chronic respiratory symptoms. Predicted FEV1 was significantly reduced for chronic cough (aOR: 3.09, CI: 1.26, 7.56), chronic wheeze (aOR 1.98, CI: 1.05, 3.71) and shortness of breath grade 2 (aOR: 2.07, CI: 1.05, 4.07). The risk of decrease in lung function significantly increases with the addition of chronic symptoms on predicted FEV1; cough + wheeze (aOR: 2.08 CI: 1.05, 4.10), cough + shortness of breath grade 2 (aOR: 2.47, CI: 1.18, 5.18), phlegm + shortness of breath grade 2 (aOR: 2.59, CI: 1.23, 5.43) cough + wheeze + shortness of breath grade 2 (aOR: 4.64, CI: 1.97, 10.93) (aOR: 4.18, CI: 1.68, 10.37). We found low sensitivity and high specificity and negative predicted values for the respiratory symptoms.

Discussion: The presence of respiratory symptoms is an important predictor of impaired lung function. The use of ATS - DLD - 78A questionnaire is an effective tool in approximating the burden of respiratory symptoms in occupational setting.

Barriers in Adoption of Improved Stoves in Pakistan: Inquiry among Users, Non-Users and Program Managers in Sindh and Punjab Provinces

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Introduction: Household air pollution from burning of solid fuels is an important environmental health issue globally. In Pakistan its annually costs 1% of GDP. Improved stoves are considered as the mainstay intervention for household air pollution for the poor communities. This article inquires about the barriers to adoption of improved stoves and the perceived health effects in two programs in the provinces of Sindh and Punjab, Pakistan.

Methods: Semi-structured exploratory in-depth interviews of program managers and focus group discussions (FGDs) with group of women using improved and traditional stoves, were conducted during May-August, 2014 in Kasur district in Punjab and Dhabeji in Sindh. Total 48 women, who were primary cooks attended the focus group discussion. Semi structured guidelines were developed to explore the factors facilitating or inhibiting the adoption of improved stoves.

Results: Across the sites, women using improved stoves believed in its beneficial impacts including decrease in the respiratory symptoms, burning of eyes, blackening of utensils and walls. Most of the rural Sindh participants were more satisfied with the traditional stoves, owing to the decreased amount of fuel and time consumed. Potentially important drivers to the use of improved stoves included credit and supply-chain strengthening.

Discussion: This paper highlighted the importance of the health effects of stove smoke to stove users and the uptake of the improved stoves. Knowledge alone is insufficient in modifying the cooking practices. Modification of behavioral factors such as regularly maintaining the stoves are important for achieving the cook stove interventions.

Low Prevalence of Asthma among Textile Workers in Karachi, Pakistan

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Objective: The purpose of this study was to determine the prevalence of asthma among textile workers through post-bronchodilator spirometry and to compare the differences in prevalence based on different criteria used to assess asthma.

Methods: This secondary of data from a cross-sectional survey included 372 textile workers from 15 textile mills of Karachi and its outskirts. The study assessed asthma and associated respiratory symptoms through the American Thoracic Society Division of Lung Diseases Questionnaire (ATS-DLD-78A), and post-bronchodilator spirometry.

Results: The overall prevalence of asthma in textile workers was 5% (95% CI: 3–7.8), as diagnosed on post-bronchodilator spirometry. The prevalence of self-reported and physician diagnosed asthma was 4% (95% CI: 2.4–6.5) and 2.1% (95% CI: 1–4.1%) respectively. Work in spinning section, young age, and duration of work in textile industry (≥ 10 years) were found to be important predictors of asthma.

Conclusion: The textile industry workers were found to have low prevalence of asthma, assessed through post-bronchodilator spirometry, compared to estimates for the general population. This finding could possibly be due to some protective effect of endotoxin exposure although further evaluation with better exposure assessment is warranted.

How Systematic Exposure Monitoring can Predict Changes in Long-Term Temporal Trends in Personal Exposure Concentrations in the Workplace

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Objectives: Monitoring programmes lasting over a decade across an entire industry are unique. The IMA Dust Monitoring Programme has collected respirable dust and quartz measurements from more than 35 companies across Europe producing industrial minerals. The database offers opportunities to monitor long-term temporal trends in exposure concentration and gain insight into the association between (changes in) day-to-day variability and long-term temporal trends.

Methods: The respirable dust and quartz measurements are being collected in accordance with a standardised monitoring protocol and strategy, which follows strict quality criteria. Currently the database includes over 20,000 personal respirable dust measurements. Linear mixed effect modelling has been applied to estimate day-to-day and personal variability in exposure concentrations. Long-term temporal trends in exposure and their association with day-to-day variability were studied.

Results: Just before 2008 increases in day-to-day variability were noticed suggesting diminishing control and more variable exposure conditions. Recent analyses showed striking downward trends in exposure which came to a halt at around 2009. Careful analyses and discussion with occupational health and safety representatives pointed at direct detrimental effects of the current economic crisis. At sites with less than 50 employees in the most affected Southern European countries temporal trends even reversed.

Conclusions: Systematic data collection proved to be very efficient when describing and monitoring long-term trends in occupational exposure for an entire industry. Increased day-to-day variability in exposure seem to clearly indicate reduced control of individual exposure resulting in consequently slowing down and even reversal of downward trends in exposure concentrations.

Practical Risk Management in a Challenging Workplace Scenario

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Emergencies caused by hurricanes, tornados, earthquakes, and floods are occurring with increasing frequency. These events often result in structural, mechanical, electrical, and plumbing failures. The health and safety risks associated with these failures are significantly increased if the structure houses sensitive populations such as infants, elderly, and immune compromised individuals.

Building system failures during emergencies require rapid assessment of potential hazards, implementation of temporary environmental controls, remediation and transition to stable conditions. The applicability of the risk management approaches used in this scenario to other emergency situations that involve sensitive populations is presented.

The poster discusses real-time responses and risk management in a hospital cardiopulmonary intensive care unit (ICU) flooded by a construction accident. The ICU could not be evacuated without immediate risk to the patients. The management of the biological risks (fungal and bacterial) was complicated by the presence of asbestos-containing materials in the flooring and wall board materials, which had to be removed before remediation of the biological risks.

The application, integration and on-going assessment of environmental controls through a combination of real-time particle size air monitoring, polymerase chain reaction (PCR) targeting of selected nosocomial fungi as well as bulk and surface samples are discussed. The applicability of international and United States standards and guidelines such as ISO 14644, USP <797>, USP <1116> and ASHREA 188P were considered to develop the strategy for the situation outlined in the poster.

The Effect of Visible Light on Human Health and Implications for the Work Environment

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Introduction: Occupational hygienists are often asked to look at lighting problems. Typically, they will measure light levels using a luxmeter, and compare their results with the recommended illuminance levels in national standards documents. Their findings and recommendations reflect the ergonomics of the lighting environment; and apart from vague conditions such as 'eyestrain' this type of survey does little to inform on the possible adverse health effects of light.

Objectives: It is argued that quality of lighting needs to be considered as a health factor in the human environment and that existing standards, such as the ACGIH TLV for visible light, are inappropriate for this purpose.

Methods: This paper is based on a review of the literature on the neuroendocrine effects of light. Following recent discoveries of non-visual lighting receptors in the eye and their physiological role, there is now substantial evidence showing how light elicits a systemic hormonally mediated response in humans, and how 'poor' lighting can adversely affect the health of individuals.

Conclusions: There is a need for a completely new exposure standard for lighting, or a lighting regime designed to protect the health of individuals. This is a new paradigm requiring completely new tools in the hygienist's armoury, in addition to a much different understanding of the lit and the unlit or dark environment. This paper proposes one such approach.

New Guidelines for Identification and Surveillance of Infectious *Legionella pneumophila* Populations in Potable Water Systems

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Objective: Existing strategies for identification and surveillance of *Legionella pneumophila* in potable water systems do not distinguish between infectious and non-infectious contamination.

Regular control of drinking water focuses on monitoring intestinal bacteria, thus ensuring that freshwater is not contaminated with faecal flora. Today's infectious challenges from water, e.g. *Legionella*, Norovirus and *Giardia/Cryptosporium* are not included in regular controls and only exceptionally surveyed, mainly as a consequence of an outbreak.

We recently identified *Legionella pneumophila* (*Lp*) together with free-living amoebae (FLA) on board Norwegian Naval vessels (1). Coexistence between *Legionella pneumophila* and certain species of FLA has been documented as the training ground for increased pathogenicity in *L. pneumophila* (2). The amoebae also protect *Lp* against disinfectants.

Guidelines for an optimal Legionella surveillance of water systems with repeated Legionella problems must therefore in addition to demonstration of the *L. pneumophila* bacterium also demonstrate presence of free-living amoeba hosting legionella.

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Integrating Occupational Hygiene, Medicine and Engineering in a Mining Context

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Objectives: To set out an occupational health management framework integrating the disciplines of occupational hygiene and medicine in particular showing how the work can be integrated rather than working in silos.

Methods: The poster describes how a ten steps process was developed integrating the well understood occupational exposure identification and assessment methods with medical assessment and management. It examines the functional requirements of the job as well as the potential health effects to inform medical assessment methodologies as well as rehabilitation processes.

It also displays preliminary innovative work using sophisticated statistical techniques relating occupational hygiene and medical assessments with work carried out by researchers at the Queensland University of Technology.

It is based on a case study of a copper and gold mine in country New South Wales

Results: The process involves the following steps: (1) categorise similarly exposed groups based on function; (2) determine SEG essential functional requirements; (3) risk assess health affecting agents in each SEG; (4) validate risk register and functional requirements; (5) review all relevant drivers; (6) determine medical standards based on all drivers; (7) determine schedule of medical examinations; (8) conduct medical examinations; (9) provide certificate of medical fitness of work; (10) ongoing monitoring and review.

Conclusions: Occupational hygienists, occupational physicians, health advisers and university researchers can work together to deliver a sound management framework with participation from management and the workforce.

The authors plan to publish a compact booklet setting out the ten steps process prior to the Conference.

E- Learning for Ergonomics

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Objectives: The main objective of this abstract is to show the usefulness of e-learning for training workers in ergonomics.

Methods: The method was the following:

- 1) To develop an e-learning course in ergonomics which included:
 - a. Ergonomic theoretical concepts
 - b. Ergonomic Risk self-assessment
 - c. Videos of workplace exercises
 - d. Course assessment test
- 2) Each worker was given a user and performed the course. To perform the course takes approximately thirty minutes.

- 3) EHS Department made the data processing and gave feedback to each worker regarding the results of the ergonomic risk self-assessment

Results: The results were the following:

- 1) Arouse awareness between workers regarding ergonomic risks at work
- 2) Corrective actions were taken at workplaces with ergonomic risk detected
- 3) Workplace exercises were implemented at the middle of the day

Conclusions: The ergonomic e-learning course proved to be a good tool for training workers because the following reasons:

- 1) It is easy to use
- 2) It is funny
- 3) Each worker can choose when to take the course
- 4) It only takes 30 minutes to be trained

Sun Safety in Construction: An Intervention for the UK Construction Sector

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Objectives: Creation and evaluation of an intervention to promote sun safety in the UK construction sector. The project was funded by IOSH.

Methods: *Sun Safety in Construction* was developed as a low-cost, brief, and easy-to-administer DVD-based awareness film (intervention). Following administration of a sun safety knowledge, attitude and behaviour survey ($N=1,279$ construction workers) the DVD was shown to workers in 22 geographically dispersed UK construction companies (summer 2012). The survey was re-administered 12-months post-intervention (summer 2013).

Results: Pre-intervention questionnaire responses showed that respondents worked outside for an average of almost 7 hours per day and the majority had a high-risk skin type. Two-thirds thought they were not at risk from skin cancer or did not know if they were at risk. Almost three quarters reported that they had never received any form of occupational sun safety training. Use of sun safety measures was low.

Post-intervention questionnaire responses showed that respondents who had viewed the DVD (intervention group) demonstrated positive change across a set of knowledge, attitude and behaviour indicators. There was increased use of sun safety measures. Those who had not seen the DVD (control group) generally showed little or no improvement.

Conclusions: The *Sun Safety In Construction* intervention is effective in producing positive change. It is recommended that the film is made freely available online and employers are encouraged to incorporate the intervention into health and safety training. The development of a sun safety culture in UK construction is likely to require action from employers and government.

Gas Exposure and Health Hazards during Silage Work

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Objectives: In general silage gases created during the fermentation process, mainly carbon dioxide and nitrogen dioxide tend to settle close to the surface of the silage and the potential to displace the oxygen in the silos. Objective of the study was to investigate the concentrations of hazardous gases in the silos. The aim is to focus on the gases that arise in the process of fermentation of silage: oxygen and carbon dioxide, carbon monoxide, nitrogen dioxide and nitrogen monoxide. The study focused on the cubic type and round tower silo, because in these types of bins might be situations where the gases formed cannot get out.

Materials and Methods: All together 18 farms and 37 silos were measured. Direct reading instrument made by Draeger, Germany were used. Measurements after 12–24 hours after making silage were done inside silos.

