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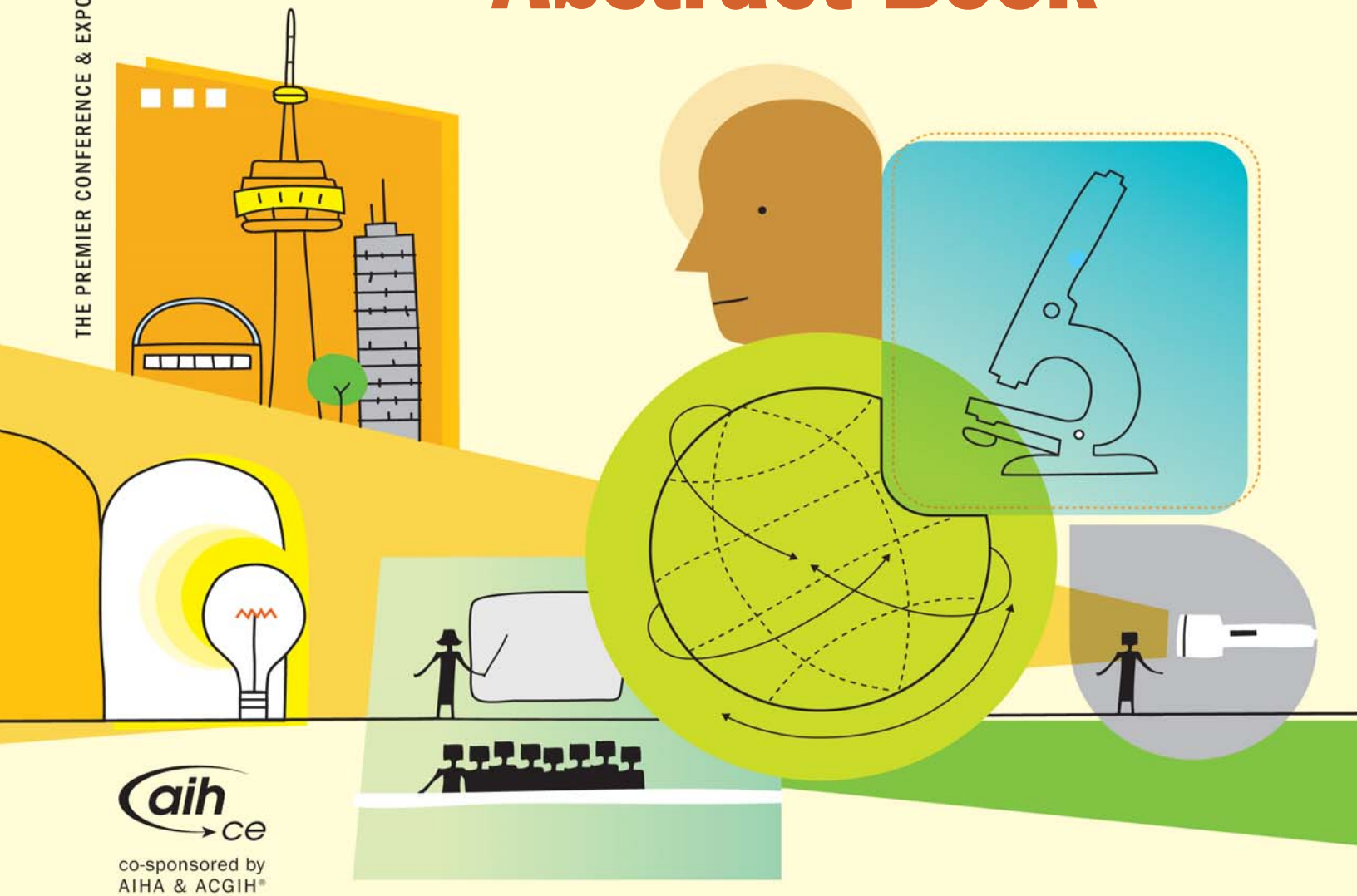

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2009 AIHce Abstract Index by Session Topic

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Podium Session 101: Computer Applications

Monday, June 1, 2009, 10:30 a.m.– 12:30 p.m.
Papers 1–6

1

Internet Tools for the Industrial Hygienist

A. Duane, R. Strode, T. Peveto, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO

Industrial hygienists use a wide variety of information to characterize exposures during their investigations, including chemical and physical properties, toxicological properties, and other health and safety information. The Internet is a tremendous repository of information; however, much of the information desired is not contained in any one web page. In this podium session, we direct IHs to various websites, databases, and other web resources to facilitate effective and efficient research to assist in their investigations. We will explore toxicology databases and how best to find the information needed. We will show sites that give chemical and physical property data. Governmental websites and other resources are offered to aid in hazard communication (including MSDS development). We also will include additional websites to help IHs when developing presentations and papers. Case studies for applications will be given, as well. All these resources help IHs perform their work effectively, from initial research to field sampling to program development to data communication.

2

Creation of a Map-Based Data Repository

M. Rollins, Thermo Fisher Scientific, Waltham, MA

Many global organizations have the challenge of documents' retention, as well as a loss of "tribal knowledge." All too often reports, contact names, permits, agency audits, and other pertinent data are stored in such a way as to be difficult to access. Because staff today is very dynamic, due to such things as retirement and personnel changes, it is very difficult to have continuity as it relates to a site's history. The project being discussed is an attempt to have global health, safety, and environmental and risk management staff access to a map-based repository of all past, present, and future data. The system is designed to place an indicator on a map for each company location. Clicking on the indicator brings up a data summary for the site, which includes contact names, historic audits, and related documentation. The system also allows"scoring" to be implemented, whereby a site's overall score in such rubrics on safety, property conservation, or environment is indicated by a colored indicator. Such a scorecard is a real-time, dynamic way for senior management to have a "10,000-foot view"of a businesses' rating, allowing key emphasis to be allocated where it is needed.

3

Exposure Risk Management Using the DoD Industrial Hygiene Exposure Assessment Model

M. Baghoomian, P. Tennison, Northrop Grumman Mission Systems, Clearfield, Utah

Risks to employees as a consequence of chemical and workplace exposures are complex issues that have several implications for a facility and its healthy work force. The effective management of workplace risk is an important issue that DoD facilities face daily. To help manage workplace risk, especially related to chemical hazards, the DoD's Industrial Hygiene Exposure Assessment Model (IHEAM) and Defense Occupational and Environmental Health Readiness System (DOEHRS) provide the infrastructure to capture, analyze, control, and document all human exposure concerns. IHEAM provides bioengineers and industrial hygienists a consolidated exposure record to support diagnosis and epidemiological analysis critical to maintaining a fit and healthy work force. The information provided by IHEAM constitutes the foundation for longitudinal exposure record mandated under public law and provides support to combatant and garrison commanders regarding the medical readiness of their personnel. In addition to IHEAM, the use of DOEHRS at a facility or base can organize, structure, and compile scientific information to help identify existing hazardous situations or problems, anticipate potential problems, establish priorities, and provide a basis for regulatory controls and/or corrective actions. In this presentation, we will demonstrate how IHEAM and DOEHRS are used to manage risk associated with workplace exposures.

4

Physiologically Based Pharmacokinetic (PBPK) Modeling of N,N-Dimethylformamide (DMF) for Humans Involving Respiration and Skin Exposure

J. Fong, C. Lee, National Cheng Kung University, Tainan, Taiwan

Physiologically based pharmacokinetic (PBPK) models are sophisticated dosimetry models that offer great flexibility to simulate exposure scenarios even though limited data exists. Those models are of particular interest to environmental health scientists because they provide relevant predicting data to conduct low-level exposure health risk assessment. N,N-Dimethylformamide (DMF) vapor had been demonstrated that it could be readily absorbed via skin and inhalation routes for occupational exposure group. The aim of this study was to clarify the potential for inhalable exposure and dermal absorption and the disposition kinetics of DMF for human by PBPK modeling. A Windows®-based DMF PBPK model was developed and used in this study. Human exposure data came from a previous study that six volunteers were tailgated by DMF-exposed employees completely for two exposure scenarios: with and without wearing a respirator. Urinary N-methylformamide (U-NMF) concentrations in 48-hr consecutive urine sample were determined. Results of PBPK model simulation showed the half life of U-NMF throughout 48 hr was 7 hr and 10.7 hr for dermal absorption and combined exposure (inhalation and skin), respectively. Further, the half life showed two phases in combined exposure,; 3.3 hr and 16.5 hr for phase I and phase II, respectively. Sensitivity analysis showed that partition coefficients of skin/blood and /blood had higher positive effects for U-NMF, and partition coefficient of fat/blood had higher negative effect for U-NMF. This PBPK model can be used in the future to simulate other exposure scenarios, and help health risk assessors obtain additional information and relationship between internal dose and different exposure routes of toxic chemicals.

5

Best Practice Guidelines for CFD Application to Safe Building and Laboratory Design

A. Kolesnikov, CPP, Fort Collins, CO; D. Walters, KCP, Inc., Raleigh, NC.

Over the years computational fluid dynamics (CFD) has been used to simulate increasingly more complex fluid/gas flows and heat exchange processes for applications encountered in the aerospace, automotive, and nuclear industries. The physics and computing resources available for large-scale, indoor airflow modeling have matured, and CFD is now used as a viable and trusted (via extensive benchmarking) tool for indoor airflow prediction. This highlights the need to establish best practice guidelines to ensure modeling accuracy and consistency. The goal of this presentation is to benchmark the use of CFD in providing accurate predictions of indoor airflow patterns and contaminant distributions, and to present an overview of the current CFD capabilities (computer resource requirements, model scale capabilities, and limitations), as well as outline future research challenges facing CFD HVAC applications. Because of rapid advances in the areas of turbulence modeling and parallel computing technology, CFD is uniquely positioned to provide high fidelity airflow distribution data. Just a few years ago, models consisting of 1-2 million cells represented a standard of "high-fidelity" CFD. Today's computer resources allow for 20-30 million cell models to be used routinely for large-scale simulations, providing reliable flow field predictions for several hundred thousand ft^2 of indoor floor space. While the initial validation benchmark within this presentation establishes the ability of a CFD simulation to accurately reproduce experimental room airflow results, the following sections focus on a specific full-scale section of a research laboratory consisting of 32 laboratory hoods and equipment with corresponding supply and exhaust diffuser configurations. This study illustrates the use of computer modeling to address laboratory hood operation effectiveness as related to hood cross-talk and supply airflow cross-drafts within the space during normal day/night operations. Several turbulence models are considered to ascertain simulation accuracy.

6

Modeling Potential Carbon Monoxide Exposure Due to Operation of a Major Rocket Engine Altitude Test Facility Using Computational Fluid Dynamics

M. Blotzer, J. Woods, NASA, Stennis Space Center, MS.

NASA is building a new facility, the A-3 Test Stand, to test the J2-X rocket engine that powers both the second stage of the new Ares I and the earth departure stage of the new Ares V launch vehicles that will return astronauts to the moon. The J2-X engine must be tested at a simulated altitude of 100,000 feet. To achieve this simulated altitude chemical steam generators using isopropyl alcohol, liquid oxygen, and water will deliver approximately 4900 lbs per second of steam and combustion products to a 2-stage steam ejector system which reduces the pressure in the test cell and downstream of the engine. The steam and combustion products are discharged to atmosphere. Each J2-X engine test requires 650 seconds of steam production, which will release approximately 33 tons of carbon monoxide. To evaluate the potential for exposure to carbon monoxide in nearby facilities, carbon monoxide plume dispersion modeling was performed using the ANSYS CFX Computational Fluid Dynamics (CFD) software suite running on 32 processors of a LINUX Computational Cluster. Modeling consisted of creating a three-dimensional computational grid approximately 1.9 miles long by 1.2 miles wide by 0.6 miles high of the volume surrounding the A-3 Test Stand and nearby facilities. CFD was used to simulate the evolution over time of the exhaust plume and its chemical constituents within the simulated volume. The simulation results were post-processed to create carbon monoxide plume contours at 1250 ppm, 200 ppm, 50 ppm, 35 ppm, and 25 ppm. Plume dispersion was simulated over a range of wind speed and direction to assess worst case scenarios. The results of the modeling were used to assess the need to vacate adjacent test stands and buildings, modify building ventilation systems to achieve positive pressure indoor environments, and identify safe viewing locations.

Podium Session 102: Risk Management in a Global Context

Monday, June 1, 2009, 10:30 a.m.–12:30 p.m.
Papers 7–12

7

Essential Supply Chain Communication Under REACH: Case Study

K. Kawar, Actio Corp., Portsmouth, NH.

Communicating with your upstream (suppliers) and downstream (customers) is essential in complying with the European Union's REACH regulation. Communication begins with the preregistration and registration intentions of suppliers followed by the need to accumulate and categorize use data from your customers. Historically, the safety data sheet (SDS) or MSDS was the main tool for hazard communication. The manufacturer provides a one-way flow of information based on studies down to the end user. This one-way flow of information doesn't take into account the myriad ways in which a product is used and the environment it's used in. Under REACH, the manufacturer/importer is required to add an annex to the SDS containing the exposure scenario(s) (ES) when certain volume thresholds are exceeded. An ES is the set of conditions that describe how the substance is manufactured or used during its life-cycle and how the manufacturer/importer (M/I) recommends to the downstream user(s) (DU) what is needed to control human exposure and persistence in the environment. These sets of conditions contain a description of both the risk management measures (RMMs) and operational conditions that the manufacturer or importer has implemented or recommends be implemented by DUs. A DU may be faced with multiple ESs attached to a single SDS, and have to decide the relevance to using a particular substance or preparation in a particular way in the workplace. In this presentation, we will discuss tools that enable collaboration upstream to the supply chain and downstream to their customers. These tools are intended to enhance data collection and reduce the cost for migrating from a standard one way compliant SDS to a REACH-compliant extended SDS.

8

REACH Implementation in a European Aluminum Company

M. Lavoie, A. Lectard, Rio Tinto Alcan, Dunkerque, France; R. Lapointe, Rio Tinto Alcan, Montreal, QC, Canada; B. Buclez, Rio Tinto Alcan, Voreppe, France.

On June 1, 2007, the European commission published the REACH regulation, established for use in the Registration, Evaluation, and Authorization of CHemicals. It replaces about 40 existing chemical substances regulations in the European Union. All chemical substances produced or imported at a weight above 1 ton, including those already in circulation, fall within the scope of this regulation. These substances have to undergo detailed risk analysis, including gathering their toxicological data, if not already available. Failure to respect the regulation in the prescribed delays could imply to stop the production or use of substances in the European market. In this presentation, we will outline the Rio Tinto Alcan (RTA) REACH implementation strategy and the difficulties inherent in compliance with the new regulation. Topics include substances and legal entity identification, communication plans with customers and suppliers, toxicological data acquisition, participation in SIEF and consortia, preparation of chemical safety reports, and costs. All our customers, as well as our suppliers of critical products, were contacted to ensure the maintenance of the supply chain in our industry. A series of bioavailability surveys, in line with approximately 22 potential exposure scenarios, are currently being conducted by a Canadian university to better document the final chemical safety report to be turned into the European Chemical Agency by Dec. 31, 2010. Classification of coal tar pitch as a substance of very high concern with industry partners is also discussed.

9

Exposure Control Validation at a Pharmaceutical Manufacturing Supply Chain in India

G. Desai, International Safety Systems, Inc., Vadodara, India; T. Mehta, International Safety Systems Inc., Washingtonville, NY

Multinational pharmaceutical companies are contracting manufacture of active product ingredient (API) in such countries as India and China. Although quality assurance is validated, exposure control to reduce exposure below the stringent occupational exposure limit (OEL) for API continues to be a concern. Either exposure control know-how is not available or implementing the exposure controls is cost prohibitive in these and other like countries. Multinational pharmaceutical companies increasingly are requiring their suppliers to demonstrate through containment validation that an employee exposure will be below the exposure limits when their APIs are manufactured. An exposure control validation study was conducted at one of the largest suppliers of APIs in India. Free-flowing lactose of USP grade was used in place of API for containment validation. Fifty personal and area samples were collected during weighing and dispensing, sifting, granulation, milling, blending, compression, and coating. An AIHA-accredited laboratory in the United States analyzed the samples. The results of personal and area samples collected indicated that an employee exposure could exceed the OEL for the API scheduled to be manufactured. Containment validation results were used to improve exposure controls (e.g., vacuum transfer) and safe work practices (e.g., vacuum cleaning in place of dry sweeping). Supplied air respirators were recommended in place of dust masks. The supply chain pharmaceutical company communicated the results and exposure controls to the parent multinational pharmaceutical company. Requiring an API supplier to demonstrate through containment validation that an employee exposure will be below the API OEL, is the most effective approach in reducing employee exposure below API OEL. Suppliers are eager to implement exposure controls because the sale of API to multinational pharmaceutical companies is dependent on the containment validation.

10

Prioritization of High Production Volume Chemicals Under the U.S. Chemical Assessment and Management Program — An Overview

C. Fehrenbacher, N. Nguyen, EPA, Washington, DC.

The Chemical Assessment and Management Program (ChAMP) is EPA's new Chemical ChAMP was created to implement commitments under the Security and Prosperity Partnership (SPP) of North America, which was launched in March 2005. SPP is a trilateral effort to increase security and enhance prosperity among the three North American countries through cooperation and information sharing. Under ChAMP, the United States has committed to assessing and initiating needed action on about 6750 existing chemicals by 2012. ChAMP will apply the results of EPA's work on HPV chemicals (those chemicals produced or imported in the United States in quantities of 1 million pounds or

more per year), and moderate-production volume (MPV) chemicals (those produced or imported in quantities above 25,000 and less than 1 million pounds per year). ChAMP will build from prior efforts, including the High Production Volume (HPV) Challenge and the Inventory Update Reporting (IUR). EPA has developed a process for screening-level hazard characterizations (HCs), risk characterizations (RCs), and risk-based prioritizations (RBPs) on HPV chemicals. RBP documents summarize basic hazard use and exposure information available to EPA on HPV chemicals, identify potential risks, note scientific issues and uncertainties, and indicate the initial priority being assigned by the agency for potential future appropriate action. Prioritization decisions made on HPV chemicals include consideration of the potential for occupational, consumer, general population, and environmental exposures, and the potential for children to be exposed. In 2008, EPA posted HCs for about 340 chemicals, RBPs for 150 chemicals, and continued developing and posting HCs and RBPs. In addition, EPA posted initial MPV HCs. By the end of 2012, EPA will assess and initiate needed action on about 6,750 existing chemicals produced above 25,000 pounds per year in the United States (includes HPV and MPV chemicals), and make and publicly release screening-level decisions and initiate needed action.

11

It's Not Easy Being Purple — Preparing for the Globally Harmonized System

B. Foster, ICC The Compliance Center, Inc., Mississauga, ON, Canada.

In this presentation, I will cover the origins of the Globally Harmonized System, the basics of the system, and guidance on what hazard communication specialists need to be doing to prepare for the implementation of this system.

12

Will REACH Kill the TLVs ?

M. Guillemin, Institute for Work and Health, Lausanne, Switzerland.

The new European regulation for Registration, Authorization, and Evaluation of Chemicals (REACH) will impact the practice of occupational hygiene in many ways. One aspect of major concern is the acceptable or tolerable concentrations of chemicals at the workplace, levels referred to as derived no-effect levels (DNELs). These values will be proposed by manufacturers or importers of chemicals in Europe, and they will be used as "safe concentrations," similar to the way the TLVs are used. However, they will not be derived by neutral scientific committees but by the experts from industry. The traditional occupational exposure limits concern about 6 to 700 chemicals, but the DNELs will be derived for thousands of compounds, with an unknown level of confidence about the workers' health protection., They either will be very severe because the safety factor (uncertainty factor used to divide the no observable effect level) will be set at a high value or they will not be severe enough, due to obvious commercial factors. I will present a list of relevant issues to evaluate which scenario is the most probable. In Europe, there is a Scientific Committee for the Occupational Exposure Limits, which provides proposals for individual limits to the European community. These values are then discussed by the social partners, and eventually approved by the European Parliament. For DNELs, a procedure has been developed as part of the REACH regulation. I will compare and analyze both methods, with comments made from the perspective of the chronic risk management and under the concept of the evidence-based medicine or the precautionary principle.

Podium Session 103: Radiation: Ionizing and Nonionizing

Monday, June 1, 2009, 10:30 a.m.–12:30 p.m.

Papers 13–18

13

Does Radon Present a Health Risk to Nova Scotia Workers?

H. Mersereau, Cape Breton University, Sydney, NS, Canada.

Radon is an invisible, odorless, naturally occurring radioactive gas that is emitted by the natural breakdown of uranium and can be found in high concentrations where the rocks and soils contain uranium, granite, shale, or phosphate and in soils contaminated with certain types of industrial waste. A recent change in the Canadian NORM Guidelines, to 200 Bq/m^3, has elevated the concern Nova Scotians have regarding radon. Long-term exposure to high concentrations of radon has been shown to increase the risk of lung cancer and may also give concern to significant doses to the skin. A systematic assessment carried out in Nova Scotia has shown that many areas in the province are radon prone due to elevated levels of natural radioactivity in soil, with levels second only to Sudbury when compared on a national level. In addition to potentially elevated radon levels in Nova Scotia, the Department of Health has identified higher than average lung cancer rates within the Cape Breton district, as well as higher than average lung cancer rates within the province overall, as compared with national averages. Two hundred alpha track detectors have been placed in approximately 30 workplaces within mainland Nova Scotia and Cape Breton Island. I will compare results against the NORM guidelines, with recommendations given for mitigation. Provision of the test results to workplaces will take place in June 2009, with education sessions provided as requested.

14

Working with Radioactive Materials in the Laboratory: Assessing the Leachability of 99 Technetium in a Grout-Stabilized Waste Form

G. Bowman, RJ Lee Group, Inc., Monroeville, PA; B. Mull, RJ Lee Group, Inc., Pasco, WA.

Solidifying concentrated brines into cementitious monoliths has been investigated as a means of sequestering toxic materials in stable waste forms. Recently, a test procedure for stabilization of technetium in a cementitious matrix has been developed and investigated through small-scale laboratory testing. The premise of this work is to reduce the highly mobile $^{99}Tc^{7+}$ ion to the immobile $^{99}Tc^{4+}$ state followed by solidification. The mobility of Tc in this waste form is then tested by two leaching protocols. When in the heptavalent state, Tc is highly mobile and spreads rapidly in the vadose zone. It is therefore a contaminant of concern at the Department of Energy Hanford Site in southeast Washington state. The various waste streams, as well as groundwater contamination at Hanford, underscore the importance of continual development and assessment of means for stabilizing radionuclide-bearing materials. In this presentation,, we will address establishing a small-scale, low-level radiation laboratory, as well as the hygiene and safety precautions necessary for working with radionuclides in the laboratory within the context of the Tc-stabilization project. When applying ALARA (as low as reasonably achievable) principles, surrogates for radioactive elements are often used. Technetium (Tc) 99 is a beta emitter generated as a byproduct of nuclear fission. The radioactively stable element rhenium (Re) is regarded as chemically similar to Tc and is often used as a surrogate. In this study, we assessed the behavior of the actual heptavalent Tc ion in the grout matrix. Side-by-side testing with Re was also performed to further assess the ability of this element to function as a Tc surrogate within the environment of the grout matrix and conditions of this study.

15

Developing UV Index-Compatible Biological Indicators for Alerting Health Hazards from Overexposure to Solar UV Radiation

C. Chen, C. Wu, Y. Chen, China Medical University, Taichung, Taiwan.

Overexposure of human skin to ultraviolet (UV) irradiation has been recognized for decades as a hazard contributing to various acute and chronic health effects. The Global Solar UV Index (UVI) system is the predominant tool used when communicating the hazards resulting from exposure to UV irradiation. However, in its current form, the UVI does not provide causal indication, in (semi-) quantitative terms, to the health hazards that may arise from excess solar UV exposure. In this study, we evaluated the changes in human skin physiology in response to solar UV irradiation under normal exposure scenarios, and investigated the adequacy of specific physiological parameters to serve as indicators for the health hazards from solar UV exposure. The physiological parameters examined included transepidermal water loss (TEWL), erythema (expressed as E-index), and melanogenesis (as M-index). A two-stage experiment was conducted. First, study participants were assessed for the intended physiological responses in a climatized environmental chamber to investigate the stability of these parameters, under influences of environmental temperature and humidity, as a tool of reporting preclinical physiological events in the skin following solar UV irradiation. In the second stage, out-of-door measurement of parameters proceeded to examine level of change in parameters as a result of exposure to natural, solar irradiation. Hourly reported local UVI levels were collected simultaneously. The results show that environmental temperature significantly influenced the occurrence and time course of TEWL change, thus posing interference to the application of TEWL as an indicator to solar UV exposure. Erythema and melanogenesis were best indicators for alarming potential health

hazards arising from, short- and long-term UV exposure, respectively. Dose (UV level)-response (physiological change) relationships were established by linearly regressing E-index and M-index against UV irradiance, and the resulting predictive models will be discussed.

16

Outdoor Workers' Exposure to Ultraviolet Radiation in Northwest Ohio

F. Akbar-Khanzadeh, B. Weaver, S. Khuder, M. Dennis, University of Toledo Health Science Campus, Toledo,Ohio.

Outdoor workers, such as those in construction, landscaping, and similar settings, are exposed continuously to ultraviolet radiation (UVR) that may exceed the acceptable exposure limits. UVR effective irradiance ($E_{eff}I$) levels were measured using an Actinic Hazard detector (Model SEL240 #6070; Input Optic T2ACT5 #26271) and a radiometer (Model IL1400A, International Light Inc.). The data were collected on three land surfaces (grass, asphalt, and snow), every 1.5 hours during October - December. The monitoring was performed during the entire day, for 10 days, within an open field at a height of approximately 1.5 meters (5 ft) from the ground. Percentage cloud cover and climatic factors were determined. Overall, the results showed that $E_{eff}I$ ($\mu W/cm^2$) was 0.94 ± 1.18 (3.60) [mean ± SD (max)], the highest measured, in the direction of the sun, followed by those in the directions of south, 0.77 ± 1.01 (3.4); up, 0.60 ± 0.70 (2.60); down/snow, 0.39 ± 0.54 (1.40); east, 0.36 ± 0.49 (1.80); west, 0.33 ± 0.47 (1.80); north, 0.24 ± 0.34 (1.50); down/asphalt, 0.12 ± 0.23 (1.30); and down/grass, 0.07 ± 0.26 (1.30). Predictive models have been devised to determine UVR $E_{eff}I$ for any hour of the day and for specific cloud coverage and geographic direction. The models were most reliable when the sun was not covered more than 75% with clouds. When compared with the UVR TLV recommended by ACGIH®, the data indicated that a worker could not spend a full eight hours outdoors unprotected, regardless of usual cloud coverage or weather conditions. At times, 30 or 45 minutes were the most a worker could spend outdoors unprotected. We suggest outdoor workers be protected by using awareness training; shading;, shielding; scheduling work to avoid peak solar UV times; breaks; wearing sunglasses, wide brimmed hats, neck covers, and clothing covering the body; or sunscreen.

17

High-Powered Hand-Held Portable Lasers — A New Hazard on the Job Site?

D. Hewett, FDA, Rockville, MD.

In the last decade, the power and availability of battery-powered hand-held portable lasers has rapidly increased, and these lasers are appearing in the workplace. What should you, as a site safety officer or industrial hygienist, be on the lookout for if a high-powered portable laser is brought into your workplace? Is the laser legal? The FDA, under the Federal Food, Drug and Cosmetic Act, regulates laser product manufacturers and collects accidental radiation occurrence reports. However, incident and injury data are sparse. In this presentation, I will explain how certain laser safety regulations are applied to portable hand-held lasers, what role the FDA plays in regulating laser use, and other safety aspects of portable lasers that could be purchased by workers and carried onto your work site. I also answer the question, "does the FDA ever 'approve' a laser"? I also will give incident and injury statistics collected by the Federal Aviation Administration that may be of particular interest to those who work in the aviation industry.

18

Power Lines and Health: An Update of the Evidence

P. Barn, National Collaborating Centre for Environmental Health, BC Centre for Disease Control, Vancouver, BC, Canada; R. Copes, BC Centre for Disease Control, Vancouver, BC, Canada.

Recently in British Columbia, the construction of new power lines in a residential area was met with resistance that was fueled by residents' fear over health impacts posed by the lines. Exposure to electromagnetic fields (EMFs) is ubiquitous, and power lines are only one source; others include electrical wiring and electrical appliances. The potential for health effects from living near power lines has been an ongoing debate, and policies regarding power line exposures to the public differ worldwide. We will discuss the current state of knowledge on power lines and the associated health effects, as well as public health implications of policies relating to power lines.. There is a large body of research investigating the health effects of occupational and residential EMF exposure. While earlier studies did suggest associations between exposure and a variety of health effects, including brain cancer, breast cancer, cardiovascular disease, and reproductive and developmental disorders, most of these associations have not been substantiated by more recent research. One notable exception is the association with childhood leukemia. Researchers first suggested an association between magnetic field power line exposures and childhood leukemia more than 25 years ago, and since then, numerous studies have found evidence to suggest a small elevated risk. Governments worldwide have responded with different policies regarding EMF exposure and public health. Some have taken a precautionary approach, with the banning of power line construction near schools, homes, and hospitals, whereas other governments have chosen to promote voluntary exposure reductions. Other approaches include burying power lines and increasing the "buffer" zones between residential areas and new power lines.

Podium Session 104: Facts and Fixes—Ergonomic Problems and Solutions

Monday, June 1, 2009, 10:30 a.m.–12:30 p.m.
Papers 19–24

19

Solving the MSD Conundrum

T. Pena, ART Corporate Solutions, Inc., Colorado Springs, CO.

Attendees will understand the nature and causation of soft tissue disorders. Take a journey through cumulative injury cycle while realizing cost-effective mechanisms through which to brake and reverse the process. Gain an understanding of relatively new histological findings that directly relate to challenges health and safety professionals, with aging work forces, regularly face. Case Studies: Learn how three very different corporations (manufacturing, biotech, and white collar) implemented allied soft tissue intervention programs as a component of their first aid, ergonomic, and wellness initiatives. Gain insight from their achievements with respect to OSHA-recordable injury and workers' compensation claim reductions while learning from the challenges each realized during a 2- to 3-year period.

20

Low Rolling Resistance Wheels Reduce Force to Push Carts

R. Marklin, S. Wieszczyk, A. Stone, Marquette University, Milwaukee, WI.

Few studies have quantified the effect of wheel rolling resistance on the force required to push an industrial cart with a heavy load. A field experiment was carried out in an electric utility. The independent variables were wheels (conventional and low rolling resistance wheels) and floor surface (smooth concrete and metal grating). The dependent variables were the 3-axis forces to initially push the cart to a steady speed and then to sustain the cart at that speed. Twenty-four male utility workers participated in the study. The cart was 2 × 5 ft, and weighed a total of 750 lbs, and it had two fixed casters in the front and two swivel casters in the rear. The wheels were 8 inches in diameter and 2 inches wide. The cart was pushed straight at a speed of 1.25 mph over an approximately 20-ft distance. Participants pushed on a handle that was outfitted with a 3-axis load cell (forward, side, and vertical). The initial push force to move a cart with low rolling resistance wheels was decreased by 15% to 23%, as compared with a cart with conventional wheels. The average initial force was approximately 68 lbf for pushing the cart with low rolling resistance wheels on smooth concrete, compared with 85 lbf with the conventional wheels. For metal grating, the reduction was from more than 100 lbf to approximately 80 lbf The sustained push force decreased 34% to 40% with the low rolling resistance wheels. For both surfaces, the sustained push force averaged about 40 lbf with conventional wheels, compared with approximately 25 lbf with low rolling resistance wheels. Low rolling resistance wheels increase the percentage of workers who have the strength to push carts with heavy loads and may decrease the risk of shoulder and low back injuries.

21

Low Back Loading During Lifting of Wire Mesh Screens

S. Gallagher, C. Mark, C. Compton, NIOSH, Pittsburgh, PA; S. Kotowski, K. Davis, R. Huston, J. Connelly, University of Cincinnati, Cincinnati, Ohio.

Bolting large sheets of wire mesh screen (WMS) to the roof of underground mines helps prevent injuries due to rock falls. However, WMS can be heavy and awkward to lift and transport. Six male subjects (mean age, 45.8 years ± 7.5 SD) were recruited to lift WMS in a laboratory investigation of the biomechanical demands associated with lifting WMS. A biomechanical model was used to estimate the three-dimensional external moments about

L5-S1 for 16 lifting tasks. Two sizes of WMS (full and half-size screens) were used. Lifts were performed under 168 cm and 213 cm vertical space conditions (simulating different coal seam heights). The initial orientation of the WMS was either flat on the floor or leaning against a wall, and screens were lifted to either a side-carry or an overhead-carry position. *A priori* orthogonal contrasts were used to evaluate differences in L5-S1 moments experienced between screens, seam heights, and lifting techniques. Restriction in vertical space increased the maximum L5-S1 extensor moment from 254 Nm to 274 Nm ($t = 2.77$, $p < 0.01$) and right-lateral bending moment about L5-S1 from 195 Nm to 251 Nm ($t = 5.54$, $p < 0.001$). Lifting full sheets of screen (as opposed to half-size sheets) resulted in an average 33 Nm increase in peak L5-S1 extensor moment ($t = 4.54$, $p < 0.001$). The peak L5-S1 extensor moment was increased by an average of 44 Nm (18%) when lifting screens positioned flat on the floor ($t = 6.19$, $p < 0.001$) as opposed to when screens were positioned in an upright position. Results of this study suggest that changes in the methods of handling WMS can significantly reduce loading on the lumbar spine for mine workers who perform this task.

22

A General-Purpose Office Chair Reduces Heart Rate During Typical Office Tasks

S. Freier, Marquette University, Milwaukee, WI.

A major office furniture manufacturer is developing a new office chair that may provide a health benefit to users. Health professionals suggest that the upwardly tapered backrest of this chair may open the chest cavity of the user more than a conventional chair with a wide backrest, allowing for an increase in tidal volume (liters/breath) and a decrease in respiratory rate (breaths/min). The objective of this study was to determine whether the new office chair increases a user's ventilatory and cardiac efficiency, compared with a conventional office chair. Of the 31 subjects tested, 16 were females and 15 were males. The sample size was distributed approximately evenly between the younger (18-35 years) and older (36-55 years) age groups. The experimental protocol consisted of a subject sitting in one of the two chairs for two hours while working on a desktop PC and watching a movie. The dependent variables were respiratory rate, tidal volume, other measures of lung function, and heart rate. A wireless Cortex Metamax 3B unit was used to record ventilation measures. Results from statistical analysis showed there were no trends of statistically significant differences in respiratory rate and tidal volume between the two chairs for all subjects. However, compared with the conventional chair, heart rate ranged from 2.6 to 3.4 fewer beats per min (bpm) for female users of the new chair for six of the eight tasks, while heart rate ranged from 4.6 to 7.9 fewer bpm for the male subjects for all eight tasks. Heart rate is increasingly considered as a predictive factor of cardiovascular disease. Based on a study of 25,000 patients, resting heart rate was shown to be an independent risk predictor of cardiovascular mortalities (Diaz et al., 2005). Thus, the new office chair may decrease the risk of cardiovascular disease for its users.

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A Comparison of Anti-Vibration Gloves' Effectiveness vs. Reduction in Manual Dexterity Performance

S. Chervak, U.S. Army, APG, MD.

At a U.S. Army installation, the workers on a vehicle disassembly line use power tools, such as impact wrenches, grinders, and cutting wheels, during the disassembly process. These tools expose the workers to hand-arm vibration (HAV), which can lead to occupational illnesses such as carpal tunnel syndrome, Raynaud's syndrome, and tendonitis. Anti-vibration gloves are often used as a quick fix to reduce the workers' exposure to HAV. Six gloves were tested for their effectiveness in reducing workers' exposure to HAV. HAV was measured in accordance with American National Standards Institute (ANSI) measurement standards. Seven participants used a ½-inch impact wrench to tighten six bolts while wearing each glove. Vibration measurements were made via an adaptor placed between the surface of the glove and the surface of the hand. Gloves that met the ANSI S3.40 standard exhibited the lowest vibration exposure levels. In addition, each glove's influence on workers performance was measured via a Bennett's hand-tool dexterity test. The timed test measured gross motor skills by having the participant disassemble nine fasteners in a specific order from a wooden frame and then reassemble the nut, washers, and bolts on the other side of the frame using wrenches and screwdrivers. Time to complete the test was used as the measurement of dexterity. Gloves that had the lowest vibration exposure measurements showed the greatest loss of dexterity while the glove that had the highest vibration exposure measurements showed the least amount of dexterity loss when compared with the other gloves. The results of this study indicate that care needs to be taken when using anti-vibration gloves as a quick fix for mediating hand-arm vibration exposure, especially among tasks that require both fine motor skills and the use of vibrating power tools.

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Prevalence of Hand Disorders Among Hand-Held Device Users and Their Relationship to Patterns of Usage

R. Wells, S. Berolo, The University of Waterloo, Waterloo, ON, Canada; B. Amick, Institute for Work and Health, Toronto, ON, Canada.

Mobile hand-held devices, such as cell phones, iPods and personal digital assistants have been linked, in the press and in clinical professional literature, to musculoskeletal disorders (MSD) of the upper limb. Despite the media attention, this research provides the first scientific evidence on the association between mobile hand-held device use and pain in the upper limb. The objective of this research was to determine the prevalence of hand, arm, shoulder, neck, and upper back pain in people who use mobile hand-held devices, and to evaluate the association between specific factors of hand-held device use and MSD symptoms of the upper limb. It was hypothesized that an increase in duration of device use would be associated with higher prevalence of symptoms. A cross-sectional study design was used. Study participants were asked to fill out a five- to eight-minute, Internet-based, anonymous questionnaire to identify specific factors of device use - i.e., time spent on a typical day in the last week performing tasks of typing, scheduling, Internet browsing, answering/making phone calls, media activities and gaming;, and musculoskeletal symptoms present, if any, in the hand, arm, shoulder, neck, and upper back. Demographic data and information on regular computer use was also collected. Statistical analysis focused on descriptive statistics about the characteristics of device use and the prevalence of musculoskeletal symptoms in the upper limb.

Podium Session 105: Laboratory Health and Safety

Monday, June 1, 2009, 2:00 p.m.–4:20 p.m.
Papers 25–31

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Lessons Learned: Basic Chemical Hygiene Survey in a Large Biomedical Research Facility

J. Nesbitt, J. Klancher, Mayo Clinic, Rochester, MN.

Maintaining the casual atmosphere of an academic research laboratory is perceived as necessary to support a collegial and positive work environment. However, as part of this casual atmosphere, chemical hygiene/safety may not enjoy the same rigorous attention to detail as in an industrial laboratory environment. In this presentation, we will discuss the inception, development, and implementation of a chemical hygiene audit process in a large biomedical research facility. Some of the challenges to be discussed include gaining leadership endorsement and support for the audit process, aligning the evaluation with existing compliance initiatives, and establishing an accountability network to support improvement recommendations. The process described in this session, initiated in early 2006, included audits of 211 research laboratories to evaluate the state of the laboratory environment, and continues through the successful implementation of subsequent improvement recommendations. We will share examples of evaluation and communication tools , as well as offer discussion of the key standards used as a framework for auditing criteria. Numerous recommendations from the audit were behavior based and within the laboratory personnel's ability to complete without a capital investment. However, some of the recommendations required acquisition of equipment and remodeling of the physical space. It was critical to have leadership support in advance of generating recommendations for equipment and facility changes and in having done so, these recommendations were met with acceptance and collegiality.

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Developing a Local Exhaust Ventilation Management Program

L. deLaski, Emilcott, Chatham, NJ.

Managing local exhaust ventilation (LEV) in large laboratory facilities can be a very complex issue. Many facilities have both old and new systems, with different configurations and controls. Maintenance of the systems is often controlled by a facilities group or outside contractors, and labora-

tory workers are not always aware of the proper operation and use of LEV or the potential exposures they face from improper use. Consequently,, an LEV management plan that addresses all aspects of the operation, use, and maintenance of LEV should be instituted to ensure the protection of workers from potential contaminants. In this session, I will explore the lessons learned during the development of a LEV management plan for a large pharmaceutical R&D facility. I will present the realities of working with facilities and systems that are 50-years old, some important issues that are not described in the applicable publications, and some successes in improving LEV operations and protecting workers.

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An Easy and Practical Quantitative Method to Evaluate Exhaust Ventilation Equipment and Particle Removing Devices

K. Ahn, J. Caravanos, Hunter College, New York, NY.

Visualization of airflow patterns using smoke-generating equipment is often used to qualitatively evaluate exhaust ventilation systems. Counting the number of particles using a particle counter can be used to identify and measure pollutant sources. By combining those two methods, the performance of exhaust ventilation equipment and particle-removing devices can be quantitatively evaluated. This method measures a dilution ratio of the exhaust ventilation equipment (the ratio between the particle number concentration within the exhaust ventilation equipment and that in the operator's breathing zone) or a leakage percentage of the particle-removing device (the ratio between the concentration downstream of the particle-removing device and the concentration upstream of the particle-removing device). In this presentation, we will outline and illustrate the necessary equipment and procedures of the method. We will provide several use cases such as testing a biological safety cabinet, an exterior hood, and a laboratory fume hood. We also will discuss the limitations of the method. This new method can be used as an easy and practical quantitative method to evaluate the performance of exhaust ventilation equipment and particle-removing devices.

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A Pilot Project to Reduce Fume Hood Face Velocities in a Research Chemistry Laboratory

A. Kalil, H. Lee, P. Greenley, J. Mannion, Massachusetts Institute of Technology, Cambridge, MA.

Both public and private institutions are facing increasing financial and environmental pressures to improve energy conservation. Because laboratories require far more energy to operate per unit area than offices, increases in lab energy efficiency can have large effects in overall energy use. The objective of this pilot study was to ensure six previously commissioned fume hoods in a large university research chemistry building maintained adequate containment as hood face velocities were reduced from 100 fpm to 80 fpm. This fume hood model had been approved for use by the manufacturer at 60 fpm. The project involved coordination between facilities, EHS, the fume hood manufacturer, and an ASHRAE 110 testing company. After the face velocity reduction was completed, ASHRAE 110 testing showed two previously commissioned fume hoods now failed at a 0.1 ppm SF6 leakage
criterion. It was determined that the poor hood containment was due to cross drafts. Measures to control supply air distribution were implemented and retesting of hoods was successful. After commissioning was completed, researchers' chemical exposures in the lab bay with the reduced airflow and a nearby control bay were assessed. Personal and area air samples for three of the solvents the lab groups commonly used, acetone, dichloromethane and n-hexane, were collected with passive badges. Participating researchers recorded their activities at the fume hoods during the sample period. Information collected included chemicals used, process, duration and sash position. Sampling was conducted throughout two consecutive days. Air concentrations for the targeted contaminants were not detectable or very low in comparison to exposure limits for both groups, and there was no apparent difference in exposure between the two groups. This pilot study suggests that fume hood face velocities in previously commissioned laboratories can be reduced but that recommissioning must be performed to ensure that fume hood containment is still effective.

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Case Study: Substituting Type IIA2 Biosafety Cabinets for Type IIB2 Cabinets — Reducing Exhaust Airflow to Eliminate the Potential for Reverse Flow While Reducing Energy Costs

K. Capwell, US Pharmacopeia, Rockville, MD; S. McClung, Laminar Flow Consultants, Ashburn, VA.

Six type IIA2 biosafety cabinets were purchased and installed in a newly built 6,000 square foot multiroom laboratory. The recommended exhaust volume for this model when thimble-connected is 650 cfm. Original lab design called for type IIB2 biosafety cabinets, with a design exhaust of 1,100 cfm each, which produced air exchange rates in individual rooms far in excess of 10 air changes per hour. At initial certification the third-party certifier warned of the potential for reverse flow if the internal cabinet blowers in the A2 cabinets were turned off. In the reverse-flow condition, airflow is reversed through the supply HEPA filter, so dust may load up on the clean side of the supply filter. When the cabinet blower is restarted and proper airflow direction reestablished, dust from the clean side can be blown into the sterile work area. Calculations indicated that reducing the cfm exhaust to an amount appropriate for a type IIA2 cabinet would still provide adequate general exhaust from these spaces. Manually controlled adjustable air valves were determined to have adequate range of adjustment to be reset to the desired exhaust flow rate. Arrangements were made for a licensed and NEBB-certified airbalancer to make the necessary air valve adjustments to both exhaust and supply air valves. We will discuss savings in heating and cooling of make-up air.

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The Protection Capability of Biological Safety Cabinets

W. Lin, J. Liu, C. Wen, China Medical University, Taichung, Taiwan.

This study was conducted to evaluate the effects of operation on the protection performance of biological safety cabinets (BSCs). Two types of BSC, including class IIA1 and class IIA2, were tested. NSF/ANSI 49 2007 standard for Class II biosafety cabinetry established minimum requirements for materials, design, construction, and performance of class II (laminar flow) biosafety cabinetry that is designed to protect personnel, product, and the environment. Severed performance was used for qualification of an installed BSC, such as A7 personnel, product, and cross-contamination protection (biological) tests, and an A11 airflow smoke-patterns test. In general, the guidelines for work practices and procedures for BSCs users were suggested in "Biosafety in Microbiological and Biomedical Laboratories." For example, material can be placed on the work surface but not on the front or rear grille openings. However, the rules were sometimes not followed, and the performance of BSC should be considered unsafe in those instances. In this study, the performance of BSCs was tested by NSF/ANSI 49 methods when several fault or unusual procedures were in operation, such as placing materials on the front or rear grille openings, using open flames (alcohol burner), or opening the sash in the wrong position. Computational fluid dynamics were applied under these conditions to simulate the created turbulence that disrupts the pattern of HEPA-filtered air being supplied to the cover surface.

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Airborne Nanoparticle Exposure Evaluated While Using Conventional, Constant Velocity and Air-Curtain Isolated Hoods

S. Tsai, M. Ellenbecker, University of Massachusetts Lowell, Lowell, MA; R. Huang, National Taiwan University of Science and Technology, Taipei, Taiwan.

Tsai et al. found that the handling of dry nanopowders inside laboratory fume hoods can cause a significant release of airborne nanoparticles. Hood design affects the magnitude of release. With traditionally designed fume hoods, the airflow moves horizontally toward the hood cupboard; the turbulent airflow formed in the worker wake region interacts with the vortex in the conventional fume hood, and this can cause nanoparticles to be carried out with the circulating airflow. Experiments showed that the exposure magnitude for a conventional hood had high variability. The newly designed air curtain isolated hood (Huang et al.) induces a push-pull air curtain at the face of the hood and a downward flow from a top grille. The air curtain is generated by a narrow planar jet issued from the double-layered sash and a suction slot located on the floor of the hood just behind the doorsill. Tracer gas tests with this hood showed high stability with very low exposure. Airborne particle concentrations were measured for three hood designs (conventional, constant-velocity. and air-curtain) under two scenarios. First, the manual handling of nanoalumina particles was evaluated.

The second scenario involved the use of a dust generator to release airborne nanoalumina particles in the hoods. A TSI Fast Mobility Particle Sizer was used to measure airborne particle concentration from 5 nm to 560 nm. Air samples also were collected and characterized. Measurement locations were the room background, the researcher's breathing zone, and the source. The highest breathing-zone concentration was detected while using the conventional hood; the concentration increase was as high as 10,000 particles/cm^3 using the dust generator. However, breathing-zone concentration at the air-curtain hood was barely detected using the dust generator, with stable and very low exposure during manual handling. We will present and discuss the complete results of the evaluation.

Podium Session 106: IH General Practice

Monday, June 1, 2009, 2:00 p.m.–4:40 p.m.
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Field Validation of the Releasable Asbestos Field Sampler (RAFS-I)

J. Kominsky, Environmental Quality Management, Inc., Cincinnati, Ohio; J. Thornburg, RTI International, Research Triangle Park, NC; W. Barrett, National Risk Management Research Laboratory, EPA, Cincinnati, Ohio

A risk assessment for intermittent, low level exposure to asbestos requires personal breathing concentration data. Currently, activity-based sampling is the preferred approach to provide measurements of a person's inhalation exposure; i.e., asbestos structures per cubic centimeter. However, alternative methods are needed to reduce the time and expense necessary to obtain breathing-zone concentration data. One approach uses dual technologies working in a series to economically and rapidly generate asbestos breathing-zone data. The combination of the Releasable Asbestos Field Sampler (RAFS) and the Breathing-Zone Model eventually may eliminate the need to perform activity-based sampling. RAFS was designed to provide repeatable and representative asbestos aerosolization data from soil in situ. The RAFS simulates a raking motion to aerosolize the asbestos fibers. A gentle airflow transports the generated aerosol laterally inside a tunnel to one end, where filter samples or real-time instruments are located. A comparison of asbestos concentrations generated by the RAFS, with activity-based sampling data, is presented. The comparisons were made with multiple activity-based sampling tests with different activities (e.g., raking), different soil/environmental conditions, and at different geographical locations. Although highly correlated, the RAFS concentrations can be several orders of magnitude higher than the activity-based sampling concentrations. In part, the large regression slope is due to the RAFS direct measurement of asbestos emission from the soil, without consideration of meteorology and personal activity on the asbestos transport to the breathing zone. This finding highlights the need for the Breathing-Zone Model to link the RAFS data with a person's breathing-zone concentration. Field tests also showed the RAFS aerosolized asbestos concentrations were correlated with total particle concentrations.

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Asbestos: Reduce, Reuse, Recycle?

A. Bianco, D. Wytrykush, Golder Associates, Calgary, AB, Canada.

In the 1970s and 1980s many Canadian municipalities added small quantities of asbestos to asphalt pavement to facilitate greater oil content, which increased durability by enhancing the pavement's ability to resist rutting and degradation by the elements. Typically, when asphalt roadways are resurfaced, the pavement is milled off, the asphalt is hauled away to a recycling facility, and new asphalt is laid down. As the time comes to resurface asbestos-containing asphalt roadways, one wonders if the process should be different -should asbestos-containing asphalt be recycled? There are stringent regulations, codes, and guidelines dedicated to the handling and removal of friable products such as asbestos-containing building materials, and there is the public perception that asbestos has been banned from general use; however, it is no secret that non-friable asbestos products are available, and asbestos still is actively mined in North America. The scope of this IH study included conducting air monitoring during paving processes that generate considerable dust: milling, scarifying, hauling, loading, handling, saw cutting, jack hammering, recycling, and repaving. In this presentation, we will summarize the observations, sampling data, limitations in sampling methodology and logistics, and recommendations for worker exposure and public communication. We also will reveal the lessons learned while performing a study under an integrated work plan bound by the summer season; political and environmental pressures to reduce landfill waste; an expectation to follow visible practices of other jurisdictions, the idea of establishing industry practice, and delicate conditions caused by public scrutiny of a governing body. In accordance with the challenge for industrial hygienists to become members of the overall business team, this IH study and the subsequent recommended process improvements to eliminate or reduce worker exposure were an essential contribution to the business decision regarding the fate of asbestos-containing, asphalt-planing chips in a large Canadian city.

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ERMI Correlates with Abnormalities in Innate Immune Inflammatory Responses

R. Shoemaker, Center for Research on Biotoxin Associated Illnesses, Pocomoke, MD.

We surveyed the results of our first 500 ERMI results performed by four different laboratories looking for correlations between a building index and indices of human health. We reported to AIHA 6/08 the observed sequence of acquisition of abnormalities in innate immune responses identified in treated, but previously ill, patients who were followed prospectively after re-exposure to the interior environment of a water-damaged building. ERMI results were predictive of recrudescence of illness and predictive of development of central nervous system metabolic abnormalities. With this study we associate ERMI in cases and controls with symptoms and multiple inflammatory markers, including TGF beta-1, a cytokine that produces dysregulation in T-regulatory cell function; measures of autoimmunity, AGA and ACLA; measures of activation of genes associated with hypoxia inducible factor, VEGF and erythropoietin; a measure of complement activation, C4a; and markers of coagulation in the von Willebrand's profile. Mean symptoms in controls were 3.8. Controls showed no correlation of ERMI with any metabolic parameter. Mean symptoms in cases were 20.1. Cases showed clear associations of multiple parameters if ERMI exceeded 2, but not for ERMI less than 2. However, the same correlation was seen for ERMI values greater than (-) 1, if any prior value of C4a exceeded 20,000. No significant inter-lab differences in associations with ERMI were found. These results suggest that the likelihood is high (1) when ERMI exceeds 2 and (2) patients are identified by presence of symptoms that blood tests profiling inflammation using innate immune responses will reproducibly identify metabolic abnormalities in blood tests not usually run as part of routine health screening. Fortunately, these metabolic/inflammatory disturbances can be corrected with specific therapies. We will present an algorithm for case detection and treatment for use by medical practitioners and indoor air quality professionals.

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The Incidence of Treated Eye Injuries Associated with Occupational Settings

H. F. Felmet, Stephen F. Austin State University, Nacogdoches, Texas; T. Nalbone, University of Texas at Tyler, Tyler, Texas

This study researched the incidence of eye injuries in an occupational setting in East Texas. The objective of this study was to determine whether there are any trends in the incidence of eye injuries in industries in East Texas, with a retrospective review of a sole practitioner's ophthalmology practices' medical records for occupationally related eye injuries. Eight diagnoses were analyzed to show a relationship to a categorized industry list of seven. The industries were then analyzed against 11 variables. The medical records were reviewed from January 2000 through May 2007, giving a population size of 44 patients. The 44 medical records were taken from a sole ophthalmology practice in East Texas. After a statistical evaluation of the data, using the chi-square-based Cramer's V measure of association through descriptive statistics, it was noted that the highest number of treated occupational eye injuries occurred in 2007. The growth of the sole ophthalmology practice was taken into consideration due to the increase of patient records from January 2000 through May 2007. In addition, the most common occupational eye injury diagnosed was corneal foreign body. The most treated occupational eye injuries were in 2007, 16 of the total 44. Construction occupation injuries have increased during the past three years, and they doubled from 2006 to 2007. This led to the conclusion of the need for companies' awareness of increasing occupational eye injuries in the construction industry in East Texas. The research also concluded that the most common occupational eye injury, not including sole diseases of the eye, was corneal foreign body.

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A Local Piece in a Global Jigsaw — A Case Study

L. Burgess, Astrazeneca, Cheseapeake, VA; S. Bastin, Astrazeneca, Wilmington, DE.

The supply chain for many products in a global pharmaceutical company is typically very complex. This often requires a blend of using internal and third- party providers to meet the challenges of maintaining supply demands while at the same time meeting the needs of multiple business drivers in moral/ethical, legal, and financial arenas! Meeting IH needs in a holistic way in this complex jigsaw requires flexibility, innovation, and multidisciplinary discussions. In an increasingly cost-constrained economy, meeting these key needs is even more important, and while this is very challenging, it is also very exciting. While there will be general themes relevant to manufacture, formulation, and packing activities of a given product that are globally applicable, there also are local differences that must be considered. The list is long but includes factors such as culture, legislation, local environment (within and outside the facility), production volumes, and available equipment and facilities, whether the facilities are planned new facilities or existing facilities, etc. This reality means that there may be potentially different approaches and solutions to ensure that an appropriately balanced end point is reached. In this presentation, we will outline an example of how a "global jigsaw" influences local decisions and how the local piece of that jigsaw can be positioned to ensure it fits with the global picture!

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A Case Study of Worker Exposures to Landfill Gas

R. Wills, WM Safety Services LLC, Houston, Texas; D. Malter, Malter Associates, Bull Valley, IL

The gas generated within municipal solid waste landfills is primarily comprised of methane and carbon dioxide, with trace quantities of other gases such as hydrogen sulfide. Degradation of solid waste constituents by anaerobic bacteria creates this mixture of landfill gas (LFG). Methane, hydrogen sulfide, and other LFG component gases are explosive in certain mixtures of air. LFG may have potentially toxic components such as hydrogen sulfide. Reports sponsored by regulatory agencies and the solid waste industry focus on topics such as gas collection and control systems, LFG emissions, safety and health work practices, etc. Given the potential dangers of LFG, there is a need to improve our understanding of LFG exposures in the work environment and under what circumstances these exposures occur. The purpose of this study was to evaluate landfill employee exposures to an index of LFG - hydrogen sulfide and combustible gases, during a five-month period. Five landfills in Minnesota and Iowa were selected. A MultiPro model, 4-gas portable gas monitor was worn by employees who participated in the study. Air concentrations of hydrogen sulfide, combustible gases, carbon monoxide, and oxygen were measured. Carbon monoxide was included in the study as a means of evaluating concurrent exposures to exhaust from earth-moving heavy equipment and diesel/gas-powered equipment commonly used in landfill operations. The preliminary results of the study showed 8-hr TWA exposures to carbon monoxide and hydrogen sulfide are generally below applicable ACGIH and OSHA limits. Peak results for carbon monoxide, hydrogen sulfide, and combustible gases, and minimum results for oxygen can occasionally exceed applicable ACGIH and OSHA limits during the course of the workday. The use of direct-reading instruments allows workers to recognize and properly respond to those occurrences.

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WITHDRAWN

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WITHDRAWN

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Approaches to Promoting Industrial Hygiene in India

P. Bhatt, International Safety Systems, Inc., Baroda, India; T. Mehta, M. Mehta, International Safety Systems, Inc., Washingtonville, NY.

The last decade witnessed phenomenal growth of industrial hygiene in India. Ten years ago, India's first Master in Industrial Hygiene program started at Saradar Patel University in India. More than 100 graduates of this program are now working in industries, academia and research organizations in India. The Central Industrial Hygiene Association in India, representing growing number of industrial hygiene and safety professionals, is established. CIHA publishes quarterly magazine on industrial hygiene and safety. Similar industrial hygiene program also was started at Sri Ramachandra University (SRU) in Chennai, India.

Industrial hygiene in India received much-needed boost when (a) American Industrial Hygiene Association identified India as a priority nation (b) AIHA appointed an Ambassador to India (b) AIHA Presidents and executives visited India in three successive years. Rather than working independently, AIHA adopted a prudent approach of associating with institutions and originations within India. Two Memorandum of Understanding (MoU) have been signed with National Safety Council (NSC), India's largest organization of the safety professionals. AIHA is in collaboration with the Confederation of Indian Industries (CII), India's largest organization representing industries. AIHA representatives presented several sessions at the national conference of Indian Occupational Health Association, India's largest organization of Occupational Physicians.

Several institutions have started offering short-term training programs in Industrial Hygiene. Hyderabad based, Nayati International offered a Workshop on industrial hygiene last year and one more Workshop is planned this year.

These initiatives would undoubtedly result into promoting industrial hygiene in India and reducing occupational health risk to the working people of India.

Podium Session 107: Health Care Industries I: Bioaerosols, Negative Pressure Rooms, and Other Infection Control Topics

Monday, June 1, 2009, 2:00 p.m.–4:40 p.m.
Papers 40–47

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C. difficile and MRSA: Environmental Impact and Proper Sampling Techniques

J. Dell'Aringa, EMSL Analytical, St. Louis, MO.

Perhaps two of the most notorious nosocomial-to-community acquired pathogens in recent years are methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile* (C. diff). These clinically derived organisms have plagued hospital infection control departments for years; recently they have become the focus of environmental investigations in an attempt to curb outbreaks and validate cleaning procedures. Understanding the fundamental characteristics, growth requirements, and survival mechanisms of these organisms is essential to effectively recovering them from the environment. In this presentation, I will compare and contrast notable characteristics of the two organisms, address potential environmental and industry impact, and discuss proper sampling techniques and considerations.

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Quarterly Monitoring of Airborne *Aspergillus* Fungi in Hospital Intensive Care Unit (ICU) Using qPCR to Document Trends with Control Charting and Warning Limits

P. Kaminski, Forensic Analytical Consulting Services, Inc., Hayward, CA.

Awareness of fungal infections in health care environments continues to be a high priority for hospital infection control personnel. Following an outbreak of Aspergillosis at a local hospital in 2005, administrators and facility staff were concerned about identifying potential fungal sources. We were retained to assist in that endeavor. After conducting a thorough visual examination of the area, a regime of air monitoring was prescribed. Using a quantitative polymerase chain reaction (qPCR) analytical method with a customized infection control panel, fungal species level data was collected throughout the ICU and adjacent areas. Monitoring has been conducted on a quarterly basis since January 2006. Since that time, airborne *Aspergillus* levels have been charted to understand and illustrate fluctuations. Using the cumulative data collected, mean total *Aspergillus* levels and the standard deviation for the data were calculated. Based on the mean plus 2 standard deviations, an upper warning limit was calculated that may be used as an indicator for fungal amplification. Charting these results may be useful in establishing "normal" conditions or ranges for each of the sample locations, since no new cases of Aspergillosis have been reported.

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Hospital Air Surveillance: Air Sampling and Rapid Testing by Real-Time PCR

Q. Li, EMSL Analytical, Inc., Westmont, NJ.

Hospital infections caused by fungi, bacteria, and virus have become a serious concern. Infants, the elderly, immune-compromised patients, cancer patients, and patients who need surgical operations are the most vulnerable hospital visitors. SARS,, varicella-zoster virus, tuberculosis, *Legionella*, MRSA, and *Aspergillus spp*. were reported in hospital infections through air. Aspergillosis is a disease caused by *Aspergillus* species such as *A. fumigatus* and *A. flavus*. Hospital expansion and renovation can change air quality significantly. Several *Aspergillus* species, including *A. fumigatus* and *A. flavus* were found in hospitals with building projects. *Legionella spp* were associated with hospital humidifier systems, and can be a risk to hospital visitors. Collecting hospital air samples and testing for the infectious microorganisms is the most effective air surveillance procedure. Air sampling from multiple sites can detect and track the routes of microorganisms. A single room air sample is normally used for surgical operating rooms with installed air-purifying systems. Air sampling for bacteria has been reported for *Mycobacterium tuberculosis*. A real-time PCR (DNA-based) method for testing *M. tuberculosis* in air samples was developed and is commercially available. The most common tests used are for fungal contaminants. Direct examination techniques for detecting fungal spores is not very sensitive, and fungal culture methods take too long. Rapid detection by real-time PCR has become a popular hospital air surveillance method. Real-time PCR is not only sensitive but also allows detecting multiple species at the same time. Mold-specific quantitative PCR has been applied to monitoring 15 common *Aspergillus* species, 20 water damage-related fungal species, and 6 nosocomial *Aspergillus* species. In conclusion, real-time PCR provides rapid detection of airborne pathogens and mold for hospital air quality control.

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The Concentration of a Negative Pressure Isolation Room

W. Lin, C. Wen, J. Liu, China Medical University, Taichung, Taiwan.

During the SARS outbreak, many patients moved into the negative pressure isolation room (NPIR), which served as a disease control system. The performance and indoor air quality of NPIR were a concern for public health workers and occupational health managers in the hospitals. This study evaluated the characteristics of the bioaerosols in the NPIR of five public hospitals. MAS 100 and Andersen six-stage bioaerosol samplers were used. The sampling locations included the fresh outdoor air inlets of the NPIR, breathing zones, and nursing stations outside the NPIRs. During the bioaerosol sampling, we also recorded the environmental information, including temperature, relative humidity, and number of people in the ward or at the nursing station. In hospital A, the bacterial concentrations were 458±170, 389±30, and 260±51 CFU/m^3 at the fresh air inlet, breathing zone, and nursing station, respectively. In hospital B, they were 485±81, 1134±115, and 161±18 CFU/m^3, respectively. In hospital C, they were 75±7, 346±70, and 194±20 CFU/m^3, respectively. In hospital D, they were 348±65 CFU/m^3, 527±195 CFU/m^3, and 188±14 CFU/m^3, respectively. In hospital E, they were 1059±779, 1060±60, and 516±8 CFU/m^3, respectively. In hospital A, the fungal concentrations were 368±51, 346±60, and 249±4 CFU/m^3, respectively. In hospital B, they were 263±16, 1067±140, and 207±33 CFU/m^3, respectively. In hospital C, they were 409±55, 919±50, and 139±24 CFU/m^3, respectively. In hospital D, they were 384±147, 580±180, and 239±10 CFU/m^3, respectively. In hospital E, they were 88±14, 194±15, and 86±14 CFU/m^3, respectively. It was found that the bacterial concentrations at breathing zones were higher than those from fresh air inlet for four out of five hospitals. In addition, the concentrations in wards were usually higher than those at nursing stations.

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Acceptable Pressure Differentials for Isolation Rooms with Door Opening

P. Raynor, R. Gonzalez, University of Minnesota, Minneapolis, MN.

By establishing ventilation in health care facilities that maintain air in airborne infection isolation rooms (AIIRs) at a pressure lower than in connected spaces, infectious particles generated by patients are not allowed to reach patients, visitors, or staff in other spaces. When doors leading to an AIIR are opened and closed, this pressure relationship is disrupted. The objective of this research was to determine the pressure differential required to keep contaminants inside an AIIR when the door is opened. As a surrogate for airborne microorganisms, carbon dioxide was introduced at elevated levels into mock AIIRs with room-to-hallway pressure differentials ranging from -7.5 to +2.5 Pa and ventilation rates of 12 and 21 air changes per hour (ACH). Door opening frequencies during tests included no opening, opening every 5 minutes, and opening every minute. One mock isolation room included an anteroom between the AIIR and the hallway, and the other did not. Concentrations of carbon dioxide in the room and in the adjacent hallway were monitored, and ratios of the time-integrated hallway and room concentrations were calculated. Data were evaluated statistically as a function of pressure differential, ventilation rate, frequency of door opening, and presence of an anteroom. Although results without the anteroom indicated that no leakage of carbon dioxide was detected at any negative room pressure during tests when the door remained closed, leakage rates when the door was opened every minute with a ventilation rate of 12 ACH were 0.94% at -0.25 Pa, 0.74% at -2.5 Pa, and -0.04% at -7.5 Pa. The presence of an anteroom reduced, but did not eliminate, leakage when doors were opened and closed. This research indicates that pressure differences larger than the current U.S. recommendation of -2.5 Pa may be required to keep agents inside AIIRs when their doors are entered.

