

# Abstract Book

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# 2016



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## PS401

### Poster Session 401

Monday, May 23, 2016, 10:00 AM - 12:00 PM

## SR-401-01

### Collection Efficiency of Membrane Filters for Respirable Size-Selective Sampling

*J. Soo, T. Lee, M. Kashon, and M. Harper, CDC/NIOSH/ HELD/EAB, Morgantown, WV*

**Objective:** To measure the collection efficiency of commercial air sampling filters with polydisperse sodium chloride (NaCl) under different filter pore sizes and sampling flow rates for respirable size selective samplers.

**Methods:** Collection efficiency experiments were conducted with four different 37 mm diameter membrane filters: mixed cellulose ester (MCE; 0.45, 0.8, 1.2 and 5 µm pore sizes), polycarbonate (0.4, 0.8, 2 and 5 µm pore sizes), polytetrafluoroethylene (PTFE; 0.45, 1, 2 and 5 µm pore sizes), polyvinyl chloride (PVC; 0.8 and 5 µm pore sizes) and silver membrane (0.45, 0.8, 1.2 and 5 µm pore sizes) with polydisperse NaCl in the size range of 10-400 nm. Test aerosols were nebulized and introduced into a calm air chamber through a diffusion dryer and aerosol neutralizer. The testing filters were mounted in a conductive polypropylene cassette within a metal testing tube at the flow rate varied between 1.7 and 11.2 l min<sup>-1</sup>. A Scanning Mobility Particle Sizer (SMPS, Model 3936, TSI, Inc.) was used to count number particle concentration before ( $C_{in}$ ) and after ( $C_{out}$ ) test filters. The different pressure across the filter was measured with a digital manometer. The total number of runs was 1044 (29 filter types with different pore sizes x 4 sampling flow rates x 3 filters x 3 replicates).

**Results:** In general, the collection efficiency varied with flow rate, pore size, and sampling duration. Collection efficiency and pressure drop increased with decreased pore size and increased sampling flow rate, but they differed among filter types and brand. The collection efficiencies of the MCE, PTFE

and PVC filters were > 92% under all test conditions while the collection efficiencies of the polycarbonate and silver membrane filters were in the range of 40.2 to 99.6% and 38.6 to >99.9%, respectively.

**Conclusions:** The present study confirmed that the MCE, PTFE and PVC filters have a relatively large collection efficiency for challenged nanoparticles much smaller than their nominal pore size and have significantly larger sampling efficiency than that of polycarbonate and silver membrane filters at large pore sizes. The collection efficiency of polycarbonate and silver membrane filters varied with flow rate, pore size, and time duration. Although collection efficiency increased with decreased pore size and increased flow rate so, also, did pressure drop across the filter.

## CS-401-02

### Respirable Manganese Exposures During Hand Grinding of Carbon Steel

*A. Sauter, Liberty Mutual Insurance, Waukesha, WI; A. De Guzman, Liberty Mutual Insurance Company, Woodbridge, VA*

**Situation/Problem:** Since the reduction of the Manganese TLV® in 2012, much of the focus has been in the welding process, since the fume generated is in the respirable range. Industrial hygiene sampling of Manganese has resulted in overexposures inside the welding helmet of typical welding process such as TIG, MIG and SMAW. An allied task to welding is grinding of metal in preparation for the weld and finish grinding after the weld has been made. This evaluation looks to determine if metal dust from hand grinding can result in overexposures to Mn in the respirable range. Preliminary IH sampling indicates there is a potential exposure to Mn in the respirable range based on our surveys.

**Resolution:** Sampling using parallel particle impactors (PPI) placed in hand grinder breathing zones was conducted. Isolated hand grinders were selected to limit interference from welding fume exposures.

**Results:** Sampling results ranged from 55% - 700% of the ACGIH® TLV®.

**Lessons learned:** Further studies are needed to better characterize and validate the exposure to Manganese containing particulate from grinding tasks.

### SR-401-03

#### A Cyclone for End of Shift Silica Measurement

*T. Lee, L. Lee, J. Soo, and M. Harper, CDC/NIOSH, Morgantown, WV; J. Hummer and E. Cauda, CDC/NIOSH, Pittsburgh, PA*

**Objective:** 1) To develop a respirable size selective sampler for direct-on-filter silica measurement at the End of Shift (EOS) using a portable Fourier transform infrared spectrometer, and 2) to determine its size selective sampling performance compared to international standards respirable convention.

**Methods:** A new cyclone, based on the concept of the GS3 respirable dust cyclone, was designed to use a 25-mm filter holder with an effective dust deposition diameter of approximately 8.5 mm. The new sampler (EOS cyclone) was constructed using a 3 dimensional printer loaded with ABS-M30 material. Sampling efficiency of the EOS cyclone was determined using polydisperse glass sphere particles and a time of flight real time direct reading instrument (Aerodynamic Particle Sizer). The test aerosol was generated with a fluidized aerosol generator and the aerosol was introduced into a calm air chamber. The EOS cyclone and a reference sampler were placed horizontally inside the chamber positioned at the same sampling plane. The flow rates of the reference sampler were the same as the test cyclone and the inlet diameter for the reference sampler was calculated so as to obtain a representative sample of the aerosol in calm air conditions. Five EOS cyclones were tested at flow rates of 1.1 and 1.2 l min<sup>-1</sup>. Using the bias map approach, the measured performance for the EOS cyclone was assessed against the respirable convention defined in American Conference of Governmental Industrial Hygienists (ACGIH®)/Comité Européen de Normalisation (CEN)/International Standards Organization (ISO).

**Results:** Sampling efficiency of newly developed EOS cyclone was determined. Average cut off diameters of the EOS cyclone at flow rates of 1.1 and 1.2 l min<sup>-1</sup> were 4.4±0.06 and 4.1±0.15 µm, respectively. Bias of the EOS cyclone ranged -4-10% at 1.1 l min<sup>-1</sup> and -16-4% at 1.2 l min<sup>-1</sup>. Coal mine dust was used to assess the deposition area on the filter; the preliminary assessment showed an area with an 8.7 mm diameter.

**Conclusions:** The newly developed EOS cyclone showed minimum bias compared to the international standard respirable convention with flow rates of 1.1 or 1.2 l min<sup>-1</sup>. The cyclone will be further investigated for direct on filter silica measurement with coal and non-coal mine dusts using a portable Fourier Transform infrared spectrometer.

### SR-401-04

#### Development and Validation of Sampling and Analytical Methods for Determination of Mold Spores Concentration in Settled Dust of Heating, Ventilation and Air-Conditioning systems (HVAC)

*M. Biyeyeme Bi Mve and M. Debia, Environmental and occupational health, University of Montreal, Montreal, QC, Canada; Y. Cloutier, N. Lacombe, and G. Marchand, Institut de recherche Robert-Sauvé en santé et sécurité au travail (IRSST), Montreal, QC, Canada*

**Objective:** The objectives of this project were to (1) evaluate a sampling method for dust in air duct surfaces and (2) compare analytical methods for the evaluation of mold content in the collected dust in HVAC.

**Methods:** Five dust generations were made in an exposition chamber mimicking a HVAC duct system. Twelve preweighed plates were placed on the horizontal surface of the chamber during generation. A modified 37-mm cassette with a pre-weighed PVC filter was used to collect the settled dust. Particles recovery percentages collected by the cassettes and those deposited on the filters were calculated for 54 samples. Once the sampling method has been optimized, ten other generations were performed with dust using different levels of mold spores. Sixty samples were analyzed with four methods for evaluation of fungal biomass: Beta-N-Acetylhexosaminidase assay (BNA) (modified Mycometer), Spore Counting Method (SCM) by direct microscopy, 18S-q-PCR assay and culture on Malt Extract Agar (reference method). The detection limit (DL), repeatability and reproducibility of each method were calculated

**Results:** For the dust generation samples, the recovery percentage between the pre-weighed plate and the cassette varied between 88 % and 100 % with a median at 99 % recovery efficiency. The recoveries obtained between the cassette and the filter varied from 65 % to 95 % with a lower median of 88 %. The median concentrations of spores/100 cm<sup>2</sup> measured in the contaminated dust samples were 10,000 for the SCM; 676,000 for the enzymatic BNA, 224,000 for the q-PCR and 10,000 CFU/100 cm

**Conclusions:** The new proposed sampling method showed very good dust collection efficiency. The PCR method is recommended due to its higher sensitivity and a better correlation with the culture reference method.

## SR-401-05

### Silica Exposure During Core Processing in Mining Exploration

*S. Kalenge, Occupational Cancer Research Centre, Cancer Care Ontario (CCO), Toronto, ON, Canada; V. Arrandale, Dalla Lana School of Public Health, University of Toronto, Toronto, ON, Canada*

**Objective:** Although, there is extensive research on occupational exposure in active (production phase) mines, there is limited information on the occupational exposure of workers during the exploration phase of mining. The aim of this study was to assess personal exposure to airborne particulates and crystalline silica in a core processing facility that was part of a mining exploration project in Northern Ontario, Canada.

**Methods:** Personal air samples were collected on pre-weighed 37mm PVC filters (5 µm) with 3-piece open-face cassettes attached to SKC aluminum cyclones. All samples were analyzed for respirable particulates using gravimetric analysis (NIOSH Method 0500) as well as respirable crystalline silica using Fourier Transform Infra-red spectroscopy (FT-IR) (NIOSH Method 7602). Time weighted average concentrations were calculated for respirable particulate, respirable quartz and respirable cristobalite/tridymite.

**Results:** Sixteen personal air samples were analyzed. Full shift respirable particulate exposure ranged from 0.069 to 2.24 mg m<sup>-3</sup> with a geometric mean (GM) of 0.28 mg m<sup>-3</sup> and a geometric standard deviation of 2.76. The Ontario exposure limit for respirable particulate is 3 mg m<sup>-3</sup>. Respirable particulate concentrations were significantly higher among workers in the core cutting area compared to the core logging area (GM 0.43 mg m<sup>-3</sup> vs. 0.088 mg m<sup>-3</sup>; p=0.02). No samples had detectible levels of cristobalite / tridymite. Full shift quartz exposure ranged from 3.3 to 55.4 µg m<sup>-3</sup> with a geometric mean (GM) of 6.53 µg m<sup>-3</sup> and a geometric standard deviation of 2.67. The Ontario exposure limit for respirable quartz is 100 µg m<sup>-3</sup>. Quartz concentrations were higher among workers in the core cutting and core sorting areas, as compared to those in the core logging area. No pairwise differences reached statistical significance.

**Conclusions:** Workers employed in core processing facilities as part of mining exploration activities are exposed to respirable particulates and silica. Although no individual measurements exceeded the Ontario occupational exposure limits, some personal exposures approached the limits among workers who were performing core cutting tasks. Exposure to respirable particulates and silica in mining exploration should be monitored as exposure controls may be needed.

## SR-401-06

### High Flow Rate Thoracic Size Selective Samplers

*T. Lee and M. Harper, NIOSH, Morgantown, WV*

**Objective:** To calibrate high flow rate thoracic size selective samplers (GK4.126 and FSP10), which can be used for dual fraction size selective sampling to measure the respirable and thoracic size fractions.

**Methods:** Six different sizes of monodisperse ammonium fluorescein aerosols were generated using a vibrating orifice aerosol generator. Airborne particles were collected

with samplers in a cylindrical calm air test chamber. After sampling, the fluorescent intensity was measured using a luminescence spectrometer. Because the size interval of the Aerodynamic Particle Sizer for particles > 8 µm is large (> 0.6 µm), projected area diameters of the monodisperse ammonium fluorescein particles were measured with a field emission scanning electron microscopy. At least 100 particles of projected area diameters were measured for each particle size. Equivalent volume diameter was calculated using average project area diameters. From equivalent volume diameter, an aerodynamic diameter was calculated with the particle's specific gravity and dynamic shape factor. Three repetitions with each sampler units were conducted at each size of particle size. The measured performance data for the cyclone was assessed against the thoracic target convention defined in American Conference of Governmental Industrial Hygienists (ACGIH®)/Comité Européen de Normalisation (CEN)/International Standards Organization (ISO).

**Results:** The measured cut off diameters (d<sub>50</sub>s) for the GK2.69, GK4.126 and FSP10 cyclones were 9.7, 9.8, and 10.9 µm, respectively. Bias maps for the cyclones were generated from the measured sampling efficiency compared to the ACGIH/CEN/ISO thoracic convention for a range of mass median aerodynamic diameter 1-30 µm with geometric standard deviation of 1.5-4. The GK2.69 cyclone was tested at a flow rate of 1.6 l min<sup>-1</sup> as a reference sampler for comparison and its performance was similar to that observed in a previous study. The estimated biases for the measured experimental GK2.69 cyclone performance compared with ACGIH®/CEN/ISO thoracic convention were negative up to 25 % while those of the GK4.126 and FSP10 cyclones were positive up to 7 and 11 %, respectively.

**Conclusions:** High flow rate cyclones normally used for respirable size selective sampling were calibrated to measure the thoracic size fraction. The recommended flow rates of GK4.126 and FSP10 cyclones for thoracic size selective sampling are 3.5 and 4.0 l min<sup>-1</sup>, respectively. Higher flow rate samplers will collect more sample for subsequent analysis resulting in an increase in sensitivity making them more useful for the measurement of low concentration aerosols or during short term or task specific sampling. The cyclones should be further investigated for sampling of specific occupational aerosols.

## SR-401-07

### Evaluation of Bioaerosol Properties and Antibiotic Resistance in Animal Hospital

*C. Lai, M. Wang, and C. Chan, Department of Occupational Safety & Health, Chung Shan Medical University, Taichung, Taiwan; W. Lee, Veterinary Medical Teaching Hospital of National Chung-Hsing University, Taichung, Taiwan; A. Kuo, Chung Shan Medical University Hospital, Taichung, Taiwan*

**Objective:** Biological pollution deeply impacts health of human beings and bioaerosols can result in infection or allergy. Under different animal host (including human) and interaction of different environments, microorganisms may have a resistance to antibiotics. In this study, we sampled in animal hospitals in order to investigate microorganism species, concentration and resistance to antibiotics of bioaerosols at different temperatures, and evaluate their hazards to human health.

**Methods:** In this study, three types of bioaerosol samplers

like Andersen six stage, AGI-30 and BioSampler were used for sampling bacteria and fungi in four seasons. The sampling locations were respectively the hall and the animal wards of an animal hospital in central Taiwan. Bacteria were cultured by tryptone soya agar (TSA) at 25°C, 37°C and 42°C. Colonial morphology was observed and counted after gram stain. The full automatic microorganism identification instrument BD Phoenix™ was used to identify strains and analyze resistance to antibiotics. Fungi were cultured by malt extract agar (MEA) at 25°C. The Atlas of Clinical Fungi Identification index was used to identify fungi genus and strains.

**Results:** The result showed that the Andersen six stage collected dominant bacteria like *Micrococcus* spp. and *Staphylococcus* spp. from bacteria at each stage, and collected *Cladosporium* spp. and *Penicillium* spp. from fungi. The AGI-30 and BioSampler samplers all cultivated *Staphylococcus* spp. (7 species) and *Micrococcus* spp. (2 species) at three different temperatures (25°C, 37°C and 42°C). By analysis, the resistance to antibiotics about *Staphylococcus* spp. collected from hall and wards could resist Ampicillin, Oxacillin and Penicillin G. *Staphylococcus* spp. (7 species) collected from the hall had an extensive resistance to antibiotics.

**Conclusions:** All the results showed that most bioaerosols are mainly environmental bacteria, but they still are opportunistic pathogenic bacteria, which can contaminate therapeutic apparatus and result in hospital nosocomial infection and allergy.

## SR-401-08

### Sampling Evaluation of Bioaerosol and Antibiotic Resistant Characteristics in Intensive Care Unit

*C. Lai, N. Wu, Y. Lin, and A. Kuo, Chung Shan Medical University Hospital, Taichung, Taiwan*

**Objective:** Our research was based in a medical center's Internal Medicine Intensive Care Unit (MICU) and Surgery Intensive Care Unit (SICU) located in central Taiwan. The research objective focus was on the bioaerosols and their antibiotic resistant characteristics in both locations.

**Methods:** Three bioaerosol samplers were utilized (Anderson six-stage, AGI-30, and BioSampler) for sampling before and during patient visiting. Upon acquisition of samples, they were inoculated and cultured on BBL™ Trypticase™ Soy Agar (with 5% Sheep Blood) medium for growth. The bacterial colonies were later identified and analyzed for antibiotic-resistant characteristics via BD Phoenix™ medium and microbial identification and susceptibility test analyzer.

**Results:** Research results have showed from the bioaerosol samples acquired within the MICU that dominant concentration of bacteria and fungi were below the cut off size of 3.3 µm. Thus, they had a high possibility to enter human lung's alveolar regions of the body, thereby causing opportunistic infections. The factor of season and air change rate per hour did not statistically associate with bioaerosol concentration ( $P > 0.05$ ); However, factor of patient visiting and temperature, relative humidity during sampling showed statistically agreement with bioaerosol concentration ( $P < 0.001$ ). In terms of bacterial strain identification, Gram-positive bacteria were mainly isolated with risk group (RG) of II. In the MICU, antibiotic resistant strains were identified and 63.5 % were resistant to National Health Insurance Administration (NHIA) designated first (17 types)

and second (18 types) line antibiotics. This phenomenon could very likely affect the medical staffs working within the hospital environment.

**Conclusions:** As a result, recommendations for MICU ventilation designs should be carefully evaluated for the effectiveness of controlling nosocomial infections as well as proper implementation of personal protective equipment in order to reduce bioaerosol opportunistic infections and harmful exposure effects.

## SR-401-09

### Comparative Evaluation of Strategies for Assessing Occupational Exposure to Carbonaceous Nanomaterials

*M. Debia, C. Catto, and M. Skulinova, Université de Montréal, Montréal, QC, Canada; G. L'Espérance and C. Allard, Polytechnique Montréal, Montréal, QC, Canada; J. Kroeger, Raymor Industries Inc., Boisbriand, QC, Canada*

**Objective:** Carbonaceous fibrous nanomaterials (CARF) include carbon nanotubes (CNTs), which can be single-walled (SWCNTs), double-walled (DWCNTs) or multi-walled (MWCNTs), and carbon nanofibers (CNFs). Pulmonary health effects have been associated to these compounds. A cautious and reliable exposure assessment is thus needed to control the risk and ensure workers' protection. This study aims at comparing various methods used to assess occupational exposures to CARF.

**Methods:** Personal sampling was carried out during the recovery and cleaning operations of SWCNTs' production process in a primary manufacturer. Elemental Carbon (EC) was measured following the NIOSH 504 method as marker for (i) respirable fraction of airborne particles samples monitored using cassettes equipped with quartz filters and BGI cyclone (GK 2.69) [REC-CYC], (ii) respirable fraction of airborne particles monitored using personal particles impactors (PPI) equipped with quartz filters [REC-PPI], and (iii) thoracic fraction of airborne particles monitored using PPIs with quartz filters [TEC-PPI]. Airborne particles were also collected on copper numbered microscopy grids using a mini particulate sampler (MPS) and SWCNT structures were counted by (a) Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) and (b) Raman spectroscopy analysis.

**Results:** EC concentrations ranged from non-detected ( $n=3$ ), 4 to 58 µg/m<sup>3</sup> ( $n=5$ ), and 40 to 70 µg/m<sup>3</sup> ( $n=5$ ) for REC-CYC, REC-PPI and TEC-PPI, respectively. SEM/TEM analyses showed large agglomerates structures between few hundred nanometers to tens of micrometers. Several SWCNT structures were attached to large dumps of spherical particles identified as black carbon, nickel and iron. Concentration of SWCNTs was 0.058 SWCNT/cm<sup>3</sup>. Raman analysis indicated that less than 5 % of particles collected on the grid were SWCNTs.

**Conclusions:** Quantifying occupational exposures to CARF is challenging since the NIOSH 5040 method is not specific to carbon contained in CARF but include all form of elemental carbon such as the carbon contained in the black carbon used to produce CARBF. MPS is well suited to collect particles and proceed later to non-destructive quantification by counting CNT structures without any handling and disturbance of the collected materials and Raman analysis.

## SR-401-10

### Workplace Measurements of Semiconductor Nanowires During Production at a Small-Scale Company

*M. Hedmer and H. Tinnerberg, Occupational and Environmental Medicine, Lund University, Lund, Sweden; C. Isaxon, P. Nilsson, J. Rissler, A. Gudmundsson, M. Bohgard, and J. Pagel, Ergonomics and Aerosol Technology, Lund University, Lund, Sweden; L. Ludvigsson and M. Messing, Solid State Physics, Lund University, Lund, Sweden*

**Objective:** The industrial use of novel manufactured nanomaterials with enhanced or completely new properties is increasing globally. During the last decade, there have been growing concerns of adverse health effects of nanofibers e.g. carbon nanotubes. A new type of nanofibers is the semiconductor nanowires (NW), which have the potential to be used in applications e.g. solar cells, light-emitting diodes and batteries. Semiconductor NWs are fiber shaped manufactured nano-objects with a length of 1-2  $\mu\text{m}$ . The industrial use is growing as well as the potential for worker exposure. Aerotaxy is a new method for industrial mass production of NWs. Production takes place in closed reactor systems and NWs of GaAs are grown in the gas phase on catalytic seed nanoparticles of Au by addition of gaseous precursor molecules. The aerotaxy reactor system was opened up during maintenance e.g. manual cleaning operation. The aim was to quantify the personal breathing zone (PBZ) exposure and emissions of NWs to air during production work at a small-scale company. The potential for dermal exposure was also assessed.

**Methods:** PBZ and emission filter samples were collected on 25 mm filters for 8 production stages for determination of particle number concentration, mass concentration, and metal content. Also direct reading instruments were used in the emission zone and background to measure particle number concentrations and number size distributions with high time resolution. Tape samples (N=14) were collected from workplace surfaces in the facility. The samples were gravimetric analysed with SEM and ICP-MS.

**Results:** Concentrations up to 98 NWs/cm<sup>3</sup> were detected in the emission zone during the 8 production stages. In the PBZ, a concentration of 0.025 NWs/cm<sup>3</sup> was measured. The emitted NWs had a mean length of 4  $\mu\text{m}$  (range 0.5-24  $\mu\text{m}$ ). One surface inside the tool enclosure was found to be contaminated with NWs, Au and semiconductor material. The cleaning operation was identified as the production stage with highest emission.

**Conclusions:** During maintenance NWs, particles of Au and semiconductor material were emitted to the workplace air and surface. The emitted NWs were longer than the produced ones. The personal protective equipment used for this production stage was essential to avoid worker exposure. The company has now modified the cleaning operation and it is now performed within the closed system.

## SR-401-11

### Evaluation of Bacteria Reducing Efficiency Using Bactericide Under Full Scale Field Study—A Negative Pressure Pattern Testing

*C. Lai, Y. Wang, Y. Lee, and A. Ku, Chung Shan Medical University, Taichung, Taiwan*

**Objective:** Many nosocomial infections of patients are derived from secondary infections during their hospital stay via pathogens or by its toxins. Thereby, causing local or systemic adverse reactions in patients, that are not present prior to admission or not at a latency stage. The major nosocomial infection route can be divided into two pathways, airborne and contact transmission. According to recent research, general disinfection methods are direct contact to pathogens but seldom relate to airborne disinfection method. Our research first conducted the paper disk diffusion test to initially understand the effectiveness of the bactericides. Then, in a full scale test ventilation laboratory equipped with stable ( $\Delta P=0$  pa), negative ( $\Delta P=-8$  pa), or positive ( $\Delta P=+8$  pa) pressure ventilation. The main objective was to evaluate bacteria reducing efficiency using bactericide under full scale field study.

**Methods:** The dimensions of full scale test laboratory were 3 x 3 x 3 meters, that could provide different dilution ventilation flow patterns, included the short circuit and displacement pattern. Moreover, the operation parameter also compared different air change rates per hour (ACH). The experimental procedure was to deploy bacteria and bactericides and test their effective bacteria reducing rate under different flow patterns and pressure drop (negative, stable, positive) setting. For experimental comparison, the bacteria of *Bacillus subtilis* was used as challenge aerosol while the Collison Atomizer was used for producing the bioaerosol and the bactericide. The bioaerosol disinfection efficiency was compared via the Andersen Single Stage Microbial Sampler. As for the bactericides, different proportions of diluted bactericides were atomized and sprayed in the full scale test laboratory with the selection of hypochlorous acid, terpinen-4-ol, and lemon grass oil.

**Results:** The research results indicated that most bactericides worked most effectively under negative pressured airflow field environments. There was a significant reduction in bactericidal effect under positive or stable pressured environments. In particular, the hypochlorous acid showed a high bactericidal effect under different pressure drops. Under the short circuit airflow field, both the terpinen-4-ol and lemon grass oil showed significant bactericidal reducing effect. The resulted bactericidal rates were also related to the particle sizes of the bactericides and the experimental bacteria used.

**Conclusions:** The resulted bactericidal rates were also related to the particle sizes of the bactericides and the experimental bacteria used. The greater the difference of the particle sizes between the bactericides and experimental bacteria used, the greater was their coagulation, which may produce a better bactericidal reducing effect.

## SR-401-12

### Physicochemical Properties of the Powder By-Products Generated from a Metallization Process and Its 1st Scrubber in the Semiconductor Industry

*K. Choi, M. Jung, and H. An, Samsung Health Research Institute, Samsung Electronics, Yongin-Si, Korea (the Republic of)*

**Objective:** It is feared that the formation of powder by-products

and their attachment on the equipment chambers and parts during the ongoing semiconductor process, may result in workers' exposure during maintenance. Little is known about detailed physicochemical characterization of powder by-products generated from semiconductor processes. The aim of this study is to identify the physicochemical properties such as chemical composition, size, shape and crystal structure of powder by-products generated from a metallization process and its 1st scrubber in the semiconductor industry.

**Methods:** This study was conducted in three 200 mm semiconductor wafer fabrication facilities. The powder samples were collected from their inner chamber during maintenance of W-plug process equipment using tungsten hexafluoride ( $WF_6$ ) and silane ( $SiH_4$ ) as precursor materials and its 1st scrubber. The chemical composition, size and shape of the powder particles were determined by field emission scanning electron microscopy (SEM) and transmission electron microscopy (TEM) equipped with energy dispersive spectroscopy (EDS), respectively. The crystal structure of the powders was analyzed by X-ray diffraction (XRD).

**Results:** From the SEM-EDS and TEM-EDS analyses, the O and W were mainly detected which indicates the powder by-products are tungsten trioxide ( $WO_3$ ), whereas Al, F and Ti were detected as low peaks. The powder particles are spherical and nearly spherical. The particle size collected from process equipment and its 1st scrubber showed 10-20 nm (aggregates: 55-90 nm) and 16-20 nm (aggregates: 80-120 nm) as primary particles, respectively. The XRD patterns of the yellow powder by-products exhibit five peaks at  $23.80^\circ$ ,  $33.90^\circ$ ,  $41.74^\circ$ ,  $48.86^\circ$  and  $54.78^\circ$ , which correspond to the (200), (220), (222), (400) planes of a cubic  $WO_3$ .

**Conclusions:** This study should provide useful information for the development of alternative strategies to improve the work environment and workers' health.

## SR-401-13

### Experimental Study of Surgical Smoke and Its Control

*T. Lee, J. Soo, R. LeBouf, D. Burns, and M. Harper, CDC/NIOSH, Morgantown, WV; D. Novak, CDC/NIOSH, Pittsburgh, PA; J. Bowers, Ruby Memorial Hospital, Morgantown, WV*

**Objective:** To evaluate airborne particulates and volatile organic compounds (VOCs) from surgical smoke in an experimental settings when the local exhaust ventilation (LEV) system is present or absent.

**Methods:** Airborne particles and VOCs were collected for 45 minutes in four different experimental settings: 1) background (without any activity), 2) smoke generation without LEV utilization, 3) smoke generation with LEV control (wall irrigation suction unit with an in-line ultra-low penetration air (ULPA) filter positioned between the wall suction and suction canisters), and 4) smoke generation with LEV control (smoke evacuation system (PlumeSafe®Turbo) installed a four-stages filter including charcoal and ULPA filters). Surgical smoke was generated from excised human tissues in unoccupied operating rooms using an electrocautery surgical device for 15 minutes. Flow rate of both LEVs was approximately  $35 \text{ l min}^{-1}$  (normal setting at the hospital) and suction was maintained within 2 inches of generation point. A total of 4 experiments were carried out. Particle number and mass concentrations were measured in real time with direct reading instruments

including a Condensation Particle Counter (CPC), a DustTrak, a Scanning Mobility Particle Sizer (SMPS), an Aerodynamic Particle Sizer (APS) and a BioTrak. VOCs from the surgical smoke were collected using evacuated canisters both area and personal samples (from experimental personnel) following NIOSH draft canister method for VOCs in air. The canister samples were analyzed using a pre-concentrator and gas chromatography-mass spectrometry system.

**Results:** The average particle number concentrations of background, without LEV, wall suction and smoke evacuation system measured with the CPC were 300, 9000, 2300 and 1500 particles  $\text{cm}^{-3}$ , respectively. The average particle mass concentrations of background, without LEV, wall suction and smoke evacuation system measured with the DustTrak were 3, 24, 8 and 3  $\mu\text{g m}^{-3}$ , respectively. Count median particle diameters from the SMPS measurements were found at 84 nm (background), 90 nm (without LEV), 81 nm (wall suction unit) and 29 nm (smoke evacuation system). Particle number concentration from the SMPS were close to the concentrations from the CPC in all experimental settings. Particle number concentration in particle size  $> 0.5 \mu\text{m}$  including viable particles were not large ( $< 200 \text{ cm}^{-3}$ ) in all experimental settings. Ethanol and isopropyl alcohol were dominant VOCs from all canister samples. Acetaldehyde, acetone, acetonitrile, benzene, hexane, styrene and toluene were detected in grab samples but their concentrations were in low range ( $< 100 \text{ ppb}$ ).

**Conclusions:** Utilization of the LEVs for surgical smoke control can reduce possible exposure to healthcare workers in operating rooms but airborne ultrafine particles still remain.

## P0101

### Assessments of Residential and Workplace Environmental Microbiology Exposure

Monday, May 23, 2016, 10:30 AM - 12:30 PM

## CS-101-01

### Exposure of Residential Occupants to In-Home Sewage

*H. Burge, EMLab PK, San Bruno, CA*

**Situation/Problem:** In healthy people, gut microbial populations are formed of nonpathogenic microbes that are necessary for the maintenance of a healthy digestive system. These and any ongoing disease organisms will be in the sewage. In general, gastrointestinal organisms within residences are shared by hand to mouth transfer, not from sewage. Exposure to gut organisms occurs when using the toilet, and especially when flushing. Gastrointestinal pathogens are shared within families in this way as well. Sewage spills include toilet overflows during flushing, and backup of sewage from a blockage outside the home. In single family residences the sewage from both of these events includes only those organisms that were present in the occupants and visitors and thus are likely to include organisms to which the occupants have already been exposed. A backup from a main sewer line exiting a multifamily unit will contain organisms from all of the occupants in the building. These spills are likely to contain

a variety of pathogens to which all individuals in the building have not been exposed. The risks associated with sewage contact are for the most part infections. Once out of the human body microorganism populations dwindle at an exponential rate. Once a spill has spread across the floor, the entrained organisms attach to surfaces and as the area dries, the death rate increases. Once completely dry, relatively few organisms will have survived, and both living and dead organisms will be firmly attached to surfaces and are very unlikely to enter the air.

**Resolution:** The risk of contracting a GI disease from cleaning up sewage from a single family residence is very low. Cleanup of sewage from a multifamily common line may contain pathogens that could cause disease, and these could cause illness in some people provided the spill is cleaned while still wet. It is advisable to have these spills cleaned by a professional. Professionals have a relatively low risk of contracting a disease because they use protection and are trained how to avoid hand to mouth exposure.

**Results:** This information should allay fears that are common in homeowners, and reassure professionals of the minimal risks associated with cleaning dry sewage spills.

**Lessons learned:** Residential in-home sewage spills are of little hazard to single family residents. Sewage backup from on the property also carries little risk for occupants. Multifamily sewage may have pathogens to which all the residents of the complex have not been exposed. These should be handled by a trained professional.

## SR-101-02

### Airborne Mycobacterium Tuberculosis Profiles in a Hospital with a Nosocomial TB Outbreak

*Y. Yen, Kaohsiung Medical University, Kaohsiung, Taiwan*

**Objective:** The main purpose of this study was assessing the airborne Mycobacterium tuberculosis profiles in a hospital to identify high risk areas. In addition, the difference of airborne Mycobacterium tuberculosis concentration before and after ventilation improvement was also evaluated.

**Methods:** The airborne samples were collected by a Nuclepore filter with sampling time of 8 hr. at sampling flow rate of 20 L/min. A total of 192 air samples were taken from negative pressure isolation wards, medical wards, waiting rooms and consulting rooms of medical department and pediatric department in the period of December 2005 to July 2006. The concentration of airborne M. tuberculosis was quantitatively determined by the ABI 7700 real time quantitative polymerase chain reaction (real time qPCR) system.

**Results:** It was found that the positive rate of airborne M. tuberculosis is 6.25%. In addition, all positive samples were in the wards of chest and infectious disease division in the internal medicine department. The airborne M. tuberculosis concentration was in the range of 54 copies/m<sup>3</sup> to 1109 copies/m<sup>3</sup>. The highest concentration was found in the nursing station of chest division. After improvement of ventilation system, no M. tuberculosis was detected in the air. In addition, the airborne bacteria concentrations were also declining after the improvement. Our results showed that the improvement of air conditioning may reduce the risk of M. tuberculosis exposure. In addition, it was found a good correlation between

M. tuberculosis and airborne bacteria.

**Conclusions:** In regard to the culturable bacteria and fungi concentration in the air, 122 samples were analyzed in the hospital. According to the IAQ Recommended Values of Taiwan EPA, the failure rate was 64% and 8% for bacteria and fungi, respectively. In addition, the airborne bacteria concentrations in the nursing station of chest division were all higher than the recommended values, even after the improvement of ventilation.

## CS-101-03

### Inspection of Building Water Systems for Legionella Control

*L. Nguyen Weekes, InAIR Environmental Ltd., Ottawa, ON, Canada*

**Situation/Problem:** Legionnaire's disease is again a topic of great interest to IAQ practitioners as the incidence of this disease worldwide is on the rise. Several professional organizations (e.g. ASHRAE and the American Industrial Hygiene Association) and governmental agencies (e.g. Canada's Public Works and Government Services) have recently produced or reissued guidance documents on the design, operation and maintenance of building water systems in order to prevent the growth of Legionella bacteria on building water systems.

**Resolution:** The emphasis of the existing documentation is on the proper operation and maintenance of building water systems and the creation of a Legionella Bacteria Control Management Plan (LBCMP) for these buildings. In order for these Management Plans to be effective, a detailed inspection of building water systems is essential to determine where the potential for bacterial growth exist.

**Results:** This presentation will provide experienced tips and examples on how to inspect different building water systems and how to evaluate the risk for Legionella contamination within these systems. Examples will include centralized water systems and compartmental systems as well as the design trend in newer buildings such as high energy efficiency buildings and their water systems.

**Lessons learned:** Based on the lessons learned from the inspections, recommendations can be made on how to correct the design, operation or maintenance issues that might lead to a Legionella growth.

## CS-101-04

### 2015 Bronx Legionellosis Outbreak: A Consultant's Perspective

*C. Cooper, VERTEX companies, Kingston, NY; S. Zouak, Airtek Environmental Corp, Long Island City, NY*

**Situation/Problem:** A Legionellosis Outbreak is defined by the US Centers for disease Control as two or more confirmed cases of Legionellosis occurring in the same locality within a six-month period. Between July and August, 2015, more than 120 cases of Legionellosis were identified in the South Bronx, a corner of New York City's northernmost borough, resulting in 12 deaths. This was largest outbreak of Legionnaires' disease in New York City's history. In response the City issued, and shortly thereafter New York State issued emergency regulations affecting cooling tower owners and operators

State wide requiring inspection, disinfection, and testing of all cooling towers and evaporative condensers with a 30 day compliance deadline. In addition, these new regulations include requirements for tower owners to develop and implement written maintenance plans by March 1, 2016 in accordance with ANSI/ASHRAE Standard 188-2015 and, thereafter, annual certification reporting of tower compliance.

**Resolution:** These new regulations have far reaching implications, primarily on increased monitoring, testing, maintenance and surveillance for these systems. Although the CDC, the New York State Department of Health and a variety of industry groups have all published guidelines for maintaining cooling towers and potable water systems to prevent the spread of Legionella bacteria, prior to these regulations cooling towers and potable water systems in New York were unregulated and no tower registration was required. For the first time under these new regulations, owners in New York are required to register, test, and annually certify and report their testing and maintenance program.

**Results:** Our presentation will briefly review the chronology of the Bronx outbreak, report the current status and requirements of the NYS cooling tower and potable water systems regulatory programs for control of Legionella, and will describe case examples for bringing two university campuses, a hospital, and several retirement homes all located in the south Bronx into compliance with these new Legionella regulations. We describe: investigating the water systems, implementing safe inspection and sampling programs, assessing the data, drafting written compliance plans, and working with these institutions to implement their plan elements.

**Lessons learned:** Important elements identified for implementing new Legionella control programs include integration of program inspection, testing, records maintenance and reporting elements into existing facilities management and operations infrastructure, effective training for maintenance personnel, and routine third party auditing.

## CS-101-05

### Survey for Exposure to Human Pathogens from Pigeon Droppings in a Petroleum Refinery

*P. Owens, Shell Oil Company, Martinez, CA*

**Situation/Problem:** Pigeon live and roost in petroleum refineries thus droppings accumulate on elevated platforms, ground level walkways and other surfaces workers contact. During routine refinery operations workers may walk on surfaces where dropping have accumulated or may handle equipment with residue of droppings.

**Resolution:** To help investigate workers' health risks, a risk assessment, including an exposure survey, was initiated. A literature review indicated the possibility for human pathogens to be present in some pigeon droppings. A survey of the refinery pigeon droppings was conducted to evaluate the presence of human pathogens in bulk droppings. Several air samples were collected to evaluate the likelihood of pathogens becoming airborne from routine work. A variety of locations and environmental conditions were sampled. Air samples were taken during routine and worst-case exposure scenarios.

**Results:** In bulk samples, pathogens were detected at a rate similar to published percentages; 22 detected in 126

samples (17%). The least harmful pathogen was detected most frequently (*C. neoformans*, 22%), and the most harmful was detected less frequently (*H. capsulatum*, 9%). The risk of personnel exposure to airborne avian pathogens appears low; only one detectable air sample. Given the IRRST control banding guidance, the exposure control measures seem sufficient: frequent gentle water wash down areas to reduce aged feces accumulation, half-facepiece air purifying respirators with P-100 cartridge during any potential feces aerosolization, predators, nets where feasible, noise deterrents, and hygiene practices. And the ongoing birth control agent treatment appears to be an effective, humane method to greatly reduce the refinery pigeon population.

**Lessons learned:** One lesson learned from this survey is, it is possible to for human pathogens to exist within refinery pigeon droppings. Another lesson learned is controlling the pigeon population is the best proactive method to reduce the risk of exposure. And lastly, it appears the risk of pathogen exposure and infection is low during routine refinery work.

## SR-101-06

### A Count-Based Method for Improved Quality Control Acceptance Limits of EMLAP Air Direct Fields of Testing

*M. Saleh, Sporometrics, Toronto, ON, Canada*

**Objective:** AIHA-LAP, LLC accredited laboratories are required to perform 10% retesting of samples as part of their quality control program. There are several statistical methods suggested in guidance documents but they do not include a count based approach. The objective of this research was to correlate the coefficient of variation to different spore loads to create more accurate acceptability limits for inter/intra analyst comparisons.

**Methods:** Our method was based on daily reference slide counts of varying spore concentrations; ranging from 0 spores to >100 spores per slide. Data was collected by daily readings from six analysts and the coefficient of variation was determined for each spore load.