Results: In about 60% of the measured silos, oxygen content was less than 20% by volume and in three cases at very harmful level in the breathing zone of a person standing. In seven cases, the carbon dioxide levels were above 70 000 ppm. Farmers reported respiratory symptoms connected to exposure in a questionnaire

Conclusions: The highest concentrations occur during first days after the closing the silo. The significant factors affecting the formation of gases probably are the feed compression, use of silage chemical as well as silage quality. Therefore the harmful concentrations of gases cannot be predicted precisely. The most important risk communication is to inform farmers for these possible hazards during silage work.

Musculoskeletal Injuries in Amateur Sport Practiced in Organizations

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The practice of sport contributes greatly to this overall well-being. However, the increase in the practice of physical exercise can lead to potential accidents/incidents leading, in turn, to the development of musculoskeletal disorders (MSDS). Physical activity, in some professions, like the military, is a labor component, should be contemplated in the issues related to the prevention of occurrences, in particular labour injuries in sports.

Despite the possibility of occurrence of MSDS is essential to exercising, being proven that has an active role in reducing morbidity and mortality.

The present study intends to evaluate quantitative and qualitatively the main risk factors that may lead to MSDS on non-professional sportsmen belonging to the Portuguese Air Force. The Portuguese Air Force requires its military fitness and continuous practice of physical exercise, and therefore critical to understand the prevailing reasons for the occurrence of MSDS that can have in addition to the consequences described above, lead to a labor stoppage. A questionnaire was applied to the participants in order to obtain data such as age, gender, weight, academic qualifications, frequency and mode of sporting activity, injuries and/or illnesses early, cause, consequences and treatment of old injuries, among others. These data have enabled a detailed analysis of MSDS in this sample, enabling the preparation of a plan of preventive measures, in order to reduce any adverse consequences as a result of these occurrences.

Musculoskeletal Disorders (MSD) related to Aircraft Maintenance

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The modern aircrafts, regardless of its type, able to achieve very high performances, are subject to a very high level maintenance of electronic, mechanical and structural requirement. They need for greater and more rigorous technical intervention, forcing the physical and psychological demanding work. The aircraft maintenance can increase exposure to risk factors during the occupation and occupational context, could lead to the development of MSDS.

The study population is comprised by the mechanics who work on maintenance of the aircraft of the Portuguese Air Force and stands at 613 individuals, showing a 5 margin of error and a confidence level of 95.

A questionnaire has been prepared and made available online.

The Herniated Discs and Tendonitis are MSDS that can associate the activities of aircraft Mechanics, due to the necessity of demanding postures in some tasks, and the manual handling of loads or overexertion.

It was verified some obesity in individuals, and this is also possibly one of the causes, associated with low frequency in the sport, to the emergence of Herniated discs. Carrying out maintenance work on aircraft over the years can be also be an enhancer factor of the emergence of MSDS, because the mechanics with more seniority have a higher incidence of symptoms.

There was not found a significant relationship between factors such as Diabetes, hypertension, smoking habits or alcohol consumption and the emergence of MSDS.

Numerical and Analytical Development Factor Correction for Thermometer Globe 50 mm

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To determine the WBGT (Wet Bulb Globe Temperature) index accordingly to the ISO 7243:1989 norm is recommended the use of a dark globe thermometer of 150 mm diameter. However the market offers equipment that uses smaller dark globes. This study has the objective of verifying if there are differences between the temperatures of dark globes using different equipment. And in this case also establish an equation that allows us to determine a correction factor that could be used when using dark globes with different sizes from the standard one. In this study, it was possible to observe differences between the measurements made with different dark globes, where in fact it's not possible to determine directly the WBGT index from measurements with dark globes different from the standard one, without using a correction factor. For the study, it was used a standard dark globe thermometer (Delta OHM HD2307.0 RTD) and three dark globe thermometers of 50 mm diameter (Casella Microtherm Heat Stress WBGT; Casella B.S.2842:1992 AOS497; Delta OHM HD32.2 WBGT Index). The equipment was placed in front of a heat source, built with 56 lamps (dichroic halogen lamps ø51mm GUS,3 brand OSRAM) at different distances. It was determined the calibration curve for each equipment for the interval of temperatures measured. For the calculation of the WBGT index, it's necessary introduce a correction factor suitable for the correct transposition of the temperature of the dark globe of 50 mm (Tgn50) for the standard globe temperature of 150 mm (Tgn150).

Evaluation of Muscular Tension by Myotonometrical Method

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Objectives: The aim was to investigate musculoskeletal disorders development as a result of continuous computer work.

Material and methods: The health complaints were mapped based on the Nordic Musculoskeletal Questionnaire

The myometric method is worked out in University of Tartu. Myoton-3 enables to measure the following characteristics of muscles: frequency, decrement and stiffness.

Results: 66 (37 women and 29 men, the mean age of 41.7 years) display screen workers were investigated. The average length of service was 9 years, and the employees declared average working time with display screens of 7.1 hours each day.

Thirteen employees (20%) were completely free from muscle and joint complaints. The majority of subjects declared the existence of two or more local pains. Neck pain complaints occurred in 37 workers (56%), and the pain was assessed an average of 4 on a scale of pain (0–10).

The presence of pain was generally short-term, the duration of pain was mostly assessed from 1 to 7 days.

According to myotonometer measurements significant changes regarding muscle decrement were apparent in most display screen workers as compared to the norm:

- M. abductor poll brevis left 1,86 vs 1,2; t-test $p < 0.001$.
- M. abductor poll brevis right 1,96 vs 1,2; t-test $p < 0.001$.
- M. trapezius med left 1,38 vs 1,2; t-test $p < 0.001$.
- M. trapezius med right 1,38 vs 1,2; t-test $p < 0.001$.

Conclusions: There are no persistent muscle tone changes in office workers muscles. Increased logarithmic decrement results indicate a slight muscle overload rather than a persistent audition.

Study of Burnout Syndrome in Portuguese Volunteers Firefighters

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The present work aims to contribute to a better knowledge of the Burnout Syndrome in Portuguese Volunteers Firefighters, also addressing the relationship between Burnout, Control Requirements at Work and Satisfaction with Social Support. An empirical study was conducted, following the model of analytical epidemiological study of type cross-sectional. The study technique adopted was the questionnaire, having been used for assessment of Burnout the MBI-GS, the scale of demands and control of Work and the scale of satisfaction with Social support. Was surveyed a total population of 791 firefighters. The obtained results allow to conclude that the proportion of firefighters with clinically significant Burnout was reduced, having registered just 4.7% of cases.

The results may still withdraw the following conclusions: i) the requirements of the task contribute to an increase in the levels of Burnout, emotional exhaustion and depersonalization of firefighters, while, on the other hand, the control has a positive contribution to reducing Burnout, as well as exhaustion and depersonalization and increasing professional effectiveness; ii) there is only an effect of moderation in the control work in the relationship between the demands of work and the depersonalization dimension; iii) social support and its dimensions contributes to the promotion of professional effectiveness of the firefighters and to reduce their levels of emotional exhaustion, depersonalization and burnout; iv) social support constitutes an important mediator agent on relationship between the demands of work and emotional exhaustion, depersonalization, and Burnout, cynicism of the firefighters, contributing to the reduction of negative effects verified.

Development of an Intrinsic Fiber-Optic Chemical Sensor for Formaldehyde Monitoring

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In 2004 IARC recognized formaldehyde as a group 1 carcinogen agent. Recently EU regulations have classified formaldehyde as carcinogen of category 1B (presumed carcinogen in humans) and for this reason additional control measures shall be implemented to prevent occupational cancers in the workplaces.

More than 50% of the worldwide production of formaldehyde is used for the synthesis of phenol-, urea- and melamine-formaldehyde resins. Formaldehyde is also used as disinfectant, tissue fixative and as a reactant in the manufacture of many industrial chemicals.

At present, many different detection equipment can be found in the market that go from simple accumulative systems and subsequent lab analysis, to more sophisticated electrochemical sensors and spectroscopic methods (FTIR, RAMAN) that either lack of distributed sensing capability, display interferences with other chemical species or bear a high cost.

A fiber-optic sensor based on evanescent wave interrogation of a chemically-sensitive cladding has been developed in this work as affordable, sensitive, selective, field-deployable systems for the realtime monitoring of formaldehyde. In short, the sensor components are the functionalized optical fiber, the LED light source and the photodetector [1].

The novel opto-chemical sensor for formaldehyde is versatile and could be integrated in direct reading instruments or alarm systems. Large areas can be monitored with a single optical fiber. Formaldehyde levels as low as 14 µg L⁻¹ in air can be detected with a 1-m fibre-optic device.

[1] G. Orellana, M.C. Moreno, J. López, R. Chamorro, M.A. Alba, "Sensors and methods for detecting and quantifying aldehydes", Spanish Patent ES2424772.

Evaluation of Potential Risks of Exposure to Natural (Asbestos) and Man-Made Mineral Fibres (MMMF) in Different Types of Industries

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Background: Friable asbestos containing insulation materials (ACM) were widely used in previous years. At present such materials are recognized as one of the most important sources of exposure to asbestos fibres. In this regard they are practically not used in construction and are replaced by other insulating materials. One of the most common alternatives is MMMF. The evaluation of potential risks of exposure to asbestos and MMMF in different types of industrial and nonindustrial buildings where insulation materials containing these fibres were used are performed in Russia.

Materials: There were made inspection of more than 30 different enterprises and office buildings. It included general examination, air contamination measurements, analysis of bulk materials and samples of dust settled at surfaces with difficult access to regular cleaning.

Results: ACM including friable insulation are still widely persisting in buildings constructed in the XX century. In case of their unsatisfactory technical condition, they perform a significant source of air pollution. In modern buildings insulation materials containing MMMF were predominantly detected. Air sampling demonstrated sufficient contamination of air by MMMF (up to 10 f/ml) during dismantling or repair of old insulation. Samples of settled dust in many cases were contaminated by MMMF of respirable size. In samples of most insulation materials containing MMMF sufficient amounts of respirable fibres were found.

Conclusion: Friable asbestos containing insulation materials still perform sufficient source of exposure to asbestos fibres. Similar materials containing MMMF in specific cases could be also source of risk of exposure to mineral fibres.

Prevent Respiratory Problems by Increasing Knowledge on Safe Use of RPEs in Northern Norway

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Objectives: We wish to find the level of knowledge among occupational health services (OHS) on the use of respiratory protective equipment (RPE), and the use and effect of using RPE in occupational settings in Northern Norway. We also wish to increase the knowledge of correct use of RPE where needed.

Method: A pilot study was performed where a questionnaire was sent to occupational hygienists in 8 OHSs asking about knowledge on RPE and whether they felt like they had control over the subject. 6 companies were visited and interviewed about how they handled the process of purchasing RPEs and how they train the workers before using RPEs. Fit testing was performed on groups of workers using their own type of mask and TSI Portacount® Quantitative Fit Testing instrumentation. A two-day seminar was offered to OHSs and businesses including relevant information brochures.

Results: The OHSs in our study feel they have a lack of knowledge (on RPE) and wish to attend courses. The level of awareness of good practice when using RPEs

is increasing among workers and OHSs in our area. In our fit tests, 338 persons performed the test. The two-day seminar got feedback from some of the participant as the most useful.

Conclusion: Workers who attended the fit testing got more focus on safe use of RPE. Workers and occupational hygienists will have better conditions to handle workplaces where it is recommended using RPE. Increased knowledge about safe use can prevent workers from developing respiratory diseases caused by dust exposure.

Gas Chromatographic Method for the Determination of 180 Different Volatile Organic Compounds in Occupational Hygiene Air Samples

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Objective: Aim of the study was to develop and validate a highly specific gas chromatographic (GC) method, allowing single-run identification and quantification of 180 different volatile organic compounds (VOCs), in order to evaluate occupational inhalatory exposure.

Methods: A carbon disulfide based extraction procedure was optimised for charcoal based media: air sampling sorbent tubes and diffusive monitors. Analysis was done by GC with flame ionisation detection. Sample injection was simultaneously done on two capillary analytical columns with different stationary phases. VOCs were identified on the basis of a unique set of two relative retention times. Quantification was based on a compound-specific relative response factor. The recovery upon carbon disulfide extraction was pre-assayed for each compound.

Results: The optimised GC analysis allowed chromatographic separation of 180 different VOCs. An in-house made computer program allowed rapid, automated data-processing of the obtained GC chromatograms. Extraction recoveries were generally found to be concentration-independent but for different polar VOCs, desorption isotherms were established to correlate extraction recovery with concentration. Compound-specific analytical limits of quantification were obtained between 0.5 µg/ml and 5 µg/ml. The developed protocol provided highly reproducible and accurate results of airborne VOC concentrations with analytical precision generally < 3% and global measurement uncertainty generally < 10%.

Conclusion: A single-run analytical GC method was successfully developed and validated for the evaluation of occupational inhalatory exposure to 180 different VOCs. The presented method was successfully applied in several studies and for different types of occupational hygiene air samples.