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Aerosol-Transmissible Diseases — Potential Implications of California's Proposed Standard

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Beginning in the middle of 2008, CAL-OSHA proposed two new standards related to aerosol-transmissible diseases and zoonotics. Comparisons were made with existing NIOSH, CDC, OSHA, and ANSI guidelines and standards with similar protocols, yet some significant differences were identified. Working with California's local AIHA section stakeholders, hospital, infection control, biological safety, national industrial hygiene experts, and occupational health professionals, a thorough analysis of the technical and feasibility issues was conducted with, comments submitted by the stakeholders to the CAL-OSHA Standards Board. Changes to the standards of care related to identification, patient care, notification, and isolation. Additional worker safety and health issues related to patient contact, respiratory protection, fit-testing, training, and vaccinations. Identification and handling of key organisms were generally similar to established protocols but were more stringent than the CDC's, with some undetermined benefits. Discussions, conferencing, and suggestions to improve the standards were submitted. Regardless of the regulatory outcome, the final versions of these standards should not be considered specific to California, but may be a model wherever a higher than normal risk of exposure to aerosolized microorganisms may exist.

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A National Surveillance System for Blood/Body Fluid Exposures and Influenza Immunization Among Health Care Personnel

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Nearly 9 million health care personnel (HCP) are at risk of acquiring infections from occupational exposures in the United States. Risks include bloodborne (e.g., hepatitis B and C viruses, human immunodeficiency virus) and respiratory (e.g., influenza, tuberculosis) pathogens. Although recommendations, guidelines, and regulations to minimize exposures to such hazards have been developed, compliance has been difficult to measure. In 2008, the Centers for Disease Control and Prevention developed a new HCP Safety component within its web-based surveillance system, the National Health Care Safety Network (NHSN), which supersedes the National Surveillance System for Health Care Workers. .The HCP Safety component allows participating facilities to enter data about individual occupational blood/body fluid exposure events and exposure management (e.g., postexposure prophylaxis, adverse side effects and laboratory test results). For seasonal influenza immunization uptake, facilities may enter data on accepting/declining immunization and adverse reactions to vaccination, as well as medications used for prophylaxis/treatment and adverse reactions to such medications. Through an annual survey, baseline data will be collected, including use of safety devices, implemented strategies to increase immunization, and denominator

data regarding the numbers of HCP stratified by occupational group. Training materials are available online to assist facilities and institutions with successful enrollment in and implementation of this new surveillance system for HCP. The NHSN HCP Safety component will assist participating facilities in developing surveillance and analysis methods that permit timely recognition of HCP safety problems and prompt intervention with appropriate measures. At the national level, the system will aid in monitoring rates and trends, identifying emerging hazards for HCP, assessing risk of occupational infection, and evaluating preventive measures, including engineering controls, work practices, protective equipment, postexposure prophylaxis, and immunization uptake strategies.

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Collaboration Among the Industrial Hygienist, the Occupational Health Nurse, and the Infection Control Professional

G. Byrns, Illinois State University, Normal, IL.

In the past interaction and cooperation between the industrial hygienist , the occupational health nurse (OHN), and the infection control professional (ICP) have not been optimal. A likely problem is a lack of awareness of expertise of other disciplines and the value of cooperation. The IH has expertise in identifying, evaluating, and controlling hazards. The OHN knows the clinical status of the work force, and the ICP has expertise in disease surveillance and identifying infection hazards. In this session, we will identify areas of common interest and describe the ways the IH can work effectively with the other professionals. The most obvious area of mutual interest is the control of airborne infectious disease such as tuberculosis (TB). The ICP may have overall responsibility for TB prevention. However, the OHN has an important role in screening and identifying which employees may be infected, and the IH can play an important role in assuring that barriers are in place to prevent the spread of the disease. The IH also can assist in the outbreak investigation team. Other IH roles include assessment of the use of personal protective equipment in tasks such as endoscopy that present an infection risk; in writing policies such as the Bloodborne Exposure Control Plan that involve overlap between the three disciplines; and in conducting routine tasks such as product evaluation, construction planning, and managing medical waste. In summary, these three disciplines have much to share that is mutually beneficial in controlling morbidity and mortality in a health care setting.

Podium Session 108: Chemical Vapor Sampling and Analysis

Monday, June 1, 2009, 2:00 p.m.–4:40 p.m.
Papers 48–55

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Dynamic Sampling Method for Diacetyl and Acetoin Using Tenax TA Solid Sorbent and (2,3,4,5,6-Pentafluorobenzyl) Hydroxylamine Hydrochloride (PFBHA)

S. Takaku, S. Que Hee, University of California, Los Angeles, Los Angeles, CA.

The research was performed to develop a dynamic sampling method for diacetyl and acetoin based on 10% (w/w) (2,3,4,5,6-pentafluorobenzyl)hydroxylamine hydrochloride (PFBHA) coated on Tenax TA (80/100 mesh). Diacetyl (buttery taste and smell) and acetoin are the dominant flavoring-additive ketones used for microwave popcorn, and both are associated with incidents of *Bronchiolitis obliterans*. Because diacetyl has two carbonyl groups, the monosubstituted and the disubstituted, O-oxime derivatives had to be synthesized to assess the chemisorption of diacetyl onto the coated solid sorbent. The O-oxime of acetoin and mono- and disubstituted O-oximes of diacetyl with PFBHA were synthesized to make standard curves. The yields of the derivatives were 93.9±1.8%, 93.8±4.2%, and 73.8±2.8%, and their purities were 98.9±0.6%, 99.1±0.2%, and 88.8±8.3%, respectively, using temperature-programmed capillary gas chromatography-mass spectrometry by m/z 181 selective ion monitoring. The linear range was 17-32 ng for the acetoin derivative and 2.4-42 ng for the mono- and disubstituted diacetyl derivatives. Five different concentrations (0, 0.1, 0.5, 1.0, 1.5, and 2.0 mg/m^3) of acetoin and diacetyl were generated in Tedlar gas bags by injection of the appropriate mass of ketone in water solvent and using the appropriate air volume. Each gas bag, in triplicate at each concentration, was sampled using a personal sampling pump set at calibrated flow rates of 10 and 50 mL/min. Preliminary results showed that the 50 mL/min flow rate caused breakthrough through a 200-mg front section onto a 50-mg back section at 2.0 mg/m^3. The 2.0 mg/m^3 concentration of acetoin and diacetyl was detected on the front section, with 82±20% and 79±16% recovery, respectively, at 10 mL/min. Similar recoveries were obtained at 1.0 and 1.5 mg/m^3. Both diacetyl and acetoin can be separated and determined by this method from the same air sample.

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An Alternative to Thermosorb/N and GC-TEA for Nitrosamines Determination in Workplace Air

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The goal of this study was to adapt the sampler developed by the Institut National de Recherche et de Sécurité (INRS) of France to propose a more simple sampling device and analytical method for the determination of nitrosamines in air by gas chromatography with nitrogen phosphorus detection (GC-NPD). The sampling was done by drawing air through a sampling train containing two tubes placed in series. The first tube contained sulfamic acid and was acting as a guard to trap amines (potential contaminants to the analysis). Only the second tube, which contained Florisil®, was sent to the lab for analysis. The Florisil was then transferred in a vial, and a liquid-solid extraction was performed with 1.5 mL of acetone containing an internal standard. The extract was then analyzed by GC-NPD using internal calibration to quantify eight nitrosamines: nitrosodimethylamine, nitrosomethylethylamine, nitrosodiethylamine, nitrosodipropylamine, nitrosodibutylamine, nitrosopiperidine, nitrosopyrrolidine, and nitrosomorpholine. The matrix thus obtained with the acetone extraction was much cleaner than the one obtained by the extraction of a Thermosorb/N according to NIOSH 2522 or OSHA 27. A complete validation was carried out, and a LOQ of 0.040 µg per sample was obtained for all eight nitrosamines, which correspond to a concentration in air of 0.06 µg/m^3,assuming a sampled volume of 720 L. The precision obtained for six replicates on five different levels of concentration was in the range of 2.7-5.8 % for the eight nitrosamines. A study on nitrosamines exposure actually taking place in a rubber plant will allow parallel sampling of Thermosorb/N and INRS tubes, and the results obtained will be discussed.

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Passive Air Sampling for Nonylphenol by Solid-Phase Microextraction

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Nonylphenol (NP) is a degradation product of nonylphenol ethoxylates (NPE), which are widely used as the nonionic surfactants detergents. Exposure to NP is suspected to cause adverse effects on growth and the reproductive system. Due to the possible human exposures, the estrogenic activity of NP has raised concerns about human exposure to these compounds,. EPA has mentioned that NP in household cleaning products could be an important source of indoor air pollution. For the assessment of gas-phase NP exposures, sampling with PUF and XAD2 resin are currently the most available. However, solvent desorptions are commonly needed for the techniques, which make the methods inconvenient. On the other hand, solid phase microextraction (SPME) presents many advantages over conventional analytical methods, by combining sampling, preconcentration, and direct transfer of the analytes into a standard gas chromatograph system. Therefore, the purpose of this research was to develop a passive sampler for NP based on the technique of SPME. Known concentrations of NP were generated in gas bags for the validations of SPME diffusive sampler, with an 85-µm PA fiber used. After exposure of NP, the SPME fiber was placed in a 4-mL vial that contained 100 µL of MTBSTFA, with 1% TBDMCS at 45°C for 10 min to allow further derivatization. The headspace extraction of MTBSTFA and on-fiber derivatization with NP were performed at 45°C for 10 min. The derivatives, t-BDMS, were then determined by gas chromatography/mass spectrometry by directly inserting the SPME fibers into the injection port for thermal desorption and analysis. The experimental sampling constant of the designed passive sampler, as well as the effects of different environmental factors on the samplers, also were validated.

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WITHDRAWN

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Optimizing Sampling and Analytical Parameters for Soil Vapor Samples Using Automated Thermal Desorption/Gas Chromatography/Mass Spectrometry

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The principles of soil vapor intrusion are based on the protection of human health. The sampling is performed at contaminated sites to investigate if potentially present subsurface volatile contaminants have pathways to indoor air. The results are interpreted using applicable regulatory limits to determine if the levels are a health concern, and whether corrective measures are viable. We will present data collected from several contaminated sites, including dry cleaning and petroleum (gasoline and diesel range) properties.. We will discuss the sampling procedures and results. Samples will be analyzed and quantified using techniques that have been optimized to achieve enhanced recoveries, precision and detection limits. Adsorbents are selected to prevent detectable carryover, to minimize water interference, and to maximize sample volume without breakthrough. Experiments and results will be submitted supporting these values. We also will discuss the additional advantages of thermal desorption as the optimal tool for the investigation of soil vapor.

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Pesticide Evaluations Using Thermal Desorption Gas Chromatography/Mass Spectrometry

S. VanEtten, V. Daliessio, EMSL Analytical, Westmont, NJ; L. Marotta, Perkin Elmer, Shelton, CT.

This study examines the effectiveness of collecting samples from indoor air spaces for a wide range of pesticides in air using gas chromatography/mass spectrometry (GC/MS). Many pesticides are currently used, and sometimes misused, by homeowners today. They are either overapplied or applied incorrectly. Some of these compounds are known to affect certain sensitive individuals, and can have severe toxicological effects. Even though the vapor pressure of these pesticides is low, this study will evaluate the sensitivity of this method compared with known NIOSH and OSHA collection methodologies. Useful applications of this technique include real estate prepurchase evaluations, incidents of overapplication of pesticides, verification that the correct pesticide was applied, and general evaluations of indoor air spaces. The GC/MS technique also allows the analyst to submit compounds for a mass spectral library search, which is helpful in performing the broadest screen possible. This study will compare conventional HPLC/UV and GC analysis methods to thermal desorption techniques using GC/MS. Sampling procedures also will be evaluated, including flow rate implications and breakthrough volumes.

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Occupational Exposure to Organophosphates Originating From Hydraulic Fluids

P. Molander, K. Solbu, S. Thorud, D. Ellingsen, National Institute of Occupational Health, Oslo, Norway; E. Lundanes, Institute of Chemistry, University of Oslo, Oslo, Norway.

In recent years attention has been paid to workers' exposure to hydraulic fluids and the possible health effects related to such exposures. The hydraulic fluids contain, among other additives, certain organophosphates, which are a group of chemicals that include compounds with large differences in toxicity. For example, the most toxic compounds among organophosphate pesticides are well known for their neurotoxic effects, including acetyl cholinesterase inhibition in the nerve cells. For that reason, it has been brought into question whether exposure to organophosphates used in hydraulic fluids may show similar harmful effects at relevant exposure levels. On this basis the National Institute of Occupational Health in Norway has developed analytical methodologies and performed exposure assessments to document exposure to organophosphates originating from hydraulic fluids in occupations in Norway. These fluids are used mainly in turbines within aviation and offshore industry. Today, there is a lack of scientific publications describing such exposures. In particular within aviation, there are several known incidents of pilots reporting such symptoms related to "smoke in cabin" incidents. Due to that the cabin air is bled off the compressed air from the turbines there has been plausible to hypothesize that the source of contamination to the cabin air is addressed to the engines and turbines, especially from hydraulic fluids containing organophosphates. The aim of this project was to develop analytical methodology that allows air exposure assessment of selected organophosphates originated from hydraulic fluids. We will present method development and exposure assessment data.

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Simultaneous Assessment of Vapor and Particle Concentrations Using a Semivolatile Aerosol Dichotomous Sampler

S. Kim, P. Raynor, University of Minnesota, Minneapolis, MN.

The Semivolatile Aerosol Dichotomous Sampler (SADS) was tested and compared with existing vapor- and particle sampling methods such as filtration, electrostatic precipitation, and vapor adsorption. Three different types of semi-volatile test droplets were generated: four single component materials, one mixture of single component materials, and two commercial metalworking fluids (MWFs). The single component chemicals were toluene, tetradecane, hexadecane, and bis(2-ethylhexyl) sebacate (BEHS). Particles having a 1.1-µm count median diameter were generated into a dynamic chamber, and their concentrations and composition in each phase were evaluated using gas chromatography. The amount of wall loss inside the SADS was also measured. Combined vapor and particle concentrations for each test aerosol were not measured to be statistically different except that the BEHS concentrations measured by activated carbon sorbent were lower than those from other methods. However, the particle concentrations estimated using the SADS were statistically higher than those from the other methods. For hexadecane, the average particle concentrations measured by the SADS and an electrostatic precipitator were 77.4% and 1.5%, respectively, of the combined vapor and particle concentrations; and for tetradecane, they were 52.1% and 0.020%, respectively. The wall loss of hexadecane and BEHS was 0.2% and 26.5% of overall concentrations in the SADS sampling, respectively. In the tests of the chemical mixture, a similar pattern of vapor/particle concentration ratio was observed. For the commercial MWF droplets, compounds having low molecular weight were more prevalent in the vapor phase than those compounds with high molecular weight. The compositions of particle phase were similar to those of the original fluids. The SADS separates vapor and particle instantly, and evaluates the concentrations of each phase individually. Our data suggest the SADS samples the particle phase of semivolatile aerosols more accurately than existing standard methods do.

Podium Session 109: Current Topics in Exposure Monitoring

Monday, June 1, 2009, 2:00 p.m.–4:40 p.m.
Papers 56–63

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The Investigation of Bioaerosols in the Carriages of the Kaohsiung Rapid Transit System

W. Lin, C. Lin, N. Hung, China Medical University, Taichung, Taiwan.

In 2008,, the Kaohsiung Rapid Transit System (KTRS), which includes the red and orange lines, started regular service in the largest city of southern Taiwan. There are there carriages for each time, and connect to each other without doors. According to the KTRS report, the average number of passengers was more than 100,000 per month. The bioaerosol concentrations in the indoor environment of the Taipei Metro have been reported to be highly correlated with the number of passengers. When the number of KTRS passengers increased, concerns about indoor environmental quality (IEQ), including bioaerosol concentrations, also increased, especially in the carriages. Recently, there was an IEQ guideline suggested by the Taiwan Environmental Protection Administration. Both the bacterial and fungal bioaerosol concentrations are suggested to be below 1000 CFU/m^3 for anytime in the indoor environment, such as in the carriages. This study was conducted to investigate the bioaerosol concentrations inside the carriages. The bioaerosols were collected by MAS 100 biosamplers inside the carriages when the door of the carriages opened and closed. During the bioaerosol sampling, relative humidity, number of people, and concentrations of carbon dioxide were recorded. One of the results determined the bacterial concentrations to be 580, 350, 660, and 70 CFU/m^3 when the door opened at four selected stations, respectively. They were 450, 940, 850, and 160 CFU/m^3 when the door closed. The genus of the fungal and bacterial samples are to be identified by microscopic and API identification system. All the relationship of bioaerosols data and environmental information will be analyzed further.

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The Characteristics of Bioaerosols in the New Metro Stations

W. Lin, N. Hung, C. Lin, China Medical University, Taichung, Taiwan.

The rapid transit system could bring convenient transportation to people. To promote the quality of public transportation and the upgrading of the city, the Taipei Metro has operated for more than 10 years in the largest urban area of northern Taiwan. In 2008, the Kaohsiung Rapid Transit System (KTRS), which includes the red and orange lines, started regular service in the largest city of southern Taiwan. According to the KTRS report, the average number of passengers was more than 100,000 per month. The bioaerosol concentrations in the indoor environment of the Taipei Metro have been reported to be highly correlated with the number of passengers. When the number of passengers increased, concerns about indoor environmental quality (IEQ), including bioaerosol concentrations, also increased, especially at the underground stations. Recently, there was an IEQ guideline suggested by theTaiwan Environmental Protection Administration. Both the bacterial and fungal bioaerosol concentrations are suggested to be below 1000 CFU/m^3 for anytime in the indoor transportation stations. This study evaluated the characteristics of bioaerosols in five underground KTRS stations, using MAS 100 bioaerosol samplers. The sampling sites included outdoors, concourse, and platform;and the samples were collected once each at morning, afternoon, and evening for each sampling day. The airborne bacterial and fungal concentrations outdoors were 220$\pm$182 and 75$\pm$8 CFU/m^3, respectively. At concourse, they were 487$\pm$416 and 36$\pm$24 CFU/m^3, respectively. At platform, they were 592$\pm$483 and 50$\pm$34 CFU/m^3, respectively. It was found that the bioaerosol concentrations did not exceed 1000 CFU/m^3 in the KTRS station. We will discuss the relationships between the concentrations and identification of bacterial and fungal samples and the environmental parameters.

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Performance Evaluation of Fluorescent Multiplex Array Technology for Allergen Exposure Assessment

E. King, S. Filep, B. Smith, M. Chapman, Indoor Biotechnologies Inc., Charlottesville, VA; P. Thorne, University of Iowa, Iowa City, Iowa; R. van Ree, Academic Medical Centre, Amsterdam, Netherlands; S. Arbes, A. Calatroni, H. Mitchell, Rho Inc., Chapel Hill, NC.

Monitoring the performance of allergen assays is essential to ensure reproducibility of allergen exposure assessments. We evaluated quality control and interlaboratory variability of a Multiplex ARay for Indoor Allergens (MARIA), which measures the eight most common indoor allergens in a single test. The 8-plex array measures Der p 1, Der f 1, Mite Group 2, Fel d 1, Can f 1, Rat n 1, Mus m 1 and Bla g 2. To evaluate performance, we analyzed reproducibility of positive control standards and spike recovery rates. We also performed a multicenter study in 10 laboratories across the United States and Europe to determine interlaboratory variability. All MARIA reagents required for the trial, as well as aliquots of 156 dust samples, were sent to 10 participating centers, and analyzed by each laboratory on three separate occasions. A hierarchical model was applied to the nested data (repeat nested within laboratories, laboratories nested within samples). The CVs of high and low positive control samples used in MARIA ranged from 11.2-15.9% (high) and 12.55-25.5% (low). Comparison of 14 samples spiked with 0.05-5 ng/ml Mus m1 or Rat n 1 gave recovery rates of 90.7% and 93.3%, respectively. Complete data for 3 of 10 laboratories participating in the multicenter study were available at time of submission, based on more than 10,000 individual allergen measurements. Allergen levels covered a wide range, from below detection limit to greater than 100 µg/g (Mus m 1 < 35 µg/g). Results were highly reproducible within, as well as between, the three laboratories, with correlation coefficients >0.95 for intra- and interlaboratory reproducibility. The quality control data indicates that MARIA is a robust assay with performance criteria that are reproducible within and between laboratories. Application of multiplex technology will provide standardized and consistent allergen measurements that will streamline indoor air quality exposure assessments.

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Quantitation of *Stachybotrys chartarum* Sch34 Antigen Using ELISA and Fluorescent Multiplex Array Technology

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Stachybotrys chartarum is a mold that grows well on high cellulose-containing materials and is commonly found in water-damaged buildings. *S. chartarum* can produce mycotoxins that may present a health risk upon prolonged exposure. Determining the risks associated with exposure requires reliable methods for assessment. Our aim was to develop sensitive immunoassays using ELISA and fluorescent multiplex array technology for the detection of *S. chartarum* antigen. Extracts of 13 isolates of *S. chartarum,* as well as of 10 other mold species commonly found in water-damaged buildings, were screened using ELISA for Sch34 antigen (see *J. Immunol. Methods* 332:121-128, 2008). These extracts also were tested by fluorescent multiplex array, using monoclonal antibodies covalently coupled to internally labeled microspheres. A panel of five newly developed monoclonal anti-*S. chartarum* antibodies was tested against mold extracts to determine species-specificity. ELISA and the multiplex array for Sch34 antigen did not cross-react with the 10 mold species tested, and were shown to be specific for *S. chartarum* and *S. chlorohalonata*, a species that shares the Sch34 antigen. Both assays exhibited high levels of sensitivity; dynamic ranges were 6-0.38 ng/ml for ELISA and 6-0.01 ng/ml for the fluorescent multiplex array. Results between ELISA and the multiplex array were closely correlated (r=0.99, n=16). The five newly developed monoclonal antibodies were found to be species-specific for *S. chartarum*. In addition, based on results of ELISA inhibition assays, these antibodies may bind to *S. chartarum* antigens other than Sch34 or different Sch34 epitopes, as they did not competitively inhibit binding in the Sch34 ELISA. We have developed species-specific and highly sensitive assays for *S. chartarum* antigen using monoclonal antibody-based ELISA and fluorescent multiplex array. The data suggest that murine antibody responses to *S. chartarum* tend to be species-specific and/or that *S. chartarum* produces unique antigens.

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Evaluating Occupational Exposure to Hydrogen Sulfide, Carbon Monoxide, PNOS, and Crystalline Silica (Quartz) During Remediation of a Glass-Based Foam Product

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A glass-based rigid insulation material was found during ongoing renovations to convert a school basement into a classroom. A review of the material safety data sheet identified hydrogen sulfide (H_2S), carbon monoxide (CO), glass dust (particles not otherwise specified or PNOS), and crystalline silica as hazardous ingredients of the blowing agent and rigid foam cell walls. The insulation material is composed of millions of closed glass cells and is friable. A concern was expressed that overexposure to the hazardous ingredients may occur if the insulation material is crushed or cut during the removal process. Personal air sampling was conducted using multigas monitors with electrochemical sensors for H_2S and CO in the worker breathing zone. Workers were assessed wearing full-face supplied air respirators, disposable coveralls with hood, double gloves, and boot covers while performing manual scrapping and foam removal from building surfaces inside a Type-III asbestos enclosure equipped with mechanical exhaust ventilation to the outdoors. Observed CO exposures ranged between 0.1 - 2.9 ppm STEV; <0.1- 0.9 ppm TWAEV and H_2S between <0.1 - 0.4 ppm STEV; and <0.1 ppm TWAEV. All were well below legislative and ACGIH exposure guidelines, indicating that mechanical exhaust ventilation was effective at controlling worker exposure to CO and H_2S. However, area sampling found average respirable quartz silica between <0.026 - 0.043 mg/m^3 and potentially exceeding the ACGIH TLV-TWA. Follow-up personal air sampling for silica ranged from <0.004 - 0.143 mg/m^3 TWAEV, and respirable PNOS values ranged from 0.13 - 3.11 mg/m^3 TWAEV. Respiratory protection, within the enclosure with mechanical exhaust, was downgraded to a full-face air-purifying respirator with P100 filter to prevent overexposure to glass dust and quartz silica and mechanical irritation of face and eyes.

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Worker Exposure to Respirable Silica and PNOS in Ontario Granite Shops

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Evaluating the exposure of granite shop workers to respirable silica and respirable particles not otherwise specified (PNOS) involved sampling and analysis of air and bulk material in several granite shops during routine operations, including dry and wet grinding. The concurrent sampling used cyclone size selection and preweighed filters permitting gravimetric analysis followed by XRD. This study presents results, including respirable quartz, cristobalite, and tridymite, and respirable PNOS for TWAEV personal air samples and percent quartz

and cristobalite for corresponding bulk substrate samples. Correlations between respirable PNOS and respirable silica are presented, and a basic analysis of the relationship between bulk silica content and airborne dust silica content is given. The study verifies the reduction in exposure to silica and PNOS attending control with water at the grinder head. For typical granite substrate, dry grinding operations demonstrate an overexposure to respirable quartz, cristobalite, and PNOS. For all operations with respirable PNOS exceeding the 3 mg/m^3 limit, respirable silica exposure was excessive. Silica exposure was also excessive at PNOS levels between 1 mg/m^3 and 3 mg/m^3. A basic equation to estimate respirable silica from typical granite grinding using a direct measurement of PNOS is explored. The sizing effect of dry grinding results in a reduction in the silica concentration of the respirable fraction airborne dust vs. the original bulk material. Sample overloading in one case influenced the lower detection limit for silica and substantiates the use of partial period sampling. In all cases, silica control programs were required, including provisions for engineering controls, work practices and hygiene practices, and facilities to control exposure, monitoring practices, personal records of worker exposure, medical monitoring, and training programs on the health effects of silica and the measures and procedures required.

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Evaluation of the Collection of Hexavalent Chromium Samples by OSHA ID-215 v2 on PTFE Filters

V. Daliessio, S. Van Etten, EMSL Analytical, Westmont, NJ.

This study aimed to validate the effectiveness of collecting samples for hexavalent chromium exposure on PTFE filters for subsequent analysis by method OSHA ID-215 v2.A known concentration of potassium dichromate solution was spiked onto filters, then method volumes of air were drawn through them. Samples were analyzed immediately, at 5 days, and at 10 days post-spike. The spiked samples were evaluated for analyte recovery and retention. This study was necessitated by a global shortage of PVC membrane used for the most common collection medium used for the method. Sampling procedures were evaluated, including flow-rate implications and breakthrough volumes.

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Evaluation and Extension of OSHA CSI Method for 4-Phenylcyclohexene for Area Sampling

V. Daliessio, S. Van Etten, EMSL Analytical, Westmont, NJ.

This study aimed to validate the effectiveness of collecting samples from indoor air spaces for 4-phenylcyclohexene (4-PCH; "new rug odor") at elevated volumes. Test atmospheres of known concentration (<10 ug/m^3) of 4-PCH were generated in an environmental chamber and sampled by the OSHA method at 0.05 L/min for 4 hr, 2.4 times the method volume. The methodology was evaluated for analyte retention and breakthrough. Useful applications of this technique include U.S. Green Building Council LEED Construction indoor air quality sampling, real estate prepurchase evaluations, odor and irritation complaints, and general evaluations of indoor air spaces. Sampling procedures were evaluated, including flow-rate implications and breakthrough volumes.

Podium Session 110: Aerosols

Monday, June 1, 2009, 2:00 p.m.–5:20 p.m.
Papers 64–72

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Characterization of Manganese Exposure in Welding Processes

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To explore a potential relationship between welders' neurological effects and exposure to airborne manganese in welding dust and fumes, a pilot project was conducted in three steel structure manufacturing facilities to characterize welders' exposure to airborne manganese from common welding processes. Manganese air concentration was measured as manganese in total and respirable dusts, while manganese size distribution was assessed by Cascade impactors with cut points of $PM_{2.5}$, $PM_{1.0}$, $PM_{0.5}$, and $PM_{0.25}$. The welding processes investigated were shielded metal arc welding (SMAW), gas metal arc welding (GMAW), submerged arc welding (SAW), and plasma arc welding (PAW). Manganese air concentration varied more than 19-fold by process, with 7 µg/m^3 for a PAW process and 135 µg/m^3 for a GMAW process (8-hr time-weighted averages). Besides process type, material composition and duty cycle (the amount of time the arc is on) were important determinants that significantly influenced manganese air concentration. Although SMAW usually generates less fumes, the measured manganese air concentration was 80 µg/m^3 due to high manganese content in the material (30% w/w in flex as MnO_2). Furthermore, manganese mass percentage in the welding particles varied by process, with total dust from a manually operated GMAW containning 6.5% manganese and that from a PAW process containing 1.7%. In addition, the concentration of manganese was higher in respirable particles than in total particles. Data from the multiple stage impactors further revealed that manganese mass percentage increased as the particle size decreased, indicating that manganese was more concentrated in small particles in welding fumes. This finding is of great significance in that manganese primarily targets the central nervous system and small particles in the nanosize range may reach the brain via olfactory transportation, bypassing the blood-brain barrier.

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Enhanced Generation of Nanoparticles with a Nebulizer-Cyclone System

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Nanotechnology presents many challenges for industrial hygiene research and practice. These challenges include the generation of aerosols suitable for testing air samplers, developing control equipment, and exposing animals in toxicological studies. Historically, the Collison nebulizer has served this purpose but produces droplets outside an optimal range for nanoparticle production. In our study, a cyclone was used to tailor the size distribution of droplets produced with a Collison nebulizer for optimal production of nanoparticles. A commercially-available cyclone (SCC112, BGI, Waltham, MA) was selected to provide a nominal 1-µm cutoff diameter when mated with a 3-jet Collison nebulizer (BGI, Waltham, MA) operating at 20 psig. This system was used to nebulize a dilute solution of fluorescein in 0.1 N ammonium hydroxide that dried to form solid particles. A scanning mobility particle sizer (TSI I Shoreview, Minn.) was used to measure the size distribution of the dried aerosol with and without the cyclone present at nebulizer pressures of 5, 10, 20, 30, and 40 psig. The resulting aerosol was substantially and significantly ($p < 0.001$) smaller and more narrowly distributed with the cyclone than without, indicating that the cyclone effectively removes larger droplets. Penetration by particle size curves derived from these data show that the cyclone provides a smaller cutoff diameter for greater nebulizer pressure. These curves also show an enhancement of the output of <100 nm particles with increased pressure. This finding was attributed to the shattering of large droplets on the wall of the cyclone opposite the cyclone inlet. These shattered droplets form nanoparticles when dried, thereby enhancing output. Nanoparticles generated with this nebulizer-cyclone system apply to a wide range of uses, from toxicological testing to sampler development.

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Exposure Assessment of Abrasive Blast Medias in Use at a Large Petrochemical Facility

R. Tutt, Exxon Mobil Corp., Baytown, Texas.

Abrasive blasting is an important and frequently used tool in the preparation, repair, and maintenance of petrochemical equipment. Blast media in use today include slags from smelting, fuel waste byproduct, and mined materials. Chosen for their typically low quartz content and performance characteristics such as hardness and profiling, they can contain varying levels of heavy metals. A 1998 NIOSH study of blast medias in a controlled abrasive blasting environment identified and ranked associated free-silica and heavy metal exposures. In 2006 an exposure assessment was conducted of abrasive blast media (Copper Slag, Garnet, Coal Slag and Olivine) in use at a large petrochemical facility. Results of the NIOSH study were used to help select agents of interest for evaluation. Virgin bulk samples were collected and analyzed for quartz and metal content. Air monitoring was performed of blasting activities in open area blasting (limited containment), in open-topped enclosures, and in enclosed spaces (vessels, unventilated blast rooms). The blast medias/activities evaluated were: (1) garnet, used for all thermal spray aluminum (TSA) prep-work and interior preparation of vessels to be coated; (2) copper slag, used for inspection blasting and exterior paint work; (3) olivine, used in "speed blasters" to prep small, localized areas for TSA coating and painting; and (4) coal slag, for blasting performed inside tarp enclosures. Sample results were above the occupational exposure limit (OEL) for free-silica and heavy metals for blasting performed on uncoated metals in enclosures and enclosed spaces with garnet and copper slag blast

medias. Statistically significant exceedances included (1) garnet - 95% confidence > OEL 34% of the time for manganese; and (2) copper slag - 95% confidence > OEL for silica 87%, for arsenic 36%, for cadmium 10%, for lead 27%, and for manganese 7% of the time.

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Mapping of Respirable Particulate and Noise Exposures Using Geographical Information System in Selected Stone Crushing Units in Central India

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In India, stone quarrying and crushing industries are an important class of essential industry that supplies the raw material for different scale of construction and transport-related projects. In stone crushing units, workers are involved with various dust-emitting and noise-creating operations such as loading, feeding, crushing, screening, and unloading. Few previous studies have attempted to recognize, evaluate, and map hazards in this sector. Lack of baseline information, confounded by lack of awareness and lack of willingness among unit workers, has resulted in extreme exposures being prevalent in this sector. The present exercise was carried out to generate an exposure profile and map spatial gradients so that specific cost-effective engineering and administrative control recommendations may be made. Measurements for respirable particulate were made using NIOSH protocol 0600. Area noise measurements were taken according to ANSI protocol S12.19-1996, using a direct read-out sound level meter. Measurements were performed on different days in both the first and second shifts. Numbers and activity of workers in each area were noted to see the workers exposure. Once the data were collected, they were averaged and referenced to the plant geography, and then the data were imported into Mapinfo GIS. The maximum time-weighted average (TWA) concentrations of respirable dust were found in primary and secondary crushers (range 10.709-5.288 mg/m^3) followed by screening (range 8.838-3.582 mg/m^3), unloading (range 4.163-1.736 mg/m^3), and loading (range 0.942-0.232 mg/m^3) operations. Whereas the maximum TWA measurements of noise were recorded in feeding (range 100 - 102 dBA) followed by primary crushing (range 97-99 dBA), secondary crushing (range 96-98 dBA), screening (range 93-96 dBA), and the unloading end (range 84-88 dBA). Following the creation of the exposure profile, a combination of dust and noise control strategies have been developed.

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Investigating the Aspiration Efficiency of a New High-Flow Inhalable Aerosol Sampler

R. Anthony, University of Arizona, Tucson, AZ; J. Volckens, Colorado State University, Fort Collins, CO; M. Van Dyke, National Jewish Health, Denver, CO.

This work focused on preliminary computational fluid dynamic (CFD) assessment of a new sampler designed to meet the inhalable particulate mass criterion at 10 Lpm sampling flow rate. A sampler with increased flow rate will increase the detection limit for inhaled aerosol exposure methods, which is critical to assessing and protecting the risk to workers in sensitive, low-concentration operations such as found during beryllium machining. This sampler uses a flat, porous mesh as a new inlet of the standard three-piece 37-mm cassette. The surface of this new meshed cap used 1043 254-µm pores in the central 15-mm of the sampler, resulting in 30% open area within the porous region. This sampler was oriented facing the wind, but 30 degrees below the horizon, mounted on an elliptical cylinder in a three-dimensional flow simulation. Three mesh densities were explored at three global tolerance levels to evaluate the quality of the fluid flow field in these simulations. Particle simulations were conducted for seven unit-density particle sizes and four bounce conditions to investigate both solid and liquid particle aspiration. Solid particles were aspirated within the range of aspiration efficiency reported by wind-tunnel manikin and CFD studies. The percentage of particles that hit the face of the sampler before being aspirated contributed from 24% to 64% of the critical area defining aspiration. The difference between solid and liquid particle aspiration efficiency increased with increased particle size through 50 µm. However, this difference decreased with increased particle size above 50 µm. Our results indicate that particle bounce is a critical component to porous-sampler aspiration. Consequently, this design and likely other small-porous samplers may underestimate the actual inhalable fraction when used to estimate exposures to liquid aerosols.

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Personal Sampler Performance for Coarse Aerosols in Ultralow Wind Speed Environments

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The development of personal inhalable aerosol samplers is based on criteria for the inhalable aerosol fraction under the assumption that such conventions were set with regard to realistic workplace conditions. Most of the research used to develop such standards was performed in fast-moving air, at wind speeds above 0.5 m/s. Aside from highly ventilated environments such as underground mines this is not representative of most modern workplaces where typical wind speeds are in the range from 0.25 m/s to 0.35 m/s. The research presented here was therefore intended to provide an assessment of personal samplers, specifically for the inhalable fraction, in very low wind speed environments. This required the use of a wind tunnel that was capable of creating a distribution of aerosols uniform in both concentration and particle size, and yet accounted for the increased effect of gravitational settling on aerosols in such environments. The ultralow-speed wind tunnel developed for that purpose was used in conjunction with a simulated life-size heated, breathing human manikin, continually rotated over a full 360 degrees. Four personal samplers commonly used by industrial hygienists (closed-face cassette, IOM inhalable sampler, GSP conical inlet sampler, and button inhalable sampler) were attached to the manikin for concurrent sampling. The aspiration efficiency of each sampler was compared with the inhalable aerosol concentration as measured by the breathing manikin. Results showed that while the closed-face cassette did not provide a good assessment of the inhalable fraction, the IOM, GSP, and button samplers all proved adequate. These findings will be important considerations for industrial hygienists doing not only routine monitoring, but also taking measurements for epidemiological studies attempting to link personal sampling data to health outcomes.

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A Personal Sampler for Assessing Inhaled Nanoparticle Exposures

J. Volckens, A. Marchese, A. Prieto, Colorado State University, Fort Collins, CO.

The goal of this work was to develop an accurate, sensitive, and specific method to assess personal exposures to engineered nanoparticles. We designed and constructed a small thermal precipitator to measure human breathing-zone concentrations of airborne nanoparticles. Specifically, our approach was geared toward distinguishing engineered nanoparticles from other incidental nanoparticles (i.e., ultrafine particles) that are ubiquitous in typical workplace and environmental atmospheres. We hypothesized that engineered nanoparticles could be identified and distinguished from incidental and biogenic nanoparticles based on the use of energy-dispersive spectroscopy conducted directly on collected particles. This sampler used thermal force to capture airborne nanoparticles on transmission electron microscopy (TEM) substrates. Furthermore, by rotating several TEM substrates through the collection zone during the sampling period, we hoped to resolve an individual's exposure in time. These substrates were subsequently analyzed off-line to determine the size, shape, and chemical composition of individual particles. We will present results from initial laboratory testing, including collection efficiency as a function of particle size (5 - 250 nm), along with instrument sensitivity and specificity for identifying and quantifying concentrations of nanoparticle aerosols.

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Glass and Metal Arts Exposure Assessment

G. Croteau, J. Camp, University of Washington, Seattle, WA.

Artists and artisans working in the metal and glass arts are potentially exposed to airborne contaminants generated in a wide array of tasks. Despite the potential for occupational exposure in the metal and glass arts, there is very little exposure assessment data available. Consequently, the relative risk posed by the use of different materials in different processes is not well understood, nor is the need for engineering controls or personal protective equipment. In the glass arts, primary exposures of concern include trace metals contained in colorants, leaded glass, crystalline silica, and combustion products. Exposure levels in the glass arts were typically found to be less than the respective OSHA permissible exposure limits. The cold processing of leaded glass, however, poses a concern as elevated lead exposures were associated with glass polishing, cutting, and grinding tasks, despite the use of water spray. Compared with the glass arts, the metal arts use many different processes and a wider array of feedstocks, providing a challenge to exposure monitoring. Low exposures to trace metals and flux components were associated with soldering and metal

grinding/polishing tasks. However, the use of silica-containing grits and polishes in poorly ventilated areas could result in elevated exposure levels. Task-based exposure associated with the sieving and application of lead containing enamels also indicated a potential for overexposure, depending on the duration and frequency of the task. Artists use a number of controls for reducing the potential for exposure, including substitution/elimination and engineering controls. In this presentation, we will review several of the controls that were being used in the glass and metal arts studios visited.

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Control of Microbial Exposure from Metalworking Fluids

R. Gorny, A. Lawniczek-Walczyk, A. Niesler, A. Wlazlo, D. Lis, E. Anczyk, Institute of Occupational Medicine and Environmental Health, Sosnowiec, Poland.

Water-based metalworking fluids (MWFs) are excellent nutritional sources for numerous microorganisms and these, if spread into the air and then inhaled, can cause health hazards to exposed workers. Therefore, the proper methods of microbial exposure assessment need to be applied to control the hygienic quality of the occupational environment. The aim of this study was to compare the applicability of stationary and personal sampling strategies to control the exposure to MWF bioaerosols. The study was performed in two-year cycles (in all seasons), at two multiple tool cutting and machining departments in a factory of medical equipment. Stationary measurements were carried out using three different sampling techniques (impaction, impingement, and filtering) and were compared with personal exposure data obtained by filter sampling. The differences in exposure estimated on the basis of culturable (viable) and total (viable plus nonviable) microbial counts were also addressed. Quantitative analyses were supplemented by identification of bacterial and fungal strains. The microbial concentrations obtained by personal sampling were always higher than those measured by stationary samplers. Whereas an impactor sampler revealed the highest bacterial and fungal species diversity in the air (41 bacterial strains and 47 fungal strains were identified), its quantitative estimations of microbial counts always were significantly lower than those obtained using impinger and filter samplers. The culturable microbial counts were significantly lower than total counts. The size distribution analyses showed that bacteria were mostly present in the air as agglomerates of bacterial and MWF particles, whereas fungi were usually present as single particles. This study showed that personal sampling of microbial aerosols derived from MWFs more precisely characterizes worker exposure than stationary sampling. If possible, the total microbial counts obtained by personal sampling, should be included in bioaerosol exposure assessment. However, an impactor sampling can provide more detailed qualitative information than other tested sampling methods.

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Lead Fraction of Total Settled Dust from Single-Family Housing Demolition

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A study team from the University of Illinois at Chicago and the National Center for Healthy Housing collected settled dust using passive dust collection techniques from the vicinity of 101 scattered-site, single-family home demolition events. Approximately 450 demolition events and 120 reference (background) samples were collected and analyzed for total and lead dust. In addition, air samples were collected from a subset of 25 areas. The study was supported by HUD. Preliminary data indicated that the lead fraction of the dust collected near the demolition events was about 10 times greater than the lead fraction of dust collected from reference areas. This fraction was also greater than the fraction of lead normally found in urban soils. The study hypothesized that the source of settled lead dust near the sites was lead-based paint from the demolished structures. In this platform presentation, we will explore this hypothesis with statistical analyses of the data, as well as other information about urban lead sources. The purpose of the study was to evaluate the potential for demolition to generate settled lead dust levels relative to EPA and HUD indoor settled dust standards. The long-term goal of the study is to evaluate evidence for controlling dust and lead dust from demolition and to make evidence-based recommendations regarding total and lead dust control appropriate for housing demolition activities.

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Lead Dust Contamination from Paint Remediation in Workers' Personal Vehicles

C. Boraiko, E. Wright, F. Ralston, Middle Tennessee State University, Murfreesboro, TN.

Professional workers who perform lead-based paint abatement and interim control activities in homes built before 1978 are at risk of exposure to harmful levels of lead dust. Because of the generally low level, but variable exposure concentrations in airborne lead dust levels during the residential interim control and abatement process (remediation), adherence to training and personal protective equipment usage may decrease throughout time as perception of exposure decreases. Harmful levels of lead dust can be brought home to families by those working in the lead hazard control trades because airborne lead dust settles onto horizontal surfaces, including floors. The purpose of this study was to explore tracking of lead-contaminated dust by remediation workers from residential work sites to their personal vehicles, thereby potentially exposing their personal homes and families. EPA protocols for the remediation worker require the use of personal protective equipment, including a full body cover, foot covers, gloves, and a respirator for particular tasks within the work site containment area. It was hypothesized that a significant population of workers did not consistently follow EPA protocols for required foot covers, resulting in personal footwear contamination. Wipe samples were collected from the driver and passenger floorboards of the workers' vehicles and analyzed for lead. The laboratory's level of quantitation for lead on the wipe samples, 10 $\mu g/ft^2$, was used in this study to indicate lead contamination. This level was exceeded in 50% of the floorboards sampled. These results confirm that floorboards in many vehicles used by remediation workers are contaminated with lead dust, potentially resulting in transfer of lead into private homes.

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Lead and Total Dust Deposition as a Function of Distance from Demolition

A. Welch, ChemRisk, Boulder, CO; S. Cali, B. Catalin, P. Scheff, A. Mucha, S. Erdal, University of Illinois at Chicago, Chicago, IL; S. Dixon, National Center for Healthy Housing, Columbia, MD; D. Jacobs, University of Illinois at Chicago and National Center for Healthy Housing, Chicago, IL.

Researchers from the University of Illinois at Chicago and the National Center for Healthy Housing used passive dust collection methods to sample for lead and total dust during the demolition of 101 scattered-site, single-family homes. Background sampling was also performed at a number of relevant sites. In total, roughly 120 background and 450 demolition samples were collected and analyzed for lead and total dust. Air samples were also collected at a subset of 20 demolition and 5 background sites. The study was supported by HUD. In this presentation, we will provide a summary of the total settled dust and lead dust sampling results; primarily our presentation will focus on the relationship between lead and dust settling rates as a function of distance. Our goal was to determine the distance at which lead and total dust generated during demolition became equivalent to background lead and total dust deposition rates. Comparing these results was important for evaluating compliance with settled lead standards, as well as protecting the health of residents. Preliminary results indicated that demolition activity resulted in elevated lead and total dust. Elevated lead and total dust settling rates were measured as far as 100 meters from demolition. The purpose of the study was to evaluate the potential for demolition activities to create settled lead dust levels and to compare those values with EPA and HUD indoor settled dust standards. The long-term goal of the study is to evaluate the effectiveness of dust control on lead and total dust generated during demolition and to make recommendations regarding methods of dust control.

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Characteristics of U.S. Workers Whose Blood Lead Levels Triggered the Medical Removal Protection Provision, and Conformity with Biological Monitoring Requirements, 2003-2005

W. Alarcon, S. Tak, J. Sestito, A. Sussell, G. Calvert, NIOSH / CDC, Cincinnati, Ohio; R. Roscoe, NIOSH (retired), Cincinnati, Ohio; J. Ju, Constella Group LLC, Durham, NC.

Workers with blood lead levels (BLL) greater than or equal to 60 µg/dL (50 µg/dL for construction workers) or with three or more consecutive BLLs taken during at least 6 months that averaged 50 µg/dL or greater are required to be removed from work involving lead exposure that exceeds the OSHA action level. This study estimated the proportion of workers with BLLs that triggered the medical removal provision by industry sector, and examined whether workers received appropriate follow-up blood lead testing. Three years (2003-2005) of data from the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program were analyzed to identify those industries with a high percentage of workers with BLLs that triggered the medical removal provision. Adjusted rate ratios (RR) of adults with such BLLs were estimated by industry sector compared with the battery manufacturing industry using Poisson regression models. Out of 13,724 adults with BLLs greater than or equal to 25 µg/dL, a total of 533 adults had BLLs that triggered the medical removal provision. RRs of adults with BLLs triggering medical removal were highest for 'painting and wall-covering contractors' (RR = 22.1); followed by highway, street, and bridge construction'workers (RR = 14.7);amusement, gambling, and recreation'' workers (RR = 11.4);and glass product manufacturing workers (RR = 10.1). Overall, 29% of adults with BLLs triggering medical removal received appropriate follow-up blood lead tests and met the eligibility to return to lead work. These findings suggested that additional efforts are needed to prevent occupational overexposure to lead in adults and to ensure proper medical management of those workers who meet medical removal criteria.

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The Scientific Evidence for Updating the Residential Lead Dust Standard

D. Jacobs, S. Dixon, J. Gaitens, J. Wilson, National Center for Healthy Housing, Washington, DC.

There is evidence that the federal government standard for lead dust in housing established in 2001 should be made more protective. New data on dust lead (PbD) and childhood blood lead (PbB) from the 1999-2004 National Health and Nutrition Examination Survey (NHANES) show that when floor PbD equals 10 µg/ft^2, more than 95% of children will have PbB less than 10 µg/dL; 73% will have PbB less than 5 µg/dL and geometric mean PbB equals 3.9 µg/dL; after controlling for confounding variables, such as age of child; race/ethnicity; serum cotinine; poverty; country of birth; year of building construction; floor surface condition; presence of deteriorated paint; house/apartment type, smoking in the home, and recent renovation. The NHANES cohort included 2155 children 12-60 months old , with measured PbB and PbD, and is the first time environmental data have been collected in a nationally representative health survey. Data from housing surveys and from NHANES showed that between 90-98% of U.S. homes already have PbD less than 10 µg/ft^2. The population-weighted geometric mean floor and window sill PbD was 0.5 µg/ft^2 and 7.6 µg/ft^2 , respectively. Only 0.16% of the floors and 4.0% of the sills had PbD at or above the current federal standards of 40 µg/ft^2 and 250 µg/ft^2, respectively. Other data showed that the mean floor PbD in homes abated six years ago is 4.8 µg/ft.^{2} Another study showed that 95% of floors had PbD less than 10 µg/ft^2 one year after intervention. Laboratory reporting limits for dust wipe samples have improved, which means a more protective standard is feasible, measurable, and necessary. EPA should review this new evidence and establish a more protective standard, as it already does for other exposure limits. A standard of 10 µg/ft^2 on floors and 100 µg/ft^2 on interior window sills will protect more than 95% of all children.

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U.S. Army Artificial Turf, Dealing with Lead

V. Belfit, U.S. Army, Gunpowder, MD.

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) identified lead as a potential hazard associated with lead in artificial or synthetic turf fields. The Army uses thousands of artificial turf fields on installations worldwide. In an effort to evaluate potentially lead-containing turf, USACHPPM issued preliminary guidance for industrial hygiene sampling and laboratory analysis, and recommended interim health-based standards to apply to lead in bulk and dust samples, in the absence of federal standards. USACHPPM also issued guidance on personal hygiene practices to protect infants and young children exposed to potential lead in turf in Army child development centers. In addition, the Army is conducting a comprehensive inventory to identify locations of all synthetic playground surfaces in child, youth and school services programs; Army family housing areas; and garrison parks and picnic areas. The inventory will include available information regarding the synthetic material, including manufacturer, material safety data sheets, name and address of the installer, and date installed. Once the data has been collected, the Army will evaluate this information and determine whether additional testing is required. USACHPPM is currently working with the Consumer Product Safety Commission, EPA, and CDC to develop a voluntary national standard for maximum level of total lead content in synthetic turf fibers. This action is being accomplished through collaboration with EPA and the ASTM Committee 21006 "New Specification for Maximum Lead Content in Synthetic Turf Fibers." In this presentation, we will discuss the results of the Army comprehensive lead in synthetic turf data inventory, and the most current USACHPPM guidance, recommended actions, surveys conducted, and progress in consensus standards development.

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Real Occupational Hygiene: What Does It Take to Remove Toxic Metals from the Skin?

E. Esswein, NIOSH, Denver, CO; M. Boeniger, Public Health Consultant, Cincinnati, Ohio; K. Ashley, NIOSH, Cincinnati, Ohio.

For decades, occupational health and safety professionals have encouraged (or supported the notion) that hand washing is essential for preventing the transfer of toxic contaminants to the peri-oral region and preventing percutaneous absorption. However, the efficacy of the means by which hands are washed (or decontaminated) is seldom tested or challenged in terms of acceptability. Toxic metal (especially Pb, Cd and CrVI) contamination on the hands of workers continues to be a known occupational health risk. NIOSH field studies have shown that workers and management are generally not aware of how much contamination is present on workers' hands, and especially how ineffectively they might be removing metal contamination when washing skin (i.e., hands) with soap and water. Failing to understand the degree of contamination (or the effectiveness of decontamination) results in increased ingestion risks for exposures while eating, drinking, or smoking. NIOSH field studies have documented incomplete removal of metals (especially Pb) from skin using hand washing with soap and water. To address this, NIOSH researchers invented a highly effective method of decontaminating skin exposed to lead and other toxic metals. The method involves a patent-pending systems approach of the combined effects of surfaction, mechanical removal, pH adjustment, and chelation. The method was conceived and designed to be skin compatible and easy to use. In this presentation, we will discuss the conception, invention, and laboratory evaluation of the Handwipe Removal Method for Toxic Metals, which was developed as an ensuing method to the Handwipe Disclosing Method for the Presence of Lead (also a NIOSH invention).

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WITHDRAWN

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Federal Healthy Homes Programs

W. Friedman, HUD, Washington, DC; G. Chew, Centers for Disease Control and Prevention, Atlanta, GA.

With more than 6 million substandard U.S. housing units, the scientific evidence suggesting that such health problems as asthma, lead poisoning, and unintentional injuries are linked to preventable housing deficiencies indicates that substandard housing is creating major health problems. Creating healthier, safer, and more efficient housing can save billions in health care costs. Federal agencies, including HUD, CDC, EPA, and USDA are developing a national framework that establishes a coordinated and comprehensive approach to preventing diseases and injuries related to health hazards and deficiencies in housing. We will describe and discuss regulatory, policy, research, and outreach needs and their implications in the development of comprehensive, integrated approaches linking health and housing to ensure safe, healthy,

and efficient housing. Major aspects of the framework being developed include building capacity to deliver healthy housing, mainstreaming healthy housing principles, creating healthy housing through research, developing enforcement and regulatory strategies, marketing healthy housing, and educating the public and practitioners.

Podium Session 112: Agricultural Health and Safety

Monday, June 1, 2009, 2:00 p.m.–5:00 p.m.
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Risk Factors for Musculoskeletal Symptoms Among Louisiana Crawfishermen

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Crawfish farming is a valuable industry, with more than 79,000,000 pounds manually harvested in 2006, with a value of more than$95,000,000. Ninety percent of the crawfish produce in the United States is harvested in Louisiana. Physical risk factors for musculoskeletal disorders (MSDs) and symptoms (MSS) have been associated with work in commercial fishing; however, little information exists on MSS among crawfishermen. Therefore, this study assessed prevalent MSS among crawfishermen, and will identify associations between MSS and factors of occupational exposure among crawfishermen. A self-administered questionnaire, which assessed MSS in nine body regions, and descriptive information about work in crawfish production was mailed to 1180 crawfishermen in Louisiana. Of the 184 crawfishermen who responded, preliminary results suggested that 62% experienced shoulder MSS and 61% experienced low back MSS. Furthermore, 48% experienced neck MSS, and 47% experienced wrist/hand MSS. The prevalence of shoulder, low back, and wrist/hand MSS was much higher than previously reported among commercial fishermen. These data will be analyzed for associations with work practices. The results will have a significant impact on understanding MSS among crawfishermen. This study will provide important information for future studies on ergonomic interventions for the crawfish industry, as well as other subsets of the commercial fishing industry.

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Exposure Assessment Surveys of Rural Iowa Farm Homes

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The Keokuk County Rural Health Study (KCRHS) was a prospective cohort study of a population in a highly agricultural, southeastern Iowa county that is typical of the row crop farming and livestock production in Iowa. Agricultural exposures in the rural Midwest arise primarily from raising livestock and row crop production. The association between the environmental and agricultural exposures that farm families encounter and their risks for respiratory and neurobehavioral diseases, hearing loss, and injuries were studied. The study included in-home hazard surveys to measure the airborne dust levels inside and outside of the farm homes, using PM 10 and PM 2.5 air monitors. Evaluations of potential exposures to lead, mold, pesticides, and solvents were also evaluated in and around the homes. The condition and presence of safety features on farm equipment also were assessed. As of October 2008, 70 farm home surveys were completed. The goal of the study was to conduct surveys of all 300 farm families enrolled in the study and to use the results of these surveys to evaluate the health risks associated with farm exposures. Preliminary results indicated that dust levels are quite variable, and factors such as in-home pets, living near animal raising facilities, grain handling operations, and dirt roads influences dust levels. Pesticides and solvents were generally stored outside the home. Many older tractors without proper lighting and marking or rollover protective structures were still used by farmers in the study. The use of protective equipment such as respirators, hearing protectors, and safety glasses remains low. The results of the study indicate that farmers continue to encounter a wide variety of occupational and environmental exposures that may affect their health.

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A Task-Specific Assessment of Swine Worker Exposure to Airborne Dust

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Numerous studies have demonstrated that workers in large swine "confinement" buildings have an elevated risk of acquiring a number of respiratory ailments and consistently demonstrate a marked decrement in lung function during a workshift. Currently, very few studies have focused on task-related exposures. Therefore, the purpose of this study was to identify tasks that produced the highest exposure levels to provide guidance to workers in these facilities as to when respirator use would be advised. Six workers in each of two gestation/farrowing facilities wore personal dust-sampling devices during each sampling episode. Each facility was visited three times, once each during summer, winter, and spring . Workers reported the tasks and corresponding start times they performed with the use of a small binder. Each worker was equipped with a backpack containing a sampling pump and light-scattering aerosol photometer. A flexible sample line attached the sample pump to an inhalable dust sampler located near the worker's lapel. The self-reported task types were categorized into nine general task types. Photometer readings were adjusted so that their average corresponded to the paired inhalable dust concentration. Task-level concentrations were then computed from the average of adjusted photometer readings during the time period recorded for the task. A significant difference was found between concentrations measured during each season ($p < 0.001$) but no difference between sites ($p = 0.268$). The highest personal concentrations ranged from 0.1 mg/m^3 in the summer to 10.6 mg/m^3 in the winter. Interestingly, there was no significant difference between task types in the winter ($p = 0.083$), but there was in the summer ($p < 0.001$). The task resulting in the highest exposures was related to the weaning process. Recommendations include wearing a respirator during that task and whenever possible in the winter months.

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Aerosol Characterization During Farm Field Activities in Northwest Ohio

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This study characterized aerosols in a farm field during major activities (post-harvest/preapplication of fertilizer, baling, fertilizer application, between disking, post-disking) compared with a control farm field with no activities. In addition to increasing the understanding of the aerosol characteristics, the data are being used to devise predictive models within the farm fields. Direct reading instruments (DustTrack Model 8520, P-Trak Ultrafine Particle Counter Model 8525, TSI Inc. & ARTI HHPC-6, Hach Ultra Analytics) were used in the direction opposite the wind, during seven days of monitoring at locations across the fields at 1.5 m from the ground. In some locations (immediately inside/outside the field boundaries and field center), aerosols were monitored at 0.5, 1.5, 2.5, 3.5 and 4.5 m. Ultrafine particles (UFP) (counts/cm^3), aerosol counts/liter (in the six particle-size channels of 0.3, 0.7, 1, 2, 5, and 10 µm) and respirable/ total concentrations of aerosols, climatic factors and GPS locations were determined. The study field showed significantly ($p < 0.01$) higher particle counts (except at 0.3 µm particle size) and concentration (µg/m^3) than those in the control field. Although the (mean ± SD) concentration of total aerosols (32.3 ± 16.7) was higher than those of respirable aerosols (28.6 ±15.3), the difference was not significant, showing that the majority of aerosols was respirable. The levels of aerosols did not change with the height from ground. During major activities (e.g., fertilizer application, disking), the aerosol counts/concentration increased significantly. The respirable particle concentration was significantly ($p < 0.01$) correlated with total concentration and the counts of smaller particle sizes (UFP, 0.3, 0.7 µm). The aerosol counts and concentration changed minimally during the days of monitoring, except for during the major activities.

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Adolescent Noise Exposure Among the Rural Agricultural Population

M. Humann, W. Sanderson, J. Moore, University of Iowa, Iowa City, Iowa; G. Flamme, Western Michigan University, Kalamazoo, MI.

The prevalence of noise-induced hearing loss is higher among farming and rural populations due in part to exposure to livestock and noisy machinery normally found on the farm. This common occupational illness is not fatal, but can seriously affect the quality of life for those affected. While hearing loss is mostly associated with farmers older than 50 years of age, it is believed that hearing loss among farmers begins in early adolescence. The purpose of this study was to assess the noise exposures of farming and nonfarming adolescents in rural areas. Noise exposures for adolescents were determined by self-administered personal noise dosimetry. Study subjects were mailed a preprogrammed, calibrated, noise dosimeter and asked to complete two days of monitoring while they were engaged in typical farm/rural activities. In addition, the subjects

were given activity cards for each day of monitoring and asked to keep a time-specific record of the activities, equipment usage, and hearing protection usage. Noise exposures were collected, using ACGIH criteria with and without a threshold setting. Subjects completed two rounds of sampling for a total of four samples for each subject. Noise exposures for adolescents living in a rural environment ranged from 45 dB to 103 dB, with an average noise exposure of 80.4 dB. The highest exposures were associated with tasks that involved mechanized equipment. The study methodology, while cost effective and less time consuming, may not be a reliable or efficient data collection strategy for noise exposure. To gather two days of data, a dosimeter was usually in the field for three to four weeks and in some cases for more than a month. Furthermore, the task cards were frequently filled out poorly or had missing data. However, even kids as young as 13 didn't have a problem correctly operating a noise dosimeter.

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Farm Workers' Perceptions About Hearing Loss

M. Vela Acosta, The University of Texas, Health Science Center-School of Public Health, Brownsville, Texas.

Occupational hearing loss is the most common occupational disease in the United States. It affects all workers regardless of age, gender, or industrial sector. Agricultural work has been associated with a high prevalence of hearing loss. Farm workers directly associated with intense field work and transport activities are potentially at risk for the development of hearing loss. The Hearing Ability Survey (HAS) uses the Gallaudet scale to identify persons with hearing problems and grades them according to the extent of hearing loss. This study described perceptions about hearing loss among farm workers and assessed the feasibility of using HAS in Spanish. Farm workers (n=25) participated in three focus groups to assess perceptions about occupational hazards (noise and chemical exposures) and hearing loss. The sensitivity and specificity of the Spanish-HAS farm workers responses were compared using audiometric pure tone. Farm workers described their exposures to noise, chemicals and pesticides, dust in adverse work environments. They lacked personal protective equipment and training in hearing conservation. Most farm workers (73%) reported working in a noisy environment, and some reported working in a noisy environment for more than 6 years (39%). Nine farm workers (39%) had hearing loss (≥25dB average; 500, 1000, 2000 Hz). The proportion of hearing loss increased to 69% when criteria included higher frequencies (≥25dB average; 4000, 8000 Hz). The Spanish-HAS proportion of responses classified correctly was 70%, sensitivity was 46%, and specificity was 90%. This study grants further assessment of the prevalence and risk factors of hearing loss among farm workers. Translational research is needed to implement and evaluate methods for detection of hearing loss to plan effective implementation of prevention programs among a socioeconomic disadvantaged population. Validation of the HAS may enable screening among Spanish speaking farm workers.

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Occupational Noise Exposure Assessment of Rural Small Farmers in Kentucky

E. Iyiegbuniwe, C. Nagy, J. Rudolph, Western Kentucky University, Bowling Green, KY.

This pilot study was conducted to assess occupational noise exposures and to develop an intervention program for a sample of 24 rural small farmers in Kentucky. Although hearing loss due to hazardous noise is preventable, many small farmers continue to be overexposed. Reducing noise exposures and hearing loss among farmers in rural communities represents an important opportunity to demonstrate the benefits of occupational noise prevention and control programs in a special and underserved population of farmers. Questionnaires were administered to elicit demographic information, exposure history and use of farm machineries, tractors, and hearing protection. Personal and real-time noise monitoring was conducted across various activities and producer groups. Descriptive statistics from the questionnaires and noise exposures were analyzed to evaluate relationships between noise, work history, and farming activities. The results showed that farmers' mean age was 31 years (range = 19-59) and an average of 18 years (range = 4-45) working on the farm six days a week. Self-reported questionnaires showed that 56% of farmers never used hearing protection during farming, and 78% do not know how to correctly use hearing protection. The results of noise exposures showed that the poultry operation recorded the lowest noise levels (<85 dBA) while the cattle operation had the highest noise level of 97 dBA. Real-time noise monitoring ranged from 86 dBA while moving a spreader truck to 106 dBA during packaging. Approximately 38% of the farmers exceeded 85 dBA, without regard for the use of hearing protection. The project also identified key activities and various intervention options, including engineering controls, substitution, and the use of hearing protection. A successful hearing conservation program for this group of small farmers would require support from various stakeholders, policy development and enforcement, education, motivation, and an effective use of hearing protection to prevent hearing loss in this high-risk population.

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Occupational Health Clinics for Migrant Farm Workers

M. Lawrence, Occupational Health Clinics for Ontario Workers (Hamilton Clinic), Hamilton, ON, Canada.

In 2006 the Occupational Health and Safety Act was extended to farming operations affecting, among others, 1474 employers and the 17,786 temporary farm workers in the Seasonal Agricultural Worker Program. There were 8942 workers from Mexico and 8842 from the Caribbean (Jamaica, Trinidad and Tobago, Barbados, and East Caribbean countries). The farming operations include fruit, vegetables, tobacco, ginseng, sod, flowers, nurseries, greenhouses, food canners/processing, and bee keeping. For the past three seasons, the Occupational Health Clinics for Ontario Workers have provided occupational health services for these workers in Southern Ontario. Clinics are held in locations where farm workers congregate on weekends, and they are staffed by a team that includes a physician, occupational health nurse, occupational hygienist, and Spanish translators. This presentation will be a discussion of the occupational health problems that we have seen in this group of workers. Many resource materials developed in the United States for the Worker Protection Standard are adaptable to this context, and some of these will be described.

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There Is Another Respiratory Protection Regulation for Pesticide Handlers in California

H. Fong, Cal/EPA, Department of Pesticide Regulation, Sacramento, CA.

In California, there is a bifurcation of jurisdiction for pesticide handlers/users. Pesticide handlers are primarily regulated by the Department of Pesticide Regulation (DPR). As such, DPR has its own set of health and safety regulations concerning personal protective equipment use, medical monitoring, training, and other such aspects. The respiratory protection regulations (Title 3 CCR Section 6738 [h]) had been in place since the mid 1980s and with the development of Title 26 CFR Part 1910.134, DPR decided to update its respiratory protection regulations. After reviewing 1910.134, DPR began development of respirator regulations that were specific to the pesticide-using industry. Some parts of 1910.134 were discarded for obvious reasons (there are no firefighters involved in pesticide use), others for reasons of jurisdiction (oxygen-deficient atmospheres are not truly a pesticidal activity and are cited as OSHA jurisdiction), while still other parts were modified because of the peculiarities of the pesticide workplace (air monitoring is not routinely conducted). We will compare the recently introduced respiratory protection regulation (Section 6739) with 1910.134, and explain why the differences make Section 6739 most appropriate when dealing with pesticide handlers.