**Results:** Results of the statistical analysis of this data show that coefficient of variation and spore load have an exponential decay relationship ( $x^{-0.5}$ ), with a coefficient that is dependent on the analytical method used (i.e. magnification, percentage of sample read, etc.).

**Conclusions:** In conclusion, this model (vs. a pooled CV model) improves acceptability thresholds at very low and very high counts and reduces false negative QC failures. From a laboratory analysis perspective, this model is easy to adopt into current quality control practices, makes inter/intra analyst comparisons more realistic and improves the quality of results.

## P0102 Emerging Issues and Lessons Learned in the Oil and Gas Industry

Monday, May 23, 2016, 10:30 AM - 12:30 PM

### CS-102-01

#### Industrial Hygiene Monitoring Strategy for Unconventional Gas Drilling Sites in Texas and Pennsylvania Using the GGP-U Sampler

*L. Anderson and Y. Zagagi, Golder Associates Inc.,  
Jacksonville, FL; J. Leamont, M. Sanchez, and T. Meijster,  
Shell Oil Company, Houston, TX*

**Situation/Problem:** Hydrocarbon based fluids are used during horizontal drilling operations at unconventional oil and gas well sites. These fluids can be diesel based or synthetic based drilling fluids. The work was done to assess air and dermal exposure and control risks to As Low As Reasonably Practicable (ALARP).

**Resolution:** An industrial hygiene air sampling strategy was developed using the GGP-U sampler, which is rarely used in the U.S. A semi quantitative dermal assessment was designed using the DREAM process as guidance. Worker exposure was evaluated at four drilling sites in Texas and Pennsylvania. This strategy allowed for accommodation to the logistical challenges associated with an unconventional site while still providing the basis to provide representative exposure data for an accurate exposure profile. Personal exposure monitoring was completed for BTEX/ Hexane/ Heptane. Selected jobs at each site with the highest exposure potential were evaluated by the on-site industrial hygienist.

**Results:** The use of synthetic based drilling fluid resulted in lower airborne exposures to hydrocarbons and a lower degree of dermal risk when compared to the diesel based drilling fluids. Worker inhalation exposure to BTEX/Hexane/Heptane was found at some sites using diesel based drilling fluids, but all results were well below the OSHA PEL. BTEX/Hexane/ Heptane results below limit of detection for sites that used synthetic drilling fluids. The sampling strategy used in this survey demonstrated an effective approach for determining both airborne and dermal risk to hydrocarbons.

**Lessons learned:** More work needs to be done to identify what characteristics of synthetic drilling fluid are responsible for the observed lower exposure levels. For dermal exposure quantitative assessment of exposure will strengthen our insight in some of the potential differences in exposure observed.

### CS-102-02

#### Impacts to Your DOT-111 Rail Tank Car Fleet

*B. Dawson, Shell Chemical LP, Houston, TX*

**Situation/Problem:** Based on the Department of Transportation's (DOT) directives to make critical modifications to the widely used DOT-111 class of rail tank cars, many segments of the rail, chemical, oil & gas, and other industries find themselves facing decisive challenges to both meet the deadlines and keep their fleets moving. The catastrophic and

high profile failure of some DOT-111 rail tank cars, carrying hazardous materials, has given additional emphasis to the industry as public opinion has dramatically shifted to an unpopular view regarding the use of these rail cars.

**Resolution:** The DOT directives established specific deadlines for industry to remove and replace certain rail tank car valves sold by McKenzie Valve & Manufacturing. In addition, the directive to improve the safety of Bottom Outlet Valves (BOVs) is yet another focus of DOT's efforts to improve the overall safety performance of the DOT-111 class of rail cars. Methods that industry has or may deploy to deal with these directives include: increased shop time for rail tank cars, use of other classes of rail tank cars, negotiation of contractual obligations, and Management of Change.

**Results:** While the exact economic impacts of these directives has not yet surfaced, the tight inventory of rail tank cars will inevitably impact a wide range of industries. The ability of a manufacturer to deliver its product on time and on schedule, the ability of rail tank car maintenance providers to meet the demand of these directives on top of existing regular rail tank car maintenance needs, and the ability of enforcement agencies to monitor the implementation of their directives will be key metrics by which we measure the safety of our railroads moving forward.

**Lessons learned:** The aging of a rail tank car fleet can be observed through many different metrics. However, when the regulatory environment forces an abrupt change, industry must be nimble enough to adjust.

### SR-102-03

#### The Effects of Overtime Among Rotating Shiftworkers in the Oil Industry

*K. McNamara and W. Robbins, UCLA, Santa Monica, CA*

**Objective:** Refinery operators work extended shifts(12-hour), rotating shifts and increasing overtime rates have been reported. This study analyzes the effects of overtime on the frequency and intensity of shift rotation, and associated impacts on sleep, health, and quality of life indicators among the workforce.

**Methods:** We administered a self-reported health questionnaire to refinery workers who were members of the United Steelworkers' Oil Sector in 15 states. Reported work schedules, overtime estimates, typical sleep schedules and an evaluation of sleep quality were used to estimate fatigue exposure. Self-reported diagnoses of cardiovascular disease, hypertension, diabetes, and gastrointestinal illness were used to calculate disease prevalence within the workforce. Job stress and quality of life indicators were measured and a depression assessment was performed.

**Results:** Overtime was associated with increased numbers of shift changes, longer work sets, and fewer days off. Overtime impacted sleep quantity and quality. Poor sleep quality was associated with numerous mental and physical health problems. Overtime was highly correlated with recent GI discomfort, chest pains, elevated resting blood pressure, stress levels, and depressed mood. Individuals with more overtime-intensive work schedules also reported limited time for exercise and leisure, which correlated with elevated BMI and other chronic health conditions.

**Conclusions:** The 12-hour shift, a compressed work schedule

designed to offer more time at home, has affected many industries. But increasing rates of overtime diminish available recovery time needed to relieve work related fatigue. We found associations between overtime and decreased quality and quantity of sleep, with impacts on long term health and well-being.

## SR-102-04

### Analyzing Exposure Data from a Global Dataset

*M. Shin, ExxonMobil Biomedical Sciences, Annandale, NJ*

**Objective:** As part of ExxonMobil's Exposure Assessment Strategy, workplace exposure results (qualitative and quantitative) are collected globally and stored in one database. This allows for global data analysis of exposure data and the assessments which have been completed by industrial hygienists to identify trends, evaluate exposure management program effectiveness, and prioritize continuous improvement activities. In this study, a global exposure data management system consisting of over 80,000 industrial hygiene samples was queried, resulting in a sub-set of approximately 27,300 samples. The samples were then further categorized to examine the effectiveness of controls during the performance of specific tasks. A second objective of this analysis was to identify key factors that would be critical for ensuring accurate interpretation and use of data from such a large data set.

**Methods:** Short term, personal benzene exposure monitoring data (sample duration of 180 minutes or less) were identified and sorted by task. The dataset was further narrowed down to focus on specific tasks where the use of specific controls could be verified. The analysis included samples collected from the time period 1999-2015 at multiple global manufacturing sites. Tasks such as loading materials, process sample collection, and tank gauging/dipping were grouped further by business line (e.g., supply and distribution, aviation, refining), source material, and control type. The final dataset was then analyzed to assess the effectiveness of control measures.

**Results:** The analysis of global monitoring data indicates that engineering controls can effectively mitigate exposures. A variety of engineering control categories was evaluated and the effectiveness of control types was compared. For loading tasks, top loading with vapor recovery and bottom loading resulted in significant reductions compared to top loading activities without vapor recovery. For process sample collection, closed system sampling resulted in significant reductions in benzene air concentrations compared to open system sampling.

**Conclusions:** This study demonstrates the effective reduction of exposures during the performance of typical tasks through the use of various engineering controls, it also highlights the utility of managing and understanding the data in large datasets, and summarizing it appropriately for use by other professionals, organizations, and researchers.

## CS-102-05

### Assessment of N.O.R.M in Crude Oil Process Equipment During Turnaround Activities

*J. Pierrero, Chevron Canada Limited, Delta, BC, Canada*

**Situation/Problem:** HES identified the potential for residual NORM to be present in crude oil refining process equipment

(asphalt storage tank) during a maintenance turnaround due to preceding/unrelated work activities.

**Resolution:** HES developed a turnaround NORM assessment plan using information collected from a cross-functional team to: (i) identify designs that might mask detecting activity externally and (ii) target specific equipment (anticipated to contain NORM residues) for internal assessment. Plan utilized externally screening equipment during normal operation and after process unit was shut down (pre- and post- chemical cleaning.) Internal surveys were conducted when equipment was initially opened and after additional cleaning. Surveys used a GM Survey Meter equipped with an internal scintillation counter and an external pancake GM detector probe.

**Results:** External and internal NORM surveys were successful in identifying equipment with residual NORM. Loose NORM residues were reduced to background levels after removal of sludge and areas of fixed NORM were identified. Soiled PPE showed no activity above background levels. Radiochemical analysis of sludge samples identified alpha and beta emitting isotopes.

**Lessons learned:** Incorporate NORM surveys within the maintenance schedule if mapping NORM distribution patterns. Distribution of NORM activity is not uniform within a process unit or within vertical columns. Plan for physical access challenges for some anticipated NORM accumulation areas. Loose NORM residual sludge is removable and activity levels can be reduced to background. Areas/surfaces near equipment feed inlets showed fixed NORM activity requiring exposure control protocols if the fixed NORM residue is physically disturbed.

## CS-102-06

### Heat Stress Management for Heater Hot Spot Repair

*L. Yong, ExxonMobil Asia Pacific Pte Ltd, Singapore, Singapore*

**Situation/Problem:** This is a presentation on the control measures that were taken to address the risks from working in an environment with ambient temperature of more than 38°C. The worsening of a hot spot led to the formation of a hole on a heater roof. The elevated temperature and flue gas egress that resulted posed a risk to the operators who needed to assess the area regularly to perform their routine rounds. There was a critical need to make the area safe. However, as the heater was slated for shutdown in a few months and there was no suitable window for immediate shutdown, an online repair was performed to temporarily cover the hole.

**Resolution:** An inclusive heat stress management plan was applied to mitigate the risk of heat stress. Hierarchy of controls implemented were: 1) engineering (such as cutting off burners directly below the hot spot, increased ventilation, insulation, etc.), 2) administrative (considering water intake, work schedule, fitness to work, heat acclimatization, personal temperature monitoring, training, etc.), and 3) PPE (aluminized suit with vortex cooling vest). Two rounds of trial runs were conducted to test the above controls & the rescue plan. Controls were proven effective and areas of improvement were identified.

**Results:** The work was monitored closely to assess the effectiveness of the measures. Globe & ambient temperature

recorded were close to the trial value (46.2°C-51.2°C & 47.8°C-51.7°C). When personal temperature excursions above 38°C occurred occasionally, the pace of work was immediately moderated.

**Lessons learned:** The above experience showed that proper planning and holistic controls minimized the risk, resulting in safe execution of the work. Trial runs were useful in confirming that proposed measures were effective and to familiarize workers with the job steps. Suitable parameters, such as ambient and globe temperature instead of WBGT, were selected for monitoring to enable proper risk assessment and mitigation. Measures implemented should commensurate with the risk and should be revised accordingly as new monitoring data became available.

## PO103

### Risk Assessment Science

Monday, May 23, 2016, 10:30 AM - 12:30 PM

## SR-103-01

### Benzene Exposures and Risk Potential for Vehicle Mechanics

*P. Williams, E Risk Sciences, LLP, Boulder, CO*

**Objective:** Benzene exposures among vehicle mechanics in the United States and abroad were characterized using measured data and exposure modeling. These data, which have not been previously analyzed, may be used to assess benzene risks for mechanics exposed to gasoline or other petroleum derived products.

**Methods:** Time weighted average (TWA) and task based benzene concentrations were estimated based on published air sampling data and statistical analyses compared benzene concentrations by region, season, and job task. Also, the predictive ability of a mathematical model to estimate task based benzene concentrations under 216 gasoline and 384 aerosol spray cleaner scenarios was evaluated. The potential for dermal exposures among vehicle mechanics was discussed. Cumulative benzene exposures for mechanics with varying work histories were estimated.

**Results:** TWA airborne concentrations of benzene for vehicle mechanics in the United States averaged 0.01-0.05 ppm, since at least the late 1970s, with maximal TWA concentrations ranging from 0.03-0.38 ppm. Benzene exposures were notably lower in the summer than winter and in the Southwest compared to other geographic regions. Exposures were significantly higher during known gasoline related tasks such as changing fuel pump or filter. Measured benzene concentrations were greater for vehicle mechanics in other countries due to the higher benzene content of gasoline (5% vs. 1-2%) and other factors. Short-term airborne concentrations of benzene frequently exceeded 1 ppm during gasoline related tasks, but remained below 0.2 ppm for tasks involving other petroleum products. Application of a two zone model using reasonable input values yielded predicted task based benzene concentrations similar to those measured. Dermal exposures were found to contribute little to total exposure. Estimates of

cumulative benzene exposure ranged from 0.5 to 1.5 ppm-years after the late 1970s, and 3.5 to 4.5 ppm-years before and after this time period.

**Conclusions:** Available data suggest that vehicle mechanics have not experienced significant exposures to benzene in the workplace, except perhaps during short-duration gasoline related tasks. Exposures are below occupational exposure limits and levels associated with an increased leukemia risk, but not necessarily for myelodysplastic syndrome (MDS) risk. These findings are consistent with epidemiology studies which have not demonstrated an increased risk of benzene induced health effects in this cohort of workers.

## CS-103-02

### Give 'Em a Break: Getting Aggressive with Understanding Brakes

*F. Boelter, RHP Risk Management Inc., Boise, ID; J. Persky, RHP Risk Management Inc., Chicago, IL*

**Situation/Problem:** Isaac Newton's First Law states that a body in motion tends to stay in motion unless acted on by an outside force (1642-1726). If it moved, rotated, or slid, it would need to be stopped. Various types of Brakes were developed during the industrial revolution for our increasing use of powered mechanical equipment. In 1907, asbestos lined pads were used and outlasted other friction materials by a wide margin. Increased speeds, power and weight mandated further developments in wet and dry braking technology, but, linings do not last forever and need to be maintained and replaced.

**Resolution:** Our studies have examined the more aggressive brake activities involving drilling, grinding, compressed air, hammers, chisels and riveting. Maintaining and replacing brake linings involves numerous steps, situations, sizes, shapes, designs, and applications. The study on which we report relates to brake drums with shoes and to the process of arc grinding, a technique to obtain a perfect fit between the radius of the shoe and the radius of the drum which cannot be successfully achieved with hand tools. The arc grinding process involves two steps: turning the drum and arcing the shoe. A time and motion study was done on a professional mechanic while collecting personal TWA, EL, and area samples.

**Results:** During the course of 8 hours, a total of 8 jobs representing work on 13 axles were done. There were no visible emissions during the activities and all of the shoes were asbestos containing. Air samples were first analyzed for total fiber counts by NIOSH method 7400. The personal 8hrTWA total f/cc was 0.019 for the mechanic and 0.018 for the helper. Regarding personal 30-minute short term sampling, out of 32 total samples on the mechanic and helper, only 7 were above the LOQ and ranged from 0.049 to 0.086 total f/cc. Out of twenty 4-hour area samples, 17 were above the LOQ and ranged from 0.012 to 0.052 total f/cc.

**Lessons learned:** Studies regarding exposures are challenging to conduct and when examining historical products and methods, it is critical to have OEM parts, vintage equipment, and a knowledgeable tradesperson. While the relative risks are probably obvious, taking our study results into the arena of Big Data might incorporate transportation maps, vehicular densities on highways, NHTSA databases, fosterite, NOA, nonregulated amphiboles, and NOAA weather patterns, just to name a few. Perhaps through Big Data we will relearn the value of scientific parsimony and first order analysis.

## SR-103-03

### Benchmark Dose Modeling for Respiratory Irritation from 2,3-Pentanedione Exposure

W. Cyr, D. Dussex, A. Monnot, and M. Glynn, *Cardno ChemRisk, San Francisco, CA*

**Objective:** Beginning in the early 2000s, artificial butter flavorings have been scrutinized for their potential to produce adverse health effects. Of the numerous compounds in these flavorings, diacetyl has become the target of industrial hygiene monitoring and control efforts. When possible, it has been eliminated altogether and substituted with other flavoring chemicals, including 2,3-pentanedione (23PD). However, the potential toxicity of 23PD is questioned based on its structural similarity to diacetyl. There are no current occupational exposure limits (OELs) for 23PD. The objective of this research is to use benchmark dose modeling (BMD) of the available toxicological data to determine benchmark concentrations for 23PD.

**Methods:** All nine available models in EPA's BMDS v. 2.6.0 modeling software were used to determine 23PD concentrations associated with a 10% excess risk (BMC10) of bronchial irritation and the 95% lower confidence limits (BMCL10). Modeled bronchial inflammation data were obtained from exposed rodents in the inhalation study with the longest exposure duration of 12 days. In that study, 11 to 12 mice were exposed to concentrations of 0, 50, 100, and 200 ppm 23PD each for 6 hours per day, and experienced minimal to mild inflammation.

**Results:** BMD analysis yielded BMC10s ranging from 3.3 to 13.8 ppm, and BMCL10s ranging from 0.5 to 9.7 ppm. Only 2 models fit the data well, judging by goodness-of-fit p-values greater than 0.1. The LogLogistic and LogProbit models produced BMC10s of 3.3 and 7.0 ppm, respectively, and BMCL10s of 0.5 and 4.2 ppm, respectively.

**Conclusions:** These results are similar, if not slightly lower, to those obtained by others for diacetyl, suggesting that 23PD might have similar if not greater toxicity. However, there are several notable problems with the data: most measured health effects had response rates of either 0% or 100%; the lowest response rate in the actual modeled data was high at 75%. Lastly, the modeled results were highly inconsistent. Because of these issues, an OEL development approach based on LOAEL to NOAEL extrapolation (e.g., 50 ppm ÷ 10) might be more appropriate than BMD analysis of these data. More importantly, a study with a greater number of exposed animals and exposure concentrations and a longer exposure period would likely provide better dose-response data upon which one could develop a health based OEL for 23PD.

## SR-103-04

### Anthophyllite Asbestos: State of the Art Understanding of its Toxicological Properties

S. Gaffney, B. Simmons, M. Grespin, L. Garnick, and D. Paustenbach, *Cardno ChemRisk, San Francisco, CA*; A. Gauthier, *Johns Hopkins University, Baltimore, MD*

**Objective:** Anthophyllite is an amphibole form of asbestos. Historically, it was used in a limited number of products because of its lack of strength and brittle nature. No published

resource currently exists that offers a complete understanding of anthophyllite toxicity and of its effect on exposed populations over time. Therefore, we performed a review of published and unpublished literature relating to anthophyllite, focusing on how its toxicity was scientifically understood through time, and how such knowledge fits into the larger context of asbestos research.

**Methods:** In this review, we conducted a comprehensive search of publicly available documents that discussed the use, mining, properties, toxicity, exposure, and potential health effects of anthophyllite. Over 200 documents were identified, of which, 78 contained relevant and useful information that we present in this assessment, according to four different eras in time.

**Results:** Our analysis confirms that anthophyllite, including its potency and other toxicological properties, has not been well-studied. This is likely because of several factors: anthophyllite is a relatively rare form of amphibole; its use was historically minimal compared to other forms of asbestos; and it is often only included in studies as a component of mixed asbestos exposures (thus not making it possible to understand the pure form). Toxicology studies from the 1970s have indicated that, at sufficient doses, anthophyllite can potentially cause asbestosis, lung cancer, and mesothelioma. Studies of Finnish anthophyllite miners through the 1980s, though, found increased incidence of asbestosis and lung cancer, but not mesothelioma. It wasn't until the mid-1990s that an epidemiological link with mesothelioma was observed.

**Conclusions:** Based on our assessment, we found that characterizing the true risks of anthophyllite is difficult. Distinguishing between its asbestiform and nonasbestiform mineral form is essential from both a toxicological and regulatory perspective. Anthophyllite's toxicity has generally been assumed to be similar to other amphiboles, with the exception of 1980-1998, when ACGIH® set its TLV® the same as chrysotile, not amosite and crocidolite. Based on the limited amount of information available, for a better understanding of anthophyllite's toxicity alone, significant additional study is needed.

## CS-103-05

### Ebola and PPE: Developing a Protection Strategy

P. Lilley, *US Army, 5158 Blackhawk Rd, MD*

**Situation/Problem:** In 2014 Operation United Assistance was launched to aid with the Ebola Virus Disease (EVD) pandemic in West Africa. The Army had developed a plan for personal protective equipment (PPE) for the soldiers deploying, but had no clear guidance for staff at Military Treatment Facilities (MTF) located within the United States. It became evident that there would be the potential for EVD cases on military posts, with military deploying to EVD endemic areas.

**Resolution:** To facilitate a rapid and protective plan development, the Surgeon General of the Army requested that the Army Public Health Center (Provisional) and the United States Army Medical Research Institute of Infectious Diseases (USAMRIID) collaborate. Based on the questionnaires developed for assessing the potential risk associated with individual EVD patient, a risk level was assigned and a three tiered approach for PPE usage was developed. The first tier would be minimal PPE for lower risk of EVD exposure, and each subsequent tier

would be substantially more PPE for higher risk EVD exposure. It became evident due to the unfortunate cases of nosocomial EVD transmission, the process of donning and doffing was of critical importance. A detailed sequence for donning and doffing was provided for each tier level and training was given to MTF personnel.

**Results:** From the collaboration, a standardized system of PPE use was created and employed across all army MTFs. This allowed for centralized purchasing and distribution of the EVD specific PPE. It also accommodated the mobility of army personnel in that every MTF was following the same broad procedures only modified for their physical setup.

**Lessons learned:** Through the active period of Operation United Assistance, it became clear that the initial understanding of PPE needs was inconsistent with the threat. It was determined that a more robust questionnaire would eliminate costly donning and doffing of higher levels of PPE. Also, clear communication and risk assessment is necessary when developing a PPE scheme to be applied to a group as large as the Army.

### CS-103-06

#### The Fluidized Bed Asbestos Segregator (FBAS) as a Risk Assessment Tool for Asbestos in Soil

*E. Cahill, EMSL Analytical, Cinnaminson, NJ*

**Situation/Problem:** With increasing awareness of the potential for exposure from asbestos contaminated soil, a growing number of remediation projects now include a focus on analysis of soil for asbestos content. Most analytical techniques focus on determining the overall percentage or concentration of asbestos, however this information provides little insight into risk. Soil has always been a problem matrix for microscopic analysis due to homogeneity and particle size issues. Various sample preparation and analysis approaches have been developed to address these issues but each approach has its own set of advantages and disadvantages. The two primary approaches involve either sieving or milling the sample prior to analysis. The sieving method separates the soil into a coarse, medium and fine fraction which aids in the detection of asbestos or asbestos containing material during analysis. The milling method reduces the soil sample's particle size so that a representative sub-sample can be prepped to slide for a microscopic analysis.

**Resolution:** The Fluidized Bed Asbestos Segregator (FBAS) technique looks at asbestos in soil in a completely different way. With this approach a carefully controlled flow of air is passed through the dried sample. Any fibers that have been liberated are sampled via isokinetic sampling onto filter cassettes for direct preparation techniques and analysis by TEM. Analysis is typically performed by the ISO 10312 method and provides a result in respirable fibers per gram that can aid in risk assessment. The FBAS was originally designed by the Idaho National Laboratory. The EPA later improved the design of this instrument and performed numerous validation studies with blind prep and analysis of spiked samples. They have recently been using this technique on various soil related superfund sites.

**Results:** Through a Cooperative Research and Development Agreement (CRADA), the author is working with the EPA on various operational and design experiments and further

validation. The data so far is showing a linear relationship between known asbestos concentrations of spiked samples and respirable fiber concentrations by FBAS.

**Lessons learned:** This presentation will provide an overview of the primary techniques used for soil analysis including the new FBAS. After this technical session, participants should walk away with a better understanding of the issues surrounding asbestos in soil as well as a firm knowledge of their sampling and analytical choices.

### P0104

#### Laboratory and Healthcare Issues: Ventilation, Drug Exposures, Dust Control, Microbial Contamination, and Radiation

Monday, May 23, 2016, 10:30 AM - 12:50 PM

### SR-104-01

#### Vortex Ventilation in the Laboratory Environment

*L. Meisenzahl, Vortex Hoods, LLC, New Castle, USA Minor Outlying Islands*

**Objective:** The objective is to improve safety by reducing exposure to contaminants by the users of ventilated enclosures including laboratory fume hoods. It is proposed that containment is enhanced in a hood that has a particular interior shape that causes a natural vortex to occur. The sustained vortex improves the efficiency of hood containment at low air flow.

**Methods:** The method used to test this hypothesis was the ASHRAE 110 tracer gas test. A known volume of tracer gas was emitted in the hood. A MIRAN SapphIRe infrared spectrometer was used to measure the concentration of tracer gas that escapes the enclosure. The design of the experiment included a written operating procedure, data collection plan and statistical analysis of the data. A chemical fume hood of traditional design was tested. The hood interior was then reconstructed to enhance the development of a vortex inside the enclosure. The hood was retested using the same method to compare the performance of the traditional interior shape with the enhanced vortex shape.

**Results:** The results are that in every aspect, the vortex hood showed significant improvement over the traditional hood design. Use of the Hood Index characterizing the dilution of gas in an air stream, as a logarithmic function, indicates a causal relationship between containment and volumetric air flow through an enclosure.

**Conclusions:** In conclusion the use of the vortex effect provides better protection for researchers using laboratory fume hoods. The use of air changes per minute, rather than face velocity, improves hood efficiency and reduces owner operating cost.

## CS-104-02

### Hazardous Drug Handling and Contamination in Research Labs

*T. Barton, St. Jude Children's Research Hospital, Memphis, TN*

**Situation/Problem:** The same hazardous drugs that are the focus of safe handling guidelines in clinical care settings are also handled in research labs. Awareness about the safe handling guidelines in research labs is not comparable to what has become common in clinical care areas. The disparity in awareness and safe handling practices may result in potential exposure risk to lab researchers.

**Resolution:** Wipe samples were collected on various surfaces in several research labs where hazardous drugs are handled. A survey was administered to lab staff to assess how frequently they handle hazardous drugs, their handling practices, and use of PPE. Observations were made in laboratories to further evaluate common practices and compliance with PPE requirements.

**Results:** Hazardous drug contamination was found to be present on benchtops, lock boxes, and other surfaces in concentrations similar to what has been observed and published in several journal articles and NIOSH Hazard Alerts. The frequency with which researchers in these labs self-reported handling hazardous drugs was as high as or higher than the frequency reported of hazardous drug handling in clinical care areas. The use of engineering controls and PPE was not consistent with either institutional guidelines or safe handling guidelines.

**Lessons learned:** Although the NIOSH Alert promoting the Safe Handling of Hazardous Drugs in Health Care Settings was intended to be applied in research laboratories, researchers are often unaware of the term "hazardous drugs" or with applicable elements of safe handling guidelines. What is conventionally thought of as good chemical hygiene practices may not be sufficient when handling hazardous drugs whose health effects may include acute toxicity, carcinogenicity, and reproductive health effects. Efforts must be made to promote the overlooked elements of these safe handling guidelines and raise awareness of precautions that include the handling of closed chemical containers, the proper use of PPE, the use of engineering controls, and chemical decontamination of surfaces with a suitable agent (often bleach). Lab researchers must be aware of the potential for surface contamination with hazardous drugs and may need to rethink their application of regulatory requirements such as Designated Areas.

## CS-104-03

### Hazardous Drug Exposure: Assessment and Hazard Communication

*P. Lilley and J. Mancini, Army Public Health Center (Provisional), Aberdeen Proving Ground, MD*

**Situation/Problem:** Anecdotal evidence suggested that pharmacies compounding and dispensing Hazardous Drugs (HD) may have a problem with lingering surface contamination by these same HD. An assessment was initiated to understand the extent of exposures in various sized pharmacies. Six common potential exposure contaminants were selected from the NIOSH list of HD.

**Resolution:** A two phase study was conducted, assessing the extent of HD surface contamination and evaluating a sampling model developed by the Army Public Health Center (Provisional) [APHC (Prov.)] During the first phase of the study, five representative Military Treatment Facility (MTF) Pharmacies were assessed to determine the scope of contamination across the Army. The pharmacies ranged in size from prescribing all of the target drugs multiple times daily, to prescribing only one of the target drugs annually. Each pharmacy was supplied with a commercial sampling kit, to take two samples. Simultaneously, with the first phase of the study, the APHC (Prov.) laboratory developed and validated an in-house analytical method to analyze 100 square centimeter wipe samples for the six HDs of interest. The second phase of the study commenced with extensive sampling at eleven Army MTFs pharmacies, including two pharmacies that participated in the first phase.

**Results:** Assessment of the sample results indicated an extensive surface contamination problem. Results showed that fourteen of the fifteen MTFs sampled had HD contamination in at least one sampling location at least ten times the limit of quantitation of the laboratory analytical method. One of the sites that participated in both phases enacted a major upgrade to their cleaning procedures between phases, resulting in a dramatic reduction in contamination from the initial assessment.

**Lessons learned:** Hazardous drug contamination occurred in nearly every pharmacy in the study. A lack of understanding about both the HD contamination and the potential exposure risk combined for an air of complacency among the workers handling and compounding HD. The presence of a HD specific cleaning protocol in a pharmacy does not guarantee that it is followed or effective. Improved hazard communication and training on cleaning procedures are necessary to implement an effective program that will reduce residual HD contamination.

## SR-104-04

### Protecting Nurses from Antineoplastic Drug Exposures

*T. Smith, Indiana University School of Public Health - Bloomington, Bloomington, IN; H. Woldu and D. DeJoy, University of Georgia, Athens, GA; A. Dyal, Kennesaw State University, Marietta, GA*

**Objective:** The objective of this study was to assess the impact of work and organizational factors, including safety climate, on the use of safe work practices to reduce nurses' exposures to antineoplastic drugs.

**Methods:** Data, to include only nurses from various work settings (n=1915), from the web-based NIOSH Health and Safety Practices Survey of Healthcare Workers were analyzed. Following preliminary analyses, two multiple linear regression analyses were completed to examine safe work practice outcomes including the use of engineering controls and personal protective equipment (PPE).

**Results:** For the first model, where PPE usage was the dependent variable, safety climate and familiarity with guidelines were the strongest positive predictors of use (p <0.0001). Nonprofit status, hospital setting, and having more employees were also relatively strong predictors of improved compliance (p=.002 to .006). Having additional precautionary

measures (i.e. spill kits) was also related to improved compliance ( $p=.03$ ). Number of treatments administered ( $p=0.00$ ) and not being trained in the past 12 months ( $p=.008$ ) were negative predictors of PPE utilization. In our second model, relevant policies/procedures, safety climate, and familiarity with guidelines were the strongest positive predictors for engineering control utilization ( $p < 0.0001$ ). Engineering control usage was also better for those who work for non-profit ( $p=.001$ ) and government organizations ( $p=.007$ ). Working in a hospital ( $p=.01$ ) and the availability of precautionary measures ( $p=.05$ ) also had a positive impact on engineering control practices, while usage was less for those who never received training ( $p=.002$ ).

**Conclusions:** The findings of this study illustrate how organizational factors and safety management practices enhance safe work practices that will protect nurses from antineoplastic exposures. Familiarity with guidelines and a positive safety climate predicted both PPE use and engineering control use. Conversely, training deficiencies diminished the effective use of safe work practices. Interestingly, nurses working in nonprofit organizations exhibited the greatest safe work practices. Ultimately, the integration of a formal safety management system (such as AIHA/ANSI Z10) may prove beneficial in enhancing safety climate and improving nurses' safe work practices.

## CS-104-05

### Compliance with ICRA Dust Control in a Hospital

*R. Beall, Entek Consulting Group, Inc., Rocklin, CA*

**Situation/Problem:** This presentation will address practical application for compliance with the Infection Control Risk Assessment (ICRA) permit process to address the situation/problem of dust control on construction projects inside hospitals.

**Resolution:** Resolution to these challenges will include four examples of compliance for dust control that include: use of a mini-enclosure, two examples of larger containments, and one containment of dry-out of a wet ceiling in an operating room using the dehumidification machine to create the negative pressure. One of the larger containments will demonstrate a nontraditional approach to create the required negative pressure work containment by thinking outside the box. Finally, a discussion on the use of particle testing inside of the containment compared to outside of the containment. We will demonstrate how measurement of particles of different sizes can provide a valuable metric to the completion of the construction work before allowing the contractor to remove the containment barriers.

**Results:** Dust control in a sensitive work environment such as a hospital can be achieved by different approaches to obtain negative pressure. Negative pressure can be created within mini enclosures, larger containments using the traditional negative air units and within a small enclosure using a dehumidifier.

**Lessons learned:** Lessons learned from this presentation will be to realize there are different approaches to meet the intent of the ICRA requirements with the knowledge and experience

of industrial hygienists to assist in presenting options. In addition, particle testing can be a valuable tool to assist Infection Control and the construction team and hospital staff to assure control of the construction area.

## CS-104-06

### Evaluation of Microbial Surface and Air Contamination Using Active UV-C Technology in a Healthcare Setting

*L. Lee, American Green Technology, South Bend, IN*

**Situation/Problem:** UV-C technology has been used as a disinfection method for decades in the healthcare industry. The UV-C wavelength of 253.7 nanometers has been proven to be effective at eliminating or neutralizing dangerous pathogens like *C. difficile*, Methicillin resistant *Staphylococcus aureus* and more. The challenge with UV-C technology has always been the method of delivery. It can't be used in an occupied spaces and is only effective on areas that are in its direct line of sight. The current technologies focus on cleaning surfaces to reduce healthcare associated infections. This study was designed to look at the relationship of surface and air contamination compared to the control and challenge areas for total bacteria counts in colony forming units.

**Resolution:** A study was conducted at an acute care hospital to evaluate the levels of both air and surface contamination using an active UV-C system, which utilizes a set of fans to draw air into the ceiling grid where a completely shielded UV-C chamber is hidden from view, operating 24/7. Air is pushed through the chamber, pathogens are neutralized and then disinfected air is pushed back out into the room. This system can operate in an occupied space.

**Results:** Before and after air and surface samples from the study showed that installation of the active UV-C systems reduced total bacteria count. The study reported the results of total bacteria per cubic meter of air in terms of raw cfu data and correction hole factor. The surface data was reported as raw cfu counts per 25 cm<sup>2</sup>. Cleaning and disinfecting the air had a dramatic effect on the bacteria levels of the air and surface contamination.

**Lessons learned:** This study was critical to understanding the causal relationship between air and surface contamination. Reducing the bio load of pathogens in the air appears to have a direct effect on the amount of pathogens that collect on surfaces. Continued research is needed to develop the relationship between reduction of biological loading and its association with healthcare associated infections. Understanding this relationship can help engineer controls to improve the risk of healthcare associated infections by reducing exposures to patients, staff and visitors to dangerous pathogens.

## CS-104-07

### Serious Questions About Radiation Measurements

R. Johnson, Radiation Safety Counseling Institute, Rockville, MD

**Situation/Problem:** How often do we find ourselves interpreting data based on someone else's radiation measurements without really knowing if the data are valid? Defensible decisions for radiation safety should begin with good radiation measurements. Unfortunately, many safety decisions are based on measurements with uncertainties, which are either unknown or neglected. Once a measurement is written down, it seems to take on a life of its own and all uncertainties are lost. We may not ask questions to verify the data, especially if the number is above an action level. However, before measurements are interpreted, they are just numbers. Once interpreted the numbers mean whatever people believe, often related to their fears of radiation. There are numerous errors which can result in measurements that do not represent the real world.

**Resolution:** Before making expensive decisions for radiation safety people need to understand that radiation is a random phenomenon. Even with great care, radiation measurements are only best estimates from a random distribution. When uncertainties are reported for measurements, in most cases they only account for the randomness of radiation. Ideally, they would include uncertainties due to calibration, energy response, and numerous operator judgment factors (geometry, location of measurement, speed of probe movement, etc.). Measurements should not be made in contact with a source without taking into account the location of potentially exposed people and occupancy time. Measurements made for gamma ray exposure should, also, consider a possible beta component. Also, care needs to be taken when reading the scale multiplier.

**Results:** Many expensive decisions for radiation safety may be avoided by careful evaluation of the quality of radiation measurements. However, because of fears of consequences, people may want to quickly implement radiation safety decisions without confirming the initial measurements. We will review several case studies where protective actions were implemented based on erroneous measurements that would not justify the safety decisions.

**Lessons learned:** The golden rule for measurements should be to repeat the sample and measurement for confirmation, ideally with different people and instruments, before making an expensive decision. By asking serious questions about radiation measurements, IHS may avoid making expensive decisions that are not warranted by poor quality radiation measurements.

## PS402

### Poster Session 402

Monday, May 23, 2016, 2:00 PM - 4:00 PM

## CS-402-01

### Recommendations to Improve Employee Thermal Comfort When Working in 40°F Refrigerated Cold Rooms

D. Ceballos, Environmental Health, Harvard University, Boston, MA; K. Mead and J. Ramsey, CDC/NIOSH, Cincinnati, OH

**Situation/Problem:** Cold rooms for food storage and preparation are usually kept around 40°F following food safety guidelines. Some food preparation employees may spend 8 or more hours inside cold rooms but may not be aware of the risks associated with moderately cold temperatures. Moderately cold work conditions are not well covered in current occupational health and safety guidelines or educational materials.

**Resolution:** We characterized work conditions of cold room employees and provided recommendations to improve thermal comfort and prevent health and safety problems. We observed employees in two cold rooms at an airline catering facility, reviewed daily temperature logs, and evaluated employee's physical activity, work and rest schedules, and protective clothing use. We measured temperature, relative humidity, and air velocities at work stations inside the cold rooms.

**Results:** Employee's thermal comfort was influenced by air drafts at workstations, insufficient use of personal protective equipment (PPE) due to dexterity demands of their food preparation work, and lack of knowledge about good health and safety practices in cold rooms. We measured some air drafts that exceeded recommended guidelines.

**Lessons learned:** Recommendations included redesigning air deflectors, installing suspended baffles to change air patterns, providing more options on PPE, changing out of wet clothing, providing hand warmers, and educating employees on cold stress. There is a need for guidelines and educational materials tailored to employees in moderately cold environments to improve thermal comfort and prevent health and safety problems.

## CS-402-02

### Manganese Exposure and the OSHA Standard: The Relevance of the 5.0 mg/m<sup>3</sup> Ceiling PEL

D. Duffy, ESIS, Inc., Chicago, IL

**Situation/Problem:** OSHA established a Ceiling Permissible Exposure Limit for manganese many years ago. The issue is whether that standard is still relevant and whether ceiling exposures in excess of the 5 mg/m<sup>3</sup> PEL during welding, air arcing and related processes can occur.

**Resolution:** Manganese is a component of steel, welding wires and electrodes, albeit at relatively low percentages. TIG, MIG, arc welding, and plasma cutting will generate manganese fumes to varying degrees. The adopted TLV® of 0.02 mg/m<sup>3</sup> as a time weighted average has focused all the attention on controlling full shift average exposures to below that guideline. The TLV® is based on potential adverse neurological effects from long term manganese exposures. However, since the OSHA standard has regulatory and compliance ramifications, we decided to investigate ceiling manganese exposures during seam welding and plasma cutting to determine if short term exposures could approach or exceed the Ceiling PEL.

**Results:** Short term manganese exposures during TIG, MIG arc welding and plasma cutting were determined for exposure times of up to 15 minutes. Exposures during each welding process and during the use of various welding wires were determined during seam welding and plasma cutting. Our results indicated that during constant welding and plasma cutting, the 5.0 mg/m<sup>3</sup> PEL could be approached and exceeded. We also showed that when the manganese PEL is exceeded, iron oxide and total particulate exposures were quite high.