Exposure Assessment of Noise and Dust in Agriculture

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Introduction: Farming in Australia is a vital industry, historically playing a major role in the development of Australia's economy. The Australian farming is diverse and unique, presenting itself as one of the most dangerous industries to work in from a health and safety perspective.

Aim and Methodology: This study aimed to assess exposures to dust and noise among farm workers in mixed grain and livestock farms in WA during seeding operations. Forty small family farms were contacted and twenty five agreed to participate in the study. We assessed personal exposure to dust using IOM samplers and SKC sampling pumps. Real-time measurements to assess ambient dust concentrations were also conducted. Assessments of noise exposure were carried out using Bruel and Kjaer Type 4448 personal noise dosimeters.

Results: Exposure to noise is a significant issue on farms as a large number of farm workers were exposed to A-weighted (dB(A)) levels above 8-hour exposure limits with many peak values also above short term exposure limits of 140 dB(C). Exposure levels to dust were high for all activities performed outside equipment cabins. The mean personal exposure level was 0.208 mg/m³ and the mean ambient concentration was 0.467 mg/m³. This dust can be considered to be predominantly grain dust. Several of the PM values exceeded all the adjusted grain dust limits.

Conclusion: This preliminary study confirmed that farm workers are likely to be exposed to high levels of dust and noise which can be associated with adverse health effects.

Planning of an Effect Verification System for Respirators

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Objectives: Disposable masks are also an important material that the general public can purchase on the market to prevent airborne pathogens, such as SARS and influenza. Under circumstances, quality surveillance before and after the launch of the disposable masks into the market is indispensable in the process. Given the fact that, currently, there is few verification system established by neither law nor third party verification agency in Taiwan.

Methods: Taking disposable masks for example, this study collected, analyzed and compared respirator effect verification rules and systems from home and abroad, in an attempt to plan the mechanisms, including verification rules, verification experimental capacity, instrument specifications, qualification label management, post-market inspection, and fee collection, etc., required in our local respirator effect verification, and provide them as reference for establishment of the system.

Results: In addition to establishing testing labs and third party verification agencies, issuing testing reports and processing document review, label management and post-market inspection, promotion of the respirator effect verification system still needs support from related government agencies, such as Ministry of Labor, Bureau of Standards, Metrology & Inspection and Taiwan Food & Drug Administration, etc. through administrative commission and cooperation from respirator suppliers.

Conclusions: The study suggests that, given that there is few ways to judge the effect of respirators from their appearance, a respirator effect verification system shall be established and an exclusive verification agency shall be set up in Taiwan to strictly control the quality, ensure product safety and protect users' health.

The Source of Endotoxin Exposure and Indications for an Effective Exposure Control Strategy

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Endotoxin exposure is a known health issue in amongst others agricultural industries. Although personal exposure to endotoxins has been studied extensively the past few decades, very little is known about the actual source of this exposure, which hampers the effective control of this occupational exposure in the work environment. To study the source of endotoxin on the products that enter companies for (industrial) processing, the endotoxin levels of several parts of agro-food products were studied. 330 product samples were collected for potatoes (outside potato, plant material, soil), onions (outside onion, plant material, soil) and vegetable seeds (seeds before and after cleaning process, waste from cleaning process, plant material), also taking into account differences in type of product and type of soil. The samples were analyzed with a quantitative kinetic Limulus Amoebocyte Lysate (LAL) assay, and reported as EU/gram product sample. The range in endotoxin levels was very large (0.7-16.400.000 EU/g). The highest levels were found on samples from respectively onions ((GM 93.000 EU/g), vegetable seeds (GM 17.800

EU/g) and potatoes (GM 30.900 EU/g). In general endotoxin levels were higher on samples from sand than from clay. Furthermore, in general the highest endotoxin levels were found on plant material, followed by soil and the outside of the products. Together with information about the production process, mitigation techniques to remove the endotoxins, and personal exposure levels, this data is used to develop a strategy to effectively reduce endotoxin exposure in agricultural industries.

The Occupational Injury Investigation And Safety Policy Analysis Over Vietnam Workers in Taiwan Manufacturing Industry

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In this study, Vietnam workers in Taiwan manufacturing industry are the subjects for research, mainly wanting to know Vietnam workers' occupational injuries and exploring the worker protection in the workplace, as well as Taiwan Government able to set the safety policy for them. This research adopts the field research, personal interviews, information collection, as well as literature review. The Introduction data in the period from 2009 to 2014 is from the field survey and the data is gathered by the researcher.

The study found that the interviewees did not receive the occupational safety and health-related education and training before they came to Taiwan. In Taiwan, if they work in small and medium factories, lacking an access to relevant training opportunities, so the hazard prevention and response mode is unknown to them. Because small and medium-scale factories apply less stringent legal provisions, in the occurrence of occupational accidents, the units are easy to avoid the government inspection. After the occupational accident, if the factories do not repair the broken machine, actually they can still it.

This study suggested that Taiwan government labor inspection offices should widely advocate the concept of security management, and they have to check and screen strictly those small and medium machines and equipment in the manufacturing plants. This can ensure the workers' safety in the workplace and also contribute directly to achieve the goal of industrial upgrading.

Study on Sterilization Efficiency Using Different Bactericides Under Negative Pressured Isolated Room

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Objectives: In recent years, hypochlorous acid water (also known commonly as HOCl water), phytoncids, flavonoids, and plant based oils are confirmed by researches to have bactericidal effects. If proper atomization of hypochlorous water or other phytoncids and fragrances can be used, along with effective indoor airflow ventilation, the clean indoor air can be effectively mixed with them and spread evenly to every corner of space to achieve an optimal bactericidal effect.

Methods: Our research first conducted the paper disk diffusion test to initially understand the effectiveness of the bactericides. Then, in a full-scale 3 x 3 x 3 meters isolated laboratory, which included the short-circuit type and displacement type airflow patterns, and varies pressure conditions (negative, stable, positive). The bacteria of *Bacillus subtilis* was used as challenge aerosol while the Collision Atomizer was used for generating the aerosol and the bactericides. The bioaerosol disinfection efficiency was studied by using Andersen Single Stage Microbial Sampler. Hypochlorous acid water, terpinen-4-ol, catechin, wood vinegar, and lemon grass oil were used as the bactericide.

Results: The hypochlorous acid water showed a high bactericidal effect under different pressure conditions. In the short circuit airflow field, the terpinen-4-ol and lemon grass oil both also showed significant bactericidal effect. The resulted bactericidal rates were also related to the particle sizes of the bactericides and the experimental bacteria used.

Conclusions: The greater the difference of the particle sizes between the bactericides and experimental bacteria used, the greater was their coagulation factor, which may produce a better bactericidal effect.

Improvement and Performance Testing of Bioaerosol Generation & Sampling

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Objectives: In the process of sampling bioaerosols, many microorganisms may die because of the impactation. If the collection density of the bacteria is too high, the sampled bacteria may over growth or have the masking effect. Therefore, the purpose of this study was to improve the cultured efficiency of the Andersen single-stage, to develop a bioaerosol generator, and to develop bioaerosol diluter for the sampling of high bioaerosol concentration.

Methods: The research modified the Andersen single-stage sampler by using a 15 cm culture medium, and also used ultrasonic orifice atomizer (UOA) to generate bioaerosols. A bioaerosol diluter was developed for Andersen single-stage to sample high bioaerosol concentration.

Results: UOA with 7 µm set at 10V, 0.22A could had a more stable and higher concentration of bioaerosols than Collision three-jet nebulizer at 15 psi. By using 15 cm culture medium on the Andersen single-stage in the collecting of the sample, the efficiency could increase as much as 24.2 % and in addition, there were three different kinds of bacteria found: *Arcanobacterium pyogenes*, *Corynebacterium amycolatum*, and *Enterococcus hirae*.

Conclusions: In the sampling, *Staphylococcus* species could increase 42–69 % in density but *Micrococcus* species decreased the cultured density to about 1/4. On the sampling of fungi, the density of *Penicillium citrinum* increased 3 times and the density of *Cladosporium oxysporum* increased 1.6 times. There was about 22 % loss of bioaerosols in the newly invented bioaerosol diluter due to sampling wall losses.

Exposure to Aerosols When Visor of Air Fed Respiratory Protective Equipment is Raised during Spraying of Motor Vehicles: Exposure Control*

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Air-fed visors (AFV) are almost universally used to provide respiratory protection against isocyanates for vehicle repair paint sprayers. A well maintained and correctly used AFV is capable of providing adequate protection, yet wearers are still becoming sensitised and new cases of occupational asthma occur annually in the UK. A contributing cause of these cases may be due to sprayers habitually lifting their visors immediately after spraying to inspect the quality of the paint finish. HSE commissioned research to quantify the potential inhalation exposure during visor lifting, and to explore possible engineering solutions to reduce this exposure.

A series of tests was conducted on a selection of commonly used AFV, using breathing simulators and human subjects to determine the potential exposure to airborne contamination while the visor of an AFV was lifted for different time periods. Exposure during visor lifting using modified AFV designs was tested using breathing simulators.

The study confirmed that when AFV are used correctly they provide more than enough protection against airborne contamination (PF > 5000), and demonstrated that when the visors are lifted, the protection during that time is very significantly reduced (PF < 2). Data analysis showed that, after refitting the visor following lifting, it took in excess of 15 seconds for the protection offered by the device to recover to pre-lift levels. A number of potential design improvements showed significant reduction in wearer exposure during visor lifting and will need to be explored further.

Monitoring Worker Exposure to Benzene in a Bulk Liquid Storage Terminal

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Objectives: In a bulk liquid storage terminal, various fuels and other materials are being stored in bulk tanks. Some of these liquids contain benzene. Typical for this situation is that exposure to benzene and other volatile organic compounds only is expected during short but frequently executed operations. The goal of this study was to assess the workers' peak exposure and daily average exposure to benzene in the given situation, and the effectiveness of the personal protective equipment used.

Methods: Over a period of several weeks, personal air and biological samples were taken and analysed. Using a combination of active and passive air sampling (PID Meters and 3M Passive Monitoring Badges) airborne concentrations were quantitatively assessed. Urine samples provided insight into the actual internal exposure of the operators. After two years, the measurements were repeated. Extra care was paid to the representativeness and quality of the study by including several duplicate and blank measurements and using internal and external reference populations.

Results: The results show low daily average air concentrations of benzene in the workers' breathing zone. The measurements with PID provide insight into periods of increased air concentrations and the corresponding work operations. The urine measurements show very low actual internal exposure to benzene. In this presentation, the air and urine measurements will be discussed.

Conclusions: Using a smart integrated sampling strategy, limited effort was required to assess exposure to benzene in a situation with frequent short term exposure. The results show daily average air concentrations of benzene well below the Occupational Exposure Limits.

Comparison of Asbestos and PM_{2.5} Air Area and Personal Samples in Occupational Settings: the Case of Brake Mechanics

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Objective: Retrospective asbestos exposure studies have tried to estimate personal asbestos exposures of workers using both asbestos and particulate matter (PM) air area concentrations. Asbestos containing friction products are still commercialized in Colombia. Our research group has studied asbestos exposures of brake mechanics (i.e., riveters) that manipulate asbestos containing brake products (ACBP). The aim of this study is to compare area asbestos and area PM_{2.5} concentrations against personal asbestos concentrations collected during manipulation activities of ACBP in brake repair shops (BRS).

Methods: Thirty-minute personal asbestos samples were collected while riveters performed manipulation activities of ACBP, and simultaneous asbestos and PM_{2.5} area samples were collected at ~1m from manipulation equipment. T-tests and Pearson's correlation coefficients were used to determine associations and correlations between different types of matched samples. Asbestos sampling followed NIOSH method 7400. PM_{2.5} samples were collected using a Sioutas SKC cascade impactor, following standard procedures.

Results: Thirty matched short-term personal and area samples were collected in 11 BRS. Asbestos personal samples' arithmetic-mean (0,394f/cc) was higher than asbestos area samples' arithmetic-mean (0,142f/cc), and the difference was statistically significant (p=0,019). Pearson's correlation coefficient using log-transformed data between personal and area asbestos samples was 0,655, between personal asbestos samples and PM_{2.5} area samples was -0,036, and between asbestos area and PM_{2.5} area samples was 0,196.

Conclusion: Our results indicate that asbestos area concentrations collected at ~1m from manipulation equipment have a stronger correlation with personal

asbestos exposures than PM_{2.5} area samples. However, caution is required to avoid exposure underestimation.

Is There Scientific Evidence to Assess The "Safe Use" of Asbestos?

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Introduction: Asbestos has been banned in less than one third of the countries of the world. One argument used to justify the distribution of asbestos containing products has been that a "safe use" of this material can be accomplished. The aim of this study is to determine the scientific evidence that exists to support this claim.

Methods: A literature review was conducted to identify articles that either support or oppose the "safe use" statement, using search engines such as PubMed and Science Direct. Studies regarding potential toxicological differences between chrysotile and amphiboles were not included in this review. Countries where the studies were conducted were grouped according to their income level, following the country-income classification of the World Bank. The literature review was limited to articles published between 2000 and 2014, written in English.