Podium Session 113: Advancing Concepts in Microbial Investigations

Tuesday, June 2, 2009, 10:30 a.m.–12:30 p.m.
Papers 91–96

91

Defensible Strategies for Mold Investigations

H. Burge, EMLab P&K, San Bruno, CA.

No guidelines for interpreting indoor mold data exist, and investigations are unique. Therefore, developing hypotheses, planning steps for testing hypotheses, and establishing criteria for hypothesis acceptance are essential. There are two hypothesis categories for mold investigations, (1) those that address only the environment, and (2) those that address human exposure. Type 1 hypotheses address questions such as "is there mold in this crawl space" and "are mold spores from the crawl space entering the occupied space"? Hypotheses must address the negative case to avoid bias. For the first hypothesis (there is no mold in the crawl space), sampling may not be necessary, since there is always mold in crawl spaces. For the second (mold in the crawl space is entering the occupied space) sampling in both the crawl space and the occupied space is

necessary. Spore trap sampling can be used with microscopic analysis, and the number and timing of samples is calculated based on the probability you require of having the correct answer. The second hypothesis category addresses human exposure. The first step in the development of human exposure hypotheses is to decide which agents of disease are of interest. For example, if sick building symptoms are reported, hypotheses should address agents that have been reported to cause these symptoms. The second step is to develop a set of hypotheses addressing possible sources for exposure. Third, hypotheses must be generated to address actual exposure of those with symptoms to the materials in the hypothetical reservoirs. Data interpretation involves deciding what constitutes "exposure," what is the relative level of exposure, and is the exposure level unusual relative to other environments? Sampling strategy must address these interpretation questions. Hypothesis-driven investigation strategies will enable the accurate assessment of mold problems, and will provide scientifically and legally defensible data.

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Dynamics of Surficial Mold in Indoor Environment

R. Sahay, S. Parvataneni, R. Barnes, F. Aguirre, A. Wozniak, A. Singh, J. Gasana, EDLab at Pure Air Control Services, Clearwater, FL.

Surficial mold samples were collected on BioScan400™,a sample collection device for environmental surface sampling. More than 6500 specimens were collected during a five-year period (2004-2008) from both residential and commercial facilities across the United States to determine the types and abundance of mold growing on indoor surfaces such as dry wall, insulation liner, carpet, and other building materials. This study established a reliable reference, including numerical value in terms of counts/cm^{2}, for evaluating mold in a building. Findings suggest that numerically, 50 counts/cm^{2} should be adapted as a cutoff value for determining normal background mold levels in buildings, although mold population dynamics vary greatly with the nature and composition of the surface.

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Bootstrap Evaluation of Detection Frequency Differences as an Analytical Criterion for Bioaerosols

R. Spicer, H. Gangloff, WCD Consultants, Pennington, NJ.

Sampling for environmental fungi to evaluate a suspect indoor environment is frequently conducted within the context of testing a hypothesis of similarity between the indoor zone and a reference zone. However, there is a general perception that determining statistical significance is not practical due to the highly variable and sparse nature of the data, and statistical hypothesis testing methods are seldom used. Subjective "data interpretation" guidelines and criteria (i.e., rank order analysis, various indoor/outdoor ratios) have been forwarded, but have been shown through bootstrap/Monte Carlo (BMC) analysis to exhibit high false positive and negative error rates. The statistical comparison of two sets of highly variable data is not unique to building fungal growth as a public health concern, and a direct calculation of probability was originally developed by R.A. Fisher (1935) to determine significance between comparative sets of data. A derivation of Fisher's approach using differences in detection frequency (relative to the combined median) is a statistical hypothesis testing technique applicable to bioaerosol data, and was similarly evaluated against BMC. Five sets of culturable spore samples (Andersen N-6; MEA) from 4 different building sites during 2005 - 2008 consisted of 30-35 samples, split evenly between the indoor test and outdoor (reference) zones. Significant differences in detection frequency between the two zones were directly calculated for each fungal type. BMC was then conducted to empirically estimate the frequency that differences in detection greater than what appeared in the actual field data would randomly occur. The BMC result was therefore a parallel calculation of significance, and was within ± 0.03 of the direct probability calculation. The results support differences in detection frequency as an objective criterion for microbial data analysis, and underscore the difference between data interpretation and data analysis.

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Fungal Characterization During Typical Household Activities

S. McCarthy, M. Suen, J. Hicks, P. Rey, Exponent, Oakland, CA.

Most fungal investigations typically deal with potential exposures related to adverse or unusual environmental conditions. These conditions can be the result of a water intrusion incident, building defects or malfunctions, or improper temperature controls. There is ample literature describing the types of mold and concentrations of mold and mold spores in these adverse environments. Few studies have examined the types and concentrations of airborne fungi encountered during nonadverse conditions. This study investigated fungi present during normal household activities, both indoors and outdoors, in environments not affected by unusual fungal reservoirs. Five activities were chosen (three outdoor and two indoor): cutting grass, cleaning up leaf debris, cycling, dust removal from interior surfaces, and vacuuming indoor carpets. One set of indoor and two sets of outdoor air samples were taken that were not related to any activities. Both culturable and nonculturable personal air samples were taken during the tasks and after each task was completed. Three-minute culturable samples were taken using Biocassette devices. Nonculturable samples were taken with a spore-trap device during five minute sample periods. Airborne concentrations of fungi were presented and compared with the outdoor nonactivity samples, and to selected activities reported in the literature. This study provides information about airborne concentrations of mold and mold spores not related to adverse conditions or incidents, but rather to potential exposures from routine activities.

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Use of PCR Test in a Retrospective Investigation of Mold Contamination

C. Yang, Prestige EnviroMicrobiology, Inc., Voorhees, NJ; P. Morey, Environ Corp., Gettysburg, PA.

PCR is a DNA-based test that detects the presence of DNA specific to prescribed species. The PCR methodology for indoor fungi was developed by EPA. In this presentation, we will describe an approach to using PCR testing for the detection of obscured, hidden, or dead fungal spores and structures in a retrospective investigation. A house in the southwest United States suffered from a pipe burst and fungal growth while owners were away. An IH consultant assessed the house and issued a report with recommendations for remediation. Among fungal contaminants detected by the consultant using culture methods were *Aspergillus sydowii, A. versicolor, Chaetomium globosum, Paecilomyces variotii, Penicillium* species, *Stachybotrys chartarum,* and *Ulocladium botrytis*. Subsequent remediation resulted in complaints of hidden mold covered by encapsulant and contamination of fungal spores on clothing and contents, which were supposedly dry cleaned and in storage under protective cover. To confirm or rule out such complaints, a retrospective investigation was proposed. Encapsulant chips were removed from encapsulated wood, and dust was vacuumed from dry cleaned and stored contents. Because fungi and their spores can be killed by encapsulant or dry cleaning process, and there was a need to better identify them to species, the PCR test was chosen. Additional culturing was also performed. The samples were analyzed using the PCR test for the detection of 24 fungal species. Marker fungi, based on prior results, *A. sydowii, A. versicolor, C. globosum, Paecilomyces variotii, Penicillium brevicompactum, Penicillium chrysogenum, S. chartarum,* and *U. botrytis* were included in the panel. Although the PCR test yields quantitative results, the detection of targeted species is considered a much more significant outcome. Both chip and dust samples had one or more species of the marker fungi detected at various concentrations. The results confirmed that the encapsulant covered fungal contaminants and dry cleaning failed to remove all fungal contaminants.

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Short-Period Variations in Concentrations of Outdoor Fungal Spores and Their Use in Comparing to Indoor Spore Levels

M. Suen, S. McCarthy, Exponent, Inc., Oakland, CA.

A common practice used to interpret fungal spore concentrations found in the indoor environment is to compare those levels with concentrations found outdoors. This comparison is based on the principle that types and species of fungal spores found indoors should be similar to those outdoors, and the concentrations indoors should be no greater than outdoor concentrations. An important issue is how many outdoor samples are sufficient to obtain an accurate picture of the levels of fungal spores in the outdoor air and consequently, allow for appropriate and informed indoor/outdoor comparisons. It remains common practice by some investigators to compare the results of indoor air samples with a sin-

gle outdoor air sample result. In this presentation, we will include data from multiple outdoor air samples collected during several evaluations at a variety of geographic locations. The data demonstrated the wide and significant variations in airborne spore types, and especially concentrations, during relatively short periods of time. Comparisons were made with the results from indoor air samples, and simple statistical evaluations were used to determine the probability of reaching certain conclusions if the indoor air results were similar or dissimilar to the outdoor results. Case studies were used to demonstrate the frequency in which correct or incorrect conclusions may be reached based on comparing results with a single air sample result.

Podium Session 114: Occupational Epidemiology and Retrospective Exposure Assessment

Tuesday, June 2, 2009, 10:30 a.m.–12:30 p.m.
Papers 97–102

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Retrospective Assessment of Worker Exposure to NTA

B. Silverstein, Bernard D. Silverstein Inc., Yardley, PA; C. Kirman, R. Tardiff, The Sapphire Group Inc., Bethesda, MD.

Sodium nitrilotriacetate monohydrate (NTA) was used for a few years in the United States in the production of laundry detergents. Limited toxicity data indicate that NTA caused cancers of the urinary tract in laboratory animals ingesting high doses for their lifetime. A retrospective worker exposure assessment was conducted as part of a broader risk assessment. This study incorporated exposure assessment processes characterizing spacial and temporal relationships between workers and exposures. These characterizations allowed establishment of similar exposure groups (SEGs), the cornerstone to the assessment. Using SEGs, a wide variety of information was able to be incorporated into the assessment. A comprehensive approach was used to reconstruct exposures to NTA that workers may have experienced while making NTA-containing detergents. Inhalation was the major route of exposure, but dermal contact was also included, as solubilized NTA is absorbed across the skin. The process to assess NTA exposures was divided into three parts: (1) developing a workplace characterization, (2) identifying and assessing employee monitoring data and other exposure indices to estimate external exposure, and (3) estimating internal doses of NTA. Lifetime average daily dose (LADD) was calculated from the data, using EPA guidelines and methodology for exposure assessment and associated dose estimation. Total worker LADD was calculated by combining estimated inhalation and dermal exposures. Worker exposure estimates were derived for five SEGs: bulk unloaders, tower operators, utility operators, finishing technicians, and maintenance workers. The results of the exposure assessment included LADD for workers during the manufacture of NTA-containing products, with tower operators having the highest exposure and finishing technicians the lowest.

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Descriptive Analyses of Occupational Vibration Exposure Among Participants in a Case-Control Study of Parkinson's Disease

M. Harris, S. Marion, J. Tsui, K. Teschke, University of British Columbia, Vancouver, BC, Canada.

Occupational exposure to vibration has been identified as a risk factor for back injury, impaired gastric motility, and peripheral neurologic and vascular symptoms. The cumulative effects of vibration on the risk of disease affecting the central nervous system are unknown. This study described vibration exposure in a sample of participants selected for an epidemiologic case-control analysis of Parkinson's disease (paralysis agitans), a neurodegenerative disease affecting at least 35 thousand Canadians. Participants from south coastal British Columbia were identified via use of antiparkinsonian medication (cases) or sampled from the BC Ministry of Health Client Registry database (controls). Occupational exposure to vibration was ascertained through in-depth work history interviews. Descriptive exposure analyses were blinded to case-control status to prevent influence on analytic decisions. In preliminary analyses of 391 participants, 302 (77%) reported vibration exposure and 145 (37%) reported at least five sources of vibration exposure. A total of 2004 reports of vibration exposure were recorded. Common sources of vibration exposure included light vehicles (256 reports), chainsaws and other saws (94 reports), electric drills (69 reports), and forklifts (48 reports). These descriptive analyses will guide the construction of a vibration exposure metric for use in epidemiologic analyses of Parkinson's disease.

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Exposure and Genetics Contribute to the Risk of Beryllium Disease

M. Van Dyke, J. Martyny, P. Mroz, L. Silveira, M. Strand, L. Maier, National Jewish Health, Denver, CO; D. Cragle, W. Tankersley, Oak Ridge Associated Universities, Oak Ridge, TN; L. Newman, University of Colorado at Denver, Denver, CO.

For many years, evidence has been accumulating to indicate that risk of chronic beryllium disease (CBD) is related to both exposure and genetic factors. Much research has focused on identifying exposure factors (chemical form, particle size, and alternate exposure pathways) and genetic factors (HLA-DPB1 E69 genotype) that may increase the risk of CBD and beryllium sensitization (BeS). Few studies have examined both exposure and genetic factors in risk of CBD and BeS. In this presentation, we will examine the combination of exposure and genetic factors affecting risk of CBD and BeS, using results from a recently completed case-control study conducted at three beryllium facilities (Y-12, RFETS, and a private beryllium machining facility). This study enrolled a total of 648 current and former workers from these facilities (CBD =95, BeS = 108, controls = 445). Exposures were estimated by combining employee interview information and exposure ratings developed by industrial hygienists. In separate models, using logistic regression, significant predictors of BeS/CBD included E69 status, exposure, and duration of employment. Results showed increased BeS/CBD risk for E69 carriers, with odds ratios ranging from 17.1 (95% CI 6.5-48.3) for E69 carriers in the Y-12 population and 6.65 (95% CI 4.3-10.3) per E69 allele copy for the RFETS population. Regardless of E69 status, increased beryllium exposure also increased the risk of BeS/CBD with an OR = 2.94 (95% CI 1.3-6.8) per unit increase in rated exposure for the RFETS population. These results demonstrate that beryllium exposure and E69 status contribute individually to the risk of Bes/CBD. High exposure confers increased risk even in the absence of E69 genetic susceptibility.

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Predictive Modeling of Exposures from Small Hot Processes

N. Esmen, R. Hancock, University of Illinois at Chicago, Chicago, IL.

In small workplaces and in hobbies, uncontrolled small but intensely hot operations such as soldering, brazing, hot gluing, and melting are common. While some measurements of exposure exist for some operations, a workable exposure estimate model is not available. The emission from small hot operations is a function of the source properties such as temperature, geometry, and contaminant vapor pressure; and the workroom properties such as turbulent mixing rate, room temperature, geometry, and forced airflow. Using these properties and fundamental relationships for emission, concentration buildup. and convective airflow, approximate equations for near- and far-field exposures are developed. The semi-empirical model contains physicochemical parameters such as source temperature, vapor pressure that can be easily obtained from the literature, easily measurable parameters such as source or room geometry, as well as hard-to-measure or estimate parameters such as turbulent diffusivity and room air velocity. These equations suggest that while the first category of factors plays an important role in both near- and far-field exposure levels, the second category plays an important role in the far-field exposures and a minor role in the near field exposures. We could only partially validate the model by comparing the calculated results with samples that were collected in a number of diverse studies. For the comparison, similar operations were pooled. The comparison suggested that the model proposed is predictive with reasonable accuracy. The most successful predictions were related to heating operations (such as hot gluing - half order of magnitude), and the least successful predictions were related to metal joining (soldering and brazing - more than an order of magnitude). Even though the available field measurements were sparse and do not cover a broad spectrum of conditions, the predictions of exposure levels by the model are satisfactory and compare favorably with the existing artificial intelligence programs.

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Inter-Rater Reliability of Retrospective Exposure Assessment with Limited Work History Data

F. Boelter, ENVIRON International Corp., Chicago, IL; V. Roggli, Duke University School of Medicine, Durham, NC; L. Birkner (deceased), Birkner/McIntyre, Thousand Oaks, CA; J. Rasmuson, E. Rasmuson, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO; W. Dyson, Workplace Environments, LLC, Hillsborough, NC; C. Redinger, Redinger & Associates, Inc., Harvard, MA.

A physician's database describing the work history in six or less words for 363 individuals was provided to four experienced certified industrial hygienists. Birth date, sex, and date of investigation were also provided. Each industrial hygienist worked independently to estimate f-yr/cc total exposure for each individual. Unambiguous estimates of total lifetime asbestos exposure were obtained for 322 of the 363 individuals. Although lung tissue analysis for asbestos bodies and free asbestos fibers was part of the physician's database, this information was withheld from the industrial hygienists. An intra-class correlation coefficient (ICC) of 0.759 was found between raters. This ICC is in the excellent range. ICC values for lung tissue analysis of asbestos bodies by light microscopy and SEM, and asbestos fibers by SEM were found to be in the same range as the ICC value for the raters. Highly significant correlation was found between log-transformed exposure estimates and a composite of the laboratory analyses for each individual. However, even better correlation was found by an ANCOVA procedure when SEM analysis of asbestos fiber type was used as one of four class variables, along with the two continuous variables. The better correlation is explained on the lung's ability to clear chrysotile fibers as well as the fiber type associated with different exposures by individual. The analysis suggests that better than an order of magnitude precision and accuracy is generally possible when experienced industrial hygienists perform a retrospective exposure assessment of lifetime exposure even with limited information. This implies retrospective exposure assessment performed by experienced industrial hygienists having access to more information than was available in this study should reflect even better precision and accuracy. This correlation also demonstrates a general agreement between experienced industrial hygienists about the relative significance of exposures in different trades, products, and activities.

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Application of Epidemiology to Inform the Industrial Hygiene Exposure Assessment Strategy

F. Boelter, C. Simmons, ENVIRON International Corp., Chicago, IL; W. Parsons, ENVIRON, Amherst, MA.

Industrial hygienists and epidemiologists often work together toward similar goals: measuring exposure and estimating dose to various agents, with the intent of assessing and associating their effect on human populations. Industrial hygienists provide the epidemiologist with capabilities for measuring attenuated exposures, on the scale of micrograms, fibers per cubic centimeter, or parts per billion, and an understanding of how these exposures change given complex interrelations of work activity, airflow, temperature, process, etc. The precision of these measurements is valuable to epidemiologists, who then must determine if other factors could influence the relationship between the exposure and the effect in humans. An effective exposure assessment strategy developed by industrial hygienists, therefore, can be informed by epidemiology to account for sources of human variability. In our example, an exposure assessment was conceived based on professional experience in a field of industry. Emission-generating activities and time and motion distributions were developed a priori. To determine how well the a priori concepts agreed with current industry practices, a questionnaire developed by cooperative effort of industrial hygienists and epidemiologists was administered to 11 supervisors of workers in the industry in different regions across the country. The 131-point questionnaire was designed to elicit information on factors that may produce variability in emissions and human exposures. The questionnaire identified factors such as techniques, materials, tools, and project size that could affect emissions. The results suggested the a priori concepts agreed well with real-world practice. The questionnaire also identified as significant factors such as volume of work, time at task, and other health risk factors. The correlation analysis produced nine correlations that were significant at an α of 0.05, and four correlations that were nearly significant ($0.05<p<0.07$). A questionnaire based on cross-disciplinary experience between industrial hygiene and epidemiology can inform a well-developed exposure assessment and sampling strategy.

Podium Session 115: Professional Judgment and Exposure Modeling Strategies

Tuesday, June 2, 2009, 10:30 a.m.–12:30 p.m.
Papers 103–108

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Accuracy of Professional Judgment in Occupational Exposure Assessment

M. Vadali, G. Ramachandran, S. Banerjee, University of Minnesota, Minneapolis, MN.

Results are presented from a NIOSH-funded research study that looked at occupational exposure judgment capabilities of occupational hygienists across a wide range of industries. Participating companies provided monitoring information on specific tasks. A total of 49 hygienists from 6 companies participated in the study, and 22 tasks were evaluated. The number of monitoring data points for tasks varied between 5 and 24. The AIHA exposure assessment strategy was used to make judgments on the probability of the 95th percentile lying in one of four exposure categories relative to the occupational exposure limit. After reviewing all available job/task/chemical information, hygienists were asked to provide their judgment in probabilistic terms. Both qualitative and quantitative judgments were recorded. In addition to task judgments, hygienists' task experience and information on determinants such as educational and statistical background, years of IH and exposure assessment experience, and measures of cognitive ability was also obtained using a questionnaire. Data interpretation training, with simple rules of thumb for estimating 95th percentiles was provided to all hygienists. A data interpretation test was also administered, and all judgments were collected before and after training. Data was analyzed using SAS 9.1. The data interpretation scores increased from 48% to 67% after training ($p < 0.001$). The quantitative judgments improved from 46% to 69% ($p < 0.001$) post training. Some of the determinants that seemed to predict better judgment accuracy were the type of certification (CIH, CSP, IHIT), number of years an IH was using the AIHA strategy, and career air sampling surveys done. For quantitative judgments their statistical experience was also found to be a significant predictor. The study results suggest that the research should be continued to better understand the impact of determinants and training, and suggests use of statistical tools as an aid for quantitative judgments where limited data is available.

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The Impact of Data Interpretation Training on Exposure Judgment Accuracy and Bias

P. Logan, 3M, St. Paul, MN.

The availability and accuracy of exposure assessments can determine whether resources are appropriately allocated to engineering and administrative controls, medical surveillance, personal protective equipment, and other programs designed to protect workers. In this presentation, I will report on a desktop study performed to evaluate the accuracy and potential bias of participants' exposure judgments before and after a simple training exercise. Desktop exposure judgments were obtained from occupational hygienists for material handling jobs with small air sampling data sets (0-8 samples) and without the aid of computers. Participants were presented with an exposure data interpretation training which included a simple set of rules for estimating 95th percentiles for small data sets from a lognormal population. Results of each data interpretation test and qualitative and quantitative exposure judgments were compared with a reference judgment obtained through a Bayesian probabilistic analysis of the sampling data to investigate overall judgment accuracy and bias. The data interpretation tests and quantitative judgments were significantly better than random chance and much improved by the rule-of-thumb training. In addition, the rule-of-thumb training reduced the amount of bias in the data interpretation tests and quantitative judgments. The mean data interpretation test percent correct scores increased from 47% to 64% after the rule-of-thumb training ($p < 0.001$). The accuracy for quantitative desktop judgments increased from 43% to 63% correct after the rule-of-thumb training ($p < 0.001$). The rule-of-thumb training did not significantly impact accuracy for qualitative desktop judgments. The finding that even some simple statistical rules of thumb improve judgment accuracy significantly suggests that hygienists need to routinely use statistical tools while making exposure judgments using monitoring data.

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How Do My Predictions Compare? Correlating Predictive Modeling with Actual Results

M. Plisko, J. Spencer, M. Nealley, Environmental Profiles, Inc., Baltimore, MD.

Examples of mathematical models used for predicting and/or estimating occupational exposures have routinely been discussed in the literature. Few examples, however, have discussed the need for evaluating the performance of one model over another in a specific application. When faced with the option of using several models for a potential application, each model should be evaluated to determine which is more accurate with respect to the parameters of interest. Quantitative and qualitative tools for evaluating indoor air quality models have been provided by ASTM Standard D 5157, Standard Guide for the Evaluation of Indoor Air Quality Models. Three studies involving the use of volatile solvents were modeled, and the predictions were compared with actual air sample results using the elements of D 5157: the single-box model with a constant generation rate; the two-box model with a constant generation rate; and the two-box model with an exponentially decreasing emission rate. The comparative results of evaluating each model in the context of the three solvent studies indicated the two-zone model with a constant generation rate provided the most accurate predictions. The correlation coefficient (r) between predicted and observed values was 0.874, with a slope (b) of 0.893 and a normalized mean square error of 0.027. According to the guidance presented in ASTM D 5157, these resultant values are indicative of "adequate model performance."

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A Simple Statistical Method to Determine the Probability of Exceeding an Occupational Exposure Limit Using Representatively Sampled Air Monitoring Data

R. Strode, J. Rasmuson, E. Rasmuson, D. Hall, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO.

The use of Bayesian methods and related software has offered methods for determining the probability of compliance with predetermined thresholds, with specific application to occupational exposure limit (OEL) data. At the same time, the rationale for the use of Bayesian methodologies has identified limitations in the standard statistical methods used for assessing exposures (i.e., the use and evaluation of air sampling data) in comparison with OELs. While Bayesian methods make use of additional information of which the industrial hygienist may be aware besides the air monitoring data alone, standard statistical methods in many instances can be used to analyze air monitoring data when a common-sense approach is applied. Traditional statistical analytical procedures of air monitoring data continue to have a place in exposure assessment and should not be abandoned. This presentation offers straightforward and simple computational methods to compare air sampling data with OELs when the air sampling program is appropriately designed to collect data that are representative of long-term variability (i.e., the air sampling data must have been collected over multiple days, representing all process conditions, etc). Example data sets will be analyzed using more traditional statistical approaches, and the results are compared with a standardized Bayesian approach. Advantages and disadvantages of both methods will be compared.

107

Predictors of Airborne Concentrations of 2-Butoxyethanol Generated from Cleaning Tasks — A Quasi-Experimental Study

A. Bello, M. Perry, Harvard School of Public Health, Boston, MA; M. Quinn, D. Milton, University of Massachusetts Lowell, Lowell, MA.

Existing epidemiological studies that have investigated asthma and respiratory symptoms of exposures to cleaning agents have used only qualitative assessment of exposures. Quantitative assessments of airborne cleaning exposures are difficult because cleaning products are complex mixtures of chemicals and require application of many integrated sampling and analytical methods. We hypothesized that airborne concentration of a single volatile ingredient in a cleaning product can be predicted using statistical models: (a) with total volatile organic compounds (TVOC) measured with a direct reading instrument (DRI), and (b) without the TVOC measurements if we knew the concentration of the ingredient in the bulk product and other environmental factors impacting exposures. The models were developed for one compound: 2-butoxyethanol (2-BE) - a chemical ingredient that is commonly used in cleaning products. Simultaneous measurements of TVOC and 2-BE in the air were performed during 10-min simulations of several cleaning tasks. Personal breathing-zone samples of 2-BE were collected and analyzed with NIOSH-1403 method, and TVOC were measured using a photo ionization detector (PID) from Gray Wolf Sensing Solutions. Statistical analyses were performed with Statistical Analyses Software (SAS) Version 9.1 using proc REG procedure. Prediction models with TVOC explained a significant portion of the data variability for both TVOC average (R2 = 68) and maximum measures (R2 = 0.72). In addition, 2-BE concentrations can be predicted with a model without TVOC, but with "product type," "task performed," "concentration of 2-BE in the product," "room volume," and " room ventilation" (R2 = 0.77). The models developed can be used by health and safety professionals for assessing 2-BE workplace exposures using easier measurement methods. The latter model is preferable for epidemiological investigations for estimating workers' exposures without the use of measurement devices, because the data required are assessable via questionnaires and from building specifications where cleaning is performed.

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A Test Chamber Method to Measure Respirable Dust for Developing Dust Emission Generation Rates

K. Rickabaugh, RJ Lee Group, Monroeville, PA; M. Jayjock, EHS LLC, Langhorne, PA; S. Arnold, EHS, LLC, Roswell, GA.

Good emission source data for estimating generation rates often remains a critical data gap in mathematical modeling exercises. This sometimes results in modelers resorting to emission estimate options having a propensity to grossly overestimate the true generation rates, thus creating greater uncertainty in the resultant modeling results. To improve source data for estimating emissions of respirable particulate matter, a method was developed using a test chamber to create a suitably controlled environment. The test chamber included a controllable ventilation rate and oscillating fans to create a good mixing. Different dust-generating activities and activity rates were used during the testing. Real-time direct read instrumentation used in conjunction with traditional integrated sampling techniques aided in on-the-spot adjustments to testing protocols to prevent under- and overloading sampling filters, while observing dust generation from different tool use and activity rates. This resulted in a significant savings of time and effort for collecting usable and valid results. In this presentation, we will describe the design of the chamber, method used to develop the source data, the resultant data comparing different dust-generation activities, and a summary of the benefits gained from using the method. Data from these studies were deemed suitable for the development of respirable dust generation rates useful for mathematical modeling of exposure impacts.

Podium Session 116: Noise Control — Theory, PPE, and Practice

Tuesday, June 2, 2009, 10:30 a.m.–12:30 p.m.
Papers 109–114

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Issues in Measuring the Exposures from Recreational Earphone Systems

E. Berger, Aearo Technologies, Indianapolis, IN.

One of the most prominent noise-exposure issues in popular culture today is that of potential noise-induced hearing loss from personal digital audio players, commonly known as mp3 players, of which the iPod® is the most conspicuous. Numerous posts on the Internet and articles in the popular press raise concerns and speak of impending auditory doom. Hearing conservationists are concerned about their use and contribution to exposure in the workplace, as well as to off-the-job use and noise exposures. As an alternative for workplace utilization, some wish to recommend hearing protector designs with built-in earphones and/or the ability to connect external sources. How can the typical user or IH/hearing conservationist know of the levels to which wearers are exposed and assess their risk to determine OSHA compliance? Can they simply take an inexpensive sound level meter and hold it next to an earphone to measure the sound levels, and then compare those values with the oft-cited 85-dBA criterion or the manufacturer's spec sheet? Do they simply know that something is wrong if the units sound too loud? This study compared data derived from the preferred measurement approach, using an acoustic manikin or simulator with an earcanal coupler [and transformation of those values by subtracting the transfer function of the open ear (TFOE) per ISO 11904-2], to casual measurements using simplified manikins, or no manikin at all and no TFOE correction. The errors in casual measurements are reported, amounting to 10 dB or more depending on

frequency. Guidance is provided to IHs on how to properly evaluate earphone levels and the possibility of making suitable corrections to casual measurements. In addition, a review of the literature will be presented discussing typical use patterns, including comments on the epidemiological evidence on use and noise-induced hearing loss to date, so that risks can be evaluated.

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The Effects and Dynamics of Worker Exposure to Industrial Noise

J. McGuire, Risk Technologies, LLC, Knoxville, TN.

Today, measurements of noise are common, but the most useful and meaningful measures of exposure to noise are not really well known. More is known about the importance of individual worker susceptibility to noise than the importance of spectral differences between noises with the same A-weighted sound levels. The practical consequences of some of the differences in noise frequency spectra have been made obscure by sound-level weighting. The premise that hearing loss appears and grows differently for different frequencies has, in the weighting process, been severely discounted. A better understanding of industrial hearing loss has not been achieved in the past, partially due to standard techniques used in obtaining data, inappropriate statistical comparisons, and the use of the discounting dBA noise measurement scale. Although there is little evidence or theory to support the use of the dBA noise standard, billions of dollars have been, and will be, spent to abate industrial noise and supposedly protect the worker's hearing in the process of meeting this noise standard. Doubt has been raised by many researchers as to whether worker hearing loss will decrease or increase with the use of the dBA measurement scale to regulate noise exposure. A variety of data types can be useful in understanding the dynamics of worker exposure to noise in an industrial environment. Investigations have been made of the extent to which noise exposure data, observational data on worker behavior, projected worker noise exposure mapping, plant operating conditions, and employee audiometric data are useful in studying the problems of employee noise exposure. The interrelationships among these different types of data have been explored for suggestion of effective strategies in engineering and administrative noise control.

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WITHDRAWN

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Evaluating Ear Plug Noise Attenuation in the Workplace Using a Portable Audiometer

P. Owens, Shell Martinez Refinery, Martinez, CA.

A portable audiometer was used in the field to estimate workers' real ear attenuation thresholds with and without their choice of expanding foam ear plug. A hand-held personal computer running audiometric software was calibrated to provide pure tone frequencies at 500, 1000, and 2000 hertz, with output ranging from 0 dB to 65 dB by 5-dB increments. The audiometer headphones included ear muffs to lessen background noise. Participants were tested in as quiet a setting as possible, typically offices, but some occurred in field maintenance buildings. Employees already wearing ear plugs were asked to participate prior to making any adjustment to the earplug fit. Those participants not wearing earplugs were asked to insert them as they typically would. One tester performed all measurements of threshold. Each participant was asked to only indicate the threshold when clearly detecting the tone and to be consistent for both tests. For each frequency, the sound output started at 0 dB and, after pausing several seconds each time, increased by only 5 dB by the tester. If any sudden change in background noise occurred, the tester kept the tone at the same output level until the background noise returned to normal. Hearing thresholds were estimated for the left then the right ears for the test frequencies: 500, 1000, and 2000 hertz. The result for each frequency was compared with the ear plug manufacturer's NRR for that frequency. The arithmetic average of these frequencies was recorded as the average for the individual's personal NRR. On average employees found wearing ear plugs obtained a slightly lower personal NRR than employees tested after donning the ear plugs. The average personal NRR was about half of the manufacturer's NRR, and only about 2% of all results were less than 10 dB.

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A Comparison of Estimated and Observed Sound Reduction in a Full-Scale Longwall Coal Mine Shearer Mock Up

D. Sweeney, J. Slagley, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Noise-induced hearing loss is one of the top occupational health concerns in the United States and is the second highest self-reported occupational disease. Hazardous noise affects approximately 30 million U.S. workers, and miners are disproportionately affected. Controlling noise exposure has traditionally relied on personal protective equipment in the form of ear plugs or muffs. Recent studies have shown workers' use of personal hearing protection devices may not be as effective as advertised. Therefore, engineering controls may be a much more effective means of controlling noise exposure. In a preliminary noise investigation, it may be necessary to estimate the area of concern's total absorption to determine the most suitable engineering control. Among noise-exposed underground coal miners, the most heavily exposed are those at the longwall face. An ongoing project is testing simple engineered noise controls at a full-scale mock up of a longwall coal mine shearer machine. The geometry of the workspace is quite complex and, while reflective, leads to a different total absorption than what would be calculated by traditional methods. This estimate may lead to different engineered solutions. The current study compared estimated and observed sound reduction at the full-scale mock-up in an effort to best prepare for implementation of a suite of noise controls underground.

114

Potential Environmental Noise Controls for a Subsonic Aerodynamic Research Wind Tunnel

R. Schmidtgoessling, D. Sweeney, T. Batten, B. Shuler, J. Slagley, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

The Subsonic Aerodynamic Research Laboratory (SARL) on Wright-Patterson AFB is a wind tunnel used to study the aerodynamics of various airframe models at wind speeds up to Mach 0.5, and it is capable of producing noise levels in excess of standards. The purpose of this study focused on identifying potential engineering controls that could be used to reduce the noise level by 10 dB. A comprehensive evaluation was conducted looking at sound pressure and octave band levels throughout the areas of concern. Three distinct control measures were compared: louvers added to inlet, partial enclosure of exhaust turbine, and acoustically hardening the surrounding buildings. The expected noise reduction associated with the addition of louvers to the inlet of the SARL was calculated. The expected reduction for an airfoil louver system with two walls of steel with interior absorptive material and coated with an absorptive visco-elastic layer to reduce is approximately 20 dB across the octave bands. The SARL exhaust is located in a reverberant field of a sound, where noise reduction can be achieved by increasing the amount of sound absorption on the exterior of the building. Noise reduction in the far-field can be achieved with a partial enclosure built to direct the noise upward and to serve as a barrier between the exhaust and receiver on the street level. The expected noise reduction for a partial enclosure for a receiver at street level would be approximately 20 dB across the octave bands. Cost and efficacy were used to rank the feasibility of controls. The most favorable control was the installation of louvers, which had the best combined cost/benefit ratio, followed by the partial enclosure of the turbine exhaust.

Podium Session 117: Respiratory Protection I: Air Filtration

Tuesday, June 2, 2009, 2:00 p.m.–4:40 p.m.
Papers 115–121

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Comparison of N95 Respirator Filters against Ultrafine Particles Tested with Constant and Cyclic Flows

H. Haruta, T. Reponen, R. McKay, S. Grinshpun, University of Cincinnati, Cincinnati, Ohio; T. Honda, Koken Ltd., Tokyo, Japan; R. Eninger, U.S. Air Force School of Aerospace Medicine, San Antonio, Texas.

Filtering facepiece particulate respirators (FFPRs) are widely used for reducing workers' exposure to ultrafine aerosol particles (up to 100 nm). NIOSH certification tests use a constant flow of air through respirator filters. At the same time, when respirators are worn, the flow pattern is cyclic. While several studies have addressed the adequacy of using a constant flow, the difference in filtration efficiency under constant and cyclic flow has not been thoroughly evaluated for all particle sizes.

The present study was designed to expand our knowledge of filtration efficiency for ultrafine particles. Two models of N95 FFPRs available from different manufactures were tested under cyclic and constant flow. Both models were sealed to a manikin's face and challenged with ultrafine polystyrene latex particles (25, 65, and 99 nm) at four flow rates (15, 30, 85, and 135 L min^{-1}). Each of the four constant flows used in this study were compared with an equivalent cyclic flow having the same mean inspiratory flow (MIF) rate. (Defined as the ratio of the tidal inspiratory volume to the inspiratory duration, MIF is conventionally accepted as a cyclic-flow regime comparator and analog for constant flow.) At relatively low rates (15 and 30 L min^{-1}), cyclic flow produced higher penetration values than an equivalent constant flow. In contrast, no statistically significant difference was found at 85 L min^{-1}. At 135 L min^{-1}, a reverse tendency was observed so that the penetration of ultrafine particles was higher under constant flow conditions. The findings are attributed to a complex interaction of different filtration mechanisms and can be explained using advanced filtration theory. We conclude that respirator filter testing conducted at constant flow may under- or overestimate the particle penetration under cyclic flow conditions.

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Filtration Efficiency of Filtering Facepiece Respirators Approved Per 30 CFR 11 and 42 CFR Part 84

N. McCullough, R. Weber, 3M, St. Paul, MN.

This study evaluated the filtration efficiency of filter media from five similar filtering facepiece respirator models manufactured between 1984 and 2007. The filter media was designed to meet either 30 CFR 11 or 42 CFR 84 performance criteria. The research was conducted in an active coal mine. Airborne particles were collected on filters inside and outside the facepieces, and analyzed gravimetrically. Neither a statistical nor a practical difference was found between the respirators, either for filtration efficiency of "total dust" or for respirable dust. Although the filtration tests for 30 CFR Part 11 and 42 CFR Part 84 had different laboratory test parameters for certification, the filtration efficiency demonstrated in an active coal mine showed no differences. Because the regulations governing fit did not change when 42 CFR 84 was promulgated, a change in respirator performance provided the coal miner would not be expected as a result of this regulation change.

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A Realistic Method for Testing Antimicrobial Respirator Efficacy

C. Ylitalo, N. Stepanova, S. Belgrade, J. Sebastian, 3M, St. Paul, MN.

In this presentation, we will describe 3M's novel microbiology test method for evaluating the antimicrobial effectiveness of filtering facepiece respirators and masks. Current antimicrobial claims are often based on tests using the American Association of Textile Chemists and Colorists (AATCC) Method 100, "Assessment of Antibacterial Finishes on Textile Materials." The AATCC Method 100 was designed for garments and not for respirators and facemasks. This new test method was designed to more closely simulate large droplets splashing directly onto the surface of a respirator (or mask) or its component layers. NIOSH-approved respirators, as well as nonapproved facemasks that claim to be antimicrobial, were evaluated by both the AATCC Method 100 and this new test method. The antimicrobial performance measured by the new test method was significantly different than that determined by AATCC Method 100. Because this new method more closely simulates the temperature, humidity, and time exposure conditions when wearing a respirator or mask, it is more appropriate than AATCC 100 for evaluating antimicrobial claims on respirators or masks targeted for the health care market.

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Toluene Adsorption on Various Types of Activated Carbon Fibers

J. Balanay, C. Lungu, S. Crawford, University of Alabama at Birmingham, Birmingham, AL.

Activated carbon fiber (ACF) has been demonstrated to be a good adsorbent for the removal of organic vapors in air. ACF has a large surface area and high absorption capacity when compared with granular activated carbon (GAC) commonly used in respiratory protection devices. ACF is an attractive alternative adsorbent to GAC because of its ease of handling, light weight, and dropping cost. ACF may offer the potential for short-term respiratory protection for first responders and emergency personnel. This study compared the critical bed depths and adsorption capacities for toluene among GAC and ACF of different forms and surface areas. GAC and ACF in cloth (ACFC) and felt (ACFF) forms were challenged in stainless steel chambers with a constant concentration of 500 ppm toluene via conditioned air at 25°C, 50% RH, and constant airflow (7 LPM). Breakthrough data were obtained for each adsorbent using gas chromatography with flame ionization detector. The surface areas of each adsorbent were determined using a physisorption analyzer. The results showed that the critical bed depth of GAC is 275% higher than the average of ACFC but is 55% lower than the average of ACFF. The adsorption capacity of GAC (with surface area of 1800 m^2/g) at 50% breakthrough is 25% higher than the average of ACF with surface area of 1000 m^2/g, while the rest of ACF with surface area of 1500 m^2/g and higher have 40% higher adsorption capacities than GAC. ACFC with higher surface area has the smallest critical bed depth and highest adsorption capacity, which makes it a good adsorbent for thinner and lighter respirators. It was concluded that ACF has great potential for application in respiratory protection considering its higher adsorption capacity and lower critical bed depth, in addition to its advantages over GAC, particularly for ACF with higher surface area.

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Estimating Reusability of OV Air-Purifying Respirator Cartridges

G. Wood, Consultant, Los Alamos, NM; J. Snyder, NIOSH, Pittsburgh, PA.

Reuse of organic vapor air-purifying respirator cartridges provides economic and energy savings. However, OSHA and European regulatory standards as well as manufacturers' guidance discourage reuse, presumably due to a lack of quantitative objective information. To address these knowledge gaps, storage and reuse data were collected in laboratory studies and mathematical modeling of these data was performed. Two important parameters obtained from the breakthrough curves - midpoint time (related to adsorption capacity) and midpoint slope (related to adsorption rate) - were found to be unchanged during storage. A third parameter, immediate breakthrough upon reuse (IBUR), was also determined to be significant. The all-humidity MultiVapor model (developed previously by the authors and available for download at the NIOSH website) can be used to estimate maximum IBUR, which depends on many factors, including time of first use. Calibrated with experimental measurements, MultiVapor can also provide intermediate IBUR estimates, which are very dependent on the vapor identity and first-use loading. Such estimates, with appropriate safety factors, can help industrial hygienists make informed reusability decisions.

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Determination of Service Life Using Models: Impact of Underlying Adsorption Physics

M. Parham, Y. Ding, A. Staubs, J. Cornagie, Tyco/Scott Health & Safety, Monroe, NC.

When data is unavailable to support determination of service life to satisfy the requirements of OSHA 1910.134, one must turn to breakthrough models. Application of these models, whether obtained from the open literature, NIOSH, or manufacturers must be done with an appreciation of the underlying adsorption physics that characterize the conditions being evaluated. A universal breakthrough model, predictive or descriptive, that accurately models service life for all chemical compounds, sorbent materials, and conditions does not exist. In this presentation, we will examine models currently in open literature with respect to their limitations and capabilities. We will describe the basic physics of adsorption that control breakthrough, and ultimately, service life. These include adsorption equilibrium, mass transport, and reaction kinetics. We will explore conditions that adversely impact the accuracy of breakthrough models, and then recommend how to properly apply these models to real-world conditions.

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Evaluation of Procedures and Controls Used in Chemical Challenge Respirator Test Methods Using ClO2, Tear Gas, and Other Difficult Species

C. Manning, Assay Technology, Pleasanton, CA.

While several U.S. and international laboratories engage in chemical challenge testing of air-purifying respirators, few test methods are published except for NIOSH Standard Test Procedures (STPs) and standards published by governments and international bodies. While NIOSH test methods are excellent and instructive, they normally include a statement of procedures as practiced by NIOSH without expounding on principles or providing allowable options with respect to procedures followed. Other national and international standards tend to include fewer details than NIOSH procedures, allowing discretion to knowledgeable practitioners, but providing little instructions for those

seeking to learn about the test. Further, there are few, if any, instances in which a laboratory has published an evaluation of a chemical challenge respirator test method, i.e., a study evaluating the effectiveness of the test method (i.e., accuracy, etc.) in accomplishing its stated goals. While it is common practice in other branches of laboratory testing to publish test evaluations and discuss the advantages of different test procedures, this is not common in chemical challenge testing, perhaps because there are few practitioners to form a society, and each one is very busy. This study followed up our 2008 presentation in which we presented concepts of the evaluation of procedures and controls in chemical challenge testing with an aim toward improving the accuracy and precision of test results. In this study, we analyzed the effectiveness of procedures and controls in performing challenge testing with challenge agents chlorine dioxide, tear gas, cyanogen chloride, and hydrogen cyanide. These tests were chosen because each one presents difficulties to the test lab in maintaining procedures and controls that ensure that the proper flow, chemical agent vapor generation, upstream verification, and downstream monitoring of challenge agents are actually attained. A statistical comparison of different approaches will be presented.

Podium Session 118: Engineering and Control Technology

Tuesday, June 2, 2009, 2:00 p.m.–4:40 p.m.
Papers 122–129

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Reducing 1,3-Butadiene Exposures at a Waterfront Chemical Transfer Facility

A. Sather, SABIC Innovative Plastics, Ottawa, IL; W. MacKenzie, SABIC Innovative Plastics, Pittsfield, MA.

This case study describes an engineering control installed at the waterfront chemical transfer facility of a U.S. acrylonitrile-butadiene-styrene resin manufacturing plant to reduce exposure to 1,3-butadiene. Modifications were also made to the fleet of pressurized chemical tank barges that service the facility. Typically, three million pounds of butadiene are offloaded from a barge to the facility at a frequency of two to three times per month. Prior to the installation of this control, up to two liters of liquid butadiene could accumulate in the barge deck piping between the isolation valve to the cargo tank and the flange blind where the connection is made to the shore transfer hose. This liquid will rapidly evaporate when the blind is removed to make the shore connection. Barge tankermen and shore facility workers are potentially exposed to high concentrations of butadiene vapors for a short period until the chemical dissipates. In addition, these same workers may be exposed to residual butadiene vapors when disconnecting the transfer hoses after offloading is complete. Review of 20 personal, short-term exposure samples during barge offloading throughout the last five years indicates that exposures ranged from <0.56 ppm to 292.4 ppm, with a mean of 22.9 ppm. Workers must wear either air-supplied or air-purifying respirators to perform these operations, which can restrict vision and may increase the risk of slips or falls on the barge or dock. This engineering control uses nitrogen gas to purge the transfer line at the connection prior to making or breaking the connection. Butadiene vapors are released to the environment at a remote location to the barge dock. These modifications are expected to dramatically reduce exposure to 1,3-butadiene during cargo transfers. Personal and area samples are planned for Spring 2009 to confirm their efficacy.

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Reducing PCDD/F and PAH Emissions and Their Lung Cancer Risk from Iron Ore Sintering Process by Optimizing Operation Parameters

Y. Chen, P. Tsai, National Cheng Kung University, Tainan, Taiwan; J. Mou, Chung Hwa University of Medical Technology, Tainan, Taiwan.

This study set out to reduce PCDD/F and PAH emissions and their calculated lung cancer risk from the iron ore sintering process by optimizing its operation parameters obtained from the Taguchi experimental design. Four operating parameters, including the water content (Wc; range = 6.0-7.0 wt %), suction pressure (Ps; range = 1000-1400 mmH_2O), bed height (Hb; range = 500-600 mm), and type of hearth layer (HL; including sinter, hematite, and limonite) were selected and conducted on a pilot-scale sinter pot to simulate various sintering operating conditions of a real-scale sinter plant. PCDD/F and PAH samples were collected from the sinter pot exhaust using an isokinetic sampling system. We found that the resultant optimal combination (Wc = 6.5 wt %, Hb = 600 mm, Ps = 1400 mm H_2O, and HL = hematite) could reduce the emission factor of total I-TEQ ($EF_{I\text{-}TEQ}$) and BaP equivalent concentration (EF_{BaPeq}) up to 67.1% and 65.7%, respectively, in comparison with the current operating condition of a real-scale sinter plant (Wc = 6.5 wt %, Hb = 550 mm, Ps = 1200 mm H_2O, and HL = sinter). The calculated lung cancer risk also could be reduced 64.8%. Through the ANOVA analysis, we found that Ps and Hb were the top two parameters affecting total $EF_{I\text{-}TEQ}$ and EF_{BaPeq}. By examining both the sinter productivity and sinter strength, the values obtained from the optimal combination were quite comparable to those of the current operating condition. These results further confirm the applicability of the obtained optimal combination for the real-scale sinter plant.

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Reducing Dust Exposure from Contaminated Work Clothing Using a Clothes Cleaning System

A. Cecala, D. Pollock, NIOSH, Pittsburgh, PA; A. O'Brien, Unimin Corp., Winchester, VA.

A system was developed and tested that is able to quickly, effectively, and safely remove dust on a worker's clothing without exposing the worker, the work environment, or co-workers during the cleaning process. For many years, workers' clothing has been a known source of dust contamination. In an effort to minimize this dust source, a clothes cleaning system was developed. To use this system, a worker dons a half-mask fit-tested respirator, hearing protection, and eye protection and then enters a cleaning booth and activates an air spray manifold that blows the dust from his/her clothing. Because the cleaning booth is under negative pressure, all the dust and product removed from the worker's clothing is contained within the cleaning booth. Two methods were developed to safely remove this material. In the first method, the dust-laden air is exhausted to a dust collector system. Because most operations do not have excess collector capacity, a second method was developed to duct this exhaust outside the plant and into the atmosphere. Both of these systems were tested at silica processing operations and shown to be very effective. The clothes cleaning system was shown to be 10 times faster and 50% more effective than the federally approved method of vacuuming, or the most commonly used method of blowing the clothes off with compressed air. Dust samples taken inside the respirator of test personnel performing the clothes cleaning process showed very minimal to no respirable dust exposure. Although this system was developed to address the stringent respirable dust standards in the silica mining industry, it would be applicable to all industries where worker clothing contamination is an issue.

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Engineering Controls for Reducing Wood Dust Exposures During Sanding

G. Croteau, University of Washington, Seattle, WA.

Despite the considerable amount of attention given to controlling wood dust exposures in the forest products industry, it is not uncommon to find high exposures resulting from the use of hand-held orbital sanding equipment. Sanding is an activity that generates a considerable amount of wood dust, and exposure levels often exceed regulatory criteria. The forest products industry has largely relied on downdraft tables and sanding equipment fitted with local exhaust ventilation for controlling exposure levels. Downdraft tables, a work surface that captures dust by pulling air around the work piece in a downward direction, can effectively control dust exposures for small work pieces. Local exhaust ventilation entails the installation of a shroud or hood on the orbital sander to which air is pulled by a ventilation source. Ventilation is provided by the device itself, through an impeller or pneumatic exhaust air, or an independent source, which is typically an industrial vacuum cleaner. Field-based monitoring data has shown both of these engineering controls to be effective in reducing airborne wood dust exposures by 80% to 90%. Overall, downdraft tables are effective if the workpiece is about the same width as the orbital sander and the air is being pulled at a velocity greater than about 100 feet per minute. Devices that rely on the tool to generate ventilation air are typically not adequately effective to control worker exposures. However, much greater dust control can be realized if the ventilation air is provided by an industrial vacuum. Limited data suggest an airflow rate of at least 50 CFM (measured with the vacuum hose and tool in place) needs to be provided to obtain adequate dust control. In addition to presenting field-based monitoring data, we will present criteria for the successful design and implementation of engineering dust controls for orbital sanding.

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WITHDRAWN

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Effectiveness of a Ventilation System for Preventing Exposure to Formaldehyde in a Pathology Laboratory

Y. Kubota, K. Kamifukumoto, K. Kimura, T. Iwasaki, KOKEN-LTD, Tokyo, Japan.

In pathology laboratories, cells and tissues are observed under a microscope for diagnosing diseases. In preparing the tissues, they are usually fixed with 10-20% formalin. This is likely to result in the evaporation of formaldehyde, particularly when organs are soaked in fixing solutions; when fixed organs are washed, cut or photographed; and when formalin is divided into smaller portions. Thus, health care professionals may chronically be exposed to formaldehyde. In Japan, the rules for preventing injuries caused by specified chemicals were revised in March 2008; among them, formaldehyde was reclassified from Class III to Class II, and its standard allowable concentration was set at 0.1 ppm. Therefore, employers need to take appropriate measures, such as installing proper ventilators. Furthermore, to prevent the formaldehyde level from increasing in pathology laboratories, it is important to re-evaluate the work procedures, such as tightly sealing trash bins and containers with organs containing formaldehyde. To develop proper ventilators, the formaldehyde levels in the pathology laboratories of two hospitals were measured. The mean concentrations were 0.23 ppm and 0.22 ppm, respectively, well above the standard allowable concentrations for formaldehyde. Among the various procedures performed in the pathology laboratories, a high concentration of formaldehyde was found to evaporate while cutting out samples, which took a long time and included organs containing a high concentration of formaldehyde. Because conventional draft chambers are easy to work with, a push-pull ventilation system was developed to facilitate cutting out samples from fixed organs: a "push" hood was placed above to generate a uniform flow velocity of 0.4 m/s, and a "pull" hood was positioned below, integrated into the worktable. With this, the exhaust airflow is 6.3 m^3/min, which was found sufficient for reducing the airborne concentration of formaldehyde to a level below the allowable concentration of 0.1 ppm.

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Estimating Appropriate Dilution Ventilation Flow Rates for Fume, Respirable-Sized, and Other Small Particles

D. Burton, IVE Inc., Bountiful, Utah.

Dilution ventilation quantifying techniques and equations exist for gases and vapors. But what about determining the appropriate dilution ventilation flow rates for small particles, e.g., metal fume and particles designated as PM-10, PM-2.5, or respirable? Such particles qualify for dilution ventilation as a control because they virtually behave as the air does. But what are the appropriate quantities of dilution? It is possible to estimate the dilution ventilation flow rates for industrial processes that generate small particles, such as welding, where studies have determined emission factors for use in modeling and prediction. This presentation describes a novel approach that can be used by IHs to quantify dilution ventilation flow rates required for common operations that generate small particles.

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Use and Approximation of the Air Mixing Factor, Km, Used in Dilution Ventilation

D. Burton, IVE Inc., Bountiful, Utah.

Dilution ventilation is an ancient and effective method of exposure control, and is required in every human occupancy. (Contaminated air is diluted by fresh, clean air to some acceptable concentration, Ca, e.g., "carbon monoxide reduced to the occupational exposure limit of 25 ppm.") The air volume flow rate required to dilute a gas or vapor is often described by the following general equation: Qd = (G/C)K, where, at steady state conditions, Qd = the dilution airflow rate. G = the contaminant generation rate. C = an average equilibrium concentration of the gas or vapor in the space. (When using the equation to determine a suitable Qd, C is the acceptable or desired concentration, Ca). K = a "safety" factor. Throughout the years, different definitions for K have been used. Historically, IHs have combined several elements into the factor: (1) poor air mixing in the space, (2) a safety factor for toxicity, and (3) other considerations known to the user or designer. Texts and manuals have suggested factors ranging from 1 to 10. Because of its subjective nature, determining the actual factor in an existing space has been difficult, and published values of K are meager, at best. This presentation will describe an approach that separates the various elements of K and evaluates each on its merits, i.e., let Km represent air mixing only, and then determine separate factors of safety for toxicity, choosing the acceptable Ca, etc. This "separation" approach allows the estimation of actual mixing factors in existing spaces. This presentation will describe a simple and novel approach IHs can use to estimate Km in existing employee-occupied spaces.

Podium Session 119: Community and the Environment

Tuesday, June 2, 2009, 2:00 p.m.–4:40 p.m.
Papers 130–137

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Residential Development of Brownfield Site; a Former Phosphate Mine

K. Warren, C. Black, S&ME, Inc., Mount Pleasant, SC.

A developer planned to construct multifamily housing on a former phosphate mine and fertilizer plant, circa 1880-1920. Magenta-colored iron pyrite slag was present in the soil, a suspected byproduct of the production of sulfuric acid that occurred during the milling of super-phosphate. The site was listed on the State Hazardous Waste Sites database. The developer applied to develop the site under a Voluntary Clean-Up Contract as a registered Brownfield site. A hazard assessment was performed by testing the soil, groundwater, and slag on the site. Soil testing identified arsenic and lead as the contaminants of concern at levels that exceeded EPA Region 9 - Residential Preliminary Remediation Goals. A remediation plan was developed that established target soil remediation levels for arsenic and lead and approved by the state regulator. Remediation was performed by removal of contaminated soil. Analytical costs were reduced by direct-soil screening at incremental depths using portable X-ray fluorescence analysis with confirmation laboratory analysis at the target level. The removed soil was staged for on-site stabilization for disposal as nonhazardous waste. A health and safety plan was prepared to protect workers during remediation activities. As directed by the plan, personal exposure monitoring for lead and arsenic dust was performed on remediation workers. Ambient air perimeter monitoring for lead, arsenic, and total particulate (PM-10) was performed downwind at the property line, using a combination of direct-reading and active sampling methods with laboratory analysis. Target remediation goals were initially met for lead, but not for arsenic. A risk assessment was performed to establish a new target remediation goal for arsenic with land use restrictions. The target goal for arsenic established by the risk assessment was achieved with land use restrictions, restrictive covenants, and engineering controls. The site was developed with state approval.

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Sustainable Strategies to Thwart Pandemic Influenza Virus in the Workplace

L. Dlugosz, Walter Reed Army Medical Center, Washington, DC.

Influenza pandemic may cause widespread morbidity and mortality before an effective vaccine becomes available. A possible candidate, the H5N1 (avian flu) virus, has shown peak mortality in the 18-32 age range. Employers should develop preventive strategies now to protect workers and their families. Prevention methods include planning (developing SOPs), training (employees and family members), and preparation (purchasing supplies such as N95 respirators, disinfectants, and plastic bags). Family protection plans should include provisions to set up an airborne-infection isolation room (e.g., develop negative pressure with a small window fan and under-door make-up air, duct tape to seal return vents, small electric heater, bottled water, extra sheets and pillow cases, bleach to launder clothing and linens, etc.). Work-site plans should include provisions to increase social distance (telecommuting, staggered work hours, and closing common congregation points such as coffee shops, water fountains, elevators, etc.), disinfecting common touch points (ATMs, door knobs, vending machines, stair rails, card readers, copier buttons, faucet handles, etc.), and administrative controls (e.g., cough etiquette rules and prohibitions on handshakes and meetings). Employers with high-risk employees (e.g., frequent travelers, health care workers, sales, receptionists, and security personnel) and workplaces (e.g., clinics, shelters, bus, rail, and airline terminals) should consider starting PAPR, N95 respirator, and other personal protective equipment programs (with training in doffing, donning, fit-testing, and hand hygiene), as well as upgrading HVAC systems with increased maintenance, MERV 13 filters and/or UV germicidal irradiation (UVGI) lights in ducts, and installing upper-area UVGI fixtures above high occupancy areas.

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Remediation of Mercury and Other Environmental Concerns in a Foreclosed Dental Office

D. Obermeier, Bureau Veritas, Medina, Ohio; J. Hogue, Environmental Services & Consulting Inc. (ESCO), Powell, Ohio; E. Shamberger, Bureau Veritas, Akron, Ohio.

During the past several years, mercury issues have gained attention both for the public and for health, safety, and environmental professionals. While much national attention is given to methylmercury within the environment, elemental mercury from spills and historic use and/or releases affects many properties. This case study detailed a remediation project involving a former dental office in a building that went into foreclosure. The lending institution wanted to facilitate a cost-effective remediation to recover its investment in the property. When this facility was foreclosed, following the arrest of the dentist and owner of the building for drug and sex crimes, the building was boarded up and condemned by local officials. Vandals entered the building on numerous occasions, causing major damage, including dispersing mercury throughout the building. This project brought together many disciplines, with clear project goals from the owner, his representatives and agents, and regulatory agencies. Initial building decontamination of mercury was achieved in a short time frame. However, during final clearance sampling, additional mercury contamination was discovered within the sanitary plumbing system in the building. Testing of discharge water revealed that elevated levels of mercury were present in violation of the local pretreatment standards set by the Publicly Owned Treatment Works (POTW). What began as a straightforward building decontamination in order to sell the building ended with a cost-prohibitive plan to decontaminate the plumbing system within the building to meet the POTW pretreatment standard for mercury discharge. In addition to the mercury remediation, project issues included disposal of pharmaceuticals, biohazard waste, X-ray equipment with radiological sources, confidential patient files, asbestos, and mold. In this presentation, we will present the project planning, clean-up goals, project complicating factors overcome, project outcome, and challenges faced by each stakeholder involved.

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Release of Asbestos Fibers from Weathered Asbestos Cement Slate Roofing

H. Kim, The Catholic University of Korea, Seoul, Republic of Korea.

Due to the New-Community (Saemaeul) Movement of the 1970s, traditional thatched-house roofs were replaced with asbestos cement slate. Today, roofs of many houses and factories are still covered with asbestos slate. However, several researches have shown that weathering and corrosion of asbestos cement products could release dangerous asbestos fibers into the surrounding environment. The amount of asbestos fibers released, though, has not yet been quantified in Korea. The purpose of this study was to confirm and quantify asbestos fibers released from the asbestos slate. Three houses were selected, based on their year of construction - 1960s, 1970s, and 1980s, and were investigated. All were located in downtown of Seoul. Rain or melted snow water was collected from the roofs in a plastic bottle. A known amount of collected water was filtered on a 37-mm membrane filter, and the filter was ashed in a muffle furnace and subsequently treated with HCl to remove organic material. The treated material remaining was refiltered on a 27-mm membrane filter for PLM and PCM analysis. The NIOSH 7400 method was used for PCM counting. In addition, SEM/EDX was used to confirm the asbestos types. The results showed that chrysotile fibers were confirmed by PLM in all samples analyzed. A significant amount of asbestos fibers was found in the water samples. The ranges of asbestos fibers counted from the samples collected in the 1960s, 1970s, and 1980s were: 10,406.3~55,575.6 f/L, 5218.8~38,126.2 f/L, and 2906.3~7798.6 f/L, respectively. As anticipated, concentrations of asbestos fibers increased with time of installment of the roofing material. We conclude that weathering can be a significant factor on the release of asbestos fibers from the asbestos cement products. Because asbestos fibers released into the environment can be a source of significant health hazards countermeasures, such as replacement, removal, and encapsulation of weathered asbestos slate, should be initiated immediately.

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Nontraditional Environmental Sampling in the Community: Expanding the Industrial Hygienist's Role

J. Durant, P. Kowalski, S. Metcalf, ATSDR, Atlanta, GA.

The Agency for Toxic Substances and Disease Registry's (ATSDR) mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease-related exposures to toxic substances. ATSDR prepares public health assessments (PHAs) to determine whether hazardous substances may result in exposure and whether exposure might cause any harm to people. Where critical exposure data gaps exist, ATSDR conducts environmental sampling investigations to estimate worst-case exposure to hazardous substances and to evaluate possible health effects related to those exposures. Some examples of ATSDR's nontraditional environmental sampling investigations include (1) estimating personal exposure to asbestos during recreational activities at an urban beach in Illinois, (2) biota sampling to determine dioxin exposure from ingestion of locally caught seafood in coastal Mississippi, and (3) air sampling of hydrogen cyanide in a community near a gold mining operation in Colorado. While these investigations are not formal exposure studies, ATSDR uses the results of these investigations to help draw conclusions about the public health consequences of community exposure. Under most circumstances, recognized industrial hygiene methods transfer from the workplace to these community investigations.

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Intervention Strategies to Reduce Residential Pesticide Exposures

M. Shum, C. Bos, National Collaborating Centre for Environmental Health, Vancouver, BC, Canada.

Most nondietary exposure to pesticides occurs primarily in the home (Lewis et al., 1994; Whitmore et al., 1994). One pathway for exposure involves indoor pesticide use, which is prevalent; the EPA reported in 2002 that 74% of U.S. households used pesticides. Another possible pathway for pesticide exposure is through track-in of pesticides from outdoors. The take-home exposure pathway has been shown to be a significant contributor to residential contamination in agricultural workers (Curl et al., 2002; Curwin et al., 2005), but only a few studies have investigated track-in exposures in urban or nonagricultural settings (Nioshoka et al., 2001). In this presentation, we will provide an overview of the intervention strategies reported in the scientific literature to reduce indoor residential pesticide use and to reduce take-home exposures from outdoor use of pesticides. Education has been shown to be effective in several cases to reduce pesticide use in residences (i.e., integrated pest management has been shown to reduce pesticide use and pest infestations; Campbell et al., 1999; Brenner et al., 2003; Williams et al., 2006). In agricultural settings, education has been shown to be useful for increasing personal protective measures and increasing positive behaviors such as changing out of work clothes or removing shoes before entering homes (Perry et al., 2003; Mandel et al., 2000; Liebman, 2007). In a study investigating track-in exposures from application of pesticides on lawns, consistent removal of shoes upon entering homes was observed to have a greater effect on reducing take-home exposures than changing application factors (Nishioka et al., 2001). Although there have been many studies in agricultural settings and a few in residential settings, a substantial data gap remains on intervention strategies to reduce pesticide exposure in residences.

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Risk Management, Community Health, and Exposure Assessment of Naturally Occurring Asbestos (NOA) in a Remote Alaskan Village

J. Hargesheimer, A. Winterfeld, NORTECH Environmental Engineering, Health & Safety Consultants, Fairbanks, Alaska.

Ambler, Alaska, home to a population of 300+ Kowagniut Inupiat Eskimos , and with only air, boat, or snowmachine access, is located 45 miles north of the Arctic Circle, on the north bank of the Kobuk River, near the confluence of the Ambler River. During 2003-2005, samples of gravel sources used to construct the community airport, roads, and utility systems reported chyrsotile NOA at variable concentrations as high as 10%. A DOL limited health survey in 2003 recommended mandatory footwear cleaning before entering buildings, HEPA vacuuming of settled dust, and covering existing site surfaces with clean soils. An ATSDR 2007 exposure assessment concluded that dust and airborne asbestos levels were a public health concern, and recommended closing access to the gravel sources and elimination of their use. These findings resulted

in indefinite delays of public funding of airport, road, and utility projects that jeopardized the community's public health systems and impacted the local economy. The 2008 project results involved the development of an alternative work plan to repair the gravel airstrip using NOA gravel prior to a dust palliative application to reduce airborne dust concentrations. Project efforts included a village public meeting to inform and educate the village residents and tribal leaders regarding NOA, safe work practices, and exposure monitoring to be completed. Area and personal sampling of FAA work tasks and ADOT alternative work practices were monitored and documented no exceedences of the OSHA permissible exposure limit (PEL). The project effort improved the safety of the airport, reduced airborne dust concentrations, and facilitated the village residents and tribal leaders in better understanding NOA and appropriate methods to complete necessary community public projects with NOA gravels while reducing their personal exposure to asbestos.

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The Stink Lake Caper: A Case Study in Normal Environmental Processes and Urban Sprawl

W. Rahorst, Wendell Rahorst, Inc., Golden, CO; M. Richen, Boulder County Health Department, Boulder, CO.

With the increasing population, more rural areas that were previously used as agricultural land are being developed as urban housing corridors. This increases exposures in areas that had low population density which have been rezoned for family housing. This prairie pothole lake was called Stink Lake (formal name "Little Gaynor Lake") by many locals until it was acquired by a developer, who was successful in having it rezoned for family housing. After several years of dry summers and construction of half-million dollar homes around the lake, it became apparent to residents that this lake had annual releases of hydrogen sulfide during the summer. This case study concerned the continuous measurement of airborne concentrations of hydrogen sulfide over a two week period, background information on normal environment processes in regard to prairie pothole lakes, the resulting exposure assessment, and methods to control the generation and release of hydrogen sulfide from the lake.