**Lessons learned:** The TLV® for manganese has garnered attention as a full shift exposure concern. However, the OSHA Ceiling PEL of 5.0 mg/m<sup>3</sup> still presents regulatory and compliance issues. We determined that manganese exposures during short term seam welding and plasma cutting can approach or exceed this PEL. Variables such as the manganese content in the steel, the type of wire or stick electrode used, the presence of local exhaust ventilation and ambient air movement and where on the welder the sample was collected influence compliance with the OSHA standard. The OSHA PEL is relevant for compliance, for upper respiratory tract irritation and is relevant in the sense that when short term manganese exposures are high, so too will be iron oxide and total particulates exposures.

### CS-402-03

#### Phenol—Side by Side Passive and Active Sampling and Analysis

*J. Kenny, ESIS Environmental Health Laboratory, Cromwell, CT; K. Bujak, ESIS Inc. Health, Safety & Environmental, Wadsworth, OH; J. Cochran, ESIS Inc., Health, Safety & Environmental, Austin, TX*

**Situation/Problem:** Phenol has traditionally been collected using a pump and an XAD-7 sorbent tube and following desorption in the lab is analyzed by Gas Chromatography. Recently, multiple companies manufacturing passive monitors have published passive sampling collection rates for phenol. The rates published have indicated that they have been calculated but have not been partially or fully validated. Calculated passive sampling rates are determined by using the diffusion coefficient of a specific chemical and the cross-sectional area of the monitor and the monitors sample path. Partial or Full Validation of a passive monitor would involve the generation of a vapor to prove the passive monitor would collect at the calculated rate and would verify capacity, effects of humidity, reverse diffusion and storage. Side by side sampling of phenol using both passive monitors and active samplers were collected and analyzed to determine the variation between the two methods.

**Resolution:** Passive and active samplers were collected side

by side in multiple locations for comparison of the analytical results.

**Results:** A number of investigations were performed collecting side by side active and passive samples for phenol. The phenol passive monitors concentrations consistently correlated with the air concentrations but were consistently lower than the air concentrations obtained with solid sorbent tubes and pumps. Side by side concentrations were from 14 % to 34 % lower for passive samples as compared to active samples. While our limited sampling set demonstrated a negative bias, the monitor results would still meet the OSHA method's acceptable criteria of +/- 25 percent. The results demonstrated that the phenol passive monitor consistently correlated with the active sample.

**Lessons learned:** The use of passive monitors simplifies the field industrial hygienist's work effort. But, when using passive monitors, it is important to know how the sampling rate was calculated and if the badge has gone through partial or full validation. Sampling rates and the type of calculated or validated sampling rate is available in the catalogs and on the passive monitor manufacturers' websites. Sharing field data with monitor manufacturers can assist these companies in their investigating and performing vapor recoveries and adjusting theoretical sampling rates if needed.

### CS-402-04

#### Solder Fume Extraction—Do ADB Remove Abietic Acid

*J. Lohkamp, A. DiMaggio, and L. Felker, ESIS, Inc. Health, Safety & Environmental, Dallas, GA*

**Situation/Problem:** Hand soldering operations are commonly encountered throughout the electronics industry. Components within soldering may include rosins which may cause allergic skin reactions and occupational asthma. The current ACGIH® TLV® for rosin core solder thermal decomposition products (as colophony) reads "Sensitizer: reduce exposure to as low as possible". In other countries including the United Kingdom HSE, there are similar standards that follow the new TLV® approach (as colophony or resin acids). Barring substitution, engineering controls (local exhaust ventilation), is the preferred method for reducing exposures to as low as possible. One form of ventilation for use during soldering operations are stand-alone air displacement boxes (ADB) that filter and recirculate the air back into the workspace. The question remain, do these devices effectively remove decomposition products effectively?

**Resolution:** To address this issue, air sampling, air velocity measurements and smoke tests were conducted for three exhaust units during use of rosin core solder wire in three separate locations. Measurements were taken in front of the exhaust units, in the exhaust stream, and on the person soldering. Air samples collected were analyzed for abietic acid.

**Results:** Smoke was used to determine placement of sample collection devices and to observe air flow patterns. The results of the air sampling for Rosin Core Solder Thermal Decomposition Products (RCSTDP-measured as abietic acid) indicated the following: Abietic acid was detected in front of fume extractor ranged between 260 - 830 mg/m<sup>3</sup> Abietic acid was detected 1-2 foot down wind ranged between 14 - 20 mg/m<sup>3</sup> Abietic acid was detected in the breathing zone ranging between 1.2 - 6.7 mg/m<sup>3</sup> The air sampling indicated that exposures to RCSTDP are still possible when using these devices.

**Lessons learned:** As indicated in a UK HSE publication, “It would probably be more accurate to think of the ADBs as a fume disperser than a fume extractor”. Air sampling from this test confirms that while the concentrations of decomposition products is reduced when using these fume extractors, exposures to a known sensitizer is still possible potentially putting people at risk. Additionally, since the fumes were observed passing through the units, other persons around the soldering activities may also be exposed to these decomposition products.

## CS-402-05

### Chromium—Total Chrome and Hexavalent Chrome Air Concentrations While Welding Carbon Steel

*J. Kenny, ESIS Environmental Health Laboratory, Cromwell, CT; G. Stratton and M. Newport, ESIS Inc. Health, Safety & Environmental, Andover, CT*

**Situation/Problem:** Welding metals can produce hexavalent chromium if the base metal, rods or wires contains chromium. Most carbon steels, including rods and wires, have low levels of chromium (0.01-1 %) while stainless steel will contain chrome as a major component (5-30 %). Companies collect air samples to have objective data to demonstrate compliance with the OSHA hexavalent chromium standard. A client company sampled during welding of carbon steel using a metal scan which analyzed for iron, manganese and total chrome along with some other metals. They chose not to sample for hexavalent chromium since the chrome level was low in the carbon steel. The total chromium for the sample collected was over 5 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). Subsequent to this sampling, an OSHA inspector requested the client demonstrate that they had performed initial monitoring for hexavalent chromium since the total chrome exceeded the  $5 \mu\text{g}/\text{m}^3$  PEL. They could not prove that the chrome that was detected was not in the hexavalent state. This issue provoked the retrospective analysis of a years’ worth of side by side sampling of both hexavalent and total chromium in various plants welding carbon steel.

**Resolution:** An analysis of side by side sampling results for both hexavalent and total chrome for welding processes involving welding of carbon steels in multiple locations and using different welding methods was performed. Most of the samples collected represented full shift sampling of welders. The data generated over a year’s time at over ten plants and involved over sixty side by side samples was analyzed retrospectively.

**Results:** The results demonstrated that the hexavalent chromium levels measured were always less than the total chromium air concentrations and never exceeded 30 % of the total chromium concentration. The concentrations of hexavalent chromium compared to the total chromium concentrations when welding carbon steel was from 5 to 30 percent, with an average concentration being 8 %.

**Lessons learned:** Welding carbon steel will produce measurable levels of both total and hexavalent chromium. For full shift welders welding carbon steel total chromium levels never exceeded  $10 \mu\text{g}/\text{m}^3$  while hexavalent chromium concentrations never exceeded  $1 \mu\text{g}/\text{m}^3$ . For full shift welding on carbon steel hexavalent chrome is not likely to exceed the OSHA action level of  $2.5 \mu\text{g}/\text{m}^3$ .

## SR-402-06

### Reducing Welders’ Exposure to Manganese Welding Fume Using Low Manganese Emissions Flux Core Wire

*J. Capuzzi, ESIS, Cape May Courthouse, NJ*

**Objective:** The purpose of this study is to determine if welders’ exposure to manganese welding fume is reduced by substituting low manganese emissions flux core wire for the standard flux core wire.

**Methods:** Full shift or representative full shift personal breathing zone samples were collected for welding fumes using 25mm mixed cellulose ester filter sampling cassettes at a flow rate of 1 - 2 liters per minute. SKC AirChek sampling pumps provided the vacuum source. Pumps were calibrated prior to and after the sample collection using a TSI 4100 Series mass flow meter traceable to the National Institute of Standards and Technology in conjunction with the filter media. The filter cassette was placed inside the welding helmet. Nine welders using the standard flux core wire (ESAB Dual Shield 7100LC flux core welding wire) were monitored on day one of the study while conducting typical welding activity during the construction of a river barge. Nine welders using the low manganese flux core wire (Hobart Element 71T1C low manganese emissions flux core wire) were monitored on day two of the study while conducting typical welding activity during the construction of a river barge.

**Results:** The mean worker exposure using the 71T1C low manganese flux core wire was  $0.188 \text{ mg}/\text{m}^3$  which represent a reduction from the baseline XL-550 wire mean of  $0.521 \text{ mg}/\text{m}^3$ . The T-test for dependent means showed that the difference between the data was statistically significant at  $p = 0.05$ . Twenty-two percent (22%) of the exposure levels measured using the 71T1C low manganese flux core wire were less than the ACGIH® Threshold Limit Values (TLVs®) of  $0.02 \text{ mg}/\text{m}^3$  as an 8-hour time-weighted average (TWA) for manganese. Using the ESAB 7100LC wire, 100% of the exposure concentrations exceeded the TLV®.

**Conclusions:** The low manganese emissions flux core wire did have a statistically significant desired outcome of reducing welders’ exposure to manganese. The use of the low manganese emissions flux core wire is recommended, if it is technically feasible and meets the welding quality requirements/specifications. The reduction in employee exposure to manganese using the 71T1C low manganese emissions flux core wire was similar to the reductions obtained during railcar construction and which was presented in a poster at AIHce 2015. The low manganese emissions flux core wire in conjunction with other control measures such as local exhaust ventilation, which was not used during this study, and welder awareness training is also recommended to aid in reducing welders’ exposure to manganese welding fume as well as to other welding fume.

## CS-402-07

### Sensitization to Platinum Salts—Easy to Take the Wrong Approach

*A. Smith and H. Meeds, ESIS Health, Safety & Environmental, Philadelphia, PA*

**Situation/Problem:** A site had repeated cases of sensitization

to platinum salts, spanning a prolonged time period. A course of action had been to set in place. The actions were believed to be correct; controls (with emphasis on PPE) and a long-term program of in-house exposure monitoring. Large amounts of air monitoring data were accumulated and exposures considered well below the ACGIH® TLV®. Sensitization cases continued to occur and the site became resigned to being unable to prevent them.

**Resolution:** A qualified Industrial Hygienist was appointed to investigate. By observing and analyzing each stage of the process, incorrect assumptions and misunderstandings of where/how exposure could occur were revealed. Sources of exposure were identified and suitable controls devised without, at this stage, undertaking any monitoring measurements. Accordingly, a program was set in place to manage controls. A program of carefully targeted monitoring was set up at a later stage, but greater emphasis remained upon reviewing and improving control at source.

**Results:** In having a greater understanding of how platinum sensitization occurs and being fully aware of how exposure was potentially occurring, the site was much better able to manage and control the risk. No further incidences of platinum sensitization have occurred and are believed far less likely to occur in the oncoming future.

**Lessons learned:** The site incorrectly believed: they had sufficient understanding of platinum sensitisation; were able to sufficiently identify sources of exposure; and focus should be upon PPE and air monitoring. This case study demonstrates how resolution to a serious ongoing issue was able to be obtained through careful observation and analysis, professional input, and without any initial monitoring measurements. It sets out to highlight: common types of misunderstanding surrounding an exposure issue; how they occur without utilization of specialist input; and the essential need to follow the basic principles of Industrial Hygiene.

## SR-402-08

### Improving the Accuracy of the Well-Mixed Room Model Used in IH Mod for the Estimation of Exposures to Aqueous Solvents

*C. Castro Ruiz, D. Bégin, D. Drolet, and M. Debia, Université de Montréal, Montréal, QC, Canada; S. Halle and W. Chouchen, Ecole de Technologie Supérieure, Montréal, QC, Canada*

**Objective:** Exposure modelling is important in the practice of industrial hygiene for managing occupational exposure to chemicals. The well-mixed room model (WMR) describes the concentration of a contaminant in a room with high turbulent airflow using simplifying assumptions. Raoult's law works well for mixtures of substances that are similar. However, for nonideal mixtures, including aqueous solvents, a correction factor, the activity coefficient (AC) must be used when estimating the partial vapour pressure. The objective of this work was to evaluate the effect of introducing AC values when using the well-mixed model for aqueous solvent mixtures.

**Methods:** First, generation rates of four commonly used organic solvents (acetone, 2-propanol, n-hexane and toluene) were determined using an experimental setting. Subsequently, an exposition chamber (0.09 m<sup>3</sup>) with controlled ventilation

rates (0.5 L/min) was used to carry out evaporation tests with the five organic solvents at molar fractions of 1%, 10%, and 100% in water. Solvent concentrations were measured in real time using a Gas Chromatography-Thermal Conductivity Detector (Model Varian CP2300). Finally, simulations were performed using IH Mod (version 209) and ACs were calculated using the <sub>xi</sub> UNIFAC computer program (Randhol, 2000). The accuracy of the simulations was assessed by comparing the concentration peaks and the percentages of evaporation calculated after 150 minutes for both the IH Mod generated curves and the ones obtained during experimental measurements.

**Results:** Calculated generation rates were 25, 26, 111 and 135 mg/min for 2-propanol, toluene, n-hexane, and acetone, respectively. ACs were high for hexane and toluene, but were much lower for 2-propanol and acetone at molar fractions of 1% and 10%. For instance, calculated ACs were 5222 and 173 for 1% and 10% of hexane in water, compared to 10 and 5 for 1% and 10% of acetone in water. At 1% and 10%, maximum concentrations obtained when using ACs were on the same range (+/- 10%) as the simulated concentrations but none of the maximum concentrations were on the same range when not considering ACs into the models. After 150 minutes, percentages of evaporation ranged from 65% to 90% for real concentrations, from 70% to 90% for models using ACs, and from 5% to 65% for models without ACs.

**Conclusions:** AC is an essential parameter for the estimation of exposure to aqueous solvents and it should be implemented in the WMR model equation used in IH Mod.

## SR-402-09

### Elemental Properties of Coal Slag Bulk Samples and Measured Airborne Exposures at Two Coal Slag Processing Facilities in the United States

*C. Mugford, R. Boylstein, and J. Armstrong Gibbs, Respiratory Health Division, CDC/NIOSH, Morgantown, WV*

**Objective:** In 1974, NIOSH recommended a ban on the use of silica sand abrasives containing more than 1% silica due to the risk of silicosis. This recommendation gave rise to abrasives substitutes such as coal slag. Coal slag is used to produce abrasive granules because it is an inexpensive and effective blasting abrasive. In 2010, an OSHA investigation uncovered a case cluster of suspected cases of pneumoconiosis in four workers at a coal slag processing facility. In 2014, NIOSH conducted an industrial hygiene survey at two coal slag processing facilities to characterize elemental properties of coal slag bulk samples and airborne exposure to dust, silica, and metals.

**Methods:** The industrial hygiene survey consisted of the collection of: a) bulk samples of coal slag and finished granule products for silica and metals; b) full shift area air samples for total and respirable dust, silica, and metals; and c) full shift personal air samples for total and respirable dust, silica, and metals.

**Results:** Bulk samples consisted mainly of iron, manganese, titanium, and vanadium; and trace amounts of arsenic, beryllium, cadmium, and cobalt. Only unprocessed coal slags from Illinois and Kentucky contained up to 0.46% (4,600 mg/kg) silica. Elevated total dust was identified in the screen and

bag house areas (11–36 mg/m<sup>3</sup>). Area air samples identified trace amounts of beryllium, chromium, cobalt, copper, iron, nickel, vanadium, and manganese in total dust. Respirable airborne silica ( $\geq 0.005$  mg/m<sup>3</sup>) was identified in the screening areas. Overall, personal dust air samples (0.1– 6.6 mg/m<sup>3</sup> total; and 0.1– 0.4 mg/m<sup>3</sup> respirable dust) were lower than area air samples. All personal air samples for total and respirable dust, silica, and metals were below their respective OSHA PEL.

**Conclusions:** Silica was less than 1% in all bulk samples, supporting the claim that coal slag is a suitable abrasive substitute for silica sand. All personal air samples for dust and silica were lower than the air sampling results from the 2010 OSHA investigation. Prior to the NIOSH survey, the facility changed procedures to limit time spent in screening and crushing areas and perform maintenance tasks before start up, which may have contributed to lower dust and silica levels. These data are from only two coal slag processing facilities and more air monitoring is needed to better characterize occupational exposures.

## CS-402-10

### Auto Correction of Flow Rate in a Personal Air Sampling Pump for Changes in Barometric Pressure

*R. Robertson and W. Davis, Sensidyne, LP, St. Petersburg, FL*

**Situation/Problem:** Air density, viscosity, and other factors change with barometric pressure and ambient temperature. This has been a major source of error in personal monitoring pump sampling. Flow constancy at ambient conditions is important for determining volume sampled and is particularly critical when using inertial particle size separators such as impactors and cyclones, where flow rate changes affect cut off point.

**Resolution:** A commercially available personal monitoring pump allows for automatic compensation of ambient temperature and barometric changes, such as calibrating at ground level and sampling in an underground mine or at altitude in a passenger airplane. Bench testing in a pressure chamber produced and verified the data that was used to form a correction algorithm. The pump contains pressure and temperature sensors that provide the data to maintain constant volumetric flow during sampling.

**Results:** Unit operation was confirmed in field testing at a deep gold mine in South Africa. The results indicate that the pump is capable of maintaining the flow rate at +/- 5% (volumetric) when calibrated at the surface and operated at depth.

**Lessons learned:** Real time measurement of temperature and pressure along with a correction algorithm can be used effectively to correct for air density changes in a personal air sample when the volumetric pump is calibrated at one altitude and operated at another.

## CS-402-11

### Analysis of Metals in Paint Using X-Ray Fluorescence Spectroscopy

*Y. Zagagi, Golder Associates Inc., Jacksonville, FL*

**Situation/Problem:** Metal-based paints are used to protect ship surfaces from corrosion and can contain up to 30

percent heavy metals. Varying levels of lead, chromium, and cadmium can be found during ship repair and maintenance with older ships having a higher likelihood of heavy metal occurrence. Removal of paint containing heavy metals may require specialized abatement which can be costly and time-consuming. Permissible Exposure Limits (OSHA's PELs) and Threshold Limit Values (ACGIH® TLVs®) for exposure to these metals are measured as inhalation exposure (mg/m<sup>3</sup>). There are no OSHA regulations specifying acceptable or threshold levels of lead or other heavy metals in paint [measured either as mg/kg or ppm]. The Environmental Protection Agency (EPA) considers paint with 600 ppm of lead or less to be a non-lead-based paint (HUD, 2012). Similar recommendations are not available for chromium or cadmium.

**Resolution:** The goal of the study was to develop a reliable field method using x-ray fluorescence spectroscopy (XRF) to measure levels of cadmium, chromium (total), and lead in marine paint and to compare XRF sample results to traditional laboratory results analyzed using inductively coupled plasma atomic emission spectroscopy (ICP-AES) technology. A reliable field method was desirable to reduce the time and costs associated with sending maritime paint samples to a lab for analysis prior to disturbance and/or repair activities. This would reduce the time needed to determine the proper level of employee protection prior to paint disturbance or removal operations.

**Results:** Based on the data collected and compared to pre-determined threshold levels, upper and lower XRF cutoff values (ppm) were established to determine, with a high degree of confidence, a correlation to a laboratory result that is less than or greater than the predetermined threshold level that requires specialized abatement while removing the paint. Between the upper and lower XRF cutoff values, laboratory analysis will be required.

**Lessons learned:** XRFs can be used to determine the presence of cadmium, chromium, and lead in maritime paint. Such results allow decisions on the need for specialized abatement or other precautions to be made rapidly based on paint samples taken by an XRF device, in lieu of sending samples to a laboratory for analysis, which can minimize laboratory costs and assist in scheduling work with minimal delay while maintaining employee safety.

## CS-402-12

### Improving Industrial Hygiene: The Benefits of Organization Development

*S. Milz, University of Toledo, Toledo, OH*

**Situation/Problem:** As industrial hygienists our job includes recommending steps that can be taken to ensure the well-being and health of workers. These steps may include changes that if done more strategically will better help protect worker health. We are taught in our degree programs and in our workplaces what changes need to be made, but we receive little to no training in how to make these changes more strategic so that the changes are sustainable.

**Resolution:** The field of organization development (OD) provides a means of creating strategic sustainable change within organizations. Cummings and Worley (2009) defined OD as "a process that applies a broad range of behavioral science knowledge and practice to help organizations build their capacity to change and to achieve greater effectiveness."

Further, strategic sustainable change requires a systemic approach of building awareness, checking for motivation, assessing abilities, and creating opportunities. From this perspective, workplaces need to change if we want our workers to remain safe. By implementing the use of OD, we ensure that our goal of protecting the health of workers is met.

**Results:** Industrial hygienists evaluate workplaces looking for potential overexposure environments. We follow exposure assessment guidelines and OSHA regulations. We use the results of these evaluations to recommend changes at the source of the exposure, but we don't look for possible organizational or departmental changes that could minimize the potential for overexposure throughout the organization. Adding OD tools to the IH toolbox provides the industrial hygienist with tools to maximize protection from the organizational level. OD tools focusing on Appreciative Inquiry and the Intentional Change Theory provide organizations with the ability to build strong departments and to obtain the buy in from employees on any proposed changes. These tools and a sustainable change process help the industrial hygienist to go beyond the immediate location of the possible overexposure to the department, the plant, and the organization.

**Lessons learned:** The field of OD offers a wide variety of tools for creating strategic sustainable change. These tools are beneficial to the industrial hygienist's toolbox by giving them the ability to affect sustainable changes in the workplace to attain our goal of protecting the health of workers.

## CS-402-13

### The Quantification of Free Drug and Antibody Drug Conjugate (ADC) Molecules Collected During Surface Industrial Hygiene (IH) Monitoring Procedures

*N. Tsekhanovskaya, SafeBridge Consultants Inc., Mountain View, CA*

**Situation/Problem:** Surface cleanliness monitoring is an important part of Industrial Hygiene (IH) procedures. Surfaces in antibody drug conjugate (ADC) manufacturing facilities may be contaminated with free drug (payload), active forms of conjugated drug, or a mixture of both, depending on the type of processes undertaken in the facility.

**Resolution:** IH monitoring of surfaces depends on successful surface wipe sampling procedures, protection of biomolecules from degradation and sampling media adsorption during transportation and storage, as well as effective fit for purpose validated analytical methods.

**Results:** Validated surface sampling procedure and immunoassay methods for quantification of free maytansinoid (competitive EIA) and antibody conjugated maytansinoid (double-antibody sandwich ELISA) collected on the same surface sample will be presented. The importance of immunoassay interferences in surface swab samples which can often occur due to trace contamination by cleaning agents will be emphasized.

**Lessons learned:** The importance of removing cleaning agents from surfaces and the verification of this action e.g., by pH or oxidation monitoring, before surface sampling is undertaken should not be overlooked as the continuing presence in the sample can lead to the destruction of the analyte and disruption of immunoassays. However, some contamination

of the surface wipe sample can be tolerated with the use of a stabilization buffer (into which samples are placed during transport to the testing laboratory). Selection of an appropriate swabbing solution is critical to ensure that free drug (payload), active forms of conjugated drug, or a mixture of both can be captured by the swabbing media. The payload and biomolecule component of the ADC often require different solvents.

Systematic planning of extraction and immunoassay steps can generate simple, effective immunoassays to accurately quantify the ADC and components.

## SR-402-14

### Comparison of Active and Passive Sampling Methods for Formaldehyde in Pathology/Histology Labs

*E. Lee, M. Kashon, and M. Harper, HELD/EAB, CDC/NIOSH, Morgantown, WV; R. Magrm and S. Guffey, West Virginia University, Morgantown, WV*

**Objective:** The purpose of this study is to compare formaldehyde concentrations between active and passive sampling methods.

**Methods:** One pathology and one histology lab voluntarily participated in the present study. In each lab, personal and area exposure measurements were collected using sets of active air samplers (Supelco LpDNPH tubes) and passive (diffusive) badges (ChemDisk Aldehyde Monitor 571). At the pathology lab, samples were collected in two campaigns, 15 personal and 10 area sample pairs in one and 21 personal and 4 area sample pairs in the other. At the histology lab, 13 personal and 3 area sample pairs were collected. Participants were lab personnel who handled formaldehyde solution and personnel who did not, but, were in close proximity. Samples were analyzed by the NIOSH contract laboratory according to NIOSH method 2016 for active samples and OSHA method 1007 (using the manufacturer's updated uptake rate, which is different to that cited in the OSHA method) for passive samples.

**Results:** All active 8-hr time-weighted average (TWA) exposure measurements, which ranged from 0.004-0.25 ppm (median 0.04 ppm), showed compliance with the OSHA PEL (0.75 ppm), but not with the lower NIOSH REL (0.016 ppm). Passive TWA exposure measurements, which ranged from 0.01-1.98 ppm (median 1.19 ppm), showed > OSHA PEL. The median of concentration ratios (passive/active) was 1.19 (range: 0.27-17.28) for all data and 1.16 (range: 0.27-6.58) after removing four outliers using Cook's distance method. The regression analysis of log-transformed data (Ho: Slope (b)=1) indicated statistically no significant difference of concentrations between active and passive samples for all data (b=0.88 with adj. R<sup>2</sup>=0.616), but a significant difference was detected for the data without outliers (b=0.88 with adj. R<sup>2</sup>=0.785). In addition, statistical differences were observed from the comparison of exposure measurements between the active and passive samples (all p-values < 0.05) both with and without outliers.

**Conclusions:** The regression analysis test result without outliers and the comparison of means indicated that there is bias between the methods. The small sample loading on the passive sampler and/or the uptake rate used may have contributed to this bias. The higher concentrations shown by the passive badges result in a more conservative assessment of risk, but the difference between methods lead to a different conclusion with regard to legal compliance in this situation.

## CS-402-15

### Firing Range Residue Hazard Characterization and Cleanup

*T. Sleight, U.S. Air Force, Enid, OK*

**Situation/Problem:** Indoor firing ranges pose numerous airborne and surface hazards. At one point several years ago, lead rounds had been used on Vance AFB's range, leading to concerns of historical lead contamination. Frangible bullets are composed of copper, rather than lead, reducing many of the airborne contaminants. However, air currents cause the fine dust from the expenditure of frangible rounds to mix with propellant and debris, creating a complicated mixture. Cleaning this up created a challenging hazard characterization. Limited data was available for comparison, and stories of firing ranges catching fire from bullet ricochet or other mechanical ignition source were discovered. Concerns of both toxicity and flammability came under consideration.

**Resolution:** Air Force guidance forbids dry sweeping firing ranges, and no suitable options could be found for wet methods. Some stories indicated that nitroglycerin, used in frangible bullets, could congeal into a solid explosive when it was wet and allowed to dry in a mass. HEPA vacuuming was determined to be the only viable option for cleaning the range. The cost of contracting the cleanup was estimated at \$5,000 per session, and it was determined that the range should be cleaned once a quarter. Cleaning the range in-house saves the Air Force approximately \$20,000 per year and enables flexibility in range usage.

**Results:** The residue was initially analyzed for leachates via the EPA Toxic Characteristic Leaching Procedure Method. This analysis confirmed that the primary metallic contaminant in the green dust was copper and that trace amounts of lead could be detected in both the target fragments and the metallic dust. In order to address concerns of flammability, the waste residue was tested with EPA 1010, ensuring that the flashpoint was above 149° F. Three rounds of air breathing zone sampling indicated that the HEPA vacuum did not cause resuspension.

**Lessons learned:** Other bases have noted lead contaminant within their firing range residue. The use of frangible ammunition for training is becoming increasingly popular for indoor ranges. Each range's unique mix of ammunition and use will dictate the exact characteristics of the waste stream. The risk of lead contamination and explosive hazards should be considered locally based on who has access to the firing range and what ammunition is used. Under current conditions at Vance AFB, the HEPA vacuuming method is an effective method of cleaning the range.

## PO105

### Communicating and Training with Confidence

Monday, May 23, 2016, 2:00 PM - 4:20 PM

## CS-105-01

### Using Technical Videos for Effective Communication and Training

*M. Strange and B. Bethel, ESIS Health, Safety, & Environmental Services, Sonora, CA*

**Situation/Problem:** Today's workforce is the most techno-savvy in history. Information on anything is readily available at one's fingertips. This evolution of technology and methodology of communications often creates a situation/problem where traditional training methods become less effective. To close this communication gap, the industrial hygiene community must embrace changes and learn to use these same technologies to our benefit.

**Resolution:** Through the use of inexpensive equipment, often available as apps on smart phones, we can film and edit videos of real-world workplace situations and use a video sound bite as part of our training and communication programs. Technology alone cannot resolve all communication issues. The technique of supplementing face to face interaction with demonstration videos does align with today's worker better than the traditional classroom training program.

**Results:** The result of using video technology can increase knowledge retention by employees who have access to video sound bites as part of their communication. More importantly, we have seen a change of behavior by employees who have access to sound bite videos on topics such as proper body mechanics when riveting, how to properly adjust an office desk chair, or the proper work practices associated with handling fine powders such as active pharmaceutical ingredients or fine pigments.

**Lessons learned:** Videography is only one tool of many available for industrial hygienists to effectively demonstrate the need to change the work environment, work practices, and effective use of PPE. It should not be considered a substitute for direct instructional contact but rather an enhancement. If a picture is worth a thousand words, how much more for a film clip?

## CS-105-02

### Crisis Communication: Translating Technically Rich Data into Understandable and Actionable Information

*W. Weisman and R. Campbell, Consulting, Newport News, VA*

**Situation/Problem:** Crisis communication during technological, man-made or natural disasters requires the translation of large volumes of technically rich data into specific, understandable, actionable information that can be clearly communicated by a Public Information Officer (PIO). A crisis communication failure occurs when responses do not match the actual risks, as occurred during the recent U.S. Ebola crisis. Messages from often contained conflicting information requiring affected communities to divert resources

to damage control rather than response operations and normal risk communications. Health care personnel and communities faced greater uncertainty over their risk of exposure. These breakdowns in communication occur when technically trained individuals, who are comfortable with understanding and interpreting their data, are not fully integrated into a Joint Information Center (JIC) where they can collaborate with nontechnical personnel. The development of these messages is often accomplished in a vacuum with neither the input of risk managers nor the aid of a defined process or approach. This uncoupling of risk assessment from the risk management process puts greater stress on risk communicators.

**Resolution:** This presentation outlines a systematic approach that explains how critical information should be used within a JIC to build a clear and actionable message. This approach requires a team effort involving technicians, risk assessors, public information officers, and others to validate the clarity of the message. Finally, the approach involves the integration of predeveloped messages and drills to hone the spokesperson's ability to deliver messages.

**Results:** Without this collaborative approach, each agency at different levels of government will continue to disseminate contradictory information that will lead to a secondary crisis from competing messages and loss of trust from the public.

**Lessons learned:** Thousands of hours of classroom instruction, drills, and field exercises demonstrated the utility of this method. Application of lessons learned from the recent Ebola crisis should be incorporated into all crisis communications curriculum. Communities must properly design and utilize a JIC to fuse technical risk assessment inputs from multiple agencies along with political and public information officers.

## CS-105-03

### Improving Staff Ability to Access Safety Data Sheets

*T. Barton, St. Jude Children's Research Hospital, Memphis, TN*

**Situation/Problem:** The OSHA Hazard Communication standard requires that all staff members be able to access Safety Data Sheets for the hazardous chemicals in their work area. For several years after switching to an online SDS database, staff ability to access Safety Data Sheets (SDS) was poor. Most staff members were able to identify that SDS were on the internet. But, when asked to demonstrate access, their success rate averaged approximately 70% (over a period of three years).

**Resolution:** Staff ability to access SDS was adopted as a Performance Improvement metric. Lean principles were applied to improve staff performance. The subsequent intervention focused on both waste reduction and the incorporation of eight core learning values into the training presentation.

**Results:** Following completion of the training program staff ability to demonstrate SDS access during random surveys has improved significantly. (For the last three quarters the success rate has been 95%, 100% and 97% with sample numbers of 62, 22, and 34 respectively).

**Lessons learned:** Staff ability to access SDS, although not necessarily a compelling subject, may be representative of the overall health of an institutional hazard communication

plan. Incorporating lean principles and designing interventions that employ learning values that personalize the message can enhance the efficacy of safety training programs.

## CS-105-04

### Insights on the Underlying Ethical Rationale for Occupational Health from Mosaic Law

*C. Keil, Wheaton College, Wheaton, IL*

**Situation/Problem:** In recent years, the rationale for the practice of occupational health and safety (OHS) has been more and more supported with business case arguments providing the motivation for the continuous improvement of healthy work environments. But without an underlying ethical basis, business case arguments could theoretically be made that would limit or discourage OHS efforts. Some of the fundamental documents that provide a foundational rationale for OHS come from the United Nations in the Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights. The World Health Organization also provided fundamental statements about the right to a health and safe workplace with the WHO declaration of Occupational Safety and Health for All. Also, the International Labor Organization in its constitution and many other declarations assumes the right to healthy workplace conditions. These statements of workers' rights are recent (since 1900).

**Resolution:** The fundamental ethical assertions in these documents can be supported by another, more ancient, source of insight regarding workers' rights, the Mosaic Law. Workers' rights issues are particularly present in the book of Deuteronomy.

**Results:** A paradigmatic understanding of the agricultural/pastoral economy of the region and the Law of the people reveals patterns that can inform modern ethics. In particular, the prescriptions in the Law regarding relationships between the landed people of ancient Israel and sojourners or other unlanded individuals can support the underlying ethical basis for OHS.

**Lessons learned:** The presence of legal protections for workers in this ancient source provides additional support the more recent declarations for workplace health and safety that goes beyond simply making a business case for OHS.

## CS-105-05

### Graduate Development Program (GDP) for Industrial Hygienists at a Mining Company

*F. Crowne, Goldcorp, Toronto, ON, Canada*

**Situation/Problem:** It is often difficult to find and employ suitable, experienced industrial hygienists with a sound foundation in mining for remote mining sites.

**Resolution:** A graduate student development program was created for industrial hygiene at a mining company to attract, develop and retain industrial hygienists.

**Results:** A pool of university graduates is currently employed at the company in the GDP program. The program defines and provides training in the technical competencies necessary to become fully functional as an industrial hygienist in a mining environment. It also provides the skillset necessary to move into a supervisory role and an opportunity for full-time

employment upon completion of the program.

**Lessons learned:** The program has been successful in attracting and developing IH graduates for a mining environment. The program has also been modified based on learnings from the initial cohort, and input from site management to improve on the current process.

## CS-105-06

### U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) Ebola Virus Disease Testing Mission in West Africa

*R. Schoepp, US Army Medical Research Institute of Infectious Diseases (USAMRIID), Ft Detrick, MD*

**Situation/Problem:** Early in 2014, USAMRIID had a team of scientists in Kenema, Sierra Leone studying undiagnosed febrile illnesses. Previous work had demonstrated that Ebola Zaire virus was circulating in West Africa as early as 2006. When the first suspected EVD cases occurred in the region, the USAMRIID team had Ebola assays to begin immediate testing. The EVD testing mission eventually expanded to Liberia in March of 2014.

**Resolution:** Diagnostics have proven to be critical to the medical management and control of the Ebola Virus Disease (EVD) in West Africa. At the Liberian Institute for Biomedical Research (LIBR), the USAMRIID-NIH Integrated Research Facility (IRF) Team converted an HIV testing lab to a BSL-3 plus laboratory, trained the Liberian staff in biocontainment procedures, and molecular testing for EVD.

**Results:** The laboratory continues EVD testing today and has tested over 17,000 clinical samples from medical facilities and oral swabs from dead body management teams since the start of the outbreak.

**Lessons learned:** The EVD testing in West Africa evolved. There were technical and cultural challenges that had to be overcome and the institution of solutions resulting in success.

## CS-105-07

### Residential Ventilation and Its Effect on Inhalation Exposure

*M. Jayjock, Jayjock Associates, LLC, Langhorne, PA*

**Situation/Problem:** It has often been said “the solution to air pollution is dilution”. Ventilation represents a primary exposure control measure in the workplace and other indoor environments. As such, ventilation appears in essentially every model predicting the breathing zone concentration of a generated airborne contaminant. The problem is, how does one best quantitatively describe ventilation in the scenario of interest. The answer for outdoor concentrations from point or area sources is pretty well defined via the use of meteorological data. The situation indoors is much more complicated and involves answers to such questions as the nature of the source(s), the overall directionality and speed of air in the indoor space and the nature of the air movers indoors. For example, homes with forced hot/cool air ventilation will have very different ventilation patterns and levels for specific scenarios compared to homes without a central fan.

**Resolution:** Exposure scenarios, especially indoor air pollution scenarios are primarily driven by two factors; namely,

the characteristics of the source(s) and the nature of the ventilation. Understanding both these entities to the extent possible by historical or measured data allows one to best match and parameterize an appropriate exposure model. This matching and variable assignment, in turn, provides the most accurate estimate of breathing zone concentration for the (sub) population of interest.

**Results:** Three (3) specific examples will be provided that demonstrate how one should characterize the ventilation and generation scenario for each example and how this characterization impacts the predicted exposures for specific populations of interest. The impact and importance of mismatching of ventilation types will be discussed.

**Lessons learned:** One needs to understand the nature of the exposure scenario of interest in as much depth as necessary to provide the best analysis. Significant subpopulations and the ventilation conditions extant within these populations always need to be considered in providing population estimates of exposure in any scenario.

## P0106

### Evaluation of Occupational, Community and Recreational Noise Exposures

Monday, May 23, 2016, 2:00 PM - 5:00 PM

## SR-106-01

### Development and Translation of a Job Exposure Matrix for Occupational Noise in the US and Canada

*R. Neitzel, B. Roberts, K. Sun, R. Long, and S. Ramdas, University of Michigan School of Public Health, Ann Arbor, MI*

**Objective:** Noise-induced hearing loss is highly prevalent in the US and Canada. Noise is increasingly being linked to other nonauditory health effects such as cardiovascular disease, sleep disturbance, and stress. However, our knowledge of noise exposures associated with many US and Canadian occupations is lacking. To address this critical need, we have developed a Job Exposure Matrix (JEM) for noise using full shift noise measurement data contributed by regulatory, industry, research, and peer reviewed literature sources.

**Methods:** As of September 2015, we have collected 1,136,766 noise measurements representing 436 unique jobs as coded by Bureau of Labor Statistics (BLS) Standard Occupational Classification (SOCs) and 679 unique industries categorized by the 2012 North American Industry Classification System (NAICS). We used mixed effects regression models to estimate exposures for each job in the JEM, and are in the process of translating the estimates from the JEM into a searchable public web interface.

**Results:** Using the web interface, users can search for information by SOC or NAICS code, or via free field text, in order to obtain estimates of average and maximum exposure, as well as exceedance fractions (e.g., percentage of measurements >85 dBA) for data collected according

to the criteria of the US Occupational Safety and Health Administration (OSHA) and, in some instances, the criteria of the US National Institute for Occupational Safety and Health (NIOSH).

**Conclusions:** This JEM allows, for the first time, quantitative estimation of workplace noise exposures on a national scale in both the US and Canada. This gives industrial hygienists, epidemiologists, occupational health practitioners and other relevant stakeholders a vital tool that could dramatically improve the accuracy and efficiency of noise exposure assessments. This tool also provides the opportunity to assess temporal trends in occupational noise exposures, to benchmark specific industries or jobs, and to focus and guide development of targeted efforts towards noise control and hearing loss prevention.

## SR-106-02

### What Can More Than 30 Years and 700,000 Measurements Tell Us About Noise Exposure in the Mining Industry?

*B. Roberts, R. Neitzel, K. Sun, R. Long, and S. Ramdas, University of Michigan School of Public Health, Ann Arbor, MI*

**Objective:** Collect, organize, and analyze over 700,000 noise measurements made by the US Mine Safety and Health Administration (MSHA).