Results: A total of 558 articles were reviewed, and from these, 213 articles could be used to assess the "safe use" claim. The number of articles by country income level group was 135 (63.4%) in the high-income group, 58 (27.2%) in the upper-middle income group, 17 (8%) in the lower-middle income group, and 3 (1.4%) in the low-income group.

Conclusions: Few studies published in the peer-reviewed literature assessed the "safe use" claim in low-income countries. We found a limited number of studies in lower- and upper-middle income countries, which are the largest asbestos consumers in the world. Overall, the peer-review literature to assess the "safe use" claim seems insufficient in countries where asbestos is currently used.

HR and H&S IT Systems Interface

ANA GABRIELA MAIA

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Objective: To allow online update about risk exposures when an employee has a change on his activities.

Method: A committee were created to discuss the process change including HR, IT, H&S and Legal teams.

The HR and H&S IT systems were modified to reflect the new process.

At Vale employee management is made thru Positions, what is an HR product which contains several information to aggregate employees with same characteristics like job, location, shift, etc.

The decision was to include a new item into Position structure: function. Until then employee management was made only on job basis, what is a too generic information to allow risks association. The job is everything the employee can do, and function is what the employee really does.

We had a hard work on H&S teams and HR teams locally to make them understand the impact this information has on everything related to risk management.

Another really hard work and we are still working on this, is to involve leaders who managed employees on system only requiring job and now need to change their mind to include function and to understand the impact of an adequate function.

It is a culture change.

Result: We started this process on August and so far we already have around 800 employees associated online to their respective SEG.

Conclusion: To have a sustainable process we need to have all areas involved and engaged. In the beginning the workload is really high, but tend to decrease and get better data.

Potent Skin Allergens Identified in Chloroprene Rubber Products

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Objectives: Many cases of contact allergy towards chloroprene have been reported. The objective of this study was therefore to examine the content of suspected skin allergens, namely dialkylthioureas and their degradation products (isothiocyanates), in common commercial chloroprene materials, such as medical, sports and diving gear.

Methods: LC/MS was used for quantification of dialkylthioureas, while solid-phase microextraction (SPME)/GC/MS was applied for measuring the volatile isothiocyanates. The murine local lymph node assay (LLNA) was used for testing the sensitization potencies.

Results: Diethylthiourea (DETU) was the only identified thiourea compound in the chloroprene samples, with levels varying between 2.7 and 9.4 µg cm⁻². It was also found that DETU decomposes in all materials to ethyl isothiocyanate (EITC) already at 37 °C, thereby emitting EITC into the surrounding air. The emission rates varied between 15 and 335 pg cm⁻² h⁻¹. LLNA showed extreme sensitization potency for EITC.

Conclusions: This study showed that DETU is acting as a prehapten in chloroprene materials, decomposing to EITC at low temperature. Traces of EITC could be a contributing cause of skin reactions to chloroprene, since DETU itself previously has been shown to be weakly or non-sensitizing. Even if the emissions from the materials are low, the EITC exposure at long-term skin contact might be sufficient for the development of contact allergy. However, further studies must be performed in order to find the main route for skin sensitization towards chloroprene.

Health and Safety Executive/Local Authority Legionella Intervention Programme

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Legionnaires' disease remains a matter of public concern in Great Britain and there is no apparent downward trend in the number of confirmed cases. Reviews of historic outbreaks and enforcement action taken have suggested that standards of regulatory compliance by some companies is low.

The Health and Safety Executive, Local Authorities and the Office for the Nuclear Regulation, undertook a proactive national inspection campaign in 2012–2014. Inspectors visited around 2500 premises with cooling towers and/or evaporative condensers to assess compliance with health and safety law.

As well as inspection, the intervention programme also involved extensive stakeholder engagement with trade bodies/associations and the supply sector for industrial cooling water.

Most site visits were completed by the end of March 2014. The results and conclusions are discussed here.

How to Improve Risk Communication along the Supply Chain of Chemicals?

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Objectives: The European chemicals regulation REACH aims at better and more reliable information for a safe use of chemical substances in their life-cycle. But currently the huge amount of risk management information challenges

downstream users to identify the relevant information. Therefore it is necessary to find solutions for a comprehensible supply chain communication.

Methods: Control banding approaches provide an opportunity for a more structured and easy-to-understand communication of exposure scenarios for occupational risk management. Therefore we want to promote control guidance sheets (CGS), which are part of several control banding tools. CGS describe model solutions for the most frequent activities with hazardous substances and cover four different levels of control strategies ranging from general baseline of occupational hygiene to expert advice.

Results: The control banding tool EMKG developed by BAuA in 2005 provides guidance to support small and medium-sized enterprises in fulfilling their legal demands for risk management. With the current EMKG 2.2 risks from inhalative and dermal exposure can be assessed, it takes also exposure limits into account and new modules for fire & explosion risks and storage will be part of a future EMKG 3.0. New EMKG-products providing transparent risk communication shall be promoted for any member of the chemical supply chain.

Conclusion: Control banding tools provide an opportunity for suppliers of chemicals to fulfil the requirements of REACH and also support downstream users with their risk management. This will effectively support a high level of safety and health at workplaces in the EU and beyond.

Exposure to Pulsed Magnetic Fields during Transcranial Magnetic Stimulation Treatment

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Objectives: To investigate the exposure received by nurses during treatment using transcranial magnetic stimulation (TMS).

Methods: A TMS treatment system was investigated without patient present with exposure assessment during different treatment modes.

Results: The exposure measured displayed exposures far exceeding the given guidelines up until distances of 40 cm from the transmitting coil.

Conclusion: The study confirms high exposures surrounding exposure apparatus' used in treatment for depression. The finding necessitates good routines in information- and treatment procedures to minimize this exposure on the treatment staff.

The Effect of Wearer Stubble on the Protection Given by Filtering Facepieces Class 3 (FFP3) and Half Masks: Exposure Control*

SHIRLEY FROST

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Objectives: Wearers of tightfitting Respiratory Protective Equipment (RPE) facepieces are advised to be clean-shaven in the area of the faceseal. This study considered the effect of facial hair on the effectiveness of filtering facepieces and half masks. These types of facepiece are commonly used in the UK in a range of industries, and workers have been identified as wearing such facepieces when they are not clean-shaven.

Methods: Daily repeat Portacount fit tests were carried out on 15 male volunteer test subjects from clean-shaven to 7 days of stubble growth, with an additional test being conducted within the first 24 hours of shaving. Three models of filtering facepieces of different faceseal types and a half mask, which were all a good fit on the test subject when clean-shaven, were selected for the repeat tests. The results were converted into inward leakage measurements and statistically analysed using the standard multilevel change curve model approach.

Results and Conclusions: The results show that protection may be reduced where stubble is present and that this reduction may begin within 24 hours from shaving and increases as facial hair grows. The effect of stubble is quite

specific to the facepiece and test subject combination, is unpredictable, and may be dependent on the work activity. For some facepieces for several test subjects, percentage inward leakage increased significantly by the end of day 4. The statistical analysis showed that the predicted inward leakage may reach an unacceptable level in all of the facepieces tested.

Fibres in the Working Atmosphere: an Update on Hazards and Risks

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Objective and Method: In the working atmosphere different types of fibres may occur. In recent years the hazards of these fibres were (re)evaluated and published in various reports. These reports and publications on occupational exposures have been reviewed in order to provide an update on the hazards and risks.

Results: Recently, The Netherlands have adopted very stringent exposure limits for asbestos: white asbestos 0.002 fibres/cm³, blue and brown asbestos 0.0003 fibres/cm³.

The European SCOEL recommends a limit of 1 fibre/cm³ for fibres with no indication of carcinogenicity, such as glass wool, rock wool and high temperature Insulation wool (HTIW) of the type Alkaline Earth Silicate Wool (AES).

For HTIW of the type Aluminium Silicate Wool (ASW, refractory ceramic fibre) SCOEL recommends a limit value of 0,3 fibres/cm³, because this fibre is considered a non-genotoxic carcinogen.

Conclusions: The hazards of glass wool, rock wool but also HTIW are relatively limited. Based on the most recent exposure limit values, the hazards of these fibres relate as follows: (glass wool, rock wool, HTIW type AES): (HTIW type ASW): (white asbestos): (brown asbestos, blue asbestos) is as 1: 3: 500: 2380.

Workers are at risk when applying loose insulation fibres and during the removal of used insulation material, regardless the type of fibre. In the case of glass wool, rock wool and HTIW adequate respiratory protection will generally be sufficient to avoid adverse lung effects. The removal of asbestos requires a very high level of protection.

Assessing Exposure to Two Engineered Nanomaterials in the Inks and Pigments Industry

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The results of an inhalation exposure assessment for the production {of cobalt aluminate spinel (nano-CoAl₂O₃) and titanium dioxide (nano-TiO₂) powders} and downstream use {of nano-TiO₂ powder} of engineered nanomaterials (ENM) in the pigments and inks industry, is presented here.

Initial assessment (NANOMICEX scoping visits) followed by full measurement surveys were carried out at three companies. The processes monitored were the synthesis of nano-TiO₂ powder by pyrolysis and its downstream use to prepare a nano-TiO₂ colloidal dispersion (nano-fluid) and to formulate prototype UV-resistant paint. The manufacture of nano-CoAl₂O₃ was also monitored at the company producing nano-TiO₂.

During the scoping visits the processes were discussed, observed or monitored with portable instruments and pumped filter samples. Contextual data on material streams, scale of production, equipment, operating conditions, work patterns, number of workers and level of manual intervention and risk management measures were collected for all processes.

Full measurement surveys were undertaken to monitor particle size concentrations and distributions prior to and during ENM manufacture or use. Real time measurements were taken using multiple direct reading instruments including the fast mobility particle sizer (FMPS) and aerodynamic particle sizer (APS).

Filter and surface tape samples were analysed by Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy (SEM/EDXS) for morphological and compositional data on airborne and settled particles respectively.

The measurement results for these processes will be reported in the conference presentation.

Acknowledgement: funding from EC under the 7th Framework Programme (Grant Agreement number 280713)

Effectiveness of Vehicle Cabs Used in the Quarry Industry to Reduce Operator Exposure to Dust: Exposure Control*

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Most commercial material handling vehicles used in the quarry industry are fitted with enclosed driver cabs. The size and layout of the cabs vary from vehicle-to-vehicle but most, if not all, enclosed cabs are fitted with ventilation systems, some which may include filtration.

In-cab ventilation systems on such vehicles, whether integral to the equipment or retro-fitted, are perceived to provide operator protection from the external airborne dust. Therefore, where quarry companies rely on in-cab filtration as a control measure, it is important that they are aware of the performance and potential confounding factors relating to in-cab filtration.

The aims of the research project were to bring together existing and newly acquired data on cab contamination, manufacturers' performance standards and duty holders' expectations, and use all of the above to inform plans to influence operators and duty holders in the quarry industry.

This was achieved by reviewing existing data and acquiring new data through on-site air sampling coupled with on-site measurement of vehicle cab filtration efficiency. In addition, the project gathered data on the human dimension via interviews with quarry management and vehicle operators. Information on the ventilation system design and supply chain was gathered through interviews with a range of vehicle and cab manufacturers as well as companies supplying replacement parts and offering retro-fitting services. Dialogue with industry stakeholders was undertaken in two workshops, the last of which was in October 2014.

This presentation focuses on the on-site measurements and the culture surrounding the manufacturing supply chain.

Validity of Different Biomonitoring Strategies in the Polyacrylonitrile Fibre Production

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Objectives: During the production of polyacrylonitrile (PAN) fibres the employees may be exposed to acrylonitrile (ACN) and N,N-dimethylformamide (DMF). For both compounds different biomonitoring strategies exist. DMF biomonitoring parameters are N-acetyl-S-(N-methylcarbonyl)cysteine (AMCC) in urine and the hemoglobin adduct N-(N-methylcarbonyl)valine (MCV). Acrylonitrile biomonitoring parameters are cyanoethylmercapturic acid (CEMA) in urine and N-cyanoethylvaline (CEV). Biomonitoring was performed during regular working situations and after accidental exposure and evaluated for its validity.

Methods: We withdrew blood and urine samples from 152 employees of the PAN fibre production. For 69 employees urine samples were additionally collected several times during a period of three weeks prior to blood sampling. Moreover blood samples and urine samples were collected from 4 employees after accidental exposure to acrylonitrile. CEV and MCV in blood were determined by GC-MS. CEMA and AMCC in urine were determined by LC-MS/MS.

Results: During regular working situation AMCC and MCV levels ranged from 0.01–78.8 mg/g and 0.5–414 nmol/g, respectively. A significant association was found between current AMCC excretion and MIH levels. However, statistical reliability increased distinctly using the average AMCC excretion of the three weeks period. The CEMA levels of the accidental exposed workers were extremely elevated (range: 5650–33400 µg/l), whereas the CEV levels (256–1020 pmol/g) demonstrated a moderate exposure only.