Podium Session 120: Eclectic Topics in Safety, Confined Space, and Construction

Tuesday, June 2, 2009, 2:00 p.m.–5:00 p.m.
Papers 138–146

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Evaluation and Redevelopment of Confined Space Entry Programs in a Utility Plant: Utilizing OSHA Standard 1910.146(c)(7)

S. Shelat, None, Alexandria, VA.

Permit Required Confined Spaces (PRCS) are found throughout general industry and pose hazards that can result in injury and death for the entrant. Although OSHA's confined space standard (1910.146) provides a framework for identifying, evaluating, and controlling hazards, compliance with PRCS entry requirements can be daunting. For companies that do not have internal access to rescue teams, the cost to hire contractors can exceed $10,000 per day. Subparagraph (c)(7) of the standard allows reclassification of confined spaces from a PRCS to a temporarily reclassified nonpermit-required confined space. We evaluated an existing PRCS entry program at a utility plant to determine if entry procedures could be modified by applying subparagraph (c)(7). The entry standard can be implemented if all atmospheric hazards have been eliminated without entry into the space for the duration of the elimination. Approximately 76 confined space entry categories were identified in the plant. In 2006, 232 entries into 24 separate spaces were conducted. Of these entries, 65.5% of the spaces were classified as PRCS and analyzed for reclassification. Our program included comprehensive baseline hazard identification and assessment. The hazard identification process facilitates the determination whether hazards can be eliminated, thus making the spaces eligible for reclassification. We prepared documentation from interviews with plant personnel, review of equipment manuals, historical entry documentation, and lockout/tagout procedures. The evaluation method included consultation with operations and maintenance supervisors on the thoroughness of the hazard identification process and review of lockout/tagout procedures related to each space to ensure measures could be taken to eliminate all baseline hazards. A certified industrial hygienist was consulted and concluded that the documentation process was thorough and comprehensive. Implementation of the revised program resulted in 100% of the permit required entries evaluated eligible for reclassification under the stipulations of OSHA standard 1910.146(c)(7).

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Hazard Identification and Work Process Flow During Demolition at a Former Process Safety Management Facility

G. Ertel, Arcadis, Rochester, NY.

A Fortune 100 Company is in the process of decommissioning a large industrial facility used to process explosives and energetic materials that was covered under the Process Safety Management (PSM) Standard.

Problems:
• Significant physical hazard while working with buildings and equipment contaminated with explosives residue
• Potential exposure to asbestos, lead and other site contaminants during decontamination and demolition
• Prepare a comprehensive Hazard Identification and Work Process flow for a multiple contractor site

Project Objectives:
• Provide user-friendly hazard identification and ranking system
• Establish work process flow to allow for Process Hazard Assessment in accordance with the PSM standard
• Maintain compliance with regulatory requirements under a variety of industry and construction standards
• Document decontamination is adequate to meet military and environmental requirements

Resolution:
Technical:
• Accurate defensible hazard identification process with no lost time incidents for over 850K hours worked
• Input from multiple contractors and regulatory agencies with no regulatory issues
• Zero energetic injuries or unplanned equipment damage

Qualitative:
• No safety/security related incidents
• No claims or liability issues
• Over 250 buildings assessed and removed from the site with no incidents or unplanned environmental releases

Benefit to Others:
Lessons learned from this Project
• "Real-World" Process Hazard Analysis technique on a unique application of PSM
• Clearly define scope of work and each contractors responsibilities
• Maintain continuous communication
• Develop detailed training matrix
• Train project staff and monitor performance
• Rigorous PHA required for this type of work

Specific examples of each provided in presentation.

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Worker Exposure to Asbestos During Removal of Drywall with Asbestos Joint Compound

D. Pinchin, Pinchin Environmental Ltd., Mississauga, ON, Canada.

The use of asbestos in drywall joint compound (DJC) was extensive in both the United States and Canada prior to the 1980s. Most early asbestos regulatory actions and projects focused on friable asbestos fireproofing, mechanical insulation, and decorative/acoustic finishes. Recently, a much greater emphasis has been placed on the abatement of nonfriable or less-friable ACMs, including the asbestos-containing DJC. Very few studies have been published on worker exposure during this work. The current study presentsdata on worker exposure to airborne fibers (all types) using Phase Contrast Microscope (NIOSH 7402) and to asbestos fibers only using the Transmission Electron Microscope (NIOSH 7402). Data from six separate field projects that reflect typical field practices are presented. These field practices require the use of enclosures around the work area, although negative pressure is not routinely used. The use of water for dust suppression is exceedingly limited, if used at all. Air sample results from the six projects analyzed by NIOSH 7400 typically range from 0.3 f/mL to 10.5 f/mL. These are typical of results reported elsewhere during removal of drywall with asbestos-containing DJC. Analysis of these samples using NIOSH 7402 shows fiber concentrations in almost all cases less than the analytical sensitivity (<0.045 f/mL). The highest level of airborne asbestos was 0.052 f/mL for a single personal sample. These field results indicate that a review, and possibly a simplification, of work practices can provide adequate worker protection.

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Noise Exposure During Hand-Held Concrete Grinding - Effects of Dust Control Methods and Grinder Size

F. Akbar-Khanzadeh, S. Milz, C. Wagner, A. Ames, M. Bisesi, University of Toledo Health Science Campus, Toledo, Ohio.

Hand-held concrete grinding activities impose several distinct hazards on workers, including noise, silica dust, vibration, and ergonomics issues. Noise exposure assessment during these activities is challenging because of many confounders such as those related to tools/accessories, work surfaces and set up, and worker's position and work habits. This study used noise dosimeters (Spark 705+, Larsen Davis) to examine the extent of personal noise exposure while a concrete grinding worker used a variety of grinder sizes, types, and attachments, including available dust control methods. Noise monitoring was conducted in an indoor field laboratory located in a concrete cutting firm for nine days, covering 44 grinding sessions from 5 minutes to 60 minutes. The worker's minute-time-weighted average (dBA) exposure during grinding was 95.4 ± 5.2 (mean ± SD), ranging from 77.8 to 113.2. Background noise was 71.9 ± 4.6, ranging from 58.5 to 82.7. The levels of noise exposure were different for three methods of dust control; traditional (no dust control) grinding created significantly higher noise levels (98.0 ± 5.8) than those of wet grinding (96.7 ± 5.1) or local exhaust grinding (93.5 ± 4.4). The levels of noise exposure were also different for four sizes of grinding diamond cups (blade); 7-inch (17.8 cm) grinder cup generated significantly higher noise levels (97.9 ± 4.7) than those of 5 inch (12.7 cm), with noise levels of 95.6 ± 5.2, 4.5 inch (11.4 cm) with noise levels of 93.9 ± 2.3, and 4 inch (10.2 cm) with noise levels of 91.8 ± 5.2. There were no significant differences in the noise levels when grinding concrete in horizontal or inclined position or when the general ventilation in the shop was on or off. The results indicate that noise exposure levels during concrete grinding can exceed the recommended limits by ACGIH, and workers should be protected accordingly.

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Moisture Management During the Construction Process

E. Light, R. Gay, J. Bailey, Building Dynamics, LLC, Ashton, MD.

While water damage is a longstanding quality control issue at construction sites, recent concerns related to mold exposure have resulted in increased attention to prevention, assessment, control, and documentation of moisture during the construction process. We have adapted current industrial hygiene strategies for mold identification and remediation (developed for occupied buildings) to the unique conditions presented by building construction. Recognition of potential moisture pathways and material susceptibility is a prerequisite to the development of preventive measures and monitoring protocols. Assessment is based on visual inspection and moisture measurement. Remediation procedures emphasize replacement of water damaged materials and sanitizing work areas before project completion. Coordination with other construction activities presents many logistical challenges. Investigators must characterize observed moisture problems as to root cause (e.g., design oversight vs.construction defect) and differentiate these from future moisture issues that may arise during building operation. We will present a case study illustrating a comprehensive moisture management program during construction of a large commercial facility.

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A Community-Based Participatory Approach to Preventing Falls and Silica Exposure Among Latino Construction Workers

C. Roelofs, M. Brunette, S. Shepherd, L. Azaroff, ,University of Massachusetts Lowell, Lowell, MA; M. Gagliardi, Laborers Local 175, Methuen, MA; M. Grullon, City of Lawrence, Lawrence, MA; G. Lawtowsky, JSI Research and Training Institute, Boston, MA.

Latinos, the fastest growing ethnic group in the United States, are overrepresented in both fatal and nonfatal occupational injuries. The construction sector, with a large share of Latino workers (17%), is also one of the most dangerous industries, accounting for 20% of all occupational deaths. Despite extensive research that has addressed fall prevention in construction, the number of fall-related fatalities continues to rise. In the United States, approximately one of five workers who die from falls on the job is Latino. Silica exposure among Latino construction workers is much less well characterized, yet also likely to be a problem. Occupational safety and health interventions shown to be effective in other settings may not be completely appropriate or accessible to the Latino workers and the contractors who employ them. Interdisciplinary, participatory approaches are urgently needed to develop and evaluate measures for protecting the health of immigrant workers. We will describe our Community-Based Participatory Research project, "Protección en Construcctión: The Lawrence Latino Safety Partnership," and present results from the assessment phase of this intervention research project. The major hypothesis of our project is that a community-based participatory process involving city agencies, a labor organization, academia, construction safety experts, workers, contractors, family members, and Lawrence residents can develop an effective approach to prevent exposure to fall-related hazards and silica exposure affecting Latino construction workers. This initiative also aims to build a community-wide support system to carry on the program in the future. By involving employers, health care providers, government agencies, insurance companies, and the broader community with workers and their union, this project is offering the potential for sustainable, systemic change at the multiple levels required for intervention effectiveness.

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Comparison of Quantitative and Qualitative Approaches for Evaluating Health and Safety Hazards in a Pharmaceutical Facility

A. Bird, B. Treppa, M. Frechen, C. McGlothlin, Oakland University, Rochester, MI.

A pharmaceutical facility in Detroit, Mich., recently was evaluated for health and explosion hazards due to release of n-butanol vapors in a protein-filtration process. Quantitative and qualitative approaches were used in the assessment. Quantitative analyses included air sampling, airflow pattern measurements, and temperature measurements. The resulting data were mapped to a 3D representation of the filtration process area as part of quantitative risk assessment. In addition, computational fluid dynamics simulations using STAR-CCM+ 3.02 (CD-adapco, Melville, N.Y.) were used to predict n-butanol distribution patterns. The simulation results were used to extend the understanding of this workplace environment to a wider range of operating conditions beyond what was measured using instruments. Separately, qualitative analyses were conducted using the precautionary principle. The precautionary principle is a widely applied qualitative approach for mitigating hazards that may lead to adverse health effects. It is used to predict undesirable events and focus key corrective actions where perceived risk is highest. The quantitative and qualitative approaches were conducted by different groups of safety and health professionals in order to have unbiased outcomes. Results from the quantitative approach demonstrated likely overexposures to n-butanol and potential for explosion hazards in certain operating conditions of the filtration process. Results from qualitative analyses, while less specific, indicated an urgent need to reduce the n-butanol exposure at its source. In general, these approaches resulted in similar conclusions. However, results from application of the precautionary principle show there is bias based on experience level of safety professionals who would be conducting the assessment. We conclude that both quantitative and qualitative approaches should be used, but at different times in the assessment process. Finally, we propose a complete procedure for application of these approaches for evaluating workplace hazards in pharmaceutical manufacturing.

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Lithium Battery Safety Program at Woods Hole Oceanographic Institution

R. Reif, Woods Hole Oceanographic Institution, Woods Hole, MA.

The Woods Hole Oceanographic Institution (WHOI) uses primary and secondary lithium batteries in a variety of oceanographic research applications. Primary (nonrechargeable) lithium batteries generally contain lithium metal, whereas most secondary (rechargeable) lithium batteries contain an ionic form of lithium (lithium-ion). Because lithium batteries contain more energy per unit weight or a relatively higher energy density than conventional batteries, they have become popular and widely used in a variety of applications. However, the same properties that result in a high-energy density also contribute to potential hazards if the energy is released at a fast, uncontrolled rate. In general, the risks posed by lithium batteries are a function of battery size (the amount of lithium content and corresponding energy density) and the likelihood of short-circuiting or rupture. A lithium battery is susceptible to thermal runaway, a chain reaction leading to self-heating and uncontrolled release of stored energy. Flames produced by lithium batteries are hot enough to cause adjacent cells to vent and ignite. Multiple external and internal events involving primary and secondary lithium batteries (includ-

ing hot cells, fires, ruptured cells, and leaking cells) have prompted WHOI to develop and implement a comprehensive lithium battery safety program. Key program elements include cell handling procedures, cell storage criteria, hazard analysis, battery pack design criteria, shipment procedures, battery disposal, emergency procedures, and training.

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A Novel and Efficient Approach to Develop Numerous Equipment-Specific Energy Control Procedures

C. Torres, ENVIRON International Corp., Monument, CO; D. Regelbrugge, ENVIRON International Corp., Chicago, IL.

In this presentation, we will outline a novel and efficient approach taken to develop more than 1200 equipment-specific energy control procedures (ECPs) to comply with OSHA's Control of Hazardous Energy (lockout/tagout) Standard (29 CFR 1910.147). The development of equipment-specific ECPs represents significant challenges that often lead to a substantial amount of time spent by professional health and safety practitioners and associated equipment support personnel (e.g., equipment engineers, technicians, and operators); these challenges include, but are not limited to identifying all equipment energy sources and their magnitudes; determining appropriate means of energy isolation and verification of isolation; documenting effective lockout/tagout equipment, location of application, and methods necessary to effectively control all equipment energy sources; establishing appropriate equipment shut-down and start-up procedures; and utilizing all data collected "in the field" (i.e., at the equipment or during collaboration with equipment support personnel) to actually draft the ECP document. To address these challenges while ensuring appropriate and effective ECPs were developed, a process was created in partnership between health and safety practitioners and equipment support personnel. The resulting process minimized the amount of time needed in the field per piece of equipment to collect the requisite data. The key efficiency strategies employed by the process, which will be explored in more detail during the presentation, include use of a standardized data collection sheet to capture all relevant data while in the field; utilizing digital photography to document all energy sources for each piece of equipment; scheduling in the field data collection times involving equipment support personnel only for equipment requiring such assistance (i.e., equipment with numerous energy sources, complex configurations, redundant energy feeds, etc.); and employing nontechnical data-entry staff to input data from data collection sheets and related digital images into a commercially available software program to create the ECP documents

Podium Session 122: Biosafety and Environmental Microbiology

Wednesday, June 3, 2009, 10:00 a.m.–Noon
Papers 147–152

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Is Sampling After the Completion of Mold Remediation Necessary?

B. Caddick, G. Crawford, ENVIRON International Corp., Chicago, IL; P. Morey, ENVIRON International Corp., Gettysburg, PA.

Once mold remediation activities have been completed, various final clearance mold sampling techniques are implemented in an effort to determine if mold remediation activities were successful in returning the area back to normal conditions. The sampling is usually conducted on recently remediated surfaces, within containments prior to the area being reconstructed or once the area has been reconstructed. Exploring more than 30 case studies in which sampling was conducted upon completion of mold remediation activities revealed that post-remediation sampling was generally not necessary. In the vast majority of the cases, the remediated areas that were assessed and found to be free of remediation dust and debris were also found to be free of mold growth conditions. In only a few cases where the remediated areas were visually cleared (black/white glove sampling technique), did sample results indicate unsatisfactory remediated conditions. In these cases, additional concealed mold growth conditions that were not part of the initial scope of remediation were found. Further, in some cases the post-remediation sampling indicated acceptable conditions, whereas the visual inspections found mold growth conditions in or near the remediated area. Overall, the data suggest that a thorough visual inspection of the remediated area to ensure the area is free of visual mold growth conditions and remediation dust and debris have been removed is the most important aspect of judging remediation success. For most buildings, air and surface sampling for documentation of successful mold remediation is of limited value.

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Mold Remediation in a High-Rise Building — Challenge and Lessons Learned

L. Hung, USPHS/Federal Occupational Health, Philadelphia, PA.

Building-related respiratory symptoms had been constantly reported by employees in a high-rise office building. The building had experienced elevated relative humidity and numerous water incursions in the past. Stained ceiling tiles and visible mold growth behind wall coverings and baseboards were observed. Numerous samples collected by employees or their consultants showed the presence of water-damaged indicator fungi in the building envelope. The building owner began a building-wide mold remediation project to remove all exterior walls and a portion of the perpendicular interior walls on each occupied floor. A mold remediation specification was developed, and a remediation company was hired. On each floor (approximately 10,000 square foot area), three containments were established with polyethylene layers and negative air pressure was maintained in each containment. An independent third-party firm was hired by the building owner to inspect the containment and perform final visual inspection and microbiological sampling after remediation crews reported completion of removal and thorough cleaning. Another consulting firm was hired by the tenant to oversee the owner's activities provided by the third-party firm. Both parties performed visual inspection together, and then each collected its own air and surface samples and sent them to separate laboratories for analyses. *Aspergillus flavus, Aspergillus versicolor, Chaetomium,* and *Stachybotrys chartarum* were detected from air and surface samples collected inside the containment before removal activities took place. For clearance sampling, one consultant collected 12 nonculturable air samples and 12 tape samples while the other collected 50 air samples (25culturable and 25 nonculturable) and 204 surface samples (102 contact plates and 102 tapes). We will present results from clearance samples and the fates of these containments. Challenges and lessons learned from this project, such as open communication, trust among different parties, issues related to QA/QC and clearance sampling, and a whole building approach, etc., also will be discussed in this presentation.

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Is Fibrous Insulation Along the Air Stream Surface of HVAC Ductwork Compatible with a Healthy Building?

P. Morey, ENVIRON International Corp., Gettysburg, PA; B. Caddick, G. Crawford, ENVIRON International Corp., Chicago, IL; T. Rand, St. Mary's University, Halifax, NS, Canada.

Approximately 15 years ago, Phil Morey co-authored a paper questioning whether or not the presence of fibrous insulation within HVAC supply air ductwork was compatible with a healthy building. It was recognized at that time that the dirt and dust (nutrient for molds) that accumulates on air stream surfaces is hydrophilic, and mold growth commences on the air stream surface when the equilibrium moisture content of the dirt and dust becomes adequate to support germination. During the past decade, we have evaluated HVAC systems for the presence or absence of mold growth on fibrous and nonfibrous air stream surfaces. We have found that as long as moisture is adequate, mold growth as evident by the presence of a hyphal network or fruiting structures (cellotape sampling) can occur on the dust and dirt present on all kinds of HVAC air stream surfaces. Physical cleaning can remove mold growth that occurs on smooth, nonfibrous surfaces such as sheet metal ductwork, drain pans, cooling coils, diffusers, etc. We have, however found, and will present, photomicrographic evidence showing that mold hyphae can enwrap or grow around the fibers of porous insulation affected by mold growth. When insulation fibers become enwrapped with hyphae, conventional cleaning is impossible or problematical, and the moldy insulation should be discarded. The presence of fibrous and moldy materials on the air stream surfaces of HVAC equipment are thus reaffirmed as being incompatible with the healthy building concept. Recommendations to minimize mold growth on HVAC system air stream surfaces will be reviewed.

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Interior Wallboard Wall Cavity Growth: A New Twist on Vinyl Covers?

B. Kasher, Charlotte Mecklenburg Schools, Charlotte, NC.

In this presentation, we discuss wall cavity colonization involving vinyl wall covering on interior sheetrock walls located in slab on grade construction, though not resulting from exterior wall vapor barrier or EIFS related issues. Discussion will illustrate the scenario from initial building occupant complaints, maintenance department response, IAQ investigation, problem identification, root cause analysis to remedy. Occupant complaints of musty odors resulted in initial maintenance response. The issue was forwarded to the EHS Office when maintenance staff could not remedy occupant concern. Initial IAQ surveys did not observe signs of moisture intrusion, elevated humidity, or growth. Occupant complaints of upper-respiratory irritation and odors persisted. Through process of elimination, hidden colonization was uncovered below vinyl wall covering and inside wall cavities. Root causation analysis resulted in different potential moisture sources offered by different engaged professions. Use of direct-read equipment resulted in identification of a significant moisture intrusion source not generally realized as problematic: electrical conduit penetrations through slab on grade. A four-phase remediation approach was implemented throughout: investigation, remediation, repair, and post remediation air sampling. The investigation phase determined extent of remediation necessary per wall. Remediation was then conducted using negative pressure containment or under controlled conditions, depending on size of wall repair. Repairs included removal of damaged material, sealing moisture sources, fungicidal treatment, and patching or replacement of wall systems. Post remediation sampling included concurrent sporetrap sampling inside work areas and near HVAC intakes outside of the subject buildings. Changes in construction techniques include improved sub-slab vapor barrier systems and in quality assurance function related to areas concealed early in the interior construction process to prevent recurring issue in new construction. In this presentation, we will guide participants through the complete scenario from occupant complaint to post remediation sampling, while identifying the interior moisture intrusion source not widely discussed in published literature.

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Clearance Sampling for Sewage Clean Up

H. Burge, EMLab P&K, San Bruno, CA.

Indicator organisms commonly used to detect the presence of sewage include total coliforms, *Escherichia coli*, and *Enterococcus*. While these organisms do indicate the possible presence of sewage, they do not evaluate possible health risks; they may be from animal rather than human sources, and they may not be representative of remediation effectiveness. Enteric viruses, primarily noroviruses, are important disease agents. Recent data indicates that enteric viruses than the bacterial indicator organisms, and are less sensitive to chlorine. In a laboratory setting, 8, 16, and 30 mg/L free chlorine produced >5log10 declines in the indicator bacterial populations, whereas viral indicators (phage and poliovirus) were more resistant (0.2-2.8 log10 unit declines). Naturally occurring enteroviruses were even more resistant ($p > 0.001$) (Tree et al., 2003). These data are especially important for sewage clean up clearance sampling. Sewage spills may take days to be completely resolved, during which time most of the indicator bacteria will have died, whereas many of the pathogenic viruses may remain infective. In addition, sodium hypochlorite is the biocide of choice for most sewage clean up efforts. The use of viral indicators may be more appropriate both for water contamination and for sewage clean up. A further problem with sewage spill clearance is the extent of such spills. Clearance sampling is designed to prove the negative case. Thus, either a large integrated sample must be collected, or many spot samples. Vacuum collected dust could provide the required sample volume to actually document clearance, but the bacterial indicators are unlikely to survive the collection and transport of such samples. Viral indicators using molecular methods may provide the answer. A recently reported plant virus, which is present in human but not animal waste, shows particular promise.

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Express Analysis of Spore Traps Based on Classification of Airborne Spore Patterns

M. Sogonov, EMSL Analytical Inc., Westmont, NJ.

Spore traps serve as a tool for characterization of moldiness in buildings by counting spores in a given volume of air pumped through a cassette. Spore counting is a time-consuming, tedious procedure, and the numeric results are not very precise due to errors of both sampling (variation of spore concentration in space in time) and reading (partial reads on traces having uneven spore distribution, and ambiguous identification of some spore categories). The question raised here is whether we ultimately need exact numbers, or whether a qualitative or semi-quantitative result would suffice. We used an approach analogous to one used by plant ecologists for decades. Instead of providing counts of all individual plants of each species in a plot of given area, they often use plant community categories. Although patterns observed on spore traps do not directly reflect fungal communities as they grow, and may contain spores coming from different sources, we assumed this approach could be applied with a fair level of approximation. Instead of "fungal communities" we suggest using the term "airborne spore pattern types" (ASPT). ASPTs could be defined by an expert's judgment, or, in a less biased way, by using multidimensional statistics methods. In this study, a dataset was created from independent counts of 1172 Air-O-Cell and Allergenco spore traps from different locations (mostly Mid-Atlantic United States) throughout a year. The dataset was processed with Principal Component and Correspondence Analyses. The results suggest the following ASPTs: (1) summer outdoor samples with high concentrations of asco- and basidiospores); (2) moderately to heavily contaminated indoor samples with significant numbers of *Aspergillus/Penicillium* spores (with potential subranks); (3) indoor samples with *Chaetomium/Stachybotrys* contamination (with potential subranks); (4) clean indoor and winter outdoor samples with very low spore counts.

Podium Session 123: Emerging Issues in Emergency Preparedness and Response

Wednesday, June 3, 2009, 10:00 a.m.–Noon
Papers 153–158

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Triage and Treatment Strategies for Radionuclide Inhalation Scenarios

E. Waller, University of Ontario, Oshawa, ON, Canada.

In the event of a release of radiological material to the atmosphere, it is possible for radionuclides to enter the human body through inhalation. There is a need to rapidly triage potentially exposed persons, to (a) decide on appropriate treatment strategies, (b) perform dosimetry assessments, and (c) clear nonexposed persons from the scene (and alleviate the worried well phenomena). The triage strategy assumes that (i) there exists a field capability to measure the presence of contamination, identify the isotope(s) involved, and estimate the activity order of magnitude inhaled; (ii) once identified, there is a treatment strategy available; and (iii) there exists sufficient decorporation pharmaceuticals to treat affected personnel. From a medical perspective, removal of radionuclides leading to dose aversion is of high importance. The efficacy of medical decorporation (accelerated removal of the insult from the body) strategies is dependent on the time of treatment delivery after intake. To assist first-response personnel in making timely triage assessments, it is desirable to have a hardware solution for rapid field assessment of internal contamination and a software tool that compiles existing radionuclide decorporation therapy data and allows a user to perform simple diagnosis leading to potential appropriate decorporation treatment strategies. In this talk, I will present a comprehensive triage and treatment strategy, using a radiological triage mask for detecting orofacial contamination, and complementary software to assist medical personnel with decorporation strategies.

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Lessons Learned: Hurricane Ike

L. Lee, University of Texas M.D. Anderson Cancer Center, Houston, Texas.

In a perfect world, hospitals learn to become more effective during emergency events throughout time by means of situational exercises and training. Unfortunately, the best lessons are those that are learned through an actual experience. Located in close proximity to the Gulf Coast, The University of Texas M.D. Anderson Cancer Center had the opportunity to implement its emergency preparedness response plan when Hurricane Ike directly hit the Houston/Galveston area in September 2008. Destruction and devastation spread widely throughout the city and surrounding areas, including the Texas Medical Center where M.D. Anderson facilities are located. Although, the institution continually exercised and trained for ongoing emergency preparedness, opportunities were identified. Emergencies are dynamic, and it should be understood that there will be areas of improvement that should be recognized for future response efforts. In this presentation,

I will identify the shortcomings and lessons learned discovered pre and post Hurricane Ike, which will be categorized under four broad topics: logistics, training, communication, and departmental issues. The focus will be centered on emergency plan preparedness, implementation, and recovery.

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Critical Measures in Pandemic Planning

L. Koonin, CDC, Atlanta, GA.

Planning for an influenza pandemic is an important part of occupational/environmental health and safety. The World Health Organization and the CDC continue to warn of the very real threat of a global influenza pandemic, characterizing the threat as a "when and not an if." While the severity of a pandemic will be unknown until the specific viral sub-type emerges, experts agree that the businesses and the community at large need to plan and prepare for the worst-case scenario, where as many 30% of the population may fall ill, with a 2% death rate. Although pharmaceutical and nonpharmaceutical intervention methods are being developed, employers are likely to experience drastic threats to their business survival as a result of employee absenteeism rates as high as 40%. This will be a *people* problem resulting in health impacts and the potential significant adverse effects on supply and demand of essential goods and services and challenges to all types of organizations. There are two primary aspects to mitigating the effects of a pandemic on any organization. First is to defend against infection of the virus itself by implementing effective nonpharmaceutical and hygiene measures, protocols, and administrative policies to minimize spread of infection. And second, to prepare the organization to operate under a "*critical* functions only" model in anticipation of the change in demand for their particular goods and services and to allow effective industrial hygiene and infection prevention protocols and policies to be implemented. This program will provide the most current, scientifically based information on U.S. guidance for how organizations should prepare for effective intervention and mitigation measures of a pandemic event, and it will offer viable solutions and resources to narrow the staggering gap between current preparedness levels and those required to ensure continuity of private and public-sector organizations.

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Trials and Tribulations: Response and Sampling for *Bacillus anthracis* After a Containment Breach at a Biodefense Laboratory

A. Intrepido, ChemRisk, San Francisco, CA.

Sampling and clean up operations after a biothreat agent contamination incident are closely linked and can continue for months. However, response to a *Bacillus anthracis* (Ba) containment breach at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), one of the nation's leading biodefense laboratories, needed to be efficient and expedited to continue operations and protect the work force. The response occurred as a result of unauthorized sampling done three days prior by a USAMRIID microbiologist who found Ames strain Ba surface contamination at three non-containment areas, including his office. This strain of Ba was the same type used in the letters during the 2001 anthrax attacks, in which USAMRIID analyzed two of the letters' powder and more than 10,000 related samples. During the response, three separate environmental sampling phases were implemented to support an initial assessment and determination of sites with contamination (screening sampling), establishing the extent of contamination at concerned sites (characterization sampling), and verifying the effectiveness of the remediation of those sites (clearance sampling). Designing targeted and probabilistic sampling strategies was integral in meeting the goals of all three phases. Targeted sampling utilized incident details and expert judgment to determine locations that were most likely contaminated for each plausible pathway. The probabilistic strategy consisted of randomly sampling a portion of all locations, based on a statistical design. Screening and characterization sampling also played a key role in identifying the need for preventive medical treatment among potentially exposed workers. Results of the targeted sampling found additional contamination in two of the three initially identified areas and probabilistic sampling found zero positives, adding confidence that other locations were not contaminated. This response enforces how imperative it is to develop a multifaceted sampling plan that integrates both probabilistic and targeted approaches to provide an objective determination of whether remediation was successful.

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The Unknown Risks of Urban Exploration

M. Levitsky, O. Malik, ECOH Management Inc., Mississauga, ON, Canada.

An urban explorer was fatally injured at a demolition project where we were the health and safety consultants. Urban explorers make up a little-known subculture, with some cult-like qualities. They trespass, explore, and photograph on sites such as subway tunnels, sewers, drains, utility tunnels, power plants, and industrial buildings. The risks and illegality of these ventures are an integral part of the appeal to many urban explorers, who pride themselves on their daring and defiance of authority. Several urban explorers have died in pursuit of their hobby, as occurred in this case when the deceased fell almost 30 feet into a hopper while trying to photograph some unusual aspects of the project. The presence of hazardous materials on the site, including asbestos and silica, subjected workers and emergency responders to exposure during the rescue effort and its aftermath. In our presentation, we will explain the urban explorer subculture, provide an overview of legal and liability issues, and offer recommendations on preparing for and preventing injuries, fatalities, and hazardous exposures that may be associated with urban exploration.

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Integrating Health and Safety into an Incident Response or Recovery Operation: An Ongoing and Critical Process

J. Ignacio, U.S. Coast Guard/U.S. Public Health Service, Waldorf, MD.

Incident safety or assistant safety officers at either response or recovery operations must effectively integrate their health and safety efforts into a structured operations planning cycle. The National Incident Management System describes in detail this planning cycle, but leaves the health and safety integration officer with little guidance. However, the RAND/NIOSH Study for the World Trade Center 2001 response and recovery operation clearly articulated the importance of an integrated incident-wide safety management program. In each critical step of the operations planning cycle, there are specific safety and health tasks that should be accomplished, and information conveyed to members of the command and general staff. By working within this cycle, with specific health and safety tasks identified for each of the critical steps, an effective health and safety integration to prevent or minimize mishaps can occur in a proactive manner

Podium Session 124: Personal Protective Equipment

Wednesday, June 3, 2009, 10:00 a.m.–Noon
Papers 159–164

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A Speech Recognition Approach to Automatic Objective Speech Intelligibility Assessment for Personal Protective Equipment

Q. Li, J. Hajicek, T. Burchfield, Y. Yin, Li Creative Technologies, Florham Park, NJ; K. Coyne, D. Barker, Edgewood Chemical Biological Center, APG, MD.

Users of personal protective equipment (PPE) are faced with several challenges. One of these is diminished speech intelligibility caused by several factors: the equipment's own noise and resonances, physiological noise, and hearing attenuation and distortion. Current methods for measuring PPE's effects require the use of human subjects, making such tests costly, dependent on motivation and attentiveness of the subjects, and time consuming. An objective approach for measuring speech intelligibility is therefore sought in order to overcome the drawbacks of subjective testing. A proposed objective test system will utilize automatic speech recognition (ASR) software and two advanced artificial head and torso simulators. Each simulator can be fitted with PPE, and one functions as the speaker and one as the listener. The speaker has an artificial mouth, a loudspeaker. The listener has artificial ears. In preliminary experiments, speaker and listener simulators were placed facing each other at a distance of 3 meters to replicate the current face-to-face human subject test standard. Words from the CAT and MRT speech databases were played through the speaker simulator and recorded by the listener's artificial ears. An acoustic model was developed for the ASR software with no PPE worn on the simulators. ASR word accuracy scores without PPE correlated well with human subject data under the same conditions. When PPE was fitted onto the simulators, word accuracy scores were reduced nonlinearly. Using these robotic simulators for human subject correlation will bridge the gap between subjective and objective evaluations for a wide range of PPE, and the goal of a novel objective speech intelligibility assessment system can be met.

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Quantification of Perceptual Effects for Personal Protective Equipment

J. Hajicek, T. Burchfield, Q. Li, Li Creative Technologies, Florham Park, NJ; D. Barker, K. Coyne, Edgewood Chemical Biological Center, APG, MD.

Auditory-based measurement standards and specifications essential for quantifying the effects of personal protective equipment (PPE) on hearing are generally nonexistent. Quantification of perceptual effects on the auditory system is necessary to understand how wearing any given PPE can change awareness of one's environment. In many situations where PPE is worn, users must rely heavily on amplitude, pitch, and localization cues to avoid danger or harm. Methods were developed to characterize and measure important auditory parameters affected when PPE is worn. Parameters such as attenuation, head-related transfer functions, interaural level differences, interaural time differences, PPE-created noise, and speech transmission effects were evaluated and quantified for several PPE systems and subsystems. Theoretical relationships to human perceptions were also made using the above quantifications. From these measurements and characterizations, design suggestions are given that will enable manufacturers to develop PPE with improved auditory performance and fidelity. Additional efforts will provide practical PPE auditory measurement and performance standards, as well as ratings to increase the available database of auditory specifications.

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Derivation of Dermal Vapor Protection Factors for Chemical Warfare Agents: NFPA 1994 Class 2 Nonencapsulating (Level B) CBRN Chemical Protective Ensembles

D. Matthews, Shaw Environmental Inc., Alpharetta, GA; L. Verdier, Shaw Environmental Inc., Cincinatti, Ohio.

The U.S. Army operates and maintains storage and disposal facilities for chemical warfare agents (CWAs), including blister and nerve agents. Personal protective equipment worn by personnel performing CWA operations and maintenance activities include Level A and Level B military chemical protective ensembles (CPEs). CPEs are certified for use with chemical, biological, and radiological particulates (CBRN) under NFPA Standard 1994, "Protective Ensembles for First Responders to CBRN Terrorism Incidents." They include Class 1 CPEs (fully encapsulating suits with NIOSH-certified SCBAs, analogous to Level A) and Class 2 CPEs (chemical-resistant suits/hoods, gloves, and boots with NIOSH-certified SCBAs, which are similar to Level B). An evaluation was conducted to determine if certified NFPA 1994 Class 2 "nonencapsulating" CPEs could provide adequate dermal vapor protection at CWA levels above the two-hour maximum use concentrations (MUCs), which are used as guidance for upgrading to Level A protection. NFPA 1994 requires that CPEs meet various performance criteria, including a test protocol that utilizes a vapor simulant under laboratory conditions. This protocol was adopted from ASTM F 2588, "Standard Test Method for Man-In-Simulant Test (MIST) for Protective Ensembles." CPEs are tested in a chamber under dynamic conditions to assess the level of vapor penetration. Dosages are determined with personal adsorbent devices that are placed on the skin of human test subjects at specific locations on the body, while the subject performs physical exercises wearing the suit. The dosage data is used to calculate a series of local physiological dosage factors ($PPDF_i$) and a systemic physiological protective dosage factor ($PPDF_{sys}$) for the ensemble. $PPDF_i$ and $PPDF_{sys}$ values were back-calculated for selected CPEs, using two-hour exposure times (vs. the standard 30-minute MIST duration). Estimated protection factors were then derived and used to develop adjusted two-hour MUCs for dermal vapor protection against selected CWAs.

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An Improved Approach for Using Permeation Test Data in Glove Selection

C. Hintz, Dow Chemical, Port Lavaca, Texas; M. Spence, M. Sczepanski, D. Seiler, J. Cikalo, Dow Chemical, Midland, MI; J. Twisk, J. Hendrix, Dow Chemical, Terneuzen, Netherlands.

Relating laboratory glove permeation test results to practical real-world glove use recommendations has been problematic for industrial hygienists for many years. Glove users will often go to the manufacturers' glove selection charts and simply select a glove with the highest breakthrough time on the chart, adhering to the overly simplistic view that breakthrough time is the same as glove use time and is the primary factor when selecting a glove. We will report that a different approach has been developed that can better serve the practical needs of the end user. The approach is based on the concept that permeation test data are best used in the first step of selection to establish the set of glove materials that provide an adequate chemical barrier. The approach to be discussed involves a "weight of evidence" approach to evaluating glove materials. Instead of looking only at the breakthrough time for a particular make and model of glove, this new approach systematically generates a calculated index that takes into account the thickness-normalized breakthrough time and permeation rate data available for all gloves of a particular material. The result is, in effect, a property of the barrier material itself, instead of a property of a particular make and model of glove. To enlarge the data pool, the approach also facilitates the inclusion of data on chemicals of similar size and chemical functional group. We also will discuss how this approach has been used to produce glove material use statements for material safety data sheets.

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Critical Heat Stress Evaluation of Clothing Ensembles with Different Levels of Porosity

T. Bernard, C. Ashley, University of South Florida, Tampa, FL; J. Trentacosta, V. Kapur, S. Tew, E.I. duPont de Nemours Co. Inc., Wilmington, DE.

Protective clothing is known to influence the level of heat stress experienced by the user. The progressive heat exposure protocol provides a method to estimate the critical WBGT above which thermal equilibrium is difficult to maintain and to estimate the apparent total evaporative resistance of the clothing ensemble. Both the WBGTcrit and the Re,T,a are useful for comparing the effects of protective clothing ensembles under heat stress conditions. The hypothesis of this study was that increases in air permeability through levels of porosity will influence the convective transfer of heat (convective mass transfer of water vapor instead of diffusive transfer). The prototype military protective clothing ensembles had six levels of porosity (0, 1, 2, 5, 10, 20%) and the control ensembles were work clothes and a typical military chemical protective ensemble. Six men wore each of the ensembles while walking at a metabolic rate of 160 W/m^2. There were no statistically different means of WBGTcrit (34°C-WBGT) and the Re,T,a (0.014 m^2 kPa/W) for the prototype coveralls with 2% or more porosity and work clothes. Likewise, the Saratoga and prototype with no porosity were not different (31°C-WBGT and 0.022 m2 kPa/W). While not statistically significant, there was good evidence that the prototype with 1% porosity performed at an intermediate level (33°C-WBGT and 0.016 m^2 kPa/W). Thus, there was a progression of lower heat stress with increasing porosity, but the level of porosity reaches diminishing returns above 2%.

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Whole-Glove Permeation Testing of Disposable Gloves with Simulated Movement

R. Phalen, California State University, San Bernardino, San Bernardino, CA.

According to NIOSH, more than 13 million workers are exposed to chemicals that can be absorbed through the skin. In addition, about 2.9 million workers suffer from dermatitis each year in the United States. One critical gap in knowledge is the protection afforded by chemical protective clothing under worker-use conditions. The aim of this study was to develop a method to conduct whole-glove chemical permeation testing with simulated movement. First, a novel method was developed to measure bi-directional stretching at the different regions of the glove. Measurements were taken on gloved hands with both extension and flexion hand postures. The gloves were then inflated using pressures ranging from 0.06 to 0.12 inches of water to determine the optimal pressure that would simulate the hand postures. A three-inch outer collar was used at the cuff to restrict inflation in this region. Inflation and deflation of the glove were controlled using an available pneumatic controller. Permeation testing of disposable nitrile gloves was conducted using ethanol. Continuous monitoring was performed with a photoionization detector in a closed loop. The normalized breakthrough time (NBT) was 12.5 ± 1.9 min with movement and 14.6 ± 2.2 min without ($p \leq 0.05$). The steady-state permeation rate was 10.5 ± 1.6 $\mu g/cm^2/min$ with movement and 8.7 ± 1.1 $\mu g/cm^2/min$ without ($p \leq 0.05$). Overall, whole-glove movement decreased the NBT by more than 14%, and increased chemical permeation by greater than 20%. For a 30-minute exposure, the average permeation rate with movement (2.6 ± 1.3 $\mu g/cm^2/min$) was twice ($p \leq 0.05$) that without movement (1.3 ± 0.7 $\mu g/cm^2/min$). Simulated hand movement significantly affected the permeation of ethanol through a disposable nitrile glove. The methods developed in this study can be used to evaluate whole-glove performance and the influence of hand movement on chemical permeation.

Podium Session 125: Risk Assessment/Risk Management

Wednesday, June 3, 2009, 10:00 a.m.–Noon
Papers 165–170

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Establishing Quantitative Priorities for HSE Program Management

A. Sheaffer, J. Yasalonis, LMI, Belcamp, MD.

Establishing objective priorities for improving health, safety, and environmental (HSE) programs is essential for cost-effective HSE program management. As integrated HSE programs gain popularity in industry, managers need quantitative tools for identifying risks and establishing program priorities. In this presentation, we will discuss a process for prioritizing HSE aspects to achieve maximum benefits with available resources. Our objectives in this project were to: (1) create a single protocol and ranking system that allows quantitative assessments of health, safety, and environmental risks, and (2) integrate gap assessment and benchmarking results with traditional risk estimating methods. This process begins by quantifying the base risk associated with each HSE aspect, using a customized matrix expressing the likelihood and severity of the HSE impacts associated with each aspect. Base risk results are expressed as a number from one (very low risk) to five (very high risk). These base risk results are then modified to reflect the effectiveness of management controls for each aspect. Gap assessment results provide a convenient source of management control scoring data. Finally, the results of a recent benchmarking study are used to increase the priorities of those HSE aspects where the organization's programs ranked lower than those of peer organizations. This customized prioritization process is useful because it begins with typical hazard probability and severity estimates, and then adjusts the results to account for program effectiveness and the typical "standard of HSE performance" for a specific industry sector. This results in a more objective and realistic prioritization of program elements. Using this documented risk prioritization system allows HSE managers to periodically review and adjust priorities to account for new HSE threats or improved HSE program performance. Using the quantitative priority scheme also helps HSE managers explain and justify specific initiatives and requirements within the HSE budget.

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Prioritizing Audit Findings for Risk Using a Consequence-Likelihood Matrix

L. Wash, 3M, St. Paul, MN.

Audits are an essential part of an occupational health and safety management system (OHSMS). They provide an objective assessment of the overall effectiveness of the OHSMS, as well as a means to identify specific hazards for controlling risks. Success depends on addressing the audit findings, and prioritizing the findings is an important step in developing an action plan. Prioritization can be accomplished in a variety of ways but, to be most credible and effective, it should be done consistently from audit to audit and from auditor to auditor. Effective training is important to help assure consistency among auditors. Workshops using an audience response system can help identify and measure variability among auditors. These systems are commonly used to capture individual responses and display them to the audience for immediate feedback and further analysis. Auditors are asked to prioritize audit findings and submit their opinion using the system keypad. Group and individual responses can be analyzed before and after training to provide information that can help to identify possible sources of variability among auditors. The analysis can also be used to tailor training to reduce auditor variability and improve overall documentation of findings.

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Risk Reduction Through Substitution - EnviroRisk — An Integrated Tool for Chemical Management, Early Feedback, and Documentation

H. Smedbold, Occupational Hygiene Solutions AS, Stavanger, Norway.

Chemical legislation requires an integrated approach to chemical management considering health, environment, and safety aspects. Few companies have available expertise and management systems to fulfill these requirements. The EnviroRisk project aims to close parts of this knowledge gap by providing an interactive web-based chemical management tool. The tool will support risk reduction through early substitution,, a cost-effective way of reducing risk. The management module will make it possible to document these substitution activities. The EnviroRisk project is aiming to develop an integrated web-based chemical management tool addressing health, environment, and safety aspects for the users and the community, for SME companies. The work is currently supported by the Norwegian Research Council and ConocoPhillips Norway. The tool is based on EU legislation and chemical labeling, and will later be adapted to GHS. The work is linked to ChemiRisk(R). The tool will consist of three main parts - an application module, an evaluation engine, and a management module. The application module provides an interactive tool for the chemical requisitionist, giving assistance describing the product and its usage. The evaluation engine provides the requisitionist with instant feedback on the actual chemical, and guidance for identifying less hazardous alternatives (substitutions). The evaluation is on both the properties of the chemical product itself and its ingredients. The evaluation is based on information gathered from the requistionist, the MSDS, and information about chemical substances collected from external sources and recorded in an internal database. The methodology is based on a control-banding approach. The management module makes the chemical manager able to monitor, and finally approve, the evaluation. For hazardous chemicals, additional information about actual usage and exposure controlling barriers are needed. The evaluation engine provides guidance and links to more advanced tools.

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Application of Exposure Matrix and Risk Assessment of Industries and Process-Treated DMF in Korea

K. Ha, D. Paik, Changwon National University, Gyungnam, Republic of Korea; D. Park, Korea Open National University, Seoul, Republic of Korea; C. Yoon, Seoul National University, Seoul, Republic of Korea.

Recently, occupational exposure to DMF (N,N-dimethylformamide) is creating serious problems such as fulminant hepatitis in Korea. The reduction of risk of DMF within the workplace has been the focus of attention through both industry initiatives and legislation. Exposure matrices of 19 industries and 80 process-treated DMF were constructed based on the exposure database of the Korean Occupational Safety and Health Agency, which was gathered from a workplace hazards evaluation program in Korea. These exposure matrices were assessed by danger value that was calculated from a combination of hazard rating, duration of use rating, and risk probability rating of exposure to chemical hazardous agents, according to Hallmark Risk Assessment Tool to control risk. The results of risk assessment were divided into four kinds of control bands that were related with control measures. The applicability of risk assessment using exposure matrices was performed by field study and survey for high matrices group. A total of five workplaces were investigated through walk-through survey and employees' exposure assessment. This study found that more attentions should be paid to industries that manufacture clothing and textiles and to processes of coating, processing, and mixing, which were regarded as having the highest risk among 19 industries and 80 processes. The results indicated the risk assessment using exposure matrices was applied as a general exposure information system for hazard control, risk quantification, and hazard surveillance. The exposure matrices included work force data, and they provided information on the numbers of exposed workers in Korea by agent, occupation, and level of exposure and risk.

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Investigation of the Accuracy of Reported Flashpoint Values on Material Safety Data Sheets

D. Radnoff, Alberta Employment and Immigration, Edmonton, AB, Canada; R. Lockhart, R. Echavarria, Golder Associates Ltd., Burnaby, BC, Canada.

Material Safety Data Sheets (MSDSs) are the foundation of the Workplace Hazardous Materials Information System (WHMIS) in Canada. Information contained on an MSDS is used at the work site to ensure that hazardous products are used correctly and safely, to develop safe work procedures using the products, and to develop worker training programs. If the information provided is incorrect or inaccurate, there can be serious health and safety implications to workers. The federal WHMIS legislation has requirements for the disclosure of 54 separate information categories on MSDSs for hazardous products. One of these is the flashpoint of a product (the lowest temperature at which a flammable or combustible liquid gives off enough vapor to form an ignitable mixture with air). While

flashpoint must be measured using a particular method specified by the legislation, there is no legal requirement to test the product to determine its flashpoint, so flashpoint values for mixtures can be estimated using information on the ingredients in the product. There is some concern that this may not be a suitable method for determining a product's flashpoint and could give rise to potential fire hazards at the work site. In this project, a variety of flammable solvent mixtures were sampled at work sites across Alberta. The flashpoint was determined using the methods specified in the Controlled Products Regulation, Schedule IV, and compared with the value disclosed on the MSDS. We will present the results of this study.

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Experiences of Polish Safety and Managing System in Coal Mines During the Last 10 Years

R. Tkocz, Occupational Hygienists Association Poland, Radlin, Poland

In this presentation, I will discuss Polish experiences in the field of underground exploitation of hard coal during the last 10 years, focusing on tragedies such as methane gas and coal dust explosions in coal mines: Silesia, Halemba, Jasmos, Rydutowy, Borynia, and the implementation of a safety and hygiene managing system into the Polish coal mine industry with risk evaluation, health protection, and low regulation.

Podium Session 126: Exposure Assessment/ Reconstruction Strategies

Wednesday, June 3, 2009, 10:00 a.m.–Noon

Papers 171–176

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Monte Carlo Application and Demonstration of a Generalized Similar Exposure Group (SEG) Concept to Retrospective Exposure Assessment (REA) of Individuals

E. Rasmuson, J. Rasmuson, R. Strode, D. Hall, Chemistry & Industrial Hygiene Inc., Wheat Ridge, CO.

Performing a retrospective exposure assessment (REA) for an individual can be challenging because of potential uncertainty in exposure history, varying work practices, spatial and ventilation conditions, and other variables. In addition, there is a need to continue to standardize this process. Using the standardized exposure assessment paradigm described in current and past editions of the Exposure Assessment Strategies Committee's publications, *A Strategy for Assessing and Managing Occupational Exposures* and *Mathematical Models for Estimating Occupational Exposure to Chemicals,* provides a recognized approach to address these needs for standardization. One base concept in the standardized exposure assessment paradigm is to classify workers into similar exposure groups (SEGs). We will describe an approach that involves numerical assessment of exposure probability distributions for SEGs and present a basis for determination of whether a particular individual is a member of a particular SEG(s). Case examples will be presented that illustrate the utility of broadening the number of locations, work practices, and ventilation conditions within a particular SEG. Increased inclusivity for a particular SEG widens the associated exposure range but makes inclusion within the SEG possible for individuals where not all exposure variables are known. Case examples demonstrating that the log-normality of the distribution of exposure measurements associated with an expanded SEG is generally maintained as the scope of an SEG increases will also be presented.

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Historical and Exposure Reconstruction in the Taconite Mining Industry — Study Design

J. Hwang, G. Ramachandran, University of Minnesota, Minneapolis, MN.

We will present the design of the exposure assessment for an epidemiological study of the relationship between exposures to components of taconite dust and adverse health effects, specifically mesothelioma and silicosis. The goal of this study was to assess historical and current exposures of workers to asbestos and nonasbestos fibers, respirable dust, and respirable silica in the taconite industry between 1955 and 2008. Exposure histories will be evaluated for a cohort of workers selected from three large mining companies in northeastern Minnesota. Historical exposure data are available from the Mine Safety and Health Administration, the Mineral Resources Health Assessment Plan database, and internal databases from each of the mining companies. They include impinger, personal gravimetric, and area gravimetric measurements. The exposure data matrix will have dimensions of year, job title, task, job location, duration of shift, and type of process. We expect that monitoring data will be missing for substantial portions of the matrix. To fill in these missing data, we plan to use information on historical exposure determinants such as ventilation and generation rates using various exposure models. Interviews with veteran workers will help provide information on historical working conditions. Several statistical imputation methods will also be used. A comprehensive assessment of current exposures, including personal measurements of asbestos and silica exposures and particle size distributions based on cascade impactor data will be used to provide a benchmark from which past exposures can be extrapolated. A Bayesian framework will be used to combine available monitoring data with modeling predictions and expert judgments.

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The Use of Bayesian Techniques in Retrospective Exposure Assessment: Case Study at a Chemical Manufacturing Facility

J. Sahmel, ChemRisk Inc., Boulder, CO.

Bayesian statistical techniques can be an effective way to refine the results of a retrospective exposure assessment and dose reconstruction. Based on inductive reasoning, Bayesian techniques statistically combine prior information about an exposure scenario with existing data or generated estimates. In this case study, industrial hygiene expert judgments about benzene exposures at a chemical manufacturing facility during a period of almost 30 years were used to create a "prior" probability distribution for the potential for benzene exposure during key tasks at the facility. The expert judgments collected contained a numeric best estimate of the likely exposure concentration for specific job tasks of interest based on knowledge of the processes, worker practices, and exposure controls for those tasks. For each expert judgment, a self-reported numeric level of confidence in the estimate was also recorded. In addition, multiple estimates were collected for job tasks in which significant process changes likely affected the potential for benzene exposures over time. The results were then considered in combination with quantitative sampling data for the same tasks of interest at the facility over the same time period. The resulting final "posterior" distribution function statistically considers all available information. The quantitative sampling data for this facility was extremely robust for certain tasks with the potential for benzene exposure, and less so for other tasks. The results of this analysis will be discussed for the individual tasks evaluated and also compared with a more common quantitative statistical data analysis to highlight the differences that may result from using Bayesian methods to help refine a retrospective exposure assessment.

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Application of Chemical Risk Management (Control Banding) Toolkits for Generating Control Guidance in Selected Industrial Processes in India

R. Ayyappan, K. Balakrishnan, R. Raghunathan, S. Sankar, Sri Ramachandra University, Chennai. Tamil Nadu, India; M. Surianarayanan, Central Leather Research Institute, Chennai. Tamil Nadu, India.

Control banding tools are user-friendly, simple matrices that provide the user with guidance for controlling exposures to hazards. It is also meant to overcome the scarcity of technical expertise in industrial hygiene and lack of resources. Agencies such as WHO, ILO, NIOSH, and GTZ, as well as NGOs such as IOHA and IEA, are involved providing guidance for the simple chemical risk assessment for use by industries. We will present the results of the application of an effort implemented by the host institution in Southern India. The approach involved sensitization of owners to a range of available toolkits (COSHH Essentials, The GTZ guide and the ILO Toolbox), allowing owners to select an approach (based on their perception of utility of a specific toolkit), application/evaluation of toolkits by investigators alongside plant managers, and development of supplemental information databases and/or toolkits based on feedback. Wherever feasible, investigators performed independent industrial hygiene measurements to aid in the understanding of the risk management framework required in these settings. Nearly 45 processes (34 in leathers, textiles, and petrochemicals; 4 in oxygen manufacturing; 2 in offset printing; 2 in refrigerating and air conditioning; 1 in jewelry; and 2 in metal degreasing) were evaluated using the toolkits. Data from more than 100 industrial hygiene meas-

urements performed as part of ongoing research projects were compiled for comparative risk assessments. While many of the challenges encountered in the application of the toolkits have been or are likely to be solved successfully from a technical standpoint, lack of local regulation requiring such an approach is likely to be the single largest obstacle for wider adoption of such approaches by local industry. Despite its simplicity, without accompanying policy thrust to encourage its application, control banding runs the risk of being a research exercise instead of creating a sustainable local framework for chemical management.

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WITHDRAWN

Podium Session 127: It's About Noise, With a Little Bit of Heat

Wednesday, June 3, 2009, 10:00 a.m.–Noon
Papers 177–182

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Noise Exposure Characterization Among Residential Trash Collectors in Puerto Rico

S. Rodriguez, S. Caporali Filho, M. Vargas, M. Vincenty, Universidad de Puerto Rico, San Juan, Puerto Rico.

Environmental noise levels in the metropolitan areas of Bayamon and Dorado, Puerto Rico, are considerably higher than their counterparts around the world. High demographic and vehicular densities are considered to be important contributors to these higher noise levels. The objective of this study was to characterize noise exposure among trash collectors within the municipalities of Bayamon and Dorado, Puerto Rico. Full-shift noise dosimetry data was collected during the school period from January 2008 to September 2008 for one entire crew in each municipality to obtain one full-shift estimate for each crew member in all four workdays of the week. Throughout the sampling period, both crews remained with the same truck, and the crews were made up of a truck driver and two trash collectors. Work shifts varied from 6 hours to 9.2 hours, depending on the daily route, which was completely dependent on the day of the week. Noise exposure data was compared with traffic patterns and tested for significant differences between different weekdays, crew member, and municipality. The day of the week had a significant, 5% level, effect on the individuals' noise exposure. In that sense, Monday was associated with the highest noise exposure, whereas Tuesday was associated with the lowest, as well as with the least disperse noise exposure data. On the other hand, no significant differences were found between the driver and the two collectors, which is most likely due to the different impacts that the noise from the truck engine and from the environment had on each crew member's exposure. The driver seemed to be more affected by noise exposure from the engine, whereas the trash collectors seemed to be more affected by the overall environmental noise. Finally, no significant effects were found due to the municipality in itself.

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Heat and Noise Measurements in a Brazilian Iron Ore Railway

S. Eston, W. Iramina, M. Schrage, USP, São Paulo, Brazil.

Iron ore is an important product exported by Brazil, and the railway system is a vital part of the iron ore production chain. Trains with diesel-electric engines may take from several hours to several days to reach their destination. Several Brazilian iron ore mines and their transportation networks are located in areas with rugged topography that may slow down the trip to the port. The time spent inside the cabin exposes operators to many hazards, predominantly heat stress, noise, and ergonomics issues. Conditions get worse in the summer when cabins expose operators to dangerous conditions. The number of locomotives to be analyzed was above 600, and a sampling strategy was devised to estimate the workers' exposition. Thermal measurements were taken with WBGT thermometers in order to verify compliance to Brazilian standards. Noise dose and spectral distribution were also evaluated. Several types of locomotives sets were studied, and the results showed that the temperatures ranged considerably and that some were above Brazilian standards. Noise doses projected to an eight-hour shift, ranged from 51% to 595% of Brazilian legal exposure limits, showing the need for engineering control measures such as barriers, shielding, and personal protective equipment. These workplace hazards could result in mistakes, bad judgments, and other behaviors that could lead to incidents and accidents. Managing these hazards is now part of the company's industrial hygiene program.

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Noise Exposures on Shooting Ranges

A. Rouse, Ontario Ministry of Labour, Toronto, ON, Canada.

A field study of the noise on shooting ranges was conducted at police training ranges. The purpose of the study was to assess the noise exposures of the weapons trainees and, more specifically, the training officers. The recently revised Ontario Noise Regulation requires that noise be kept at or below 85 db(a) integrated, over eight hours, using a 3 dB(a) exchange rate. The time exposure halves with each 3 dB increase in noise levels such that 88 dB is allowed for four hours, and 115 dB is allowed for about 30 seconds. We will discuss the process of conducting the noise measurements, and the problems associated with conducting measurements in an extreme noise environment. Noise levels during some training exercises at the indoor shooting ranges were in excess of the integrating sound level meter's capability, and required adjustments to be made to noise measuring methodology and interpretation. The results of testing will be discussed. In addition, the limits and assumptions used in the testing, and interpretation of results, will also be discussed. The primary noise overexposure concerns are with the training officers. Methods of mitigating the noise will be discussed, including sound absorption by the surfaces in the shooting range, personal protective equipment in use and recommended, and alternatives to "live" weapons testing that may have some utility.

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Noise Exposure Assessment Technique for Occupations Where Wind Is a Significant Contributing Factor Toward Overall Noise Exposure

S. Caporali Filho, University of Puerto Rico, Medical Sciences Campus, Graduate School of Public Health, San Juan, Puerto Rico.

In this presentation, I will describe the development and validation of a technique for the assessment of noise exposure in occupations where wind noise represents a significant contributor toward the overall noise dose, such as motorbike-riding police officers. The proposed noise assessment technique consisted of using in-ear binaural microphones with premolded silicon fixtures for ear insertion, connected to a portable digital recorder. Very few studies have been conducted to assess motorcycle driver noise exposure, all of which have addressed noise dose inside the driver's helmet. Due to communication and environmental purposes, police officers' helmets in Puerto Rico don't cover their ears (half-shell helmets), increasing the contribution of wind noise toward the overall exposure. To validate the proposed technique, an experiment was designed and conducted with a full-torso instrumented manikin with a half-shell police helmet inside a wind tunnel with wind speeds of 12, 32, 70, and 114 km/h . The binaural microphones were located as close as possible to the instrumented manikin's ear canal, while the instrumented manikin had an internal half-inch microphone used as reference, simulating the individual's hearing. In this experiment, the readings coming from the binaural microphones were statistically validated at all tested wind speeds against the reference microphone readings.

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Assessment of Occupational Noise Exposures Using Subjective and Objective Measures

R. Neitzel, W. Daniell, L. Sheppard, H. Davies, N. Seixas, University of Washington, Seattle, WA.

Characterization of variable noise during long periods of time presents a major exposure assessment challenge. Strategies such as assignment of exposure based on job title may not provide adequate exposure contrast or precision for variable exposures. This study evaluated subjects' perceptions of occupational noise exposure as an alternative or complementary exposure assessment strategy. There were 20 subjects recruited at each of three work sites with different noise environments (continuous, intermittent, and highly variable). Full-shift dosimetry measurements (n=206) were made on each subject during four workshifts during two weeks. Perceived exposure information was collected via surveys on subjects' first (n=58) and last (n=57) monitored shifts, as well as through timeline logs completed during dosimetry. The first survey focused on the first shift only, whereas the second survey covered the whole two week period. Timeline log data suggested that subjects could detect changes in noise level and variability within a workshift. Survey items on perceived noise variability and impulsiveness performed well at the continuous and highly variable sites. The contrast between exposure groups created using job title was generally

smaller than that provided by subjective survey items. Finally, the precision of exposures predicted from survey items was comparable to, or slightly better than, that of job title for several survey items, and the addition of survey items to prediction models, which included job title improved model fit and precision. Supplemental perceived noise exposure information appears to offer promise for improving exposure estimates, particularly for individuals with highly variable exposures.

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Humidex: Trying to Simplify Heat Stress Prevention

J. Oudyk, Occupational Health Clinic for Ontario Workers (Hamilton Clinic), Hamilton, ON, Canada.

In 2002 the union representing a member who died of heat stroke in a bakery requested a simpler version of the wet bulb globe temperature (WBGT) to evaluate heat stress risks in small and medium-sized workplaces. The union asked if the WBGT could be translated into the commonly used Canadian heat index called the Humidex. Using the Modified Discomfort Index reported by Moran and Pandolf, which is based on dry bulb and wet bulb temperature measurements, a preliminary scheme was derived by collapsing the categories specified in the ACGIH Heat Stress/Strain TLV. This scheme was piloted in a mid-sized auto parts manufacturing firm. Three students took WBGT/Humidex readings continually over three shifts during the summer. After collecting more than 7000 individual measurements, the agreement between the Humidex categories and the unacclimatized moderate metabolic category was in excess of 89%. Outdoor measurements were correlated with cloud cover data to provide estimates of the globe temperature. While the use of the WBGT is still recommended for complex heat stress exposure situations, the use of the Humidex translation has empowered workplaces not having access to industrial hygiene expertise with the ability to prevent heat-related illnesses based on easily obtainable measurements of temperature and humidity during hot weather episodes. Extended use of the system has led to "self-calibration," where workers can recognize and act upon the signs of heat strain without taking measurements. The simplicity of the Humidex measurements has shifted the balance of power in conducting heat-related hazard assessments from those with technical expertise to the shop floor.

Podium Session 128: Nanotechnology

Wednesday, June 3, 2009, 1:00 p.m.–3:00 p.m.
Papers 183–188

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A Control Banding Tool for R&D Nanotechnology Operations

S. Paik, D. Zalk, Lawrence Livermore National Laboratory, Livermore, CA.

Control banding (CB) strategies offer simplified solutions for controlling worker exposures to constituents that are found in the workplace in the absence of firm toxicological and exposure data. These strategies may be particularly useful in nanotechnology applications, considering the uncertainty about what nanomaterials and nanotechnologies present as potential work-related health risks and how risk related to these materials might be assessed and managed. This study introduced a CB tool (CB Nanotool) that was developed specifically for characterizing the health aspects of working with engineered nanoparticles and determining the level of risk and associated controls for several ongoing nanotechnology-related operations being conducted at a Department of Energy (DOE) research laboratory. The control band for a particular operation is based on the overall risk level (RL) determined for that operation, which in turn, is determined by a "severity" score and a "probability" score. Based on the application of the CB Nanotool, 21 of the 25 operations evaluated in this study were found to have implemented controls equal to or more protective than what was recommended by the CB Nanotool. Four operations were determined to require an upgrade in controls. By developing this dynamic CB Nanotool within the realm of the scientific information available, this application of CB appears to be a useful approach for assessing the risk of nanomaterial operations. This success can be seen in providing recommendations for appropriate engineering controls, facilitating the allocation of resources to the activities that most need them, and initiating an appropriate discussion of these risks with nonexperts. In this presentation, we will show the science behind the simplified CB Nanotool approach, its applications, and its future applications.

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Occupational Exposure Assessment for Nanoparticles Using Multiple Metrics

J. Park, G. Ramachandran, P. Raynor, University of Minnesota, Minneapolis, MN.

Recently the appropriateness of the "mass concentration" metric for ultrafine particles has been called into question, and surface area (SA) and number metrics have been considered. In this study, exposure assessments were performed in a restaurant, an aluminum die-casting factory, and a diesel engine lab generating incidental nanoparticles using various exposure metrics. Aerosol measurements were taken using six aerosol instruments simultaneously: three aerosol photometers for concentrations of PM1.0, PM2.5, and respirable mass, a condensation particle counter for number, a diffusion charger for SA, and an optical particle counter for size distribution by number. Each workplace was divided into high- and low-exposure groups using preliminary measurements, and three locations were selected for each group. Measurements were made twice at each location during a 6-hour sampling time with 3-minute averaging times. In the restaurant, fine particle number and SA concentrations in the high-exposure group were a factor of 20 and 9 greater than those in the low group, but respirable mass concentration was slightly lower in the high group than the low group. Exposure rankings by fine particle number and SA concentration were the same, but rankings by the other metrics were different. In the die cast facility, all metrics showed significantly greater concentration in the high-exposure group than in the low group. In the diesel engine lab, SA and fine particles number concentrations were 2.5 and 3 times higher in the high group than those in the low group, but they were not significantly different. The ratios of high to low for mass concentrations ranged from 0.8 to 1.3. Fine particle number and SA concentrations were more related to particle generation sources than mass concentrations. The finding that exposure rankings depend on the exposure metric chosen has significant implications for epidemiological studies.