**Methods:** As part of a larger effort to construct a job exposure matrix (JEM) for occupation noise, records of full-shift personal noise dosimeter measurements were obtained from MSHA through a Freedom of Information Act (FOIA) request. The data was imported into STATA 14 for analysis. Records were excluded if they did not provide an exposure measurement, did not have a valid job title, or had a time-weighted average (TWA) less than 60 dBA or greater than 120 dBA. The 2012 North American Industry Classification System (NAICS) and the Standard Occupational Classification (SOC) System was used to standardize the records by industry type and job title respectively. The first 4 digits of the NAICS code was used to differentiate between different mine types. Occupations were categorized using the first two digits of the SOC code, ranging from 13 to 53. Average noise exposure levels were computed by year and stratified by SOC and NAICS codes. Linear regression was used to predict the average change in noise exposure by year while controlling for mine type and job title.

**Results:** In total, 716,142 measurements from 1979 to 2014 were collected from MSHA after the exclusion criteria were applied. A total of 61 unique job titles were identified. The overall TWA was 82.3 dBA with a standard deviation of 9.2. Prior to the implementation of MSHA's revised noise standard in 2000, the TWA was 84.8 dBA which was significantly higher ( $p < 0.001$ ) than the TWA of 78.8 dBA after the implementation of the standard. Of the 61 unique job titles, 37 were found to have significantly ( $p < 0.05$ ) lower exposures after the implementation of the new standard. Linear models predicted that the mining sector has become progressively quieter; while a few occupations within the mining sector have remained the same or become louder.

**Conclusions:** Overall, the mining industry has become less noisy. However, there are some occupations that are still exposed to hazardous levels of noise. The construction of

the JEM has made it possible to identify occupations with hazardous noise exposure so that additional sampling and controls can be implemented to protect the worker's hearing.

## SR-106-03

### Descriptive Evaluation of Noise Dosimetry Values in the Defense Occupational and Environmental Health Readiness System—Industrial Hygiene Component (DOEHRS-IH)

L. Whitehead, D. Tucker, D. Gimeno, K. Whitworth, and J. Betancourt, University of TX Health Sci. Ctr. at Houston, Houston, TX; S. Leonard, Hearing Center of Excellence, San Antonio, TX; A. Zhang, Knowesis, Inc., Fairfax, VA; A. Senchak, Walter Reed National Military Medical Center, Bethesda, MD

**Objective:** Describe noise dosimetry data for active duty military personnel in the Department of Defense (DoD) Defense Occupational and Environmental Health Readiness System-Industrial Hygiene component (DOEHRS-IH).

**Methods:** Data in DOEHRS-IH, covering from 1995 to 2015, were obtained on 12,072 personal 8-hour dosimetry samples (85/3 dBA rule, threshold = 80 dBA), as recommended by NIOSH and the ACGIH® TLV®. These include any repeat data from Service Members with annual dosimetry. An 84/4 rule was used previously by the Navy, but unless 85/3 results were also reported, these are not included. While DOEHRS-IH uses Similar Exposure Groups, workers performing like processes, these are base-specific and unstandardized. So, initial analyses are for standardized military occupational codes (MOCs, including MOS, AFSC, Ratings, and Navy Officer codes).

**Results:** Of about 8,000 MOCs, 773 had at least one time weighted average (TWA) value and 362 had 5 or more. Of 12,072 TWAs, 57% are  $\geq 80$  dBA, and 43% are  $< 80$  dBA, with 17% = 0. The 80 dBA threshold acts as a de facto detection limit, but many MOCs have values  $< 80$  dBA, including some at zero. Arithmetic averages are distorted downward by the zero values, and to some extent by any  $< 80$  dBA. For epidemiology, it is not desirable to discard values  $< 80$  dBA, so the whole distribution of exposures is included in averages. Since values near and above 85 dBA are more important for hearing loss, various metrics were considered. The metric used was decibel averaging, in effect averaging of the underlying sound power, of the TWAs within each MOC, although simple arithmetic averaging is more typically used across workers. This statistic deemphasizes low values and emphasizes the high that have the most sound power and hazard. Since there is also an averaging step, some influence is present for the low values. We are also considering the average or proportion of values  $\geq 80$  (or 85) and are investigating estimation of low values consistent with a lognormal distribution (though that may bias arithmetic averages low). On the dB-average metric, MOCs (5+ TWAs) range from  $< 80$  to 134 dBA with 73%  $> 85$  dBA.

**Conclusions:** Noise dosimetry data in DOEHRS-IH offer a rich source for research. Data are likely skewed toward MOCs suspected of having high noise, hence there are few or no data for many MOCs not so suspected. Still, many MOCs, especially those suspected of high noise exposures, have sufficient data to characterize the MOC exposures.

## SR-106-04

### Are Noise and Neurotoxic Chemical Exposures Related to Workplace Traumatic Injuries?

*C. Estill, S. Wurzelbacher, and T. Morata, CDC/NIOSH, Cincinnati, OH; C. Rice, A. Bhattacharya, and M. Rao, University of Cincinnati, Cincinnati, OH*

**Objective:** The contribution of noise exposure and chemical hazards to traumatic injury is not well understood. The study was conducted to determine if there is a significant relationship between workers' compensation (WC) injury claim rates and hazardous exposures for companies. Specific aims were to evaluate WC claims for workplaces with noise exposures above and below the occupational exposure limit and to determine the influence of the synergistic effect between ototoxic and neurological chemicals and noise exposure for predicting traumatic injury.

**Methods:** Noise and chemical exposure data were gathered from WC consultation site visit reports from 2008 to 2012. WC claims from these companies were evaluated for those same years by gathering data from the Ohio Bureau of Workers' Compensation (OBWC) including the number of employees for each company. Noise exposure measurements were averaged by company/year and matched with company WC claim rates. Claims were evaluated by International Classification of Diseases (ICD) diagnoses code and 90% were considered traumatic injuries using the Barell Matrix method.

**Results:** Of 222 companies, 40% had noise exposure levels above established OSHA Permissible Exposure Limit (PEL) and about half were evaluated for chemical exposures. Noise exposure was significantly related to trauma claim rates when adjusting for industry, company size, and hearing conservation programs. Likewise, neurotoxic chemical exposure above the OSHA PEL was significantly related to trauma claims when adjusting for industry and company size. When evaluating only those companies and years with both noise and neurotoxic chemical exposure, noise exposure, chemical exposure, and its interaction were significantly related to trauma claims. This relationship was strengthened when limiting to smaller sized companies. The relative risk of a trauma claim was 1.45 for those companies with average noise exposures above 85 dB compared to those with lower noise exposures.

**Conclusions:** There was an exposure response relationship for companies with higher average noise exposure and having higher relative risk of trauma claims. Workplace managers should consider evaluating safety hazards if they have elevated noise or neurotoxic chemical exposures.

## CS-106-05

### Correlating Worker Position Through Time with Noise Exposure Measurements for the Prioritization of Noise Source Mitigation

*J. Leasure, Associates In Acoustics, Austin, TX*

**Situation/Problem:** Noise dosimetry reports the total noise exposure a worker experiences during their shift, with some instruments reporting sound levels through time. Frequently, workers are active in multiple areas throughout a shift with no records kept of time spent at any location. Other than consideration of the worker's responsibilities, there are few

clues for identifying the noise sources responsible for a worker's noise exposure. Blanket noise control policies that seek to reduce noise levels throughout a facility are effective in controlling exposure, but can be inefficient when resources are devoted to mitigating noise sources that are unimportant to actual exposure.

**Resolution:** Three techniques were employed at a manufacturing facility to determine the most important locations in terms of worker noise exposure. During their shift, workers wore noise dosimeters recording noise levels at 1 second intervals and carried a device used to map their position in time through variation in ambient Wi-Fi signals. Simultaneously, the surveyor measured ambient noise levels throughout the work area and observed the activities of each worker, measuring the time spent in key locations. The 1-second intervals were compared to a noise contour map created from the ambient noise measurements to calculate the exposure accumulated by workers in certain high-noise areas. Notes from activity observations were used to create a map estimating the time workers spent in high-noise areas. A map of worker position and noise exposure was created by the Wi-Fi location system.

**Results:** Results from the three methods were generally in agreement. They identified short-duration entries into an enclosed area containing high noise sources as the primary cause of exposure for workers who exceeded the PEL. Previous to the study, it was unclear whether the majority of exposure was from activities in the enclosure or elsewhere.

**Lessons learned:** Measuring, observing, or calculating a worker's movements through a facility in time creates the opportunity to correlate position with measured noise levels. Position, noise, and time data can be combined to create noise exposure maps that identify areas where noise exposure occurs, either for an individual worker or for any subset of members of a shift. Estimates of noise level reduction achieved by mitigation in high-exposure areas can be used to predict the expected reduction in worker noise exposure from implementation of mitigation, which provides a clearer view of its cost-benefit.

## CS-106-06

### Exploration of Potential Applications for Noise Relative Risk Visualization Tools

*E. Jones, ExxonMobil Biomedical Sciences, Inc., Annandale, NJ*

**Situation/Problem:** When evaluating whether hearing loss is potentially work related, information characterizing occupational and nonoccupational exposures is routinely collected. A straightforward approach was needed to consistently interpret this information and inform understanding of how exposures from each category may contribute to overall noise exposure risks.

**Resolution:** A noise relative risk visualization tool was developed to aid understanding of the contribution of occupational exposures to overall noise exposure risks. The tool is based on the equal energy hypothesis of noise induced hearing loss, building on a conceptual approach presented at AIHce by RM Burton, *et. al* in 2013. Within the tool, measured or estimated average noise exposure levels (in decibels, dBA) are converted to Sound Pressure Level (Pascals), weighted by estimated exposure duration, and summed to estimate a

cumulative noise exposure intensity for the scenario of interest. The relative contribution of various noise sources or categories of noise sources can then be compared using simple data visualizations, such as pie charts.

**Results:** Preliminary testing of the tool was completed using historical Injury and Illness management information. Based on preliminary testing, the tool provided a consistent approach to analyze this information and data visualizations facilitated comparison of relative noise exposure risks. Further testing of this application is planned, and other potential applications for the visualization approach have been identified. For example, it could also be used to estimate the potential impact of short term noise exposures on long term average exposures, which can be beneficial when developing exposure monitoring strategies or prioritizing risk mitigation projects. The tool could also be used to communicate relative noise exposure risks to managers and potentially exposed individuals.

**Lessons learned:** The limitations and sensitivities of both the visualization tools and the underlying concepts must be well understood to avoid biasing or misapplying tool results. Therefore, training is recommended to educate users on key concepts and limitations.

## CS-106-07

### Case Study: Industrial Facility Community Noise

*P. Murphy, Associates in Acoustics, Los Angeles, CA*

**Situation/Problem:** An industrial facility has received numerous noise complaints from a nearby residence in a new housing development. Despite the facility's initial noise mitigation efforts, noise complaints continue.

**Resolution:** An exterior noise survey was conducted to document the existing noise levels at the industrial facility, to locate the noise sources triggering the complaints, and to determine if the facility is in compliance with the local noise ordinance. The survey consisted of noise level measurements recorded at the facility's property line, near exterior noise sources and at strategic reference locations. The survey revealed the industrial facility was noncompliant with the local noise code, of which they were unaware. Noise sources causing noncompliance and triggering noise complaints from neighbors were verified using frequency spectral analysis and outdoor sound propagation calculations. Noise control methods were recommended for the offending exterior noise sources.

**Results:** Exterior noise propagation calculations confirm that the facility will comply with the local noise ordinance and reduce noise complaints following the implementation of noise mitigation recommendations for offending noise sources. These efforts will avoid noise related legal issues with the local jurisdiction and establish a good neighbor approach towards residential neighbors. The industrial facility has not received noise complaints since the implementation of noise mitigation recommendations on the offending exterior noise sources.

**Lessons learned:** Facilities should conduct an exterior noise survey to ensure compliance with code and establish good neighbor practices. Noise mitigation of exterior equipment may be required to bring the facility into compliance and to

avoid complaints. Lack of equipment maintenance is often a primary cause of elevated noise levels. The industrial facility should establish a routine inspection, service and maintenance schedule for all exterior noise producing equipment. Once in compliance, noise surveys should be conducted twice per year.

## CS-106-08

### Noise Control for Portable Ventilation Blowers

*D. Chute, Atrium Environmental Health and Safety Services, LLC, Reston, VA*

**Situation/Problem:** Portable Ventilation Blowers (PVB) used in manufacturing and construction present many noise control challenges. In addition to the noise generated by motors, fans and air movement, noise control in many work environments is complicated by noise and vibration conductive mounting surfaces, frequent relocation, rugged handling and irregular maintenance. Experience, observation and testing has suggested that several practical control options such as vibration isolators, acoustical jackets, duct silencers and enclosure partitions have the potential to offer feasible noise reduction solutions. No published studies or reports were found to demonstrate how these noise control strategies may be achieved in practice.

**Resolution:** This work included a review of PVB in use in two major shipyards, with selection of the two largest and most commonly used models for follow up testing, treatment and evaluation. This was a year-long study with multiple field evaluations and collaboration between the research team, the site health and safety and facilities maintenance staff. Treatments tested included: outlet and inlet silencers (mufflers), acoustical jackets, spring and rubber type vibration isolation mounts and acoustical curtains.

**Results:** Noise reduction treatments, applied both individually and in combination, yielded significant noise reduction benefits without measureable impacts on airflow or ventilation performance. Some treatment combinations yielded measured noise reductions as much as 10 to 12 decibels. In addition, variability in the frequency and content of maintenance practices were cited as a key factor in the wide range of baseline noise levels generated by the same model of PVBs at the same site.

**Lessons learned:** Practical and cost effective noise reduction for PVB is readily achievable through the application of basic isolation and vibration control treatments. Regular maintenance and repair may also provide further ongoing noise control benefits.

## SR-106-09

### Indoor Hockey Officials' Noise Exposure, Temporary Hearing Loss, and Effect of Helmet Visor Length on Exposure to Whistle Noise

*K. Adams and W. Brazile, Environmental & Radiological Health Sciences, Colorado State University, Fort Collins, CO*

**Objective:** Noise exposure and hearing thresholds of hockey officials in amateur and collegiate hockey leagues were

measured to assess the impact of hockey game noise on hearing sensitivity. In addition, the effect of the hockey helmet visor length on the level of whistle noise to which hockey officials are exposed was evaluated to determine if visors may introduce a reflective plane for the whistle noise, resulting in increased noise exposure.

**Methods:** Twenty-nine hockey officials participated in the study. Personal noise dosimetry was conducted to determine if officials were overexposed to noise, as per ACGIH® recommendations. Pure tone audiometry was used to measure the hearing thresholds of officials before and after officiating hockey games to determine if there was a 10 dB or greater decrease in hearing sensitivity. Audiometry was conducted in both ears at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hertz. In addition, noise generated from whistle blowing was measured in the left ear of the Knowles Electronic Manikin for Acoustic Research for each of three helmet configurations: without visor, 2.75" visor, and 4.0" visor.

**Results:** Mean personal noise exposure level was 92 dBA (SD=2.2) using ACGIH® sampling parameters. Hearing threshold shifts of 10 dB or greater were observed in 86% of sampled officials, with statistically significant differences between pre- and post-game hearing thresholds observed in both ears at 2000, 3000 and 4000 Hz. Mean peak whistle noise levels measured at the ear of the manikin without a visor and with the 2.75" and 4.0" length visors were 117 dB (SD<1), 117 dB (SD<1) and 121 dB (SD=1), respectively. Measured peak noise levels were significantly different between the helmet configuration with the long (4.0") visor and the other helmet configurations (p<0.05), but were not significantly different between the helmet without a visor and with the shorter, 2.75" visor (p>0.05).

**Conclusions:** The results suggest that indoor hockey officials experienced temporary hearing loss after officiating games. Further temporary threshold shift research may identify hockey officials at larger venues and those officiating other sports are at increased risk of noise induced hearing loss. Manikin study results suggest that longer visors may act as a reflective plane for whistle noise and increase hockey official's noise exposure. Understanding that longer visors may increase the noise exposure from whistle noise may provide insight for better design of helmet visors in the future.

## PS403

### Poster Session 403

Tuesday, May 24, 2016, 10:00 AM - 12:00 PM

## SR-403-01

### Comparison Measurements of MDI Isocyanate During the Application of Spray Polyurethane Foam Insulation

*J. Brown, G. Oishi, O. Shimelis, M. Halpenny, E. Barrey, K. Espenschied, and M. Ye, R&D, Sigma-Aldrich / Supelco, Bellefonte, PA*

**Objective:** Methylene diphenyl diisocyanate (MDI) is a key component used in spray polyurethane foam (SPF) insulation products. Monitoring the airborne isocyanate concentration in the workplace environment is important because exposures can cause respiratory disorders like occupational asthma. Since MDI is fast reacting it's important the sample collection device is capable of derivatizing MDI into a stable compound until the analysis is performed.

**Methods:** In this field study, two different types of sampling devices were used to collect air samples while a two component foam was sprayed into 2" x 4" wall cavity. The first sampling device was impregnated with 1-(2-pyridyl) piperazine (1-2PP) and this device is commonly used in the OSHA method 47. The second sampling device was impregnated with Dibutylamine. Both samplers work by derivatizing the isocyanates during sampling process. One study focused on determining the effect of varying the field extraction time (5, 10, and 30 minutes). Another study explored the effect of waiting seven days to carry out the analysis. For this study, the 1-2PP samplers were field desorbed within 30 minutes after sampling and stored in a refrigerator. The Dibutylamine samplers were only capped and stored at ambient temperature.

**Results:** The MDI Concentration decreased by 25%, when the field extraction was carried out at 5 and 30 minutes using the 1-2PP samplers. Whereas, the Dibutylamine samplers showed no significant change in the captured MDI concentration over the same time frame. The study of waiting seven days to conduct the analysis resulted in an average MDI monomer concentration of 2.8 µg/m<sup>3</sup> with the 1-2PP samplers, and 19.1 µg/m<sup>3</sup> with the Dibutylamine samplers.

**Conclusions:** The 1-2PP samplers produced lower concentrations of MDI compared to samplers made with Dibutylamine. Different field extraction times did not affect the captured MDI concentration of the Dibutylamine samplers. In both studies the 1-2PP samplers under estimated the concentration of MDI.

## CS-403-02

### Consultation, Sampling Strategy Development and Performance of Industrial Hygiene Personal and Worst-Case Grab Sample Area Monitoring for Identified Hydrocarbons Related to Potential Oilfield Exposures for Routine Tank Gauging Operations

*J. Koehn, L. McKelvey, and J. Wiley, JK, Inc., Houston, TX; R. Acker, Ackcellent Consulting, LLC, Monument, CO; D. Deutsch, Apache Corporation, Houston, TX*

**Situation/Problem:** Professional and technical consulting services have been addressed for occupational exposure assessment of specified oilfield personnel in Texas, Oklahoma, and Louisiana related to potential airborne hydrocarbons associated with oil and gas production and processing operations. Sampling strategy development was undertaken for identified Total Volatile Organic Compounds (TVOCs) involving a combination of personal breathing zone and also worst-case area grab samples during tank gauging operations

in 2015. Monitoring data with input for an industry specific task force was requested to assist with investigation of potential workplace exposure controls.

**Resolution:** Specific knowledge of oilfield operations by health and safety personnel is vital for representative assessment of occupational airborne exposures of tank gauging job positions and general work site monitoring within these environments. Published sampling and analytical methods were employed in addition to field site use of calibrated direct-reading instruments to obtain benzene and hydrocarbon exposure data to assess existing work practice controls.

**Results:** Exposure assessment monitoring for defined airborne chemicals related to the variable oilfield occupational environment involving tank gauging operations is necessary for specific hazard identification and evaluation procedures. Industrial hygiene monitoring results are compared with current OSHA regulatory standards and other published technical recommended guidelines to better assess and manage the existing potential for elevated workplace airborne exposures. Worst-case grab samples with calibrated direct-reading instruments were also recorded for defined field site work activities and noted weather conditions.

**Lessons learned:** A range of industrial hygiene techniques were utilized to provide workplace assessment and oilfield site investigation of existing hydrocarbon exposures. Specific airborne monitoring procedures involving referenced methodologies along with subsequent data interpretation assisted with outlined HSE evaluation needs and provided data documentation to assess employee protection and proper hazard management. Investigation of further process design and control measures was also conducted for limitation of existing occupational airborne exposures and provision of useful information for employee protection.

### SR-403-03

#### Characterization of Naturally Occurring Airborne Diacetyl Concentrations Associated with the Preparation and Consumption of Unflavored Coffee

*J. Pierce, A. Abelmann, J. Lotter, C. Comerford, and K. Keeton, Cardno ChemRisk, Chicago, IL; B. Finley, Cardno ChemRisk, Brooklyn, New York, NY*

**Objective:** Diacetyl, a suspected cause of respiratory disorders in some food and flavorings manufacturing workers, is also a natural component of roasted coffee. The purpose of this analysis was to characterize diacetyl exposures that could plausibly occur in a small coffee shop during the preparation and consumption of unflavored coffee.

**Methods:** The study was conducted in duplicate, with one simulation in the morning and one in the afternoon, each with a total duration of 3 hours. Airborne samples were collected for 3 hr. (long-term) or 15 min. (short-term). Personal (long- and short-term) and area (long-term) sampling was conducted while a barista ground whole coffee beans, brewed, and poured coffee into cups. Simultaneously, long-term personal samples were collected as two participants, the customers, drank one cup of coffee each per hr. Air sampling and analyses were conducted in accordance with the OSHA Method 1012.

**Results:** Diacetyl was detected in all long-term samples. The

long-term concentrations for the barista and area samples were similar, and ranged from 0.013-0.016 ppm; long-term concentrations for the customers were slightly lower and ranged from 0.010-0.014 ppm. Short-term concentrations ranged from below the limit of detection (< 0.0047 ppm) to 0.016 ppm. Mean estimated 8 hr. time-weighted average (8 hr. TWA) exposures for the barista ranged from 0.007-0.013 ppm. These values exceed recommended 8 hr. TWA occupational exposure limits (OELs) for diacetyl and are comparable to long-term personal measurements collected in various food and beverage production facilities. The concentrations measured based on area sampling were comparable to those measured in the breathing zone of the barista. Exceedances of the recommended OELs may also occur for coffee shop workers who do not personally prepare coffee (e.g., cashier, sanitation/maintenance).

**Conclusions:** These findings suggest that the practicality and scientific basis of the recommended OELs for diacetyl merit further consideration.

### SR-403-04

#### Occupational Exposure to Vapor, Gas, Dusts, and Fumes Among Rural Residents

*M. Humann, B. Doney, and P. Henneberger, Division of Respiratory Disease Studies, CDC/NIOSH, Morgantown, WV; B. K. Kelly, The University of Iowa, Iowa City, IA*

**Objective:** Occupational histories combined with a job exposure matrix (JEM) can be used to assess work-related exposures when direct measurements are not available. The objectives of this study were to use the occupational histories of adult participants in the Keokuk County Rural Health Study to describe the distribution of jobs among rural residents and their occupational exposures to vapor-gas, dusts, and fumes (VGDF).

**Methods:** The Keokuk County Rural Health Study was a long-term prospective cohort study of residents living in a rural county in the US state of Iowa. Data collection was conducted in three rounds, each lasting 5 years, between 1994 and 2011. Over the three rounds, 1,893 adult participants completed study questionnaires that included an occupational history documenting all jobs since age 12. US Census 2000 occupational codes were assigned to all reported jobs and combined with a JEM for airflow limitation to yield exposure levels of never/low, medium, or high for total VGDF. We assigned an exposure level for each participant based on the last job in their occupational history.

**Results:** The combination of the farm, fishing, and forestry occupational group with farmers and farm managers from the management group accounted for 20.5% of participants at last job. The next four most common occupational groups were office and administrative support (14.0%), sales (9.0%), production (7.7%), and education, training, and library (6.3%). The 20.5% of participants in farming, fishing, and forestry jobs was considerably greater than the comparable national figure of 1.3% from the 2000 US Census. For VGDF exposure in last job, the distribution of participants in the high, medium, and never/low exposure categories was 28.1%, 17.8%, and 54.1%, respectively. This is in contrast to findings from a predominantly urban population where the distribution by the same exposure categories based on the last job was 5.3% high, 9.8% medium, and 85.0% never/low.

**Conclusions:** These results suggest that the unique work history (e.g., farming and other manual labor) of rural residents may lead to higher occupational exposures to VGDF. We will be using the assigned occupational exposures in an upcoming study to investigate whether they are associated with decrements in the spirometry of adults living in a rural county, in order to inform strategies for prevention.

## CS-403-05

### Options for the Placement of Breathing Zone Air Samples Inside a Welder's Helmet

*C. Pomeranke, Liberty Mutual Insurance, Boston, MA*

**Situation/Problem:** Breathing zone air sample placement during welding job tasks presents a challenge inside welding helmets. The OSHA Directorate of Compliance Programs states that the correct placement for air samples is near the breathing zone of the employee. Furthermore, the OSHA Technical Manual for Personal Sampling states, "when sampling for welding fumes, the filter cassette must be placed inside the welding helmet to obtain an accurate measurement of the employee's exposure". The American Welding Society also recommends placing the sample inside the helmet. The issue is where to place the sample inside the helmet so it doesn't interfere with the welder's work and comfort.

**Resolution:** This study presents two options for the placement of air samples inside a welder's helmet that are acceptable to working welders. One option is to clip the sample on a bandana that is tied around the neck. The second option is to clip the sample on a welder's skull cap so it hangs down and along the cheek between the nose and mouth. Employee feedback on the two options indicated they were user-friendly and did not disturb the welder or hinder their job tasks.

**Results:** Five different welders in 3 separate workplaces were sampled. Side-by-side monitoring was conducted using the bandana and skull cap locations during Gas Metal Arc (GMAW) or MIG welding. NIOSH Method 7303 was followed for air sampling and laboratory analysis. Manganese data was selected for statistical analysis as it is the component of welding fume that is of most concern when welding carbon steel. Statistics computed for the bandana sample data and the skull cap sample data validated this study's proposed sample locations.

**Lessons learned:** Secure the bandana sample to the welder's shirt so it stays securely inside the helmet. Coach the welder to keep the bandana sample tucked inside the welding helmet. Consider the possibility of skin irritation from sweat, dirt and welding fume accumulation on the bandana. One out of five sampled welders mentioned this concern.

## CS-403-06

### A Quantitative Model to Predict Allergic Contact Dermatitis from Wearable Technology Products

*A. Singhal, K. Bogen, R. Kalmes, and P. Sheehan, Exponent, Inc., Oakland, CA*

**Situation/Problem:** Wearable products with electronic components are being introduced to consumers without formal biocompatibility testing or health risk assessment. Some products that assess physiological functions involve prolonged skin contact with plastic and metal components

under occluded conditions. Recent media reports have described occurrences of skin reactions such as allergic contact dermatitis (ACD) from wearable technology products. These products therefore present a new product stewardship challenge.

**Resolution:** A quantitative risk assessment model was developed that incorporates estimates of both dermal exposure and ACD elicitation risk. Product prototypes were tested in artificial sweat solution for varying time periods to reflect product-specific dermal exposure use scenarios. Leachates were analyzed for sensitizing metals and organic chemicals to derive potential applied dermal dose or load (in  $\mu\text{g}/\text{cm}^2/\text{unit time}$ ) per sensitizing chemical. To estimate ACD risk per chemical, a nickel ACD-elicitation risk model was developed using published human patch test nickel data. The reported fraction of sensitized user populations exhibited ACD reactions at specified dermal nickel loads. This nickel distribution was then generalized to predict ACD risk for chemical sensitizers with limited patch test data. Prediction was based on the observation that estimated distribution of population sensitivity to nickel is similar to distributions of patch test dose response data for other sensitizing chemicals.

**Results:** Results indicate that the sensitizing metals (nickel, chromium, and cobalt), and sensitizing organics (primarily acrylate and epoxy compounds) are leached from a variety of tested wearable product prototypes. Dermal loads were estimated to range from  $<1$  to  $>50 \mu\text{g}/\text{cm}^2/\text{week}$  with chemical loads potentially posing a wide range of risks of ACD reaction in sensitized users, with  $<0.01\%$  to  $>10\%$  of the sensitized users expected to react.

**Lessons learned:** This methodology can help manufacturers in identifying components of wearable technology products that pose a high risk of leaching and consequent ACD reactions, in order to make their products biocompatible prior to introduction into consumer markets.

## SR-403-07

### A Bayesian Approach for Summarizing Real-Time Exposure Data with Left Censoring

*E. Houseman, Oregon State University, Corvallis, OR; M. Virji, NIOSH, Morgantown, WV*

**Objective:** Direct-reading instruments are valuable tools for measuring exposure. They provide real-time data and valuable information on short-term exposure variability. However, statistical analysis is complicated by autocorrelation among successive measurements, nonstationary time-series, and presence of left-censoring due to limit-of-detection (LOD). A Bayesian framework is proposed for analyzing exposure time-series that accounts for nonstationary autocorrelation and LOD issues.

**Methods:** A spline based approach was used to model nonstationary autocorrelation with relatively few assumptions about autocorrelation structure. Left censoring was addressed by integrating over the left tail of the distribution. The model was fit using Markov-Chain Monte Carlo within a Bayesian paradigm. The method can flexibly account for hierarchical relationships, random effects and fixed effects of covariates. The method was implemented using the rjags package in R and is illustrated by applying it to real-time exposure data.

Estimates for covariates from the Bayesian model were compared to those from the frequentist models including linear regression and mixed effects models with different autocorrelation structures. Simulations studies were conducted to evaluate method performance.

**Results:** Simulation studies with LODs ranging from 0-50% showed lowest root mean squared errors for task means and the least biased standard deviations from the Bayesian model compared to the frequentist models across all levels of LOD. In the application, task means from the Bayesian model were similar to means from the frequentist models, while the standard deviations were different. Parameter estimates for covariates, e.g., source enclosure, were significant in some frequentist models, but in the Bayesian model their credible intervals contained zero; such discrepancies were observed in multiple datasets. Variance components from the Bayesian model reflected substantial autocorrelation, consistent with the frequentist models. Plots of means from the Bayesian model showed good fit to the observed data.

**Conclusions:** The proposed Bayesian model out performs the frequentist models in estimating task means, standard deviations and parameter estimates for covariates, thus providing an approach for modeling nonstationary autocorrelation in a hierarchical modeling framework.

### CS-403-08

## Noise Exposure Assessment in a Dog Grooming Operation

*R. Higley, G. Gruenwald, and T. Knepper, ESIS, Corona, CA*

**Situation/Problem:** Noise exposures to bathers/groomers in a national pet store chain may exceed the OSHA Action Level. Noise exposures had not been monitored previously. The store needed to determine if bathers/groomers were required to participate in a Hearing Conservation Program per the OSHA Noise Standard. If noise levels did exceed the Action Level of 85 dBA TWA, what methods of noise control are available in order to achieve compliance with the OSHA noise standard.

**Resolution:** Employees were selected and fitted with Casella CEL 350 noise dosimeters. The noise dosimeters were calibrated before and after the monitoring period. Observations of employee work procedures were made identifying peak noise exposures. Direct sound level measurements were made of specific noise sources. Noise sources were identified as blowers (some with faulty bearings), positioning of the air blower nozzle in relation to the dog, and barking dogs in the kennel area. Administrative controls were also identified to help reduce employee noise exposure.

**Results:** Four different stores were visited and a total of 15 employees were evaluated. Two of the fifteen had noise exposures at 85 dBA TWA, other employees were below the Action Level. Recommendations to further reduce noise exposures included the following: Engineering Controls: Replace defective blowers that generated a loud squeal over 90 dBA with newer and/or quieter blowers. Move blowers adjacent to the drying tables located at head height to underneath the tables. Enclose the blower unit to help further reduce noise transmission Provide plastic strips or other barrier material between the kennel area and the bunker to reduce noise from barking dogs. Administrative Controls: Some workers performed more bathing tasks, while other workers performed more grooming tasks (cutting/trimming fur) which is a quiet

task. Schedule work so that employees' work tasks are more equally balanced between bathing and grooming. Train workers to maintain the blower nozzle away from the dog's body. Placing the air nozzle close to the body generates air turbulence and excessive noise.

**Lessons learned:** Relatively simple solutions including administrative controls, placement of blowers and barriers to prevent sound transmission are effective in reducing employee noise exposures.

### CS-403-09

## Evaluation of Noise Exposures During High Pressure Washing, Piglet Vaccinating and Room Relocation at a Hog Farrowing Facility

*D. Weber, Liberty Mutual Insurance Company, Glastonbury, CT*

**Situation/Problem:** Hog breeding farms require labor intensive operations including thoroughly cleaning animal housing and farrowing rooms, vaccinating each individual piglet and moving piglets from room to room. High pressure power washers are used to clean all farrowing room surfaces including ceilings, walls, floor grates and basins, etc. Additionally, piglets are vaccinated and moved in groups from room to room. Personal Dosimetry revealed selective operations expose workers to high noise levels. Two of three individuals experienced noise above the OSHA PEL of 90 dBA for an eight hour TWA. HC TWA noise exposures during: room pressure washing were up to 99.5 dBA, piglet relocation were up to 86 dBA and piglet vaccination were up to 81 dBA. Excessive occupational noise exposures have been linked to noise induced hearing loss.

**Resolution:** Management investigated lower noise power washer guns, modified work schedules, limiting duration of power washing by any individual and continued to include exposed workers in hearing conservation program

**Results:** Attempts to identify suitable replacement power washer units proved unsuccessful. The employer's main focus was to ensure their hearing conservation program was adequate and to strive to schedule a rotational work schedule limiting any employee's daily operation of a power washer to an hour or less per day to reduce PEL TWA exposures to below 90 dBA.

**Lessons learned:** No suitable quieter pressure wash guns were identified. Worker rotation was a means of lowering an individual's noise exposure on days that pressure washing is performed. Worker rotation does not reliably reduce worker exposures to below 85 dBA for a full shift TWA. In order to reduce worker noise exposures to below the PEL of 90 dBA on days when power washing is performed, workers are limited to one (1) hour or less of pressure washing. In general, limiting the power washing duration to one hour per person per day is estimated to result in noise exposures ranging from 84 dBA to 88 dBA TWA. A two hour power washing operating limit is estimated to result in a TWA exposure range of 87 dBA to 91 dBA.

## SR-403-10

### Evaluation of Noise in a Division 1 College Football Stadium

*M. Valigosky, A. Ames, J. Taylor, F. Akbar-Khanzadeh, and S. Milz, University of Toledo, Toledo, OH*

**Objective:** Noise exposure during spectator sporting events has the ability to impact event workers, event participants and spectators. Noise exposures can impact communication efforts and cause temporary and permanent hearing loss. The current study characterized noise exposure of workers and spectators during Division I college football games. The stadium is a medium sized college football stadium in Northwest Ohio, with a current seating capacity of 26,248.

**Methods:** Noise levels were measured during three Division 1 college football games in 2014 to determine whether the noise levels exceeded standards and guidelines. Noise levels were measured using a set of dosimeters (Larson Davis Spark 705+) placed throughout the football stadium to characterize noise generated by the cannon, the band, the students section, field level game noise and stadium level crowd noise. Dosimeters were programmed to record noise for the entire length of the football game (at one minute intervals), using ACGIH® and OSHA dosimeter parameters. The dosimeters were calibrated using a Larson Davis CAL150. Data from the instruments were uploaded to Blaze software and exported for analysis in SPSS.

**Results:** The findings suggested significant variations in noise levels depending on monitoring location and attendance. The minute average noise levels [Mean±SD (Min-Max)] in terms of Leq (dBA) during nonscoring were: student section, 85.3±5.4 (73.5-102.5); home team 50-yard line, 86.1±3.9 (77.5-99.6); visiting team 50-yard line, 83.9±3.8 (73.8-94.1); and stadium center of home team, 84.6±3.4 (75.9-98.1). The minute average noise levels [Mean±SD (Min-Max)] in terms of Leq (dBA) during scoring were: student section, 95.1±4.6 (84.9-100.1); home team 50-yard line, 92.4±3.6 (88.3-100.2); visiting team 50-yard line, 89.2±2.8 (83.6-93.6); and stadium center of home team, 92.0±3.1 (85.0-96.1). A canon is fired after every home touchdown and field goal. Peak noise levels during canon fire were: student section, 132.3; home team 50-yard line 130.0; visiting team 50-yard line, 135.2; and stadium center of home team, 130.0.

**Conclusions:** During nonscoring time, the student section and home team 50-yard line mean noise levels were above the ACGIH® TLV® for noise (85 dBA). All locations after scoring were above the ACGIH® TLV® for noise. Peak noise levels during canon fire, at all locations, were below the WHO guidelines for peak noise (140 dBA).

## SR-403-11

### Environmental Noise Evaluation After Implementation of Controls near a Higher Education Research Facility

*A. Ames, M. Valigosky, C. Barber, F. Akbar-Khanzadeh, and S. Milz, University of Toledo, Toledo, OH*

**Objective:** Controls were installed at two noise sources at a higher education facility after results of a 2013 study suggested a possible noncompliance with the city's noise ordinances based on measurements at a residential property line. The current study investigated whether noise at the higher

education site was reduced after implementation of controls, with a resulting effect on local neighborhoods.

**Methods:** A temporary L-shaped wood barrier was installed on the North (N) roof of a research building near the strobic exhaust fans. Absorbers were placed on a ground level condensing unit abutting the research building. Dosimeters (Larson Davis Spark 705+) were used to measure noise levels around the sources and at the property line of the higher education site. Four days of sampling were performed during August and September 2015. Using ACGIH® and OSHA parameters, the dosimeters recorded noise at one minute intervals, for 24 hours a day. The dosimeters were calibrated daily (Larson Davis CAL150). Recorded data were uploaded to Blaze software and exported for analysis in SPSS.

**Results:** The findings indicated significant variations in noise levels depending on monitoring location and time of day. An intermittent source is present, a generator that runs a weekly 20 min test. The minute average noise levels [Mean±SD (Min-Max)] in terms of Leq (dBA) of daytime noise (generator off), can be summarized as follows: property line, 63.3±3.0 (54.6-85.3); N roof, 71.6±5.1 (60.6-98.6); and condensing unit, 63.3±5.2 (51.4-92.5). The minute average noise levels [Mean±SD (Min-Max)] in terms of Leq (dBA) of nighttime noise (generator off) can be summarized as follows: property line, 63.1±1.1 (61.2-70.6); N roof, 66.2±0.4 (65.3-69.2); and condensing unit, 59.6±1.1 (54.8-66.5). Compared to the precontrol study, mean noise levels (dBA) with the generator off demonstrated a reduction in daytime (nighttime) levels: -9.6 (-13.8) at the N roof (barrier), -22.9 (-26.2) at the condensing unit (absorbers) and -0.3 (-2.4) at the property line.

**Conclusions:** Based on the noise ordinance for the city, noise levels within a residential area must not exceed 60 dBA between 7 am and 10 pm or 55 dBA between 10 pm and 7 am. While implemented controls have reduced noise levels at the source, the noise levels measured at the residential property line continue to be affected by the noise emissions. Additional controls are recommended to achieve continuous compliance.

## SR-403-12

### Sound Level Area Assessments Using Noise Mapping

*G. Battista and M. Sheehan, West Chester University, West Chester, PA; R. Morrison, The Dow Chemical Co., Collegetown, PA*

**Objective:** Noise is a ubiquitous hazard in workplaces and work induced hearing loss is one of the most prevalent occupational illnesses. Commissioning of a new plant provides challenges for protecting employees and contractors especially in the building's mechanical spaces. The purpose of this study was to evaluate baseline sound levels within the mechanical areas of a new facility by using noise mapping to assist in the identification of sources and areas needing exposure controls.

**Methods:** The methods used in this study included measuring noise with a calibrated sound level meter at several locations within seven mechanical areas once per month over a four-month period. Building diagrams of mechanical areas were reformatted with a grid and were used by the surveyor for data collection/notation. Measurements were inputted into a company designed mapping tool which created color coded maps of noise levels within these areas for each sampling date. Outside weather conditions were also noted to assist with noise

source interpretation. Spatial and temporal comparisons of sound levels were made using the Kruskal-Wallis ANOVA.