Conclusions: In the case of regular exposure situations haemoglobin adducts enable the supervision of the chronic exposure to the chemical agent most valid. However in the case of accidental exposure Hb adducts do not reach steady-state and short-time parameters are most beneficial for biomonitoring.

International Proficiency Tests for Biomonitoring of Chemical Exposure at the Workplace

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Objectives: To assure the comparability and the accuracy of biomonitoring results an appropriate external quality assessment of laboratories is essential. The international programme of the German External Quality Assessment Scheme (GEQUAS) provides proficiency testing for most of the biomonitoring parameters. The presentation introduces the GEQUAS programme and presents recent results.

Methods: Proficiency tests of GEQUAS are carried out twice the year. In the last run (no. 53) 61 inorganic (10 in blood, 40 in urine, 11 in plasma) und 102 organic parameter (11 in blood, 15 in plasma, 62 in urine, 4 in human globin) were provided. For each parameter two samples with different exposure levels were sent to the participants. The target values and the tolerance ranges were estimated on the basis of the results of reference laboratories. The successful participation was certified if the participant results scored within the tolerance ranges for both samples.

Results: More than 200 laboratories from all global regions participated in the run. The most frequent requested parameters were lead in blood (70), mercury in urine (66) and nickel in urine (58) for inorganic parameters and methylhippuric acid (75), t,t-muconic acid (72) and mandelic acid (67) for organic parameters. The rate of success ranged from 44 to 100% (mean: 79%). Poor success rates were found for arsenic in urine (hydride technique), diethyldithiophosphate in urine and several headspace parameters.

Conclusions: GEQUAS provides the proficiency testing for most of biomonitoring parameters and supports the reliable assessment of occupational exposure to hazardous substances.

Bioaerosol Exposure Assessment and Health Effects of the Workers in Five Occupational Environments in Taiwan

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Background: Bioaerosols are ubiquitous in our daily environments and various occupational environments. In many occupational environments, workers have higher chance to expose to bioaerosols and results in significant health outcomes such as respiratory infection, decreased lung function, and allergies.

Objective: This study aimed to assess the impact of bioaerosol exposure on the workers' health at different occupational settings with high bioaerosol levels.

Methods: Five kinds of occupational setting were investigated, including florists, chicken farms, mushroom farms, vegetable fields, and composting facilities. Personal sampling was performed using the IOM sampler with polycarbonate filters at a flow rate of 2 L/min. Samples were analyzed for culturable fungi/bacteria,

total bacteria, fungal spores, and endotoxin. Standardized questionnaires and spirometry were used to evaluate the health conditions of the workers.

Results: The ranges of average personal exposure levels of all workplaces were: culturable bacteria 324 - 1.16×10^6 CFU/m³, culturable fungi 871 - 2.53×10^4 CFU/m³, endotoxin 33 - 3,592 EU/m³, total fungal spores 3,420 - 36,142 spores/m³, and total bacteria 2.66×10^5 - 2.30×10^6 cells/m³. Overall, chicken farms had the highest bioaerosol levels. Bioaerosol composition had significant variation, depending on the environmental condition and on site activities. Regression analysis shows that many bioaerosols, such as endotoxin and various fungal taxa were significantly associated with workers' health.

Conclusion: In this study, the bioaerosol levels were high in all occupational settings. Therefore, it is important to lower the exposure of the workers through environmental control and proper use of personal protection equipment.

Regulators' Update on Asbestos Guidance

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The new GB asbestos Approved Code of Practice (ACOP) was recently introduced following formal consultation. The document amalgamated two previous ACOPs L143 "Work with materials containing asbestos" and L127 "The management of asbestos in non-domestic premises". The document was published in line with HSE's policy on simplification and clarification.

There have been a number of significant, as well as several subtle, changes in the guidance, both in working with asbestos and in managing asbestos. There have also been many points of clarification.

The presentation will highlight the changes and explain and discuss these in terms of requirements on duty-holders and employers. It will focus on the main "duty-to-manage" alterations which include: changes in managing work and workers; clarification on information to be provided to building occupants, regarding asbestos which is to remain in place; and also clarification of the monitoring frequency to assess the condition of asbestos. In addition, it will also clarify the frequencies for updating the management plan and for auditing the management procedures.

The presentation will highlight and describe the guidance in controlling the spread of asbestos in both licensed and non-licensed work. It will also clarify the differences between "notifiable non-licensed" work and "non-licensed" work. The presentation will explain the position regarding awareness training (including "refresher" training) and explain the position regarding training certificates.

Finally, the presentation will provide a regulator's view on the implications of the changes.

Energy Institute's 'Code of Practice for the Safe Handling of Drilling Fluids'

KAREN BUFTON, GRAHAM MCPHERSON, DARRIN HAWKES

Energy Institute, London, UK

In 2014 the Energy institute's (EI) 'Code of Practice for the Safe Handling of Drilling Fluids' was revised by the EI's Occupational Health and Hygiene Committee to take account of changes in technology, processes and regulations. This publication serves as a reference document for drilling and well services personnel and their associated management, as well as HSE and occupational health and hygiene professionals and compliments the International Petroleum Industry Environmental Conservation Association (IPIECA) Office of Environmental Policy (OEP) guidance (2009) on drilling fluids and health risk management.

Drilling fluids include muds, cuttings, well service chemicals, cements, and chemical additives. Exposure to these fluids is associated with the exploration and production of oil and gas and may give rise to health risks, unless appropriate

measures are taken to eliminate or control them. Health effects can include cancer, dermatitis and respiratory irritation and sensitisation.

The EI code of practice includes guidance on roles and responsibilities, hazards from drilling fluids, evaluation of risk depending on activity and type of drilling fluid, control of the risk (including elimination, substitution, process modification and engineering controls, ventilation, work practices and personal protective equipment), occupational hygiene surveys and monitoring as well as information and training.

Note: The Energy Institute is the professional body for the energy industry, delivering good practice and professionalism across the depth and breadth of the sector. For further information about the EI and to purchase the 'Code of Practice for the Safe Handling of Drilling Fluids' access the EI web site at <https://www.energyinst.org>

Energy Institute's 'Petroleum Road Tanker Drivers: Evaluation and Control of Exposure to Noise'

SARAH LEESON

Energy Institute, London, UK

The Energy Institute has recently updated the 2002 publication 'Petroleum road tanker drivers: evaluation and control of exposure to noise'. The document provides an essential framework within which the noise exposure of petroleum road tanker drivers may be recognised, evaluated and controlled. The document also considers:

- Effects of noise on hearing at noise levels in the range experienced by petroleum road tanker drivers.
- A brief review of action levels and exposure limits relating to occupational noise exposure.
- A summary of available noise measurement results.
- A protocol for measurement of noise exposures; and control methods tailored to petroleum road tanker drivers.

The presentation will provide an overview of the key messages within the publication. Although of particular relevance to those with responsibility for the health of tanker drivers, the information is also relevant to anyone responsible for noise evaluation and control.

Note: The Energy Institute is the professional body for the energy industry, delivering good practice and professionalism across the depth and breadth of the sector. For further information about the EI and to purchase the 'Petroleum road tanker drivers: evaluation and control of exposure to noise' access the EI web site at <https://www.energyinst.org>.

Visual Aids to Risk Management in Small Businesses and Teams

PHILIP ROBERTS, LEN MORRIS, BOB RAJAN

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The Health and Safety Executive (HSE) provides guidance and information to large and small companies in relation to exposure to hazardous substances. Many smaller businesses do not have the resource, time or technical expertise to follow and understand the importance of all relevant written guidance. Therefore, over recent years the HSE has invested in a number of projects aimed to raise awareness of exposure to hazardous substances and practical control approaches using images and video clips. As technology has developed and more people have access to social media sites, then this type of awareness-raising method has proved successful in communicating good control practice. It also supports other successful tools such as eCOSH Essentials. This presentation will illustrate and discuss examples of successful projects.

In particular, it will outline how moving images can have a significant effect on exposure awareness for small teams, for example surgical teams potentially exposed to diathermy fume in the operating theatre. The presentation will also discuss how such imagery can be used to 'nudge' employers and employees towards good practice.

The use of video clips can also effectively engage with those who have limited reading skills or for whom English/Welsh is not their first language.

As health and occupational hygiene standards are being improved in the developing world, then video clips such as the ones presented can be used to raise awareness of potential hazards to health and to support implementation of effective control strategies.

Inhalation Exposure Estimates of Adhesive Remover Use in Korea Consumer Product Exposure and Risk Assessment (COPER)

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In 2013 Korean government enacted a chemical regulation for some consumer products that might cause harm. A consumer product that falls under this regulation should perform risk assessments to prevent health and environmental hazard. The purpose of this study was to estimate inhalation exposure from adhesive remover use as a part of Consumer Product Exposure and Risk Assessment (COPER) project.

Ten most popular adhesive removers were selected. Chemicals in the products were analyzed for VOCs, PAH, aldehydes, and metals. Exposure factors were collected by home visit survey of 10,000 participants. Based on chemical analysis results, physical properties, and exposure factor, inhalation exposure was estimated based on the algorithm used in E-FAST (exposure and fate assessment screening tool) version 2.0.

Fourteen volatile chemicals, four PAHs, two aldehydes, and eight metals were detected. Copper, nickel, and iron were found in all 10 products. D-limonene, xylenes, and ethyl benzene were detected in eight products. Benzene was detected in five products. Proportion of user population was 1.9%. Mean use frequency per month was 0.83 times (range: 0.08 - 8). Mean amount per application was 0.60 mg/use (range: 0.06 - 2.13). Time spent to apply products each use was 8.4 min (range: 0.5 - 30). Benzene and toluene inhalation exposure estimated using the algorithm were 9.7×10^{-6} to $0.054 \mu\text{g}/\text{kg}/\text{day}$ and 3.6×10^{-5} to $0.20 \mu\text{g}/\text{kg}/\text{day}$, respectively.

The exposure assessment in this study could be useful to a regulatory agency that sets safe guidelines to assure the safe use of adhesive removers.

Session: Can Occupational Hygiene Practice Benefit from the REACH Process? Topic: REACH Registration - How the Information is Generated and Used

BRIDGET GINNITY

ECHA, Helsinki, Finland

Objective: To illustrate how occupational hygienists can be involved in the REACH process, both in generating and utilising the information on safe use.

Method: A substantial amount of information about chemicals is generated and collated through the REACH registration process. Much of the information generated from the REACH process is publicly available and can be utilised at site level to support safe use.

Occupational hygienists can play an important role in ensuring that the information that is generated and communicated in the supply chain is of practical benefit by contributing to chemical safety assessments at the registration stage. The talk outlines the chemical safety assessment process and directs occupational

hygienists to where they can find the necessary support to undertake these activities competently.

The information provided at substance registration is used by ECHA and authorities to decide on appropriate regulatory action, such as authorisation and restriction. These processes are outlined, together with advice on how to follow and influence the regulatory status of substances.

Session: Can Occupational Hygiene Practice Benefit from the REACH Process? Topic: Improved Communication of Risk Management Measures along the Supply Chain of Chemical Substances

NICOLETTA GODAS, ANN CAROLIN DUMKE

BAuA, Dortmund, Germany

Objectives: Assembling chemical safety reports (CSR) with regard to the European Chemicals Regulation

REACH is a very high effort. Experience so far shows that there is still improvement necessary for communication of risk management measures (RMM) for worker exposure based on the information of the CSR along the supply chain and within the different REACH contexts. This regularly very generic information is passed via exposure scenarios in the extended safety data sheet (eSDS) and is often not directly applicable to the work place situation in question. The aim is to have

- clear, concise and concrete descriptions of RMM (also in exposure assessment models),
- a comprehensible communication of RMM to downstream users and
- suitable information for occupational safety and health.

Methods: The CSR/ES Roadmap, a joint effort of ECHA, member state authorities and European industry associations has been developed for improving the content and use of exposure scenarios during the years 2013–2018. Within this plan the German Federal Institute for Occupational Safety and Health (BAuA) has started the project “How to build a link between existing risk management advice and REACH exposure scenarios?”.

Results: Risk management advice like control guidance sheets (CGS) was originally designed to support employers to implement the required measures for safe work places. But they also offer the opportunity to describe RMM and forward this information down the supply chain.

Conclusion: Therefore BAuA developed REACH-CGS for its EMKG-Expo-Tool giving the REACH-registrants the opportunity to include safe-use information already in their CSR and subsequently their eSDS.

Session: Can Occupational Hygiene Practice Benefit from the REACH Process? Topic: Case Studies Illustrating How Information Generated Under REACH Can Help an Industrial User of Chemicals

MONIQUE PILLET

ECHA, Helsinki, Finland

Objective: To illustrate how information generated under REACH can help users comply with other environmental and occupational safety and health legislations

Operators of industrial installations that use chemicals in their activities are key actors in ensuring that chemicals are used safely for both human health and the environment. In doing so, they need to comply with a number of environmental and occupational safety and health legislations, including REACH and CLP.