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Nanoparticle Exposures at Fossil-Fuel Fired Power Plants

J. Hicks, S. McCarthy, Exponent Inc., Oakland, CA.

Nanoparticles are aerosols defined as having a particle size of less than 0.1 µm. The generation of nanoparticles is known to be related to the combustion of fossil fuels. Considerable interest in the presence and concentration of nanoparticles exists, in part because of technological advances that allow for their study, and in part because of possible significant health effects attributed to them. We will present the results of measurements for nanoparticles at coal- and gas-fired power plants, in locations where workers may be exposed to these materials. Two coal-fired, multiunit plants were studied (positive pressure and balanced draft boilers), and one combined cycle, gas-fired combustion turbine was evaluated. Direct-reading instruments were used to measure nanoparticle concentrations, and nanoparticle surface area concentrations, at multiple locations where workers may be present during normal operations as well as during maintenance work. A nanoscale cascade impactor was used to collect nanoparticles from one plant, and the collected particles were analyzed by electron microscopy, energy dispersive spectroscopy, luminescence, and related techniques. The results reveal important relationships between specific power plant locations and exposures to power plants. The particle analysis demonstrates the typical morphology and chemical composition of the collected particulates.

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Novel System for Delivering Aerosolized Nanoparticles in Experimental Inhalation Studies

A. Madl, S. Teague, T. Guo, Y. Qu, K. Pinkerton, University of California, Davis, Davis, CA.

Assessing the human health risks associated with engineered nanomaterials is particularly challenging because of the wide range of plausible exposure scenarios. While workers, consumers, or the general public may potentially be exposed to nanoparticles through a number of pathways (e.g., dermal, ingestion, ocular), inhalation, at least from an occupational standpoint, is likely to be one of the most significant routes of exposure. For hazard assessment of inhaled nanoparticles, it is critical to have a means to deliver respirable airborne nanoparticles for experimental animal studies. An aerosolization system was developed to administer nanomaterials from a dry bulk media into respirable

airborne particles for delivery into a nose-only inhalation system. Utilization of a cannula-based feed system, diamond grinding wheel, cyclone-type conditioning chamber, and Krypton-85 source (charge neutralization) allows for efficient delivery of otherwise difficult-to-produce respirable-size particles. Different nanomaterials (e.g., single-walled carbon nanotubes, ultrafine carbon black) were tested with the aerosolization system, and aerosolized particles were characterized by size, mass, and number distribution using a gravimetric filter analysis, inertial cascade impactor, and scanning mobility particle sizer with a condensation particle counter, as well as by particle morphology using transmission electron microscopy. Aerosolized particles represented a wide range of size and morphological characteristics, with particles spanning the fine (0.1-2.5 μm) and ultrafine (<0.1 μm) size range mostly in an agglomerated state. An advantage that this system offers over other aerosol-generating systems is that it uses relatively small amounts of dry material (<0.3 g) to generate respirable particle concentrations up to 1 mg/m^3 continuously throughout a 6-hr period. Relating airborne particle characteristics in experimental studies to those in human exposure settings will be important for establishing exposure/dose-response relationships and standards to protect human health.

Podium Session 129: Biological Monitoring: Biomakers, Exposure, Symptomology and Correlation

Wednesday, June 3, 2009, 1:00 p.m.–3:40 p.m.
Papers 189–196

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Determinations of THMs and HAAs in Urine Simultaneously by Microwave-Assisted Solid Phase Microextraction

Y. Liu, I. Chen, S. Tsai, National Taiwan University, Taipei, Taiwan.

Disinfection byproducts, such as trihalomethanes (THMs) and haloacetic acids (HAAs), are formed when disinfection agents, such as chlorine, react with natural organic matters or bormide/iodide. Because there are many sources of organic matter, including hair, urine, sweat, and bacteria in swimming pools, concentrations of THMs and HAAs formed could be higher than what are usually found in drinking water. To assess the exposures of THMs and HAAs from swimming pools, a method of determining THMs and HAAs in urine simultaneously was developed. Solid phase microextraction (SPME), combined with microwave-assisted system technique, was adopted in this study. Known concentrations of THMs and HAAs were first spiked to urine samples, followed by the derivatizations of HAA acids to ethyl esters with hydrochloric acid and methanol under 45°C with microwave (raised from 0°C to 45°C under 50 watt) for 45 minutes. The THMs and HAAs derivatives were then extracted by the SPME fibers. Gas chromatography with electron capture detector (GC/ECD) was used for the analysis. The results showed that CAR-PDMS fiber provided the best extraction efficiencies under low stirring rate and without salt addition. The linear ranges of the analysis were 6-99 ppb and 0.01-20 ppb for HAAs and THMs, respectively. Compared with conventional methods for the determinations of THMs and HAAs, the microwave-assisted SPME technique provided a time saving, easy for operation, and solvent-free procedure.

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Total-Body Exposure to Cobalt and Tungsten Compounds

A. Stefaniak, G. Day, M. Virji, NIOSH, Morgantown, WV.

Workers are exposed to cobalt- and tungsten-containing dusts during production of cemented tungsten carbides. Exposure may occur via ingestion, inhalation, and dermal pathways, with each compound and pathway contributing to total-body burden. To better understand body burden, dissolution of aerodynamically size-separated cobalt, tungsten, and tungsten carbide powders was evaluated in artificial gastric juice, lung fluids, and sweat. In gastric juice (pH 1), cobalt dissolution was biphasic, with half-times from 0.03 to 0.6 days; tungsten and tungsten carbide dissolution was single phase, with half-times from tens to hundreds of days. Chemical dissolution rate constants (k) for cobalt were 4×10^{-4} (initial) and 2×10^{-5} (long-term); tungsten and tungsten carbide $k \approx 1 \times 10^{-5}$ g cm^{-2} day^{-1}. In airway epithelial lining fluid (pH 7.3), dissolution of all three powders was biphasic: 1 and 2 days, 0.1 and 34 days, and 0.1 and 460 days for initial and long-term half-times of cobalt, tungsten, and tungsten carbide, respectively. Associated k values were 1×10^{-5} and 5×10^{-6} (cobalt), 1×10^{-3} and 3×10^{-6} (tungsten), and 1×10^{-3} and 0.2×10^{-6} (tungsten carbide) g cm^{-2} day^{-1}. In artificial alveolar macrophage phagolysosomal fluid (pH 4.5), dissolution of cobalt was slightly faster, and dissolution of tungsten and tungsten carbide were slower than in airway lining fluid. Cobalt readily dissolved in artificial sweat, whereas tungsten and tungsten carbide were less soluble. Estimates of k values coupled with absorption rates across biological membranes support the occurrence of multipathway, total-body exposures to cobalt and, to a lesser extent, tungsten compounds. These data have implications for sample collection, interpretation of biomonitoring results, and understanding the risks of cobalt- and tungsten-induced adverse health effects. Efforts should be made to minimize body burden of cobalt and tungsten compounds via ingestion, inhalation, and dermal pathways.

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Neurobehavioral Functions Among Adolescent Workers Exposed to Organic Solvents in Car-Painting Workshops in Port-Said

A. Mishriky, Faculty of Medicine, Ismailia, Egypt.

Child labor is the most severe form of child exploitation in the world today. Adolescent workers working in car-painting workshops are at significant risk of exposure to organic solvents and consequent risk to develop neurotoxic disorders. There is a lack of data that determine the magnitude of this problem in Egypt. The purpose of this study was to determine the magnitude and patterns of neurobehavioral changes among adolescent workers exposed to organic solvents. The study was conducted in Port-Said City. Eighty adolescent workers exposed to organic solvents in car-painting workshops were compared to an equally matched unexposed control group. Data were collected through interviews, and neurological and psychological examination and biological monitoring were done. The study was approved by the ethics committee. The results revealed statistically significantly higher reporting of neurotoxic symptoms (dizziness, numbness in hands and feet, decrease of muscular power in arms, impairment in sleep patterns, difficulty concentrating, and irritability) in the exposed group. The mean counts of digit span forward and backward, digit symbol, and pursuit aiming were significantly lower among exposed adolescents, compared with the control group, $p < 0.05$. The mean concentrations of hippuric acid, methylhippuric acid, total phenol, and mandelic acid in urine were also significantly higher among them, $p < 0.05$. In conclusion, there is an association between exposure to organic solvents and impairment of neurobehavioral performance in adolescent workers. Tests measuring motor steadiness, perceptual motor speed, and auditory memory could be good indicators for measuring neurobehavioral changes among adolescent workers exposed to organic solvents. Recommendations are given regarding preplacement and periodic medical examination, workers and environmental measures, with suggestions for further studies.

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Urinary 1-Hydroxypyrene Levels in Offshore Workers

N. Hopf, S. Kramer, P. Succop, M. Genter, T. Carreon, J. Mack, G. Talaska, University of Cincinnati, Cincinnati, Ohio; J. Kirkeleit, B. Moen, University of Bergen, Bergen, Norway.

Crude oil contains polycyclic aromatic hydrocarbons (PAHs), a complex mixture known to cause cancer. Although most of the processes on offshore installations are performed in closed systems during ordinary operations, workers are at risk of exposure to PAHs and other aromatic hydrocarbons whenever the system is opened for surveillance of the production, cleaning, inspection, and maintenance. Workers can be exposed to PAHs through ingestion, inhalation, and percutaneous absorption. In the present study, PAH internal exposure was measured as urinary 1-hydroxypyrene (1OHP) in offshore workers. The objectives of this study were: (1) to compare differences in mean (point estimate) post-shift and pre-shift urinary 1OHP levels between exposed and nonexposed workers, after adjusting for covariates such as smoking, job, and age; and (2) among the exposed workers, to model the relationship between post-shift urinary 1OHP levels, after controlling for pre-shift 1OHP levels, smoking, job, age, and other variables. Participants (n=42) provided two urine samples; the morning void before starting a job with known exposure to crude oil and immediately at the end of the 12-hour shift on the end of the study period. Urine samples were analyzed using high performance liquid chromatography with fluorescence detection. Statistical analyses performed were ANCOVA that included in the model pre-shift urinary 1OHP levels and other covariates. Significant predictors in the model for post-shift urinary 1OHP were exposure group, 1OHP pre-shift levels, and the age-exposure group interaction term.

Mean post-shift 1OHP levels were significantly higher in the exposed workers compared with the controls, after controlling for age and pre-shift 1OHP levels. Tank workers and process operators did not show significantly different post-shift 1OHP levels, after controlling for age and pre-shift 1OHP levels. Future studies should include use of personal protective equipment because dermal PAH exposures could potentially account for the 1OHP levels seen in these workers.

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Evaluation of Bakery-Associated Allergen Exposures at a Commercial Bakery

C. Dowell, E. Page, C. Mueller, R. Biagini, NIOSH, Cincinnati, Ohio.

NIOSH investigators evaluated a commercial bakery to characterize exposures and compare sensitization and symptom rates. PBZ and GA air monitoring was performed to measure inhalable flour dust, α-amylase, and wheat. All study participants completed a questionnaire, and their blood was drawn and tested for total IgE and IgE specific to flour dust, wheat, and α-amylase. The highest individual PBZ inhalable flour dust concentrations were found on sponge mixers and sanitation employees, followed by scalers and mixers. PBZ measurements for the employees in these groups ranged from 0.55 mg/m^3 to 65 mg/m^3, and all 32 exceeded the CalOSHA PEL and ACGIH TLV of 0.5 mg/m^3 for inhalable flour dust. Other employees who had contact with dough also had exposure to inhalable flour dust. Of 26 PBZ measurements for the employees in these groups, 22 exceeded the CalOSHA PEL and ACGIH TLV for inhalable flour dust. Employees in the high-exposure group had significantly higher prevalences of work-related wheezing or whistling in chest than those in the low-exposure group. They also had significantly higher prevalences of work-related runny nose, stuffy nose, and frequent sneezing. In the high-exposure group, 27% of employees reported having a rash on their face, neck, hands, or arms, compared with 14% of employees in the low-exposure group. The prevalences of IgE ≥ 0.35 kU/L specific to wheat allergens, inhalable flour dust, and α-amylase allergens were higher in the high-exposure group, but the differences were not statistically significant. However, the prevalence of IgE ≥ 0.35 kU/L specific to wheat allergens was significantly higher among employees who reported either a current or past job in the high-exposure group, compared with the low-exposure group. NIOSH investigators recommended engineering controls, work practice changes, the use of respiratory protection, and a medical surveillance program for employees exposed to bakery-associated antigens.

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Biomonitoring and Modeling of Plasma 1,6-Hexamethylene Diamine (HDA) Levels in Workers Exposed to 1,6-Hexamethylene Diisocyanate (HDI)

S. Flack, K. Fent, L. Gaines, J. Thomasen, L. Nylander-French, L. Ball, The University of North Carolina at Chapel Hill, Chapel Hill, NC; S. Whittaker, Local Hazardous Waste Management Program in King County, Seattle, WA.

Plasma levels of 1,6-hexamethylene diamine (HDA) in 46 autobody repair shop spray painters were correlated with dermal and inhalation 1,6-hexamethylene diisocyanate (HDI) exposure levels. One blood draw was performed at the end of the work shift on repeated visits from spray painters who were applying clearcoat-containing HDI. Total HDA in the plasma fraction was quantified by GC-MS after derivatization with heptafluorobutyric anhydride (method detection limit, 0.020 µg/L plasma). HDA was detected in 75% of plasma samples at 0.012 µg/L to 0.92 µg/L. After log-transformation of the data, HDA plasma concentrations correlated with the daily sum of the personal breathing-zone HDI level multiplied by paint time ($µg/m^3$-min) for each paint task ($r = 0.50$, $p < 0.001$). We also observed a positive association between HDA plasma concentrations and total HDI monomer levels on the skin (ng/mm^3) ($r = .51$, $p < 0.001$). Using linear mixed modeling and backward elimination of insignificant covariates ($\alpha = 0.10$), we identified significant variables among factors related to the work environment, personal protective equipment, and dermal and inhalation exposures measures for predicting HDA plasma levels. Of these covariates, breathing-zone HDI concentrations, air sampler type implemented during field sampling (one- or two-stage filters), respirator type (PAPR), and booth type (downdraft) were significant predictors of plasma HDA levels ($p < 0.10$).

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Cross Reactivity and Parallel Independent Sensitization to Environmentally Important Fungi

B. Cortes, EMSL Analytical Inc., Orlando, FL.

Cross reactivity has been defined by the ability of an antibody to react with or bind an antigen that did not stimulate its production. No prior exposure is necessary for cross reactivity to occur. Sensitization occurs via inhalation or through contact to the skin in response to levels of fungal exposure, and is characterized by IgE antibodies and positive skin-test reactions to the allergen. IgE-mediated allergies are usually associated with Type I hypersensitive reactions. We reviewed the scientific literature and while the mechanisms of antigen-antibody recognition and response are beyond the scope of this presentation, we pooled the results involved with cross reactivity and sensitization to environmentally significant fungi. We examined levels of exposure that trigger IgE-mediated reactions. As little as 60 spores/cubic meter of *Epicoccum niger* can trigger an attack in an affected child. Closely related genera such as *Aspergillus* and *Penicillium* show cross reactivity. However, trans-genera cross reactivity has been documented. Worldwide, the most prevalent fungus associated with allergic reactions is *Alternaria alternata.* Species of *Cladosporium, Penicillium, Curvularia, Aspergillu*s, and *Epicoccum* that can trigger Type I hypersensitive reactions on their own, show cross reactivity to *A. alternata. Penicillium chysogeneum, Memnoniella echinata and Trichodema harzianum* showed cross reactivity to monoclonal antibodies of *Stachybotrys chartarum*. Other fungi examined were *Chaetomium, Ulocladium*, basidiospores of *Coprinus* and *Ganoderma* and yeast. Cross reactivity and sensitization are species specific and propagule specific. Parallel sensitization to mold seems to be rare, but there are concerns that the affected individuals may be at risk of developing allergic asthma. Often, symptomatic clients allergic to a particular fungus can't explain why their symptoms prevail in the absence of the target fungus in the analysis. Cross reactivity is a plausible explanation for this response. We recommend viable sampling to the species level to supplement the initial nonviable assessment.

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Urine 1,6-Hexamethylene Diamine (HDA) Levels Among Workers Exposed to 1,6-Hexamethylene Diisocyanate (HDI)

L. Gaines, K. Fent, S. Flack, J. Thomasen, L. Ball, D. Richardson, L. Nylander-French, University of North Carolina, Chapel Hill, NC; S. Whittaker, Public Health - Seattle & King County, Seattle, WA.

Levels of urinary 1,6-hexamethylene diamine (HDA) in 48 autobody repair shop spray painters were correlated with dermal and inhalation exposure levels to 1,6-hexamethylene diisocyanate (HDI). One urine sample was collected before the exposure while multiple samples were collected each workday during three separate visits approximately one month apart. Of the 417 samples analyzed, 259 samples had detectable levels of HDA. HDA concentrations varied throughout the day and ranged from 0 µg/L to 65.92 µg/L ,with a mean of 0.53 µg/L (standard deviation, 3.32). The geometric mean was calculated as 0.136 µg/L (geometric standard deviation, 4.28) when samples with nondetectable levels of HDA were assigned the value of 0.030 µg/L (method detection level/sqrt[2]). The last urine sample of the day did not always have the highest HDA level for that day. After log-transformation of the data, dermal exposure and inhalation exposure, accounted for with the type of respirator worn, were both significant predictors of urinary HDA levels, indicating that both the skin and the lungs are important pathways for HDI exposure. Creatinine and specific gravity, when used as independent variables, were highly significant, indicating that exposure assessment models must account for the water content of urine. Models with HDA normalized for creatinine content gave similar results to models with unnormalized HDA and creatinine used as an independent variable.

Podium Session 130: Management and Training Issues

Wednesday, June 3, 2009, 1:00 p.m.–3:40 p.m.
Papers 197–204

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Using a Paired-Comparison Process to Create Relative Rankings of Programs or Assets

J. Yasalonis, S. Stone, LMI, Belcamp, MD.

DoD preventive medicine assets and programs provide services focused on the industrial hygiene, environmental health, and safety aspects of terrorist and disaster response, disease and injury prevention, and health promotion. Preventive medicine centers, laboratories, technical boards, and mission-tailored response teams play a vital role in the overall DoD Force Protection mission by preventing or reducing the severity of diseases and injuries; they provide primary Force Health Protection (FHP) and reduce demand on clinical care assets. Due to their impor-

tance in executing FHP, they are included in the DoD Critical Infrastructure Program seeking to identify and protect critical assets and programs. This case study describes development and selection of nine criteria, such as the effect on acute morbidity and mortality and the technical depth, scarcity, and response time of assets, to define criticality of preventive medicine program assets. We will discuss how the Analytical Hierarchy Process was used in paired comparisons of the nine criteria to assign a numeric weight to each criterion. In addition, we will discuss the techniques used to control subject matter expert evaluation panel bias while they were relating each weighted criteria to specific asset types to produce a relative ranking for the preventive medicine-related infrastructure essential to execution of the National Military Strategy. We conclude that the use of relative ranking can enhance mission assurance and focus protection on task-critical assets. This work illustrates how, with the creation of suitable goals and criteria, this methodology can be used to add analytical rigor and consistency to a qualitative ranking of the importance between and among industrial hygiene, safety, environmental, and ergonomic programs seeking shares of limited resources.

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The Internal Responsibility System — How It Is Functioning

P. Strahlendorf, Ryerson University, Toronto, ON, Canada; M. Holliday, Michael Holliday & Associates, Ottawa, ON, Canada.

The Ontario Occupational Health and Safety Act (OHSA) is based on the Internal Responsibility System (IRS), a term coined by Dr. James Ham in his 1976 Royal Commission report on the health and safety in mines, and is an OHS management system philosophy. Everyone within an organization has direct responsibility for health and safety as an essential part of his job. It does not matter who or where the person is in the organization, he achieves health and safety in a way that suits the kind of work he does. He does this both singly and cooperatively with others. It is one of the personal responsibilities of a company president to ensure that the entire system of direct responsibility for health and safety within a company is established, promoted, and improved throughout time. Successful implementation of the IRS should result in progressively longer intervals between accidents or work-related illnesses. In 1999, the Ontario Ministry of Labour commissioned the development of an audit tool to measure how effectively the IRS was working in the underground mining environment. The project was guided by a tripartite committee that, once a preliminary tool had been designed, selected six mines (encompassing a relatively wide range in safety performance) to be the subject of a trial audit. The trial audit enabled validation and refinement of the audit tool, which became the property of the Ontario Mines and Aggregates Safety & Health Association. Since the development of this validated tool, we have expanded and further refined the approach and have conducted audits at a number of mines in Ontario and a large electrical utility. In this presentation, we will discuss the results of these audits and what it says about the role of the IRS within the occupational health and safety management system of these organizations.

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Intensive Training Programs in Environmental and Occupational Hygiene: Application and Lessons

R. Eninger, S. Morrill, USAF, Brooks City-Base, Texas.

The U.S. Air Force School of Aerospace Medicine (USAFSAM) annually trains 250 airmen in disciplines similar to civilian industrial hygiene technicians (200 enlisted students/yr) and traditional hygienists (bachelors degree or higher, 50 officer students/yr). The purpose of the intensive training program, which lasts 14 weeks for enlisted technicians and 16 weeks for officers, is to ensure graduates possess adequate knowledge and skills to support Air Force preventive medicine operations through environmental and occupational hygiene activities. We will present selected challenges and lessons learned from managing a large, intensive training program in environmental and occupational hygiene. The primary challenge of the training program is translating classroom and laboratory training into future workplace performance. These challenges include: (1) striking the right balance between practical skills and basic knowledge; (2) instructing students of different learning types; and (3) instructing students with heterogeneous educational backgrounds and academic preparation. There are faculty-related challenges as well, such as (4) dedicating the time and manpower to maintaining a continuously evolving but high quality curriculum; and (5) identifying and maintaining the appropriate breadth and depth of instructor competency and qualification. We propose several solutions that help mitigate programmatic impacts of these challenges. First, the right balance between knowledge and skills is dictated by the stakeholder(s)—they must be identified, and their feedback must be aggressively sought on a routine basis. Second, individual instruction and small-group coaching can identify and considerably assist students with training deficiencies or alternative learning styles. Third, centralized—rather than decentralized—curriculum management appears to have strengths in keeping curriculum up to date and correlated. Lastly, instructors should have a clearly delineated body of knowledge for which they are responsible, with access to subject matter experts, as required. Although not comprehensive, the proposed solutions have been effective in improving the quality of training at USAFSAM.

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Why Should Workers Participate in the Management of Health and Safety in the Workplace?

V. Lederer, Université de Montréal, Montreal, QC, Canada.

Over time, a multitude of strategies has been developed to measure and analyze risks to workplace health and safety. These methods remain impregnated with the dominant paradigm characterized by a tendency to systematic quantification and a very narrow and legalistic vision of the management of workplace health and safety to the detriment of a more profound consideration of the definition of risks, of occupational health and well being, and of the underlying reasons for the appearance of problematic situations in the workplace. Through examination of the question, "Why should workers participate in the management of health and safety in the workplace"? we will demonstrate the potential of a participative, worker-involved approach to exceed limits imposed by traditional methods of risk evaluation and management in the workplace. This approach fits within the Anglo-Saxon "human factors" theory, and supports the values of democracy, autonomy, responsibility, and confidence. The principle, practical, philosophical, and political justifications for the development and implementation of this approach in Quebec and elsewhere are the improvement of organizational and psychological conditions of a given enterprise, increased productivity, and the notion of a legal and ethical duty being implied in a company's decision-making process.,A company's attitude regarding participative management of workplace health and safety, the various motivations for its implementation, and the adoption process used to move to the new approach from a company's usual practices will greatly influence the results of implementation. Researchers agree, however, that participative management of workplace health and safety is about an effective and profitable approach to risk management, making it possible to exceed limits imposed by traditional approaches, the most important of which is the relevance of and adherence to the health and safety regulations in place.

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Occupational Hygiene and Safety Training in Poland: A Success Story of Collaboration with AIHA

J. Grzesik, Institute of Occupational Medicine and Environmental Health in Sosnowiec, Sosnowiec, Poland.

In Poland, a great fraction of the employed population is exposed to hazardous factors. Up to the end of the 20th century , professional training in industrial hygiene was provided only by secondary technical schools, and no possibilities of education on an academic level existed. In 1996, inspired by AIHA and with substantial assistance from members of the International Affairs Committee for Central and Eastern Europe, and especially from Aleksandra Nawakowski - the AIHA Ambassador to Poland - the Institute of Occupational Medicine and Environmental Health launched, in cooperation with the Technical University in Gliwice, a postgraduate certificate program, Studies in Industrial Hygiene and Safety. The certificate program was intended for graduates in engineering; physics; chemistry; technical, biological, and medical sciences;lawyers; and also for teachers and other academics employed as hygiene inspectors or leaders of hygiene departments in large industrial enterprises. The curriculum was developed with help from American university professors and members of AIHA and ACGH. The first two sessions had enrollment made up mostly of mining engineers responsible for safety and hygiene issues in coal mines. Participants in the next sessions covered a broad spectrum of academic faculties, and many of them worked as hygiene inspectors in different enterprises. The graduation ceremonies for the first two sessions were attended by AIHA presidents, and graduates received AIHA Acknowledgement Diplomas. After nine successful sessions, the number of graduates exceeds 200, and the program continues. The 10th

session started in the 2008-2009 academic year and has about 40 participants. Worth mentioning is the fact that all graduates are working in the field of occupational hygiene and safety.

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Exploring the Industrial Hygiene Curriculum: Expectations and Perceptions of the Profession

D. Breeding, Texas A&M University - TEES, College Station, Texas.

Although the multidisciplinary profession of industrial hygiene (IH) has been established for many years, and IH practitioners have been prolific in developing the technical tools for recognition, evaluation, and control of workplace hazards, few in the IH discipline have turned the tools and methods of academic research toward the academic curriculum itself. A review of the literature revealed that published research in IH curriculum has been minimal, and that none has considered comparing faculty and employer expectations. Evaluating the nature of the current IH curriculum, and the preferences and expectations of the IH profession for graduates' competencies, is true to the goal of IH practice, i.e., conducting research as a basis for ongoing evaluation and review of existing programs, and using research findings to plan preventive interventions to ensure continued good health of both programs and impacted individuals. This research was an initial, exploratory study to identify and assess the expectations and perceptions of the IH faculty and employers in the areas of IH curriculum content and structure. The expectations and perceptions of IH academic program faculty were compared with those of employers of graduates of IH programs. Characteristics of current IH academic programs were identified, as a baseline for future evaluation of the IH curriculum. Actual and expected undergraduate majors of those entering IH masters programs were identified to aid in targeting effective recruitment programs and efficient resource allocation. The study populations' skill and capacity with computers and the Internet were assessed as an indicator of readiness to incorporate distance learning methodology and electronic media delivery into traditional classroom delivery of industrial hygiene education. Recommendations were given for model IH curricula derived from the survey participants' responses, and for future work.

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Teaching Industrial Ventilation in an Undergraduate Curriculum

G. Gillespie, The University of Findlay, Findlay, Ohio.

The University of Findlay has for more than 15 years offered an undergraduate industrial ventilation course as part of its Environmental, Safety, and Occupational Health Program. While the course includes the study of a number of hazards, including noise, temperature extremes, ergonomics, and radiation, a primary focus is the detailed study of ventilation principles of the control of hazardous gases, vapors, and aerosols. The course includes lectures, case studies analysis, calculations, and problem solving in the topic areas of the principles of airflow; natural ventilation; dilution ventilation; fans; collectors; testing instruments and construction blueprints and guidelines for local exhaust systems; and design of industrial ventilation systems. Ten separate instruments for velocity, flow rate, temperature, etc., are used by the students in the field investigation of university operations such as laboratory hoods, kitchen exhaust, etc. A recent addition to the course, possibly unique in undergraduate industrial ventilation courses, is the construction of a model ventilation system. A 5-hp blower exhausts four main branches, three of which represent the types of hoods (receiving, capture, and enclosing) and the final fit with exchangeable hoods and flanges. The model system allows the actual measurement of the types of situations pictured in the text and to test the equations and relationships described in the text. In this manner, the course allows the lecture of a particular principle, the assignment of homework and case studies about the principle, and now the visualization of the principle with hands-on measurement of hood face and multiple duct locations. The model system allows for the comparison of several types of instruments for the same measurement value.

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WITHDRAWN

Podium Session 131: Health Care Industries II: Hazardous Drugs and Other Health Care Topics

Wednesday, June 3, 2009, 1:00 p.m.–3:40 p.m.
Papers 205–212

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Reducing Cytotoxic Drug Exposure in Health Care: Approaches and Challenges to Determining Cleaning Effectiveness

P. Chua, Q. Danyluk, Fraser Health, Burnaby, BC, Canada; W. Chu, University of British Columbia, Vancouver, BC, Canada; C. Hon, Vancouver Coastal Health, Vancouver, BC, Canada; G. Astrakianakis, Occupational Health and Safety Agency for Healthcare in BC, Vancouver, BC, Canada.

Cytotoxic drugs are commonly used in health care facilities to treat a range of medical ailments. However, these drugs also pose a risk to both the health care workers who prepare or administer them, and to those who work in areas where they are used. To reduce the occupational risks associated with cytotoxic drugs, recommendations and guidelines have been published by several health and safety organizations that suggest standard procedures and appropriate techniques be coupled with personal protective equipment. However these recommendations do not provide specific direction in terms of cleaning procedures. A review of current guidelines and practices was conducted at British Columbia health care facilities. Three most commonly used cytotoxic drugs in British Columbia hospitals were selected: methotrexate, cyclophosphamide (CP), and 5-fluoruracil (5-FU). Research was undertaken to determine the effectiveness of cleaning agents and procedures used on stainless steel surfaces contaminated with these drugs. A range of cleaning agents and procedures were examined. Variables included varying the amount of drug contamination, the type of cleaning agent, the method of application, and additional cleaning isopropanol wash. The results of this research produced recommendations and strategies to reduce health care workers' exposure to cytotoxic drugs. Although none of the tested cleaning agents completely eliminated drug residues from the stainless steel surfaces, they all reduced contamination by at least 19%. The most effective cleaning agent was able to remove as much as 96.2% of the CP residues and more than 100% of the 5-FU residue off the stainless steel surfaces. Our findings suggest that workers currently have a false sense of security, arising from the belief that current cleaning practices are sufficient. Determining the most effective cleaning products and procedures for removing cytotoxic drugs will facilitate changes in workplace practices. The ultimate goal is to reduce health care workers' exposure to these harmful substances.

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Hazardous Byproduct Created Due to Cleaning Antineoplastic Contamination with Household Bleach

C. Barzan, W. Chu, School of Environmental Health, Vancouver, BC, Canada.

Antineoplastic (cytotoxic) drugs are used to inhibit or prevent the spread of tumor cells in cancer patients, and are prepared and administered daily in hospitals worldwide. These drugs are known to have highly toxic effects, and many have been shown to be carcinogenic or mutagenic, including cyclophosphamide (an IARC group I substance). Although occupational exposure to cytotoxic drugs can lead to serious adverse health effects, contamination has been widely reported throughout hospitals and hospital pharmacies. It has been reported that standard cleaning procedures in health care settings are not effective in eliminating workers' exposure to these toxins. Currently, 5.25% sodium hypochlorite solution (household bleach) is typically used to remove cytotoxic drug contamination via oxidation of the parent compound. However, breaking down potentially carcinogenic compounds may not necessarily remove the hazard. Depending on the byproducts, it can actually increase occupational exposure to potentially toxic chemicals. The aim of this research was to determine if nor-nitrogen mustard results as a byproduct of decomposing cyclophosphamide with household bleach. Nor-nitrogen is anticipated by the IARC to be a human carcinogen. It is an analog of the infamous mustard gas used during World War I, which causes DNA damage, powerful irritation, and increased risk of lung and respiratory tract cancer. The reaction between household bleach and cyclophosphamide (in solid and solution phases) was analyzed by GC/MS. It was found that bleach oxidizes cyclophosphamide and cleaves the nitrogen-phosphorous bond, producing potentially volatile nor-nitrogen mustard. Moreover, the use of bleach as a cleaning agent may pose serious health hazards due to its strong oxidizing properties. Now that we have determined nor-nitrogen mustard to be a byproduct of cleaning cyclophosphamide with household bleach, it is anticipated that these results will strongly influence future cleaning protocols for cytotoxic drugs in health care facilities.

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Preventive Measure and Medical Surveillance for Health Care Workers Exposed to Antineoplastic and Other Hazardous Drugs

M. Zaidi, S. Wasti, Sheikh Khalifa Medical City, Abu Dhabi, United Arab Emirates; M. Zaidi, Public Health Agency of Canada, Ottawa, ON, Canada.

There are an estimated 20 million health care providers dedicating their lives to improving the health of more than 6.6 billion individuals around the globe. Health care providers are exposed to biological, chemical, and mechanical hazards every day, in addition to the emotional and mental stress they face. Workers having occupational exposure to hazardous drugs exceed 5.5 million (according to U.S. Census Bureau 1997; BLS 1998, 1999; NCHS 1996). Hazardous drugs include those for chemotherapy, antivirals, hormones, a few bioengineered drugs, and other miscellaneous items. Pharmacists and nurses are the two occupational groups that are most at risk of exposure.Health care institutions need to have preventive measures in place to minimize workers' exposure to these drugs. At Sheikh Khalifa Medical City, we are diligent in minimizing the risk of exposure to the staff to hazardous materials. The preventive measures include orientation, a sensitizing and training of the staff in the use of protective equipment and adherence to the procedures. Access to antineoplastic and other hazardous drugs is restricted to trained and authorized individuals. The drugs are prepared and dispensed in a designated and ventilated safety cabinet. Proper protective equipment is donned, and clearly set procedures are adhered to. This minimizes the risk while handling the drugs using closed system drug transfer devices. All staff members who handle antineoplastic or other hazardous drugs are enrolled in an annual medical surveillance program. This includes detailed medical and occupational exposure history, physical examination, and laboratory tests for complete blood count with deferential, liver function tests, and urine microscopic examination. In our three years of follow up, we found a few cases with skin conditions and urine reports. On further surveillance, these cases were found to be related to renal conditions.

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Development of Qualitative and Quantitative Measures for Pentamidine Aerosol in the Health Care Environment

D. Krageschmidt, J. Nesbitt, Mayo Clinic, Rochester, MN.

Pentamidine isethionate is an antimicrobial for lung infections in immunosuppressed patients. Overexposure to pentamidine can result in allergic and toxic insults, including severe kidney, cardiac, blood, and reproductive disorders. Pentamidine is administered via a nebulizer in isolation rooms with an air exchange rate of 10-12 per hour. Respiratory therapists, nurses, and patient visitors may be exposed to extraneous pentamidine. High exposures may occur during administration because of incorrect procedures, inhalation techniques, or patient behavior. Occupational exposures may also occur when drugs are administered correctly and hazard controls are inadequate. And, insufficient purging of the patient room prior to reoccupation may result in exposures to staff or visitors. Purge times are based on published concentrations or calculations with a protection factor added. Exposure assessments are usually not performed because sampling and analytical methodologies are difficult and expensive. Problems with using purge-time assumptions include: nursing and other staff may need to occupy the room for treatments or other activities during the isolation period and may not have authorization/training to wear a respirator; patients (especially children) and their families may be stressed from a long period of separation; and the evacuation calculations assume steady-state production of aerosol, which is a gross overestimation because of factors such as breathing rate, intermittent breathing, lung absorption and the nebulizer scrubber. We have qualitatively determined when a room has purged itself by measuring the aerosol with three common particle analyzers used by industrial hygienists. They identified a characteristic infrared spectrum that will allow for calibration and quantification. We have shown that the ventilation models overestimate the actual purge time at a given ventilation airflow by two to four times. These methodologies will allow health care workers and visitors access to patients with considerably less purge time, and will allow industrial hygienists to more easily assess worker exposures.

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Decommissioning of a Beta-Lactam Pharmaceutical Development Facility

D. Calhoun, Affygility Solutions LLC, Lafayette, CO.

Beta-lactam compounds used as antibacterial and antibiotic drugs have a long history of producing allergic reactions in sensitive individuals. These allergic reactions can range from simple rashes to anaphylaxis. In the pharmaceutical industry, beta-lactam compounds are considered to be potent compounds. Once a facility has been used for handling beta-lactam compounds, the potential for surface contamination makes it difficult to use the facility for other unrestricted activities. A method using a hydroxylamine, ethanol, and water solution for deactivating the beta-lactam compound will be presented, along with a wipe test sampling and analytical method, as well as the results of decommissioning of a former beta-lactam pharmaceutical development facility.

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Case Study: Walking and Standing in Hospital Bedside Nursing Personnel

T. Fuller, Environmental Performance Group, Boston, MA; E. Bain, Massachusetts Nurse's Association, Canton, MA.

After a recent facility expansion of the medical surgical unit (MSU) at a local hospital, staff/bedside nurses in the area were concerned about the additional floor space required to be covered on each shift, and the potential for associated increased lower extremity disorders. They requested a workplace evaluation to be conducted by a certified industrial hygienist and an occupational health nurse with experience in ergonomic workplace evaluations. A study was conducted to evaluate the facility transition and resulting potential impacts on worker health. The study consisted of a worker questionnaire, measurements of walking distances, literature review, and workplace observations. Although the alterations made to the physical facilities at this workplace were not shown to increase musculoskeletal risks in this case, results of the study indicated that during the past several years there was a trend for nurses to work longer hours. Further investigation indicated that this trend was true at many other institutions, and that the long durations of walking and standing were leading to an increase in the potential for adverse health effects to the lower extremities. Nurses, administrators, and professional organizations need to consider the consequences of long work durations, and consider alternatives in work practices, footwear selection, and organizational design.

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Strategic Planning for Bioterrorism in the Health Care Industry

J. Koerner, OSHA, Washington, DC.

The federal government has established a number of scenarios to use as the basis for response and recovery planning for both natural and man-made catastrophic events. Using a number of initiatives, venues, and processes throughout the federal government, the federal government has engaged federal, state, local, tribal, and private-sector stakeholders, and is actively researching and planning for the response and recovery from these catastrophic events. Prevention of and response to the wide-scale terrorist release of a biological agent (such as anthrax or plague) is among the planning scenarios. In addition, the health care industry has been identified as a key resource to be targeted for response preparation and planning activities. Furthermore, protection of responders and first receivers has been established as an overarching strategic priority for this planning and is the subject of this presentation. I will summarize key concepts related to strategic planning for bioterrorism in the health care industry as they relate to the protection of employees. The information presented is based on lessons learned, best practices, and current federal guidance. Focus areas will include an emphasis on planning priorities (such as ensuring that staff will report to work and evaluating personal protective equipment needs), the concept of dual-use capabilities (using competencies and equipment such as biodefense protective measures, training, and exercise results for pandemic influenza preparedness), and highlighting current federal guidance from the CDC, HSC, and OSHA.

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Best Practices for Environment of Care Risk Assessment in Health Care Organizations

Y. Wang, Kaiser Permanente, Oakland, CA.

The Joint Commission, a standards-setting and accrediting body for health care organizations, has comprehensive risk assessment requirements for hospitals. Under its 2009 Environment of Care (EC) standard, it requires every accredited health care organization to manage its risks associated with the following five areas: safety and security, hazardous materials and waste, fire, medical equipment, and utility systems. In order to properly manage and minimize these risks, a comprehensive risk assess-

ment process for each area is necessary. Based on mock EC surveys and internal audits from the past two years conducted in 17 Kaiser Permanente hospitals in northern California, I will share risk assessment tools and present best practices on hazard identification, exposure assessment, and risk prioritization and elimination process in each of the areas covered in EC. Furthermore, I also will explain how to implement risk reduction strategies, evaluate effectiveness of actions taken to reduce risk, and the relationship of risk assessments to program planning and development of annual goals and objectives to improve performance. The audience may adopt this approach with minimal modification for their own EC risk assessment process.

Podium Session 132: Stewardship/Sustainability/ Green

Wednesday, June 3, 2009, 1:00 p.m.–3:40 p.m.
Papers 213–221

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Product Stewardship and the Implementation of GHS in a South African Petroleum Company

A. Vismer, Engen Petroleum Ltd., Cape Town, South Africa.

Product stewardship at Engen Petroleum covers the product life cycle management process using product risk management as the basis. On approving the final product, a safety data sheet (SDS) is compiled and captured by a computerized management system for publishing on the Internet. Emphasis is also on extended supplier responsibility to ensure that used product and containers are disposed or recycled in an environmentally friendly manner. The World Summit on Sustainable Development 2002, hosted in Johannesburg, motivated the publishing of SANS 10234:2007. This is the South African Nation Standard for the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). This standard was gazetted into the regulation in February 2008, giving enterprises an interval of three years for implementation and compliance. At Engen Petroleum, the SDS data populates an embedded database that forms an excellent source of information for producing consistently dependent guidelines, procedures, and reports, which include transport emergency cards, safety operating procedures , emergency response plans, labeling requirements, and waste management cards. Engen Petroleum operates in a number of African countries where challenges include different languages and diverse regulations. In this presentation, I will share the challenges faced in compiling SDS that are GHS compliant

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The ABCs of Carbon Footprinting — Measuring, Managing, and Minimizing Strategies

C. Zwiebel, ENVIRON International Inc., Princeton, NJ; A. Scheaffer, ENVIRON International Inc., Chicago, IL; D. LaCroix-MacDougall, ENVIRON Canada Inc., Toronto, ON, Canada.

In this podium discussion, we will provide an explanation of exactly what a carbon footprint is, and a review of the calculation protocols used in the determination of an organization's carbon footprint. We will compare the three major types of GHG emissions and their effect on your footprint - onsite GHG emissions from stationary combustion; GHG emissions from on-site electricity use;and GHG emissions not directly under the control of the organization, such as emissions resulting from manufacturing, transportation, and disposal of products.We also will discuss waste disposal and treatment. GHG calculation protocol review will be presented in the context of carbon footprint reduction strategies and how emerging topics such as energy efficiency, renewable energy, and carbon credit emissions trading all may be employed by EHS professionals to measure, manage, and reduce their organizations carbon footprint.

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The Road to Sustainability

L. Sedlak, BDHHI, Foothill Ranch, CA.

Sustainability has been defined by the World Business Council as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."The creation and implementation of a robust sustainability program has become a consumer, investor, and customer expectation. Employers are beginning to understand that job seekers are interested in a company's sustainability program and will evaluate employment offers based on the existence of a program. Companies are discovering that their competitors are branding themselves and their products as sustainable. Gaining the commitment of the organization to implement a sustainability program is often left to the health, safety, and environmental professional. The challenge presented to the health, safety, and environmental professional lies in presenting the business case that clearly communicates that sustainability is more than just being "green." A company's leadership team must be convinced that if properly implemented, sustainability will drive opportunities for innovation and growth, and provide a competitive advantage. In this presentation, I will cover the development of a sustainability program for a division of a major corporation. I will include a discussion of corporate social responsibility, the three Es of sustainability, and the need to educate and communicate with all employees to help them take ownership of the corporate sustainability strategy. I also will include the development of the business case for sustainability, obtaining management buy in, a review of selected best practices in the industry, and the process used to implement a program.

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WITHDRAWN

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From Compliance Specialist to Sustainability Leader: What Today's Industrial Hygienist Needs to Know About Communicating Sustainability

M. Bernhart, True Blue Communications, Atlanta, GA.

What do chemical spills, lost-day rates, greenhouse gas emissions, and wastewater discharges have in common? Of course they all represent issues routinely monitored by industrial hygienists and environment, health, and safety managers. In addition, however, they are among the environmental and health and safety performance indicators increasingly recognized by companies—and their stakeholders—as critical to sustainability performance. And, as companies embrace the benefits of tracking and reporting their sustainability performance, they look to the EHS department to provide the necessary data. Unfortunately, in many organizations, the role of the IH or EHS specialist in sustainability performance remains limited. The EHS department may be asked to provide the necessary data for communicating and reporting, but often is not included in that communication process, which instead is carried out by a corporate group. How can IH and EHS specialists add greater value to sustainability improvement efforts? And how can they leverage their significant expertise in many of the areas that comprise sustainability (including more than 30 health,safety, and environmental sustainability performance indicators commonly included in corporate sustainability reports) to assume a central role in sustainability success? Through effective communications. IH/EHS experts can support - and lead - sustainability performance by speaking the language of sustainability, developing skills to communicate the business case for sustainability, and positioning the EHS department as essential to overall company sustainability performance. In this session, I will teach participants: tips for communicating sustainability practices and benefits, both internally and externally; ways to communicate environmental and health and safety performance in support of sustainability objectives; the integral role of the IH/EHS specialist in sustainability, along with communication strategies to strengthen company perceptions of the IH/EHS function; and how to leverage years of experience in IH/EHS management to create a valued and central role in sustainability programs.

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How Any Organization Can Mine Their Data to Green Chemical Inventories

M. Johnson, IHS Dolphin, Lake Oswego, OR.

Even as government regulators, shareholders, and the public are demanding greater scrutiny around the use of hazardous chemicals, many businesses and municipalities feel unprepared to move their operations toward sustainability. A common organizational misconception is that there is not enough information available to start even a modestly effective chemical greening program. While that assertion may have been true years ago, in recent times data-mining tools and industry best practices have evolved. Today, using these tools and strategies, virtually any size entity can dip into its data to kick off a prudent, results-yielding, chemical sustainability program. Using a variety of case studies across a range of businesses from heavy manufacturing to municipalities, we will look at on-the-floor solutions that have been used for hazardous product elimination, substitution, and inventory greening. Case studies range from modest programs starting with outdated, paper-based, MSDS systems, and progress to companies that have accomplished electronic-driven physical inventories and suspect-product flagging, to multisite programs incorporating data mining, analysis and

tracking, inventory management, greener-supply-chain sourcing, and even cost reductions. The bottom line, fleshed out with real-world success stories, is that the tools and knowledge exist today to start any organization on the road to greener and safer chemical inventories.

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Automotive and Sustainability: Becoming Green

H. Butler, Environmental Profiles Inc., Baltimore, MD; J. Schnieder, Rochester Institute of Technology, Rochester, NY.

Being green is the new public mantra for numerous businesses, many of which have integrated this effort into larger sustainability efforts. The automotive industry, in particular, is faced with the challenge of providing mobility to an increasing amount of global consumers in more environmentally and socially sustainable ways. Two of the sector's main concerns are climate change and responsible supply-chain management (specifically in terms of product take-back requirements). Using case studies of the automotive sector, we will examine the emergence of the green corporate movement and delineate the maturation of sustainability and the building of corporate ethicism in a sector that is tied to public sentiment. The conundrum that faces many corporations is defining what activities or actions are appropriate from both a business and an ethical standpoint. We will also benchmark the state of the sector activities to demonstrate how actions translate into measurable performance. The benchmarking will be shown through the automotive companies participation in the initiatives related to sustainability, such as Global Environmental Management Initiative, World Business Council for Sustainable Development, and ISO. Participation in these and other voluntary initiatives does not necessarily make one corporate entity better than another. However, emerging technology and awareness of green issues is changing the practices that correspond with how consumers choose to behave and make buying decisions, thus affecting the automotive industry's bottom line and causing them to rethink their business practices.

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Looking at the Big Picture: The Future is Now in Greenhouse Gas Regulation

C. Zwiebel, ENVIRON International Inc., White Haven, PA; D. LaCroix-McDougall, ENVIRON -Canada Inc., Toronto, ON, Canada; A. Scheaffer, ENVIRON International Inc., Chicago, IL.

Greenhouse gas regulation is already in force in Kyoto signatory countries, and will be a reality in North America soon. As with other environmental and occupational safety and health compliance matters, managing compliance with GHG regulations typically falls within an EHS management system and those professionals tasked with its operation. Experience demonstrates that companies that proactively inventory GHG sources and plan for regulations will have a significant competitive advantage over those that do not. We will provide informative viewpoints on pending GHG legislation summary and review in the United States, Canada, and globally, and discussion will serve as a basic education in Greenhouse Gas management, including steps required in developing a GHG strategy and identification of GHGs inventory within an organization.

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Micromanaging Your Electricity Use — Overview of Submetering

C. Zwiebel, ENVIRON International Inc., Princeton, NJ; A. Partridge, ENVIRON - Canada, West Vancouver, BC, Canada.

EHS professionals including industrial hygienists are more often becoming directly involved or responsible for the use and management of energy. In this discussion, we will focus on the practical benefits of monitoring energy usage "inside the fence" and realistic approaches with costs benefits analysis of establishing energy usage patterns throughout a facility. Actual data collected from sub-metering projects will be presented in the context of return on investment.

Podium Session 133: Field Detection and Analysis

Wednesday, June 3, 2009, 1:00 p.m.–4:40 p.m.
Papers 222–231

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Measurement Capability of Field Portable Organic Vapor Monitoring Instruments Under Different Experimental Conditions

C. Coffey, NIOSH, Morgantown, WV.

The performance of field portable direct-reading organic vapor monitors (DROVMs) was evaluated. The DROVMs tested were the ppbRAE, IAQRAE, MultiRAE, Century Toxic Vapor Analyzer (photoionization detector), Century Toxic Vapor Analyzer (flame ionization detector), and the SapphIRe™ (single-beam infrared spectrophotometer). Four of each DROVM (two Century Toxic Vapor Analyzers and SapphIRes) were tested. The DROVMs were evaluated at three temperatures (4°C, 21°C, and 38°C), three relative humidities (30%, 60%, and 90%), and two hexane concentrations (5 ppm and 100 ppm). These conditions were within the operational parameters of all the instruments. At least four replicate trials were performed across the 18 environmental conditions (3 temperatures × 3 relative humidities × 2 concentrations). The four-hour time-weighted average readings from the DROVMs in a given trial were compared with the average of two charcoal tube concentrations using pairwise comparison. The pairwise comparison criterion was ±25% measurement agreement between each individual DROVM and the group DROVM and the average charcoal tube concentration. The ppbRAE group performed the best, with 40% of all readings meeting the comparison criterion, followed by the SapphIRe group at 39%. Among individual DROVMs, the best performer was a SapphIRe with 57% of its readings meeting the criterion. The data were further analyzed by temperature, humidity, and concentration. The results indicated the performance of some DROVMs may be affected by temperature, humidity, and/or concentration. The ppbRAE group performed best at 21°C, with the percentage of readings meeting the criterion increasing to 63%. At the 5 ppm concentration, 44% of the ppbRAE group readings met the criterion, whereas at 100 ppm, only 35% did. The results indicate that monitors can be used as survey tools. Based on the data, the inconsistent performance of these DROVMs may not allow them to be used for determining compliance with occupational exposure limits.

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Modification of OSHA Methods for Field Portable Gas Chromatographs

J. Driscoll, PID Analyzers LLC, Pembroke, MA.

OSHA has developed hundreds of GC methods for analyzing organic compounds in the workplace as part of the standards process. These methods were developed to provide analytical methods for samples collected on adsorbent tubes in the workplace. Typical sample volumes collected range from 250 mL (at the ceiling value) to 12 liters [below the permissible exposure limit (PEL)] of sample collected on the adsorbent tubes. Once the sample (250 mL) is diluted, it is equivalent to injecting a 1-cc sample at approximately 5× the PEL. For area monitoring, we would like to have a detection limit that is 1/20th of the PEL. If these detectors were used in a portable GC in the field, analysts would have difficulty detecting half the PEL for those compounds with low PELs. In other words, many of these methods would be "sensitivity challenged" because of the use of the flame ionization detector (FID). These OSHA GC methods can still be used, but it is clear that a more sensitive method (a concentrator for the FID, or capillary columns to improve the sensitivity > 10 times) is needed to obtain the required sensitivity. Another option is the use of a photoionization detector that has 50-100 times more sensitivity than an FID. Another difficulty that occurs at low ppm or ppb levels with polar species is adsorption or reactivity on or with surfaces of the sampling system and lines. This results in serious problems with reproducibility and accuracy. Examples include amines, phenols, organic and inorganic acids, and pesticides. We will evaluate a number of methods for amines, sulfur compounds, chlorinated hydrocarbons and diphenyl oxide. We will compare the results of the FID/NPD detectors with the photoionization detector . This should provide an alternate method that has more sensitivity (.50×) and/or selectivity and does not require support gases.

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Performance of a New Hybrid Aerosol Photometer

A. Sreenath, J. Agarwal, G. Chancellor, J. Evenstad, M. Carideo, J. Farnsworth, T. Hase, G. Olson, X. Wang, TSI Inc., Shoreview, MN.

TSI Model 8533 DustTrak DRX is a new optical instrument that has the capability to simultaneously measure mass concentrations of thoracic, respirable, $PM_{2.5}$,and PM_1 throughout a wide range of concentrations up to 150 mg/m^3. This instrument combines the photometric measurement similar to its predecessor, the DustTrak TSI Model 8520, and single particle counting to extend its accuracy over the entire particle size range from 0.1 µm to 10 µm. By combining the photometric and single particle pulse measurements, this instrument can measure mass concentrations higher than typical single particle counting instruments, provide size information, and more accurate mass concen-

tration than traditional photometers. The purpose of this study was to evaluate the instrument's response to various aerosols generated in workplaces, including a machine shop, engine exhaust, and lab-generated Arizona road dust and cigarette smoke. Comparisons were also made with other real-time aerosol measurement instruments. Gravimetric samples were also taken side by side with all the instruments. This will enable us to determine a library of calibration factors for different aerosols.

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Safety Considerations in Choosing the Proper Calibration Gas for a Catalytic Sensor

R. Wanek, R. Warn, Draeger Safety Inc., Pittsburgh, PA.

There has been a movement to calibrate catalytic combustible gas sensors with pentane the past few years, with companies stating this will provide increased safety when detecting combustible gases. But is that really the case? It is possible for a catalytic sensor to calibrate and respond perfectly to pentane but have little or no response to methane. Calibration with pentane increases the sensitivity of the sensor and allows for more accurate readings for the heavier gases and higher readings for the lighter gases such as methane. The advantage of calibrating with pentane to get increased safety margins really only applies to new sensors. Any new catalytic sensor, calibrated to a pentane calibration gas, will show higher than actual readings for methane. However, as the sensor ages its response characteristics will change. Sensitivity to lighter gases, such as methane, will decrease more rapidly throughout time than the sensitivity to heavier gases such as pentane. For safety monitoring applications, the catalytic sensor is very good for detecting combustible gases, since it will respond to a very wide range of gases. Using catalytic sensors, gases with large molecular structures like nonane to gases like hydrogen with much smaller structures can be detected. However, the response of the sensor to these gases will vary greatly, depending on the properties of the gas itself. The age and condition of the sensor are also factors in how it will respond to the different gases.

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Diacetyl and Food-Flavoring Exposures at Two Flavoring Manufacturing Facilities

L. McKernan, K. Dunn, G. Burroughs, NIOSH, Cincinnati, Ohio.

Researchers from NIOSH conducted in-depth exposure assessments at two flavoring manufacturing facilities. The objectives of these assessments included characterizing potential occupational exposures, plant processes, and identifying common work practices. The flavoring facilities evaluated produced wholesale flavors, extract, syrups and other products in liquid, powder, spray dried, natural, and artificial forms. Both facilities contained a large liquid and powder production room while one facility also conducted a spray drying operation. At each facility, personal and area eight-hour time-weighted average and task-based samples were collected for diacetyl, acetoin, total and respirable particulates, acids (phosphoric, butyric, acetic, and propionic), and five specific aldehydes (2-furaldehyde, acetaldehyde, benzaldehyde, isovaleraldehyde, and propionaldehyde) on three consecutive days. Laboratory reports provided sample results in micrograms of analyte per sample and were converted to an airborne concentration by dividing by the air volume associated with the sample (mg/m^3), then converting to parts per million (ppm). The distributions of diacetyl concentrations were skewed; therefore, the natural logarithm of the sample concentration was used in all statistical analyses using SAS version 9.1.3. A total of 20 workers and 10 area sample locations were sampled on 3 consecutive days. Diacetyl concentrations had a geometric mean concentration of 0.094 ppm, with a range of 0.008-6.33 ppm. Diacetyl area samples and personal samples collected on the same day in the same production area were not significantly different than one another ($p = 0.384$). Exposure conditions were highly variable, reflecting the diversity in flavor formulations, recipes, and work practices. Task-based samples demonstrated that packaging powdered product was an activity associated with higher diacetyl exposure. Recommendations for the implementation of engineering controls, and improvements in work practices, respiratory protection, medical surveillance, and hazard communication were provided.

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Evaluation of a Miniaturized Diffusive Sampler for True Breathing-Zone Sampling and Thermal Desorption GC Analysis

J. Levin, R. Lindahl, Umeå University, Umeå, Sweden; M. Sundgren, Fenix Environmental, Umeå, Sweden.

Exposure measurements should be performed as close as possible to the nose and mouth ("breathing zone," commonly assumed to be within 30 cm from nose and mouth). Measurements close to the nose/mouth give a more correct assessment of exposure. An important issue concerning exposure measurement methods is worker acceptability. The sampling equipment should be small and with low weight in order not to affect ordinary work. It is also important that the equipments are user-friendly, with a minimum of handling before, during, and after measurement. In diffusive (passive) sampling, no extra equipment, such as sampling pumps, is needed, making the measurements more acceptable to the user. The diffusive samplers are normally attached on a shoulder, on a breast pocket, or on the lapel. There are, however, difficulties if true breathing-zone sampling is to be performed, since available diffusive samplers normally cannot be arranged close to the nose/mouth. The purpose of this work was to study the performance of a miniaturized tube-type diffusive sampler for automated thermal desorption attached to a headset for true breathing-zone sampling. The basis for this miniaturization was the Perkin Elmer ATD tube. Both the size of the tube and the amount of adsorbent was decreased for the miniaturized sampler. A special tube holder to be used with a headset was designed for the minitube. The minitube is thermally desorbed inside a standard PE tube. The new sampler was evaluated for the determination of styrene, both in laboratory experiments and in field measurements. As reference method, diffusive sampling with standard Perkin Elmer tubes, thermal desorption, and gas chromatographic (GC) analysis was used.

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Measurement of Air Pollutants Using Ultraviolet Differential Absorption Spectroscopy

E. Coker, University of Washington, Seattle, WA.

Ultraviolet differential optical absorption spectroscopy (UV-DOAS) is a remote sensing technique capable of semi-continuous, open-path monitoring of trace pollutants in the atmosphere (Scheff, 2001). The Puget Sound Clean Air Agency (PSCAA) is responsible for regulatory air monitoring in the Puget Sound region. This project intended to generate a reference library of various compounds for the UV-DOAS instrument for use in PSCAA's Open Path air monitoring program. The gases analyzed included three criteria air pollutants (NO, NO2, SO2) and several other important air pollutants (1,3-butadiene, formaldehyde, benzene). Reference absorption spectra for each compound (calibrated at varying concentrations that are reflective of community levels) have been generated in the laboratory using a Dynacalibrator instrument and an optical gas cell. These absorption reference spectra have been compared with an external reference of published UV absorption spectra, using the Mainz online "Spectral Atlas of Gaseous Molecules." Correlations are good between reference libraries ($R2 > 0.9$) for each compound tested (except for NO), indicating adequate spectra to test in the field.

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Passive Air Sampling for Nitrogen Trichloride by Solid-Phase Microextraction

Y. Liu, S. Tsai, National Taiwan University, Taipei, Taiwan.

Nitrogen trichloride might possibly be formed when organic nitrogen sources, such as creatinine, arginine, histidine, or urea, react with chlorine. In swimming pools, visitors can contribute various kinds of organic nitrogen, such as sweat, urine, or skin particles, which would further react with chlorine to form nitrogen trichloride. It has been observed that exposures from nitrogen trichloride might cause acute and chronic health effects in both children and adults. To monitor the concentrations of nitrogen trichloride in air, current available method employed sampling pump and required complicated sample preparation and analysis procedure, which makes it difficult to assess the exposures. On the other hand, solid phase microextraciton (SPME) presents many advantages over conventional analytical methods by combining sampling, preconcentration, and direct transfer of the analytes into a standard gas chromatograph (GC) system. Therefore, the purpose of this study was to develop a passive sampling method for nitrogen trichloride by SPME. Nitrogen trichloride in solution was first prepared by mixing ammonium sulphate with sodium hypochlorite in water. Known concentrations of nitrogen trichloride in air were then generated in gas bags or exposure system through the injections of nitrogen trichloride solutions, followed by the vaporizations. For the validations of the SPME diffusive sampler, 100 μm PDMS fiber was selected, and cyclohexene was first adsorbed unto the fiber. After exposure of nitrogen

trichloride, chlorocyclohexane was formed through on-fiber derivatization and determined by gas chromatography/mass spectrometry. The desorption efficiency was found to be 100% when the time for thermal desorption was 2 minutes. The experimental sampling constant of the designed passive sampler, as well as the effects of different environmental factors on the samplers, were also validated.

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Investigating Air Sampling Methods to Compare to a Threshold Limit Value Estimated from the Proposed ACGIH® Reciprocal Calculation Method for Hydrocarbon Solvent Vapors

P. Owens, Shell Martinez Refinery, Martinez, CA.

The ACGIH® Reciprocal Calculation Method for Certain Refined Hydrocarbon Solvent Vapors (the Reciprocal method TLV) provides a formula to calculate that mixture's TLV based on the mixture's composition. For a given mixture, the calculated TLV is determined from bulk analysis of specific carbon number ranges, e.g., five to six carbon atoms; and molecular structure, e.g. aromatic vs. aliphatic. There are eight such groups of hydrocarbons, and each is assigned an exposure limit for use in the formula. Airborne hydrocarbon solvent vapors have been quantified by two methods. Common laboratory quantification of hydrocarbon solvents is by gas chromatography, with flame ionization detection (FID) and gas chromatograph. One direct-reading field method of measuring hydrocarbon solvents is by photoionization detection (PID), using a 10.6 electron volt lamp calibrated to isobutylene. Both the FID and PID can vary in their sensitivity to the various hydrocarbon groups in the proposed reciprocal method. Depending on a specific hydrocarbon mixture, the FID and PID result may not be directly comparable to the Reciprocal method TLV for that mixture. One method to obtain a result comparable to the TLV is to adjust the measured value to reflect the relative response of the FID, to n-hexane, or the PID, to isobutylene. This is done by obtaining a relative response factor for each of the hydrocarbon groups in the Reciprocal method TLV. The hygienist can then use the Reciprocal method TLV bulk hydrocarbon values and insert the FID or PID group response factor in the formula. The result is an adjustment factor that could be multiplied by either the FID total hydrocarbon result or the PID result to obtain an overall result comparable to the Reciprocal method TLV.

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Development of Plasma Photometric Microsystems for Environmental Monitoring

A. Liberatore, Optomem Sensors Inc., Toronto, ON, Canada.

The research objective was to develop a system and method to measure air quality through the development of a micro-optical-mechanical, plasma emission-based, gas sensor technology. The research team was a collaboration between Optomem Sensors Inc. and the University of Toronto's Centre for Advanced Nanotechnology. The measurement of emission spectrum of an air discharge microplasma source at ambient conditions is revealed. The data observed reflects the many electronic-vibrational transitions occurring within the microplasma. It also points toward the opportunity for characteristic signatures to be developed for a given system of gas species. With the advancement of nanotechnology research, the current study takes advantage of deviations in Paschens' law to reduce the energy requirement for generating and sustaining a discharge. In this presentation, we will study the effects of deviations in Pashens law as a result of breakdown voltage, and I will take the audience through the fundamental science of microplasma generation and the future applications whereby a microplasma photometric sensor is used to monitor and analyze air quality in real time, with a low cost, compact sensor.

Podium Session 134: Face the Ergonomics Monster Head On: Assessment and Management

Wednesday, June 3, 2009, 5:00 p.m.–7:20 p.m.
Papers 232–238

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Ergonomics Management System; Using ANSI Z10 to Manage Workplace Improvements

W. Rostykus, Humantech, Ann Arbor, MI.

"ANSI/AIHA Z10-2005 Occupational Health and Safety Management System" is a model for managing safety issues following a continuous improvement model. When applied to ergonomics process it provides a systematic approach for planning, managing, and tracking changes to work environment and tasks that reduce ergonomics risk factors. Planning and implementing strategic program elements are critical for the continued support and effectiveness of the tactical activities of ergonomic risk assessments and solutions. In this session, I will illustrate the application of ANSI/AIHA Z-10 to managing ergonomics, as described in the AIHA publication, "*Ergonomics Program Guidance Document Aligned with ANSI/AIHA Z1-2005*." An integrated system for managing safety and productivity benefits with proven improvements to the bottom line of an organization. Elements of the approach provide a road map that will guide program managers through logical and comprehensive steps to establish a new, or improve an existing, ergonomics process. Steps and illustrations are based on successful practices from Fortune 500 companies. Application of this approach and all process elements will be discussed.

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Upstream Design: The Key to Getting Ahead of the Curve on Workplace Ergonomics

T. Silva, Humantech, Ann Arbor, MI.

Proactive design and specification of new products, equipment, process, and layout is critical for identifying and preventing exposures to ergonomic risk factors in the workplace. This typically is accomplished by product designers, process, and facility engineers through an integrated design, review, and approval process. As a result, organizations with mature, preventive programs are able to build in and sustain a low exposure workplace while improving productivity and quality.,In this presentation, I will demonstrate key elements of successful systems for preventing introduction of ergonomic risk factors through new product, facility, and process design. Illustrations of effective tools and methods will be provided, as will measurable results of successful programs. As a result of the presentation, participants will understand key elements for success and how to pursue these within their own organization.

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Evaluation of a Unique Approach to Reduce Musculoskeletal Disorders in Small and Medium-Sized Utilities

P. Bigelow, University of Waterloo/Institute for Work & Health, Waterloo, ON, Canada; D. Van Eerd, S. Ferrier, P. Subrata, C. Kalcevich, Institute for Work & Health, Toronto, ON, Canada; C. McKean, S. Hunt, Electrical & Utilities Safety Association, Toronto, ON, Canada.