**Results:** The results provided visual images of sources and excessive noise locations. A visual assessment of the four monthly noise maps for each mechanical area indicated variations in sound levels over time as different mechanical systems were operating due to weather conditions. Statistical analysis indicated differences among the different mechanical areas and that month two was significantly different from months three and four.

**Conclusions:** Our conclusions were: 1) sources (e.g. steam leaks) were defined for each area for each month and these were prioritized for remediation; 2) some sources were related to outside weather conditions; 3) locations were defined that required immediate actions to reduce potential exposure (warning signage/ demarcation and provision of necessary personal protective equipment); and 4) this company's noise mapping tool is an effective way to focus attention on areas and sources needing noise reduction strategies. We recommend that industrial hygienists: 1) incorporate mapping technologies into their evaluations of workplace noise and 2) take multiple area noise measurements of mechanical rooms throughout the commissioning process and throughout the year in plants that are operating. This will characterize the sound levels in mechanical areas, identify sources and reduce potential exposure to workplace noise.

## SR-403-13

### The Benefits of Quantifying the Parent Product and Its Urinary Metabolites when Assessing Occupational Exposure to Antineoplastic Drugs

*C. Hon, Ryerson University, Toronto, ON, Canada; C. Barzan, University of British Columbia, Vancouver, BC, Canada*

**Objective:** Occupational exposure to antineoplastic drugs has been associated with reproductive toxicities, genetic damage as well as an increased risk of developing cancer. In order to assess healthcare workers' exposure to antineoplastic drugs, one method that has been employed in studies is to collect urine samples and then quantifying the amount of unmetabolized drug that is voided. However, it has been suggested that this may result in an underestimate of the true body burden. It would be more appropriate to analyze the parent product as well as its urinary metabolites. To our knowledge, this has yet to be demonstrated. The aim of this study was to ascertain the benefits of quantifying cyclophosphamide (CP), a commonly administered antineoplastic drug, and three of its main urinary metabolites with respect to occupational exposure assessment.

**Methods:** We asked healthcare workers to provide 24-hour urine samples, which were subsequently analyzed using high performance liquid chromatography tandem mass spectrometry (HPLC-MS/MS). The amount of CP and three of its more stable urinary metabolites [4-ketocyclophosphamide, carboxyphosphamide, and N-dechloroethylcyclophosphamide] was quantified.

**Results:** We obtained 223 urine samples. The average urinary concentration of CP was 285 ng/24 hours (interquartile range 184 ng/24 hours) while the mean urinary concentration of CP and the three metabolites was 2,158 ng/24 hours (interquartile

range 567 ng/24 hours). In addition, only 49% of samples exceeded the LOD for CP when only CP was analyzed; however, when CP and its metabolites were examined, 94% of the samples had at least one analyte at a concentration that exceeded its corresponding LOD.

**Conclusions:** These findings suggest that analyzing the parent drug and its urinary metabolites would result in improvements concerning the accuracy of body burden levels as well as the proportion of detectable samples, two important factors from an occupational hygiene perspective. We therefore recommend that all future studies, which collect urine samples for exposure assessment purposes, quantify both the parent drug product and several of its urinary metabolites. By doing so, it will allow for more appropriate interpretation of the associated occupational exposure risk.

## SR-403-14

### Development and Administration of a Pilot Environmental Health Survey in Lucas County, Ohio

*E. Zgodzinski, S. Eitniear, G. Bingham, J. Niese, and B. Sherrick, Toledo-Lucas County Health Department, Toledo, OH; A. Ames, M. Valigosky, S. Milz, and F. Akbar-Khanzadeh, University of Toledo, Toledo, OH*

**Objective:** A goal of local public health agencies is to improve the health of their community. The Toledo-Lucas County Health Department collaborated with various stakeholders to undertake the first countywide environmental health assessment in 2015. This assessment is a multistep process to: gather information from residents and employees about environmental conditions and perceptions in Lucas County, reduce exposure to health risks, and educate the public on sources of environmental risk.

**Methods:** A pilot survey was developed with questions on demographics, perceptions on environmental health issues, including the greatest environmental health issue at different scales (yourself, your family, neighborhood, county, NW Ohio), and how one learns about the issues. The survey was administered online through SurveyMonkey. Participants were recruited via social media (Facebook and twitter); email and at public events.

**Results:** Result of the pilot data were entered into a database for analysis in SPSS 21. A total of 283 respondents were split into three groups for analysis purposes: Group 1, lives and works in Lucas County (n=187); Group 2, lives in and works outside of Lucas County (n=63); and Group 3, lives outside of Lucas County (n=33). The environmental health conditions were grouped into air (i.e., air pollution, open burning, radon, etc.), water (i.e., drinking water, beach closings, sewage, etc.), land (pesticides/herbicides, nuisance, etc.), and miscellaneous (i.e., food safety, lead, smoking, etc.). The most frequently identified environmental health condition(s) affecting residents of Lucas County: 1) air category were air pollution for Groups 1 (44.4%) & 3 (39.4%) and mold for Group 2 (44.4%); 2) water category were drinking water (59.5%, 58.7%, and 39.4% for Groups 1-3) and harmful algal blooms (HABs) (63.1%, 65.1% and 36.4% for Groups 1-3); 3) land category was nuisance, with 50.3% [Group 1], 39.7% [Group 2] and 30.3% [Group 3]; and 4) miscellaneous category were mosquitos and ticks for Group 1 (49.2%) and Group 2 (50.8%), and smoking for Group 3 (24.2%). Group 1 cited drinking water and HABs as the greatest

environmental health conditions at all scales (yourself, your family, neighborhood, county, NW Ohio).

**Conclusions:** Perceptions of environmental issues affecting residents of Lucas County were similar among the three groups. Overall, the most frequently identified issues among respondents in all categories were drinking water and HABs.

## P0107

### Chemical & Physical Aspects of Exposures in the Built Environment

Tuesday, May 24, 2016, 10:30 AM - 12:30 PM

## SR-107-01

### Indoor Air Monitoring in Day-Care Centers

*Y. Yen, Kaohsiung Medical University, Kaohsiung, Taiwan*

**Objective:** the aim of this study is to monitor the airborne influenza A and B virus in two day-care centers with different ventilation form

**Methods:** Environmental monitoring was from August 2006 to January 2007. Day care center A was near a busy traffic street and had natural ventilation and air conditioning. Center B had only an air-conditioning system and was located in a small lane. The sampling parameters are as follow: the concentration of bacteria and fungus, influenza virus in the air, indoor meteorological factors, particle numbers, CO and CO<sub>2</sub>. The seasonal variation was also investigated (Summer, Fall and Winter) to evaluate the relation between the concentration of airborne pathogen and occurrence of respiratory infections.

**Results:** Airborne influenza A and B virus were both successfully quantified from the two centers by filter and real-time qPCR. The mean concentration of 179 samples of influenza A and B virus is 8.03x10<sup>4</sup> copy/m<sup>3</sup> and 1.59x10<sup>5</sup> copy/m<sup>3</sup>. The average of influenza A virus is significantly higher in summer (p=0.019). The positive rate of influenza A and B virus is 29% and 53%.

**Conclusions:** Comparing different ventilation system from two centers, the air contaminant: total cultivable bacteria, CO and CO<sub>2</sub> concentration: center A > center B (p <0.01). The positive rate of influenza A and B virus: B>A (p <0.05). The mechanical exhaust system with less fresh air of center B might be the reason.

## SR-107-02

### Formaldehyde Emissions from Small Chamber Testing of Laminate Flooring and Comparison to Exposure Modeling

*J. Lotter, K. Unice, P. Ruestow, A. Abelmann, H. Fritz, E. Beckett, J. Bare, and J. Pierce, Cardno ChemRisk, Chicago, IL*

**Objective:** It has long been understood that composite wood products may release airborne formaldehyde. As such, the California Air Resources Board (CARB) has set limits on formaldehyde emissions from composite wood products. The purpose of our investigation was to determine (1) how chamber

test emission results from two products labeled as CARB Phase 2 compliant compared to the emissions standards in the Airborne Toxic Control Measure (ATCM) and (2) if the predicted steady-state airborne concentrations based on small chamber testing were consistent with the measured concentrations following the installation of these products.

**Methods:** Samples of two laminate flooring products (Products 1 and 2) were evaluated in accordance with the ASTM D6007 small chamber testing method. Each product was analyzed using CARB comparative and deconstructive testing protocols. The results of the tests were compared to the emission standards for hardwood plywood with a composite core [HWPW-CC] (0.05 ppm) and medium density fiberboard [MDF] (0.11 ppm), respectively. Predicted steady-state room air concentrations were determined using the small chamber CARB comparative test results. In addition, both products were installed in separate study rooms and 24-hr diffusive badge samples (n = 48) were collected over the course of 35 days. Predicted steady state formaldehyde concentrations were compared to the concentrations measured on post installation day 35, as it was determined that steady state was not reached in either study room.

**Results:** Based on CARB comparative testing, the concentrations for Products 1 and 2 were 0.018 ppm and 0.012 ppm, respectively. However, using CARB deconstructive testing, the concentrations were 0.420 ppm and 0.106 ppm. Results for Product 1 exceeded the emission standard for MDF by nearly 4-fold, and Product 2 was within 5% of the standard. The predicted steady-state concentrations were approximately 4- to 5-fold lower than the actual concentrations measured in the study rooms on post-installation day 35.

**Conclusions:** We found that certain flooring products labeled as CARB Phase 2 compliant may be classified as exceeding the CARB Phase 2 emissions standards for MDF based on deconstructive testing. Furthermore, using accepted modeling techniques designed to provide conservative estimates of room air concentrations, the modeled concentrations were considerably lower than actual measured concentrations.

## SR-107-03

### Air Corrosivity Monitoring in Museums

*E. Light and R. Gay, Building Dynamics, LLC, Ashton, MD; C. Grzywacz and C. Hawks, National Gallery of Art, Washington, DC; K. Horiuchi, ALS Global, Simi Valley, CA; K. Makos, Research Collaborator, Smithsonian, Washington, DC*

**Objective:** Corrosion of museum collections caused by air contaminants is a major concern. The authors compared several monitoring methods for use in screening materials for museum displays and tracking air corrosivity in museums.

**Methods:** A pilot project was conducted in a museum to compare several methods for assessing air for corrosive agents. Exposure to carboxylic acids and aldehydes emitted by wood products was of particular interest. Side by side measurements were made by active sampling (sorvent tubes), passive sampling (acid strips and diffusion tubes) and copper probes quantifying overall air corrosivity.

**Results:** Data are presented from samples collected in various display cabinets and museum HVAC zones.

**Conclusions:** Pros and cons of alternative sampling methods

are presented. Recommendations are made for development of air corrosivity assessment protocols for screening wood emissions from museum display cabinets and tracking ambient air quality in museums.

## SR-107-04

### Assessment of Indoor Formaldehyde Concentrations Following the Installation and Removal of Laminate Flooring

*J. Pierce, A. Abelmann, P. Ruestow, J. Lotter, E. Beckett, and H. Fritz, Cardno ChemRisk, Chicago, IL; J. Bare and K. Unice, Cardno ChemRisk, Pittsburgh, PA*

**Objective:** Concerns have been raised regarding formaldehyde emissions from laminate flooring. Given the limited sampling data available, an investigation of the potential formaldehyde emissions resulting from the installation, use, and removal of laminate flooring was conducted.

**Methods:** Two laminate flooring products were purchased and installed in separate study rooms. Passive 24-hr diffusive badge samples (n = 79) for formaldehyde were collected over 63 days during: a preinstallation period, an acclimation period (packaged products stored in the study rooms), and installation and removal. The concentrations were compared to exposure limits and guidelines that exist in the U.S. for indoor air.

**Results:** Mean background concentrations were 0.006 ppm and 0.005 ppm in Rooms 1 (R1) and 2 (R2), respectively. During acclimation, mean concentrations increased to 0.009 ppm and 0.010 ppm in the two rooms, respectively. Mean concentrations following the installation of the flooring were 0.038 ppm (range: 0.020-0.058 ppm) in R1 and 0.022 ppm (range: 0.013-0.039 ppm) in R2; these concentrations were statistically significantly higher than background ( $p < 0.001$ ) and acclimation concentrations (R1:  $p < 0.001$ ; R2:  $p = 0.011$ ). Upon removal of the flooring, concentrations decreased rapidly and, on post-removal day 7, were not statistically significantly elevated compared to background. Throughout the study (including prior to and during acclimation), mean airborne concentrations exceeded the 8-hr and chronic Reference Exposure Level (REL) of 0.007 ppm and the Proposition 65 No Significant Risk Level (NSRL) of 40  $\mu\text{g}/\text{day}$  (24-hr equivalent: 0.002-0.003 ppm) set by California's Office of Environmental Health Hazard Assessment (Cal-OEHHA). Following the installation of the flooring, the Federal Emergency Management Agency (FEMA) procurement standard (0.016 ppm) was also exceeded in both rooms.

**Conclusions:** Formaldehyde was detected in indoor air at levels that exceeded background during the acclimation of the products, following flooring installation, and up to 7 days following removal. Concentrations resulting from the use of both products exceeded nonoccupational indoor air exposure limits and guidelines in the U.S. during all study periods.

## CS-107-05

### A Review of the Health Effects of MVOCs

*H. Burge, EMLab PK, San Bruno, CA*

**Situation/Problem:** Microbial volatile organic compounds (MVOCs) are produced by bacteria and fungi during food digestion. MVOCs are not unique to microbes, nor are any specific to any one species. Hundreds of MVOCs have been identified, including 3-methylbutan-1-ol, 3-methylbutan-2-ol, fenchone, heptan-2-one, hexan-2-one, octan-3-one, octan-3-

ol, pentan-2-ol,  $\alpha$ -terpineol, and thujopsene. Many occupants of moldy buildings detect these MVOCs and worry about health effects of the mold or of the VOCs.

**Resolution:** Some sampling has been done to document concentrations of various MVOCs in some environments. These studies have used varying methods both of sampling and analysis. At least one study of odor thresholds has been done, and several laboratory and human exposure studies have been reported.

**Results:** There are few reports of measured concentrations of MVOCs. One investigator used a charcoal diffusion sampler over 4 weeks and found four week averages in the range of 0.27-15.0  $\mu\text{g}/\text{m}^3$ . Mean total MVOCs in schools in Sweden were 423  $\text{ng}/\text{m}^3$  indoors and 123  $\text{ng}/\text{m}^3$  outdoors. The odors associated with these volatiles are often the first clue that microbial growth is occurring in a building. Odor thresholds for these compounds have not been well studied, but are apparently quite low. Many human factors, both physiological and emotional change odor perception. 1-octen-3-ol which is a common volatile produced by many fungi has an odor threshold of 200  $\text{ng}/\text{m}^3$ . In lab studies embryonic stem cells have been exposed to 1-octen-3-ol. 50% inhibition concentrations were in the range of 98 and 258 ppm. The concentration capable of decreasing the respiratory frequency of mice by 50% (i.e., the RD(50) of 1-octen-3-ol, 3-octenol, and 3-octanone were 182  $\text{mg}/\text{m}^3$ , 1,359  $\text{mg}/\text{m}^3$  and 17,586  $\text{mg}/\text{m}^3$  respectively. In human chamber studies, 29 volunteers were exposed to 3-Methylfuran (a common fungal volatile) at concentrations of 1  $\text{mg}/\text{m}^3$ . There were no subjective symptoms at this concentration but there were some significant physiological changes. In epidemiological studies, some health associations with MVOCs have been noted. In Sweden, nocturnal breathlessness and doctor diagnosed asthma were associated with the higher levels of total MVOC measured. Mean levels of MVOCs were in the nanogram range. In another study, home symptoms in 4% of the study population were associated with 1-octen-3-ol.

**Lessons learned:** The question of whether or not MVOCs cause symptoms or illness in occupants of moldy buildings remains open. The existing literature leans toward the conclusion that odor perception is far below any possible irritation effect, as are measured concentrations in even moldy environments. However, there is some contradictory evidence, and more studies are needed.

## SR-107-06

### Research Report: New "Green" Tracer for Measuring Air Movement in Buildings

*C. Cooper, VERTEX companies, Kingston, NY*

**Objective:** The current methods for measuring air movement and distribution in buildings all have drawbacks that make it difficult, expensive, time consuming, and require particular scientific expertise to carry out, and hence field testing of air distribution in buildings is rarely done. In 2015 the New York State Energy Research and Development Authority (NYSERDA) supported research to characterize the performance of a new air tracing technology (Cove) over varying distances, measurement times, materials interactions, air volumes, and tracer concentrations. The invention is an air measurement platform that enables air labeling and quantitation of a wide range of interactions using sensitive quantitative real-time measurement of a labeled air parcel.

**Methods:** Experimentation on COVE air tracer chemistry, method precision, and field applications included use of a small chamber test bed, and full scale building measurements. Data objectives included determining instrumental sensor detection sensitivities to tracer mixtures, multi-instrument precision, control of broadcast concentrations, lower detection limits, and safe operating parameters. Field experiments explored useful applications and limitations for this real-time rapidly deployed tracer release and measurement method, including applications for puff release of tracer, air velocity measurements, outdoor air ventilation air supply and exhaust efficiency, and determining indoor/outdoor mixing ratios, and duct leakage. A series of tests under ASHRAE Standard 129 methods for ventilation efficiency determination were completed at building scale under controlled conditions. Comparison measurements were made with blower door methods, and with tracer sulfur hexafluoride releases (SF<sub>6</sub>).

**Results:** Our experimental results of this new COVE tracer technology showed the ability to achieve scalable precise emitter control, parts per billion detection sensitivities, excellent repeatability of experimental results, and excellent multiple sensor precision with single point calibration, over recorded time scales of seconds to days.

**Conclusions:** This new tracing technology is shown to be a safe, relatively simple and reliable measurement method for field applications to accurately determine air leakage and airflow distribution in HVAC systems and in occupied ambient space. Envisioned applications for this new technology include field determination of ventilation effectiveness, and as a surrogate for precise quantitative measurement of an engineered system's ability to either contain, remove, or dilute chemical or biological contaminants.

## P0108

### Industrial Hygiene Applications: Nanotechnology, Drugs, and Other Agents

Tuesday, May 24, 2016, 10:30 AM - 12:30 PM

## CS-108-01

### Methodology for the Assessment, Evaluation, and Control of Potential Exposure to Engineered Nanomaterials (ENM)

*C. Penniall, S. Maberti, B. Janke, and A. Jachak,  
ExxonMobil, Spring, TX*

**Situation/Problem:** Existing research and recommended worker protection guidance is focused on the manufacture of engineered nanoparticles and engineered nanomaterials (ENM). There is little to no guidance on how to protect researchers or other workers when they handle engineered nanomaterials or nano enabled products such as insulation, paints, cements, catalysts, process additives, etc.

**Resolution:** A methodology was developed to review, evaluate, and control the exposure during handling of free-form engineered nanomaterials or nano enabled products. The

methodology involves a flowchart that assesses the release potential of engineered nanomaterials during work and the relative toxicity of the engineered nanomaterials. Based on these parameters and the feasibility of control implementation, a hierarchy of work controls has been established. Separate training programs were developed for line management, IH staff responsible for research and pilot plants, and IH staff responsible for operational sites.

**Results:** The results include a comprehensive approach to the identification of potential exposure scenarios, exposure pathways, risk and the minimum work controls to protect employees during both research activities and handling of nano enabled products in process operations and maintenance work.

**Lessons learned:** IH staff require basic training on: the unique chemical and physical properties of engineered nanomaterials, the factors that drive release potential of nano size particles, potential health effects associated with exposure to engineered nanomaterials, and effective work controls, including engineering and PPE. Further, the lack of a consensus definition and lack of unique CAS numbers compound the difficulties in identification of engineered nanomaterials before they arrive in a lab or work site.

## SR-108-02

### Adsorption Efficiency Comparison of Fabricated Buckypapers (BPs) for Volatile Organic Compound (VOC) Sampling and Analysis

*J. Oh and C. Lungu, Environmental Health Sciences,  
University of Alabama at Birmingham, Birmingham, AL; E.  
Floyd, University of Oklahoma, Oklahoma City, OK*

**Objective:** To find the most adsorptive sorbent through the fabrication of different types of single-walled carbon nanotubes (SWNTs) for use in volatile organic compound (VOC) passive samplers.

**Methods:** Arc discharge (AD) SWNT solution (0.5 mg/mL) and high pressure carbon monoxide (HiPco) SWNT powder were fabricated into a buckypaper (BP), a self-standing form of carbon nanotubes. For the fabrication of AD SWNT BP, 100 mL (50 mg) of the SWNT solution was suspended in 400 mL of acetone, filtered through a membrane filter under vacuum. SWNT cake deposited onto the filter was delaminated to obtain a BP (non-cleaned BP). SWNT cake was cleaned with deionized water and acetone after SWNT solution was vacuum filtered (acetone cleaned BP). Also, methanol was used to suspend SWNTs and in the cleaning process (methanol cleaned BP). For HiPco SWNT BP, 50 mg SWNT powder was suspended in methanol and sonicated in a cold bath. The same filtration procedure was followed. The fabricated buckypapers (n=4) were examined for surface area (SA) and toluene adsorption isotherm. SA was measured with a Micromeritics® ASAP2020 physisorption analyzer. Adsorption isotherm was obtained through diffusive adsorption isotherm chamber system (lab designed) in which liquid toluene diffuses onto a sorbent at 30 degrees Celsius.

**Results:** AD BPs showed 211±61, 322±38, and 387±16 square meter/g Brunauer, Emmett and Teller (BET) SA for non-cleaned, acetone-cleaned, and methanol-cleaned BPs, respectively, while HiPco BPs exhibited 649±9 square meter/g BET SA. The toluene adsorption capacities were 24, 33, 43,

and 101 mg (toluene)/g (BP) for non-cleaned, acetone cleaned, methanol cleaned AD BPs, and HiPco BP, respectively.

**Conclusions:** HiPco BP had the highest SA and toluene adsorption capacity and among AD BPs, methanol cleaned BP was the most adsorptive, indicating that the cleaning process with methanol was the most desirable to fabricate AD BPs. Overall, toluene adsorption capacity was proportional to the SA. The fabricated BPs will be further annealed to increase SA and investigated on desorption efficiency using photothermal desorption technique which can shorten the current analytical procedure and consequently, exposure assessment time.

### CS-108-03

#### Investigation of Airborne Particulate Matter on the International Space Station (ISS) Using a Thermophoretic Sampler

*K. Rickabaugh, G. Casuccio, and K. Bunker, RJ Lee Group, Inc., Monroeville, PA; M. Meyer, NASA, Cleveland, OH*

**Situation/Problem:** It is important to maintain excellent air quality and to minimize deposition of particulates on surfaces in the International Space Station (ISS) environment. A significant challenge arises as there is a fixed volume of air on ISS and there is no dilution, venting or gravitation settling of debris or particulates. As a result, the potential release of particulates and other contaminants from on board activities needs to be well understood to adequately recognize, evaluate and control any potential emissions that may occur during operation. NASA has down-selected a thermophoretic sampler (TPS) as a means to sample airborne particulates on the ISS.

**Resolution:** Studies are underway to adapt the TPS for outer space applications for a sampling experiment on the ISS. One of the studies performed demonstrating the use of the TPS has been the preliminary testing of particulate releases from the use of 3D printers on Earth. Initial test measurements have been obtained using direct-reading instrumentation to evaluate both the number abundance and size distributions of particulates associated with a variety of different printing activities. Sampling of particulates has also been performed in order to characterize the emissions using electron microscopy techniques. The use of a miniaturized thermophoretic sampler (TPS) was implemented to sample the air because, in part, it is easy to use and particles are deposited directly onto a TEM grid for examination. This use of the TPS direct deposition technique is also preferred to minimize the likelihood that particulates could be disaggregated or dissolved in the sample preparation stages involved with filter based techniques.

**Results:** The results from the use of the direct-reading instruments often indicate the presence of airborne particulates from study related activities with particles detected being in the nano-size (< 100 nm) range. In the case of 3D printing testing, early results indicate that there are differences in particle emissions from different printing scenarios. In this instance and during other tests performed, the use of the TPS has been demonstrated to be a useful technique in obtaining samples suitable for electron microscopy examination in order to characterize particulates.

**Lessons learned:** Additional study and planning is desired in order to understand the air quality implications involved with human and other operational activities performed in the ISS environment. The TPS has already been chosen for a flight

technology demonstration. One of the challenges that has been uncovered is the need to modify the TPS design so that heat will be appropriately dissipated in a low gravity environment. A low gravity version is being fabricated and space flight hardware acceptance testing is underway. A customized version of the TPS is scheduled to be deployed on the ISS in 2016. An update on the engineering solutions and preliminary testing results from use of the TPS will be presented.

### SR-108-04

#### A Standardized Approach for the Generation and Characterization of Aerosols Released from Composite Nanomaterials in Industrial Scenarios

*L. Cena, D. Farcas, and A. Erdely, CDC/NIOSH, Morgantown, WV; J. Kang, West Virginia University, Morgantown, WV*

**Objective:** Develop and test a standardized method for generation and characterization of particles released from composite nanomaterials undergoing mechanical stress.

**Methods:** An adaptable system was developed to accommodate life-cycle events (e.g., sanding, sawing) for test materials and consumer products. The system consisted of a sand-blasting cabinet with HEPA-filtered air intakes. An electrical motor was exteriorized and connected to a pulley through a v-belt. Inside the cabinet, the pulley was connected to a shaft that could accommodate various types of equipment such as a belt sander, a saw blade or a drill chuck. A material feeder with constant force was constructed. The system was tested with a belt sander by sanding: 1) glass fiber/epoxy resin, 2) glass fiber/epoxy resin containing post-coated multi-walled carbon nanotubes (MWCNTs), 3) epoxy resin, 4) epoxy resin containing MWCNTs, 5) epoxy resin containing glass-fiber-infused MWCNTs, 6) epoxy resin containing carbon black, and 7) epoxy resin containing carbon black and MWCNTs. Total number concentrations, respirable mass concentrations, and particle size number/mass distributions of the emitted particles were measured using a scanning mobility particle sizer, an optical particle counter and a condensation particle counter. Additionally, samples for electron microscopy analysis were collected with a thermophoretic sampler and filter samples. Measurements were taken in triplicate for each material with coarse (150 grit) and fine (320 grit) sandpaper.

**Results:** The highest number concentrations (arithmetic mean = 2670 particle/cm<sup>3</sup>) were produced with coarse sandpaper, epoxy resin containing carbon black and MWCNTs. The lowest number concentrations (arithmetic mean = 600 particles/cm<sup>3</sup>) were produced with fine sandpaper, epoxy resin containing MWCNTs. The highest respirable mass concentrations (arithmetic mean = 1.01 mg/m<sup>3</sup>) were measured for fine sandpaper, epoxy resin containing MWCNTs and lowest (0.2 mg/m<sup>3</sup>) for coarse sandpaper, glass fiber/epoxy resin. Airborne particles were primarily micrometer sized with CNT protrusions.

**Conclusions:** The system provides a replicable and adaptable method for characterizing the particles released during an industrial use scenario. In this example, the number concentration, mass concentration and number size distribution of airborne particles depended on the characteristics of the material being sanded and the sandpaper grit.

## CS-108-05

### Models—What Can They Tell Us?

A. Havics, PH2, LLC, Avon, IN

**Situation/Problem:** Models have been used for years and have come to form a central part of exposure assessment. They can range from simple one-box models to complex computational fluid dynamics. Often times they are used before working through the base reasons and outcomes desired, the philosophical aspects. This would include determining the purpose, the use and level of specificity and accuracy required.

**Resolution:** Using several examples the assumptions, limitations, and practical (in context) application of some models will be explored.

**Results:** These aspects can be seen in: a) box models for paint exposure estimation, b) industrial site downwind carbon monoxide concentrations using an EPA industrial source complex model, c) 3D Fluent modeling of asbestos particle fate & transport from an abatement containment breach, d) dispersion/plume modeling of fracking fluids in groundwater and emitted from soils, and e) mesothelioma risk estimate in jewelry making. Some of these examples include other data, such as similar situation sampling data, to corroborate the models veracity (or lack thereof). The quality of the models will be addressed in this regards.

**Lessons learned:** This will demonstrate the benefits of models in terms of estimating exposure, exposure range, what is/isn't probable, key factors in exposure, limitations in estimating & control, reduced time, preplanning assistance, etc. On the downside, this talk will also look at the potential negatives, generally related to quality, such as variability, sensitivity, limitations in prediction or retrospective evaluation, overconfidence in results, etc.

## CS-108-06

### The Use of Surrogate Sampling for Evaluating the Efficiency of Engineering Controls During Hazardous Drug Compounding

E. Higgins, Environmental Health & Engineering, Inc., Needham, MA

**Situation/Problem:** Many pharmacies have struggled to meet current USP 797 standards and the proposed USP 800 standards are more strict. Older infrastructure and mechanical systems, aging equipment, small spaces have prohibited compliance, and many healthcare systems lack the capital budget necessary for retrofitting pharmacies, in order to meet compliance. The most common issues regarding compliance focus on isolation of areas where hazardous drugs (HDs) are compounded and insufficient air exchange rates and relative pressurization of compounding rooms. Retrofitting the heating, ventilating, and air-conditioning (HVAC) systems and/or purchase of compliant equipment is cost prohibitive for most organizations. Many of the HDs that are compounded are not inhalation hazards, rather dermal or contact hazards. Therefore, it is necessary to find a way to evaluate current work practices and engineering controls in an efficient and cost-effective manner.

**Resolution:** We have designed alternative approaches to evaluating the effectiveness of existing engineering controls

which involves the use of surrogate air and surface sampling. We conducted baseline monitoring, followed by air sampling for selected chemicals that are similar (chemical state, vapor pressure, particle size) to the hazardous drugs that are used during compounding. This was completed every six months following the replacement of filters (on a preventative maintenance schedule) Monitoring was conducted during typical activities using the surrogates, which includes preparing syringes for intramuscular administration, pills, and intravenous bags. Surface sampling for particulate phase surrogates were also collected on surfaces outside the primary engineering control. We also developed a strategy in which additional filtration (primarily high efficiency gas absorption filters) were used to address potential exposures of liquid phase HDs.

**Results:** Through surrogate air and surface sampling we have shown that the use of best work practices, and in some cases additional filtration, is successful in controlling potential exposures to HDs during compounding. Monitoring has also indicated that the most likely source of contamination is through direct contact. We detected surrogate on surfaces that were not adequately cleaned after compounding activities. This allowed us to work with the organization to evaluate and improve the current cleaning programs, increase awareness, and better train employees on proper cleaning methods in the pharmacy.

**Lessons learned:** As it is for many regulations, it is important to be able to interpret compliance standards, and at the same time meet the needs of clients. We have used science to quantitatively evaluate the effectiveness of the controls without breaking the bank for hospitals. The results supported data that shows the primary hazard for HDs is dermal exposures and not inhalation. The results gave us quantitative evidence that directed us to work with the pharmacies in evaluating and improving handling of products and cleaning of surfaces. We learned that you don't need to spend a lot of money retrofitting the pharmacies in order to meet compliance and keep employees safe from HD exposures.

## P0109

### Innovations in Risk Assessment & Management

Tuesday, May 24, 2016, 10:30 AM - 12:30 PM

## CS-109-01

### How to Evaluate the Science in a Scientific Study

A. Havics, PH2, LLC, Avon, IN

**Situation/Problem:** We have achieved a state of polygnosia or too much knowledge. In 1950 the number of journals recorded was about 60,000 and the estimate for year 2000 was about 1,000,000. Having so much data available, most digitally, provides a new problem, how does one value the data available?

**Resolution:** The question is not an easy one to answer because from a risk standpoint everything is gray. It is a matter of how

much gray and then how much gray is too much gray. There are several reasons to evaluate data in this fashion, and perhaps one of the best is the AIHA-ACGIH-ABIH Cannons of Ethical Conduct: "Industrial Hygienists should obtain information regarding potential health risks from reliable sources," and, "Industrial Hygienists should review the pertinent, readily available information to factually inform the affected parties." This leads to the question—how does one evaluate data, whether it is a tox study, a published case study, or another scientist's unpublished report or notes? First, one must determine the purpose of the evaluation, then one must critically review the a) data presented, b) source of the data, and c) the methodology. From there it all depends upon the findings, but there are a few resources/procedures to use.

**Results:** Example of these tools include: a) Klimisch approach, b) ToxRTool, c) the Pinto approach, d) Science Policy Council's Assessment Factors, e) Riegelman's How to Study a Study and Test a Test, and f) Hill's Criteria. They each have different applications and approaches. But, the factors considered and the steps involved can be put to good use in evaluating data. Some examples of published and unpublished papers & reports will be used to scratch the surface of how to evaluate data: air emission allocation, risk from fracking, fungal spore trap data, determining the weighted consensus from multiple toxicology papers, unpublished asbestos exposure data, etc.

**Lessons learned:** Even good data can be presented poorly and even good-intentioned scientists can present poor data or poor interpretations. The ability to accept bad data seems to come with a great need consisting first of the absence of data. I too should be very carefully about what I write, lest I become an example of poor value.

## CS-109-02

### Big Data and Assessing Exposures & Risks: When Too Much Seems Like Never Enough

*J. Persky, RHP Risk Management Inc., Chicago, IL; B. Heckman, RHP Risk Management Inc., Carlisle, PA; F. Boelter, RHP Risk Management Inc., Boise, ID*

**Situation/Problem:** Avogadro's Number is a pretty big number, even though numerically it is only a billion times more than the number of cells in the human body. Frankly, big numbers are incomprehensible for most people and the pile of data and variables to consider just keep growing. Whether the challenge is analyzing air samples from a spill response or developing a cumulative risk analysis, when it comes to exposure, stressors and risk, people ask simply What does it mean to me?. We have personal sampling techniques, biological monitoring techniques, modeling techniques, and guidelines and standards for interpretation. Will Big Data help us answer questions or just raise more questions we cannot answer?

**Resolution:** New technologies and their subsequent innovations don't directly cause social change; instead they create problems and dilemmas that drive society to seek new solutions from a diverse set of choices. Today's social ferment from growing global networks is the new breeding ground for radical innovations, for good and for ill. Social experimentation with disruptive technologies will be a prominent feature of the next twenty years and beyond.

**Results:** We explored several projects where an extraordinary amount of data was available for analysis. Tens of thousands of data points with ranges, distributions, averages, and 99thPCLs

were considered. From an industrial hygiene perspective, frequently none of the data shows overexposures and much of the data is censored or doesn't meet quality objectives. Will the era of big data yield larger amounts of higher quality data? How is industrial hygiene going to evolve to incorporate or deal with genetic diversity, epigenetic variations and arguments about susceptibility to disease?

**Lessons learned:** Big data holds out the promise to provide the ability to dig into data and answer questions that were not originally envisioned, alter the way we define and evaluate acceptable risk and potentially allow for more personalized exposure assessments and risk characterizations. Our profession needs to develop guidance on how the age of Big Data will influence developing and validating models, define risk acceptability criteria, derivation of site-specific risk-based exposure criteria, and communicate concepts of extremely low probability and de minimis risk.

## CS-109-03

### Expected Quantitative Results Based on Qualitative Evaluation

*M. DaSilva, Doulos Ambiental, São Paulo, Brazil*

**Situation/Problem:** In multinational companies with hundreds of employees in several parts of the World. It is very difficult to establish an IH program. There are not enough specialized professionals capable of collecting samples in each site. Therefore, the SHE team has to develop methodologies that may be applied by local people after receiving a basic training in managing occupational risks.

**Resolution:** A qualitative evaluation is a very helpful tool, if it has a systematic approach and comprehensive criteria. A Brazilian process named Preliminary Risk Analyze - Occupational Hygiene (PRA - OH) allows the estimating of the potential environmental risk in workplaces. It is an Excel Data Sheet having several macros developed to include all data necessary according to AIHA's book "A Strategy for Assessing and Managing Occupational Exposures". The first part is a basic characterization that presents general information about the company, workplace, position of employee, facility dimensions, etc. The second part sets information of tasks, exposure time, agents, and health effects. A critical part of the PRA - OH is the worker participation (required by Brazilian law). It is an interview with several laborers to register their opinions about concentration or level of environmental agents. Answers are in list boxes or a combo boxes for standardizing the opinions. One matrix with 5 x 5 grades allows classifying the occupational profile (Concentration-Level versus Time Exposure). The Risk Matrix is a cross-correlation of the occupational profile grades and health effects levels. The health effects are the TLV® booklet classified in five levels (1 a 5). The workers received hints about the grading system. Example, noise level 1 is an office environmental and 5 is similar to airport near the airplanes.

**Results:** The results described here resulted from the PRA - OH applied to maintenance tasks that involved electrical, mechanical, instrumentation and welding services in a petrochemical plant. Around 27 interviews related to a group of 95 employees formed by electrical, mechanical, and boilermaker welder professionals. The workers pointed out around 30 chemical and physical agents including Sulfuric Acid, Vinyl Chloride, Chlorine, Dichloroethane, Sodium Hydroxide, Hydrogen Chloride, Metal Mercury, Noise, Hand

and Arm Vibrations, Heat Stress, and others. In total, 200 grades of potential risks were documented. The distribution of the results were 26 irrelevant, 124 attention, 46 moderate, 4 severe and zero grave imminent. Based on the identified qualitative risk, mainly moderate and severe, the monitoring program included 54 noise doses, 10 heat stress (WBGT) evaluations, 6 hand-arm vibration measurements, 63 samples of chemicals (Vinyl Chloride, Welding Fumes, Dichloroethane). The quantitative results showed 61% of noise exposure equal or higher than 80 dBA, 50% of WBGT exceeded the TLV®, 1/3 of hand-arm vibration numbers were in a critical situation, 15 % of Vinyl Chloride concentrations higher than Action Level (TLV® = 0,5 ppm), and all Dichloroethane samples below 5 ppm (TLV® - Action Level)

**Lessons learned:** The PRA - OH allows the amplification of the vision of environment risk because it includes the opinion of workers who know their tasks very well, chemical and physical agents in workplace. The PRA - OH is a historic document signed by workers and EHS professionals. In general, the worker perception about environmental risk is overestimated. Some occasional exposure is routine. The interviewer needs to be aware of agents that have no subjective indicators, such carbon monoxide. The PRA - OH allows a SEG-HEG based assessment. The PRA - OH provides good information for the occupational physician because it considers environment agents and a monitoring program. A certified industrial hygienist must validate the PRA - OH. The EHS team must have access online to check the PRA - OH developed in Microsoft Excel spreadsheet.

## CS-109-04

### National Aeronautics and Space Administration, NASA, Astronaut Occupational Surveillance Program and Lifetime Surveillance of Astronaut Health, LSAH: Astronaut Exposures and Risk in the Terrestrial and Spaceflight Environment

*S. Keprta, W. Tarver, M. Van Baalen, and T. McCoy, NASA Johnson Space Center, Houston, TX*

**Situation/Problem:** Astronauts have a very unique and somewhat understudied occupational exposure profile. In order to understand these risks and properly address them, the National Aeronautics and Space Administration (NASA) originally created the Longitudinal Study of Astronaut Health (LSAH). The first LSAH program was designed to address a variety of needs regarding astronaut health and included a 3 to 1 terrestrial control population in order to compare earth normal disease and aging to that of a microgravity exposed astronaut. Over the years, the program has been modified. One example is the move from short duration Shuttle flights to longer duration International Space Station space flights (and exposures). Also, there was the move to incorporate more of an occupational health and medicine model to the study of astronaut exposure in the space environment. This presentation outlines the baseline exposures and monitoring of the astronaut population, both terrestrial and space.

**Resolution:** Outline and discuss the exposures and stressors that are part of the profession of a United States NASA astronaut. Understand the purpose and methodology of the programs designed to characterize and evaluate these stressors, the longest running of these programs being the

LSAH.

**Results:** We will discuss the typical and non-typical occupational terrestrial and spaceflight exposures to astronauts and the risk assessments used to follow them through their working career and beyond.

**Lessons learned:** Discuss how standard industrial hygiene risk assessments can, and sometimes cannot, be used to assist in the overall occupational surveillance effort of the NASA Astronaut .