Methods: A case study has been developed to explore how the data generated through the REACH and CLP

processes can support companies in managing the risks from chemicals. The case study presented is for a hypothetical company that has obligations under the

legislations considered. The process is the surface treatment of metals (electroplating). Additional aspects considered are how the information can be improved and how the benefits of efficient use of information can be made known to industrial users of chemicals.

Conclusions: The case study illustrates and identifies, in a practical way, how the information in the supply chain that is generated from REACH/CLP can be used to support downstream users in fulfilling their

responsibilities under other occupational safety, health and environmental legislations.

Energy Institute’s ‘Health and Safety Issues in the Oil Industry Related to Sudden or Unexpected Generation of H₂S by Micro-Organisms’

DOUGLAS COLLIN

Energy Institute, London, UK

Most people are aware that Hydrogen sulphide (H₂S) is a toxic gas that can cause major health and corrosion problems in particular for the oil and gas industry. Generation and release of H₂S by bacteria is unavoidable because sulphide-producing bacteria thrive when seawater comes into contact with hydrocarbon sludge. H₂S gas can be released suddenly and unexpectedly as a result of cleaning procedures or pumping operations, but the reasons behind such releases are often misunderstood on-site. Releases of low levels of H₂S may be identified by its strong odour. However, at higher concentrations H₂S is undetectable by smell, due to the sensory paralysis caused by the gas itself - this may also occur from extended exposure to low levels of H₂S.

The EI guidance provides information on factors influencing the growth and development of H₂S-generating bacteria, the areas and circumstances in which this may create problems, how to monitor and control its release and how to assess and manage risk. It is aimed at on-site personnel (e.g. health and safety/site managers) and covers the following areas:

- H₂S generation associated with microbiological activity.
- Industry-specific areas of work where microbially generated H₂S may be encountered.
- Risk assessment and management, including identifying risk situations and managing workers’ exposure.
- Methods for monitoring of microbiological activity and microbially generated H₂S.
- Control of microbial sulphide generation including use of biocides and physical or chemical management of the environment.

Session: Can Occupational Hygiene Practice Benefit from the REACH Process? Topic: Systems and Tools for Supporting DUs in Responding to Exposure Scenarios Communicated to them

BRIDGET GINNITY

ECHA, Helsinki, Finland

Objective: To present practical solutions to challenges presented by REACH

Exposure scenarios provide information on how the exposure of workers, consumers and the environment to substances can be controlled in order to ensure their safe use.

A challenge to downstream users of substances, both formulators and end users, is how to handle this information. Formulators need to identify the relevant information from exposure scenarios to communicate downstream with their mixtures/products. Industrial users of chemicals need to implement the conditions recommended in the exposure scenario or to take alternative action, including the preparation of a downstream user chemical safety assessment.

Industry sector organisations have worked together with regulatory bodies and other stakeholders to develop practical supports to enhance

the communication of safe use information and to handle this information efficiently and effectively. The generic exposure information sheet developed by AISE, International Association for Soaps, Detergents and Maintenance Products and its Dutch National Association, NVZ is described.

Re-Entry Protection Offered by Gloves in Agriculture

MARTIN ROFF¹, SUZANNE SPAAN², RIANDA GERRITSEN²

¹Health and Safety Laboratory, Buxton, UK, ²TNO, Zeist, The Netherlands

Objective: To give an overview of protection offered by different types of PPE and work clothing, including specific information on glove protection for re-entry tasks.

Methods: Within the EU BROWSE project (Bystanders, Residents, Operators and Workers Exposure models for plant protection products), an exposure database based on existing workplace studies was developed. This database was used to study the chemical penetration through different types of PPE and work clothing. Furthermore, the UK Health and Safety Laboratory (HSL) has measured the chemical protection afforded by gloves worn for other than chemical protection purposes (e.g. to prevent bruising of fruit) in matched re-entry tasks in greenhouses.

Results: BROWSE data, mainly based on operator studies, showed median penetration values of 3–15% for several types of work clothing and 0.5–10% for different types of gloves (1% for nitrile gloves and 0.5% for latex/PE/vinyl/PVC gloves) with small differences based on the type of activity performed. The HSL study showed median penetration values for re-entry tasks of 1.6% for nitrile chemical protective gauntlets and 3.3% for single-use gloves, both decreasing with challenge, and 22% for simple cotton gloves, increasing with challenge.

Conclusions: The results give valuable information on PPE and work clothing protection that can be used in exposure assessment. Furthermore, the HSL study confirms that gloves' protection depends on the challenge, which allows scope for an additional refinement to the models with regard to re-entry tasks if gloves are specified to be used.

Moving Forward with Respiratory Protection*

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Inhalation of hazardous substances caused by work activities contributes to a great many premature deaths every year and in others leads to a significant reduction in the quality of life; on a global scale the number of workers affected is in the millions. Additionally, infectious diseases, such as influenza in which there is a respiratory transmission route, and exposure to natural events such as ash from volcanic eruptions, further add to the numbers affected. With effective use of suitable respiratory protection these numbers can be reduced, but achieving a significant reduction in these high numbers of people potentially affected is not so straightforward.

Whilst there is a large range of respiratory protection on the market, poor selection and use often leads to ineffective control of inhalation exposure, and unfortunately for some all but the most basic forms of respiratory protection are beyond reach.

Also as the demand for respiratory protection in sectors such as healthcare expands, the demand for more wearable - i.e. increased comfort, improved fit and increased tolerability - respiratory protection grows. Therefore there is a need to design and engineer RPE that is both effective and wearable.

As conformance/performance standards play a role in setting the direction for product development, will the new suite of global international respiratory protection standards due for publication and implementation over the coming years

bring about positive changes, and what else must be done to make a significant positive difference to the health of those at risk?

Return to Work and Quality of Life of Tunisian Women Affected by Breast Cancer

LAMIA BOUZGARROU^{1,2}, OMRANE AMIRA^{1,2}, ANIS SLAMA^{1,3}, SALMA KAMMOUN^{1,2}, MOHAMED SAKOUHI^{1,3}, HAYET LAAJILI^{1,3}

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Introduction: In Tunisia, breast cancer is the first women-cancer with an incidence of 30 new cases/ 105 female cancers. The average age at diagnosis is 50 years. This cancer is associated to serious consequences on work and quality of life. This survey aims to evaluate the return to work and quality of life of actives women affected by breast cancer.

Methods: This study concerned all patients who were initially working and followed for breast cancer in the University Hospital Center of Monastir with a setback between 2 and 5 years (diagnosis - start of investigation). During a medical entertain, patients were invited to answer items about professional situation and validated questionnaires about quality of life (EORTC QLQ-C30 and QLQ-BR23).

Results: 100 patients were involved in the survey (mean age = 48 ± 11 years). Radiotherapy was performed on all cases, operation and chemotherapy in respectively 97 and 80 cases. At investigation, 60 patients were in healing, 25 in remission and 15 were in rechute. A lower monthly income was reported by 76 patients and Colleagues' discrimination by 95 of them. 28 patients were no longer working, only 5 women kept their initial work. Workplace management was performed in 28% cases. The average score for physical functioning was 53.7 ± 19.8; and for emotional functioning 31.7 ± 12. Global health score was below the average in 74% of cases.

Conclusion: A multidisciplinary management, which integrate various aspects of quality of life and return to work, is necessary for breast cancer patients.

Night shift Work in Great Britain Workforce

YIQUN CHEN, JACKY JONES

Health and Safety Executive, Bootle, UK

Objectives: Shift work involving night work has been suggested as a probable risk factor for cancer. As part of a feasibility study to develop Carcinogen Exposure (CAREX) database for Great Britain (GB) on shift work, we have investigated the night/shift work distribution in the GB workforce.

Methods: The most recent years of the UK Labour Force Survey (LFS) data 2009–2013, which were based on survey of around 44,000 households each quarter, were examined.

Results: The proportion of shift work had remained consistent in the past few years. About 17% (over 4 million) of the employed persons in GB were in shift work, including 2% (~ 0.5 million) in rotating night shifts, 4% (~1 million) in non-rotating night shifts, and 7% (~1.5 million) in morning or evening shifts. Transport and storage, accommodation and food services, and health and social work sectors had the highest proportion of shift work. In particular, health and social work sector (~600,000) had the highest number of workers in night shifts. Men were more likely than women to work in shifts. Workers in the youngest age group were most likely to be in shift work and the proportion of shift work decreased with age.

Conclusions: One in six responses in the LFS did not have information on shift work. We are developing a method to take this into account. Further work will combine shift work data from other population studies to produce more representative estimates for the GB workforce.

Achievements and Potentials of a Long Term Exposure Database on Respirable Dust and Quartz in the Industrial Minerals Industry

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Since 2000, members of the European Industrial Minerals Association (IMA-Europe) have systematically collected personal exposure data on respirable dust and quartz. The database enables IMA-Europe to discuss the state of affairs with regulatory agencies and social partners, notably within the framework of the social dialogue agreement on crystalline silica.

All participants monitor exposure data with a common measurement protocol and only after strict quality criteria, data will be added to the central exposure database. Currently (September 2014) the IMA-Dust Monitoring Programme (IMA-DMP) database contains 24,731 measurements collected in 19 countries at 135 different worksites owned by 33 companies. Since 2010, geographical coverage of the database expanded to Eastern Europe and now includes sites from Poland, Russia, Ukraine and Turkey.

Participating companies receive feedback after each measurement campaign. In a company report, sampling results are analysed and discussed. Hot spots with exposures above exposure limits are being identified allowing companies to take specific control measures. At industry level, long term trends in exposure concentrations are being identified. In the last decade a steady decline in measured exposure concentrations has become evident. Median GM respirable dust concentrations per job per site decreased from 0.7 mg/m³ at the start to 0.3 mg/m³ currently. Median GM respirable quartz concentrations came down from 0.08 to 0.02 mg/m³.

The enormous size and good quality of the IMA exposure measurement database permits precise estimation of (historical) exposure concentrations. It also provides a very powerful management tool to effectively improve and evaluate exposure control measures.

Potential Exposure to Benzene Contained in Petroleum-Derived Products in Korea

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Objective: This study was conducted to assess the level of benzene in petroleum-derived products (PDPs) and also to estimate the probability of exposure to benzene for workers handling PDPs contained trace level of benzene. **Methods:** We collected the information on the benzene contents in PDPs by using Korean academic search engine, Research Information Service System (RISS). A total of 120 data on the trace level of benzene in PDPs were collected from 12 prior studies and 43 epidemiological survey reports. In addition, a total of 32 products of 7 reagents (n-hexane, n-heptane, cyclohexane, toluene, ethyl benzene, xylene and trichloroethylene) were analyzed for a benzene content using GC-MS. **Results:** Major benzene-containing PDPs were thinner (43.3% of reviewed data) and it had the highest benzene content (56.7%). The amount of benzene in these PDPs remained relatively unchanged from 1980s to the present. Average benzene exposure of 1.53 ppm was reported for painters using thinner and coating materials containing benzene at 0.01%-0.1%. Benzene was detected in 13 of 32 analyzed reagent products. Maximum benzene content was 0.166% in trichloroethylene, followed by 0.146% in ethyl benzene, 0.064% in toluene, 0.009% in xylene and 0.004% in n-hexane. Nevertheless, benzene was not listed in any of 32 MSDSs. **Conclusion:** The study found that use of a PDP containing benzene below 0.1% may result in an exposure exceeding occupational exposure limits. Therefore it is suggested that benzene should be listed in the MSDS for products with benzene content less than 0.1%.

Respiratory and Neuropsychological Function among Waste Water Workers

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Objectives: Waste water workers are exposed to microorganisms and noxious gases such as hydrogen sulfide (H₂S), and may report respiratory and nervous system health symptoms. Reduced neuropsychological function may be caused by nervous system impairment, or be influenced by seriously reduced lung function. This sub-study describes the association between lung function and neuropsychological test results in a group of waste water workers.

Methods: Study participants: Waste water workers (n=148), mean age (SD): 43.7 (9.2) years, body mass index (BMI): 28.6 (5.1), mean alcohol consumption (L/year): 4.8 (5.1), current smokers: 19.2%.

Each participant performed spirometry (SPIRARE 3) and motor/sensory neuropsychological tests: Grooved Pegboard (Halstead-Reitan), tremor, simple reaction time, and balance tests (sway) from the computerized Catsys-test battery, and Lanthony D-15d desaturated colour vision test. Multiple linear regression was used for statistical analysis, including in the model as independent variables personal characteristics (age, BMI), life style factors (alcohol consumption and smoking) and lung function (FEV₁%, FVC%). Outcome variable was each neuropsychological test parameter.

Results: No significant association between neuropsychological tests and lung function (FEV₁%, FVC%) was observed in the total sample, adjusting for background and life style factors. In the sub-sample highest exposed to microorganisms (N=117), a significant association between one balance test, and FEV₁ (Regression coefficient: -4.95, R² = .08, p = .010) was seen.

Conclusion: No strong association between lung function and neuropsychological test results in the current sample of waste water workers was observed. Neuropsychological tests may be considered a relevant outcome measure of nervous system effects in this group.