Work-related musculoskeletal disorders and musculoskeletal pain are major problems for the electrical and utilities sector, and traditional prevention techniques have not led to long-term solutions. Participatory approaches have been shown to be effective but have not been widely adopted in small and medium-sized utilities (SMU). A pilot project to implement and evaluate a unique approach to implementing participatory ergonomic (PE) programs in SMUs in Ontario, Canada, was completed. Seven SMUs and the province's Health and Safety Association for the sector, along with researchers from three universities and a research institute, collaborated in both the design of the program and in conducting the theory-based evaluation. The study design was pretest-post test with nonequivalent comparison groups (derived from utilities that were delayed in their program implementation). A total of 1150 workers completed questionnaires that included measures related to program implementation (physical changes to their work environment, training, knowledge of MSD hazards, etc.), intermediate explanatory variables (influence over work, safety climate, readiness for organizational change). and outcomes (pain and discomfort, work limitations, lost time due to pain, MSD injuries). Data from interviews with employees, members of ergonomic change teams, and researchers provided a deeper understanding of the evaluation results. Measures of program implementation were correlated with a number of intermediate variables, including safety climate. Findings from multivariate analyses provided some evidence for the overall effectiveness of the program. Qualitative findings identified common barriers to implementation and program sustainability and included management support and communication. Overall, the program resulted in significant changes in work environments with the number of changes related to the level of program engagement within each utility. Changes in final outcomes were difficult to measure; however, the significant relationships between measures of implementation and intermediate variables did provide some support for the program's effectiveness.

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An Assessment of Inter-Worker Variability in Lower Body Postures During Assembly Line Work

W. Keyserling, N. Wiggermann, N. Gell, R. Werner, The Universtiy of Michigan, Ann Arbor, MI.

When conducting workplace epidemiological studies, it is preferable to perform individualized assessment of risk factors. However, due to the time and cost associated with measuring unique exposures for each participant, a common practice is to select a single worker who serves as a "proxy" for all workers assigned to the same job. The use of proxies is common in ergonomic studies for several reasons, including high data collection/reduction costs, and/or the refusal of some study participants to wear instruments or be videotaped. This study evaluated inter-worker variability in lower body posture and movement during assembly line work. Data were collected from 79 unique assembly line workstations in an engine manufacturing plant. Because the plant used work teams, 4-8 workers rotated through each workstation. We typically collected at least 30 minutes of videotape from at least three workers at each workstation. A computer-assisted work sampling procedure randomly selected 200 video "freeze frames" for each worker. Lower body posture/movement (e.g., sit, stand, walk, carry, etc.) was determined for each frame and used to estimate the percentage of time the worker spent in various postures. Chi-square analyses were performed for each workstation to assess the significance of inter-worker differences. Due to variations in individual work methods and occasional production disruptions, significant differences ($p < .05$) were found at 57 out of 79 workstations (72%). The greatest differences occurred when workers had the option to choose between standing and sitting (significant in eight of eight cases; in extreme examples, sit time ranged between 0-100% on one job, and 6.5-98% on another). This study found that the use of proxies can contribute to substantial error when estimating exposure in workplace studies. Individual measurements are preferable to proxies, particularly for jobs where workers have substantial latitude to develop individualized work methods.

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The Comprehensive Exposure Index (CEI) Model for the Assessment of Exposure to Risk Factors of UEMSDS

S. Moussavi Najarkola, Shahid Beheshti of Medical University, Tehran, Islamic Republic of Iran; S. Moussavi Najarkola, Tarbiat Modares University, Tehran, Islamic Republic of Iran; S. Moussavi Najarkola, National Iranian Oil Company, Tehran, Islamic Republic of Iran.

$UEMSD_S$ is a significant problem to ill health; therefore, to protect workers from such disorders, there is a need to introduce a model for assessment of risk factors featuring work-related $UEMSD_S$. CEI model is utilized by taking into consideration 10 variables for repetitive tasks. Single and total percentage agreement for any item was higher than 60%, and all kappa factors for strength of agreements were gained rather than 0.20. Emphasizing percentage agreement, most items were either close to or above 60%. All kappa factors for all assessment items were higher than 0.60, and test-retest agreements were all statistically significant. In laboratory study for all tasks and assessment items, percentage agreements were reached close to and above 60%. In field study for all assessment items, percentage agreements were higher than 70%. Kappa factors for all action levels were above 0.60, and percentage agreements for all action levels reached were higher than 75%. Inter-observer and intra-observer reliabilities and validity tests' agreement levels were "acceptable," according to Landis and Koch and Baty et al. classifications. By increasing work experience and submitting training about assessment items, both Cohen's kappa analysis factors and percentage agreement were enhanced. CEI model is found to be sensitive for assessing the interventions and changes in exposure and assessment items before and after ergonomic interventions. CEI model is also indicated to be highly reliable, valid, and applicable for a vast range of tasks and jobs, including, e.g., weaving and textile industries, manufacturing industries, carpentry, steel industry, post offices, service industry, electronic industry, shopping and marketing, agriculture and farming industry, tailoring and sewing, barberry, bakery, bricklaying, etc. Assessment reliabilities, validities, and exposure index applicability's will be improved with enhancing training and guiding to use the CEI model, and elevating experience in making assessment process.

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Comparison of Assessment Methods of Hand Activity and Force for Use in Calculating the ACGIH® HAL TLV®

S. Wurzelbacher, S. Burt, J. Ramsey, K. Crombie, Y. Jin, NIOSH, Cincinnati, Ohio; L. Luo, S. Allee, SRA, Cincinnati, Ohio.

Few studies have tested the assumption that alternate ergonomic exposure assessment methods for hand activity and hand force are equivalent. Variability between estimation methods could result in substantially different upper limb musculoskeletal disorder (MSD) risk categorizations. This research compared several methods for determining hand activity level and force in a large prospective ergonomics study. The specific goal was to determine if the methods were functionally equivalent for the purpose of calculating the ACGIH ® Hand Activity Level (HAL) Threshold Limit Value (TLV®), a common MSD risk metric. More than 700 task analyses were conducted on 484 workers at three study locations. Hand activity was assessed by two methods, including a trained observer on site using a 10-point visual analog scale and by video analysis of the same task to calculate the frequency of exertions and the work/recovery ratio. Hand force was assessed by three on site methods: worker force matching with dynamometers, ratings of perceived exertion (RPE) using a modified Borg 10-point scale by a trained observer, and RPE by the worker performing the task. The two methods for assessing hand activity level produced similar main TLV® result categories (safe, action limit, unsafe), with a mean agreement of 81% (SD = 11%) and a mean weighted kappa of 0.67 (SD = 0.08). The two RPE methods for assessing hand force produced comparable TLVs® (mean weighted kappa = 0.53, SD = 0.05). The worker force-matching variable did not produce similar TLVs® compared with either the worker RPE (mean weighted kappa = 0.28, SD = 0.05) or observer RPE (mean weighted kappa = 0.27, SD = 0.07). In summary, this study found that methods for assessing hand activity level and hand force are similar but not equivalent in terms of calculating HAL TLV® categories for identical job tasks.

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Development and Validation of a Personal Muscle Microsensor

W. Chu, University of British Columbia, Vancouver, BC, Canada.

In developed countries, musculoskeletal injuries are a major source of work-related disability and resultant economic burden. In Canada, musculoskeletal strains and sprains comprise approximately 50% of time loss claims for workers; the majority of these are for back injuries. In order to understand and prevent back injuries, muscle-related risk factors arising from loads, postures, and other factors must be monitored and assessed. Many approaches have been used to understand muscle-related risk factors associated with low back pain and injury. These include theoretically based biomechanical modeling, which is extremely labor intensive; and instrument-based electromyography (EMG), which can empirically quantify muscle activation but is costly and requires bulky equipment. We therefore undertook the design and fabrication of a microaccelerometer-based muscle sensor to measure the physical vibrations of a muscle - also known as mechanomyography (MMG). Our MMG device is inexpensive and unobtrusive, allowing frequent and routine measurements with minimal inconvenience and discomfort for workers. In this study, surface MMG and EMG systems were tested repeatedly on six subjects. Lumbar muscle data were recorded simultaneously and analyzed for trends. The six subjects performed isometric back hyper-extensions at 0° and15° angles from the horizontal, supporting their upper body weight for periods of 60 seconds. During each period, surface EMG and MMG data were recorded from the right lumbar erector spinae. Measurements of EMG frequency were found to decrease significantly as subjects fatigued, whereas EMG amplitude increased and then plateaued. Both of these effects were more pronounced at the 15° angle. MMG data showed that 15° tests produced vibrations of larger amplitude and significantly lower frequency vs. tests at 0°. These experimental results suggest that MMG can serve as a valuable, low-cost alternative for measuring muscle injury risk factors.

Podium Session 135: Asbestos and Benzene Exposure Assessment

Wednesday, June 3, 2009, 5:00 p.m.–7:20 p.m.
Papers 239–245

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Airborne Asbestos Concentrations Associated with Heavy Equipment Brake Removal

S. Gaffney, A. Madl, D. Paustenbach, ChemRisk Inc., San Francisco, CA; J. Balzer, Balzer, Alamo, CA.

Asbestos-containing brake linings were used in heavy-duty construction equipment such as tractors, backhoes, and bulldozers prior to the 1980s. While several published studies have evaluated exposures to mechanics during brake repair work, most have focused on automobiles and light trucks, not on heavy agricultural or construction vehicles. The purpose of this study was to characterize worker and bystander exposures to chrysotile asbestos from brake wear debris during the removal of brakes within 12 loader/backhoes and tractors manufactured between 1960 and 1980. Asbestos content in brake lining and brake wear debris was also quantified. Breathing- zone samples on the lapel of a volunteer mechanic (n=44) and area samples at bystander (n=34), remote (n=16), and ambient (n=12) locations were collected during 12 brake changes and analyzed using phase contrast microscopy (PCM) (NIOSH 7400) and transmission electron microscopy (TEM) (NIOSH 7402). In addition, the fiber distribution by size and morphology was evaluated according to the ISO method for asbestos. Applying the ratio of asbestos fibers:total fibers (including nonasbestos) as determined by TEM to the PCM results, the average airborne chrysotile concentrations (PCM equivalent) were 0.024 f/cc for the mechanic and 0.008 f/cc for persons standing 4-5 feet from the activity. Considering the time involved in the activity and assuming three brake jobs per shift, these results would convert to an average 8-hr TWA of 0.01 f/cc for a mechanic, and 0.006 f/cc for a bystander. In conclusion, these results showed that (1) the airborne concentrations for worker and bystander samples were all below the occupational exposure limit of 0.1 f/cc, (2) <2% of respirable fibers were >20 µm in length, and (3) approximately 95% of chrysotile in the brake linings degraded in the friction process.

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Exposure Assessment: Cutting and Installing Asbestos-Containing Ceiling Tile

C. Simmons, F. Boelter, ENVIRON International Corp., Chicago, IL.

This is the second exposure assessment related to asbestos-containing ceiling tiles. Both Part 1 and Part 2 were designed and conducted to capture several worst-case scenarios for a worker cutting and installing or removing and replacing ceiling tiles. These activities are associated with installation, maintenance, repair, or inspection. Part 1 was a field study involving removal and handling ceiling tiles, in which demonstrated 8-hr TWA breathing-zone results ranged from 0.008 to 0.022 total f/cc by NIOSH 7400; all results were <0.006 PCME f/cc by NIOSH 7402. Forty-six STEL results ranged from <0.045 to 0.086 total f/cc by NIOSH 7400; all results were <0.045 PCME f/cc by NIOSH 7402. Part 2 was a chamber study designed to measure breathing-zone concentrations while cutting and installing asbestos-containing ceiling tiles. The ceiling tiles contained from 1.0% to 4.25% amosite and 0.25% to 1.5% chrysotile. A layout of a ceiling was created to replicate the dimensions and protrusions of an actual room. The process in Part 2 included preparing and staging; installing thirty-four 2-foot by 4-foot ceiling tiles; cutting five 2-inch diameter round holes to accommodate sprinkler heads; cutting two round 13½-inch holes, one round 10-inch diameter hole, and one square 20-inch by 20-inch hole to accommodate ventilation registers; and making twenty-five 4-foot cuts representing the perimeter tiles in grid. Eight-hour TWA breathing-zone results ranged from 0.046 to 0.078 total f/cc by NIOSH 7400, and 0.018 to 0.019 PCME f/cc by NIOSH 7402. Seven STEL results ranged from 0.053 to 0.343 total f/cc by NIOSH 7400; all results were <0.045 PCME f/cc by NIOSH 7402.

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Evaluation of Exposures to Airborne Asbestos from Work on Suspected ACMs on Maritime Shipping Vessels (1978-1991)

D. Hollins, A. Madl, D. Paustenbach, ChemRisk, San Francisco, CA; J. Knutsen, ChemRisk, Boulder, CO.

The majority of published and unpublished literature evaluating airborne exposures from handling asbestos-containing insulation products characterize airborne asbestos concentrations in shipyard and nonshipyard (i.e., construction, manufacturing, and other industrial) settings (1978-1991). Sufficient information has been collected historically to quantitatively characterize asbestos exposures for the most highly exposed craftsmen (insulators) interacting with asbestos-containing materials (ACMs) in these settings. However, to our knowledge, asbestos exposures to merchant seamen or other tradesmen performing emergency and/or winter lay-up maintenance and repairs on ACMs on merchant vessels has not heretofore been evaluated. Therefore, our primary objective was to analyze the task-specific industrial hygiene data collected on maritime vessels during or immediately after the direct handling of insulation and other suspected ACMs. Therefore, 139 airborne asbestos measurements characterizing the exposure of seamen or other tradesmen performing this work from 1978 until 1991 are presented. Only about 8% of these samples were below the analytical detection limit. Airborne fiber concentrations collected during or immediately after activities involving suspected ACMs averaged 0.122 fibers per cubic centimeter (f/cc), with a 95th percentile of 0.521 f/cc. Average fiber concentration of air samples collected while the ships were docked and under way were 0.167 f/cc and 0.194 f/cc, respectively, with 95th percentiles of 0.82 f/cc and 1.06 f/cc. Based on these results, it appears that exposures on maritime shipping vessels during or immediately after work on ACMs were below exposures reported in the literature for insulators performing similar work in shipyard and nonshipyard settings.

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Bricklayer Exposures to Airborne Asbestos in Steel Mills (1972–1982): An Updated Analysis

D. Hollins, A. Madl, D. Paustenbach, ChemRisk, San Francisco, CA; J. Balzer, Balzer, Alamo, CA; K. Unice, ChemRisk, Pittsburgh, PA.

Little attention has been devoted to characterizing asbestos exposures to bricklayers in steel mills, although it has been previously suggested as being possibly significant. The objective of this analysis was to characterize the airborne asbestos exposures to these craftsmen as reflected in samples collected in steel mills between 1972 and 1982. An asbestos air-monitoring database was created and updated with industrial hygiene surveys conducted during repair and/or maintenance work on open hearth furnaces, blast furnaces, and stoves. Personal (n=138) and area (n=21) samples were collected while bricklayers and bricklayer helpers handled asbestos-containing products. When appropriate, these data were combined to estimate task-specific time-weighted average (TWA) exposures, and were compared with the contemporaneous OSHA 8 hr-TWA permissible exposure limits for asbestos. Results of personal air samples ranged from 0.001-3.2 f/cc, with 95% confidence interval (CI) of the mean of 0.19-0.34 f/cc. The average sample duration was 30 minutes and ranged from 5-306 minutes for all samples. The short-term sampling data were most likely collected during the periods of the day during which exposure was expected to be the highest and may not reflect the 8-hr TWA. The estimated TWA concentrations for these workers ranged from 0.004-1.4 f/cc, with a 95% CI of the mean of 0.15-0.36 f/cc for those days when masons were lining, relining, or rebuilding furnaces and stoves. These values potentially may not be appropriate in depicting the typical daily exposures of refractory masons, as only a fraction of their careers may have been involved in lining and relining furnaces and stoves. Although it would appear that masons' exposure to airborne asbestos in these steel mills during this period of time were generally low, further research is needed to understand how specific bricklayer tasks contribute to their overall TWA and potential health risk.

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Airborne Benzene Concentrations Associated with Dock Operations at the ExxonMobil Refinery (1978-2007), Baytown, Texas

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Because benzene naturally occurs in crude oil and can be retained in products derived from crude oil, the occupational exposures of petroleum industry workers to benzene have been studied for decades. To date, no extensive analysis of historical industrial hygiene data for refinery dock employees has been performed, and none have focused on the airborne concentrations for specific refineries or for specific job titles and tasks. In this study, exposures to benzene, and their variability throughout time were characterized for dock workers at the Exxon-

Mobil Baytown, Texas, refinery from 1978 to 2007. The results of 1591 personal air samples collected at the docks and loading rack are included in this analysis; 1019 were considered nontask (>3 hr) and 572 were considered task-related (<3 hr). Mean benzene concentrations (unadjusted for respiratory protection) associated with both job title and task were calculated. In addition, a trend analysis of both the nontask and the task data was performed comparing data collected in 1978-1991 to that collected in 1992-2007. The most frequently sampled job title at the docks (Dock Connecting Crew) had a mean airborne benzene concentration of 0.30 ppm (n=448, SD=0.812ppm). The most frequently sampled task at the docks was Hose Disconnect, which had a mean airborne benzene concentration of 21 ppm (n=200, SD=36ppm), although respiratory protection is required for activities with potential to exceed exposure limits. A statistically significant decrease throughout time for the Contractor Tankerman job title was observed (mean airborne benzene concentration dropped from 36 ppm in 1978-1991 to 2.8 ppm in 1992-2007), as was a nonstatistically significant decrease in benzene concentrations associated with most tasks. The results from this study indicate that benzene concentrations at the dock and loading rack at this facility are lower than the majority of similar facilities previously described in the published literature; although, they are higher than that found within the refinery operating facility.

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An Exposure Assessment of Community and Personal BTEX Exposures to Workers and Residents on the St. Regis Mohawk Tribe (SNRT) Reservation at Akwesasne

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An air toxics-monitoring campaign was undertaken to evaluate benzene concentrations on the St. Regis Mohawk Tribe (SRMT) Akwesasne reservation. The reservation is bordered to the west by a large aluminum smelter that routinely emits approximately 29,000 pounds of benzene per year. The objective of the campaign was to determine the benzene, toluene, ethyl benzene, and xylenes (BTEX) concentrations in ambient air on the reservation and characterize the BTEX sources. The BTEX samples were collected at nine locations in 6-L Entech stainless steel Silonite canisters for 24 hr every sixth day between May 2007 and July 2008. In addition, personal monitoring of BTEX was conducted on the SRMT reservation using 300 mL capillary flow-controlled stainless steel canisters. The objective of the personal monitoring was to determine the concentration of BTEX to which workers and residents on the reservation were exposed. A group of 20 volunteers living and working on the SRMT reservation was randomly selected and consented to participate in this study. The sampling was conducted between March 2008 and June 2008. The samplers were worn by the individuals at the beginning of their work schedule, typically before 9 a.m., and sampling ended between 3 p.m. and 5 p.m. The samples were concentrated and analyzed using GC/MS with the procedures listed in EPA TO15. Environmental tobacco smoke was of minor importance in this study. The study revealed that the individuals working at the gas stations and repair shops had the highest BTEX exposures of all the monitored microenvironments. The personal monitoring data was also compared with the ambient levels to assess relationship between workplace and community exposure.

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Benzene Exposure for Painters

A. Welch, J. Sahmel, K. Devlin, ChemRisk, Boulder, CO.

Benzene is present in a number of organic solvents as it is a naturally occurring compound in crude oil and natural gas. Despite distillation and refining processes, benzene remains as a trace impurity due to the nature of fractional distillation. Throughout time, changing industrial processes have reduced the benzene content in petroleum-based products. Many petroleum-based solvents appear to have had benzene concentrations of less than 0.1% benzene by volume since the late 1970s, based on available data. While OSHA does not require listing on Material Safety Data Sheets (MSDSs) of ingredients with less than 0.1% benzene by volume because they are unlikely to cause exposures through dermal absorption or inhalation exceeding the OSHA action level of 0.5 ppm, there is still concern regarding benzene exposure in some workplaces and for certain types of products. One industry where products may contain residual amounts of benzene is the paint industry. In this presentation, we will discuss the potential range of benzene exposure for painters using consumer spray paint products based on the petroleum-based components in paint, such as carbon black, ethylbenzene, hexane, various hydrocarbon solvents, lactol spirits, methylbenzene, mineral spirits, several naptha-based products, Stoddard solvent, toluene, and xylene.

Podium Session 136: Respiratory Protection 2: Respirator Fit and Physiological Factors

Wednesday, June 3, 2009, 5:00 p.m.–8:00 p.m.

Papers 246–254

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Metabolic Evaluation of N95 Filtering Face Piece Respirators with Surgical Mask Covers Using the Automated Breathing and Metabolic Simulator (ABMS)

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Experts suggest using a surgical mask cover (SM) to extend the lifetime of NIOSH-approved N95 filtering facepiece respirators (N95FFR) in health care settings during a pandemic. The automated breathing and metabolic dimulator (ABMS) was used to simulate human metabolism for characterizing average inhaled CO_2 and O_2 concentrations, and inhalation (InPr) and exhalation (ExPr) breathing pressures (mm of water), among 18 NIOSH-approved N95FFR without and with SM (N95FFR+SM). The ABMS protocol consisted of varying levels of O_2 consumption, CO_2 production, and ventilation performed consecutively for a minimum of five minutes each (units in STPD): 0.5, 0.4, and 10 L/min; 1.0, 0.8, and 25 L/min; 1.5, 1.3, and 38 L/min; 2.0, 1.9, and 62 L/min; 2.5, 2.5, and 70 L/min; and 3.0, 3.1, and 80 L/min, respectively. The mean across all N95FFR for average inhaled CO_2 and O_2 ranged from 2.7% and 17.1%, respectively, for the lowest metabolic rate to 1.6% and 19.3%, respectively, for the greatest metabolic rate. The mean across all N95FFR+SM for average inhaled CO_2 and O_2 ranged from 2.9% and 16.7%, respectively, for the lowest metabolic rate to 1.8% and 19.0%, respectively, for the greatest metabolic rate. The mean across all N95FFR for peak InPr and ExPr ranged from -5 and 7, respectively, for the lowest metabolic rate to -41 and 24, respectively, for the greatest metabolic rate. The mean across all N95FFR+SM for peak InPr and ExPr ranged from -6 and 8, respectively, for the lowest metabolic rate to -52 and 30, respectively, for the greatest metabolic rate. At the lowest metabolic rate, average inhaled CO_2 concentrations were greater than the NIOSH short-term exposure limit (3%) for 7/18 (39%) N95FFR and 9/18 (50%) N95FFR+SM.

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Oxygen Deficit with Respirator Use

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The ultimate goal for engineering design of respirators would be a model to predict work performance times of wearers. In order for such a model to be formulated, limitations imposed by the respirator on the wearer need to be understood. One hypothesis to explain the respiratory limitation of respirators is that wearers reach their maximum oxygen deficits faster when wearing respirators than without respirators. This would be consistent with the hypoventilation observed while wearing air-purifying respirators. To test the hypothesis that wearers reach their maximum oxygen deficits faster when wearing respirators, 10 subjects wearing M40 APRs were tested on a treadmill at 75%, 85%, 100%, and 115% of VO2max. In addition, the same subjects were tested at 85% VO2max without a respirator. Performance times were recorded, and oxygen deficits were determined from VO2 data throughout time. The results show that oxygen deficit at the end of work performance varied with work rate, but not with respirator use. It was concluded that the hypothesis stated above is not correct.

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Breathing Simulator for Respirator Performance Evaluations Under Work Conditions

H. Yuasa, E. Shimizu, H. Haruta, T. Honda, K. Kimura, H. Emi, K. Nozaki, KOKEN, Hanno, Japan.

Breathing machines are widely used to evaluate the performance of respirators. Normally, they generate fixed airflow patterns, such as sine, triangular, or square waves. For performance evaluations of respirators, it is desirable that the breathing machines reproduce the actual breathing patterns of workers. Because human respiration changes with time in frequency and air volume, depending on the surrounding temperature, the workload, and the rate of repetitive motion, breathing machines have not been able to simulate such complicated airflow patterns. In this study, we developed a device for sampling human respiration and an electro-mechanical

breathing simulator to record and reproduce the respiration of workers. The breathing simulator is composed of a servo cylinder, two air cylinders, a servo controller, a data-recording unit, and a data-output unit. The servo cylinder is automatically connected to the air cylinders; the air cylinder rods move with the servo cylinder, thus generating airflows. Because the servo controller controls the stroke of the servo cylinder at 100 µm intervals, precise airflows are generated. The breathing simulator can generate a wide range of airflow patterns up to 150 Lpm by inputting any flow pattern recorded by a computer while sampling the respiration of workers. Several respiration patterns of workers were recorded and successfully reproduced by the breathing simulator with a strong correlation coefficient. Thus, this development made possible the evaluation of respirator performance using actual breathing patterns at various workloads.

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Digital 3-D Headforms Representative of the Current U.S. Work Force

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Test headforms are often used in safety equipment testing in place of human test subjects. For example, more than 20 headform tests are used in respiratory protection and eye and face protection standards being developed by the International Organization for Standardization. Many headforms used in the United States are based on anthropometric data collected more than 30 years ago, including respirator certification tests conducted by NIOSH. In 2003, facial measurements were collected during a NIOSH survey of 3997 respirator users. In addition to traditional measuring techniques, 1013 subjects were scanned with a Cyberware 3-D Rapid Digitizer. Previous research established that historical military anthropometric data are inadequate for describing the anthropometric variability of the current U.S. work force and thus would not be appropriate for developing test headforms. The objective of this study was to create headforms representative of the current U.S. work force. Ten facial dimensions relevant to respirator fit were chosen for defining a principal component analysis (PCA) model, which divides the user population into five face-size categories. Mean facial dimensions were then computed to target the ideal facial dimensions for each size category. Five scans in each category were chosen based on PCA scores calculated from 3-D scan data and averaged together to construct a representative headform for each size category. Five digital 3-D headforms were developed: small, medium, large, short/wide and long/narrow. The new headforms are symmetric and include facial features not found on current standard headforms. In addition, care was taken to place the ears on each headform in the average location, based on the five chosen heads, relative to the sellion. All dimensions except for head breadth are within 3 mm of the computed means for the sample population in each size category.

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Evaluation of User's Ability to Seal Respirator Cartridge Inlet Openings of Different Sizes and Shapes

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This study was conducted to evaluate the ability to seal respirator inlet openings during a simulated negative pressure user seal check. One goal of this research was to determine the percentage of subjects that could achieve an adequate seal to a variety of commonly used respirator cartridges. A secondary goal was to identify factors that might limit an individual from obtaining an acceptable seal. An apparatus was constructed to present 12 different respirator cartridges to each subject (n=33) in a way that would maximize their ability to seal the inlet opening with the palm of their hand. Using a pump, rotameter, and digital manometer, each cartridge was kept at a pressure of -2"H_2O (±5%). An adequate seal was confirmed when the rotameter showed a complete restriction of airflow. Standing height, palm length, and width measurements were obtained for each subject. None of the subjects were able to adequately seal 100% of the respirator inlet openings. The percentage of subjects who were able to achieve an acceptable seal had a negative correlation with an increase in the area of the inlet opening. The percentage of subjects able to achieve an acceptable seal increased with a decrease in the inlet openings. Based on the findings of this study, 95% of the study population was able to adequately seal a respirator inlet opening with an area of ≤ 24 cm^2. The type of equipment developed in this study could be used by respirator manufacturers and certifying agencies to verify the probability that an adequate seal can be achieved during negative pressure user seal checks whenever a newly designed inlet opening is created.

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Nanoparticle Leakage Around Face/Mask Interface of Filtering Facepiece Respirators

S. Rengasamy, NIOSH, Pittsburgh, PA; B. Eimer, EG & G Technical Services, Pittsburgh, PA.

The aim of this study was to investigate nanoparticle leakage around the face/mask interface. NIOSH-approved N95 and P100, and CE marked FFP2 and FFP3 filtering facepiece respirators (FFR) were tested for leakage of 10-400 nm particles using a manikin under breathing conditions. An FFR was fitted with a sampling port similar to that used for fit factor measurements with a PortaCount. Two additional ports were placed on either side of the FFR at the same height as the first port. These ports were filled with nonhardening putty and placed approximately 1 cm from the seal with the manikin on each side. The respirator was sealed to the manikin and placed inside a positive pressure chamber. A breathing pump was connected to the manikin, and samples were analyzed at 30 and 40 liter minute volumes. Artificial leaks of different diameters were introduced by carefully drilling hypodermic needles (20, 18, 16, and 13 gauge) through the side port putty. Samples inside and outside of the FFR were withdrawn for analysis. Monodisperse sucrose (10-80 nm) particles were generated using an electrospray aerosol generator, neutralized, passed into the test chamber and samples were quantified using a CPC. For >100 nm particles, polydisperse NaCl aerosol was generated using an atomizer, dried, neutralized, and passed into the test chamber. Samples inside and outside of the FFR were analyzed for monodisperse particles using a DMA and a CPC. Penetrations were <5% for N95 and FFP2 respirators and <1% for P100 and FFP3 respirators for 10-400 nm particles under completely sealed conditions. Penetration levels increased with increasing leak size. No significant difference in the penetration levels for 10-400 nm size particles was obtained, suggesting that leakage of nanoparticle around face/mask interface is similar to >100 nm size particles.

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Pathways for Particle Penetration Through a Filtering Facepiece Particulate Respirator During Human Breathing

S. Grinshpun, H. Haruta, T. Reponen, R. McKay, University of Cincinnati, Cincinnati, Ohio; R. Eninger, USAF, San Antonio, Texas; S. Lee, Feng Chia University, ROC, Taiwan.

NIOSH has proposed the use of a total inward leakage (TIL) test for assessing performance of respirators, including filtering facepiece particulate respirators (FFPRs), as a part of the certification protocol. The existing protocol evaluates the efficiency of respirator filter media under constant airflow, but does not address the role of faceseal leaks. This study was conducted to differentiate the contributions of these two pathways under actual breathing conditions. To measure the total penetration, a 25-subject panel was fit-tested to N95 FFPRs using a size-selective Electric Low Pressure Impactor (ELPI). The subject's breathing pattern was recorded for each fit-test exercise (normal breathing, deep breathing, etc.) using a novel Breathing Recording and Simulation System (Koken Ltd., Japan). Each subjects' breathing pattern was then reproduced with the respirator sealed to a manikin. Filter penetration was measured as a function of the particle size (d_p = 30 nm to >1 µm). By comparing results of the human subject and manikin-based tests with the same breathing pattern, we found that the number of particles penetrating through the faceseal leakage exceeded the filter media penetration by an order of magnitude: it is (on average) ~7 fold greater for d_p = 40 nm, ~10-fold for 100 nm, and ~20-fold for 1 µm. These findings suggest that the primary effort in improving respirator design should be shifted from further enhancing the filter media toward introducing a better fit between the respirator periphery and the face surface.

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Workplace Protection Factors of N95 Respirators Against Nonbiological and Biological Particles on Agicultural Farms

K. Cho, T. Reponen, R. McKay, U. Singh, A. Adhikari, R. Shukla, S. Grinshpun, University of Cincinnati, Cincinnati, Ohio; S. Jones, G. Jones, Western Kentucky University, Bowling Green, KY.

Most of the previous workplace protection factor (WPF) studies have been based on the measurement of particle mass, and very little is known about the WPFs for biological particles. In this

study, we used a recently developed personal sampling set up, which allows simultaneous measurement of biological and nonbiological particles. Two filter samplers connected with personal sampling pumps collected particles for subsequent analysis of particle mass, endotoxin, (1-3)-β-D-glucan, total bacterial count, and total fungal spore count. WPF was measured for 13 subjects wearing a N95 filtering facepiece respirator (FFR) and a N95 elastomeric respirator (ER) while performing a variety of farming activities (e.g., animal feeding, grain handling, and sweeping/shoveling hay). Prior to measurement of WPF, all subjects were required to pass a quantitative fit-test. For the N95 FFR, the geometric mean (GM) WPFs for particle mass, endotoxin, (1-3)-β-D-glucan, total bacterial count, and fungal spore count were 45, 113, 25, 11, and 25, respectively. Corresponding values for N95 ER were 45, 116, 139, 7, and 20, respectively. The WPF values were not significantly different between the N95 FFR and the N95 ER when evaluated with paired t-test separately for each contaminant type or for all data combined. WPFs for endotoxin (GM=115) were higher than those for total bacteria (GM=8) (paired t-test: p=0.001). A similar trend was seen between (1-3)-β-D-glucan (GM=59) and total fungal spores (GM=23), but this difference was not statistically significant. These preliminary results indicate that differences in WPFs may be larger between different types of contaminants than the type of respirator worn.

Podium Session 137: Welding Safety

Thursday, June 4, 2009, 8:00 a.m.–10:20 a.m.
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Characterization and Prediction of Shipyard Welders' Exposure

J. Nelson, N. Seixas, J. Camp, V. Runnion, R. Dills, University of Washington, Seattle, WA.

Shipbuilding and repair involves extensive welding in a variety of environments, including confined spaces. Shipyard welders' exposure to welding fume has not been adequately characterized. The goals of this study were to (1) characterize shipyard welders' exposure to total welding fume and its specific metal components while working under different conditions in different environments and (2) develop a multivariate model to predict both total and individual metal exposures. This model will be useful to health and safety managers in determining PPE and ventilation requirements, and for exposure assessments in epidemiological studies of shipyard welders. Welding fume samples were collected from personal breathing zones of welders working in three shipyards. Data were also collected on tasks, welding type and position, work spaces, process parameters, consumables, respiratory protection, and ventilation. Samples were analyzed for total mass and specific metals (Mn, Fe, Cu, Pb, Co, As, Cd, Cr, Cr IV, Zn, and Al) by ICP-MS. More than 134 full-shift samples were collected and analyzed. The mean TWA exposure to welding particulate in enclosed, confined, outdoor, and shop spaces was 15.5, 13.9, 5.7, and 9.6 mg/m^3 ,respectively. The percent of samples exceeding the Washington State PEL (5 mg/m^3) for enclosed, confined, outdoor, and shop spaces were 67%, 94%, 50% and 63%, respectively. The percent of subjects using respiratory protection in enclosed, confined, outdoor, and shop spaces were 11%, 39%, 25%, and 2%, respectively. Only 2% of the subjects used local exhaust ventilation, occurring only in shop settings. When in enclosed or confined spaces, only dilution ventilation was observed. These data indicate that shipyard welders have very high exposures to metal fume, and, consequently, are at high risk for respiratory diseases from metal fume. The covariates of welding type, ventilation use, and space were considered in multivariate models. Improvements in ventilation, PPE, and management practices are needed.

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Mine Welding Audit Case Study — Woes and Wonders

T. Peveto, E. Rasmuson, A. Duane, Chemistry & Industrial Hygiene Inc., Wheat Ridge, CO.

The unique environment of a large surface mine site is the backdrop of this case study that presents the procedures and findings of a welding health and safety audit. Specifically, we will present our observations related to welding health and safety hazards and their associated risks, with a focus on the conditions associated with mine site activities. Theoretical considerations and preplanned audit procedures will be contrasted with practical methodologies and site-specific tailoring of the audit flow, based on site conditions. A brief summary of the target audit activities, data collection and analysis methods, data interpretation, and audit findings will be followed by general conclusions and recommendations for improving similar large-scope audits in the future.

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Employees' Exposures to Powder Paint and Welding Fumes During Metal Furniture Manufacturing

M. Rodriguez, CDC/NIOSH, Cincinnati, Ohio.

NIOSH received an employee request for a health hazard evaluation (HHE) concerning exposures from welding fumes and powder paint at a metal furniture manufacturing facility.. The 110,000 square-foot facility had 146 employees, including 14 metal inert gas welders, 13 spot welders, 6 grinders, and 15 painters. Painters were wearing filtering facepiece respirators. We collected personal breathing-zone (PBZ) air samples for elements and carbon monoxide on welders and grinders; and for 1,3,5 triglycidyl isocyanurate (TGIC), respirable dust, and total dust on painters. We also analyzed bulk samples of the powder paint for silica and asbestos (neither was found). Seven of the 38 samples collected on welders exceeded the ACGIH TLV®-TWA of 0.20 mg/m^3 for manganese. Four of 16 PBZ air samples collected on welders exceeded the NIOSH ceiling limit of 200 ppm for carbon monoxide. Four of the 8 samples collected on painters for TGIC exceeded the ACGIH TLV®-TWA of 0.050 mg/m^3. Concentrations of TGIC ranged from 0.002 to 0.89 mg/m^3, with a mean concentration of 0.19 mg/m^3. Painters' exposures to respirable dust ranged up to 8.4 mg/m^3, and for total dust from 0.80 mg/m^3 to 130 mg/m^3. Some of these concentrations exceeded the OSHA 8-hour PEL-TWA for respirable dust of 5 mg/m^3 and for total dust of 15 mg/m^3. NIOSH investigators recommended improved ventilation to control exposures to welding fumes and powder paint dust, and increasing the level of respiratory protection for painters until TGIC exposures are reduced below the ACGIH TLV®.

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Air Monitoring Evaluation of Hybrid Laser Arc Welding (HLAW) Operations

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Effective industrial hygiene air-monitoring evaluation of welding operations requires an understanding and close examination of many variables, including welding process, base and filler metal combinations, electrical current, arc time, welder position, use of protective equipment, workspace configuration, and the use of ventilation. Recent NIOSH publications have cited more that 80 different types of welding processes in commercial use in the United States. While many of the more common welding processes are well represented in the technical literature, no definitive air-monitoring data has been previously published to describe the fume levels generated in the welder's breathing zone during hybrid laser arc welding (HLAW). HLAW is a combination of laser beam welding and gas metal arc welding, that was developed to combine the advantages of deep-weld penetration and high welding speeds with filler metal addition, resulting in lower overall heat input and less metal distortion. Automating the process allows reduced labor and faster production times. Applications of HLAW include automated control systems, which have proven beneficial for high-quality welding applications in a variety of industries such as shipbuilding and marine construction; rail and general transportation; steel mills; automotive manufacturing; and the fabrication of tubes, pipes, and pressure vessels. This evaluation has collected a combination of personal breathing-zone and area measurements during HLAW on a variety of metal types, shapes, thicknesses, and filler metals in an established production shop. Exposures to nine metals were evaluated during this study, with all results found to be well below established OSHA permissible exposure limits.

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Evaluation of CrVI Exposure Determinants Among Welders

V. Runnion, J. Nelson, R. Wang, G. Speyer, University of Washington, Seattle, WA.

The University of Washington Field Research & Consultation Group has collected more than 75 full-shift personal hexavalent chromium samples (to date) on stainless steel welders. These samples, collected from June 2006 through the present, are from metal fabrication shops, foundries, and shipyards, with the majority collected from shipyard welders. In addition to evaluating exposures and assessing regulatory compliance, information on a variety of exposure determinants was also collected, including welding process, amperage, voltage, shielding gas, work location, and local exhaust ventilation use. Although exposure monitoring was conducted primarily for compliance purposes, the additional data were collected to assess the effect of process param-

eters on exposures. Preliminary results indicate time-weighted average exposures up to 20 times the permissible exposure limit (PEL), with the highest exposures associated with shielded metal and flux core arc welding. The mean exposure level for welders in confined spaces was more than 10 times greater than those welding in a shop or outside, and more than 10 times the PEL. Despite the fact that LEV was utilized more often than not in confined space work, exposures still exceeded the PEL. To address the need to predict potential overexposures during hot work operations that occur infrequently, a model is being developed based on process variables and exposure determinants. Multiple linear regression will be used to prioritize work process factors that have the potential for the greatest reduction of hexavalent chromium exposures as well as allow us to predict under what circumstances to expect overexposures. Data will continue to be collected and used in future refinements of the model.

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Determination of Hexavalent Chromium in Workplace Air

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The aim of this study was to develop a sampling device on which water-soluble and water-insoluble compounds of hexavalent chromium (CrVI) could be collected and specifically analyzed. This device should also be capable of eliminating or reducing the problem of aerosols collected on interior walls of the cassette. Effort also went into finding high-purity materials and starting materials free of CrVI. The amount of CrVI found on filters (e.g., quartz fiber filter) and NaOH used for impregnation varies from manufacturer to manufacturer and from lot to lot. It is also noted that significant amounts of CrVI are often deposited on interior walls of sampling cassettes. A sampling device consisting of a vinyl/acrylic copolymer filter mounted in a 3 part, 25-mm polypropylene cassette, in the shape of a "wine glass" was chosen by the IRSST. With this type of sampling device, the CrVI can be extracted specifically from the cassette and the aerosols recovered from its inside walls. Vinyl/acrylic copolymer filters were retained for their free content of CrVI. The impregnation method used by the IRSST controls the CrVI contamination coming from the NaOH when producing cassettes for sampling liquid aerosols as those generated by electroplating processes. All the other CrVI compounds are sampled on a nonimpregnated vinyl/acrylic copolymer filter. The loss in recovery of CrVI spiked on NaOH coated filters did not exceed 10% after eight days. The precision at the 95% confidence level is 3.6%, and the extended overall uncertainty procedure is ±12%. The extraction efficiency over the range of 1-40 µg was 98% ± 2. The detection limit is 0.003 µg of CrVI per filter. Similar results were also obtained for nonimpregnated filters. Samples are analyzed by ion chromatography.

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Hexavalent Chromium Exposure Assessment During Stainless Steel Welding at an Engineering Company in Mexico

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The electrode used in shielded metal arc welding (SMAW) and stainless steel contain chromium. As the weld metal being deposited during welding passes through the welding arc, electrons are stripped from some of the chromium atoms. If six electrons are stripped from a chromium atom, that atom becomes hexavalent chromium (CrVI). In the case of SMAW work, the alkaline metals in the flux tend to stabilize the CrVI so that it remains in the negative 6 valence state long enough to reach the breathing zone of the welder. A qualitative and quantitative exposure assessment was conducted for potential exposure to CrVI in SMAW work on a stainless steel block at an engineering company in Mexico. Qualitative exposure assessment consisted of determining frequency and duration of welding process and review of MSDS to determine contents of the electrode and stainless steel used. Modified OSHA Method ID 215 was used for the purpose of employee exposure monitoring for CrVI. The welding work was carried out for about eight hours, so the exposure monitoring was conducted for close to eight hours. An AIHA-accredited laboratory in the United States analyzed CrVI samples. An employee exposure to CrVI was found to be above the OSHA Permissible Exposure Limit (PEL) of 5 ug/m^3. The contributory factors for CrVI exposure appeared to be the absence of local exhaust ventilation (LEV) in the welding area and extended duration of welding work. Recommendations were made to provide LEV in the welding area. Use of powered air-purifying respirator type of welding helmet was recommended until exposure is confirmed below the OSHA PEL by means of LEV. A follow-up CrVI exposure monitoring is planned to determine the degree of CrVI exposure reduction once LEV is installed in the welding area.

Podium Session 138: IEQ: It's Not Just Mold

Thursday, June 4, 2009, 8:00 a.m.–11:40 a.m.
Papers 262–269

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Measuring the Contribution of Stress in Indoor Environment Investigations

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The indoor environment literature is replete with studies indicating workplace stress being associated with symptoms generally ascribed to air quality. To measure the contribution of work demands and job latitude on indoor environment quality (IEQ) a recognized measure of job strain (job control questionnaire or JCQ) was incorporated into the MM-040 Indoor Environment Questionnaire. A global scale for rating the IEQ was also added. Between 2001-2008 the combined questionnaires were administered in 13 buildings. The total number of respondents was 922. The percentage of respondents who fit the "Sick Building Syndrome (SBS)" case definition (adapted from NIOSH investigations) was 18%. The between-workplace variation was significant enough (6-12% for most variables) to warrant the use of mixed-model regression techniques. The regression model for predicting SBS symptom scores included two environmental factors (warm dry thermal conditions and perceptions of exposures to physical agents), gender, and an atopy score. This model accounted for 28% of the variation in SBS symptoms within buildings and 29% of the variation between buildings. These same two environmental perception factors and atopy explained 48% of the variation in the global IEQ ratings within buildings and 43% of the variation between buildings. A path analysis of the regression models with the job demands and job latitude forced in showed that the job demands construct of the JCQ influenced environmental perceptions directly, but did not directly influence SBS symptoms or the global IEQ ratings. Our observations suggest workplace stress influences symptoms and ratings of IEQ indirectly by modifying indoor environmental perceptions.

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Comparison of Total Volatile Organic Compound (TVOC) Sampling and Analytical Methods Used for Green Building Evaluation/LEED

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Total volatile organic compounds (TVOC) may be evaluated when building designers/managers are pursuing the Leadership in Energy and Environmental Design Green Building Rating System for New Construction (LEED-NC) EQ Credit 3.2. The latest LEED-NC guidance document specifies that the maximum allowed concentration of TVOC measured in a building (post construction, preoccupancy) is 500 µg/m^3; the guidance also mentions the sampling/analytical methods in the "EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air." However, none of these sampling and analytical methods address TVOC in particular, and thus the existing methods must be modified. In addition, several definitions of TVOC exist in literature; we will first explore the differences and implications of these different definitions. In practice, practitioners have used many different techniques for evaluating TVOC in buildings. Each sampling and analytical method has its own benefits and drawbacks, cost implications, and applicability. The purpose of this paper was to present real-world data where multiple simultaneous TVOC samples were collected. Techniques evaluated include traditional charcoal tubes, traditional thermal desorption tubes, Summa canisters, and Radiello passive samplers. The variety of sampling and analytical techniques allows for comparisons between whole air vs. adsorptive samples, active sampling vs. passive sampling, and chemical solvent desorption vs. thermal desorption techniques. Qualitative compositional analyses of the TVOC values are also presented. Results from these real-world samples will be presented, along with analytical interpretations related to each sampling/analytical method. This research will allow practitioners to make an educated choice of which TVOC method may be most appropriate for

their project. It will also allow practitioners to have a better sense of what typical VOCs (and what concentrations of these VOCS) may be measured by each technique, along with any inherent biases of the methods.

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Damage and Environmental Health Risk Assessment of Settled Smoke Particles from Wildfires

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Wildfires are common in many areas of the western states, especially California. California has many highly populous regions in areas of high fire risk. These fires destroy both residential and commercial buildings, damage others, and expose many more to combustion-related residues. During wildfires, many public health entities produce warnings for the public, notifying them of the potential risk to their heath of breathing the combustion-related particles. Building owners are often confused about the potential risks posed by smoke residues due to exposure to nearby fires. Often, the investigation and evaluation of damage and environmental risk from externally generated fire damage is conducted by industrial hygienists or other environmental health professionals. However, there are generally no standards for the evaluation of settled residues specifically related to wildfires. In addition, externally generated fire residues do not behave the same as those from a typical interior fire, and the composition is not necessarily the same. In such investigations, insurance issues such as "what constitutes damage?" intermingle with environmental health risk issues such as "when does contamination with smoke-related particles present a risk to the building occupant?" In this session, we will examine investigation techniques and standards being used in these types of evaluations. Testing and sampling methods are varied, and laboratories offer a variety of analyses that can be used in determination of particle composition, such as light or electron microscopy and chemical detecting instrumentation (e.g., EDX, GS-MS). Interpretation of analytical data varies tremendously between evaluators. We also will present data from some of the more than 50 evaluations in which Forensic Analytical was retained to conduct a damage and/or environmental risk assessment. Results indicate inconsistent correlation with visual assessment and difficulty in determining what constitutes contamination or damage and any inherent environmental health risk.

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A Method to Evaluate Lead Surface Dust Concentrations in Nonresidential Settings

R. Kalmes, J. Hicks, Exponent, Oakland, CA.

Clearance levels to assess lead on surfaces have historically been evaluated using wipe samples or vacuum methods that provide a value of lead per area [e.g., microgram per square foot -($\mu g/ft^2$)]. Lead clearance levels have been in place for use by HUD for public housing projects and child-related facilities for more than a decade. Although EPA established acceptable lead levels for child-occupied facilities, it provides no regulatory levels for other settings such as commercial and industrial buildings. Recently, EPA recommended an approach to be used inside buildings near the former World Trade Center complex to characterize buildings with regard to residual chemical contamination on surfaces, and to establish risk-based benchmarks that trigger further cleanup. However, the WTC levels are based on the HUD residential screening levels and, therefore, are not necessarily relevant to commercial and industrial buildings that are occupied by adults. The OSHA lead standard does not provide lead clearance values for workplace surfaces in evaluating potential occupational exposures, but rather relies on airborne concentrations. We will review methods used by various agencies in assessing lead-containing dust and summarize recent literature findings. We then will describe a health-risk-based method used to develop lead surface dust benchmark levels for a variety of workplace surfaces for industrial and commercial buildings. Finally, specific case studies will be presented demonstrating how these benchmark levels were applied to various surfaces within several commercial and occupational settings.

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Legionella Testing — What Information Do You Really Need? And How Should You Use It?

D. Miskowski, EMSL Analytical Inc, Westmont, NJ.

Many private, commercial, and state health department laboratories currently test for Legionella, but not all analytical methods are created equally. I will present an overview of the different types of analyses currently available for correctly determining the presence of Legionellaceae, identifying and enumerating the specific species of Legionella bacteria, and identifying the strains that exist within a species. Clarification will be provided for determining what level of information is warranted. The proper sampling procedures, variety of tests available, their inherent advantages and disadvantages, and how that information can be used will be discussed.

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ASHRAE's Advanced IAQ Design Guide: A Review of Microbial Growth Avoidance Strategies

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A comprehensive building design guide will be available, sponsored by a consortium of organizations that include ASHRAE, AIA, USGBC, BOMA, SMACNA, and EPA. This guide targets the upper tier of building designers interested in construction and operation of buildings and HVAC systems with strategies that go far above the minimal requirements found in building codes. In this review, will summarize some of the strategies outlined in the guide that the designer can use to minimize microbial problems in new construction and new HVAC systems. These strategies include the following: (1) Proper Construction of Roof Gardens and Living Walls. Probably the most important aspect of constructing a green roof is provision of a suitable waterproofing membrane and protecting that membrane from unanticipated punctures and penetrations that could result in a difficult to detect leakage problem. The designer of a roof garden should also consider actions to protect HVAC outdoor air inlets located in or near the roof garden from entry of molds present in rotted vegetation and from entry of pesticides and fertilizers needed for garden upkeep. (2) Dust and Dirt in HVAC Systems. Minimization of mold growth in HVAC systems can be achieved by enhanced filtration (MERV 10 is good; MERV 12 is better), design for enhanced access into plenums and ductwork, and ultraviolet germicidal irradiation of cooling coils and drain pans. Safety concerns must be addressed when designing ultraviolet germicidal irradiation for HVAC systems. (3) Legionella. Potable water systems and cooling towers should be designed with a plan for emergency disinfection in the event of a legionellosis outbreak. Careful implementation of recommendations in the "ASHRAE Advanced IAQ Design Guide" should be useful in minimizing dampness and microbial growth problems in buildings.

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Evaluation of a UVC-Equipped Vacuum at Reducing Total Surface-Bound Microbial Load on Carpets

E. Lutz, S. Sharma, B. Casto, G. Needham, T. Buckley, The Ohio State University, Columbus, Ohio.

Carpets are both sinks and sources for exposure to chemicals, allergens, and microbes and, consequently, influence health, including; asthma, allergies, and infectious diseases. Asthmatics, children, and persons who are immune-compromised are at particular risk. To address this risk, a residential vacuum cleaner with UVC was commercially developed. However, its effectiveness in reducing microbial load in carpet remains to be demonstrated in practice. Accordingly, the purpose of the current study was to evaluate the effectiveness of a UVC-equipped vacuum in reducing the surface-bound microbial load in carpets. We sought to isolate the influence of the UVC from the vacuum and the beater-bar. This was accomplished by sampling the surface of 9 ft^2 carpet sections for microbes before and after treatment. Sampling was conducted using contact plates (Sabouraud's dextrose agar) that were incubated for 24 hours before the total number of colony forming units (CFU) was counted. Three different indoor carpet-types, representing real-world settings (residential and institutional), were tested: medium-Berber, loose-Berber, and commercial tight-loop. Treatments of 2-minute- duration included UVC light only (UV), beater-bar with vacuum (BB-V), and combined UVC and BB-V (COMB). The treatment effect was evaluated by considering the decrease in CFU from pre- to post-treatment using ANOVA. The treatments yielded an average three-fold decrease for UV ($p < 0.05$), a four-fold decrease for BB-V ($p < 0.05$), and an eight-fold decrease for COMB ($p < 0.05$) in carpet surface microbial load. Accordingly, the UVC and BB-V are comparable and additively account for the combined effect. Therefore, we concluded that a UVC-equipped vacuum approximately doubles the vacuum's effectiveness in reducing surface-bound microbial load, thereby holding promise as a means for decreasing indoor infectious disease risk.

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The Effect of Plug-in-Style Air Cleaners on Indoor Air Quality

J. Hicks, P. Rey, Exponent Inc., Oakland, CA.

Plug-in air cleaners are commonly used by consumers to improve indoor air quality in office and residential environments by removing suspended particulate matter. Many of these devices are "certified" to remove 80% of the suspended particulate matter for a given room size, based on chamber testing according to a standard test method established by the Association of Home Appliance Manufacturers. Few data are available concerning the effectiveness of these devices under real-life settings. We will present data from atmospheric aerosol measurements conducted before and during operation of three certified air cleaners, in both residential and office environments. Airborne particle concentrations were measured in small offices and family rooms or bedrooms during periods when occupants were present. These data are useful in guiding consumers on their purchases of these types of air-cleaning devices.

Podium Session 139: Biological and Chemical Aerosol Sampling and Analysis

Thursday, June 4, 2009, 8:00 a.m.–Noon
Papers 270–281

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Evaluating the Level of Airborne Fungi in Buildings by Measurement of Enzyme Activity

M. Reeslev, J. Nielsen, Mycometer, A/S, Copenhagen, Denmark; L. Rogers, Mycometer Inc., Tampa, FL; D. Krause, Florida Department of Health, Tallahassee, FL; R. Rylander, Biofact Environmental Health Research Center, Lerum, Sweden.

Valid methods for measuring the level of airborne fungi are critical for building diagnostics, exposure assessment, and risk evaluation. Spore traps are presently the primary method for estimating the level of airborne fungi in buildings. However, microscopy focuses on spores rather than hyphal fragments, as these propagules (especially dead hyphae) can be difficult to distinguish from fibers. Several scientific studies have shown a correlation between the activity of the enzyme β-N-acetlyhexosaminidase (NAHA), fungal biomass, and total spore counts. NAHA activity is present in both spores and hyphae, and could prove a more accurate overall estimation of fungal propagules in air samples. The NAHA activity can be measured using portable equipment in the field in about 30 minutes. In this study, the level of airborne fungi has been estimated by measuring NAHA activity. For comparison, spore counts and ergosterol levels were determined in a number of samples. The NAHA activity was determined in buildings with known mold and moisture problems and then compared with unaffected buildings. Using a sampling volume of 300 L (typically 20 L/min for 15 minutes), air samples were collected onto a 25-mm MCE membrane filter with a 0.8 µm pore size. A fluorogenic enzyme substrate was added directly on the filter and hydrolyzed by NAHA releasing a fluorescent label into the reaction liquid. The resulting fluorescence was measured and expressed in arbitrary fluorescence units. Significant differences were found between the levels of NAHA activity in air samples from unaffected buildings compared with those with mold and moisture problems. In both building categories, the enzyme activity in the samples showed a logarithmic normal distribution. The median value was much higher in buildings with mold and moisture problems than in the unaffected buildings. Based on the data collected, interpretation criteria for affected vs. unaffected buildings could be determined.

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Assessing the Bacterial Load After Flooding and Sewage Spills, and Remediation Efficacy Using Fluorometric Detection of Bacterial Hydrolase Activity

M. Reeslev, J. Nielsen, Mycometer, A/S, Copenhagen, Denmark; L. Rogers, Mycometer Inc., Tampa, FL.

Sewage spills and flooding events lead to high bacterial concentration on indoor surfaces after the water has receded. Traditionally, post flood cleanup testing has targeted specific pathogens as the main health concern while the residue, consisting of large concentrations of nonpathogenic bacteria, is not normally addressed. It is assumed that most non-spore forming bacteria will die relatively quickly during or after the drying process. Determination of total viable bacteria (CFU) will therefore be markedly reduced in relatively short time. However, large concentrations of nonviable (gram-negative) bacteria may leave endotoxin reservoirs that can be aerosolized and have the potential to induce respiratory symptoms. Current methods for quantification of endotoxin are tedious, time consuming and can only be performed in laboratories. This time consuming effort delays the assessment and adds significant cost to the remediation. In an attempt to improve the assessment of bacteria in environmental samples this study has applied a new field detection method using fluorometric detection of bacterial hydrolase activity. The levels of bacteria on surfaces in recently flooded buildings were estimated and compared to the levels found on surfaces in unaffected buildings. The residual bacterial contamination was estimated by fluorometric detection of bacterial hydrolase activity. Sampling was performed by swabbing a 9 cm^2 area using a sterile cotton swab. The swabs were immersed in a fluorogenic enzyme substrate for 30 minutes and the resulting fluorescence measured using a handheld fluorometer. In both flooded and unaffected buildings the enzyme activity was a logarithmic normal distribution. The median value of hydrolase activity in flooded buildings was significantly higher compared to the median value found on surfaces in unaffected buildings. Based on the data collected, interpretation criteria for flooded vs. nonflooded buildings have been derived. A correlation between endotoxin levels and levels of hydrolase activity was seen (R^2=0.6469, $p < 0.0001$).

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New Method for Biological Airborne Contamination Control: ISO 14698 Validation Results

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In the context of environmental contamination control, and especially of air control in cleanrooms, Bertin Technologies (France) has developed a technology dedicated to the monitoring of airborne bioparticles. The goal was to propose a sampling method compatible with rapid microbiological methods to get reliable and specific data and tackle the impact on pharmaceutical production of time-to results within impaction method. With the cyclonic technology, airborne particles are separated from the air and collected into a sterile liquid media. This patented solution, Coriolis®,allows rapid analysis such as immunoassay, PCR assay, phase cytometry, and standard culture methods. To validate the samplers according to ISO14698-1, a study was conducted by the Health Protection Agency, (HPA, Porton Down, U.K.) to measure the physical efficiency of the Coriolis technology. It was compared to membrane filter samplers. Physical sampling efficiency was measured at 62% for the particle sizes up to 1.0 micron, 80% for the 3-micron particles, and 100% from 5- micron particle diameter, which is comparable with most air samplers. The biological efficiency was revealed at 80% for *Staphylococcus epidermidis.* Biological efficiency of the Coriolis also was compared with the standard method of impaction; the tests have shown comparable efficiency with impactors to collect bacteria (*Escherichia.coli*), molds (*Aspergillus*), and pollens (*Alternaria*). With the Coriolis technology, some other studies have been done for the sampling of pollens, allergens, or nonculturable particles and to identify them with RMM (*Pneumocystis*, *Legionella*).

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Sampling Duration and the Recovery of Culturable Fungi in Viable Air Sampling Using the Andersen N6 and RCS Samplers

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The influence of sampler design, collection conditions, and sampling duration as a function of propagule viability and biological collection efficiency is not well established for air sampling devices commonly used for viable fungi measurement in indoor air. The performance characteristics of the Andersen N6 and other devices have been established by theoretical modelling and empirical testing under controlled conditions, with focus on the particle collection and retention as a function of aerodynamic particle size. This study investigated the influence of sampling duration on recovery of culturable fungi. The Andersen N6 and the Reuter Centrifugal Sampler (RCS) were operated side by side, collecting 15 samples each of incrementally increasing duration (1-15 min). From 270 samples collected, 26 fungal genera were recovered. Species of *Alternaria, Aspergillus, Cladosporium, Epicoccum, Penicillium,* and *Ulocladium* were most

frequent. Data adjusted to CFU/m^3 were fitted to a Poisson regression model with a logarithmic link function and evaluated for the impact of sampling time on qualitative and quantitative recovery of fungi, both as individual taxa and in aggregate according to xerotolerance. Significant differences between the two samplers were observed for xerotolerant and normotolerant moulds, as well as *Aspergillus* spp. and *Cladosporium* spp. With the exception of *Cladosporium* spp., overall recoveries were higher with the RCS. When the Andersen N6 was used, the recovered levels of *Cladosporium* spp. and unidentified yeasts were reduced significantly at sampling times longer than 6 min. Similarly, when the RCS was used, recovery of *Aspergillus* spp., *Penicillium* spp., *Ulocladium* spp., unidentified yeasts, and low water activity fungi declined significantly at sampling times longer than 6 min. Industry-wide trend suggests durations of 2 and 4 minutes for viable air sampling of fungal aerosols. Our results support the routine use of a 6-min sampling time where low spore loads are expected.

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Gravimetric Reduction Prior to Point Counting Certain Types of Bulk Samples

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It is very important to gravimetrically reduce certain types of bulk samples before point counting them to get an accurate asbestos concentration result. Examples of these types of bulk samples are floor tiles, mastics/glues, joint compounds, caulks, and other bulk samples that are made of organically bound materials. If the material that is binding the asbestos present in the bulk sample is not removed, the identification and quantification of the asbestos in the bulk sample will hindered. This will cause a laboratory to report a lower asbestos concentration than what is actually present in the bulk sample. This is very critical when a bulk sample contains a low quantity of asbestos because the EPA definition of asbestos-containing material (ACM) is anything containing greater than 1% asbestos. Burning away the organic binding material in a bulk sample by using a muffle furnace and then following with treating the bulk sample with an acid (hydrochloric acid) will remove most, if not all, of the binding material from the asbestos that is present in the bulk sample. This allows the microscopist to resolve and identify the asbestos present in the bulk sample much easier. At each step of the gravimetric reduction the weight of the sample is tracked in order to back calculate the "true" asbestos concentration based on the point count result. This procedure produces a more accurate result for these types of samples.

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Asbestos PCM Proficiency Testing Using Reference Slides with Relocatable Grids

M. Harper, J. Slaven, NIOSH, Morgantown, WV; T. Pang, Ryerson University, Toronto, ON, Canada.

Three rounds of proficiency testing were carried out using chrysotile and amosite asbestos reference slides with relocatable grids for PCM analysis. Participants were drawn from around 30 U.S. laboratories through an advertisement in the AIHA Laboratory Quality Assurance Programs newsletter. Thus, the analysts likely participate in AIHA laboratory quality programs (e.g., either AAT or IH PAT) and are probably considered proficient, since failure rates in these programs are low. Due to the volunteer nature of the exercise about a 50% drop-out rate occurred from round to round, but this was usually accompanied by replacements, such that the number of individual participants in each round was 60, 54, and 54 for chrysotile and 85, 75, and 62 for amosite. In general, those who dropped out had worse scores than those who participated for more than one round. Twenty-seven analysts participated in all three rounds of chrysotile and 29 analysts participated in all three rounds of amosite. Average amosite proficiency scores were much higher than average chrysotile scores, and can generally be considered acceptable. In the first two rounds of chrysotile, however, less than 30% of analysts reached the score used to determine proficiency in a similar Canadian program (which had most recently a 72% pass rate). Adding a training component to round 3 increased the pass rate to 43%. No analyst passed all three rounds, and only a few passed in two out of three. Thus implementation of a Canadian-style proficiency program in the United States likely would cause most analysts to be regarded as nonproficient for chrysotile. However, the current U.S. proficiency scheme may be inadequate for identifying very poorly performing analysts, such as the participants in our program who made more than 100 errors per 100 fibers. Options for improving the AIHA proficiency programs are being discussed with the appropriate committees.

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WITHDRAWN

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Diesel Particulate Matter Correlation Study with Real-Time Monitoring Instruments

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Diesel particulate matter (DPM) is a particulate consisting of vapor phase hydrocarbons adsorbed on an elemental carbon core and has a particle diameter of less than one micron, which may have adverse impacts on human health. The Mine Safety and Health Administration's (MSHA) occupational exposure limit for DPM is currently 160 µg/m^3. The current MSHA DPM monitoring method requires particulate collection using cassettes and samples submitted to an approved laboratory for analytical analysis, which takes seven days to two weeks from sampling to data results. Can mine particulate concentration data measured by real-time measuring instruments be correlated to DPM concentrations that are measured with SKC DPM jeweled impactor cassettes that are designed to capture only DPM? Ten sampling trips to two different mines were scheduled where DPM was simultaneously measured with an EPAM-5000, a DustTrak, and a Grimm 1.109 while particulate samples were simultaneously collected on SKC DPM cassettes. Cassette sampling consisted of using approximately six SKC DPM jeweled impactor cassettes specifically designed to capture DPM. The SKC DPM cassette data and the real-time measuring instrument data were evaluated to determine if a correlation exists between the two sampling methods. A statistical evaluation of this data was performed using linear regression analysis and a paired t-test. The data was evaluated at a p-value of 0.05, and a p-value of 0.99 for the Grimm, a p-value of 0.999 for the DustTrak, and a p-value of 0.996 for the Haz-Dust resulted from this statistical evaluation. The EPAM-5000, the DustTrak, and the Grimm 1.109 may be used as a surrogate method to monitor DPM in underground mines, which will provide real-time measurements of DPM concentrations that can be used to implement mine controls that will reduce a miner's exposure to DPM.

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Determinations of Pesticides in Household Dusts by Microwave-Assisted Solid-Phase Microextraction

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Pesticide residuals are ubiquitous problems in the environment. Exposures to pesticides might cause immunologic, neurotoxic, and reproductive effects. On the other hand, household dust has been known as a sink for many semivolatile organic compounds such as chlorpyrifos, one of the organophosphorus pesticides. Because indoor environment can protect dust from sunlight, rain, and biological action, pesticides could be persistent and accumulated in the residential environment. Therefore, there is a need to determine the pesticides contained in household dusts to assess the possible health risks caused via the exposures. Up to now, the analysis of pesticides in dust is both solvent and time consuming. The purpose of this research was to develop a method for the determinations of different pesticides (including lindane, heptachlor, chlorpyrifos, aldrin, dieldrin, endrin, and 4,4'-DDT) in dusts simultaneously by using microwave-assisted headspace solid-phase microextraction (MAE-HS-SPME). A commercial vacuum cleaner was used to collect household dusts while particles with a diameter smaller than 150 µm were filtered out by stainless mesh. A dust sample with mass of 200 mg was put in a 4 mL vial. Water of 1 mL was added to the vial, followed by the MAE-HS-SPME procedures. Several parameters affecting the SPME extraction efficiency were optimized. The results showed the best suitable fiber coating was 100 µm PDMS, and the optimum condition was 20 minutes at 80°C. After the headspace extraction, the sample was analyzed by gas chromatograph with electron capture detector. The desorption efficiency was found to be 100% when the desorption time was 5 min under 250°C. The linear range for the analysis was 1.25~1250 ng/g dust (r=0.99). On the other hand, the relative standard deviations of the analysis for the seven pesticides on dusts tested were from 4.08% to 17.02%. Compared with tradition extraction methods, the MAE-HS-SPME provides a time-saving, easy-for-operation, and solvent-free procedure.