## CS-109-05

### Semi-Quantitative Risk Assessments: It Is About the Controls!

*P. Esposito, STAR Consultants, Inc., Arnold, MD*

**Situation/Problem:** Many of today's risk and exposure assessments find numerous references on how to identify hazards, exposures and risks. To that point, classifying these levels of risk are as numerous as are the number of references themselves. NIOSH is leading efforts in the US to identify Banding levels to help define risk factors of severity and likelihood. Classically, we use the hierarchy of controls, qualitatively. However, our assessments typically fail to determine which risk factor (Severity or Likelihood) is impacted by which control? ANSI B11.0, Machine Guarding Risk Assessment, references that only elimination and substitution impacts severity. So, what level or risk reduction do we actually get from engineering controls? ANSI B11.0 says we only get reduction in likelihood, not severity. This greatly impacts what level of protection actually exists when we use engineering, or even less so, administrative or PPE controls.

**Resolution:** Failure Modes and effects analysis methodology point us toward measuring the reliability of the control to help measure residual risk. The hierarchy of controls: Avoidance, Elimination, Substitution, Administrative, Warnings, and Personal Protective Equipment all come with their own reliability/unreliability factors. In addition, many risk assessments erroneously calculate risk reduction based on the selection of controls, rather than just the risk factor reduction; risk factors being consequences (severity) and our likelihood (probability). Therefore, developing a model where the level of risk reduction is quantitatively tied to the selection of the control or controls can help remove some of the subjectivity in risk assessments, while improving the reproducibility of the process. Also, the model helps you calculate the level of additive risk reductions when there are layers of protection, or defense in depth.

**Results:** This quantitative aspect of control identification to calculate risk reduction can be a powerful tool in determining when to stop adding controls, or determining the risk appetite of an organization. When combining this approach with some ongoing collection of additional metrics, such as conformance rate of controls, helps verify that the appropriate assumptions were made when calculating the quantitative risk reduction strategies.

**Lessons learned:** 1. Risk reductions from controls apply to the independent risk factors of severity and likelihood, not directly to the level of risk. 2. The hierarchy of controls, and even the additive effect of layers of protection, can be quantitatively determined. 3. The risk reduction quantification determinations can be independently verified as part of inspection and

observations by calculating conformance rates. These conformance rates can then be used to readjust risk reductions to actual work practices, management enforcement, etc.

## SR-109-06

### Risk Management Best Practices to Reduce Injuries and Maximize Economic Benefits in U.S. Mining

*S. Griffin, D. Bui, G. Gowrisankaran, E. Lutz, C. He, C. Hu, J. Burgess, The University of Arizona, Tucson, AZ*

**Objective:** Risk management (RM) is a cyclical process of identifying operations or activities that put workers at high risk for injuries, designing controls including engineering changes or standard operating procedures to reduce risks, implementing these controls, and evaluating their effectiveness. While RM is legally required in many countries, U.S. safety and health regulations are typically focused on compliance. The objective of the current study is to determine the effectiveness of RM interventions in reducing injuries and economic costs in the U.S. mining industry.

**Methods:** Four mining companies with extensive RM expertise, representing the metal, aggregate and coal sectors, participated in the study. Retrospective longitudinal analysis of company internal injury and compensation claims data and Mine Safety and Health Administration (MSHA) injury data was completed to determine the effectiveness of RM programs. MSHA data was also used to compare Injury rates for our partner mines to mines of similar employee size and, for coal mines, total production. Mine employees and managers identified the RM programs most effective at reducing injury. Employees provided costs of program implementation and the resulting changes in injury costs were evaluated, enabling an evaluation of return on investment (ROI). RM best practices were defined as those programs that led to a reduction in injury rates and positive ROI.

**Results:** Generally, reductions in injuries were observed following implementation of 14 RM programs at our partner mines. Rates of all injuries and lost-time injuries were lower at our partner mines than comparison mines. Implementation costs ranged from \$43,000 to \$1.2M, with a positive ROI for several programs, including behavioral-based safety interventions and engineering controls.

**Conclusions:** Several RM programs with reductions in injuries and positive ROI were identified. The results, of the current study, help build a business case for the implementation of RM programs, potentially leading to the increased practice of RM in the U.S. mining industry.

## P0110

### New Advances in Construction and Confined Space Safety

Tuesday, May 24, 2016, 10:30 AM - 12:30 PM

## CS-110-01

### Preserving the Health of Tunnelers During Construction. A Case Study of Applying a Program Approach to Occupational Hygiene on Australia's Longest Underground Rail Tunnels: The Sydney Metro Northwest Rail Link

*K. Cole, Ventia, Kingsgrove, NSW, Australia*

**Situation/Problem:** Thiess, John Holland and Dragados were awarded the AUD\$1.15 billion Tunnels and Station Civil (TSC) contract as part of the Sydney Metro Northwest Rail Link for the design and construction of 15 kilometres of twin tunnels; the civil works for new five stations; two services facilities and an onsite precast facility to manufacture the tunnel segments. A risk-based occupational health and hygiene program was developed with the aim of preventing occupational illness and disease in an industry that has been plagued historically with cases of silicosis and other diseases. The TSC works involved tunneling through sandstone containing over 90% quartz. Therefore, controlling exposures to respirable crystalline silica (RCS) was a focal part of developing an effective occupational health and hygiene program.

**Resolution:** Development of the program began with a comprehensive review of learnings from previous tunneling projects; up-front planning and the implementation of engineering controls amongst numerous administrative control measures such as risk-based exposure monitoring. The use of specialised personal protective equipment was also necessary to further reduce exposure.

**Results:** Over the period of 15 months, regular exposure monitoring coupled with the implementation of targeted control measures, demonstrated that exposures reduced over the course of the project. Although the presence of respirable dust and RCS is widespread in underground tunneling, exposure data demonstrated that the risk of exposure to respirable dust was low in comparison to both regulatory and industry standards. High and varied concentrations of quartz in the rock being tunneled, presented ongoing challenges for exposure control to RCS and will likely continue to do so in future tunneling projects in Sydney. Notwithstanding these challenges, RCS exposures were lower than measured on previous tunneling projects which resulted in an improved work environment during the construction of Australia's largest underground rail tunnels.

**Lessons learned:** The risk-based occupational health and hygiene program enabled project teams to understand the risk of exposure across their workforce and enabled targeted application of controls to where they were most effective at reducing exposure. While exposures to RCS were comparable or lower than industry standards, the use of respiratory protection continued to be needed to further reduce exposure to underground workers as an ongoing control measure.

## SR-110-02

### Developing a Comprehensive Manual to Prevent Fatal Incidents in Confined Spaces in South Korea

*T. Kim, Changwon National University, Changwon, Korea (the Republic of); K. Ahn, University of Wisconsin-Whitewater, Whitewater, WI*

**Objective:** In South Korea, 164 incidents in confined spaces resulted in 220 fatalities in the period of 2005-2015. Many of these incidents occurred because safety procedures for working in confined spaces were not followed. The objective of this study is to develop a comprehensive manual that can be used to prevent such fatal incidents.

**Methods:** We analyzed data related to the fatal incidents that occurred in South Korea in the period of 2005-2015 to determine characteristics and causes of the incidents. We also reviewed similar cases and accident prevention programs in other countries, including the U.S., Japan, and the U.K. Computational fluid dynamics (CFD) simulations were used to find proper ventilation methods.

**Results:** The number of fatal incidents and casualties were higher in the months of July and December. Oxygen deficiency (30%), hydrogen sulfide (20%), and carbon monoxide (20%) were the leading causes of the incidents. The incidents occurred in the construction (33%), manufacturing (26%), and service (11%) industry. Various causes of the incidents were identified. Based on the data analysis and benchmarking of the other countries' accident prevention programs, we developed a comprehensive manual that includes safety procedures, preventive measures, and proper ventilation methods for different types of confined spaces. Confined spaces were classified into 6 different types, and proper supply and exhaust ventilation methods were suggested for each.

**Conclusions:** This manual provides necessary information on safety procedures, preventive measures, and proper ventilation methods for different types of confined spaces. It will contribute to the prevention of fatal incidents in confined spaces.

## CS-110-03

### Breathe Freely Initiative in the UK Construction Industry by BOHS

*T. Boyle, British Occupational Hygiene Society, Pride Park, United Kingdom*

**Situation/Problem:** Construction workers in the UK are at high risk of contracting lung disease from the work that they do. In 2015, approximately 3,500 will die from cancer caused by past exposures to asbestos, 500 more from silica dust, another 5,500 will be diagnosed with occupational cancer. Today alone, an unknown but significant number will breathe in the hazardous substances that will one day seriously affect their health or kill them.

**Resolution:** There's a solution: most of these industrial diseases can be prevented by: recognizing the real hazards, evaluating the risks of being exposed to them, and effectively controlling those exposures (also known as good occupational hygiene practice). The goal is to help prevent lung disease in UK construction workers. The British Occupational Hygiene Society (BOHS) decided to take the lead by starting an initiative

directed towards that goal.

**Results:** On Worker Memorial Day, Tuesday 28th April 2015, the Breathe Freely initiative was launched. It was started as a collaborative initiative led by BOHS in partnership with key organisations within the UK construction industry. It provides guidance, tools and resources that facilitate the recognition, evaluation and control of workplace exposures leading to the implementation of a recognised management standard. Targeted specifically at managers and site supervisors within the construction industry, the aim is not just to raise awareness of the problem but also to effect action by providing practical solutions through sharing of best practices and encouraging implementation of effective exposure controls. A website has been set up to provide access to Breathe Freely resources at [www.breathefreely.org.uk](http://www.breathefreely.org.uk). To help spread best practices, we have developed a series of case studies and data sheets. We have 20 fact sheets each highlighting the main hazards, highest risks and preferred control options for all the key construction trades. We've put occupational hygiene into a construction site context so it's clear where and how an occupational hygienist can help. And we have real on-site case studies showing actual situations and solutions.

**Lessons learned:** At the time of the submission the initiative was just 5 months old. By the time of the AIHA Conference it will be over a year old and we will have much more information to share regarding both the program growth and lessons learned.

## CS-110-04

### Many Pieces to the Puzzle: Successful Implementation of Engineering Controls for Dusts & Fumes in Construction

*P. Susi, CPWR, Marlton, NJ*

**Situation/Problem:** Engineering controls are the preferred method for reducing exposure to hazardous agents. However, in the construction industry, use of one principal engineering control, local exhaust ventilation (LEV), is still not commonplace. At the same time, construction workers are routinely exposed to hazardous metal fumes when welding and silica dust associated with numerous work processes.

**Resolution:** We conducted a four-year study which utilized industry participation (from contractors, labor and equipment manufacturers) to identify important engineering control attributes and to select LEV systems for evaluation. Selected LEV systems (three for welding and four for masonry work) were evaluated in a controlled setting. In addition, training on correct use of LEV was developed and piloted. Finally, two case studies (one related to masonry work and the other involving welding) were used to explore factors that contributed to use of LEV in a large municipal area and on a large power plant renovation and maintenance project.

**Results:** LEV for welding fumes varied in performance, but reduced exposure to manganese and hexavalent by at least 50%. LEV systems tested for tuck pointing reduced respirable silica exposures by over 95%. Training impacted LEV performance. A statistically significant reduction in respirable particulate (43%) was measured based on pre-and post-training personal air monitoring.

**Lessons learned:** Implementation of engineering controls is a multi-faceted challenge. The construction industry is

comprised of numerous trades, types of contractors, clients and work environments. Therefore, factors that influence use of LEV will vary. However, for LEV to be successful, training on correct use is generally necessary regardless of the trade or work environment. Knowledge of the health effects of hazardous agents is also of value to give workers some sense of the importance of using LEV. Engaging workers in the selection of LEV increases the likelihood that the system will be viewed as practical and used. OSHA continues to be an important driver for use of LEV by contractors. However, client demand or local environmental regulations may be at least as influential in driving use of LEV on some jobs and in some local areas. At the research level, facilitating communication between workers and equipment manufacturers is essential for improving product design.

## SR-110-05

### Findings from the FACE Reports on Worker Fatalities in Confined Spaces

*K. Ahn and S. Choi, University of Wisconsin-Whitewater, Whitewater, WI; T. Kim, Changwon National University, Changwon, Korea (the Republic of)*

**Objective:** Confined spaces present many potential safety and health hazards, which can cause fatal injuries to workers who enter such spaces. NIOSH and State investigators have reviewed fatal incidents involving confined space entry and rescue efforts as part of the Fatality Assessment and Control Evaluation (FACE) Program since 1982. However, due to the narrative structure of the FACE reports, it is difficult to identify patterns and common causes to prevent similar injuries from reoccurring. The objective of this study is to systematically analyze the findings from the FACE reports and provide practical information that can be used to prevent fatal incidents in confined spaces.

**Methods:** We built a database and analyzed the data for a total of 170 NIOSH FACE and STATE FACE reports in the period of 1984-2012. The variables in this database include industry, type of confined space, hazard, existence of written safety program, existence of entry permit procedure, existence of training, and recommendation items. A total of 683 recommendation items from the FACE reports were extracted.

**Results:** The FACE reports covered fatal incidents in: agriculture (26%), manufacturing (18%), construction (17%), services (15%), public administration (14%), transportation/utilities (6%), and oil/gas industries (3%). Main hazards investigated include engulfment/burial (35%), oxygen deficient air (19%), toxic gases (16%), flammable/explosive substances (6%), drowning (5%), inert gases/asphyxiants (5%), falls (4%), and solvents (4%). Types of confined spaces include: silos/bins (23%), sewers/manholes (16%), trenches (11%), tanks/vessels (9%), vats/pit digesters (8%), utility/service rooms/vaults (7%), transportation tanks (5%), water tanks/pits/vaults (4%), manure pits (4%), wells (4%), and others (9%). The FACE reports show that 87% of fatal cases had no entry permit procedures, 64% had no safety programs in place, and 59% had no training. The top ten recommended items by the investigators were: training (12%), developing and implementing a confined space program (10%), developing and implementing safety program/procedures (9%), enforcement (8%), job hazard analysis/job site survey/inspection (7%), redesign/modification (7%), and warning signs/identification (6%). Confined space hazards, existence of written safety program, existence of entry permit

procedure, existence of training, and FACE recommendations were assessed by each industry and each confined space type.

**Conclusions:** The results from this study can provide industry and confined space specific information on contributing risk factors and practical, effective solutions. It will contribute to the prevention of fatal incidents in confined spaces in the industry.

## CS-110-06

### The New EM385-1-1: Are You Prepared for Compliance?

*P. Rice, ClickSafety/Ahtna Netiye, Walnut Creek, CA*

**Situation/Problem:** For those of us that perform occupational safety and industrial hygiene activities on US. DOD projects the rules are changing, have changed. Are you prepared?

**Resolution:** The revised 2014 Engineering Manual 385-1-1 released by the US Army Core of Engineers (USACOE) is out. Are you prepared for compliance? EM-385 is the U.S. Army Corps of Engineers (USACOE) Engineering Manual 385-1-1, Safety and Health Requirements, which has strict compliance guidelines for contractors performing construction, demolition and alteration work on Department of Defense projects. Compliance with the EM385-1-1 is required by contract specifications in construction contracts throughout Department of Defense, USACOE, Naval Facilities Engineering and Command (NAVFAC) NASA, Veterans Administration, State Department, and U.S. EPA. Key revisions such as training requirements for Site Safety and Health Officers (SSHO) Collateral Duty Safety Officers (CDSO), Accident Prevention Planning (APP) and associated documentation will be discussed.

**Results:** From this presentation, attendees shall be familiar with: the history and background of EM385-1-1, EM385-1-1 manual design and elements, applicable operations that fall under EM385-1-1 requirements, identify key changes of the latest revision, and identify key training requirements for workers and EH&S staff.

**Lessons learned:** IH's must get familiar with EM 385-1-1 if they choose to work on USACE and related (e.g. NAVFAC) activities.

## P0111

### Preparedness and Response to Ebola, and Other Healthcare-Related Issues

Tuesday, May 24, 2016, 10:30 AM - 12:30 PM

## CS-111-01

### Managing the Potential Hazards from Electromagnetic Interference (EMI) with Personal Medical Electronic Devices in Workplaces

*J. Bowman and G. Calvert, CDC/NIOSH, Cincinnati, OH; G. Girard, Medtronic, PLC, Minneapolis, MN; D. Witters, Food and Drug Administration, Rockville, MD*

**Situation/Problem:** Personal Medical Electronic Devices (PMED) such as implanted pacemakers and body-worn insulin pumps can be susceptible to EMI from the high electric and magnetic fields (EMF) in some workplaces. When employees with PMEDs want to work around EMF sources, the available recommendations on preventing EMI, such as the EMF TLVs®, can be difficult to apply. A clearer method is needed to collect and assess the information needed to make sound decisions on assuring the electromagnetic compatibility (EMC) of a PMED with workplace EMF.

**Resolution:** NIOSH initiated a collaboration with PMED experts to develop a strategy for managing and mitigating the EMI risks from lower frequency occupational EMF. The proposed strategy calls for industrial hygienists to collaborate with workers who have PMEDs and their physicians to gather key information on the EMC testing by device manufacturers, worker EMF exposures, and the health consequences of device malfunctions. The goal is an informed decision on whether the employee can work safely at the evaluated worksite. Our strategy includes PMED advisory limits on worksite EMF which we derived from acceptable EMC levels in ISO's PMED standards. When EMF exposures at a worksite exceeds either these advisory limits or a PMED's EMC levels, the device's malfunction risks can be mitigated by engineering and behavioral controls of EMF exposures, or by altering the PMED's settings.

**Results:** The proposed strategy was initially verified with EMF survey data conducted for employees with PMEDs. One example is an electrician with an implanted pacemaker who had been exposed to magnetic fields over 2,000  $\mu\text{T}$  at his tractor manufacturing plant. Under our proposal, he would not be allowed to continue in that job because its exposures exceed NIOSH's 70  $\mu\text{T}$  advisory limits. In another example, a steel worker with an implanted Spinal Cord Stimulator operated a galvanizing line exposing him to 280  $\mu\text{T}$ . Since the device manufacturer reported its EMC level was 264  $\mu\text{T}$ , the line operator might be allowed to work in this site with some restrictions.

**Lessons learned:** Safety decisions on workers with PMEDs are difficult because industrial hygienists and most physicians do not have all the needed expertise. The proposed strategy is based on a new vision of collaboration with PMED workers that can accurately assess their EMI risks and decide the best course for all parties. To improve these procedures, NIOSH will be seeking comments from industrial hygienists and other stakeholders before their publication.

## CS-111-02

### Developing an Effective and Flexible Ebola Preparedness Plan

*M. Tortora, CT Children's Medical Center, Middletown, CT*

**Situation/Problem:** The Ebola epidemic in West Africa made the international news when the first case was discovered in the US in Sept. 2014. The transfer of the virus to two healthcare workers in the Dallas Hospital, where the patient reported, created a frenzy of preparedness activity at all US hospitals in the aftermath. Most hospitals were not prepared to detect, accept and treat a patient with this virus. CT Children's, shortly after the Dallas Hospital incident, needed to get up to speed to effectively screen, accept and treat a patient with Ebola, while keeping all staff safe.

**Resolution:** A large, multi-disciplined group of individuals met shortly after the Dallas exposure and formed an Ebola Task Force committee. This committee was tasked to quickly prepare the hospital to screen, accept and treat a patient with Ebola. This group took on the form of a sub-committee of the hospital emergency operations committee (HEOP). The committee was tasked with the following activities: development of screening of all individuals entering the hospital, procedures for isolating an individual with positive travel history, training of staff in use of proper PPE and procedures for safely donning and doffing and planning exercises, practicing all aspects of caring for a patient with Ebola. This resulted in the development of the Ebola Preparedness Plan.

**Results:** The effectiveness of the program was measured by conducting several mock exercises at the main hospital as well as off-site clinics, and testing the overall incident command system during an event where an affected patient enters the hospital. Effective critiquing of the overall operations helped to develop the program successfully, instill confidence in hospital staff that we would be able to care for a patient safely and enhance our hospital emergency operations plan and incident command response.

**Lessons learned:** Lessons learned are how important it is to have supplies on hand (PPE, cleaning, etc...) due to the equipment shortages during the crisis, how quickly individuals become engaged in the planning and then exit the process as well as how complex it is to put together a response team to safely care for a patient with Ebola virus. This plan can be adjusted for any future emerging infectious disease.

## CS-111-03

### Ebola Virus Disease Waste Management in the Medical Treatment Facility

*L. Baetz, Army Public Health Center (Provisional), APG, MD*

**Situation/Problem:** In 2014, Army Public Health Center (Provisional) responded to a query concerning the Army's waste management plan for the Ebola patient treatment. The two medical waste incinerators at Fort Detrick are the Army's only permitted medical waste incinerators. According to their permit, they cannot accept waste from off-site sources.

**Resolution:** The Army's waste plan for the controlled monitoring sites includes handling all waste as routine solid waste which will be disposed of through installation channels. All waste from the treatment of EVD patients, will be collected and stored separately, packaged into approved-category A drums and transported for treatment and disposal by the existing MEDCOM-wide contract for medical waste disposal.

**Results:** An EVD waste management Standard Operating Procedure has been developed for managing waste and has been distributed to all Army MTFs to develop their MTF site-specific plans.

**Lessons learned:** The Army needed to develop guidance for handling waste generated in the care for patients under investigation (PUIs) for Ebola virus disease (EVD) or with confirmed cases of EVD.

## CS-111-04

### U.S. Army Medical Research Institute of Infectious Diseases Support in the Ebola Effort

*N. Woollen, Army Medical Research and Materiel Command, Ft Detrick, MD*

**Situation/Problem:** U.S. Army Medical Research Institute of Infectious Diseases played a significant role in assisting the Ebola virus outbreak response in West Africa (on-site laboratory support, diagnostic tools, drug and vaccine research, and biomarkers).

**Resolution:** Collaboration allows USAMRIID to bring their expertise to bear in responding to an international health crisis.

**Results:** From on-site laboratory support in Liberia, to training of key personnel, to accelerated research efforts on diagnostic, vaccine and treatment approaches. In addition to providing laboratory testing and training support for the outbreak, USAMRIID provided more than 10,000 Ebola laboratory tests to support laboratory capabilities in Liberia and Sierra Leone.

**Lessons learned:** A well-coordinated multiagency response was needed to provide an effective rapid response.

## SR-111-05

### Acute Symptoms and Exposure to Hydrogen Peroxide, Acetic Acid and Peracetic Acid in Hospital Cleaning Staff

*B. Hawley, M. Casey, M. Virji, and J. Cox-Ganser, Respiratory Health Division, CDC/NIOSH, Morgantown, WV*

**Objective:** Peracetic acid (PAA) is widely used as a disinfectant in healthcare and food production settings, however, occupational PAA exposures have been largely overlooked due to: (1) previous sampling and analytical method limitations and (2) the absence of a current OSHA Permissible Exposure Limit (PEL) or NIOSH Recommended Exposure Limit (REL). In the summer of 2015, NIOSH performed an industrial hygiene survey at a hospital where a new cleaning and disinfectant product, consisting of hydrogen peroxide (HP), acetic acid (AA) and PAA. HP and PAA are strong oxidants and their mixture is listed as an asthmagen and sensitizer by the Association of Occupational and Environmental Clinics. However, few exposure assessment studies to date have measured HP and PAA in a healthcare setting.

**Methods:** In July and September of 2015, a health and environmental assessment survey was conducted at the hospital. We collected 50 full-shift air samples (41 personal and 9 area samples) and analyzed for HP, AA, and PAA content. We also observed hospital staff performing cleaning duties and noted duration and frequency of cleaning product use. Acute irritation and respiratory symptoms were recorded in a post-shift survey (n = 50). Exposure factors associated with airway symptoms were used to develop recommendations to mitigate potential health risks due to cleaning product exposure.

**Results:** Partial air sampling results from our July survey ranged from 15-94 ppb for HP, 68-155 ppb for AA and 5-21 ppb for PAA; all measurements for HP and AA were below their respective OSHA PEL or NIOSH REL. Mucus membrane irritation symptoms were reported by 64% (n=32/50) of workers

and 84% (n=27/32) reported symptom onset while cleaning. Lower airway symptoms such as cough, wheeze, chest tightness, shortness of breath or difficulty breathing were reported in 34% (n=17/50) of workers, of which, 88% (n=15/17) reported symptom onset during cleaning activities and 82% (n=14/17) worked in areas with high cleaning product use.

**Conclusions:** Hospital workers using a disinfecting product containing HP, AA and PAA reported work onset airway symptoms despite low levels of measured exposures. Because both HP and PAA are strong oxidants, it is plausible that the mixture of HP and PAA likely contributed to the airway symptoms reported by workers despite low levels of exposure.

## SR-111-06

### Effect of Multiple Alcohol-Based Hand Rub Treatments on Tensile Strength and Elongation of Thirteen Brands of Medical Exam Nitrile and Latex Gloves

*P. Gao, G. Niezgodna, and R. Shaffer, CDC/NIOSH, Pittsburgh, PA; M. Horvatin and R. Weible, URS Corporation, Aiken, SC*

**Objective:** Current CDC guidance for the disinfection of gloved hands during personal protective equipment doffing following care of a patient with Ebola allows for multiple applications of alcohol-based hand rub (ABHR) on medical exam gloves. The purpose of this study was to evaluate the effect of ABHR treatments on glove integrity based on changes in tensile properties.

**Methods:** Thirteen brands of medical exam gloves (8 brands of nitrile and 5 brands of latex from 5 manufacturers), and two different ABHRs containing 70% ethanol and 63% isopropanol, respectively, were included in this study. For each brand, 140 gloves were tested. Thicknesses of the new gloves measured in the palm areas ranged from 0.129 to 0.226 mm among 700 latex gloves and 0.057 to 0.143 mm among 1120 nitrile gloves. A pair of gloves were worn by a test operator and outside surfaces of the gloves were treated with either ABHR for 1 to 6 treatments. Ultimate tensile strength and elongation of the gloves without ABHR treatment and after 1 to 6 treatments were measured based on ASTM D412 standard method by using an Instron Universal Testing Machine with a 500N load cell. Ten replicates were performed and analysis of variance was used for statistical comparison.

**Results:** Compared to gloves without ABHR treatment, mean tensile strength of the 5 brands of latex gloves decreased 4.3% (p > 0.05) after 6 ABHR treatments using ethanol-based hand rub (EBHR) and 18% (p < 0.05) using isopropanol-based hand rub (IBHR). Mean elongation increased 2% (p > 0.05) and decreased 2% (p > 0.05) after 6 treatments using EBHR and IBHR, respectively. For the 8 brands of nitrile gloves after 6 treatments, mean tensile strength decreased 26% (p < 0.05) using EBHR and 36% using IBHR (p < 0.05). Mean elongation increased 1.7% (p > 0.05) using EBHR and 4.8% (p < 0.05) using IBHR after 6 treatments. It appeared that changes in the tensile properties increased with each ABHR application. For instance, mean decreases of the tensile strength for the nitrile gloves after 3 and 4 EBHR treatments were 14% and 18% respectively.

**Conclusions:** The preliminary results indicate that ABHRs had more effect on tensile strength of the tested nitrile than latex gloves. In general, EBHR resulted in lesser changes in tensile strength compared to IBHR. Nevertheless, after up

to 6 treatments all tested gloves still met NFPA 1999 glove requirements for tensile strength  $\geq$  14 MPa and elongation  $\geq$  500%, except for two brands of relatively thin gloves (0.059 and 0.087 mm), 15% of the 13 brands tested.

## PS404

### Poster Session 404

Tuesday, May 24, 2016, 1:00 PM - 3:00 PM

## SR-404-01

### Time Trends in Formaldehyde Emissions from Laminate Flooring Products After Installation

*P. Ruestow, J. Lotter, A. Abelmann, H. Fritz, E. Beckett, and J. Pierce, Cardno, Chicago, IL; K. Unice and J. Bare, Cardno, Pittsburgh, PA*

**Objective:** To address recent concerns surrounding formaldehyde emissions from Chinese-made laminated flooring products, we evaluated time trends in airborne formaldehyde concentration following the installation of two flooring products in a real-world office setting.

**Methods:** Two types of laminate flooring products from a single retailer were installed in two separate rooms with similar ventilation in an office building. After installation, a total of 24 passive 24-hour samples were collected from each room over the course of 35 days using diffusive badge samplers. Expected time to steady-state in each room was estimated using results from experimental small chamber testing, room volume, and room airflow rates, assuming a constant emission rate and no adsorptive sinks. Room concentrations would be expected to remain constant after reaching steady-state. A repeated measures, mixed effects analysis was conducted. Repeated samples were defined according to sampler location in the room, and these sampler locations were assumed to be clustered by room. Mixed modeling techniques were used to investigate trends over time during the post-installation period and during the expected steady-state time period.

**Results:** The overall average 24-hour formaldehyde concentrations following the installation of the laminate flooring were 0.038 ppm (range: 0.020 - 0.058 ppm) in Room 1 and 0.022 ppm (range: 0.013 - 0.039 ppm) in Room 2, both statistically higher than their respective background concentrations. The average formaldehyde concentrations in both rooms increased with time after installation and did not appear to plateau during the post-installation study period, after accounting for correlations and clustering among samples. The amount of time required for 24-hour average concentrations to reach steady-state under ideal conditions was estimated to be 2 days or less. Time was significantly associated with concentration during the entire post-installation period ( $p < 0.001$ ) and during the expected steady-state period ( $p < 0.001$ ).

**Conclusions:** This time trend analysis indicated that steady-state was not reached during the study period, possibly due to room sinks (e.g., wall board, ceiling tiles) or changes in the source emission rate. Further study is necessary to understand

why emission trends might differ between experimental and real-world settings.

## SR-404-02

### Evaluation of Diurnal Variations in Formaldehyde Concentrations Following Installation of Laminate Flooring Using Real-Time Sampling

*H. Fritz, J. Lotter, A. Abelmann, P. Ruestow, E. Beckett, and J. Pierce, Cardno ChemRisk, Chicago, IL; K. Unice and J. Bare, Cardno ChemRisk, Pittsburgh, PA*

**Objective:** It is well known that certain building materials may release formaldehyde for some time following installation, but limited data exist regarding the variation in air concentrations as a function of room characteristics, such as ventilation rates. Therefore, a study was conducted to evaluate the concentration of formaldehyde following the installation of laminate flooring under varying ventilation conditions.

**Methods:** Laminate flooring was installed in a 27.62 m<sup>3</sup> room that was equipped with an air exhaust outlet, but no air supply inlet and contained painted drywall wall, drop ceiling tiles, and no furniture. Following installation, real-time airborne measurements of formaldehyde were collected during weekdays for five weeks using a portable direct read formaldehyde analyzer and were logged every 5 min. The ventilation rate in the study room was evaluated during daytime, when the ventilation system was in operation, and nighttime, when the system was not in operation. The overall diurnal trend in formaldehyde concentrations was evaluated and the concentrations measured during periods in which the ventilation system was in operation were compared to periods without ventilation.

**Results:** The air exchange rates were 5.1 hr<sup>-1</sup> and 0.52 hr<sup>-1</sup> when the ventilation system was and was not in operation, respectively. The higher daytime ventilation rate was consistent with rates reported for well-ventilated office buildings, whereas the lower rate was likely representative of a residential dwelling without mechanical ventilation. As expected, formaldehyde levels increased in the nighttime (average: 0.019 ppm; range: 0.008 - 0.056 ppm) and decreased during the daytime (average: 0.012 ppm; range: 0.007 - 0.023 ppm). The average nighttime concentration was about 1.6-fold higher than the previous daytime concentrations, despite the nearly 10-fold lower nighttime ventilation rate.

**Conclusions:** Within a given 24-hr sampling period, formaldehyde concentrations increased as ventilation rate decreased, though the relative increase was less than expected based on the difference in ventilation rate. These results indicate that factors other than ventilation affect the room concentrations. Further, these results suggest that persons living or working in a room without mechanical ventilation may experience higher concentrations of formaldehyde following the installation of laminate flooring.

## SR-404-03

### Studies of the Nicotine Personal Sampler Using PUF Media and That Simple Analysis

*Y. Suzuki and T. Enomoto, SIBATA Science Technology Ltd., Saitama, Japan; Y. Yanagisawa, Tokyo Univ., Tokyo, Japan; M. Noguchi, Seikei Univ., Musasino, Japan*

**Objective:** We improve a sampler system for the atmospheric Nicotine measurement that we reported in AIHA2015, and the low-concentrated measurement is enabled last time. Furthermore, we examine analysis technique and can measure nicotine in the general-purpose analytical instrument sensitively. It was in this way intended to enable the measurement to evaluate the atmospheric nicotine concentration that WHO suggested.

**Methods:** We used the Semi-Active sampler which we reported in AIHA2014 in this study. On the occasion of nicotine sampling, reexamined technique to adsorb to PUF (Poly-Urethane Form). The alkaloids-based chemical substances such as nicotine show stabilization in an acid condition. Therefore, we decided to perform acid treatment of PUF. Assumed this acid impregnation PUF an adsorbent and carried out the recovery measurement when we used the sampler. In addition, for the samples obtained for this sampler, we went a storage test of up to one week. About the examination of the analysis technique, we improved sensitivity by making the separation with the gas chromatograph better.

**Results:** Collecting efficiency showed approximately 600ml/min in this revised method. As a result, became able to evaluate nicotine concentration of 0.1-1  $\mu\text{g}/\text{m}^3$  that was the concentration that WHO guidelines required in sampling for 24 hours by this technique. we were able to confirm that we held nicotine which sampled by refrigerating a sample after the atmosphere sampling, and keeping it by 90% on PUF.

**Conclusions:** This technique was able to enable the measurement of atmospheric nicotine in the low concentration by using acid impregnation PUF adsorbent. In addition, it is thought that PUF absorbs particle-formed nicotine unless it is gaseous. We suppose that this technique can fit the measurement in the air such as semi volatile organic compounds (SVOCs) from this thing.

## CS-404-04

### Evaluation of the Stretch-Effect by the Psychosocial Stress of Workers in Small Workplaces

*S. Lee, S. Lim, S. Lee, and S. Cho, Gyeonggi Dongbu Workers' Health Center, Seongnam-si, Korea (the Republic of); J. Koo, The Catholic University in Korea, Seoul, Korea (the Republic of)*

**Situation/Problem:** This study aimed to understand the relationship between psychosocial stress levels and alterations of musculoskeletal pain perception levels after stretching treatment program in 210 workers of small workplaces with less than 50 workers.

**Resolution:** Subjects were evaluated with visual analog scale(VAS), psychosocial well-being index short form(PWI-SF), and cardiovascular disease risk factors before and after a 4 week long stretching treatment programs customized for pain

regions of each subject.

**Results:** 1. Psychosocial stress levels were evaluated in 73 subjects among 210 workers participated in this study. Twenty subjects (27.4%) were in a high-risk group of psychosocial stress with high PWI-SF values being greater than 27 while the other 53 subjects (72.6%) showed normal stress levels. 2. Subject were classified into subgroups according to body parts with musculoskeletal pain. and the shoulder was abundant pain region in 20 subjects (27.4%) followed by the lower back in 47 subjects (22.4%) and the neck in 37 subjects (17.6%). After the stretching treatment program for 4weeks, levels of musculoskeletal pain perception were significantly reduced while the VAS decreased from 4.34( $\pm$ 2.34) to 2.36( $\pm$ 1.94) after the program( $p < 0.0001$ ). 3. The VAS results prior to the stretching treatment program have been analyzed in 210 subjects and have shown a significant difference of VAS values between office and production workers( $p < 0.041$ ). 4. Statistics showed that there was no significant correlation between psychosocial stress measured with PWI-SF and musculoskeletal pain perception measured with VAS in 73 participated subjects. 5. Levels of musculoskeletal pain perception were compared in 31 subjects of both normal and high-risk psychosocial stress groups before and after the stretching treatment program of 4 weeks. Musculoskeletal pain perception measured with VAS were significantly reduced after the stretching program in the normal psychosocial stress group( $p < 0.006$ ) whereas the high-risk group showed no significant changes of VAS( $p < 0.153$ ).

**Lessons learned:** Taken all together, these data demonstrate that the 4-week long stretching treatment program was overall beneficial for subjects with musculoskeletal pain. In association with the level of psychosocial stress level, however, the stretching treatment program was effective in the normal stress group but not in the high-risk stress group. Therefore, additional interventions would be required to alleviate musculoskeletal pain in small workplaces workers with a high-risk psychosocial stress level.

## SR-404-05

### Pilot Study: Antineoplastic Drug Contamination of Surfaces at a Long-Term Care Facility

*C. Hon, Ryerson University, Toronto, ON, Canada; E. Jelley, University of Toronto, Toronto, ON, Canada; P. Demers, Occupational Cancer Research Centre, Toronto, ON, Canada*

**Objective:** Occupational exposure to antineoplastic drugs is associated with genetic damage, reproductive toxicities and an increased risk of cancer. Healthcare workers' exposure to these agents is believed to be mainly through dermal contact. As such, a work surface or object with antineoplastic drug contamination is a potential source of exposure. To date, antineoplastic drug contamination of surfaces has been detected in every publication performed within acute care facilities. However, these agents are also handled and administered in long-term care facilities and this study sought to ascertain drug surface contamination levels within such a facility in Toronto, Canada.

**Methods:** Site observations were performed to identify those surfaces most frequently contacted by nurses who handle antineoplastic drugs. These surfaces, distributed over two floors of the facility, were then wiped and the amount

of methotrexate, a common antineoplastic drug used in this facility, was quantified using ultra-performance liquid chromatography tandem mass spectrometry (UPLC-MS-MS) technology. The limit of detection was 0.05 ng/mL (0.001 ng/cm<sup>2</sup>).

**Results:** Twenty-two work surfaces/objects were sampled within the facility and none had detectable levels of methotrexate (i.e. all samples less than 0.001 ng/cm<sup>2</sup>).

**Conclusions:** From an occupational health and safety perspective, the results are reassuring. However, they should be treated with caution as this was a pilot study and several factors may have influenced the findings including, but not limited to, lower patient dose, infrequent drug administration, and medication in tablet form. All three of these parameters differ from acute care settings.

## SR-404-06

### Characterization of Emissions from 3-Dimensional Printing Operations: A Literature Review and Sampling Framework for Future Evaluations

*R. Zisook and B. Simmons, Cardno ChemRisk, San Francisco, CA*

**Objective:** The use of three dimensional (3D) printers in commercial and industrial settings is increasing. However, few studies have been conducted to characterize potential human and environmental health hazards associated with their use. The objectives of this research are to provide a synthesis of the existing information, identify data gaps, and to provide a framework for evaluating potential hazards that have not been well characterized.

**Methods:** A review of the literature on 3D printing emissions and breakdown products of common feedstock materials was conducted. For 3D printer types and feedstock materials that have not been characterized in the literature, a review of safety data sheets (SDS) was performed.

**Results:** Although limited, emissions data are available for fused deposition modeling (FDM), multi-jet modeling (MJM), and stereolithography (SLA) 3D printer types. Feedstock materials evaluated include thermoplastics (acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA)) and acrylic photopolymers/resins. Existing studies have measured: particle number, mass, and size distribution; VOCs (including styrene, a known asthmagen); and ozone (not detected). Differences in emissions were observed between feedstock and printer types. For example, styrene concentrations ranged from <LOD (PLA) to 66 ppb (ABS), and total VOC concentrations ranged from <1 ppm (FDM, MJM, SLA) to 15.1 ppm (MJM). When applicable, data were converted to potential worker exposure levels and compared to OELs. These levels were found to be below OELs; however, significant data gaps exist (e.g., individual VOCs were not measured for MJM). FDM printers were characterized as being high emitters of ultrafine particles (particle emissions were reported to be above background levels). However, particle characterization analyses have not been performed. In one study, cleaning of polymeric products was found to result in the highest potential for worker exposure. Some SDS sheets report skin sensitization hazards.