Characterization of Workers PM Exposure in Ferrochrome Smelting

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Stainless steel production is a high energy and large scale industrial process. Stainless steels are a group of iron based alloys containing minimum of 10.5% chromium for corrosion resistance properties and also other alloying metals. Ferrochrome is an essential alloy in the production of stainless steel. It is an alloy of chromium and iron containing between 50% and 70% chromium. In ferrochrome production process the chromite ore mixed with coke and slag forming materials is reduced in a submerged electric arc furnace.

In ferrochrome smelting particulate matter (PM) emissions of different elemental composition and wide size range are formed. Fine and ultrafine PM concentrations are considered to have adverse effects on the health and well-being of workers. Traditionally, in occupational hygiene, mass concentration based methods are used in airborne exposure measurements. Also OELs are given in mass values typically. Regarding fine and ultrafine particulates, other metrics, such as number concentration or surface area concentration, are considered to give better information on health related concentrations in workplace air.

In this study occupational exposure to PM during ferrochrome smelting process was characterized in a modern stainless steel production plant, using a wide range of measurement and characterization methods. Real time measurements in different size classes together with electron microscopy analyses were combined to traditional mass based methods, giving detailed information on the PM exposure of the ferrochrome production workers.

'Status and Needs of Occupational Exposure Assessment for Chemicals Management' - Overview of US EPA's Occupational Exposure Assessment Related Tools and Models

NHAN NGUYEN

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This presentation will provide an overview of the tools and models the US EPA uses for developing occupational exposure assessments of new and existing chemicals. The presentation will begin with a discussion on the programmatic needs for occupational exposure assessment as part of chemical risk assessment and management. The presentation continues with the description of the occupational exposure related support to the various programs, provides a focused discussion on the tools and models used for occupational exposure assessment, and concludes with on-going and future activities related to occupational exposure assessments.

'Status and Needs of Occupational Exposure Assessment for Chemicals Management' - SysDEA - A Research Project on Occupational Dermal Exposure

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The presentation will give an overview of the concept of the research project - *Systematic analysis of dermal exposure to hazardous chemical agents at the workplace (SysDEA)*-, which BAuA started in 2014.

Objectives: Currently the measuring methods for occupational dermal exposure are not harmonized. For existing measurement methods scientific studies are rare concerning the evaluation of significance and applicability. There is a lack of systematic investigations carried out by means of different measurement methods for the determination of dermal exposure. Especially information concerning the comparability of measurement results from different methods is missing. In addition, there is a need for a better investigation how far a measurement method takes into account the physical and chemical properties of the individual hazardous substance.

Concept: Within the frame of the research project the dermal exposure will be quantified for different exposure situations (task + ambient conditions + substance) by various measurement methods respectively. For this purpose the dermal exposure of probands performing selected tasks under defined and standardised conditions is to be determined in test chambers.

The aim of the SysDEA research project is the generation of scientific knowledge to improve and standardise measurement methods for dermal exposures to chemicals at the workplace. In addition, the comparability of results from different measurement methods will be investigated.

'Status and Needs of Occupational Exposure Assessment for Chemicals Management' - Proposal for a Tier-1 dermal Exposure Assessment Approach

ANDREW PHILLIPS

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Dermal exposure assessment in a regulatory context is subject to much uncertainty and there is heavy reliance on personal protective equipment. Dermal exposure data are relatively scarce, although best use has been made of those data in the development of exposure tools such as Riskofderm and BEAT (a biocides assessment tool). Regulatory exposure tools are required to be conservative but also need to be realistic enough to ensure risk management measures are appropriate and not disproportionate. Dermal exposure data are wide distributions; but these distributions can be used to generate a simple matrix tool that could be

further developed to support screening assessment for chemical regulatory purposes. In this talk proposals are made on how best use might be made of available data through generation of "indicative distributions". This approach could provide a basis of an alternative approach to Tier 1 exposure modelling and uses evidence from pre-existing data sets.

'Status and Needs of Occupational Exposure Assessment for Chemicals Management' - Applicability of Screening (Tier-1) Exposure Assessment Tools

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While the preferred option for any evaluation of a workplace is actual exposure data, such data are rarely available in routine and/or of sufficient quality. Tiered approaches, generating increasingly refined assessments depending on data availability/quality, are proposed in most chemical management systems. Tier 1 often makes use of modelling tools requiring relatively little input information or of analogous data. The main purpose for using Tier 1 is to do a first screening of workplaces and to identify the ones that could be at risk and require further refinement.

This screening for best allocation of risk management resources presupposes however that the exposure estimates generated by Tier 1 approaches are sufficiently conservative. Also, as exposure determinants are usually represented by a single input value, some knowledge of occupational exposure assessment is required to ensure the output makes sense and is correctly interpreted.

Several Tier 1 approaches have been developed and used across jurisdictions, whilst still being validated.

The presentation will review the conditions in which Tier 1 tools would most appropriately be used by industry, stressing the inherent boundaries and assumptions, and propose further steps that may help in increasing their reliability and applicability.

An Occupational Hygiene Workplace Assessment of Elf Magnetic Fields at a Regional Metal Smelting Operation

STEVEN KEE

OCCDEV, Perth, Western Australia, Australia

Objectives: An Occupational Hygiene assessment of alternating magnetic fields was conducted at a regional metal smelting operation.

Methods: Measurement of magnetic field strength was conducted on three levels of the smelter in the vicinity of the electrode area building.

An occupational hygiene review of the production processes and system in relation to worker exposure for specific tasks in different production locations was made to provide feedback to operations personnel and to assist management in controlling and managing sources and release points for workplace chemical and physical agents released by the operating system.

Results: Exposure to variable magnetic fields, and significant thermal loading was noted under operating conditions. Other significant occupational hygiene risks and co-exposures to workers were observed from smelting emissions in the immediate work area and management of these are briefly discussed.

Conclusions: General electromagnetic field exposures within the metal smelting operation furnace area with one set of cathode sets operating in the area was concluded to exceed Public exposure guidelines. Continuous occupational exposure to electromagnetic fields was recommended to also be managed and limited by job rotation. Screening for medical device wearers was recommended for implementation as a precaution prior to entering the metal smelting area as part of the occupational and health risk exposure reduction process.

Discussion of individual job histories, tasks, and electromagnetic field exposure estimates was prepared for operator job groups. In particular for those operator tasks involving extended work periods in order to provide more accurate estimates of personal exposure.

Evaluation of Tier 1 Exposure Assessment Models used under REACH (ETEAM Project): Background and Aims of the ETEAM Project

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Generic tools are currently widely used for chemical safety exposure assessments under REACH. Risk assessment under REACH follows a tiered approach in which the first tier should provide a conservative (i.e., protective) system that can discriminate between substances in scenarios of concern and those which are considered safe. Several 1st tier exposure models such as ECETOC TRA, MEASE, EMKG-EXPO-TOOL, STOFFENMANAGER and RISKOFDERM are recommended by the European Chemicals Agency (ECHA) for estimating occupational exposure. Although claiming a broad range of applicability, none of the Tier 1 tools has been extensively validated during development. The German Federal Institute for Occupational Safety and Health, (BAuA) therefore initiated and sponsored a comprehensive Evaluation of the Tier 1 Exposure Assessment Models (ETEAM). Carried out by the Institute of Occupational Medicine, Edinburgh and the Fraunhofer Institute for Toxicology, Hannover, the ETEAM project compared and contrasted the different REACH Tier 1 exposure assessment models in terms of their conceptual and external validity, scope of application, reliability and user-friendliness. An international Advisory Board provided the project with both objective scientific advice and workplace exposure data for use in the external validation process. The results of the ETEAM project will assist industry and registrants to choose the most appropriate tool for a given exposure situation. The results will also help authorities to assess the safety of registrants' exposure scenarios and to estimate how conservative the exposure estimates are. The results will also assist developers in the further development and refinement of the tools.

Evaluation of Tier 1 Exposure Assessment Models used under REACH (ETEAM Project): Conceptual Evaluation and Uncertainty of Tier 1 Exposure Assessment Models used under REACH

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Fraunhofer Institute for Toxicology and Experimental Medicine, Hannover, Germany

This presentation describes methods and results of the conceptual evaluation as well as the uncertainty analysis of the Tier 1 tools evaluated within the ETEAM project (*Evaluation of Tier 1 Exposure Assessment Models*).

In the course of the conceptual evaluation, a general evaluation of the tools' concepts has been done, including a description of the tools, their design and use as well as their background. The algorithm, underlying principles and data are described.

An applicability matrix has been developed, which includes a summary of the tools' scope and can be used to identify appropriate tools for different exposure situations. A so-called usemap has been created that facilitates the conversion between different use categorisation systems (e.g. DEO units, PROCs).

In the course of the uncertainty analysis different aspects have been evaluated which may lead to an uncertainty of the tool estimate, i.e. a deviation of the estimate from the actual exposure value at a workplace. These sources of uncertainty include assumptions within the tool algorithm, but also omitted influences. Sources of uncertainty can also be the tool's input parameters, i.e. their definition within the tool or their tool-inherent reflection, e.g. efficiency of a certain risk mitigation measure.

All identified sources of uncertainty have been categorised as far as possible according to transparency, knowledge base, input parameter quality and their

effect on the exposure estimate (direction and magnitude of possible deviation). Results have been collected in an evaluation matrix and are discussed in a qualitative way.

Evaluation of Tier 1 Exposure Assessment Models used under REACH (ETEAM Project): Between-User Reliability of Tier 1 Exposure Assessment Models used under REACH

JUDITH LAMB, KAREN GALEA, BRIAN MILLER, MARTIE VAN TONGEREN

Institute of Occupational Medicine, Edinburgh, UK

When applying the Tier 1 assessment tools to an exposure situation, users must select options from several possible input parameters. Previous studies have suggested that results from exposure assessments using expert judgement can vary considerably between assessors. Similar results were observed for use of exposure assessment tools, where different users may obtain different results based on similar information. This study aimed to investigate the between-user reliability of the Tier 1 tools. A remote-completion exercise and focus group were used to identify and evaluate tool parameters and other factors potentially associated with between-user variability, for example user demographics and previous experience of exposure assessment and tool use.

In the remote-completion exercise, participants (N=146) generated dermal and inhalation exposure estimates (N=4066) from a defined set of exposure situation descriptions/Tier 1 tool combinations over a fixed time period. Qualitative information on decision-making processes associated with tool use was collected during the focus group.

The interactions between users, tools and situations were analysed and described. Within user variation was minor compared with between user variation. Significant variation was observed between users when selecting task/ activity, dustiness and risk management measures within the tools. Considerable variability was thus observed in results obtained for the same situation by different tool users. This variability did not seem to be determined by the characteristics of the user. The results are based on representative participants, many of whom use the tools routinely. Therefore, these results suggest that more needs to be done to ensure consistency between tool users.

Evaluation of Tier 1 Exposure Assessment Models used under REACH (ETEAM Project): External Validation of Tier 1 Exposure Assessment Models used under REACH

MARTIE VAN TONGEREN, JUDITH LAMB, BRIAN MILLER, LAURA MACCALMAN, JOHN CHERRIE

Institute of Occupational Medicine, Edinburgh, UK

The Tier 1 exposure assessment models used by registrants under REACH are designed to provide conservative exposure estimates for a wide range of scenarios, using only a limited number of model input parameters. This study aimed to validate the Tier 1 models using exposure measurement data from a variety of sources.

Descriptions of exposure situations and related personal exposure measurements (individual and aggregated data) were obtained from providers in Europe and the US. Institute of Occupational Medicine exposure scientists entered the situation information into the models, to generate exposure estimates for comparison with the measurement data.

Initial comparisons with the individual measurement data suggested that across all the exposure types, the models appear to be conservative, but this varied between exposure categories. Relatively few measurements were available for non-volatile liquids, metal abrasion and metal processing. The study results are currently being finalised, however the limited data available could not provide any initial evidence that the models were conservative for estimating exposures during handling of non-volatile liquids, metal abrasion and hot metal processes. More data were available for powders and volatile liquids. The tools appeared to be more conservative when predicting exposure to volatile liquids, than for other

exposure types. Correlations between the measurement results and tool predictions are generally poor, with the exception of powders.

The final results will provide important information for both model developers, regarding areas that may require further development, and model users, in terms of applications where the models should be used with extra caution.

Dutch Design - Managing Risks for Occupational Allergies within the Dutch Bakery Industry

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Within the bakery industry workers are at risk of developing occupational respiratory allergies due to exposure to several flours (e.g. wheat, rye) and enzymatic flour additives (e.g. fungal amylase). Within the framework of self-regulation, as stimulated by the Dutch government since 2007, the bakery industry initiated several activities with the aim of managing risks for work-related respiratory allergies.

A health surveillance programme was introduced in 2010 for all exposed workers in small and large bakeries in the Netherlands. All workers fill in a questionnaire (N=7,500; response rate approx 65%) and based on medical triage (Suarthana et al. Am J Ind Med 2005; 48:168-74) part of these workers (N=450) are invited for further medical investigation and follow-up. Bakers with occupational allergies get individually based medical advice. Bakers with occupational asthma who need to leave the bakery occupation are getting help and financial support to get retrained to another profession.