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Evaluation of Wildfire Particulate: Comparison of Two Methods — PLM and PLM with SEM/EDX

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Twenty surface tape-lift samples were collected from 13 southern California homes for analysis of wildfire particulate (i.e., soot and char). Duplicate samples were analyzed by two commercial laboratories. Laboratory 1 used polarized light microscopy (PLM) analysis, and Laboratory 2 used PLM with scanning electron microscopy with energy dispersive X-ray (SEM/EDX). Analysis of the data using Wilcoxon Signed Rank Test for paired samples indicated that sample results between laboratories were statistically different for mean concentrations of soot ($p = 0.0001$) and char ($p = 0.029$). Laboratory 1 results were higher for soot compared with Laboratory 2 ($p < 0.0001$), and Laboratory 2 results were higher for char compared with Laboratory 1 ($p = 0.015$). PLM analysis appears to overestimate soot concentrations and underestimate char concentrations compared with the more sensitive PLM/SEM/EDX method. Previous PLM analysis of samples collected from structures not impacted by wildfire (i.e., controls) suggested a soot threshold level of 6% and a char threshold level of 1%. Application of these thresholds to this data set indicated a 70% correlation between PLM and PLM/SEM/EDX methods. Based on these results, PLM appears to be a reasonable surrogate for PLM/SEM/EDX analysis of wildfire particulates.

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Wall Deposits in Aerosol Sampler Cassettes

M. Harper, NIOSH, Morgantown, WV.

Several government research agencies have noted significant deposition of particles on the internal surfaces of filter-holding cassettes, even when dust is not visible on those surfaces. Many of these organizations already promote the use of an internal capsule containing the filter that can be weighed in its entirety, thus capturing all particles for gravimetric analysis. However, such capsules cannot be digested in acid, and so the tradition for metals has been to remove the filter from the cassette for digestion and analysis, leaving the wall deposits unaccounted for. OSHA has recently affirmed its position that all particles passing the entry orifice of the sampler count toward the sample, and has recently revised some of its sampling and analytical methods to account for wall deposits. The preferred method is to wipe the interior of the cassette and to add the wipe material to the filter for digestion and analysis. A summary of filter and wipe analyses from large numbers of samples in many different metals industries is presented to indicate the impact of this procedure. The vast majority of samples have wall deposits, and these are often a significant addition to the filter catch, in extreme cases doubling the result from the filter alone. Many commercial laboratories are unaware of this revision as they offer metals analysis based on published NIOSH, rather than OSHA, methods. Individual NIOSH methods do not include a procedure for including wall deposits. Nevertheless, in the preamble to the NIOSH Methods Manual (Chapter O, Part 7) it is suggested that the accuracy and precision of the 37-mm cassette can be improved by including internal sampler deposits by wiping or washing. An alternative resolution of this issue would be the development and validation of an in-cassette digestion procedure.

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Modeling and Measurement of Airborne Uranium During Granite Fabrication

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During the past decade, the popularity of granite countertops has grown dramatically. Much of the fabrication is done by very small shops, generally without adequate EHS programs, and often leading to particulate and silica exposures above the permissible exposure limits (PEL). In some cases, the PEL for uranium can also be exceeded. Typical granite contains approximately 10 pCi/g of uranium, although granite with up to 100 pCi/g of uranium is not unusual. Exceptional granite can contain more than 1000 pCi/g of uranium. Airborne uranium particulate is present in the breathing zones of fabricators during fabrication of granite with elevated uranium content. The model utilizes gamma spectroscopy or chemical analyses of bulk granite to predict airborne uranium concentration during typical fabrication tasks on the respective granite. Total airborne particulate concentration is generally less than 10 mg/m^3 in large shops that use wet processes and local exhaust ventilation. However, smaller fabrication shops typically lack engineering controls and the more expensive wet processes. In those shops, airborne particulates in the breathing zone can approach 100 mg/m^3. Given granite containing 1000 pCi/g of uranium, the model predicts airborne uranium concentration can exceed the PEL. The model was validated using occupational exposure data from granite fabricators performing typical fabrication tasks. Large shops use water for all processes, and particulate generation is minimal. Small shops rely on hand saws for cutting, with or without water. Handsaws generate moderate amounts of particulate, even when water is supplied to the saw. Grinding, polishing, and rodding tasks are performed without water, and substantial amounts of dust are generated. All final shaping and polishing at the installation site are performed with no water or very little water. The concentration of airborne uranium particulate is dependent on the uranium content of the granite under fabrication.

Podium Session 140: Case Studies in IEQ

Thursday, June 4, 2009, 1:00 p.m.–4:00 p.m.

Papers 282–290

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Evaluation of IEQ for Office Spaces in China Against TVOC Standards

W. Li, ENVIRON, Singapore, Singapore; D. Daugherty, ENVIRON, Emeryville, CA; E. Liu, ENVIRON, Beijing, China.

We will discuss the challenges for the industrial hygienist in evaluating total volatile organic compound (TVOC) concentration for office spaces against regulatory standards in China. When the Construction Ministry of China promulgated its indoor environmental quality (IEQ) standards in 2002 (revised in 2006), it did include common VOCs with known health effects, such as formaldehyde and benzene. However, a compulsory standard was also set for TVOC during preoccupancy inspection of civil construction projects. A comparable TVOC guideline was also published by the Public Health Ministry of China in 2003 for evaluation of IEQ during normal use of indoor space, including offices and residences. As IEQ issues gain more attention in China, evaluating IEQ based on the Chinese standards of TVOC could pose a problem for industrial hygienists because TVOC covers a broad spectrum of chemicals and thus have generally undefined health effects. This study presented a generic case study in Beijing, outlined the TVOC sampling requirements in China, performed a survey and comparison of representative TVOC standards or guidelines from other countries, and summarized research studies on health effects of TVOC. This information is useful in addressing concerns when the TVOC standards are exceeded, which is generally the case immediately after construction or renovation of office spaces. Representative questions received during office IEQ evaluations also will be summarized and answered.

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Comparing Thermal Comfort Ratings to Measured Temperature in the Field

J. Oudyk, Occupational Health Clinic for Ontario Workers (Hamilton Clinic), Hamilton, ON, Canada.

Thermal discomfort is a major contributor to dissatisfaction with indoor environment quality (IEQ). Room temperature is often measured during IEQ investigations using datalogging equipment. The ASHRAE thermal sensation scale was used to collect occupant hourly perceptions of thermal comfort when temperature datalogging occurred within close proximity of the occupant's workstation. Between 2005-2007, a total of about 150 persons completed the thermal sensation ratings in 14 separate buildings. On average, each participant filled out 7-8 forms (for a total of 1161 ratings). Because the data collected is repeated-measures data, it was analyzed using multilevel regression techniques using the rater as the grouping factor. The amount of variation in the temperature ratings due to season was only 1% between the four seasons. The measured temperature explained 20% of the variance in temperature perception within subjects and 27% of the variation between subjects. The neutral thermal sensation score on the ASHRAE scale corresponded to an average temperature of 23.7°C, with the two standard deviation ranges on either side of the mean ranging from 21.0°C to 26.4°C. The 10th and 90th percentile temperatures associated with a neutral thermal sensation score were 22.2°C and 25.2°C, respectively. It was interesting to note there was very little variation in the thermal sensation ratings between the four seasons. The 80% satisfaction range of the respondents in this consecutive sample of buildings was narrower than the guidelines provided by ASHRAE 55-2004.

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Mercury in Polyurethane Floors — Airborne Vapor Levels and IEQ Considerations

R. Rottersman, D. Regelbrugge, ENVIRON International Corp., Chicago, IL.

Elemental mercury was added as a catalyst from approximately 1960 possibly through the 1980s in polyurethane floors that were widely used in athletic and cafeteria facilities. Recent studies performed by state health departments in conjunction with ATSDR have focused on two possible concerns associated with mercury in the floors: occupant exposure and waste disposal considerations. Most of the state studies indicated no apparent risks from exposure; however, interpretations can be subject to which guidelines are selected for comparison. In many cases, TCLP analysis of the floors indicated that the material did meet the definition of a regulated hazardous waste. Two athletic facilities were selected for study to evaluate airborne mercury levels under varying conditions. The facilities included a field house with exposed polyurethane flooring and a gymnasium where a hardwood floor had been installed over polyurethane. Initial screening was performed using a direct-reading instrument to identify possible point sources of mercury vapor release. Screening identified higher levels in areas where the surface of the polyurethane floors were compromised, including a pole vault hole and where surface sealer had worn away. There were 69 airborne mercury samples collected to reflect seasonal variations and resultant building HVAC operating conditions. Airborne mercury levels were below the ATSDR residential occupancy guideline of 1000 ng/M^3 meter in 68 samples. Highest average concentrations (800 ng/M^3) were during the winter, when outside air dampers were at minimum settings, and during the summer (605 ng/M^3), when temperatures were 85 degrees with partial ventilation system shutdown. The data from this study suggest that if floors are properly maintained and ventilation systems are functioning properly, airborne levels of mercury will not likely exceed the ATSDR residential occupancy guideline.

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Moisture Damage of Gypsum Board Due to Condensation in Building Envelopes: Analysis and Solution

J. Kominsky, Environmental Quality Management Inc., Cincinnati, Ohio; J. Luckino, Archatas Inc., Worthington, Ohio.

An investigation was conducted to determine the cause of high moisture content in gypsum wallboard in 14 modular space buildings (factory-built housing modules assembled on site) located in a mixed-humid climate. Primary goals of the investigation were to determine the cause of the "concealed moisture," the extent of fungal colonization of building materials, and to recommend a repair plan. In each of the buildings, psychrometric conditions (air and dew point temperature, and relative humidity) were measured, and a moisture map was prepared of the perimeter walls. Based on the areas showing the highest moisture levels, wall areas were selected for invasive examination to expose the composition and condition of the building envelope. No evidence of infiltration of liquid water (e.g., rainwater) was observed. Observation of an improperly installed vapor barrier suggested the cause of the moisture was condensation. A dew point analysis was conducted of representative buildings to predict where condensation was occurring in the wall assembly. The primary cause of the "concealed moisture" was the direct result of warm, humid, outdoor air infiltrating into the wall cavities, followed by condensation of the water vapor on the back side of the vinyl-covered gypsum board. With the vinyl wall covering acting as vapor retarder, water vapor was trapped inside the wall cavity, resulting in "concealed condensation" when the wall temperature was below the dew point temperature. Prolonged exposure under these conditions resulted in gypsum deterioration and/or failure. A generalized theme existed in each of the buildings: lowered air conditioner thermostat (as low as 60 °F); improperly installed vapor retarder; moisture diffusion from the ground due to unsealed marriage lines and inadequate crawlspace ventilation; negative pressure across the envelope due to inadequate makeup air supply, or a combination thereof. The recommended solutions to eliminate the concealed moisture problem will be presented

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Ventilation Rates and Indoor Air Quality in South Florida Schools

R. Morse, Morse Zehnter Associates, Troy, NY.

A study of the association between ventilation rates and indoor air quality in more than 40 South Florida schools recently was completed. Current standards call for 10 cubic feet per minute (cfm) of ventilation per student in situations where a building owner has little or no information about pollutant levels in the buildings. Where pollution levels are known, the Florida Building Code allows ventilation rates to be determined by measurements of pollutants and comparison to standards. This approach is referred to as the ASHRAE Indoor Air Quality (IAQ) Procedure. The study followed the ASHRAE IAQ Procedure and measured the pollutant levels at various ventilation rates in occupied South Florida schools. It was discovered that ventilation rates substantially less than 10 cfm/student provided acceptable IAQ, meeting requirements of the building code. It was also discovered that ventilation rates above about 5 cfm/student carried an increased risk of elevated humidity and mold contamination, which was the primary IAQ problem in schools in the hot, humid environment of South Florida. The study determined that ventilation rates less than 10 cfm/student provide adequate control over pollutants, thus meeting requirements of the building code while minimizing the risk of high humidity and mold growth. Not only does this ventilation rate optimize IAQ, it also results in reduced energy and equipment costs.

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School IEQ Issues Involving a Rapid Turnaround Fire Restoration Project

G. Crawford, J. Persky, ENVIRON, Chicago, IL.

With recent trends toward greater public awareness regarding indoor wnvironmental quality (IEQ), school system officials have become acutely aware of potential liability for decisions that may negatively affect IEQ conditions in their buildings. This case study explored an instance of a public school building that endured a major fire with heavy smoke and water damage one month prior to its scheduled reopening. The restoration work was scheduled on a seemingly unrealistic timeline, which presented concerns that construction and restoration shortcuts could result in future IEQ problems. In this presentation, we will discuss IEQ-related challenges, including assuring adequate building dryness, controlling construction and demolition dusts, addressing environmental conditions favorable to mold growth, decontamination of lined ductwork, library contents salvage, chemical usage, damaged asbestos materials abatement, and generating workers' awareness of how their activities can impact future IEQ conditions upon building reoccupancy. Details will be presented on the use of infrared thermography for water damage assessment and for monitoring drying progress, unorthodox approaches to expedite the drying of typically difficult to dry building materials such as sealed concrete block, and cleaning and encapsulation of ventilation system components. Testing program results to be presented include dust monitoring data using direct-reading particle counters and microbial contamination assessment data obtained by a combination of surface dust micro-vac, surface tape-lift, and air spore-trap testing. The goal of this case study review is to present an example of methods used to complete a fire and water restoration project for a building with a sensitive population, while maintaining a tight project deadline and still successfully addressing potential IEQ concerns.

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Low-Frequency Noise Explaining Symptoms Generally Ascribed to Poor Air Quality

J. Oudyk, Occupational Health Clinic for Ontario Workers (Hamilton Clinic), Hamilton, ON, Canada.

Occupants of a newly constructed office were experiencing headaches, ear problems, dizziness, and momentary lapses of consciousness. Standard indoor environment quality measurements did not show any particular concerns. The HVAC system was newly installed. Carbon monoxide levels in the office never exceeded 1 ppm during 15 days of continuous measurement. To explore the cause of the symptoms in greater detail a survey of the occupants was conducted using the MM-040 indoor environment questionnaire. Also, occupants kept hourly symptom/perception logs whenever datalogging equipment was located near their workstation. Multivariate regression analysis indicated associations of sick building syndrome symptoms with lighting, noise, and stress. Lighting levels were found to be above recommended standards, and lowered subsequently. Noise measurements, including octave band analysis, indicated background noise levels exceeding Quality Assessment Index (QAI) associated with the Room Criteria (RC Mark II), particularly due to low-frequency noise. The noise spectrums showed peaks at the 63 Hz and 125 Hz octave band frequencies. At the location of the highest peak (87 dB at 63 Hz), observers noted peculiar sensations centered generally in the skull or specifically in the ears. Comparing the measurements with criteria recommended for residential low-frequency noise disturbances in the United

Kingdom indicated the whole office exceeded the 63 Hz criteria of 53 dB. Based on this analysis, the hypothesis that low-frequency noise contributed to the symptoms reported seems quite credible, probably in conjunction with other factors such as lighting and stress. This case study highlights the contribution low-frequency noise may have to symptoms generally ascribed to poor indoor air quality.

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Indoor/Outdoor Relationships of Particulate, Gaseous Materials, and Bioaerosols in Preschools with Urban and Rural Locations

C. Yoon, K. Lee, Seoul National University, Seoul, Republic of Korea; D. Park, Korea Open University, Seoul, Republic of Korea; K. Ha, Changwon National University, Changwon, Republic of Korea.

The ratio of indoor/outdoor concentrations (I/O) of particulates, gaseous pollutants, and bioaerosols were characterized in urban and rural preschools in Korea. Total dust; respirable dust; lead; volatile organic compounds (VOCs), including benzene, formaldehyde, CO_2, and bioaerosols, were measured in 71 classrooms of 17 preschools. All pollutant concentrations except benzene were higher indoors than outdoors, with the mean I/O ratio 2.03(SD 1.08). Total dust concentration was highest in urban indoor, followed by urban outdoor, rural indoor, and rural outdoor, with the I/O ratio 1.46 in urban and 1.30 in rural area, respectively. Indoor respirable dust concentrations were similar in urban and rural areas. Because the rural outdoor level was much lower than the urban area, I/O ratio was higher in the rural area than in the urban area. Although I/O ratios of lead were similar, lead concentrations were much higher in the urban area than in the rural area. I/O ratio of VOCs was 1.98 in urban and 1.73 in rural areas, with the highest level in urban indoor level. I/O ratio of benzene was below 1 in urban and rural areas. Indoor formaldehyde concentrations were very similar in urban and rural, but outdoor levels were higher in urban than in rural areas. I/O ratio of CO_2 was 1.74 in urban and 1.40 in rural area, respectively. I/O ratio of bioaerosol was 1.45. Bioaerosol concentration was higher during and/or after rain than it was on a sunny day. Bioaerosol concentration was high when toilet was inside the classroom, and samples were measured from the basement. Because I/O ratio higher than 1 implies the presence of indoor sources, we concluded that there are many indoor sources in preschools. Our findings can be useful for understanding potential health effects from the exposure and intervention studies in preschools.

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Building the LEED IAQ Team: A Case Study in Avoiding Pitfalls of Conducting LEED IAQ Testing

M. Posson, D. Daugherty, M. Keinath, ENVIRON International Corp., Emeryville, CA.

Organizational and administrative issues can have significant impacts on the ability to attain U.S. Green Building Council's Leadership in Energy and Environmental Design's (LEED) indoor air quality (IAQ) assessment credits. A case study involving a renovated high-rise building in San Francisco, Calif., is used to illustrate key issues that consultants and clients should consider when planning an IAQ assessment under the LEED Program. We conducted preoccupancy IAQ monitoring to gain a point under the LEED Commercial Interiors (CI) rating system through the IAQ testing approach for the Construction IAQ Management Program (CI Credit 3.2). The project team assembled involved the primary client, architectural firm, construction contractor, furniture contractor, industrial hygienists, and project managers. In accordance with LEED specifications, the IAQ monitoring involved collection of air samples and analysis for total volatile organic compounds (TVOCs), formaldehyde, particulates less than 10 micrometers in diameter (PM10), 4-phenylcyclohexene (4-PCH), and carbon monoxide (CO). With exception of TVOCs, all constituents analyzed were below LEED thresholds. Various problems (e.g., scheduling, construction activities, coordination, and communication) were encountered that potentially influenced the sample results and will be discussed. The case study will highlight the critical need to involve the IAQ testing team members early in a project to enhance project team communications, emphasize importance of IAQ testing, allow opportunities to identify and mitigate potential scheduling issues, and allow for identification of construction activities that may influence IAQ results. While appropriate materials selection and timing are critical to successful testing, exceedances of LEED thresholds can still occur, especially when these common organization or administrative issues arise. Potential ways to mitigate unfavorable outcomes of an expensive sampling campaign and ways to implement contract contingencies with subcontractors to emphasize the importance of schedule in conducting a successful LEED IAQ test will also be discussed.

Poster Session 401

Monday, June 1, 2009, 10:00 a.m.–Noon

Dermal Exposures

Papers 291–294

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Assessment of the Occupational Dermal Exposure Potential of British Columbian Health Care Workers to Antineoplastic Drugs

C. Hon, W. Chu, University of British Columbia, Vancouver, BC, Canada.

Antineoplastic drugs are used for treating cancer and act by interfering with the proliferation of cancer cells. However, due to their nonselective nature, antineoplastics also affect nontumor cells. As such, there is a risk to health care workers who handle these drugs. Occupational exposure to antineoplastics has been reported to cause liver toxicity, adverse reproductive outcomes, and cancer. Despite the use of control measures during handling and preparation, studies have found widespread drug contamination on a number of surfaces, making the potential for dermal exposure highly probable. However, to our knowledge, no study in British Columbia has examined occupational dermal exposure to antineoplastics. Six hospitals with pharmacies participated in our study. Observations were conducted to determine the types of objects touched and their associated contact frequency. Subsequently, hand wipe samples from pharmacy workers were collected to determine dermal concentration levels. To assess the efficacy of cleaning protocols, wipe samples of the contacted objects were collected pre- and post-cleaning. Both the hand and surface wipe samples were analyzed by high-performance liquid chromatography tandem mass spectrometry. We found that the surface of the biological safety cabinet, as well as a pen/marker situated inside the cabinet, were the most frequently contacted. Nearly 30% of the hand wipes had detectable drug levels. Surprisingly, 33% of those individuals who did not prepare the drugs had reportable levels. Lastly, the post-clean wipe sample concentrations were generally lower than the pre-clean samples, although five samples had greater post-clean concentrations. Our results suggest that there is a potential for occupational dermal exposure to antineoplastic drugs in hospital pharmacies. Furthermore, although objects were cleaned, detectable drug levels remained; in fact, some had greater post-clean concentrations. This indicates a need to explore the source of contamination further, as well as to thoroughly evaluate the cleaning protocols.

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Contact Dermatitis from a Mystery Source

B. Decker, C. Merrell, P. Hearty, D. Crane, K. Motley, OSHA, Sandy, Utah.

Employees involved in the manufacture of strapping material used in the fabrication of light-reflective leashes and pet collars developed a severe contact dermatitis that resolved when the employees were removed from direct exposure to the materials. A cursory examination of all materials and processes involved in the operation failed to reveal any direct cause. The material safety data sheets indicated only inert materials such as polypropylene and glass beads. The process involved laser ablation of the reflective material and mechanical handling of the product. Ruling out alternative causes, this investigation showed that the affected employees were exposed to barium-titanium glass beads on exposed skin and that this was most likely the cause of the dermatitis.

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Extending Traditional Dermal Chemical Contact Observation Data to Meet the Dermal Exposure Assessment Requirements of REACH

C. Alfonso, J. Walton, P. Logan, L. Milchak, N. Pechacek, R. Roy, R. Skoglund, 3M, St. Paul, MN.

The European Union's Registration, Evaluation, and Authorization of Chemicals (REACH) regulation requires verification that substances are used in a safe and appropriate fashion. Verification is achieved by documenting that the anticipated exposure (measured or modeled) is less than the acceptable exposure or derived no effect level for all known uses. This study outlined the extension of field observations of dermal exposure to a quantitative estimate of dermal exposure that meets the expectations of the REACH safety assessment. The intensity of each type of potential dermal contact was estimated, and a decision matrix was used to convert the observations to exposure estimates. The efficacies of the personal protective equipment

and/or engineering controls were considered, and a final estimate of dermal exposure was made.

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Assessment of Dermal Hazards via the New NIOSH Skin Notation Strategy: Lessons Learned

B. Gadagbui, A. Maier, TERA, Cincinnati, Ohio; G. Talaska, University of Cincinnati, Cincinnati, Ohio; G. Dotson, NIOSH, Cincinnati, Ohio.

The underlying decision criterion for assigning skin notations to a particular chemical is often not well documented. NIOSH has developed an enhanced strategy that provides the scientific rationale and basis for the assignment of multiple skin notations that address systemic toxicity, direct skin effects, and dermal sensitization. The current work presents experience in applying the NIOSH strategy to the assessment of the dermal hazards of more than 70 chemicals and the development of appropriate skin notation assignments. Weight of evidence decisions to address conflicting or limited data sets will be highlighted.

Exposure Assessment Strategies

Paper 295

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A Comparison of Two Tier 2 Models to Estimate Exposures for Inclusion in a REACH Chemical Safety Report (CSR)

C. Alfonso, J. Walton, L. Milchak, N. Pechacek, R. Roy, R. Skoglund, 3M, St. Paul, MN.

The European Union's Registration, Evaluation, and Authorization of Chemicals (REACH) regulation requires verification that substances are used in a safe and appropriate fashion. Verification is achieved by documenting that the anticipated exposure (measured or modeled) is less than the acceptable exposure or derived no effect level for all known uses. The ConsExpo (RIVM) and the Targeted Risk Assessment (ECETOC) models are two tools that are specifically mentioned by the Technical Guidance Document for modeling human exposures for the REACH Chemical Safety Assessment. Both of these tools use a stepwise approach to exposure modeling. The simplest models, Tier 1, are based primarily on the Use Descriptors as defined by REACH and some limited physicochemical data. If these simple, very conservative models are inadequate, these tools allow for more sophisticated, data-intense models known as Tier 2 and higher models. This study was a comparison of the Tier 2 modeling of both the inhalation and dermal routes of exposure, for a number of REACH-relevant uses of cyclohexane, by these two modeling tools. Comparisons included applicability, determinants of exposure, and estimates of exposure.

Field Detection, Sampling and Analysis

Papers 296–304

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Validation of a Diffusive Sampler for Nitrous Oxide

C. Kuhlman, L. Coyne, SKC Inc, Eighty Four, PA.

Nitrous oxide is used as an anesthetic in dentistry and surgery, a propellant gas in food aerosols, and as an inert gas to displace bacteria-inducing oxygen. Nitrous oxide is an asphyxiant and narcotic at high concentrations. Exposure to lower levels affects the central nervous system, the cardiovascular system, the liver, and the reproductive system. The current ACGIH-TLV is 50 ppm for an 8-hour exposure. A diffusive badge, the SKC 590-300, was validated over a concentration range of 12.75 ppm to 890 ppm per hour and at relative humidities from 20% to 80 % (25 c). This badge is thermally desorbable and contains 730 mg of Molecular Sieve 5A. The sorbent is transfered from the badge to a Perkin Elmer tube, where it is analyzed by electron capture gas chromatography. The sampling rate under these test conditions was 0.84 mL/min, with a relative standard deviation of 16.9%. The badge showed no reverse-diffusion effects and was able to be stored at freezer temperatures for three weeks. The data will show that this badge can be used to accurately sample nitrous oxide under a variety of workplace conditions.

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4,4'-Methylene-bis(chloroaniline) — Determination Method in Workplace Air

A. Jezewska, National Research Institute, Warsaw, Poland; B. Buszewski, Nicolaus Copernicus University, Toruń, Poland.

4,4'-Methylene-bis(chloroaniline) (MOCA)occurs as colorless to light brown crystals. It is readily soluble in alcohol, ether, acetone, aromatic hydrocarbons, and lipids, and almost insoluble in water. It has no smell or taste. MOCA is used in the plastics industry to cure urethane elastomers, epoxy resins, and isocyanates. MOCA is widely used. Exposure to MOCA can occur through inhalation, skin contact, and ingestion of contaminated water or food. MOCA is a probable carcinogen in humans, and exposure to it needs to be controlled. In many countries, limits of hygiene standards in the air in the work environment for MOCA have been defined. The value for maximum admissible concentration NDS-MAC (TWA) is 0.02 mg/m^3 in Poland. Values for NDS-MAC (TWA) in other countries are different. NIOSH recommends an airborne exposure limit of 0.003 mg/m^3 averaged throughout a 10-hour workday; ACGIH recommends 0.11 mg/m^3 averaged throughout an 8-hour workday. Determination of worker's exposure to airborne MOCA is carried out by use of a sulphuric acid-treated glass fiber filter. The filters are analyzed after extraction and derivatization by high performance liquid chromatography using a diode-array detector. Further studies on this method are still in progress.

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Exposure to Carcinogenic Substances at Selected Workplaces in the Metallurgical Industry in Poland

E. Dobrzynska, M. Szewczynska, M. Posniak, Central Institute for Labour Protection – National Research Institute, Warsaw, Poland.

According to the "Safety and Health in the Nonferrous Metals Industries: ILO Code Practice," published by ILO in 2003, the main causes of injuries or occupational diseases in the metallurgical sector, except for physical hazards, commonly encountered in the production of nonferrous metals, accidents, fires, noise, vibration, heat stress, or exposure to mineral wool and fibers is also absorption of toxic chemicals through the respiratory tract. Chemical substances that are used or emitted in the production of metals can become a serious danger to the health of workers employed in this sector of industry. They can act as irritating, allergenic, toxic, or even carcinogenic factors in the form of dusts, gases, aerosols, and vapors. Exposure to these toxic substances may cause different disorders of the respiratory system, dust diseases, lung dysfunction, and even cancer. Identification research carried out in selected areas of the metallurgical industry in Poland indicates the presence of such carcinogenic chemical substances as polycyclic aromatic hydrocarbons, formaldehyde, and other carbonyl compounds, as well as polychlorinated dibenzo-para-dioxins and furans in workplace air. Samples were collected individually on different types of sorbents, including active carbon, silica gel modified with 2,4-dinitrophenylhydrazine, and glass fiber filters. A filtration-absorption system, consisting of polyurethane foam and a filter, was used for dioxin sampling. Measurements of selected compounds were carried out by chromatographic techniques, high performance liquid chromatography with fluorescent and spectrophotometric (UV-VIS) detector, or gas chromatography/tandem mass spectrometry. Measurement studies that we carried out at the selected work stations are a basis for risk assessment related to exposure to hazardous factors in metallurgical industry.

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Determinations of Microbial Volatile Organic Compounds by Dynamic Air Sampling with Solid-Phase Microextraction

W. Lee, S. Tsai, National Taiwan University, Taipei, Taiwan.

Microbial volatile organic compounds (MVOCs) are of increasing interest considering their possible contribution to adverse health effects in humans and the role as indicators for mold growth indoors. Nevertheless, methods used to sample MVOCs, either by active or passive sampling, require a long sampling time or extensive work in the sample preparation process. Therefore, a method that is rapid, cost-effective, and sensitive enough for sampling MVOCs would be of great benefit in monitoring both indoor MVOCs concentrations and mold growth. The aim of this research was to develop a dynamic sampling method with the aforementioned advantages for the determination of MVOCs based on the solid-phase microextraction technique (SPME). Seven MVOCs, including 2-methyl-1-propanol, 1-butanol, 3-methyl-1-butanol,

2-hexanone, 2-heptanone, 1-octen-3-ol, and 2-pentylfuran, were prepared in mixtures and injected into the designed dynamic sampling system by a syringe pump. The MVOCs were then sampled in the exposure chamber with different fibers under a fixed-air velocity for different combinations of sampling time and concentrations. After exposures, the SPME fibers were inserted into the injection port of a gas chromatograph mass spectrometer (GC/MS) for thermal desorption and further analysis. The results showed that Carboxen/PDMS was the most suitable fiber for extracting MVOCs. Under 40 min of sampling, the linear range of detections was around 0.8 μg/m^3 to 8 μg/m^3,with no competitive adsorption observed. The experimental sampling rates were found to be 0.0884 ± 0.0038 cm^3/s, 0.1231 ± 0.0024 cm^3/s, 0.0268 ± 0.0008 cm^3/s, 0.0355 ± 0.0005 cm^3/s, 0.1379 ± 0.0062 cm^3/s, 0.0253 ± 0.0044 cm^3/s, and 0.0748 ± 0.002 cm^3/s for 2-methyl-1-propanol, 1-butanol, 3-methyl-1-butanol, 2-hexanone, 2-heptanone, 1-octen-3-ol, and 2-pentylfuran, respectively. The designed dynamic sampling method proved to be sensitive enough in sampling MVOCs in low concentrations and possessed the advantages of the SPME technique.

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WITHDRAWN

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WITHDRAWN

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Cristobalite or Opal? A Confirmation of XRD Determination Using FTIR

E. Stuber, J. Cole, D. MacDuff, Galson Labs, E. Syracuse, NY.

Cristobalite and quartz, both crystalline silica polymorphs (SiO_2) and Group 1 human carcinogens, are regulated in the workplace by OSHA. They can be analyzed by X-ray diffraction (XRD) methods, NIOSH 7500, and OSHA ID-142. Quartz can also be analyzed by an infrared spectroscopy (FTIR) method, NIOSH 7603. Cristobalite can be challenging to determine by XRD. Its unique characteristics can result in peak broadening, furthering the similarity of its diffraction pattern to that of opal, which is an amorphous material having the formula $SiO_2 \cdot H_2O$. However, opal can have some ordered crystalline structure. The effect is that some forms of opal, particularly opal-C and opal-CT, can have diffraction patterns that are similar to, and can be mistaken for, cristobalite. Opal is not classified as a carcinogen; therefore, it is important to differentiate between cristobalite and opal. To solve this problem, a FTIR method for cristobalite was developed by modifying NIOSH 7603. This method can be used as a confirmation of cristobalite when XRD results are indeterminate. The crystalline silica dust from the XRD filter media can be redeposited onto the FTIR filter media, with little or no sample loss. It is then scanned on the FTIR. Cristobalite is quantitated on the FTIR at its primary peak at ~798 cm^{-1} and its secondary peak at ~623 cm^{-1}. Because quartz, cristobalite, opal, and amorphous silica all share the same primary peak location on the FTIR at ~798 cm^{-1}, cristobalite may be determined using its secondary peak in the presence of those interferences. The resulting FTIR mineral pattern is then evaluated for cristobalite or opal for confirmation of the XRD determination.

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Relative Humidity Correction Equations for Diacetyl Air Samples Collected Using NIOSH Method 2557

C. Piacitelli, R. Boylstein, G. Kullman, J. Cox-Ganser, NIOSH, Morgantown, WV; G. Hobbs, West Virginia University, Morgantown, WV; W. Hendricks, M. Simmons, M. Eide, OSHA, Sandy, Utah.

Diacetyl, a chemical used to impart a buttery taste in many flavoring mixtures, has been associated with respiratory disease in several different occupational settings, including microwave popcorn, flavoring, and diacetyl manufacturing. To measure diacetyl in the workplace, NIOSH researchers developed and published an analytical method, NIOSH Method 2557, which specifies sample collection through carbon molecular sieve sorbent tubes followed by analysis with gas chromatography and flame ionization detection. Recent investigations indicate this method is adversely affected by relative humidity (RH), resulting in underestimation of true diacetyl concentrations. Using the NIOSH method, we collected air samples of known diacetyl concentrations from an atmosphere generation chamber using a temperature of 78°F with different RHs, sampling durations, and sampling flow rates. In analysis of variance models, the size of the effect of RH dominated the size of the effects of flow rate, diacetyl concentration, and sampling duration, and was statistically significant ($p < 0.01$). Flow rate had the next largest effect and was statistically significant ($p < 0.01$). Diacetyl concentration and sampling duration were not statistically significant ($p < 0.05$). Possible temperature-related effects are still being evaluated. Below an RH of about 28%, diacetyl recoveries were between 70% and 96% of expected. Between 28% and 50% RH, recoveries fell precipitously. Above an RH of 50%, diacetyl recoveries were approximately 10% to 23% of expected. The samples collected at a flow rate of 150 cubic centimeters per minute (cc/min) had slightly better recoveries than those collected at a lower flow rate of 50 cc/min. Using nonlinear models, we developed interim equations for 150 cc/min and 50 cc/min to correct diacetyl concentrations measured with the NIOSH method at different RHs (at 78ºF).

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Relative Humidity Correction of Diacetyl Air Concentrations Measured Using NIOSH Method 2557

G. Kullman, C. Piacitelli, R. Boylstein, J. Cox-Ganser, K. Kreiss, NIOSH, Morgantown, WV.

Diacetyl exposures cause fixed airway obstruction in both microwave popcorn production and flavoring manufacturing workers. From 2000 to 2007, NIOSH investigators measured diacetyl concentrations with NIOSH Method 2557 in six microwave popcorn facilities, three flavoring manufacturers, and one popcorn popping plant. With this method, sample collection is through carbon molecular sieve sorbent tubes followed by analysis with gas chromatography and flame ionization detection. Supporting relative humidity (RH) and temperature measurements were taken daily at each facility as area samples using an electronic psychrometer. Recently, exposure chamber investigations with scientists at the OSHA's Salt Lake Technical Center have shown NIOSH Method 2557 is adversely affected by RH, resulting in a progressive underestimation of diacetyl concentrations with increasing RH. We developed interim correction equations based on RH and sampling flow rate at a temperature of 78°F and applied them to correct past diacetyl concentration measurements. RH measurements ranged from 24% to 94.5% at the initial microwave popcorn plant. At sampling flow rates of 0.03 to 0.05 liters per minute (Lpm), predicted diacetyl recoveries ranged from approximately 14% to 85% of the estimated diacetyl concentration. At a flow rate of 0.15 Lpm, diacetyl recoveries ranged from approximately 19 % to 84 %. Accordingly, a diacetyl concentration of 0.09 ppm, collected at 0.15 Lpm at an RH of 65% (19.4% recovery), is estimated to have been 0.46 ppm. These interim RH- and sampling-flow-based diacetyl concentration corrections are essential to provide a more accurate measure of worker exposure from past assessments with NIOSH Method 2557. Corrections to historical exposure measurements will be applied to risk assessment analyses now under way for diacetyl.

Health Care Industries

Papers 305–306

305

Isoflurane Waste Anesthetic Gas Exposure Assessment

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Potential employee exposure to isoflurane waste anesthetic gas (WAG) was evaluated through quantitative analysis of previously collected industrial hygiene data. Exposure concentrations were converted to 8-hr time weighted averages (TWAs) and then evaluated against the U.K. Health and Safety Executive's (HSE) 50 ppm TWA Workplace Exposure Limit (WEL). Evaluations were made based on engineering controls used during small and large animal procedures to determine efficient controls for particular tasks. A data set consisting of air-monitoring samples previously collected by industrial hygienists within Merck & Co. Inc.'s West Point Safety and Environment Department (WP S&E) was compiled. Personal breathing-zone samples were collected, using either a GilAir-5 air-monitoring pump with Anasorb (747 or CMS) glass charcoal collection media or using an organic vapor badge. For both methods, field and media blanks served as controls. Personal air sample analysis indicted that 100% of air-monitoring samples were below the U.K. HSE WEL, indicating employees were adequately protected from isoflurane WAG. Quantitative analysis found that greater duration of exposure yielded higher exposure concentration for orbital bleed procedures. For large animal surgery, local exhaust ventilation was a more effective engineering control than general room ventilation. It was found that for small animal surgery, fume hoods were the most effective engineering control when compared with other engineering controls evaluated. This study provided enhanced understanding of occupational exposures to, and effective

engineering controls for, isoflurane gas. It indicates that Merck & Co., Inc.'s WP site has maintained levels below the WEL and predicts that future evaluations will continue to remain below this limit. This study allowed better understanding of exposure duration and its effects on exposure concentrations. In addition, it provides recommendations based on quantitative data analysis for task-based engineering control usage.

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The Value of Expert Resources to Joint Health and Safety Committees in the Acute Health Care Sector

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Since 1978, joint health and safety committees (JHSCs) have been a legal requirement for Ontario workplaces with more than 20 employees. They bring together a range of practice experience and technical knowledge, provide a means of communication to and from the workforce, and facilitate commitment of workers and employers to health and safety. Although JHSCs have been in existence in Ontario workplaces for almost 30 years, there has been little research done related to their functioning and impact in Ontario's acute health care sector. Research on the Canadian work force has consistently indicated that health care workers have a greater risk of workplace injuries and more mental health problems than any other occupational group. A review of the SARS outbreak in Toronto in 2003 found a grave lack of worker safety expertise, resources. and awareness in the health and safety system. It noted that JHSCs were sidelined during SARS. A study to better understand the form, function, roles, and resources of JHSCs in the acute health care sector in Ontario was implemented. A cross-sectional survey of JHSC co-chairs from acute care hospitals in Ontario was conducted, with a 58% response rate. Results showed one of the strengths of current JHSCs in Ontario hospitals was the availability of expert resources, including industrial hygienists, infection control practitioners, ergonomists, and occupational medicine physicians. These experts were available either internally or in a consultant capacity. Results also showed JHSCs in larger hospitals had more access to internal and external experts than smaller hospitals. Availability of occupational health and safety experts in the acute health care sector is a valuable resource that JHSCs need to utilize. Sharing experts/resources with larger health care organizations may be an important strategy for smaller hospitals.

Respiratory Protection

Papers 307–308

307

A Novel Design of FFPRs to Minimize TIL: Results of Adhesion Technology

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Current NIOSH certification of filtering facepiece particulate respirators (FFPR) addresses only the efficiency of filter materials. This varies according to particle penetration, and typically is 5% or less. However, hazardous airborne particles can leak between the respirator and the face (face-seal), thereby contributing to total inward leakage (TIL). With conventional banded technology, face-seal leakage could add considerably to overall particle penetration. The combination of particle penetration through the filter material and face-seal leakage may lead to significant workplace exposure to hazardous airborne particulates. In recognition of this shortcoming, NIOSH proposed to make TIL testing part of FFPR certification. The most recent document "Preparing for an Influenza Pandemic" issued by the National Academies (2008) calls for "developing more effective and consistent face seals for respirators." A novel flat respirator design was developed using a circumferential medical-grade adhesive in conjunction with a high-efficiency, low-resistance, composite filtration material to minimize TIL. Using NIOSH's stringent corn oil aerosol methodology for CBRN respirators, this FFPR design was tested and achieved extremely high fit factors without the need for prior fit-testing. Particle penetrations as low as 0.005% for 0.3 µm particles DOP, or NaCl with breathing resistance of 10 mm H_20 at 85 L/min, were achieved with the multilayered composite filtration medium. Standardized corn oil aerosol testing for TIL has shown fit factors of 20,000-60,000 for the adhesive respirator design. The evaluation data suggest that the new adhesion technology offers significantly improved respiratory protection as compared with conventional FFPRs. The new respirator is designed to protect both workers and the general population against aerosol particulates of submicron sizes.

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A Dynamic Respirator Exhalation Valve Test Apparatus

C. Yang, S. Huang, C. Chen, National Taiwan University, Taipei, Taiwan; Y. Kuo, Chung Hwa University of Medical Technology, Tainan, Taiwan; C. Chen, Institute of Occupational Safety and Health, Taipei, Taiwan.

For certain high-grade air-purifying respirators, the level of discomfort due to the high air resistance caused by the filter media is reduced by exhalation valves. These valves are equipped to permit minimal inward leakage of air contaminants during inhalation and provide low air resistance during exhalation. The certification tests currently used require the leakage into new exhalation valves not to exceed 30 mL/min at a constant suction pressure of 25 mm H_2O. However, the leakage under constant vacuum may not be representative of cyclic flow when normal breathing is performed. A piston-cylinder breathing simulator was used to produce cyclic flows of different tidal volumes and breathing frequencies. A semisphere, connected to the breathing machine, was used to simulate the respirator cavity. Exhalation valves of different brands were placed on a specially made adaptor designed to connect to the semisphere. For an aerosol penetration test, a constant output aerosol generator produced submicrometer-sized aerosols with a count median diameter around 0.2 µm. A condensation particle counter (TSI 3010) was used to measure the aerosol concentrations inside and outside the exhalation valve. An aerosol sampling probe was placed close to the valve for sampling within the respirator cavity. Preliminary results showed that aerosol penetration through the exhalation valve under cyclic flow mode has good agreement with the leakage rate measured by constant suction method. Nevertheless, the versatile dynamic method can provide additional information regarding aerosol loading characteristics and valve performance under high wind speed.

Toxicology

Papers 309–310

309

Databases and Resources for Occupational and Environmental Health Professionals from the U.S. National Library of Medicine

C. Hochstein, P. Hakkinen, National Institutes of Health, Bethesda, MD.

Industrial hygiene and other occupational health and safety professionals have a 24-hour-a-day need for access to reliable toxicology-related information resources. The U.S. National Library of Medicine (NLM) Specialized Information Services Division (SIS, http://sis.nlm.nih.gov/) offers numerous free information resources to help meet this need. These resources are continually updated and new resources developed. NLM resources are evolving to meet the information needs associated with emerging technologies such as manufactured nanomaterials. Those of potential interest to occupational and environmental health professionals include TOXNET®, a collection of toxicology and environmental health databases. TOXNET's TOXLINE® contains more than 3.000,000 bibliographic citations on the toxicological and other properties of substances. The Hazardous Substances Data Bank® (HSDB) is a peer-reviewed collection of information for more than 5000 substances, covering toxicology, industrial hygiene, human and environmental exposures, emergency handling procedures, environmental fate, regulatory requirements, and related areas. Haz-Map® links more than 2000 substances with jobs and tasks and with more than 200 occupational diseases and their symptoms. Introduced this year, RiskIE® (Risk Information Exchange) is a global database on human health risk assessment-related projects that can be used to identify opportunities for collaboration between government, industry, academic, and environmental organizations. Other NLM resources include WISER® (Wireless Information System for Emergency Responders), a system designed to assist first responders in hazardous material incidents, and TOXMAP, a geographic Information System (GIS) that uses maps of the United States to help users ex-

plore data from EPA's Toxics Release Inventory (TRI) and Superfund Programs. In this presentation, we will provide a framework for how occupational and environmental health professionals can best use these and many other toxicology-related databases and other resources, with the opportunity for attendees to note and discuss additional information resource needs.

310

Approaches for Establishing Exposure Guidance Values for Sensory Irritants: Methyl Isothiocyanate (MITC) as a Case Study

A. Maier, M. Dourson, M. Kohrman, Toxicology Excellence for Risk Assessment, Cincinnati, Ohio; W. Cain, University of California, San Diego, San Diego, CA.

Methyl isothiocyanate (MITC) is the degradate that provides the pesticidal properties of a number of fumigants (e.g., metam sodium). As a vapor, MITC can potentially affect field workers and pesticide handlers. Eye irritation, mediated through stimulation of the trigeminal nerve, appears to be the most sensitive endpoint after acute exposure. Thus, risk assessment for exposure to MITC can rely on studies of eye irritation to determine the point of departure. We used the human study by Russell and Rush (1996) to assess the risk of MITC for acute exposure. We identified subjects in this study as responders if they showed an adverse response in two or more of the three study endpoints (lacrimation, perceived irritation, and blink rate). Using this information, we then analyzed the hazards through concentration-time analyses and benchmark concentrations (BMCs) and determined a BMCL of 0.20 ppm. Because the derived BMC is based on human data, no uncertainty factor (UF) for extrapolation from experimental animals is necessary. Similarly, since the lower limits to the BMCs are NOAEL surrogates, no UF is needed for extrapolation from LOAEL to NOAEL, nor is a database uncertainty factor needed. An UF for human variability is necessary, however. Based on the available information, we conclude that an UF of 1 is appropriate because there is reduced intraspecies variability for direct-contact effects (i.e., eye irritation),since only dynamic, not kinetic, variability is relevant, and the Russell and Rush (1996) study included a sensitive population. The best estimate of a health protective concentration for MITC, based on this assessment, is 0.8 ppm for 14 minutes and 0.2 ppm for 4 hours and longer.

Poster Session 402

Monday, June 1, 2009, 2:00 p.m.–4:00 p.m.

Biosafety and Environmental Microbiology

Papers 311–312

311

Direct Reverse Transcription Real-Time PCR Testing for Enterovirus in Water

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The pollution of rivers and recreational waters by sewage and animal fecal waste has caused a number of health concerns. Bacteria such as *Escherichia coli*, *Enterococcus,* and *Bacteroides* can be monitored by standard methods and DNA polymerase chain reaction (PCR) methods. Environmental monitoring for enterovirus and norovirus has become very important due to the high frequencies of outbreaks in this country. Detecting enteroviruses is technically challenging, since virus enrichment culture methods need animal cell culture facilities. Enteroviruses are also RNA viruses requiring special precautions for handling. However, several PCR-based methods without animal cultures for detecting enterovirus have been developed recently. In the PCR-based rapid detection methods, virus particles in water samples are captured on aluminum chloride-charged nitrocellulose membranes. Then, the virus can be eluted out and concentrated using ultrafiltration. Viral RNA can be isolated from the eluted virus. Using one-step reverse transcription real-time PCR, virus RNA is converted to DNA and detected by a sensitive and specific real-time PCR. Recently, we have evaluated several methods and optimized a testing procedure. This procedure can also be used for testing other waterborne viruses, including norovirus and adenovirus, which provides an approach for rapid monitoring enterovirus and other human pathogens to prevent human infections.

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Investigation of Facility and Installation at BSL2-3 Laboratories in Taiwan

T. Kuo, Taiwan Biological Safety Association, Tainan Hsien, Taiwan; Y. Cheng, Taiwan Biological Safety Association, Hsichu Hsien, Taiwan; H. Su, National Chen Kuang University, Tainan, Taiwan.

Preliminary survey, auditing, and certification for biosafety practice and compliance have been conducted in various BSL facilities in Taiwan. College laboratories, along with 17 BSL3 facilities, were covered to clarify the overall biosafety background for the laboratories through questionnaires and actual site visits. Biological safety levels (BSL), risk group (RG) for material in use, biosafety committee, utilities, reporting system, and emergency response protocol have been reviewed. The surveys granted by IOSH and CDC, Taiwan, will be used for updating related guidelines, legislation, and training programs. The results indicated that most laboratories (87.37%) belonged to RG2, and only 1.03% were RG3 in 198 questionnaires listing species of microorganisms used in the laboratories. For the laboratory facilities, 22.54% of those laboratories using RG2 agents were equipped with biological safety cabinets. Care should be taken that 2% of BSL-2 laboratories used RG3 agents in their facility. In 290 academic laboratories, 43.10% of operating individuals were not able to properly identify the RG of microorganisms used in their environments. Other concerns included lower percentage of biohazard sign present (28%), lack of keeping biological material safety data sheets (39%), and no emergency response program (39%) available.

Community Environmental Health

Paper 313

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Pesticide Residues in Former Marijuna Grow Operations: Determining Safe Levels

J. Blair, Pacific Environmental Consulting & Occupational Hygiene Services, North Vancouver, BC, Canada; G. Wedman, Pacific Environmental Consulting & Occupational Hygiene Services, Nanaimo, BC, Canada.

In British Columbia, illegal marijuana grow operations impact numerous residential and commercial properties. The majority of these operations occur in single-family homes. Problems associated with former marijuana grow operations include fungal contamination, electrical and structural deficiencies, residual pesticides, and fertilizer contamination. Because these operations are illegal, there is limited information on the amount and types of pesticides used for the cultivation of marijuana. However, many municipal bylaws require sampling to ensure there is no residual pesticide contamination present prior to reoccupancy of the building. As there are no available standards for the determination of safe levels of pesticides in homes, determining if the house is safe to reoccupy with regard to pesticide contamination can be difficult for hygienists. The objective of this study was to identify those pesticides that are most commonly identified in former marijuana grow operations and to present a suggested guideline for acceptable levels of these pesticides in residential homes. We have examined and summarized the results of pesticide sampling from more than 100 former marijuana grow operations. A number of pesticides have been detected, but there are several that are more commonly detected than others. For these pesticides, we have reviewed the available literature and levels that are considered acceptable for consumption of food. These levels have been used to help define guidelines for use when interpreting the level of residual pesticides in homes following activities associated with illegal marijuana grow operations.

Emergency Preparedness/Response

Papers 314–315

314

Response and Recovery Work Related to Hurricane Ike Along the Texas Gulf Coast, Including Microbial Monitoring Results and Specific Site Assessment Consulting Services

J. Koehn, Jan Koehn, M.S., CIH, Inc., Houston, Texas.

Numerous types of indoor air quality (IAQ) efforts were undertaken along the Texas Gulf Coast in response to Hurricane Ike during September 2008. Based on potential site hazard assessment, including water intrusion issues, separate designed industrial hygiene sampling strategies were used. These activities included airborne microbial monitoring, as well as documentation of basic IAQ parameters. A variety of types of facilities were addressed involving hospitals, out-patient/day surgical centers, schools, and public and commercial buildings. Most assessments were requested due to facility loss of power, including humidity control

and/or water intrusion. Nonviable spore trap samples were used for routine public-facility occupied spaces, as well as building construction work areas. A variety of culturable bioaerosols were collected for critical path hospital and surgical patient care areas, as outlined by infection control personnel. Basic IAQ parameters were recorded at the site sample locations. Water intrusion was observed for numerous areas, based on impacted windows or roofs and/or excessive flood waters. Reference and use of EPA technical guidelines were used related to necessary and appropriate response activities involving hurricane impact on affected building materials (i.e., porous vs. nonporous). Screening with moisture meters was routinely accomplished to assist with further definition, and specific recommendations for removal of damaged building materials. Spore trap results indicated the additional need for any remaining sheetrock removal affected by water intrusion and/or disturbance of building materials for construction areas. Culturable bioaerosol results generally reported limited levels of airborne fungal/mold and/or bacterial organisms. These requested site assessment activities further verified the importance and need for quantitative microbial monitoring results as part of IAQ surveys in response to impact and hurricane recovery efforts. Sampling strategy design and implementation was specific to the variety of facilities investigatedas well as the specific effects of water intrusion.

315

Deriving Immediately Dangerous to Life or Health (IDLH) Values Using Refined Methodology: Evaluating the Risk of High-Priority Chemicals for Emergency Response Personnel

A. Maier, A. Parker, TERA, Cincinnati, Ohio; G. Dotson, NIOSH, Cincinnati, Ohio.

NIOSH has been investigating methods to improve the derivation of immediately dangerous to life or health (IDLH) values. In this presentation, we will discuss the objectives of the study: (1) the development of a prioritization process to aid in the identification of high-priority chemicals of specific interest to emergency response personnel, and (2) the impact of a refined weight of evidence approach for the derivation of IDLH values. The refined approach was applied to 20 case-study chemicals from the list of agents identified by the prioritization process. Lessons learned from these case studies are used to refine IDLH derivation methods as they apply to chemicals of interest to emergency responders.

Ergonomics

Papers 316–319

316

Perceived Job Stress and Health Complaints at a Call Center

Y. Lin, Chung Shan Medical University, Taichung, Taiwan; C. Chen, Council of Labor Affairs, Taipei, Taiwan.

The objectives of this study were to investigate differences of perceived job stress and health status, and the associations between inbound (incoming calls) and outbound (outgoing calls) calls for call center workers at a bank in Taiwan. A total of 289 call center workers were employed at the time of the survey, and their ages ranged from 19 to 54 years. Data on individual health complaints, perceived level of job stress, and major job stressors were obtained. Overall, 33.5% of workers for outbound services and 27.1% of workers for inbound services reported often or always feeling very stressed at work; however, the differences between inbound and outbound services were not significant. “Having to deal with difficult customers” was ranked as the most frequent job stressor. The prevalence of musculoskeletal discomfort, strained eyes, and hoarse or painful throat were found to be the most pronounced and prevalent complaints for call center workers. Association between perceived job stress and health complaints indicated that workers who perceived higher levels of job stress had significantly increased risks of multiple health problems, including strained eyes, ringing ears”, hoarse or painful throat, chronic cough with phlegm, chest tightness, irritable stomach or peptic ulcers, and musculoskeletal discomfort (odds ratio ranged from 2.13 to 8.24). These results suggest that perceived job stress in the call center has profound effects on health. This study identified major types of job stressors for further investigation.

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Evaluating Potential Ergonomic Hazards at an Aviation Engine Distribution Center

J. Ramsey, S. Tak, NIOSH, Cincinnati, Ohio.

NIOSH received a request for a health hazard evaluation (HHE) at an aviation engine distribution center. The request stated that employees who pick and/or package parts may be at risk for musculoskeletal disorders (MSDs). NIOSH investigators observed typical tasks involved in the facility, and administered medical questionnaires to assess the prevalence of MSD symptoms. The ergonomics evaluation indicated that the most common risk factors for the development of MSDs were bending and reaching. Review of the OSHA Form 300 Logs of Work-Related Injuries and Illnesses indicated that five employees reported MSDs of the upper extremity, knee, and low back between 2003-2005. Questionnaire results indicated that 55% of 73 employees who participated were experiencing pain or discomfort in one or more body parts. Recommendations, included in the final report, were to design storage areas to raise parts off the floor and to design assembly areas with more counter space to eliminate bending while filling orders. Additional recommendations were made to provide more training for employees, so they can recognize unsafe work practices and easily identify the early signs of injury. As part of the NIOSH HHE Followback Program, a site visit was made one year after the company received the final report to discuss the effectiveness of the recommendations. The company had implemented several recommendations and found the highlights page (a section of the report that summarizes the evaluation in plain language) very useful. Improvements included providing adjustable tables in several workstations, raising materials and parts stored on the floor, and purchasing electric pallet jacks, shrink wrap machines, and powered strapping machines. The company provided an occupational therapist who offered training on proper lifting techniques, particular to the situations that the employees encounter while performing their jobs.

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Development of a Readiness for Organizational Change Scale for Participatory Ergonomics

P. Bigelow, R. Wells, D. Kramer, University of Waterloo, Waterloo, ON, Canada; D. Holt, Air Force Institute of Technology, Dayton, Ohio; R. Franche, Occupational Health and Safety Agency for Healthcare, Vancouver, BC, Canada; P. Subrata, S. Krepostman, D. Van Eerd, S. Ferrier, D. Cole, Institute for Work & Health, Toronto, ON, Canada; D. Zohar, Technion Israel Institute, Haifa, Israel; S. Hunt, C. McKean, Electrical & Utilities Safety Association, Toronto, ON, Canada.

Implementing a participatory ergonomic (PE) program often requires significant organizational change. There are measures of readiness for organizational change used in management research that have been developed to assist organizations in addressing barriers to program adoption. The objective of this study was to modify an existing readiness for organizational change instrument and test it in the context of organizational changes brought about during the implementation of PE programs. Questionnaires were completed anonymously by employees (>90% response rate) in each of the six participating electrical and utilities (total n=830) in Ontario and included a 21-item [Likert-type response scale ranging from 1 (strongly disagree) to 5 (strongly agree)] instrument that measured three dimensions of readiness for organizational change. An example item in the management support dimension included “Our organization’s top decision makers have put support behind this.” Exploratory factor analysis, using 230 cases randomly selected from the total sample, was performed using a principal axis method. The confirmatory analysis was conducted with the hold-out sample of 600 questionnaires. The resulting reliabilities were .90, .90, and .90, for appropriateness (F1), management support (F2), and change efficacy (F3), respectively. A three-factor solution that emerged through principal components factor analysis using an orthogonal rotation provided eigenvalues of 6.97, 3.63, and 1.64 for F1 to F3, respectively. In the confirmatory analysis, when we compared our hypothesized three-factor measurement model (baseline) with a series of models that constrained the correlations among constructs to 1.0, for each comparison, the chi-square difference test of goodness-of-fit indicated the baseline model was the most robust. In sum, the results showed that the scale has good measurement properties and may be useful to researchers in identifying facilitators and barriers to the organizational changes that are required for successful PE programs.

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A Semi-Quantitative Model for Estimating Hand-Arm Vibration Exposure in Clinical HAVS Cases

D. Chung, P. Sampara, Workplace Safety & Insurance Board, Toronto, ON, Canada.

A semi-quantitative exposure assessment model was developed to rank workers’ exposure to hand-arm vibration (HAV) in the absence of good exposure data. It was developed as part of a larger study to examine the correlation between vibration

exposure and clinical symptoms in the development of HAV syndrome (HAVS), also known as Reynaud's Phenomenon. Two groups of workers, miners and nonminers, provided information about their jobs or industry, vibratory tools, and tool usage pattern (i.e. frequency and duration). An Excel® spreadsheet was developed to rank the exposure to HAV. Four factors considered in the exposure ranking were the frequency and duration of vibratory tool use, type of work (i.e. grip force and posture), and the acceleration of the tool. The model was used to examine the effect of successively eliminating some of these factors on the ranking of HAV exposure. Preliminary results indicated that when all the exposure factors were included, 46% of the cases were ranked as having high exposures to HAV, 37% were ranked as moderate, and 17% were ranked as low. Removing the frequency of tool use resulted in high, moderate, and low rankings of 17%, 56%, and 27%, respectively. When frequency of tool use and type of work were removed, high, moderate, and low rankings were 17%, 42%, and 41%, respectively. When all of the factors, except the acceleration of the tool, were excluded the rankings were 23% high, 33% moderate, and 11% low. In the majority of cases, the workers provided poor and inconsistent exposure information. The model indicated that, in the absence of good exposure data, the minimum factors that should be considered when ranking exposures to HAV are duration of vibratory tool use and acceleration.

International Globalization

Papers 320–321

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Flammable and Combustible Liquid: Comparison Between NFPA, TDG, NFC, WHMIS, and the Proposed GHS Classification System

M. Gagne, CSST, Montreal, QC, Canada.

The Répertoire toxicologique of the Commission de la santé et de la sécurité du travail du Québec (CSST), actively involved in the implementation in Canada of the WHMIS (Workplace Hazardous Materials Information System), received numerous requests on hazardous chemicals used in the workplace. Most inquiries concerned solvents having a WHMIS, National Fire Protection Agency,, Transport of Dangerous Goods, or National Fire Code classification or a threshold limit value. Data were extracted from the database of the Répertoire toxicologique, a computer system containing information on about 8900 chemicals used in the workplace in the Province of Quebec, and available on the web site. With the future implementation in Canada of the GHS (Globally Harmonized System) a comparison was done to evaluate the flammable and combustible liquid classification with that system of classification.

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EHS Questionnaires! What Is Important to Know Before You Apply Them in a Different Culture

J. Dias, Johnson & Johnson, Sao Jose dos Campos, Brazil; M. Benatti, UNICAMP, Campinas, Brazil; D. Alexander, Auburn Engineers, Auburn, AL.

With globalization, several multinational corporations and consultants are coming to different countries for business reasons, with a "ready" package of EHS standards. These standards can include questionnaires requiring local information, environment and health aspects, and also local regulations. Publications from several authors recommend the need for a cross-cultural adaptation for reliable existing instruments, before these questionnaires are used. The purpose of this project was to translate "Ergo Job Analyzer - High Risk Activities", condense the cross-cultural adaptation process, and determine its reliability. This instrument has existing requirements in ergonomics, for quantitative studies relative to work conditions. The cross-cultural process followed recommended international methodology standards. The process consisted of initial translation, back translation, expert committee review, and pretesting. The original questionnaire was translated into Portuguese by two independent translators. Once translated to Portuguese, a consensus version was created. The back translation was done by two other translators, from Portuguese into English, and was submitted to the expert committee for review. The expert committee reviewed the documents and created the pre-final version. The pre-final version was pretested by five bilingual translators who did not know the instrument as well as the scope of this research. Reliability was estimated through stability. The final version of this instrument was applied in the field by three research assistants to 20 different workers. Psychometric properties were obtained after field test, and results showed sufficient reliability (Cronbach alpha = 0,71); high intra-class correlation was observed (r=0,93). Few changes were necessary in the questionnaire to better reach results on this purpose. Through this cross-cultural process, it is desirable to give a contribution to Brazilian health and safety professionals, making available an easy ergonomic instrument for ergo analysis using local language.

Management and Training Issues

Papers 322–324

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Evaluating NIOSH Communication and Technology Transfer Strategies for Mining: A Mixed Methodology Approach

L. Elinson, S. Locke, K. Hamre, Westat, Rockville, MD.

Recognizing the importance of translating research findings into practice, the NIOSH Mining Program evaluated its *Technology News* publication series to determine its effectiveness in reaching the intended target audience, transferring knowledge to the mining community, and facilitating changes in mining operations. We implemented a mixed-methodology approach, using the 50 most recent articles in the series to evaluate the effectiveness of *Technology News*. The evaluation included a survey of authors to determine their intentions and expectations in writing the articles; interviews with target audience representatives to assess whether their goals were met; and a content analysis of each article, based on Rogers' theory of diffusion of innovations. Analysis of the author survey indicated that most articles targeted more than one audience, with 65.1% attempting to reach multiple mining commodities, 39.5% reaching out to multiple types of mines, and 93.0% expecting to reach more than one type of mine employee or stakeholder. *Technology News* articles appeared to be reaching their target audiences. Of those individuals requesting additional information on a *Technology News* article, 90.7% were members of the author's intended target audience. Most innovations were disseminated through multiple venues; 4.7% of authors indicated they only used *Technology News* to communicate their innovation. Although 65.1% of authors indicated an intent to convince the reader to adopt and implement the innovation, the content analysis revealed that, in general, authors were using neutral rather than positive language to describe their findings and recommendations.In this presentation, we will discuss additional findings from the evaluation, the utility of the mixed-methodology approach, and how the principles of Rogers' theory of diffusion of innovations were adapted for this project. We also will highlight the efficacy of content analysis and how this methodology can be used in similar applications.

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Estimating the Number of Occupational Safety and Health Professionals Employed at Large U.S. Construction Firms

M. Gillen, NIOSH, Washington, DC.

How many professional industrial hygienists and safety engineers work for the 100 largest U.S. construction firms? In this presentation, we will report on the number of AIHA and ASSE members reported as employed by each of the top 100 construction contractors as listed in the September 2008 McGraw-Hill *Engineering News Record*. These top 100 contractors reported 2007 total revenue ranging from $629 million for the 100th-ranked firm to $17.6 billion for the top ranked firm. Small employers (with one to nine employees) are known to dominate the U.S construction industry, comprising 79% of all establishments and employing 24% of all employees. Less than 1% of all construction firms are large (500 or more employees), and they employ 8.5% of all construction employees. These large employers are likely to have the most influence in construction safety and health, as they are most likely to employ full-time safety and health professionals on their projects. In addition to discussion of the findings, the we will describe study limitations, and potential implications for occupational safety and health partnering and practice.

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Implementation of IH Metrics in a Petroleum Company

J. Galvin, C. Mashburn, S. Clark, T. Hammon, ConocoPhillips, Bartlesville, OK; M. Blankinship, ConocoPhillips, Ponca City, OK; L. Cullom, ConocoPhillips, Rodeo, CA; G. Duncan, ConocoPhillips, Doha, United Arab Emirates; D. Havis, ConocoPhillips, Wood River, IL; O. Kampa, ConocoPhillips, North Slope, Alaska; D. Rhodes, ConocoPhillips, Ferndale, WA; S. Taylor, ConocoPhillips, Billings, MT; B. Way, ConocoPhillips, Farmington, NM.

An industrial hygiene metrics program designed to identify, correct, and communicate key leading and lagging industrial iygiene indicators

throughout the company's global operations was implemented. The key indicators are measured and shared throughout the company to develop a standard for facility exposure assessment plans; to identify, track, and correct unacceptable exposures; and to serve as a communication plan to upper management. Leading indicators include the reporting of the number of planned annual samples per a facility exposure assessment plan and quarterly updates on the completion status of those plans. These indicators strengthen the "evergreen" nature of exposure assessment plans through an annual revalidation and listing of completion status among peer business units. Lagging indicators involved the creation of a new term called an "Exposure Incident" and involves the mandatory reporting of instances where inadequately protected workers are exposed to chemical or physical agents at levels exceeding established occupational exposure limits. Exposure Incidents are reported, tracked, and investigated to resolution using an integrated database. Lessons learned are shared with industrial hygienists across the enterprise and HSE managers within the corporation to help reduce the probability of similar exposures occurring at another location. The communication plan is divided into corporate and site- level components. The corporate component captures industrial hygiene metrics on a monthly basis and includes those metrics in the company's monthly HSE performance report. The site-level component defines various industrial hygiene activities that should be captured and communicated to site management on a monthly basis. Standardized report templates, similar to those currently used for safety metrics, were created for the site-level metrics and provide a common medium for industrial hygienists to communicate and compare industrial hygiene activities and incidents globally.