**Conclusions:** Emissions during 3D printing operations vary depending on feedstock composition, printer type, and other

factors. The available data are limited and are not directly comparable. Future studies should evaluate: individual VOC concentrations, particle count/characterization, task based sampling of post-processing activities (e.g., cleaning), and the effectiveness of control measures. Additional printer types and feedstock materials (e.g., nylon/metal powder) should also be evaluated.

## SR-404-07

### Female Maximum Acceptable Peak Force for Pulp Pinch Insertion Task in Taiwan

*A. Chen and E. Lo, Department of Occupational Safety and Health, China Medical University, Taichung City, Taiwan*

**Objective:** The Occupational Safety and Health Act, enacted on July 3<sup>rd</sup>, 2014, has been issued by the Ministry of Labor, Republic of China (Taiwan). A guideline with several checklists to assess the risk of developing the work-related musculoskeletal disorders has also been proposed for a later date. However, these checklists mainly were designed and used to assess the risk in the Western countries, which may or may not be suitable in Taiwan. This methodology has been used in the development of guidelines for manual materials handling, and similar methods were applied to repetitive upper limb movements recently. The purpose of this study is to investigate the maximum acceptable force with middle and high duty cycles for pulp pinch task for females in Taiwan.

**Methods:** Eighteen females will be recruited to perform a simulated pulp pinch insertion task. There are 6 subjects in one of three age groups (20-30, 31-45, 45+). The independent variables are insertion frequency (15 and 20/min), duty cycle (50%, 65%, and 80%) and hour of day (hours 1-7). Each subject will be trained for 11 hours with each combined condition. Subjects are asked to exert force as hard as they can at the test frequency and duty cycle combinations for full 8-hour workday without developing any discomfort, injury or fatigue in the upper limb. For each trial, the dependent variables are maximum acceptable peak force and symptom rate. The wrist is in neutral position when performing the pulp pinch task.

**Results:** We expect to find out that the maximum acceptable peak force for females in Taiwan should be significantly less than the force reported from studies in U.S. The maximum acceptable peak force is decreased when the age, frequency and duty cycle are increased. The symptoms of soreness, stiffness and numbness are increased as the day progressed.

**Conclusions:** Based on aforementioned results, this study will contribute to our understanding of difference of the maximum acceptable force for pulp pinch insertion task between Taiwanese and working population in western countries. Furthermore, the results of this study can be used to see if it is necessary to make modification when applying these checklists to assess the risks of development of work-related musculoskeletal disorders.

## SR-404-08

### Risk-Based Evaluation of the OSHA Oil and Gas Benzene PEL

*A. Duane, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO*

**Objective:** Recent NIOSH studies have shed light on high levels of employee exposures to benzene experienced during

tank gauging activities in flowback operations at oil and gas production sites. Utilizing these studies and other recent benzene exposure information, we wanted to estimate the number of current oil and gas industry employees expected to contract a benzene related illness. Additionally, we wished to determine the excess risk to employees exposed at the oil and gas industry benzene PEL of 10 ppm in comparison to other commonly used exposure limits.

**Methods:** Using the recent exposure assessments, the excess risk for developing leukemia for the exposed population was calculated following the risk assessment strategies published by the National Research Council. Unit risk data was taken from the EPA's report on the carcinogenic effects of benzene. Excess risk calculations were also performed using the oil and gas industry PEL, the general industry PEL, and the NIOSH REL to demonstrate the effectiveness of protection at each limit.

**Results:** Risk for developing leukemia for an employee working 40 hours per week for 10 years exposed at 10 ppm (oil and gas PEL) is 1 in 110; at 1 ppm (general industry PEL) the risk is 1 in 1,100; and at 0.1 (NIOSH REL) the risk is 1 in 11,000. Based on U.S. Bureau of Labor Statistics information, exposure at 10 ppm for production level employees could lead to almost 1,000 excess cases of leukemia.

**Conclusions:** The current oil and gas industry benzene PEL is not sufficiently low to adequately protect workers. The findings demonstrate that compliance with the regulations does not necessarily ensure protection from illness. In many cases, a risk-based approach to evaluating exposures is more effective in communicating a need for additional controls or protective equipment than a direct comparison to exposure limits.

## SR-404-09

### An Analysis of OSHA Violations: Occupational Exposures to Benzene

*P. Williams, E Risk Sciences, LLP, Boulder, CO*

**Objective:** The purpose of this investigation was to characterize the number and type of OSHA Benzene Standard violations and corresponding violations of OSHA's Hazard Communication Standard (HCS). These data, which have not been previously reported or analyzed, may be of interest to industrial hygiene professionals involved in benzene risk assessment, risk management, or public policy issues.

**Methods:** OSHA violation and inspection data collected since the 1970s were obtained from the Department of Labor enforcement website. A total of 938 violations of the benzene standard were identified and analyzed. Over 550,000 HCS violations were also evaluated.

**Results:** The number of benzene standard violations were found to vary by time period, standard provision, industry sector, and other factors. Approximately 70% of violations occurred during the late 1980s to early/mid-1990s, soon after the 1987 final benzene rule was promulgated. The majority of violations pertained to noncompliance with the following provisions: exposure monitoring (37%), communication of hazards (23%), respiratory protection (10%), and medical surveillance (9%). However, only 200 HCS violations were attributed to potential benzene hazards in the workplace. Approximately 55% of benzene standard violations were issued to industries in the manufacturing sector, particularly

those where benzene products may be used or produced (e.g., petroleum refining). The greatest percentage of violations were issued to private facility owners (90%), during inspections where union representation was present (56%), and from complaint-driven inspections (45%). Most violations involved a single instance per facility and 10 or fewer exposed employees, with initial penalties under \$5,000 per violation. Many of these latter findings are consistent with OSHA inspection priorities and OSH Act stipulations.

**Conclusions:** Fewer than 1,000 violations of the benzene standard have been issued over the last 25+ years, compared to >80,000 violations for some other regulated substances (e.g., lead). Study limitations include a lack of information on database quality and completeness or inspections that did not result in a violation. Despite potential limitations, these data contain the best available information for assessing historical or current OSHA violations in the workplace.

## CS-404-10

### Vibration Safety Assessment When Operating a Concrete Vibrator

*J. Riddar and J. Karlsson, Faculty of Medicine, Lund University, Lund, Sweden*

**Situation/Problem:** High frequency internal vibrators are used to compact concrete by removing air. The vibrators consist of a motor connected to a flexible shaft casing with a wire core and a vibrating head on the other end of the shaft. The vibrators are divided in two main categories, vibrators with handle with lengths of 1 - 1.5 m that are used for floors and ceilings and vibrators with lengths of 5 - 8 m, without handle, that are used for casting of walls. The objective was to measure the vibration levels during casting of concrete to determine the risks the concrete workers face and what actions can be taken.

**Resolution:** The equipment used was a vibration instrument Norsonic NOR 136 with three-axle ICP accelerometer NOR 1287. Nine short vibrators were measured at the handles during casting of concrete. Six long wall vibrators were measured, three in field tests when casting concrete and three in controlled testes. In the field tests the vibrators were measured at 0.5 m from the beginning of the, the middle and 0.5-0.25 m from the vibrating head. The controlled tests were performed with 0.1 m distance from the vibrating head continuing up to 1.50 m with the vibrator dipped in a 1000 L tank with water. One of the field tests was performed with the same distances up to 1.3 m with the vibrator immersed in sand.

**Results:** Vibrators with handle had an average vibration level of 1.8 m/s<sup>2</sup> (RSD 21 %). For wall vibrators the vibration levels were on average 1.6 m/s<sup>2</sup> (RSD 21 %) until 1.5 m from the vibrating head. Closer then 1.5 m and the vibration levels increased exponential with the distance; 1.5 m = 2.5 m/s<sup>2</sup> (RSD 17 %); 1.0 m = 7.6 m/s<sup>2</sup> (RSD 30 %); 0.6 m = 16.0 m/s<sup>2</sup> (RSD 41 %); 0.3 m = 30.9 m/s<sup>2</sup> (RSD 32 %); 0.1 m = 51.9 m/s<sup>2</sup> (RSD 27 %) The tests performed in water were on average 2 times higher than the tests in concrete/sand.

**Lessons learned:** The hand arm vibrations for the vibrators with handles were below the EU action threshold of 2.5 m/s<sup>2</sup>. To avoid damaging vibrations when operating a wall vibrator, the hand grip should not be closer then 1.0 meter from the vibrating head and if possible that distance would be 1.5 m. Farther than 1.5 m from the vibrating head, the vibration levels are below the EU action threshold. We strongly recommend

that the operator change to a shorter vibrator with a handle when reaching the top layer during wall casting.

## SR-404-11

### Organophosphate Exposure and Depression in U.S. Air Force Aircraft Maintainers

*J. Hardos and D. Ott, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH; L. Whitehead, I. Han, and D. Waller, University of Texas School of Public Health, Houston, TX*

**Objective:** Previous studies found that aircraft maintenance workers may be exposed to organophosphates in hydraulic fluid and engine oil. Studies have also illustrated a link between long-term low level organophosphate pesticide exposure and depression. The aim of this study was to measure association between self-reported workplace exposure to hydraulic fluid and engine oil and major depressive disorder.

**Methods:** A questionnaire containing the Patient Health Questionnaire 8 depression screener was emailed to 52,080 aircraft maintenance workers (with n=4,801 complete responses) to determine depression prevalence, severity, and descriptions of their occupational exposures. Based on a record review of workplace duties and authorized chemical usage, workers were separated into four similar exposure groups (SEGs)—propulsion, hydraulics, crew chiefs, and other workers.

**Results:** There was no significant difference between reported depression prevalence or severity in SEGs in which aircraft maintenance workers were exposed or may have been exposed to organophosphate esters compared to SEGs in which they were not exposed to them. However, a dichotomous measure of the prevalence of depression was significantly associated with self-reported exposure levels and with each exposure route (contact, inhalation, and ingestion). A four-level measure of depression severity was also associated with self-reported four-level categorical exposure.

**Conclusions:** Based on self-reported exposures and outcomes, we cannot assume that the associations we observed are causal because some workers may have been more likely to report exposure to organophosphate esters and also more likely to report depression. Future studies should consider using a larger sample size, better methods for characterizing SEGs, methods for quantifying ingestion exposure, and bioassays to measure dose rather than exposure.

## SR-404-12

### An Updated Evaluation of Reported Chrysotile Asbestos: No Observed Adverse Effect Levels (NOAELs) For Lung Cancer and Mesothelioma

*J. Pierce and P. Ruestow, Cardno ChemRisk, Chicago, IL; B. Finley, Cardno ChemRisk, New York City, NY*

**Objective:** Historically, Chrysotile asbestos was used in thousands of products in the U.S. and is still used today in many countries. Therefore, it is important to understand the exposure response relationship between chrysotile and asbestos-related health effects. The purpose of this evaluation was to update an analysis published in 2008 in

which we characterized chrysotile NOAELs for lung cancer and mesothelioma.

**Methods:** A literature search was performed to identify all epidemiology studies that described the health experience of cohorts predominantly exposed to chrysotile (< 10% amphiboles). All studies that provided risk estimates for mesothelioma or lung cancer, stratified by at least two levels of cumulative exposure, were included in our analysis. For each study, the NOAEL was defined as the highest exposure group at and below which there was no statistically significant increased risk for lung cancer and/or mesothelioma. An overall best estimate NOAEL range was estimated for each disease using the geometric mean of the lower-bound and upper-bound of the range of the NOAELs derived from each study.

**Results:** Sixteen lung cancer NOAELs were obtained from 14 published studies. The best estimates of the lower- and upper-bound of the NOAELs for lung cancer were 89 fibers per cubic centimeter per year (f/cc-yr.) and 168 f/cc-yr., respectively. Notably, none of the six cohorts of workers primarily exposed to medium or short fiber chrysotile exhibited an increased risk of lung cancer at any cumulative exposure level. Three cohorts were identified in which pleural mesothelioma risk was stratified according to cumulative chrysotile exposure. The best-estimates of the lower- and upper-bound of the NOAELs for pleural mesothelioma were 208 f/cc-yr. and 415 f/cc-yr., respectively.

**Conclusions:** This updated review reinforces our previous findings that support the existence of a cumulative exposure level for chrysotile below which lung cancer and mesothelioma risks are not appreciably raised.

## CS-404-13

### Improving Safety Eyewear Fit for the US Workforce

*G. Judd, J. Oh, and C. Lungu, University of Alabama at Birmingham, Birmingham, AL; P. Joe, UAB, Augusta, GA;*

**Situation/Problem:** Safety glasses or eyewear are critical to protecting the eyes and vision of countless employees in the workplace. Safety glasses protect users from hazards such as flying objects, dust and particulate matter, and thermal energy. The protective eyewear needs to fit well and be worn consistently in order to provide adequate protection for the user. However, ill-fitting safety glasses are a common problem. The current size offerings of safety glasses do not afford protection to all the different face shapes found in the workforce.

**Resolution:** In 2003, NIOSH conducted a nationwide anthropometric survey of nearly four thousand subjects. The subjects' facial features were measured using surface scans and traditional anthropometric techniques. These measurements were utilized to create five symmetric headforms that represent the facial size and shape distribution of current U.S. respirator users. The NIOSH headforms can be used to improve the fit of safety glasses by adapting safety glasses size dimensions to the shape of the headforms. Key dimensions such as temple width, earpiece length, and nose bridge height were extracted from each of the headforms and incorporated into new designs of safety glasses. Five prototype safety glasses were modeled to match the features of the NIOSH headforms and the prototypes were then manufactured using stereolithography.

**Results:** Full scale physical models of the five NIOSH headforms with a silicone, skin-like outer layer were used to evaluate the prototype safety glasses. Temple width, earpiece length, and nose bridge dimensions were refined in each prototype to ensure an optimal fit with the headforms. Once final prototypes were manufactured via stereolithography, each prototype was again placed on its corresponding physical model and evaluated. The final prototype safety glasses precisely matched the headforms in temple width, earpiece length, and nose placement and breadth. Photographs were taken to demonstrate the precise fit between the prototypes and headforms.

**Lessons learned:** The prototype safety glasses were shown to have a superior fit compared to the commercially available safety glasses. The next step in this work will be conducting a small scale trial that will evaluate eyewear fit on a diverse sample population of safety eyewear users.

## SR-404-14

### Measurements of Bisphenol A in Household Dusts in Taiwan by Solid-Phase Microextraction

*C. Chang, F. Hsu, Y. Hsu, P. Chang, and S. Tsai, National Taiwan University, Taipei, Taiwan*

**Objective:** Indoor dust has been known as a sink for many semi-volatile organic compounds, such as bisphenol A (BPA). Since the indoor environment can protect dust from sunlight, rain and biological degradation, pollutants could become persistent and accumulate in the residential environment. Up to now, the analysis of BPA in dust is solvent and time consuming. Therefore, a method for the measurement of BPA in dusts simultaneously by using microwave assisted direct immersion solid-phase micro extraction (MAE-DI-SPME) has been developed to determine the distributions in Taiwan.

**Methods:** In this study, a commercial vacuum cleaner was used to collect household dusts while particles with diameter smaller than 150 $\mu$ m were filtered out by stainless mesh. Afterwards, 0.02g dust sample was spiked with 2.5  $\mu$ g/g of surrogate (bisphenol A d-16) in a 4mL vial and stood for overnight. RO water of 2.5mL was added into the sample the next day, followed by the filtration and MAE-DI-SPME extraction procedures. Gas chromatograph and mass spectrometer (GC/MS) was employed for the analysis. Several parameters affecting the SPME extraction efficiency were optimized.

**Results:** The results showed that the desorption efficiency was 100% when the desorption time was 20 min under 250 degrees Celsius. The best suitable fiber coating was 65 $\mu$ m Polyethylene Glycol (PEG) and the optimum condition of MAE-DI-SPME for extraction of BPA in dust was 20 minutes at 80 degrees Celsius. The linear range for the analysis was 1.25 ~ 1250 ng/g dust ( $r=0.99$ ). For indoor dust samples in Taiwan, the median, mean and range of BPA concentrations were 4.98, 11.06 and 1.54~39.99  $\mu$ g/g, respectively.

**Conclusions:** Relatively to headspace extraction, the established method of MAE-DI-SPME for the determination of bisphenol A in indoor dust provides good linearity and precisions. Besides, compared with traditional extraction methods, the MAE-DI-SPME provides a time saving, easy for operation and solvent free procedure.

## SR-404-15

### Microbial Secondary Metabolites in Floor Dust of a Water Damaged Office Building

*J. Park, CDC/NIOSH, Morgantown, WV; M. Sulyok, University of Natural Resources and Applied Life Sciences, Tulln, Austria*

**Objective:** Exposure assessment of fungal or bacterial secondary metabolites and their health effects in occupants of water damaged buildings is an understudied area. In this study, we simultaneously measured concentrations of 501 microbial and plant secondary metabolites in 27 floor dust samples using HPLC-MS/MS (high performance liquid chromatography-tandem mass spectrometry).

**Methods:** The floor dust samples were collected using vacuum samplers in a water damaged office building that had sentinel cases of sarcoidosis and asthma. Approximately 30 mg of dust was extracted in solvent with high acetonitrile content (acetonitrile/water/acetic acid, 79:20:1%) using a rotary shaker for 90 minutes and 100  $\mu$ l of the extract was diluted with the same volume of solvent with high water content (20:79:1%). Five  $\mu$ l of the final extract was injected onto HPLC for chromatographic separation of multiple analytes.

**Results:** We identified 32 metabolites that possibly originated from fungi, bacteria, or plants. Of these, 28 metabolites were determined to have a potential link to fungi or bacteria. Limits of detection (LOD) for these analytes ranged from 0.03 (alternariol monomethyl ether) to 75 pg/mg of dust (tenuazonic acid). Fungal and bacterial metabolites were found in more than 50% of samples, these included averufin (median concentration=0.7 pg/mg of dust), emodin (8.6), asperglaucide (23.9), usnic acid (118.9), 3-nitropropionic acid (13.4), integracin B (1.2), skyrin (7.9), integracin A (0.8), citreorosein (14.5), neoechinulin A (18.8), and alternariol monomethyl ether (0.4). Of these, averufin, emodin, asperglaucide, and usnic acid that can be produced by certain species of *Aspergillus*, *Chaetomium*, *Cladosporium*, *Mycosphaerelia*, *Penicillium*, and *Phoma* were detected in all dust samples. Although averufin (LOD=0.25 pg/mg) is one of the intermediate compounds in the biosynthetic pathway of the two well-recognized mycotoxins [sterigmatocystin (LOD=1.25) and aflatoxin B<sub>1</sub> (LOD=1.0)] all analyzed samples were found to be below the LOD for both mycotoxins.

**Conclusions:** Our findings suggest that occupants in water damaged buildings may be exposed to low levels of multiple microbial secondary metabolites and that assessing exposure to those metabolites may be important in epidemiologic studies of occupants in damp buildings.

## P0112

### Outstanding Environmental and Occupational Health Issues: Comparing the Situation in the United States and Globally

Tuesday, May 24, 2016, 2:00 PM - 4:40 PM

## CS-112-01

### Investigation and Remediation of a Former Cadmium Telluride (CdTe) Solar Panel Manufacturing Facility

*R. Strode, C. Strode, W. Mele, S. Funk, and D. Hall, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO*

**Situation/Problem:** A former solar panel manufacturing facility utilizing a CdTe thin film technology closed abruptly, leaving behind contaminated equipment and building surfaces. The building owner ultimately assumed responsibility for characterization and remediation, utilizing a voluntary clean up option. Without consensus standards, and with limited regulator experience with surface clean-up actions, the owner was required to propose and negotiate a remediation plan with State risk assessors to achieve a mutually acceptable clean-up. The RI/RA plan needed to characterize and remediate the building and equipment with the ultimate goal of achieving safe reoccupancy and a no further action (NFA) letter from State regulators. Due to the nature and extent of site contamination, a multidisciplinary approach was implemented that involved a significant IH component.

**Resolution:** A thorough review of the available literature was performed to identify existing surface standards and guidance criteria, and to identify potential detection limits and endpoints for investigative data and risk-based clearance criteria. Site-specific sampling, exposure, and risk assessment methods were developed and negotiated with regulators to achieve risk-based clearance concentrations for scope and NFA requirements. Industrial hygiene principles and methods played a key role since equipment and building surface contamination are rarely associated with voluntary clean-up actions, and the RI required novel surface sampling approaches.

**Results:** Surface concentration guidance criteria and sampling methods were identified from multiple sources, and selected methods were used to characterize existing contamination and develop a RA scope. Health-based clearance standards were then developed in cooperation with State regulators utilizing site-specific data and US EPA environmental risk assessment methods. DQOs were established for clearance standards, and the RI/RA activities successfully achieved the cleanup goals, allowing reoccupancy and receipt of a NFA from the State regulators.

**Lessons learned:** Industrial hygienists may be uniquely qualified to support atypical environmental cleanups due to their knowledge base regarding sampling, analysis, exposure, and risk assessment methods. Establishing surface clearance criteria presented a unique challenge from both a characterization and remediation perspective. Risk-based cleanups for building and equipment surface contamination can be accomplished using a multidisciplinary approach.

## CS-112-02

### Environmental Forensic Investigation of Surface Particulates in a Residential Community, Allegedly from Foundry Fugitive Emissions

*J. Kominsky, Environmental Quality Management, Inc., Cincinnati, OH*

**Situation/Problem:** A residential neighbor alleged the source of "dark particulate-like material" present on exterior surfaces (e.g., lawn furniture) was fugitive particulates from a ferrous foundry. Study objectives were to determine the chemical and physical characteristics of the material and compare the particulate to known particles from the foundry that produces ductile and gray iron castings.

**Resolution:** Potential source particulate samples (air and surface) obtained from the foundry were examined using polarized light microscopy (PLM) and scanning electron microscopy (SEM) techniques to establish source fingerprints based on particle morphology and individual particle compositions. Suspect particulate samples (wipe and tape-lift) were examined using direct phase contrast optical microscopy (PCOM), PLM, and SEM to determine whether the particulate matter had characteristics similar to the potential source samples. Prevailing wind conditions (wind direction and speed) were determined over 12 years from data obtained from a NOAA Regional Climate Center.

**Results:** PLM analysis of potential source surface dust samples showed that quartz, iron oxide, and iron spheres were major components; SEM-EDS identified iron spheres, quartz, and magnesium/aluminum-rich silicate particles. SEM-EDS analysis of airborne particulate obtained from process emissions identified iron spheres, magnesium oxide particles, and magnesium/aluminum-rich silicate particles. Analyses indicated that magnesium oxide and magnesium/aluminum-rich particles represented a chemical fingerprint of particulate generated from melting and pouring operations. Direct PCOM examination of tape-lift samples collected of the dark particulate-like material showed the dominant presence of fungal conidiophores, vegetative fungal structures, and fungal spores. PLM examination of tape-lift samples showed dominance of mold/biofilm. SEM-EDS analysis showed the presence of silicate particles. However, the silicate particles were inconsistent with the magnesium/aluminum containing silicates present in surface and airborne particulate samples obtained from foundry operations.

**Lessons learned:** Dark particulate-like material on outdoor surfaces at the residential property was predominantly fungal matter. Identification based on presence of common silicate particles would have falsely indicated that fugitive particulate from foundry emissions was also present on the outdoor surfaces.

## CS-112-03

### Nuclear Regulatory Commission Groundwater Supplemental to the Environmental Impact Statement (EIS): A Critique on Scientific and Regulatory Issues

*J. Paz, Dr. Jacob Paz Consultant, Henderson, NV*

**Situation/Problem:** On Aug 15, 2015 the NRC published a draft Supplement to the groundwater environmental impact statement (EIS) related to the proposed Yucca Mountain Project (YMP) and stated the following: "The NRC staff concludes that the estimated radiological doses are SMALL because they are a small fraction of the background radiation dose of 300 mrem/yr. (including radon), and much less than the NRC annual dose standards for a Yucca Mountain repository in 10 CFR Part 63, 15 mrem for the first 10,000 years, and 100 mrem for one million years, after permanent closure. Based on conservative assumptions about the potential for health effects from exposure to low doses of radiation, the NRC staff expects that the estimated radiation dose would contribute only a negligible increase in the risk of cancer or severe hereditary effects in the potentially exposed population. Impacts to other resources at all of the affected environments beyond the regulatory compliance location from radiological and nonradiological material from the repository would also be SMALL."

**Resolution:** The NRC conclusion raises very serious scientific issues and possible noncompliance with the NEPA Act of 1969, and its regulations, including U.S. Supreme Court ruling in the cases of: *Kloppe v. Sierra Club, 1976* (synergism), and the *Citizens to Preserve Overton Park, Inc., et al., v. Volpe, Secretary of Transportation 1971*.

**Results:** There is lack of credible scientific input into DOE Model to support the NRC calculation and analysis since: 1) unanswered questions exist: will the waste canisters be corroded or not? 2) the DOE-YMP sorption model did not consider the competing effects between radionuclides and metals in the near field, 3) why was chromium, a potent carcinogenic agent and a component of the waste canisters, not considered in the Armargosa Farm groundwater? and 4) should the NRC or the DOE study the risk associated with mixtures of metals and radionuclides?

**Lessons learned:** Provide credible scientific evidence and all applicable regulations

## CS-112-04

### Remediation of Semiconductor Facilities in International Practice: Challenges and Solutions

*E. Sawicki, Microsafe, Santa Clara, CA*

**Situation/Problem:** With the move of the Semiconductor Industry from Silicon Valley to Shanghai, legal closures of Semiconductor Fabrication Factories within the heavily governmental regulated Silicon Valley were closely monitored by regulatory agencies. This presentation will take the audience through the regulator maize based on case histories.

**Resolution:** Hazards encounter in closing these factories are unique to the Semiconductor Industry. Toxic, pyrophoric, shock sensitive, and corrosive hazards to decontamination technicians and the surrounding community are reviewed.

Effective engineering controls to mitigate these hazards are demonstrated. The presenter will reveal his unique long-term experience in effective closure projects.

**Results:** The Semiconductor closure process goes from good preplanning, regulatory notification, decontamination, shipment of hazardous waste, testing, post closure documentation and regulatory and landlord signoff.

**Lessons learned:** When properly done, these closures prevent environmental and occupational health effects. When improperly done, closures of semiconductor facilities can lead to hundreds of millions of dollars in losses and adverse health outcomes. It is vital to share the experience and success stories for a wide audience of industrial hygienists, environmental professionals, and regulators.

## CS-112-05

### Asbestos Changes in Australia—Is There a Role for Occupational Hygienists?

*S. Clarke, AIOH, Launceston, TAS, Australia*

**Situation/Problem:** Prior to 2012, work health and safety legislation varied between all of the Australian states and territories. Recently, National Model legislation and Codes of Practice have been developed and adopted by most jurisdictions. Part of this change includes the role of Licensed Asbestos Assessor, a role previously less formal, but reserved for Occupational Hygienists. Now, this license can be gained after a 5 day training program and any experience in the asbestos industry. This increase in Licensed Asbestos assessors, without the mentoring of experience Occupational Hygienists, risks reducing the level of independence and scrutiny within the asbestos industry.

**Resolution:** With an influx of Licensed Asbestos Assessors, we need to either compete for this traditional role, or reconsider our role in the asbestos industry. Some ideas tested include: 1. Educating the market of our profession. Occupational Hygienist is not well recognised in Australia. 2. Value-adding to the traditional asbestos role by utilising our other skills. 3. Creating a new role for Occupational Hygiene in the Asbestos Industry. One that cannot be conducted by any Licensed Asbestos Assessor. This may involve strategic alliances with our competitors.

**Results:** With respect to the points above, and in the opinion and experience of one humble COH: 1. We have been successful in educating many of our clients, but have picked our battles with others. We know that price not value is the key in decision making. 2. Where possible, we have moved away from the previous model of working directly for the Asbestos Removalist, enabling us to build relationships directly with the client. This provides opportunities beyond asbestos work. 3. We've created additional services, like providing nationally certified Asbestos Assessor training to future competitors, as well as mentoring and practical training programs.

**Lessons learned:** 1. Don't lose sight of our role. The art and science of Occupational Hygiene first, not consultant! 2. Don't overplay the risk. Accept that we are overqualified for some jobs, so need to stop competing with non-Occupation Hygienists. 3. Don't fight change. It is inevitable and we need to evolve with it.

## CS-112-06

### Industrial Hygiene and Worker Welfare at the Barzan Onshore Project

*R. DeHart, Rasgas Barzan Project, Ras Laffan Qatar, Matthews, NC; R. Zamuco and J. Brand, JGC Corporation, Al Khor, Qatar*

**Situation/Problem:** The Barzan Gas Project is being developed by Barzan Gas Company Limited, a joint venture between Qatar Petroleum and ExxonMobil Barzan Limited, with RasGas Company Limited assigned to develop and operate the facilities. The project is located in Ras Laffan Industrial City in Qatar, and is situated on a greenfield site. The project manpower peaked at 30,000 in 2014 with a multinational workforce of 45 nationalities, speaking 20+ languages. This paper illustrates various industrial hygiene and worker welfare activities undertaken by the project to provide workers with a safe and healthy workplace and a comfortable and safe living camp environment.

**Resolution:** Worksite health and hygiene activities included: monitoring surveys for noise, toxic gases, vibration, breathing air quality, particulates, organic solvents, radiation, heat stress, confined space ventilation and drinking water quality; hygiene specific training courses; and a fitness to work review including respiratory fitness testing. Worksite monitoring has been mainly focused on determining the magnitude of hazards generated for a particular work activity. Follow-up verification of the effectiveness of implemented control measures was based on the actual exposure to these hazards.

**Results:** Significant efforts have also been expended in the three worker accommodation camps to meet requirements for worker welfare including living accommodations, menus, recreational facilities and internet cafes. For camp infrastructure, routine health and hygiene inspections for food and life safety are performed in the canteens, kitchens, accommodations, laundry services and recreational areas. Ongoing field inspections and surveys have ensured that an environment of continuous improvement in health and hygiene is fostered for camp operations in the following areas: canteens, kitchens, accommodations and ablution facilities; recreational facilities; and overall improvements for personnel transportation from the camp to the worksite.

**Lessons learned:** In summary, the project's efforts for workers' health and safety, and related worker welfare activities have successfully contributed to a positive and sustainable safety culture within the Barzan Onshore Project.

## CS-112-07

### Developing Sustainable Industrial Hygiene Program in the Region by GE

*S. Ranpura, GE, Bangalore, India*

**Situation/Problem:** India is the second largest country in world where workers are employed in the manufacturing sector. Local regulations do not have robust Industrial hygiene requirements for industry to follow and it is up to the employer to develop, implement and maintain industrial hygiene programs. Multinational companies have their own standards, which often exceed the local IH requirements. The challenge is to implement a robust IH program with quality. The social culture outside the factory is not of high standard with poor hygiene practices, which alters program management

inside the factory for acceptability among workers. Lack of educational background is another challenge to implement sustainable IH programs.

**Resolution:** An industrial hygiene program containing comprehensive industrial hygiene risk assessment is implemented across a region. IH program element contained: program responsibilities, implementation methods, communication, training and effectiveness evaluation. Each element was owned by a champion from the shop floor for effective implementation. Maintaining quality during implementation of IH program is a key challenge due to lack of educational background and culture.

**Results:** Substantial results were achieved by implementing an IH program. These included zero occupational injuries, increased employee satisfaction, a better workplace with reduced occupational hazards, prioritizing risk and technical justification to fund industrial hygiene infrastructure like noise control and ventilation system improvements, substitution of hazardous chemical with less hazardous chemical, and reduced personal exposure to workplace chemicals. Various ways were adopted to ensure quality assurance during implementation of IH program.

**Lessons learned:** Do not get discouraged with cultural and educational limitations. Focus on core IH areas and train employees on sustaining IH programs. We can change the culture with effective program implementation.

## P0113

### Data Analysis in Exposure Assessment

Wednesday, May 25, 2016, 10:00 AM - 12:00 PM

## SR-113-01

### Aggressive or Passive Particle Sampling: An Evaluation of the Efficacy of Disturbing Settled Dust as Part of an Exposure Assessment to Environmental Allergens

*R. Allenbrand, Children's Mercy Hospital, Kansas City, MO*

**Objective:** Home environments may contain a variety of contaminant sources that can have an effect on a child's health that has asthma, allergies, or other health conditions. Allergens can be biological contaminants in homes that can lead to asthma triggers and allergic reactions depending on what allergens to which a child is being exposed. Establishing a mechanism for an exposure technique during a home assessment could provide a tool to reducing contaminants in the indoor environment.

**Methods:** CEH staff performed aggressive sampling in 40 homes in the Kansas City, MO area to evaluate the efficacy of this technique and whether it is a more appropriate technique for assessing potential exposure to certain environmental allergens and at what concentrations. During each assessment, an ARTI HHPC-6 and TSI Aero Trak 8220 laser particle counters were used to measure airborne particles per cubic feet at ranges 0.5 um, 0.7 um, 1.0 um, 2.0 um, 5.0 um, and 10.0 um. Samples were taken at 2 feet (breathing

zone for young children) and 5 feet both pre- and post- active disturbance of settled dust on child's bedroom floors. The bedroom floor was disturbed using a metal handled spatula.

**Results:** T-test results indicated that mean particle concentrations for Undisturbed vs. Disturbed particle concentrations, at the 2 foot heights showed more variability between 1.0  $\mu\text{m}$  to 10  $\mu\text{m}$  ( $p=0.05$  to  $p<0.01$ ) particle sizes as compared to 5 feet. When comparing Disturbed vs. Undisturbed particle concentrations, a statistical relationship existed between particles of the same size ( $Rho=0.67-0.99$ ). Smaller particles,  $< 2.0 \mu\text{m}$ , showed a strong statistical relationship with one another.

**Conclusions:** Using a combination of aggressive and non-aggressive particle sampling techniques at different heights, may provide a better profile of the particle concentrations present in the environment. The research indicates a slight relationship does exist between limited allergens and particles sampled. However, particle sampling alone may not indicate or determine what type of allergens may be present in the environment. Additional research needs to be performed to better understand allergen behavior when surfaces are disturbed.

## SR-113-02

### Historical Levels of Benzene, Hydrogen Sulfide and Noise to Demonstrate Exposure Trends in a Petroleum Refinery

*F. Akbar-Khanzadeh, M. Chambers, S. Milz, A. Ames, and M. Valigosky, UT HSC College of Medicine, Toledo, OH*

**Objective:** Petroleum refineries are examples of workplaces with multiple operations where exposure data are routinely collected and accumulated over the years without having a comprehensive analysis performed. If the historic data are compiled and analyzed, they can be used to examine exposure trends, build up predictive models or conduct epidemiological studies. This presentation demonstrates the application of historic data in evaluating exposure trends.

**Methods:** In a petroleum refinery, the results of exposure monitoring to harmful agents, collected over the years of 1980 to 2011, were compiled. Benzene, hydrogen sulfide and noise were chosen as indicators of overall exposure in the refinery and their levels and characteristics were entered into a statistical datafile. The exposure monitoring in this facility, which continuously keeps up with new technology, had been performed according to appropriate standard methods and under supervision of experienced industrial hygienists.

**Results:** The data analysis showed that the benzene concentration ranged from 0.01 to 14  $\text{mg}/\text{m}^3$  with a mean concentration of 0.24  $\text{mg}/\text{m}^3$ ; no significant variation observed in benzene concentrations at major locations of the refinery. Hydrogen sulfide concentration ranged from 0.08 to 220  $\text{mg}/\text{m}^3$  with a mean concentration of 3.5  $\text{mg}/\text{m}^3$ . Mean concentration for hydrogen sulfide by location revealed that in an operator position that covers multiple units had the highest exposures at 17  $\text{mg}/\text{m}^3$ , followed by the Saturated Gas Unit (7.6  $\text{mg}/\text{m}^3$ ), and Coker Unit (1.5  $\text{mg}/\text{m}^3$ ). Noise levels ranged from 43.1 to 102 dBA with a mean level of 80.3 dBA. Locations with the higher mean noise levels were the Crude Atmospheric Distillation Unit (88 dBA), Boiler (87.3 dBA), and Liquid Petroleum Gas Storage (86.3 dBA).

**Conclusions:** A linear regression analysis by year indicated that over time benzene and hydrogen sulfide concentrations remained almost unchanged; however, noise levels increased slightly but significantly ( $p < 0.05$ ).

## SR-113-03

### The Log-Binomial Model for Exposure Data Analysis

*T. Mathew, University of Maryland Baltimore County, Baltimore, MD; K. Krishnamoorthy, University of Louisiana at Lafayette, Lafayette, LA*

**Objective:** In industrial hygiene and environmental applications, binary data are very common: the presence or absence of a health condition, the exceedance or non-exceedance of an OEL, etc. Such responses usually depend on exposure levels and other covariates, and logistic regression is extensively used to model the probability of a positive response. Typically, odds ratios (OR) are reported in the context of binary outcomes. For an outcome that is not rare, the log-binomial model is sometimes used for modeling exposure-response relationships and for estimating the risk ratio, also referred to as the prevalence ratio (PR). For such outcomes, the PR is a more intuitively interpretable measures of association than the OR. However, the log-binomial model presents considerable difficulties for data analysis, even for large sample sizes, since the calculation of the maximum likelihood estimates is problematic. Our objective is to explore alternative methodology for the accurate analysis of exposure data under the log-binomial model.

**Methods:** The methodology that we shall explore is an old and underutilized approach in statistics, namely, the fiducial approach. The fiducial concept has undergone a recent revival and is now recognized to be important in applications. The fiducial method can be easily adopted to the log-binomial model. The fiducial methodology and its implementation will be explained for estimating the prevalence ratio and for testing hypothesis in order to assess possible association between an exposure variable and a health outcome.

**Results:** Simulation results show that the proposed methodology does provide accurate results. Apart from simulation results, the methodology will be illustrated using the analysis of a data set on the prevalence of carpal tunnel syndrome among employees at a poultry processing plant.

**Conclusions:** For testing hypothesis concerning the association between an exposure variable and a health outcome, the proposed fiducial approach provides an accurate test. The fiducial approach also provides considerable computational advantage, since it does not require the computation of maximum likelihood estimates.

## SR-113-04

### Preliminary Results on Testing a Field-Based Respirable Silica Monitoring Approach in Surface Copper Mines

*E. Cauda and L. Chubb, CDC/NIOSH, Pittsburgh, PA; R. Reed and E. Lutz, University of Arizona, Tucson, AZ*

**Objective:** The first objective is to assess the performance of the Direct-on-Filter (DoF) FTIR technique for the estimation of crystalline silica in respirable dust samples collected in

surface copper mines. The adoption of this technique could allow field-based silica monitoring in the future. The second objective is to investigate the variability of the crystalline silica content in the respirable dust present in surface copper mine operations in Arizona.

**Methods:** Area samples of respirable dust were collected at several copper mines in Arizona, in different areas of the mine except for the pit. Primary and secondary crushers, together with the mill were selected as preferred sampling areas for the high levels of respirable dust and crystalline silica generally present in those environments. After the collection, the samples were analyzed with a portable FTIR set up for DoF analysis for the estimation of collected crystalline silica. Because this approach does not destroy the sample, the same samples were then analyzed by an accredited laboratory with the X-ray diffraction NIOSH 7500 method for the quantification of crystalline silica. The accuracy of the DoF-FTIR estimation compared to the results of the NIOSH 7500 method was evaluated for each sample and analyzed statistically within the same set and among sets collected in different mines. The identification and quantification of the minerals present in the respirable dust in different areas of every mine was also conducted to investigate the effect of geological confounders in the silica quantification with the FTIR method. Finally, the respirable crystalline silica results obtained were used to investigate the spatial variability of both respirable crystalline silica concentration within the same mine and crystalline silica content in the dust among different mines.

**Results:** The estimation of the DoF-FTIR technique correlates well with the results of the standard NIOSH 7500 method. The accuracy of the estimation is independent from the amount of the silica present in the samples collected in different mine. More comprehensive analysis will be given at the meeting. Finally, the DoF-FTIR technique showed an LOQ for the estimation of silica of 15 micrograms.