For primary prevention, a good practice guide was developed. It provides tools (task sheets, PIMEX movies) to help bakeries to further reduce allergen exposure and to increase knowledge of the potential effects of allergen exposure. Recently, evidence-based intervention studies were performed to investigate the effectiveness of some of the good practices within the guide.

The programme within the bakery industry can be seen as an example for other sectors with coordinated activities on industry level on primary, secondary and tertiary prevention. During the presentation, the full programme will be presented, including the main results of health surveillance and exposure studies.

Dutch design: Pimex Part of Many Different Arbocatalogues in the Netherlands

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Introduction: If exposure can be visualized then there will be better understanding by workers of risks and hazards. PIMEX is a video exposure monitoring technique which aims to make invisible hazards in the work environment visible. Therefore PIMEX will facilitate the reduction of hazards in workplaces. The name PIMEX is an acronym from the words **P**icture **M**ix **E**xposure. It implies that the method is based on mixing video images, with data on a worker's exposure to different types of agents. With more than 170 films available in the Netherlands Pimex is has been proven to be a very successful tool for risk communication.

In 2007 the Arbocatalogue was introduced in the Netherlands. In the Arbocatalogue the authorities set the target requirements. The social partners (employers and trade unions) in the different branches develop tools to meet the target requirements. One of the tools used for showing best practices is the use of PIMEX movies.

Pimex movies for the metal industry: At the moment PIMEX movies are made for the metal industry. A set of approximately 30 movies will be made. The topics are in a wide range e.g. chemical exposure, welding, noise, heat stress and safety. The new movies will become part of the Arbocatalogue for the metal industry.

Compliance with the shown best practice means compliance with the Health and Safety legislation.

Discussion: In this presentation the results of the new films and their position in the Arbocatalogues will be shown and discussed

Uncertainty and Variability in the Exposure Reconstruction of Chemical Incidents - the Case of Acrylonitrile

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Objectives: The application of human physiologically based pharmacokinetic (PBPK) modelling combined with measured biomonitoring data, has a great potential to backtrack external exposure to chemicals during chemical incidents. So far, an important shortcoming of 'reversed dosimetry' is that uncertainty and variability in model predictions are often neglected. A new method that offers a solution for this shortcoming is presented.

Methods: Human biomonitoring data from a chemical incident with acrylonitrile combined with the BioNormtox PBPK model were used as a case to reconstruct the air concentration and uncertainty thereof at the time of the incident. The influence of uncertainty in chemical-specific properties, exposure duration, and interindividual variability on the reconstructed air exposure concentrations were quantified via nested Monte Carlo simulation.

Results: The range in the reconstructed air concentrations of acrylonitrile during the incident was within a factor of 3. Uncertainty in the exact exposure duration directly after the chemical accident shows to have a dominant influence on the model outcomes. It was shown that uncertainty can be further reduced by collecting human biomonitoring data as quickly as possible after the incident. The collection of specific information about individual physiological parameters from the victims may further reduce the variation by 5 to 20% in our case study.

Conclusions: The presented method appears a useful proof of concept, although there is an additional need for future research to compare reversed dosimetry model outcomes with measured air and biological concentrations to further increase the confidence in the model approach and its implementation in practice.

Dutch Design. Arbo Catalogue

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In 2007 a new Dutch 'Working conditions Act' came into force. The idea was to have less regulation from the Dutch government, and more self-regulation by individual companies or Branches. The Government only sets the goals to be achieved. But the Dutch government did no longer prescribes the way these goals had to be achieved. Instead branches developed specific Arbo-catalogues. The catalogues have been introduced as a means to address branch specific situations and controls.

First step is to identify 'priority hazards'. Mainly by analyzing statistics of inspections and incidents, and of occupational hygiene surveys; new limits coming into force; or by expert judgement.

Interesting in the process of creating an Arbo-catalogue, is that it is done in negotiation between employers, worker-unions and branches. The government does a marginal check.

The main ingredients of the Arbo-catalogue are formed by limits (set by the government, or self-imposed); evaluation tools for compliance, and of state of the art of controls; factsheets and instruction materials.

Looking back at seven years of work we can conclude that the Arbo-catalogues have raised attention to the priority hazards in the organizations/branches. These organizations can focus on these priority factors and they are led to branch specific controls. Arbo-catalogues can only be used if recognized by the Labour inspectorate. If in compliance with the Arbo-catalogue, there is compliance with legal requirements.

The challenges for the next decade are: keeping the Arbo-catalogues up to date and expanding the number of priority hazards.

Dutch Design. Health and Safety Catalogue in the Dutch Metal Sector

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Introduction: In 2007 the Arbo-catalogue was introduced in the Netherlands, in which the authorities set the target requirements. The employers and trade-unions in the different branches develop tools to meet the target requirements. In the metal sector Sxbeter was created in 2006. Sxbeter is the joint project between two employers associations and three trade-unions in the Dutch metal sector. The target of Sxbeter is to improve working conditions and to promote the image of the sector. The target group are the employers and employees in the metal sector. The themes of Sxbeter are welding fumes, noise, solvents, machine safety, physical demands, working in confined spaces, working on heights and newcomers.

Sxbeter developed improvement checks; digital checks to test whether occupational health-standards are complied with. In the improvement book employers and employees can find solutions to manage different risks. On the website (www.Sxbeter.nl) is educational material regarding the different subjects available. All this is supported by the improvement coaches.

There are four improvement checks available: welding fumes, noise, machine safety and physical load. The improvement check welding fume is a simple way to test fume-exposure limiting values of 1 mg/m₃. Compliance with this code of practice means compliance with the Health and Safety legislation.

Discussion: In this presentation the focus will be on the role of the improvement coaches and their task in helping companies to comply with the Health and Safety legislation. In the presentation the improvement checks will be introduced with the focus on the improvement check welding fume.

The Occupational Hygiene Programme of Kolomela Mine

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Objectives: Very few Occupational Hygienists are given the opportunity to design and implement an occupational hygiene programme for a new mine from the conceptual phase of the mine through to full operational status. The objective of the presentation is to describe the development and implementation of the occupational hygiene programme of the Kumba Iron Ore Mine Kolomela mine.

Methods: This presentation will touch upon the journey undertaken by the author and the mine to design and implement its flagship occupational hygiene programme to avoid or mitigate the risk of hazardous exposures, ensure regulatory compliance and to improve workplace conditions. The presentation will cover the main chapters of the Kolomela occupational hygiene programme, including Leadership and Commitment, Risk and Change Management, Roles and Responsibilities, Operational Control and Communication.

Results: Occupational hygiene programme performance parameters, both leading and lagging, have been established and reporting against these parameters is ongoing. The current health risk profile of the mine and the "health risk and

critical control register" of the mine and the mines' "health improvement plan" will be shared with the audience.

Conclusions: By using a combination of leadership, an occupational health risk management approached based on "control at source" and a sound link between occupational hygiene and the medical surveillance programme, Kolomela Mine is in the position to provide guidance on an effective occupational hygiene programme that goes beyond personal exposure measurements and that is fully integrated with the broader operational risk management programme of Kolomela Mine.

Detailed Characterization of Welding Fume in Personal Exposure Samples

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Objectives: The objective of the project was to develop a method allowing for detailed characterization of welding particles including particle number concentration, size distribution, surface chemistry and chemical composition of individual particles, as well as metal concentration of various welding fumes in personal exposure samples using regular sampling equipment.

Methods: PTFE and mixed cellulose ester membranes were tested to determine their blank levels for metal analysis. Filters were digested in a nitric/hydrofluoric/hydrochloric acid mixture and analyzed by ICP/MS. Welding fumes were collected on polycarbonate membranes using IOM samplers at the Northern Alberta Institute of Technology (NAIT) while students were welding. Five to ten filters were collected, all in the same booth. Simultaneously, number concentration of particles below 1 µm was measured using a P-Trak ultrafine particle counter from TSI. For particle characterization analysis, particles were removed from the filters and the solution was analyzed using various techniques.

Results: MCE blanks were fairly high for all metals although the blanks were reproducible. PTFE filters showed lower blanks but more variation. Number concentration of particles was very variable with a maximum around 350,000 particles/cc. Removal of particles from filter for size distribution analysis was successful.

Conclusion: For metal analysis MCE filters are not appropriate due to elevated blank levels and PTFE membranes need to be cleaned. Future work includes the evaluation of using a cascade impactor to determine the size distribution of particles, the reproducibility of the method, and the evaluation of various samplers as well as the testing of polycarbonate membranes.

Occupational Health and the Social Indicators from Sustainability in a Lumber Industry in the Amazon Region: Case Study

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The lumber industry, besides its influence in the environment, is among the three most important economic resources of the Amazon region. The objective of this paper is to determine the occupational health indicators that have influence in the sustainability development. Sustainability is a system that results from the balance among the social, environmental and economic subsystems which are formed by specific indicators. The used method was a research *in loco* in a exporter industry that processes 15000 m³/year and has 150 employees considering only three social indicators that are directly related to the occupational health: absenteeism, worker satisfaction and education. These indicators were chosen because they have each other a strong relationship. The absenteeism is motivated not only by disease or accident, but also for job dissatisfaction as result of lack of knowledge appropriated to the task to be performed. Using the fuzzy logic it was evaluated the grade of the sustainability in a range from totally unsustainable, unsustainable, moderately sustainable, sustainable and totally sustainable. The result showed that despite being over 20 years in the market

of lumber exportation the industry was classified as unsustainable related to the studied indicators. The conclusion is that the researched industry, doesn't consider the social indicators related with the occupational health to determine its sustainability. And this lack of consideration does not appear because it is hidden by others social indicators that are not related to the occupational health and so, even with an unsustainability the industry that doesn't consider the occupational health may be classified as a sustainable industry or totally sustainable one.

Workers Exposure to Indium Dusts in Indium-Tin-Oxide (ITO) Manufacturing Processes in Korea

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Indium has not been widely used until it was used for indium-tin oxide (ITO) thin films in the production of flat-panel displays, touch screens, and other electronic devices. Recently, it has been reported that 2 fatal and 8 clinical cases of indium lung disease from three countries (Japan, United States, and China). In Korea, indium-tin oxide (ITO) has been extensively produced and used. Therefore, Korean workers may also be exposed to indium dusts. This study was conducted to assess workers' exposure to indium dusts in the ITO manufacturing industries Korea.

Sampling and analysis for indium element was carried by the US NIOSH method 7303. MCE filters and personal sampling pumps were used for both total and respirable dusts. To collect respirable dusts, aluminium cyclones were used. Indium was analyzed with use of an ICP.

Total 132 samples were collected from 5 industries. Arithmetic mean (AM) of indium concentration in total dusts was 62.5 $\mu\text{g}/\text{m}^3$ and standard deviation (SD) was 86.8 $\mu\text{g}/\text{m}^3$. Geometric mean (GM) was 27.1 $\mu\text{g}/\text{m}^3$ and geometric standard deviation (GSD) was 3.9. The highest level was found in the mixing process where AM was 121 $\mu\text{g}/\text{m}^3$ and GM 54.7 $\mu\text{g}/\text{m}^3$.

AM of indium concentration in respirable dusts was 13.6 $\mu\text{g}/\text{m}^3$ and SD was 41.8 $\mu\text{g}/\text{m}^3$. GM was 4.1 $\mu\text{g}/\text{m}^3$ and GSD was 5.5. The highest level was also found in the mixing process where AM was 55 $\mu\text{g}/\text{m}^3$ and GM 10.2 $\mu\text{g}/\text{m}^3$.

Workshop -7th International Control Banding Workshop (7ICBW)

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Objectives: In 2002 the initiative and vision of IOHA improved our profession. International experts on practical chemical control came to London on 4-5 November 2002 for the first International Control Banding Workshop (ICBW). Control Banding (CB) is now applied in over 50 countries, in national regulations, taught in universities, and ubiquitous in technical literature. An ICBW back in London at IOHA 2015 is the objective.

Methods: Four roundtable categories that comprise an ICBW emerge for technical presentations and scientific discussions:

- IOHA has CB-related initiatives with WHO, ILO, IEA, and ILO-related projects.
- International CB experts have already submitted research for presentation.
- National CB initiatives are in progress and require a venue for offering updates and results.
- Technical exposure control and cross-disciplinary risk reduction challenges are emerging and multidisciplinary risk management solutions using CB strategies are in development or necessary.

Results: Healthy Workplace Initiatives involving WHO, ILO, ILO, IEA, and IOHA are advanced and collaborative efforts emerge. Results of the Evaluation of Tier 1 Exposure Assessment Models under REACH (ETEAM) and the latest CB research is presented and strengths and weaknesses emerge to assist international harmonization efforts and future endeavours. IOHA will further its reputation for affording the multidisciplinary synergy and collaborative opportunities that CB creates.

Full Day Workshop: 7ICBW - four roundtable sessions, each with four speakers, to identify the strengths, weaknesses, and research gaps in CB science and practice. More than half of the 16 speakers have already committed should this workshop be accepted.