Safety

Papers 325–326

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Sex and Age Differences in Occupational Fatalities Among Construction Workers in Taiwan

Y. Lin, J. Luo, Chung Shan Medical University, Taichung, Taiwan.

This study was concerned with sex and age differences in work-related fatalities in the construction industry, based on 1061 injury reports from case reports published by the Council of Labor Affairs of Taiwan for the years 1996-1999. These data were analyzed in terms of sex, age, work experience, accident type, and source of injury. It was discovered that sex-specific aggregated occupational fatalities were higher throughout this period for male workers. That is, the female fatality rate was 17.2 per 100,000 workers, and this rate was exceeded by the male fatality rate of 31.8 per 100,000 workers. However, female workers ages 45 and older had much higher fatality rates. The results also showed that the leading cause of death was falls (59.4% for females and 51.8% for males), and most of the accidents occurred during the first year of employment (53.6% for females and 39.3% for males). These data suggest the need for further research to examine sex-specific work-related injury risks and to devise injury prevention programs.

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Is That Electrical Outlet Safe? Recognizing Electrical Hazards in the Workplace

D. Contreras, USACHPPM-North, Fort George G. Meade, MD.

Recognizing some common electrical hazards during routine industrial hygiene surveys should be added to the governmental industrial hygienist's tool box of knowledge. I will address understanding electrical hazards and the requirements for ground-fault circuit interrupters (GFCIs) in locations such as research and development, maintenance, and spray finishing operations. The requirements for GFCIs are stipulated in Title 29 Code of Federal Regulation (CFR) Part 1910, Subpart S; National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety in the Workplace; and NFPA 70, National Electric Code (NEC). In addition, the industrial hygienist should utilize the applicable governmental regulations for that installation or facility surveyed. Subpart S (Electrical) was recently updated; the rational stated in 71 FR 7190, dated Feb. 14, 2007, was that electrical hazards in the workplace pose a significant risk of injury or death to employees, and that the requirements in the revised standard, which draw heavily from NFPA 70E-2000, and NFPA 70-2002 are reasonably necessary to provide protection from these hazards. Many electrical devices installed prior to the update of Subpart S have been grandfathered in and the opinions stated in the *Federal Register* that NFPA 70E-2004 should have been incorporated would dictate that the current consensus standards should be utilized in addition to the General Duty Clause if the absence of a GFCI could lead to death or serious physical harm to employees. The intent of this poster is to illustrate some potential workplace electrical hazards and locations where GFCIs are required to be installed, as well as locations where it might be prudent to recommend the installation of GFCIs.

Stewardship/Sustainability/Green

Papers 327–328

327

Practical Problems and Solutions for LEED Indoor Air Sampling

J. Kenny, ESIS Environmental Health Lab, Cromwell, CT; M. Strange, ESIS Global Risk Control Services, Tuolumne, CA.

Green building certification is an increasingly important issue for business. As part of the LEED certification process points are awarded for energy conservation and other green-related demonstrations. One area of obtaining LEED certification points is by demonstrating that your renovated area or new building contains airborne contaminants below certain levels. The LEED chemicals of concern are volatile organic compounds, PM 10 size particulates, formaldehyde, carbon monoxide, and 4 phenyl cyclohexene. The decision to try to obtain the LEED credit point (EQ 3.2: Indoor Air Quality Management Plan After Construction) involves a financial commitment by the builder or architect. If initial LEED air samples exceed certain levels, resampling might be required that would increase the cost of these points. In some cases, this LEED credit is not achieved after resampling due to the measured concentrations still being above the allowable LEED limits. Inappropriate building materials, interior finishing contractors still working on site during sampling, use of cleaning solvents, and sampling when occupied are some of the more common reasons for failing to meet the LEED indoor air quality standards. This research identified the methods and varying approaches to collecting LEED air samples while identifying practices and issues that can hold up or obstruct obtaining the LEED indoor air quality point after new or renovated construction projects. We will provide solutions for obtaining the LEED credit point for post-construction indoor air quality.

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The Development of an Interactive Guide to Working Safely With Beryllium and Beryllium-Containing Materials

T. Knudson, M. Kolanz, T. Civic, P. Carpenter, Brush Wellman Inc., Cleveland, Ohio; R. Newman, Brush Wellman Inc., Elmore, Ohio.

Chronic beryllium disease (CBD) and other health effects associated with occupational exposure to beryllium continue to be the focus in industries involved with the production and fabrication of beryllium and beryllium-containing materials. To assist those involved with the preventive effort, a unique and innovative program, the "Interactive Guide to Working Safely with Beryllium and Beryllium-Containing Materials," has been created to provide employers and employees with tools and guidance to work safely with these important and beneficial materials. The Interactive Guide is a computer-based program that is simple to use and understand. Upon completion of the Interactive Guide, users are provided with an action plan and information to address most types of operations and tasks performed on beryllium-containing materials in an industrial environment. The main tool introduced in the Interactive Guide is the Beryllium Worker Protection Model. The purpose of the Beryllium Worker Protection Model is to prevent CBD and other potential adverse health effects in workers engaged in operations and tasks where there is potential airborne exposure to small beryllium-containing particles. The Beryllium Worker Protection Model is being successfully used at facilities manufacturing and processing beryllium and beryllium-containing materials. This Beryllium Worker Protection Model focuses on the control of multiple exposure pathways and monitoring the effectiveness of these controls using leading measures. The Beryllium Worker Protection Model has eight elements:

Keep beryllium out of the lungs
Keep beryllium work areas clean and shipshape
Keep beryllium off skin
Keep beryllium off clothing
Keep beryllium at the source
Keep beryllium in the work area
Keep beryllium on the plant site
Keep beryllium workers prepared to work safely

This poster will show the development of the Interactive Guide and the key elements of the Beryllium Worker Protection Model.

Poster Session 403

Tuesday, June 2, 2009, 10:00 a.m.–Noon

Engineering and Control Techology

Papers 329–332

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Prevention and Contorl of Tobacco Dust Exposure in Small-Scale Tobacco Crushing Unit

R. Patel, Safe Workplace Inc., Anand, India; A. Parikh, Institute of Science and Technology for Advanced Studies and Research, Vallbh Vidyanagar, India; J. Patel, B.V.M. Engineering College, Vallabh Vidyanagar, India.

The study was carried out with the aim of prevention and control of tobacco dust exposure to workers engaged in various operations in a small-scale crushing unit. The crush tobacco is sold to manufacturers of beedi/cigarette both for smoking and chewable dry tobacco. The qualitative and quantitative exposure assessment was carried out in a tobacco- crushing unit. There was a dust cloud of crushed tobacco found during crushing, sieving, and separation operations. The walkthrough survey suggested from workers showed complaints of respiratory system and eye irritation due to the dust exposure. The SKC personal samplers, PVC filters, cassettes, aluminium cyclones, and microbalance were used for gravimetric analysis of total and respirable dust concentrations of tobacco per the NIOSH particulate method. A total of six samples was collected at each operation workplace and person, before and after installation of preventive control. The mean dust concentrations of workplace for various operations such as crusher, siever, and separator were found to be in the range of 12.23 ± 0.69, 12.22 ± 1.45, and 10.74 ± 0.76, respectively, for total dust and 4.55 ± 0.39, 3.92 ± 0.22, and 3.20 ± 0.17 for respirable dust; same way mean dust concentrations for personal exposure near breathing zone were found to be 17.08 ± 0.54, 15.27 ± 0.77, and 15.10 ± 1.007 for total dust and 6.05 ± 0.33, 5.22 ± 0.46 and 3.90 ± 0.37 for respirable dust. The dust control devices were developed for crusher, siever, and separator machines and installed at units after proper engineering design. The efficacy of the local exhaust ventilation system installed at crusher, enclosure to sieving machine, and newly designed separator was found to be in the range of 84-87%. Information regarding engineering control was given to the workers and employers of small-scale tobacco crushing units.

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Research Development of Real-Time Sterilization Units in Ventilation Ducts

C. Lai, S. Lee, W. Chen, Chung Shan Medical University, Taichung, Taiwan; P. Hung, C. Chuang, C. Chang, Institute of Occupational Safety and Health, Taipei, Taiwan.

Bioaerosols have become an important issue, as Taiwan is located in a subtropical area. The warm weather and high moisture climate are extremely suitable to growing bioaerosols. Humans, when exposed to bioaerosols, may contract asthma, allergic rhinitis, hypersensitivity, pneumonitis, aspergillosis, influenza, acute toxic disease, and even cancer. Recent studies showed high concentrations of bacteria in samples from HVAC (heating, ventilating, and air conditioning) systems in hospitals, including their clinics, wards, and emergency departments, as well as in dental clinics. Obviously, the HVAC systems in these cases were poorly sterilized and bred microorganisms in the ducts. However, an ideal HVAC system not only can provide a comfortable environment for medical employee, but also can reduce the concentrations of bioaerosols. As it is hard to evacuate all hospital patients and then sterilize the ventilation ducts, a real-time sterilization unit that is located in the ventilation ducts is a critical method to control bioaerosol-transmitted infections in hospitals.The objective of this research was to develop a real-time sterilization unit and evaluate the unit under wind tunnel system. The real-time sterilization unit consists of porous filter media and UVGI (ultraviolet germicidal irradiation) modules. A Collison nebulizer was used to generate *Bacillus subtilis* spores and *Escherichia coli* as challenge aerosols. A radioactive source, Am-241, was used to neutralize the challenge particles to the Boltzmann charge equilibrium. Andersen 6-stage samplers were used to sample bacteria concentration upstream and downstream of the new real-time sterilization unit. The results showed the new real-time sterilization unit could be used to reduce the bacteria concentration; however, the unit still needs to be studied under field conditions.

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Controlling Silica Dust Exposures During Dry Concrete Product Bag Filling

P. Klein, Liberty Mutual Group, Plainfield, IL.

The process of filling bags with dry concrete products (40-80 lb bags) generates significant airborne dust using traditional methods of bag tube filling. Silica (quartz) is present in the products, and is therefore present in the airborne dust generated by the filling process. An industrial hygiene exposure assessment was conducted utilizing air samples to characterize respirable silica dust exposures to workers at the bagging machine. The original assessment in 2006 identified respirable silica dust overexposures at the bagging station that were more than 7 times the ACGIH TLV® and more than 3 times the calculated OSHA permissible exposure limit (PEL) for respirable dust containing silica. A combination of local exhaust ventilation (LEV) improvements, as well as bag-type substitution, was recommended and implemented. Subsequent exposure assessments in 2007 showed that silica exposures were reduced to about 60% of the OSHA PEL, but could still be as high as 1.6 times the ACGIH TLV®. After further improvements, a 2008 assessment confirmed the silica dust exposure to be controlled to well below the calculated OSHA PEL for respirable dust containing silica and the ACGIH TLV®. In fact, air sample results were below the quantification limit, which corresponded to less than 32% of the calculated OSHA PEL and less than 40% of the ACGIH TLV®. Careful placement of the local exhaust hoods and covering small openings near the hoods were key factors in controlling the dust.

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Controlling Silica Exposures Associated with Abrasive Finishing During Concrete Plank Field Installation

D. Weber, Liberty Mutual Insurance, Glastonbury, CT.

Premanufactured concrete floor planks are a common construction method for commercial and industrial buildings. Planks made under controlled factory conditions are delivered to jobs ites for installation. A cementatious grout is applied, sealing the joints between side-by-side planks and walls and planks. Silica is present in both the concrete and grout. Dry abrasive surfacing, grinding, and sanding was used to level the excess grout squeezed from the corner and lap joints to improve appearance. These procedures yield very high exposures to airborne respirable dust containing crystalline silica. Abrasive surfacing worker exposures to airborne respirable dust containing quartz approximated 14 to 52 times the OSHA permissible exposure limits (PELs). Engineering controls, including local exhaust ventilation or wet methods were investigated and considered impractical by project management. A study of root causes leading to the need for surface grinding revealed that improving the quality of the plank edge at the factory in conjunction with work site modifications could reduce the amount of surfacing needed at the job site. Field installation modifications included installing backer rod and smoothing wet excess joint grout. The improved plank edge quality, use of backer rod, and sweeping wet grout seepage before drying resulted in a significant reduction in the amount of surfacing performed at the job sites and employee exposures to respirable dust containing silica. Abrasive joint surfacing was reduced from approximately 5 hours to 10-minute and 55-minute periods of the 8-hour shift, resulting in exposures below one-half and approximately 2 times the OSHA PEL, respectively. Field managers inspected the joints prior to grinding and determined that a more diligent smoothing effort would have completely eliminated the need for dry abrasive surfacing. Field management removed sanders and grinders from construction vehicles and diligently worked with their staff to ensure proper joint smoothing practices, thus eliminating the sources of the dust exposures.

IH General Practice

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Chemical and Biological Hazards in Hairdressers' Salons in Poland

M. Posniak, M. Szewczynska, E. Dobrzynska, M. Galwas-Grzeszkiewicz, M. Golofit - Szymczak, National Research Institute, Warsaw, Poland.

Employees in hairdressers' salons are potentially exposed to hazardous chemical and biological factors during their daily working activities, as well as to noise and biomechanical load, which may cause such health hazards for workers as occupational diseases or accidents. Application of chemicals in the form of gas, liquid, or solid may induce different types of harmful health effects in humans. Workers' potential exposure to chemical factors or particulates in a salon may practically occur at every stage of consumer service, from washing, hair

cutting, coloring or decoloration and modeling, to disinfecting applied working tools. The biggest risk for hairdressers is mainly the products used for performing these activities, such as shampoos or hair dyes, because of their composition. The aim of this research was to improve working conditions at the salons by carrying out an interdisciplinary evaluation of working environment parameters. This work focused on identification of chemical and biological hazards in selected salons in Poland. The first phase of the project was a questionnaire survey carried out on a group of about 100 people working as hairdressers to recognize and address their opinions and feelings concerning hazards in the working environment, as well as possible protection against the potentially hazardous factors. Based on the results of the questionnaires, identification of harmful and strenuous chemical agents existing in the salons was carried out. These results were confirmed by field sampling and chromatographic analysis in the second phase of the project. Measurement studies carried out at the workstations will be a basis for risk assessment related to exposure to hazardous factors in this service sector. Results also will enable period control of unsafe working conditions stemming from exposure to different chemical and biological factors.

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Exposure of Volatile Organic Compounds (VOCs) in Nail Shop Workers

J. Roh, C. Park, Y. Lim, C. Kim, Yonsei University, Seoul, Republic of Korea.

This study was performed to determine the exposure level to volatile organic compounds (VOCs; ethyl acetate, benzene, n-propyl acetate, toluene, n-butyl acetate, ethyl benzene, and xylene) in nail shop workers in Seoul and Inchun City, Korea. A total of 31 nail shop workers was surveyed in 15 nail shops during March 2008. Sampling protocol was used for the preparation of VOCs sampling and, GC/MS was used for analyzing those samples. The average number of workers in a nail shop was 4.0, and daily working hours were 10.0. The daily number of customers in the nail shop was 19.7, and the number of customers per worker was 6.7. The average space of a nail shop was 90.6 m^3. During the busy evening hours, the level of carbon monoxide was 1.6 times higher and carbon dioxide was 1.3 times higher, compared with those of the outdoor environment. The concentrations of ethyl acetate, benzene, n-propyl acetate, toluene, n-butyl acetate, ethyl benzene, and xylene were 1.18, 0.00, 0.17, 0.16, 0.43, 0.01 and 0.02 ppm, respectively, during working hours. The level of individual VOCs exposure was 1.63 - 7.86 times higher during working hours, compared with after-hours. Significant differences were observed in the level of VOCs, depending on the location of the nail shop (basement level or not), location of the door, number of customers, and number of workers. The number of customers and workers, space, and ventilation status of the nail shops affects the level of VOCs and other indoor pollutants. It was predicted that the nail shop workers working in a restricted space with limited ventilation are likely exposed to high levels of VOCs and are constantly faced with accumulated exposure, especially with increasing numbers of customers.

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Air Monitoring of Methyl Bromide Used in the Fumigation of Strawberries

F. Schneider, H. Fong, California Department of Pesticide Regulation, Sacramento, CA.

Shipments of strawberries for export are routinely fumigated with methyl bromide (CH_3 Br) to meet quarantine requirements of the importing country. This is a time-sensitive process where harvest to loading on an international flight runs about 16 hours. The process requires colorimetric tube testing to ensure exposures are below the California Department of Pesticide Regulation (CDPR) guideline of 0.63 parts per million (ppm) for eight hours. This air monitoring was conducted to establish procedures that would maintain worker exposures below CDPR guidelines without the use of colorimetric tube testing. Sampling followed NIOSH #2540 protocol for CH_3 Br using personal pumps and charcoal tubes. Monitoring consisted of area samples of the control room located between two intermodal-type chambers (2400 ft^3) used for the fumigation, the forklift that emptied the chambers after fumigation, the cooler, and packaging site. Each chamber contained 18 pallets of strawberries. The chambers were fumigated in two cycles, two hours apart. Aeration of each chamber began three hours post treatment and lasted four hours. Air monitoring was continuous through the process. The highest result of 3.04 ppm occurred during fumigant introduction during the first cycle. Guidelines allow for adjustment of time/concentration, and the time weighted average (TWA) for this sample was calculated to be 0.07 ppm. For pallet removal, aeration fans were to be left on while the forklift entered the chamber. This achieved sampling results for the forklift operation below the quantifiable limit of detection (0.03 ppm). TWAs calculated for the cooling process and packing site were below 0.15 ppm. Discontinuance of monitoring with colorimetric tubes was supported with changes in three processes: the applicator will be in the control room only during fumigant injection, rather than the entire fumigation; aeration fans will be on during unloading of the chambers; and aeration after treatment will be four hours.

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Comparison Formaldehyde and Total Resin Acids Concentrations as a Surrogate of Colophony Solder Flux Fume Exposure

W. Kim, Seoul National University, Seoul, Republic of Korea; I. Choi, Wonjin Institute of Occupational and Environmental Health, Seoul, Republic of Korea; W. Yang, Ministry of Labor, Korea, Seoul, Republic of Korea.

Inhalation exposure to colophony solder flux fume (CSFF) could lead to occupational asthma. There was no occupational exposure limit (OEL) for CSFF and formaldehyde, a pyrolysis product of CSFF, was used as a surrogate of flux fume exposure. But, it has been pointed out that exposure to aldehydes from flux fume could not fully explain the pulmonary health effects, especially asthma. In 90', total resin scids (TRAs) were recommended for an alternative surrogate for CSFF exposure. We measured TRAs and formaldehyde where CSFF was evaporated during soldering. The geometric mean (GM) concentration of TRAs was 87.1 (0.6~86,569.9) $\mu g/m^3$ for 8-hr time-weighted average (TWA) and 503.4 (20.0~54,797.4) $\mu g/m^3$ for short-term exposure level (STEL). Among 29 TWA samples, 76% exceeded 50 $\mu g/m^3$,which was recommended as the maximum exposure limits (MELs) by health and safety executives. In the case of STEL samples, 63.6% of the 22 cases were above the 150 $\mu g/m^3$ of MELs. On the contrary, the GM concentration of formaldehyde was 13.0 (4.4~183.2) $\mu g/m^3$ for 31 samples, and the number of cases exceeding the OEL of the Korean Ministry of Labor (100 $\mu g/m^3$) was only one. There was weak correlation (r=0.44) between concentrations of TRAs and formaldehyde. Formaldehyde and TRAs reflected different levels of contamination at the same workplace; their health effects are also different. If TRAs were not evaluated at a workplace where rosin solder flux is used, then preventive measures for control of respiratory health problems could not be constructed or planned. This study suggested that the degree of contamination by TRAs from flux fume is severe in some Korean industries, and there is a need to introduce OELs for TRAs, apart from formaldehyde, so TRAs can be assessed distinctively.

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Hazard Assessment and Exposure Monitoring for Bridge Repairs in Confined Spaces

L. Cannon, L. Xu, T. Hemenway Jr., EnviroMed Services Inc., Meriden, CT.

Large infrastructure repairing, especially inside a long concrete girder beam under a bridge, can be very challenging with respect to protecting workers in the confined space and limiting potential exposure to environmental hazards during repair. Repair of existing cracks inside the concrete girder beams for a large bridge over the Connecticut River was performed under a CT-DOT project. The contractor's activities included removing the crack surface laitance, applying poly-gel and vacuum ports, spot vacuum grinding, conducting crack continuity testing, mixing benzoyl peroxide with methyl methacrylate (MMA)-based product, and vacuum injection of MMA-based product to fill the cracks in 11 spans. A site-specific health and safety plan, in cooperation with a permit-required confined space plan, was developed based on an initial hazard assessment for the project. The confined space air monitoring was conducted utilizing a BioSystems PhD^5 Multigas Detector to test the confined space atmosphere, including oxygen level, and toxic or combustible gases in the work area and to monitor the workers' safety before entering the confined space and during the repair activities. During the repair activities, in addition to the confined space air monitoring, a series of exposure monitoring was performed to determine the level of volatile organic compounds and total and respirable particulate utilizing a real-time photoionization detector (PID), and portable aerosol monitors. Personal exposure monitoring for the workers was conducted through MMA sampling and crystalline silica sampling for compliance with OSHA requirements. The concentrations of measured parameters were compared with the applicable OSHA permissible exposure limits. Levels of personal protective equipment were recommended and selected and working procedures were adjusted based on the exposure assessment.

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Evaluation of Potential Exposures at an Electrolytic Manganese Dioxide (EMD) Processing Plant

S. Durgam, NIOSH, Cincinnati, Ohio.

The ever-increasing use of electronic products requires an unquenchable demand for energy to power these products. Primary batteries or alkaline cells are the most accessible and cheapest energy source. The most common alkaline cells are zinc and electrolytic manganese dioxide (EMD) batteries. More than 30 billion EMD batteries are produced worldwide, requiring 350 kilotons of EMD. Previous studies have shown that workers in EMD plants had manganese dust exposures up to 13 mg/m^3. The NIOSH REL for manganese is 1 mg/m^3,and the ACGIH TLV is 0.2 mg/m^3. In 2008, NIOSH conducted a health hazard evaluation at a large EMD manufacturing facility to evaluate employee concerns about exposures to manganese, cobalt, nickel, and sulfuric acid mist. Full-shift PBZ concentrations of manganese ranged from 0.052-1.6 mg/m^3 with two concentrations exceeding the NIOSH REL, and four exceeding the ACGIH TLV. These overexposures were obtained on an employee working in the product preparation area and on mechanics. We collected task-based and full-shift PBZ air samples on employees performing job tasks associated with dropping of the filter mud, such as spray washing of filters and drumming of filter mud containing cobalt and nickel. The task-based PBZ concentrations of manganese ranged from 0.12-0.27 mg/m^3; for cobalt they ranged from 0.0024-0.021 mg/m^3, and for nickel they ranged from 0.00094-0.0092 mg/m^3. The full-shift PBZ samples were below applicable occupational exposure limits (OELs) for nickel and cobalt. The employees did not exceed any OELs for sulfuric acid. Based on these findings, the company now requires the use of air-purifying elastomeric half- or full-facepiece respirators with P100 filters when employees are drumming the filter mud. We also recommended the use of respiratory protection by mechanics and employees working in the product preparation area to limit exposures to manganese until effective engineering controls can be implemented.

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Identifying Noncombustion Carbon Monoxide (CO) Source(s) in an Industrial Bakery

B. Hailu, Ministry of Labour, Toronto, ON, Canada; R. Quenneville, T. Harris Environmental Management, Toronto, ON, Canada.

Carbon monoxide (CO) (CAS #: 630-08-0) is an odourless and colourless gas. Acute exposure to CO can cause headache, dizziness, fatigue, nausea, and at higher doses, neurological damage and death by asphyxiation. CO is a byproduct of incomplete combustion of fuel and is emitted in the exhaust of gasoline, propane, or other fuel-powered equipment used in workplaces. It has been documented that a noncombustion source of CO includes chemical reaction of sodium hydroxide (NaOH) and sugars (e.g. fructose, lactose and maltose) that can produce up to 3000 parts per million (ppm) of CO under moderately alkaline (basic) conditions. Sanitation at a bakery plant is given higher priority. Manual and machine washing using alkaline chemicals to dislodge sugars and fat off baking pans is part of a daily operation. Post sanitation water drained into pits and receptor tanks is held for several days. Personal breathing-zone (datalogging) and spot (instantaneous) CO samples were collected using real-time monitoring equipment on three different days. Time weighted average personal carbon monoxide concentrations ranged between 0 and 51 ppm. Personal (tray washer operators) carbon monoxide concentrations ranged between 0 and 30 ppm. Spot carbon monoxide concentrations inside the pits, receptor tanks and maintenance holes ranged between 8 - 200 ppm on three survey dates. Carbon monoxide concentrations inside a wash bay pit exhibited considerable variation during three surveys (55 ppm, 0 ppm and 34 ppm respectively).
Results of CO measurements indicated noncombustion as well as combustion sources of worker exposure to CO.

Consistently higher measurements and variation of carbon monoxide concentrations inside the main receptors and pits may signify that if these spaces are routinely entered, the potential exists for worker exposure to exceed the Ontario short term exposure value (STEV) for CO of 100 ppm.

Laboratory Health and Safety

Paper 340

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Worker` Exposuers to Methylmethacrylate in a Laboratory

Y. Cho, Korea Occupational Safety and Health Agency, Yeosu City, Republic of Korea.

The ACGIH TLV® for methylmethacrylate is 50 ppm. and the immediately fangerous to life or health concentration is 1000 ppm. In the case of human date for methylmethacrylate, workers have experienced irritation, but tolerated 200 ppm without complaint.The present exposure of workers was evaluated in many laboratories. Knowing the reliability and limits of the measuring methods was of primary importance. This study was conducted to evaluate worker exposure in laboratories with methylmethacrylate. OSHA methods were used to assess exposure after samples were gathered from both workers and work areas. For the time-weighted average (TWA), methylmethacrylate was collected on XAD-2 (400/200mg) solid sorbent tube, at a flow of 0.05L/min. The analysis was done using gas chromatography. More than 30 samples were collected, both in the workers′ breathing zones and ambient air, for periods of 6 hours. Eight-hour TWAs showed that exposure to methylmethacrylate for workers who worked with methylmethacrylate was 1~2 ppm, and workers who had no direct contact with methylmethacrylate was 0.04~0.06 ppm. It was found that the concentration of methymetacrylate is higher in workers who worked with methylmethacrylate than the others. To reduce methymetacrylate exposure, the proper training was provided for handling methymetacrylate. In addition, personal protective equipment was provided to the workers.

Lead

Paper 341

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Potential Lead Exposure Evaluation of an Ammunition Shell Casing Sorting Operation

C. Harrison, USACHPPM-North, Fort George G. Meade, MD.

A small-arms ammunition shell casing sorting operation was evaluated at a U.S. military base to determine the potential exposure to lead. The goal of this study was to ensure personnel performing this operation, as well as other personnel working in the area and family members at home, were not exposed to lead as a result of this operation. Lead dust is produced from abrasion of bullets as they pass through the gun barrel, and lead residues remain on shell casings. As many as three times per week, and in the common area of the warehouse, two personnel collected shell casings from military units upon completion of their training at the firing range. Warehouse personnel designed and built a tray table that was used to sort, by hand, approximately 10 to 20 pounds of casings at a time to find and remove any live rounds. Casings were then scraped into large bins and when the weight reached 50 pounds, the container was lifted by hand and poured into larger containers that were labeled and sealed. More than 2000 pounds of 5.56-, 7.62-, and 12.7- millimeter shell casings were sorted during this study. Personal breathing-zone air sampling was performed to evaluate potential inhalation of lead by the individuals performing this operation. Surface wipe sampling was conducted in various locations in the warehouse to determine the distance traveled and quantity of surface contamination by lead dust generated by this operation. Personnel were provided disposable gloves as the only form of personal protective equipment. The degree of hazard associated with lead from this operation is primarily influenced by personal protective equipment, management and housekeeping practices, and personal hygiene principles. Corrective measures to address all findings were recommended, and implementation of many of these modifications resulted in meeting the stated goals.

Risk Assessment/Risk Management

Papers 342–346

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Cost Management Through Engineering Controls

E. Reed, Liberty Mutual Insurance Co, Englewood, CO; R. Newton, Liberty Mutual Insurance Co, Marietta, GA.

Traditional approaches to demonstrating the value of industrial hygiene control strategies rely on estimations of accident/illness prevention savings. Using a more detailed allocation of resources used for the development and implementation of control strategies provides for improved quantification of savings and demonstration of value. We will present a case study of the implementation of engineering changes to significantly reduce worker exposures to silica and demonstrate value using an activity-based cost management system (ABCM). The implementation of controls and application of ACBM demon-

strate, risk reduction,,dollar savings, ,improved cost management,,integration of health and safety improvements into business decision making, and preservation of quality of life. This model demonstrates the relationship between costs and risk reduction, better financial planning, reduced costs, and improved information communication for business decision making. This analysis uses a real-world industrial hygiene exposure to demonstrate value added through implementation of controls.

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Industrial Hygienist Should Consider Combustible Dust When Conducting a Risk Assessment

J. Capuzzi, ESIS Inc., Cape May Court House, NJ.

In 2003, the U.S. Chemical Safety and Hazard Investigation Board (CSB) launched investigations of three major industrial explosions involving combustible powders: at West Pharmaceutical Services in North Carolina, plastic powder exploded, killing six; at CTA Acoustics in Kentucky, phenolic resin exploded, killing seven; and at a Hayes-Lemmerz automobile wheel plant in Indiana, aluminum powder exploded, killing one worker. Following these events, the CSB launched a study to determine the scope of the problem. In its report, issued in November 2006, the CSB identified 281 fires and explosions that occurred throughout a 25-year period, resulting in the loss of 119 lives and 718 injuries. Since the study was released, there have been approximately 82 additional dust fires and explosions, including the Imperial Sugar explosion in 2008 that resulted in 14 fatalities. One common factor identified in the West Pharmaceutical, CTA Acoustics, and Hayes Lemmerz investigations was that health and safety professionals had missed the potential hazard of the combustible dust. At West, an industrial hygienist hired to evaluate employee inhalation exposure to dusts did not include any mention of combustible dust in his report. Several loss prevention, risk management, and general liability insurance companies inspected the CTA facility, including a large property insurer that inspected the facility twice a year since 1997. Despite the inspections, none of the insurers identified phenolic resin dust as an explosion hazard after 1995. Hays Lemmerz management stated that various providers of risk insurance inspected the facility, yet none of the insurance carriers identified aluminum dust hazards as an issue of concern. In this presentation, we will focus on industries at risk for a dust explosion, conditions needed for a dust explosion, conditions indicating a potential hazard, and typical ignition sources. We also will present dust control measures and ignition control methods.

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The OSHA Asbestos Standards as an Example of Rulemaking

D. Crane, OSHA, Sandy, Utah.

Regulations aimed at protecting workers from exposure to asbestos reach back more than a century, although it has been known to be dangerous for at least two millennia. The most recent U.S. occupational protection standards, established by OSHA, are based on the experience of earlier standards, quantitative estimates of risk, legal decisions, mineralogical considerations, and engineering feasibility. We will show the statutory rulemaking process OSHA is required to follow and key points along the timeline of OSHA's asbestos standards.

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Light Alloy — Welding Fumes Exposure in Ship Building

D. Cottica, E. Grignani, Fondazione Salvatore Maugeri, Padova, Italy.

In ship-building construction, the use of light-alloy materials has increased; these alloys contain some toxicologically significant metals that during the welding operations contribute to worker exposure. To control the exposure to workers the factory management worked out a risk assessment of the workers' exposure to welding fumes during training in controlled situations, in the so called "hot chamber," and during ship construction in less-controlled situations. Environmental and biological monitoring was worked out. The materials contents percents are as follows: Cu 0,1; Mg 5,5; Mn 1,0; Cr 0,25; Ti 0,2; Be 0,0008; Al to 100%. The instruments used during the workers activities were circular saw, lapping-wheel, and MIG welding machine. All the welding positions have localized aspiration. The potential chemical risks we measured and the methods: welding fumes OSHA ID 125D; Cu, Mg, Mn, Cr, Ti, Be, Al, NIOSH 7300; Cr ^{VI} NIOSH 7600; ozone OSHA ID214; NO_2 NIOSH 6014. Biological monitoring aimed to measure the urinary content of Cu, Cr, and Mn by ICP-MS at the beginning of the week, before and after the workshift. Environmental concentrations in the respiratory zone were very low compared with the ACGIH TLV. Biological monitoring confirmed the environmental measurements. Two "anomalous" results were explained - one due to probable contamination of the sample, the other due to the welder's inexperience. The exposure of the workers to chemical agents during the use of light-alloy materials during ship-building activities is lower than the respective TLV proposed by ACGIH. The biological monitoring of metals in urine confirms the results. Looking at the results in the "hot chambers" and in the ship, the influence of "dust" on the welding fumes concentrations seems to be significant.

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DNEL (Derived No-Effect Level) Values for Formamide and *N,N*-Dimethylformamide

A. Jankowska, S. Czerczak, Nofer Institute of Occupational Medicine, Lodz, Poland.

New maximum admissible concentration (MAC) value documentations for two derivative substances have been compiled in Poland. Formamide and *N,N*-dimethylformamide are widely used as industrial solvents. Both are used in markers and pens and in the manufacturing and processing of plastics and drugs. *N,N*-dimethylformamide is used especially in artificial leather manufacturing. Respiratory tract and skin are the major routes of occupational exposure to these substances. MAC value for formamide was estimated from NOAEL based on 2-week inhalation study on rats. The critical effects were morphological changes in blood and kidney damage. The NOAEL was 184 mg/m^3 (100 ppm). The MAC value was set at 23 mg/m^3 (12.5 ppm). Substance notifications Sk and Ft (substance absorbed through the skin and substance toxic to fetus, respectively) were proposed in the Polish MAC list. Current Polish MAC value for *N,N*-dimethylformamide is 10 mg/m^3 (3.3 ppm). The substance is specified in the Polish MAC list as Sk, Ft and I (irritating substance). The MAC value was estimated from NOAEL based on 2-year inhalation study on rats. The critical effects were systemic effect on liver. The NOAEL was 75 mg/m^3 (25 ppm). It was proposed to leave the existing OEL value unchanged. STEL of 20 mg/m^3 (6.6 ppm) and biological exposure index values of 15 mg *N*-methylformamide/L urine were proposed. According to the REACH regulation, derived no-effect level (DNEL) values for both substances are proposed. Appropriate assessment factors were applied. Worker $DNEL_{long\text{-}term}$ values for inhalation exposure were estimated at 2.4 mg/m^3 (1.3 ppm) for formamide and 6 mg/m^3 (2 ppm) for *N,N*-dimethylformamide. Different MAC and DNEL values result from the application of different methodological approaches, as demonstrated.

Poster Session 404

Tuesday, June 2, 2009, 1:00 p.m.–3:00 p.m.

Aerosols

Papers 347–350

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Use of Mathematical Modeling to Predict Exposures Associated with the Use of an Aerosol Spray Product

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A number of studies have been published recently regarding the use of mathematical modeling as a tool for evaluating exposures to bulk solvent products. However, a survey of the scientific literature failed to reveal any studies that utilized mathematical modeling to evaluate exposures during the use of solvent aerosol spray products. Volatile organic compound (VOC)-containing solvent aerosol spray products are widely used both at work and in the home. A recently published article evaluated occupational exposures associated with the use of a nonchlorinated solvent aerosol spray product in the vehicle repair industry. Repair technicians were found to use the products in spray bursts lasting 2 to 90 seconds, resulting in total VOC task exposures of 6 mg/m^3 to 269 mg/m^3. The objective of our study was to use the data collected in the published article to determine the predictive ability of the near-field far-field mathematical model in assessing exposures during the use of a VOC containing solvent aerosol spray. Data from the published study, including product use rates, work space size and ventilation, and breathing-zone airflow rates, were incorporated into the near-field far-field model. This air modeling provided reasonably accurate estimates of the measured personal breathing-zone VOC concentrations, and suggests that the use of the near-field far-field model may be a useful tool in evaluating exposures under these conditions.

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Use of Foam to Reduce Particle Bounce in Marple Cascade Impactor

C. Chan, S. Huang, C. Chen, National Taiwan University, Taipei, Taiwan; Y. Kuo, Chung Hwa University of Medical Technology, Tainan, Taiwan; C. Chen, Institute of Occupational Safety and Health, Taipei, Taiwan.

Marple cascade impactors fractionate airborne particles according to aerodynamic size, thereby establishing their size distribution. One inherent problem is particle bounce off the collecting plates, which increases wall losses and also gives a biased size distribution. This study redesigned Marple impactors with a porous foam plate to reduce bounce but retain the original 50% cut-off point. Adaptors were used to hold the foam filter at the same nozzle-to-plate distance as the original design. The heights of the foam filters and holders varied from 1.5 mm to 3 mm. Foam filters of different porosity ranging from 45 ppi to 110 ppi were used to study the porosity effect. An ultrasonic atomizing nozzle was used to generate challenge aerosols, and a TSI aerodynamic particle sizer was used to measure the aerosol number concentrations and size distributions upstream and downstream of the impactors, to obtain the separation efficiency curve as a function of particle size. The results showed that thickness of foam is an important parameter of cut-off size. For example, the fifth stage of Marple cascade impactor originally has a 50% cut-off size of 3.5 µm. The insertion of the foam filter caused the cut-off size to increase with the foam thickness. This is because the porous structure of foam provides extra space for the incoming impaction flow. This cut-off size discrepancy decreased with increasing foam porosity. For instance, the fifth stage regained the same cut-off size of 3.5 µm when the porosity increased up to 110 ppi. However, the slope of the separation efficiency curve was not as sharp as the original design because of the filtration effect. The foam substrate also has higher loading capacity when compared with PVC and MCE substrates coated with silicon oil.

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Development of a Louver Window Electrostatic Precipitator

C. Lin, S. Huang, C. Chen, National Taiwan University, Taipei, Taiwan.

The purpose of this study was to design a louver window electrostatic precipitator (ESP) that can both prevent pollutants from entering and shade the indoor area. This ESP was composed of a stainless steel discharge electrode with a diameter of 0.3 mm and an aluminum plate with a width of 2 mm. Particle number concentration and size distribution data obtained in power-on and power-off modes were used to evaluate the collection efficiency of the ESP. A DC power supply with positive polarity energized the ESP and connected with a watt gauge. An energy quality index was calculated to evaluate the energy efficiency of the ESP with varying wire positions, collection plate lengths and collection plate angles. A constant output aerosol generator was used to generate challenge aerosol particles. A scanning mobility particle sizer was used to measure the aerosol number concentrations and size distributions upstream and downstream of the ESP. The results showed that aerosol penetration through this ESP decreased as the wire and collection plate position became increasingly asymmetrical and interfered with the field strength. A longer collection plate length had lower penetration up to a limit. With a fixed flow rate and applied voltage, the field strength and air velocity increased with increasing angle. This resulted in changing the particle penetration and energy quality. The optimal design of this louver-type ESP had a collection length of 6 cm and a wire position symmetrical with the collection plates. For practical use, the field strength should be kept as low as possible at a reasonable particle penetration. When the louver was angled, fixed field strength was more important than fixed applied voltage due to a resulting low energy quality.

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A Comparison of Cotton Dust Concentrations Measured by Three Dust Samplers

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This study was undertaken to compare the performance of three dust samplers for collecting cotton dust fibers. For this study, three dust samplers, including a Vertical Elutriator (VE), the Total Dust Method (TDM) using 37-mm cassette, and the Institute of Occupational Medicine (IOM) sampler were selected. A total of six cotton mills and four towel factories were investigated. When measured by VE, the GM for cotton dust was 0.19 mg/m^3,which was less than the current TLV of 0.2 mg/m^3. But when measured by TDM and IOM at the same locations, the GMs were 0.37 mg/m^3 and 0.63 mg/m^3, respectively. In Korea, most industrial hygienists use the TDM for cotton dust measurements, and the results were compared with either the TLV for cotton dust or the particulates not otherwise classified of 10mg/m^3 for making decisions. The results of this study clearly showed that past cotton dust measurements and decisions made with such results were not correct. We suggest that VE should be used where cotton dust is generated and the TLV of 0.2 mg/m^3 for cotton dust be applied.

Indoor Environmental Quality

Papers 351–354

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Office Cleaners — Chemical and Biological Hazards at Work

M. Szewczynska, M. Posniak, M. Golofit-Szymczak, National Research Institute, Warsaw, Poland.

Cleaning is a generic job, carried out in all industry groups and all workplaces by more than three million employees working as cleaners in all European countries,. Therefore, the task of identifying the potential chemical hazards in the cleaning work is of great importance and significance. Chemical risk covers exposure resulting from both the presence of chemical substances in dirt, dust, soot particles, and aerosols, and on the other side, chemical ingredients of products that the cleaning workers use to remove dirt, dust, or grease from surfaces to be cleaned. These chemicals can cause different types of toxicity to people carrying out the cleaning tasks, and a wide spectrum of exposures to chemical agents with resulting health problems, such as allergies, eczema, and asthma, were reported among this group of workers. The aim of this study was to identify chemical and biological hazards present in workplace air during the most common activities of a cleaning worker. Research was carried out on selected groups of office cleaners in Poland. A questionnaire survey was carried out to recognize the opinions and feelings of workers concerning their working environment, potential knowledge about chemical hazards that they might be exposed to, and the preventive measures they could undertake.The first qualitative results indicated the presence of several groups of chemical substances,such as volatile organic compounds, aldehydes, and ketones (including formaldehyde), in workplace air during different cleaning activities, with or without application of cleaning products of a known composition. Samples for chemicals identification were taken individually during the shift of a cleaner on different types of sorbents and filters and analyzed chromatographically by high performance liquid chromatography with spectrophotometric (UV-VIS) detector or gas chromatography with tandem mass spectrometry or flame ionization detector.

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Measurement of Biomarkers of Fungi and Bacteria in Floor Dust from Three Public Schools

J. Park, J. Cox-Ganser, National Institute for Occupational Safety and Health, Morgantown, WV.

Results of culture methods provide useful qualitative information on viable fungi and bacteria, but may only represent a small proportion (<1-5%) of microbial flora in samples. To account for this limitation, biomarkers have been used to assess total fungal or bacterial biomass. There is as yet little data on biomarker levels in indoor environments. We measured ergosterol and (1→3)-β-D-glucan as fungal biomarkers, endotoxin and muramic acid as bacterial biomarkers, as well as culturable fungi and bacteria in floor dust from three public schools with no current indoor environmental concerns. We vacuumed dust from the edges of the room floors and from teachers' workstations (n=125). Ergosterol and muramic acid were quantified by gas-chromatography with tandem quadrupole mass-spectrometry; endotoxin and (1→3)-β-D-glucan by Limulus amoebocyte lysate assay. The geometric mean (GM) of total culturable fungi was 85,600 cfu/g (range=5700-5.8 × 10^6), and xerophilic fungi (*Penicillium* and *Cladosporium*) were the two predominant genera. Levels of ergosterol (GM=1.3, range=0.2-10 µg/g) and (1→3)-β-D-glucan (56, 8-318 µg/g) were moderately correlated with total culturable fungi (r=0.50 and 0.39, respectively; $p < 0.05$). Ergosterol was only moderately correlated with glucan (r=0.41, $p < 0.0001$). GMs of total, gram positive, and gram negative bacteria were 1.2 ×10^6 cfu/g (range=3.8 × 10^4-4.7×10^7), 6.0 × 10^5 (range=7100-5.4 × 10^7), and 5.7 × 10^4 (range=700-1.2 × 10^7), respectively. There were weak correlations between muramic acid (GM=7,500 ng/g, range=2300-15,000) and total bacteria (r=0.30), and endotoxin (GM=69,000 EU/g, range=13,000-3.2 × 10^5) and gram negative bacteria (r=0.35) ($p < 0.05$). Geometric standard deviations of biomarker measurements were smaller (range=1.4-2.3) than those of culturable fungi and bacteria (3.7-6.5). The greater precision of the biomarker measurements may indicate their usefulness in epidemiological

studies. Considering the moderate to weak correlations found, the use of biomarkers in addition to culturable microbes may provide a more comprehensive understanding of exposure to bioaerosols in indoor environments.

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Quality Control of Multiplex Arrays for Allergen Detection

S. Filep, B. Smith, R. Duncan, M. Chapman, E. King, Indoor Biotechnologies Inc., Charlottesville, VA.

Quantitative microarrays have recently been developed that enable multiple indoor allergens to be measured in a single test. Each allergen is tested under the same assay conditions in the microarray, which should improve standardization and reproducibility. We monitored the quality control of a multiplex array for indoor allergens (MARIA) by comparing the values of high and low positive control samples over time. The MARIA measures eight common indoor allergens: Der p 1, Der f 1, Mite Group 2, Fel d 1, Can f 1, Rat n 1, Mus m 1, and Bla g 2. Each MARIA kit contains two positive QC samples: the high sample contains 0.7 - 7.0 ng/mL(depending on the allergen), and the low sample contains 0.2 -1.7 ng/mL. We compared the CVs of the high and low QC samples over a three-month period (24 analyses) for all eight allergens used in MARIA. The assays were performed by a single operator. Mean CVs for the high and low samples, respectively, were as follows: Der p 1, 13.3:13.6; Der f 1, 11.2:12.5; Mite Group 2, 14.4:20.2; Fel d 1, 13.7:25.5; Can f 1, 15.9:19.1; Rat n 1, 14.6:17.6; Mus m 1, 12.4:16.7; Bla g 2 13.1:17.1. The CVs for the high QC samples were consistently lower than for the low QC samples. These data show that for most allergens CVs on the QC samples were <20%. The internal high and low QC samples used in MARIA are useful for validation and quality control purposes, and should improve the reproducibility of allergen measurements used as part of indoor air quality investigations.

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TEM Characterization of Asbestos Fibers from Various Building Materials

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A variety of building materials were analyzed for different asbestos fibers by using the TEM X-ray analysis method. Major building materials were from roofing material, ceiling tiles, stucco, mastics, acoustic spray, floor tiles, vinyl flooring, and insulation materials. Chrysotile was the major asbestos type associated with maximum number of samples, with a frequency of 95% occurrence. Other asbestos types were anthrophyllite, amosite, actinolite, crocidolite, and tremolite present at the frequency of 5% or less from insulation and other materials. Analysis of X-ray graphs and morphological characters from direct examination on TEM were compared and characterized to confirm the identity of these fibers. TEM technique was proved to be more dependable when a very small quantity of these fibers were present.

Nanotechnology

Papers 355–356

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Guidance for Preparation of Good Material Safety Data Sheets (MSDS) for Engineered Nanoparticles

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An increasing number of nanomaterial products and materials are becoming commercially available. These include nanoscale powders, solutions, and suspensions of nanoscale materials, as well as composite materials and devices having a nanostructure. Chemical manufacturers and importers are required to perform hazard determinations and complete material safety data sheets (MSDSs) [OSHA Hazard Communication Standard (29 CFR 1910.1200)] on the chemicals (including engineered nanoparticles) they produce or import. MSDSs specific to engineered nanoparticles were obtained from more than 40 manufacturers and were reviewed for accuracy of information as it pertains to hazard identification, exposure controls, and toxicological information. The quality of information on the MSDSs varied from good to those in need of significant improvement. Some manufacturers had unique disclaimers for their products. Many MSDSs contained the NIOSH-recommended exposure limit, and the OSHA permissible exposure limit for the bulk material (such as graphite) when the material was not graphite, but rather carbon nanotubes. Referencing the bulk chemical exposure limit without any further information may be misleading to the users, since there are published studies demonstrating that the toxicity of ultrafine or nanoparticles is greater than that of the same mass of larger particles of the same chemical composition. Preparation of MSDSs for engineered nanoparticles should include an annual literature search for updated toxicity, safety, and environmental information. MSDSs should include notation of which of the chemicals (ingredients) are nano-sized; notation that the characteristics of nanoparticles may be different from those of the larger particles with the same chemical composition; and notation that some nanoparticles may initiate catalytic reactions due to their nano size that would not otherwise be anticipated based on their chemical composition alone.,The Global Harmonization System should be consulted during preparation of new safety data sheets to ensure consistency when this format is adopted in the United States.

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A Mechanistic Model Prototype for Nanotoxicity Risk Analysis

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There is widespread belief that nanoparticles, extremely small particles with at least one dimension of less than 100 nanometers, may pose a health risk greater than that of larger particles of the same material. This research effort included building a physiological mechanistic model (cause and effect) of how exposure to nanomaterials affects the human body. A system dynamics approach was used (i.e., focus on causal behavior, defining system structure, closed-loop perspective). The resulting product is a physiologically based pharmacokinetic (PBPK) model, which includes a system of differential equations in time and state variables representing concentration of nanomaterial in various tissue groups. The model captures theorized mechanisms presented by exposures to nano-sized materials. For example, PBPK models often include assumptions of instantaneous equilibration of the concentration of a chemical of concern across the barrier between blood and an affected organ. Instead, this model includes a less-than-instantaneous assumption, e.g., a time-based transfer coefficient. Complex transport phenomena at the cellular level were factored in also, resulting in a PBPK model representing nanoparticle transport through multiple exposure pathways, with uptake in several organs/tissue groups. The ultimate contribution is the rigorous treatment of transport phenomena from first principles of transport processes as they pertain to the transport of nanoparticles within mammalian physiology. Once finalized, these individual analyses can then be inserted into the classical structures of PBPK models, and therefore can serve as useful tools for risk analysis in the absence of exposure standards for nanoparticle exposures.

Occupational Health

Papers 357–359

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Formaldehyde New MAC Value in the Working Environment in Poland and DNEL Evaluation

M. Kupczewska-Dobecka, S. Czerczak, Nofer Institute of Occupational Medicine, Lodz, Poland.

In 1989 in Poland, the maximum admissible concentration (MAC) value for formaldehyde in the working environment was set to 0.5 mg/m^3 as time-weighted average value and 1 mg/m^3 as short-term value. This value was based on the irritating effect of formaldehyde. In Poland, because of its carginogenic activity, formaldehyde has been classified to category 3, i.e., a substance which causes concern owing to its possible carcinogenic effect to humans, but for which the available information is not adequate for making a satisfactory assessment. In 2006, the International Agency for Research on Cancer classified formaldehyde as carcinogenic to humans, group 1. Three malignant tumor types: nasopharyngeal cancer, leukemia, and sinonasal cancer were taken into account in the assessment of possible carcinogenic activity of formaldehyde to humans. The Group of Experts on Chemical Agents in Poland revised former maximum admissible occupational exposure value, taking into account fresh data. In 2008, MAC value of 0.24 mg/m^3 (as time-weighted average) and MAC-STEL of 0.48 mg/m^3 were proposed. The irritating activity to the nasal mucosa and eyes was adopted as the critical effect. A NOAEL (so-called “,objective”) determined during experiments on human volunteers was used to calculate the MAC value. Derived no-effect level (DNEL) was also estimated. Nasopharyngeal cancer is not expected when the specified MAC value is not exceeded. Attempts to determine the risk of developing additional nasopharyngeal cancer in humans show that the risk of tumor in case of concentrations below 1 mg/m^3 is small. According to the most recent assessments, the risk of developing additional nasopharyngeal cancer in people

exposed to formaldehyde at 0.37 mg/m^3 for 40 years is 10^{-7} to 10^{-8}.

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New Occupational Standards for Chemical Substances in Poland

S. Czerczak, M. Kupczewska Dobecka, Nofer Institute of Occupational Medicine, Lodz, Poland.

In 2008, The Expert Group of Chemical Agents at the Nofer Institute of Occupational Medicine in Poland proposed maximum admissible concentration values (MAC) for 14 new harmful chemical agents in the work environment. The substances and their CAS numbers are as follows: 2-methoxyethanol (109-86-4); 2-methoxyethyl acetate (110-49-6); 2-ethoxyethanol (110-80-5); hydrogen sulphide (7783-06-4); 1-methyl-2-pyrrolidone (872-50-4); N,N-dimethylformamide (68-12-2); 2-ethoxyethyl acetate (111-15-9); carbon disulphide (75-15-0); phenol (108-95-2); methyl isocyanate (624-83-9); hydrogenated terphenyls (61788-32-7); but-2-yno-1,4-diole (110-65-6); tributhyltin(IV) compounds (TBTO as Sn), 4-aminotoluene (106-49-0). According to the type of biological effects, the following categories of MAC values were used:

Time-weighted average concentration for a conventional 8-hour workday and a workweek, defined in the labor code, to which workers may be exposed during their entire working life, without any adverse effects on their health (also when retired) or that of the next generations.

Short-term exposure limit is an average concentration to which workers may be exposed without any adverse health effects if it does not last longer than 15 minutes and does not occur more than twice during a workday and at intervals not shorter than 1 hour.

Ceiling concentration, which because of the threat to workers' health or life, should not be exceeded, even for an instant.

In 2007, there were 495 MAC values for chemical substances in Poland (The Ordinance of the Minister of Labour and Social Policy). Industrial plants are obliged to estimate concentrations of the toxic substances specified in the list of MAC values at a frequency and in the scope required to determine the degree of workers' exposure, and to keep records of those estimates. An improvement of working conditions is the aim of those activities. W e willshow MAC values with their endpoints and key studies for 14 substances discussed in 2008.

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Identifying Possible Work-Related Lung Cancer in the Clinical Setting — Getting Started

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Common estimates suggest that between 9% and 15% of lung cancer may be work related. However, a minority of possible work-related lung cancer is reported to workers' compensation boards. Factors that have been identified in the literature as leading to under-reporting of occupational disease include lack of knowledge and skills on the part of clinicians, time constraints, administrative bureaucracy of the workers' compensation process, and lack of clear referral routes. This study was designed as a pilot study to test the feasibility of using a standardized exposure questionnaire and to ascertain the barriers and facilitators to the practical implementation of an exposure assessment tool. The 29 patients with primary lung cancer attending a lung cancer clinic completed a focused exposure questionnaire, and 17 of these patients agreed to an occupational hygiene interview, as well. Seven clinicians were interviewed to identify barriers and facilitators to the practical implementation of an exposure assessment tool. Workers reported a number of possible exposures that could be associated with lung cancer, the most common of which was asbestos. In general, the occupational hygiene interview was consistent with the worker-completed questionnaire, but the hygienist, by asking more detailed questions regarding specific exposures, tended to identify fewer relevant exposures. Nonetheless, 41% of those interviewed were thought appropriate for submitting a workers' compensation claim and referral to an occupational health clinic. Clinicians noted that though they knew of some occupational causes of lung cancer, they did not obtain an occupational history in a consistent way or pursue workers' compensation. Key barriers included lack of knowledge, time constraints, administrative bureaucracy, and lack of clear referral sources. Templates for occupational history taking, patient completion, easily accessed information about what jobs and sectors are associated with which exposure, and easy referral routes were identified as possible facilitators.

Personal Protective Clothing and Equipment

Papers 360–362

360

Physiological Consequences of Boot Weight and Sole Type in Men and Women Firefighters

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Most firefighters wear rubber boots or lighter leather boots with either Goodyear welt or cement soles. A 5% to 12% increase in oxygen consumption per kg of weight added to the foot has been observed; however, this increase may depend on gender, boot weight, sole type, and whether subjects are wearing additional protective clothing/equipment. To determine the effects of two welt- (GW) and two cement-soled (CM) boot models on firefighters' metabolic and respiratory variables during simulated firefighting tasks, 13 women and 14 men, while wearing full turnout clothing, a 10.5-kg backpack, gloves, a helmet, and a randomly assigned boot model walked for six minutes at three mph on a treadmill while carrying a 9.5-kg hose and climbed a stair ergometer for six minutes at 45 steps per minute. Minute ventilation (VE), oxygen consumption (VO_2), CO_2 production (VCO_2), and heart rate (HR) were measured, and the data from minute six were used for analysis. Means for the GW (2.57 kg for men, 2.42 kg for women) and CM (2.75 kg for men, 2.44 kg for women) models most closely matched for weight were compared for men and women for each task. For men, HR was 9.0% greater for GW during stair climbing. VO_2 was 2.1% greater, and HR was 6.9% greater for GW during treadmill walking. For women, VO_2, VCO_2, and VE were 5.0, 5.8, and 10.5% greater, respectively, for GW during stair climbing. VO_2, VCO_2, and VE were 7.4, 6.4, and 9.5% greater, respectively, for GW during treadmill walking. These data demonstrate that, in addition to boot weight, sole type may be important in determining the physiological consequences of wearing firefighter boots.

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Worker Compliance with Glove Recommendations Following the Diagnosis of Hand-Arm Vibration Syndrome (HAVS)

I. Kudla, L. Holness, R. House, St. Michael's Hospital, Toronto, ON, Canada; J. Boudreau, A. Czettisch, C. Vermeulen, Y. Dai, S. Switzer-McIntyre, University of Toronto, Toronto, ON, Canada.

Hand-arm vibration syndrome (HAVS) is a common occupational disease. The use of protective gloves can benefit workers in prevention and remediation of HAVS. However, there is limited research exploring workers' compliance with medically recommended glove use and the factors that influence compliance. The purpose of the study was to determine the compliance rate of protective glove use following medical recommendation after the diagnosis of HAVS. A two-phased, cross-sectional approach was used. Charts of HAVS patients seen in 2007 at the Occupational Health Clinic, St. Michael's Hospital, were reviewed to identify workers who received recommendations for glove use. A total of 170 workers were identified and mailed a questionnaire. A subset also had a telephone interview. Of these workers, 28 responded. All the workers were male, and two thirds of the workers were between 45 and 65 years of age. The most common occupation was pipefitter/steamfitter. Compliance with glove recommendations for glove use was 47%. Reasons stated for noncompliance included discomfort, difficulty with gripping and dexterity, lack of availability, cost, workplace environment, and endangerment of personal safety. Approximately 50% reported the employer paid for their gloves, 30% paid for the gloves themselves, and 20% were paid for by the insurer. Themes identified from the telephone interviews included lack of education about hazards and prevention and a belief that the use of anti-vibration gloves should be mandatory and regulated. Reasons reported for using gloves related to a decrease in symptoms with use, whereas reduced dexterity, lack of durability, and lack of availability were cited as reasons for nonuse. The compliance rate of medically recommended protective glove use was less than ideal. Lack of education regarding the importance of protective glove use and characteristics of the protective gloves themselves were the most significant barriers to compliance. Efforts to increase worker compliance in using protective gloves are needed.

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WITHDRAWN

Physical Agents

Papers 363–368

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Humidex-Based Heat Stress Prevention

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The construction industry needs a simple and accurate method of using easily obtainable measurements to assess heat stress. The Construction Safety Association of Ontario, other health and safety associations in the province, and Ontario's Workplace Safety and Insurance Board developed a simple approach for using the humidex (Canadian heat index) to determine workplace responses to heat stress. This approach was based on previous work done by the Occupational Health Clinics for Ontario Workers. The humidex-based plan is an alternative to measuring and interpreting WBGT results. The plan has five simple steps: (1) train workers, (2) measure temperature and humidity, (3) look up the humidex value on a chart, (4) adjust the value for radiant heat and clothing, and (5) determine workplace response based on the humidex reading. The simplicity of the humidex approach has enabled the construction industry to conduct heat-related hazard assessments effectively, with confidence, and without technical expertise or expensive equipment.

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Evaluating the Measurement of Worker Exposure to Ultrasonic Sound

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Ultrasonic welding is the preferred system for linking polymeric materials. Ultrasonic welders operate at a distinct frequency, often 20,000 Hertz, 20 kHz. Reports suggest that the relationship between exposure and hearing loss for the 10 kHz to 20 kHz range should be similar to that for the 2 kHz to 10 kHz range. Little of the sound above 10 kHz is measured by the ANSI S1.25-1991 Class/Type 2 personal noise dosimeters generally used to evaluate noise exposures. Class/Type 1 meters measure a much higher range of frequencies. An assessment was made to determine if, during ultrasonic welding, sound-pressure level measurements by Type 1 dosimeters are the same as Type 2 dosimeters. Type 1 and Type 2 noise dosimeter microphones were placed adjacent to each other on the shoulder of employees during manufacturing, using 20 kHz ultrasonic welders. Sound-pressure levels were measured and logged, at one-second intervals, to provide personal full-shift exposure assessments. Three sets of exposures were measured each day for five days. The Type 1 and Type 2 sound-pressure levels were compared using Student t-Test for paired data. There was no significant difference between the Type 1 and Type 2 dosimeter measurements.

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Effects of Location and Time Period on Heat Stress in a Taiwan Precision Casting Plant During Summer

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Precision casting is a high-technology process with high added value suitable to be adopted by Taiwan's forging industry, since the demand for factory space is less than regular forging operation. During melting and sintering precision casting processes, the heat stress generated from the metabolic heat plus the environmental heat (high temperature and radiation from the sintering furnace) may exceed the heat tolerance of workers and result in heat-induced disorders/illnesses. The aim of this study was to measure the wet bulb globe temperature (WBGT) from 8 a.m. to 2 p.m. in different locations in a Taiwan precision casting plant during summer (July and August). The evaluation can be used to institute prevention and control measures for heat-related health effects. In a typical working day, a team of three acclimatized workers performed 12 cycles of melting and sintering processes. The duration to complete each cycle was 30 minutes, where the work/rest regimen is 50% work and 50% rest. The locations of the environmental heat measurements were made at 2 (near), 12 (middle), and 22 (far, outdoor) meters away from the sintering furnace. Time period was divided into 8-10 a.m. (P1), 10-12 a.m. (P2), and 12-2 p.m. (P3). The ANOVA results indicate that the location factor is statistically significant ($F=138.86$, $p < 0.001$). The Tukey's post hoc analysis shows that all three locations differed significantly ($p < 0.05$) from one another where WBGT value is highest at the near (32.5^0C) location, followed by middle (29.0^0C), and far (28.1^0C) locations. For this moderate workload (300 kcal/hr), the WBGT index in the near location exceeded the ACGIH TLV. indicating that prevention and control measures should be implemented. Time period is found statistically significant ($F=19.26$, $p < 0.001$) where the WBGT values are highest in P2 (30.6^0C) and P3 (30.1^0C) periods, followed by P1 (28.9^0C) period.

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Noise Measurements in the Silicon Carbide Industry

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Induced hearing loss can be found in individuals exposed to high sound pressure levels. Silicon carbide industry operators, mainly those who work at the crushing area, are part of this population being exposed to different noise sources and frequency spectrum. The use of individual hearing protectors is a routine basis in the companies due to the difficulty of engineering control measures implementation. Therefore, the objective of this study was to evaluate the sound pressure levels of the equipment in the silicon carbide crushing area and recommend noise control strategies to reduce the noise levels. The noise exposition was measured in two operator functions, and the time-weighted average (TWA) was obtained. The TWA was above the tolerance limits, so engineering, administrative, and individual control measures had to be implemented. The performance of two types of hearing protectors used was evaluated - ear shell and earplug - comparing their ear attenuation at several noise frequencies to sound pressure levels in the crushing area. The conclusion was that both hearing protectors are effective for high and medium frequencies, therefore, less attenuation for low frequencies. Despite the earplug attenuation being higher than the ear shell, the recommendation was for ear shell use due to better hygiene conditions face the characteristics of the process. The measurements had been made for three different conditions: with the crushing area equipment operating individually without feeding raw material in the circuit; with all equipment operating simultaneously without feeding raw material in the circuit; and with all equipment operating simultaneously with feeding raw material in the circuit. The frequency spectrum results identified that the equipment in the crushing area generates high sound pressure levels in a wide frequency range. Therefore, control procedures for noise attenuation in low, as well as in high, frequencies were proposed.

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Evaluating Heat Stress and Relationship Between Effective WBGT and Outdoor Weather Conditions in a Glass Manufacturing Plant

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An assessment for heat stress was conducted during a one-month period in 2006 in a glass manufacturing plant to evaluate heat stress for operators in the six forming lines and derive the "triggering" temperatures in terms of local outdoor temperature and Humidex values for the start of a heat relief plan. The effects of outdoor wind direction and spot cooling or fans on the WBGT (wet-bulb globe temperature) were also examined. Spot and continuous measurements of WBGT using portable heat stress monitors were made in various operator's position of each forming line. Work activities/rest and their duration, work clothes worn, and ventilation were monitored during a typical work shift. Local weather data were monitored using a modular weather station. Using work activities, duration, estimated metabolic rate for work activities, and clothing adjustment factor, multitask analyses were conducted for each forming line. Then, the time-weighted average of metabolic rate and effective WBGT (time-weighted average of WBGT) were calculated. Data analysis was performed to correlate calculated effective WBGT measurements to local outdoor temperature or Humidex readings. Screening temperatures for acclimatized/unacclimatized workers were derived using a linear relationship between outdoor temperature and WBGT. A good linear relationship was found in the forming lines located in the perimeter area, whereas a poor linear relationship was found in the interior forming lines. Using the average difference in effective WBGT readings between perimeter forming lines and interior forming line where the highest WBGT was observed, the derived triggering temperature, based on the data obtained in the perimeter area, may be used in a heat relief program for the protection of workers from heat stress.

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Noise Map Construction

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Area noise maps are an integral part of managing hearing conservation programs and implementing noise engineering control projects. Area noise monitoring allows industrial hygienists to identify the most critical sources of noise in a workplace and focus engineering efforts to reduce noise exposure. This poster will show a simple and effective method of constructing two-dimensional, colored noise maps, using commonly available noise monitoring equipment, presentation, and statistical software. Area noise levels can be collected using most any type of sound level meter equipment. Measurements can be documented along a grid drawn on a map of the area, which is used to create a contour map. The number and density of measurements required for each map will depend on the noise level gradients and physical barriers within a given area. The color-contoured noise maps facilitate better understanding and communication of potential noise sources, thereby driving further noise exposure risk reduction. This poster will demonstrate one method of making a color-contour noise map, using examples of before and after noise control implementation.

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