**Conclusions:** The exposure to respirable dust containing crystalline silica is a recognized occupational hazard in mining. In surface copper mines, activities in the crusher and mill areas are known sources of respirable dust with mass concentrations that can vary in time and can rise above action levels. In general, the monitoring of crystalline silica dust is still conducted with the use of traditional hygiene practices with limitations in terms of timely information available for the adoption and optimization of control technologies. The use of a field-based silica monitoring approach can allow operators to obtain early detection of concentration levels above the action limit.

### SR-113-05

#### **Toluene Diisocyanate Exposure: Exposure Assessment and Development of Cross-Facility Similar Exposure Groups Among TDI Production Plants**

*B. Doney, P. Middendorf, and W. Miller, CDC/NIOSH, Morgantown, WV; T. Feeley, Covestro LLC, Pittsburgh, PA; R. D'Angelo, Covestro LLC, Baytown, TX; L. Martinez, BASF Corporation, Geismar, LA; J. Cikalo, Dow Chemical Company, Midland, MI*

**Objective:** The objective was to characterize workplace toluene diisocyanate (TDI) exposures in U.S. TDI production plants

using standardized industrial hygiene exposure assessment procedures for use in a prospective epidemiologic study of occupational asthma.

**Methods:** A uniform exposure assessment strategy was developed by a team of industrial hygienists from the National Institute for Occupational Safety and Health (NIOSH) and from representatives of each participating plant who were knowledgeable of the plants processes and operations. To provide the exposure data needed to achieve the study's aims, the assessment strategy included: development of similar exposure groups, identification of high potential exposure tasks, quantitative and qualitative exposure assessment, and the utilization of standardized sampling and analytical methods. Air samples were collected with calibrated personal sampling pumps and analyzed using a method equivalent to the OSHA 42 Method for measuring airborne personal exposures to TDI.

**Results:** A total of over 2600 samples were collected. 1594 representative routine full shift time-weighted average (TWA) and 755 routine short term high potential exposure task (HPET) air samples were collected among groups with similar job titles across three TDI plants over a nearly seven-year period. Data derived similar exposure groups (SEGs) were developed across the plants based on TWA sampling using cluster analysis. Individual cumulative exposure estimates were developed based on the cross-facility similar exposure groups. The arithmetic mean TWA exposure was 0.65 ppb. Without adjusting for the use of respirators, the highest TWA exposures occurred among field operators, TDI loading, and TDI drumming SEGs. Of the 1594 TWA routine samples, 35 were > 5 ppb and of the 755 HPET routine samples, 83 were > 20 ppb. Workplace routine TWA exposures to TDI were adequately characterized, but HPET exposures were inadequately sampled.

**Conclusions:** The TDI exposure assessment of the primary producers of TDI in the U.S. was one of the most complete to date. The measured exposures can be used to support epidemiologic analysis of the relationship between exposures to TDI and asthma.

### SR-113-06

#### **Estimates of Occupational Inhalation Exposures on the Four Rig Vessels During the Deepwater Horizon Oil Release Cleanup**

*T. Huynh, University of Alabama at Birmingham, Birmingham, AL; G. Ramachandran C. Groth, and S. Banerjee, University of Minnesota, Minneapolis, MN; A. Blair, National Cancer Institute, Gaithersburg, MD; M. Stenzel, Exposure Assessment Applications, Arlington, VA; D. Sandle, L. Engel, and R. Kwok, National Institute of Environmental Health Sciences, Research Triangle Park, NC; P. Stewart, Stewart Exposure Assessments, LLC, Arlington, VA*

**Objective:** After the 2010 Deepwater Horizon oil release, the National Institute of Environmental Health Sciences initiated an epidemiological study (GuLF STUDY) to investigate the potential adverse health effects associated with the oil spill response and clean-up work. One component of the study, a quantitative exposure assessment, is critical because it allows the investigation of the exposure-disease relationship.

The objective of this paper is to characterize inhalation exposures to crude oil components for workers on the four rig vessels (Enterprise, DDII, DDIII, and Q4000) that had primary responsibility for remediation of the oil release at the well site.

**Methods:** We used personal measurements collected for BP during the remediation for our analysis. Exposure groups (EGs) were created based on the specific vessel, location on the vessel, job titles/tasks for four time periods from April 20 to December 31, 2010. The study utilized a large number of personal measurements collected for BP, many of which also contained the analytical limits of detections (LOD). Bayesian methods accounting for the LODs were used to analyze exposures for total hydrocarbons (THCs), benzene, toluene, ethylbenzene, xylene (BTEX chemicals) and hexane.

**Results:** THC exposures changed over time and varied by vessels and EGs. The highest exposures were generally observed in the time period from when the oil release was occurring until the well was successfully top capped (THC up to 15 ppm). Exposures gradually decreased over time to approximately 0.1 ppm except a few that were probably involved in decontaminating the vessels. BTEX chemicals and hexane exposures were substantially lower than THC. The variability of the EGs was generally high, likely reflecting the non-routine, time-dependent nature of spill response as well as the high uncertainty associated with estimating exposures with small sample sizes and high degree of censoring in some EGs.

**Conclusions:** This study, along with the ongoing epidemiologic investigation, hopes to provide new information to the limited literature on the chemical exposures during oil spill remediation and the potential health effects associated with such efforts.

## P0114 Mold and Fungal Contaminants - Detection and Prevention in the Built Environment

Wednesday, May 25, 2016, 10:00 AM - 12:00 PM

### SR-114-01 Mold Remediation & Certification Laws in the United States: A Look at Where We Are & What We Need

*E. Geltman and A. Hess, Hunter College, CUNY School of Public Health, New York, NY*

**Objective:** Concern about mold in buildings and homes increased in the United States in the aftermath of Hurricane's Katrina and Sandy. Mold is a known allergen and can cause a plethora of health issues, including mycotoxin poisoning and a range of respiratory ailments. As a naturally occurring irritant, there is great debate about the best means to safely remove mold. In order to protect the public against unscrupulous and unskilled contractors, a growing number of states enacted legislation requiring training, certification and other regulations of those in the business of mold remediation

**Methods:** In this study, we used principles of legal epidemiology to conduct policy surveillance to explore which

states enacted mold remediation and certification laws. We used LEXIS/NEXIS and <https://legiscan.com/> to evaluate the laws and regulations of all 50 states against sixteen preset codes using LawAtlas WorkBench. Coders crosschecked for consistency.

**Results:** Our review found that only a minority of states established mold remediation and certification laws and these vary in stringency and effectiveness. Some states (in the minority) are attempting to reduce consumer fraud in the mold removal industry and provide guidelines about how to both conduct proper mold removal and how to train those engaged in mold removal to protect both worker and building occupant safety. Moreover, penalties for violating laws in the few states that do provide guidelines are generally relatively insignificant; amounting to the regulatory equivalent of a parking ticket.

**Conclusions:** Overall the data shows a paucity of states establishing legal guidance and protection assuring that mold removal specialists are properly trained and/or licensed to protect the health of both removal workers and building occupants.

### CS-114-02 What Do Those Spore Trap Categories Mean?

*H. Burge, EMLab PK, San Bruno, CA*

**Situation/Problem:** Spore trap reports list counts for a variety of fungal spores. The categories listed are based on the analysts' ability to recognize the spores by their morphology. Only a very few spores can be assigned to a genus and species on microscopic morphology alone (e.g., *Epicoccum nigrum*). Other spore types can be recognized to the genus level, but there may be hundreds of different species (e.g., *Cladosporium*). Other categories group spores of different (related) genera based on similar spore morphology (e.g., *Drechslera/Helminthosporium*, *Penicillium/Aspergillus*). A fourth category unites all the spores of a particular large group that all produce spores in a similar way. Each of these groups includes hundreds of genera and thousands of species (e.g., Ascospores and Basidiospores). Finally, one of the groups often listed includes spores of completely unrelated fungi that happen to have spores of similar morphology (smuts, myxomycetes).

**Resolution:** So, given this lack of precision, of what use are these categories? They are generally used to compare populations of spore types indoors and outdoors. In fact, some reports list outdoor and indoor fungi. Note that ALL fungi are found in the natural outdoor environment, and none can grow exclusively indoors. Because of the lack of precision of listed spore categories, it is important to be familiar with the kinds of fungi included in each group, and to recognize that within each group there are those that often are found indoors, those that are occasionally found indoors, and those that have not been found in the indoor environment

**Results:** Understanding the complexity of these categories is important for interpreting spore trap data, especially when indoor/outdoor comparisons are being made. For example, high concentrations of ascospores both outdoors and in may indicate either penetration of the outdoor aerosol, or growth of an ascospore forming fungus indoors. A solution that the labs might provide would be to indicate whether or not the indoor and outdoor ascospores are similar or not. This would, of course, add expense to the analysis. Understanding the

nature of spore trap categories will facilitate interpretation and direct investigators to, perhaps, reinvestigate sites where the complexity of the report categories could lead to errors of interpretation

**Lessons learned:** Spore trap categories reported by analytical laboratories rarely represent fungal species, but rather groups of species belonging to related families or even to completely unrelated classes of fungi. Understanding this complexity will aid in the interpretation of spore trap reports.

### SR-114-03

## Airborne Endotoxin and Asthma and Allergy in Elementary School Age Children: A Case-Control Study

*Y. Yen, Kaohsiung Medical University, Kaohsiung, Taiwan*

**Objective:** The objective of this study is to evaluate the association between the presence of asthma and allergy sensitization, and airborne endotoxin in homes of school age children in Kaohsiung City, Taiwan.

**Methods:** We conducted this study using a case-control study design from a general population of children by matching age and class exposure. Data collection of home visits included an interviewer administered questionnaire, air sampling of participants' homes for endotoxin, bacteria and fungi, as well as temperature and relative humidity measurements. Airborne endotoxin was collected on filters with a sampling time of 24 hours. The houses of each case-control pair were visited within one week to ensure the similarity of the ambient environment. Questionnaires were administered to record housing characteristics. SAS statistical package (version 9.3) was used for data analyses.

**Results:** Endotoxin was detected in all air samples with a mean value of  $1.45 \pm 1.67$  EU/m<sup>3</sup>. In both the univariate and multivariate analyses, incense burning was consistently associated with increased concentrations of airborne endotoxin in the bedroom, while air fresheners and dehumidifiers were associated with decreased concentrations of airborne endotoxin. We observed that higher airborne endotoxin concentrations increased the risk of asthma/allergy. In addition, interquartile range increases of airborne endotoxin were significantly associated with asthma/allergy status (OR= 3.83).

**Conclusions:** Airborne endotoxin was significantly associated with asthma/allergy status. Reduced incense burning, and using air fresheners and dehumidifiers, may decrease airborne endotoxin in homes.

### SR-114-04

## IgE Antibodies to Fungi Among Asthmatic Children Living in Homes Damaged by Hurricane Sandy in New York City

*A. Divjan, L. Acosta, and M. Perzanowski, Department of Environmental Health Sciences, Mailman School of Public Health, Columbia University, New York, NY; M. Little, C. D'Andrea, and N. Clark, New York City Department of Health and Mental Hygiene, New York, NY; E. Sobek, Assured Bio Labs, LLC, Oak Ridge, TN; N. Soffer, Intralytix, Baltimore, MD; B. Green, Allergy and Clinical Immunology Branch, Health Effects Laboratory Division, CDC/NIOSH,*

*Morgantown, WV*

**Objective:** In New York City (NYC), domestic mold contamination has been a public health concern and the most common residential complaint following Hurricane Sandy (HS). The objective of this research was to determine the susceptibility of asthmatic children to adverse health effects from fungal exposures following catastrophic water damage.

**Methods:** Asthmatic children (n=58) living in homes damaged by HS were recruited (ages 6-15 years). Dust was collected from homes and serum from children 16-33 months after HS. Bedroom floor dust was analyzed by quantitative polymerase chain reaction for 36 fungi (Environmental Relative Moldiness Index panel) and compared to results from non-damaged homes (NYC Neighborhood Asthma and Allergy Study, n=347). IgE was measured by CAP (ThermoFisher, >0.1 IU/ml considered positive) to common fungi and those selected based on fungi detected in HS-damaged home dust.

**Results:** As compared to non-damaged homes, significantly (P<0.05) more Hurricane Sandy damaged homes had measurable *Acremonium strictum*, *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus penicillioides*, *Cladosporium cladosporioides*, *Epicoccum nigrum*, *Mucor amphibiorum*, *Penicillium purpurogenum*, and *Scopulariopsis brevicaulis*. Nearly all homes (damaged and non-damaged) had detectable levels of *Aureobasidium pullulans* and *Cladosporium herbarum*. Many (50%) of the children in HS damaged homes had measurable IgE to at least one of the fungi tested, most commonly, *Alternaria alternata* (36%), *Candida albicans* (22%), *Aureobasidium pullulans* (19%), *Aspergillus fumigatus* (17%), *Helminthosporium halodes* (17%) and *Mucor racemosus* (17%).

**Conclusions:** Among asthmatic children living in NYC homes damaged by HS, sensitization to fungi was common, including to some species that were higher in HS-damaged homes. The ongoing analysis of fungal sensitization and effects on asthma morbidity will further characterize the impacts of Hurricane Sandy on this population.

### SR-114-05

## *Aspergillus* Section *Petersonii* Sect. *Nov.* Encompassing Indoor and Soil-borne Species with Predominant Tropical Distribution

*Z. Jurjevic, EMSL Analytical, Inc., Cinnaminson, NJ; A. Kubátová, Department of Botany, Faculty of Science, Charles University in Prague, Prague, Czech Republic; M. Kolarík, Institute of Microbiology, Academy of Sciences of the Czech Republic, Prague, Czech Republic; V. Hubka, Department of Botany, Faculty of Science, Charles University in Prague, Prague, Czech Republic*

**Objective:** During mold surveys, a number of *Aspergillus* strains were isolated from the environment which did not fit any known species or genus. Phenotypic examination of these isolates showed that they were very similar but differed in some growth characteristics. Multilocus DNA sequence data was obtained for the new isolates and some related species in the broader, more inclusive clade.

**Methods:** Fungal isolates were collected mainly from homes and offices. To describe the species, we used phenotypes from 14 day Czapek yeast extract agar, CYA with 20 % sucrose, malt

extract agar, oatmeal agar, potato dextrose agar, dichloran-glycerol agar, Czapek yeast autolysate agar with 5% NaCl, and creatine agar. Cultures were incubated in darkness at 25 °C. Additional CYA cultures were incubated at different temperatures to determine the cardinal growth temperatures of the new species (20, 30, 35 and 37°C) for 14 d. This was followed by multilocus DNA sequencing of beta-tubulin (BT2), calmodulin (CF), nuclear internal transcribed spacer region (ITS), RNA polymerase II (RPB2), and phylogenetic analysis (Maximum Likelihood and Bayesian Inference analysis).

**Results:** Based on molecular and morphological analysis the new species are described as *A. asclerogenus* and *A. petersonii*. *Aspergillus arenarius* is reduced to synonymy with *A. peyronelii*. In addition, three new sections *Petersonii*, *Robusti* and *Tanneri* in the subgenus *Circumdati* are proposed.

**Conclusions:** *Aspergillus* is a diverse genus encompassing approximately 350 species with high economic impact for humans. The current classification into four subgenera and 20 sections resolves the placement of the vast majority of species with only a few exceptions. The subgenus *Circumdati* comprises important producers of mycotoxins, bioactive exometabolites, and biotechnologically important enzymes and organic acids. Some species are used in food fermentations, and some may cause food spoilage or human infections. Our phenotypical and phylogenetic data resolved the position of species with ambiguous taxonomic placement and supported the proposal of three new sections in the subg. *Circumdati*, sect. *Petersonii*, *Robusti* and *Tanneri*.

## SR-114-06

### The Influence of Children Jumping on the Bed on Airborne Endotoxin and PM<sub>10</sub>/PM<sub>2.5</sub>/PM<sub>1</sub> Concentration Profile

Y. Yen, Kaohsiung Medical University, Kaohsiung, Taiwan

**Objective:** The purpose of the present study is to detect the concentrations of airborne endotoxin, PM<sub>1</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> through the behavior of jumping on the bed and making the bed as well as the background period to understand the influences of those behaviors.

**Methods:** 60 schoolchildren's houses in Kaohsiung city in Taiwan were evaluated. PM<sub>10</sub>/PM<sub>2.5</sub>/PM<sub>1</sub> concentration was simultaneously monitored over the first five minutes to obtain background concentration profiles. Then, a common cane was used to tap the bed for about one minute, followed by keeping motionless in 7 to 10 minutes to let PM settle down. Then, we made children's bed by raising bed sheets for about one minute, followed by keeping motionless in 7 to 10 minutes. This evaluation was conducted by the same person for consistency of the beating strength, beating frequency, and beating location. We collect airborne endotoxin on 1µm pore size and 37mm diameter of Teflon filters in the plastic cassettes by using a sampling pump operating at 20 L/m for 25minutes when we performed the action of jumping on the bed and making the bed.

**Results:** This is the first study to detect the concentrations of airborne endotoxin, PM<sub>1</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> through the behavior of jumping on the bed and making the bed. When jumping on the bed and making the bed, the airborne endotoxin concentrations is higher more than eighteen times of background, and the PM concentrations of jumping on the bed is higher more than ten times of background concentrations,

and making the bed is higher nearly double than background. And also indicated that the largest ratio of PM in background was PM<sub>1</sub> (PM<sub>1</sub>, PM<sub>1-2.5</sub> and PM<sub>2.5-10</sub> accounted for 0.916, 0.009 and 0.075, respectively). When jumping on the bed and making the bed, the ratio of PM<sub>1</sub> and PM<sub>1-2.5</sub> were decreased, specifically, the ratio of PM<sub>1</sub> were decreased more than PM<sub>1-2.5</sub> (the ratio of PM<sub>1</sub> when jumping on the bed was 0.905, and when making the bed was 0.895). However, the ratio of PM<sub>2.5-10</sub> were increased when jumping on the bed and making the bed (the ratio of PM<sub>2.5-10</sub> was 0.090 and 0.097, respectively).

**Conclusions:** In conclusion, jumping on the bed and making bed significantly increased airborne endotoxin and PM concentration. These actions may increase the risk of respiratory symptoms, especially for asthma children.

## P0115

### New Assessment Tools and Interventions to Manage MSD Risk

Wednesday, May 25, 2016, 10:00 AM - 12:00 PM

## CS-115-01

### The ROI of Onsite Early Intervention to Prevent Strains and Sprains

T. Silva, Atlas Injury Prevention Solutions, Grand Haven, MI

**Situation/Problem:** Many organizations invest significant time and money into ergonomics programs and equipment, But they still fail to reach zero recordable incidents due to a variety of factors, which often include: aging, unhealthy, or overweight workforce, engineering controls impossible to implement, and employees seeking medical treatment without attempting conservative care.

**Resolution:** This presentation will look at a case study for a tier 1 auto parts manufacturer and how they implemented an on-site early intervention and ergonomics program to reduce their recordable incidents. It will show how the early intervention and ergonomics process was implemented using the Plan-Do-Check-Act model. It will also show how the flow of information in its injury management activities has been pushed upstream to manufacturing and product design engineers to address the root causes of ergonomics hazards in the facilities.

**Results:** Significant reductions in recordable incidents. Greater employee engagement. Identification of root causes in product and process design so that corrective actions can be taken to solve the problems. The full integration of data used by safety, ergonomics, HR, workers' compensation, and case management professionals.

**Lessons learned:** Learn the process for effectively launching and providing value-added on-site support using the Kaizen methodology. Discuss the keys to early intervention and how to prevent an OSHA recordable, including injury triage to determine if the concern can be managed conservatively or if further evaluation and assessment is warranted. Discuss how a comprehensive inventory of Job Demands Analyses can be used as the basis for further preventing recordable incidents through: Post-offer pre-employment screens; Ergonomics risk

assessments; and Return to work job matching.

## CS-115-02

### Ergonomics & the Aging Workforce: What's New with the Aging Population?

*B. McGowan, Humantech, Inc., Ann Arbor, MI*

**Situation/Problem:** In 2009, older workers (55 and over) represented 19% of the U.S. workforce. This group is the nation's fastest growing segment of the workforce. The Bureau of Labor Statistic (BLS) projects, for the period between 2006 and 2016, that there will be an 84.3% increase in workers age 75 and over, an 83.4% increase in workers between the ages of 65 and 74, and a 36.5% increase in workers between ages of 55 and 64. Many industrial job duties require physical demands such as lifting, lowering, pushing, pulling, bending, twisting, reaching, climbing, and kneeling, among others. Each of these job demands require forceful, repetitive, or sustained muscle contractions. For the younger worker, the physical capabilities for job duties are well defined and have resulted in the publication of several design standards. Unfortunately, the physical capabilities of the older worker have not been studied as extensively, and as a result, design standards for older workers are hard to find. The purpose of this presentation is summarize the latest physiology research and the cutting-edge ergonomic design guidelines for the aging workforce.

**Resolution:** Research was conducted to find citations related to changes in muscle physiology as we age. The aging population is considered 55 years of age or older. Topics of interest included changes to sensory/motor perception and control, strength, movement control, and cardiovascular capacity.

**Results:** The review of literature found several new changes in muscle physiology as we age. There is a loss of muscle mass and strength that occurs starting at 40 years old and continues with increasing age. Alterations in muscle fiber transitions and metabolic shifts impact the aging muscle. Key performance changes that occur as a result of the changes in muscle physiology as we age include: 1) movement speed slows during grasping and reaching; 2) movement precision (deceleration) decreases; 3) range of motion is reduced; 4) muscle strength (grip, push, pull) decreases; 5) force control decreases, as adults grip twice as hard to compensate; 6) force perception decreases; and 7) muscle endurance decreases. Based on these findings, cutting-edge ergonomic design guidelines for lifting, lowering, pushing, pulling, bending, twisting, reaching, climbing, and kneeling were developed for the aging workforce.

**Lessons learned:** The changes in muscle physiology as we age are real, and impact workers' capabilities to perform work. Understanding the capabilities of the older worker allowed for the development of design standards to optimize performance and to minimize musculoskeletal disorders for the aging workforce.

## SR-115-03

### Development of a New Assessment Tool for Musculoskeletal Disorders Associated with Lifting and Bending

*R. Phalen, University of Houston Clear Lake, Houston, TX*

**Objective:** Back injuries associated with forceful and repetitive lifting or bending activities are a major source of work-related disability, especially among those working in the

transportation, warehousing and healthcare sectors. It is estimated that the economic impact of low-back disorders is as much as \$50 billion dollars per year in the United States alone. Unfortunately, over the past decade, we have not seen much improvement in the incidence or severity of these disabling disorders. One critical barrier is the lack of effective assessment tools to evaluate and control known stressors, such as load weight, load position, human posture, frequency and duration of exposure, and dynamic motion (acceleration). Current techniques are either: 1) complex and cumbersome devices or 2) simplistic models, which often fail to take into account one or more critical stressors. The aim of this current research is to develop a new assessment tool that can be worn by a worker and assess the forces and moments (torque) on the lower lumbar region of the spine.

**Methods:** Small force plates were positioned under major load bearing regions of the feet, namely at the heel and ball of the foot, to measure lower-trunk weight distribution. Based on the position of the feet relative to the pelvis and lower lumbar region of the spine, an algorithm was used to approximate the magnitude and direction of force at the lower lumbar region. Triplicate readings were collected for various lifting, bending and twisting motions. The results were then compared to matched results for a common biomechanical model (HAT) and the revised NIOSH Lifting Equation.

**Results:** It was determined that lower trunk weight distribution can be used to approximate the moment (Nm) on the lower lumbar region. The resulting vector magnitude (N) was correlated with the corresponding HAT moment estimate (Pearson  $r = 0.8026$ ;  $p \leq 0.05$ ). The results were also correlated with the corresponding NIOSH multipliers for vertical distance, horizontal distance, and asymmetric angle (Pearson  $r = 0.7682$ ;  $p \leq 0.05$ ). In addition, the lower trunk weight distribution method successfully measured increases in force magnitude associated with dynamic motion.

**Conclusions:** Lower trunk weight distribution can be used to approximate and evaluate forces on the lower lumbar region. The results were comparable with existing assessment tools. Additionally, this new method can also be used to evaluate dynamic motion effects, associated with picking up or setting down a load.

## SR-115-04

### The Influence of Loading Parameters on Fatigue Life of MSD Tissues

*S. Gallagher and M. Schall, Auburn University, Auburn, AL*

**Objective:** Several lines of evidence have recently emerged to suggest that a fatigue failure process may be associated with the development of MSDs and may be a causal mechanism in their progression. These lines of evidence include in vitro testing of musculoskeletal tissues, results from animal models, data from epidemiological studies, and studies of eccentric exercise in humans. If true, there are numerous implications regarding MSD risk assessment. The objective of this presentation is to describe the influence of loading parameters on fatigue life of musculoskeletal tissues.

**Methods:** Data from in vitro materials testing of a rabbit medial collateral ligament (from Thornton et al. 2007) was used to develop estimates of tendon fatigue life given varying duty cycles using the Gerber criterion. Data indicate that the ultimate stress of the ligament was 100 MPa and the fatigue

strength fraction determined to be 0.42, and the endurance limit assumed to be 30 MPa. Using these data, estimates were developed for a 40 MPa load at various duty cycles (40% versus 70%).

**Results:** The mean stress for a 40% duty cycle was determined to be 13.93 MPa while the 70% duty cycle had a mean stress of 25.87 MPa. Based on the Gerber criterion, calculations of the fatigue life for these duty cycles were 19300 and 12147, respectively.

**Conclusions:** Various parameters related to loading of musculoskeletal tissues will be important with respect to the number of cycles that can be experienced before damage occurs. In this analysis, the influence of duty cycles demonstrated a significant influence on fatigue life with the 70% duty cycle demonstrating a more than one-third reduction in the fatigue life compared to the 40% duty cycle. All other things being equal, reducing the duty cycle would be expected to reduce the risk of experiencing musculoskeletal disorders.

## SR-115-05

### Prevalence of Musculoskeletal Discomfort Related to Standing Works—Results from a Multi-Organization Study

*Y. Huang, National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan*

**Objective:** Musculoskeletal discomfort is a widespread problem affecting labor intensive and office based workers alike. Causal relations with musculoskeletal discomforts on the upper limbs and lower back have been examined extensively. In contrast, relatively little has been examined as to the extent and severity of musculoskeletal discomfort due to prolonged standing. Besides occupational and work-related factors, personal characteristics may also affect the occurrence and severity of symptoms. The occurrence of musculoskeletal discomfort related to standing work and potential risk factors were examined in this study.

**Methods:** A personal questionnaire was designed for this study. Various organizations were contacted for study participation, and most of the employees at the time of site visit were invited for participation. Questionnaire items included personal characteristics (age, gender, height, body weight), work history, work conditions (including break arrangement, rest area arrangement). Finally, the study participants were asked to point out locations and symptoms of musculoskeletal discomforts at the end of a typical work day. Statistical analyses were performed with the questionnaire data to determine how personal characteristics and work factors may be related to musculoskeletal discomforts.

**Results:** In all, 1,585 personal questionnaires were collected. Most (72.7%) of the study participants were women, and over 80% of the study participants work at least 20% standing during a workday. Some also had to work on their knees, bending waist, manually moving objects, or walked a lot during the day. Before the end of a workday, 81.6% reported at least one general discomfort symptom, and 70.3% reported musculoskeletal discomfort. Compared to seated work, workers who spend some of the workday > on their feet.

**Conclusions:** Prolonged standing at work was common in this study. Although there are steps to help reduce health hazards

associated with prolonged standing, they have not been widely recognized or implemented in the workplace. Further studies are needed to evaluate possible cause of these discomfort and to find remediation to these occupational hazard.

## CS-115-06

### Do Sit-Stand Workstations Warrant the Attention They Are Receiving?

*D. Hunt, Carleton University, Ottawa, ON, Canada*

**Situation/Problem:** Sit-stand workstations have been on the market since the 1990's when the sit-stand office paradigm was proposed. Recently, we have seen a sharp rise in their popularity. It is believed that their increased demand has been related to evidence associating prolonged sitting with chronic disease and mortality. Given the increase requests from workers for these types of units, the desire for sit-stand workstations to become considered standard office furniture is possible. That type of inclusive, overarching philosophy can have serious investment (cost and time) implications.

**Resolution:** A review of the current scientific literature surrounding sit-stand devices was completed. To date, studies have focused on a wide range for outcome measures, such as: worker discomfort, health benefits, productivity, alertness, and worker perception. As an Industrial Hygienist, the increase in demand from workers makes it important to understand the effectiveness of these devices and how they play into managing musculoskeletal disorders (MSD) risk. The following issues will be addressed: 1) What are the main driving forces behind the recent demand for sit-stand workstations? 2) Are the reported benefits of sit-stand workstations supported by scientific literature? and 3) Are there any research supported sit-stand set up guidelines?

**Results:** Installing sit stand workstations as a means to encourage decreased sitting time and encourage health based outcomes are increasing in merit. Literature is also supporting the idea that sit-stand workstations may be beneficial in increasing worker comfort and decreasing MSD risk. Lastly, there are implementation details that should be considered in order to increase the success of a sitting reduction program.

**Lessons learned:** The majority of literature surrounding sit-stand workstations is favorable as it relates to reported worker discomfort, productivity and perceived value. Additional studies evaluating MSD specific outcome measures and long term compliance would be beneficial. In closing, sit-stand workstations may be helpful in providing postural changes for office workers. However, this option for encouraging movement at work is not the only tool available. As a result, caution is needed to ensure this solution is balanced with the realized MSD risk reduction obtained when installing these devices and the level of investment required at an institutional level to ensure success.

## P0116

### Non-Routine Industrial Hygiene: Evolving Issues in Emergency Response

Wednesday, May 25, 2016, 10:00 AM - 12:00 PM

#### CS-116-01

##### Industrial Hygiene OUTSIDE the Fenceline

*R. Jarecha, Paulsboro Refining Company, Paulsboro, NJ*

**Situation/Problem:** Over the last several years, there have been off-site/community impacts & concerns from either industrial facilities, train derailments, concerns over crude by rails, etc. There is a vital role that IHs can fill by establishing proper monitoring equipment, action levels, community evacuation zones, etc. that can protect both communities and industries best interests.

**Resolution:** Based on lessons learned from a railcar derailment and subsequent release of a hazardous material, our site took the community lead to establish an Air Monitoring Team. The team divided up the neighboring towns into 7 zones, and facilitated communication between State, County, and Municipal agencies to agree upon airborne limits to justify notification only, shelter-in-place or evacuation.

**Results:** We have an efficient method for performing air monitoring in the community quickly, utilizing pre-established sensitive locations in each community zone, and effective communication to officials via a paging system.

**Lessons learned:** Offsite impact (i.e. outside the fenceline) is a vital piece of emergency management and the one that public officials & agencies will be most concerned. Having a pre-established plan for the likely impacts will increase the response time, promote timely communication with the appropriate parties, and build trust among industry & public officials.

#### CS-116-02

##### A Comparison of Hazardous Materials Flow in Five Kentucky Counties: Urban vs. Rural Gradient

*J. Basham, V. Golla, and R. Taylor, Western Kentucky University, Bowling Green, KY*

**Situation/Problem:** The purpose of this study was to comparatively analyze five recent hazardous material commodity flow studies conducted in the state of Kentucky that were focused at the county level. These studies recorded the amounts and types of hazardous materials being transported, time of day, day of the week, and hazardous material incidents that occurred in the last 10 years. The five counties, Jefferson, Madison, Warren, Henderson, and Daviess were ranked on a rural-urban gradient using the National Center for Health Statistics' (NCHS) Urban-Rural Classification Scheme and then a comparison was performed using the data collected from previous studies.

**Resolution:** Multiple roadways were observed in each county. In order to compare the commodity flow in the counties, the monitored roadway with the highest hourly average of hazmat trucks was chosen from each county and used for analysis. Three of the five counties had interstates with the highest

hourly averages, Warren I-65, Jefferson I-71, and Madison I-75 while Daviess and Henderson counties had local highways with the highest hourly averages, Highway 60 and Highway 41 respectively. SPSS software was utilized for data analysis for this study. Descriptive statistical analysis revealed the frequencies for the placard identification number, the day of the week, and the time of day. A risk assessment analysis was also performed using a one-way ANOVA to determine if the average number of hazmat incidents differed based on county classification.

**Results:** Results from this study revealed that the most rural county, Madison County (I-75), and the most urban county, Jefferson County (I-71), were more closely related in terms of hazardous material flow compared to the counties in the middle of the rural-urban gradient, Daviess (HWY 60), Henderson (HWY 41), and Warren (I-65). Statistical significance was found using a post-hoc analysis: Tukey Honest Significant Difference (HSD), between the most urban and most rural counties when looking at 31 total incidents that had occurred in the last 10 years in the five counties. Descriptive statistics, including day of the week, time of day, and type of material, for the counties also found this similarity between the most urban and rural counties.

**Lessons learned:** Based on this study, more resources need to be devoted to counties that are most urban and most rural to ensure that communities in these areas are well equipped for emergency preparedness and response in view of the risk that exists due to the transportation of hazardous materials on our nation's roadways every day.

#### CS-116-03

##### Recommendations for Safe Handling of Human Remains Containing Viral Hemorrhagic Fevers (VHFs)

*J. Shugart, CDC/NIOSH, Decatur, GA*

**Situation/Problem:** As a result of multiple patients with Ebola virus disease (Ebola) seeking health care in the U.S. during the 2014 Ebola outbreak, the Centers for Diseases Control and Prevention (CDC) received numerous emails and telephone calls asking how to safely handle human remains contaminated with Ebola. Ebola can be transmitted in postmortem care settings by direct handling of human remains without recommended personal protective equipment (PPE), and through splashes of blood or other body fluids such as urine, saliva, feces, or vomit to unprotected mucosa such as eyes, nose, or mouth during postmortem care. Greater than 50% of all Ebola patients, including healthcare workers, have died. Because Ebola has a high case fatality rate, it is very likely that healthcare and mortuary workers will have to handle human remains.

**Resolution:** A stakeholder workgroup was formed with healthcare and mortuary workers in the private sector, national associations, and federal partners. As a result of a literature review and our combined fatality management experience, it was determined the existing CDC mortuary guidance issued earlier in 2014 needed to be updated. The new guidance provides additional occupational health and safety recommendations for healthcare and mortuary workers when handling human remains and surfaces and equipment used during postmortem care that may be contaminated with Ebola.

**Results:** The workgroup developed "Guidance for Safe Handling

of Human Remains of Ebola Patients in U.S. Hospitals and Mortuaries”, including a 21 step job aid specifically on the postmortem preparation in a hospital room. NIOSH staff also developed a companion training video “Recommended Postmortem Preparation of Human Remains Containing Ebola Virus”. Hospitals across the U.S. are already incorporating these recommendations into their domestic preparedness plans.

**Lessons learned:** The recommendations outlined in our guidance document and training video should be considered for other viral hemorrhagic fevers. For example, our recommendations have been used to safely handle human remains with Lassa fever in the U.S. It is crucial for public health professionals to work closely with their state and local officials and their partners who have agreed to implement these guidelines during the planning, response, and recovery phases.

## CS-116-04

### **Ebola Biosafety and Infectious Disease Response Training Needs Assessment and Gap Analysis for the NIEHS Worker Training Program**

*J. Rosen, National Clearinghouse for Worker Safety & Health Training, Research Triangle Park, NC; S. Beard, NIEHS, Research Triangle Park, NC*

**Situation/Problem:** In October of 2014, a series of Ebola Virus Disease (EVD) cases in Texas alerted the nation to a number of problems in preparedness and response to infectious diseases within the U.S. These events raised awareness of the threat posed by infectious diseases that can rapidly spread through transportation systems and of the risks they pose to workers within healthcare, transportation, emergency services, environmental cleaning, and other industries. The need to provide effective health and safety training to a broad spectrum of potentially exposed workers became apparent.

**Resolution:** Congress appropriated supplemental funds to the U.S. Department of Health and Human Services (HHS) to enhance the public health and health care system’s capability to respond to infectious diseases. The National Institute of Environmental Health Sciences in partnership with CDC, NIOSH, OSHA, and ASPR was designated to provide \$10 million dollars in worker safety and health training grants on biosafety and infectious disease response over a three-year period. To assess the gaps and needs in providing Ebola and other infectious disease training to workers who have potential exposure, NIEHS conducted a gap analysis that consisted of a literature review, survey, and focus groups of key stakeholders such as employers, union health and safety professionals, state and county health authorities, and researchers in New York, Washington, DC, California, and Ohio.

**Results:** Gaps were revealed in the areas of resources, available curricula and trainers, conflicting or vague guidance, and core competencies for worker safety and health training.

**Lessons learned:** Improvements in federal, state, and local guidance on worker safety and health protection from new or emerging infectious diseases should be clear and be rapidly implemented. Resources for ongoing training in biosafety and infectious disease preparedness and response can help stakeholders better respond to current and future infectious

disease threats.

## CS-116-05

### **A New Tool for Managing Dermal Risks: Dermal Exposure Risk Management and Logic (DERMaL) eToolkit**

*N. Hudson and S. Dotson, CDC/NIOSH, Cincinnati, OH; A. Maier, Environmental Health, University of Cincinnati, Cincinnati, OH*

**Situation/Problem:** The focus of risk management strategies traditionally has been inhalation exposures. However, dermal contact with chemicals can present significant direct, indirect, or latent health risks that are often not fully understood or addressed by the emergency management and response (EMR) community.

**Resolution:** The objective of this project was to develop the Dermal Exposure Risk Management and Logic (DERMaL) eToolkit to aid in preparedness planning and response in events involving potential dermal exposures to chemicals.

**Results:** The framework for the DERMaL eToolkit relies on three distinct decision making techniques: 1) scenario planning, 2) risk analysis, and 3) decision analysis. Using subject matter experts (SMEs) recruited from various technical fields, the resources included in the tool’s database were ranked on a set of variables (i.e., accessibility, reliability, and familiarity) to generate a value of information (VOI) score unique for each resource. This approach allows for the systematic identification, organization, and prioritization of relevant information resources in a specialized electronic library pertaining to dermal exposures to chemicals that are consistent with EMR needs (i.e. health effects, exposure assessment, exposure control methods, and medical management). By doing this, the DERMaL eToolkit provides a much needed structure based on contemporary decision analysis principles for dermal exposure to chemicals for the EMR community.

**Lessons learned:** The DERMaL eToolkit will provide access to guidance for emergency response and preparedness plans in addition to workplace procedures where dermal exposures represent a health risk. These resources contribute to public health preparedness and response by filling data gaps and providing rapid access to guidance for dermal risk assessment and risk management for the EMR community.

## SR-116-06

### **Emergency Responder Health Monitoring and Surveillance**

*R. Funk, National Institute for Occupational Safety and Health, Atlanta, GA*

**Objective:** The Emergency Responder Health Monitoring and Surveillance (ERHMS) system is intended to keep responders, volunteers, and contractors safe during all phases of emergency response (pre-, during, and post-deployment). ERHMS was designed to help determine the effectiveness of protective measures utilized during a response. It can be used to develop and target appropriate workplace interventions. ERHMS builds on lessons learned from the World Trade Center attacks, Hurricane Katrina, and Deepwater Horizon. Data collected pre-, during-, and post-deployment will help identify

those responders who would benefit from medical referral and long-term surveillance.

**Methods:** The National Institute for Occupational Safety and Health (NIOSH) developed the Emergency Responder Health Monitoring and Surveillance (ERHMS) system collaboratively with a National Response Team workgroup of federal, state, and local government agencies and responder groups.

**Results:** NIOSH has been engaged in implementation and field-testing of the ERHMS system during both real-world and simulated events. This includes responses such as the Ebola response, the Deepwater Horizon response in the Gulf, as well as a multi-agency federal exercise. The implementation phase of ERHMS seeks to determine how individual response organizations can optimally put the ERHMS system into practice themselves, as well as how an incident command structure (ICS) during an emergency response can best utilize ERHMS. Other implementation activities include classroom training, online training, and ERHMS Info Manager software. This database could streamline and standardize the use and sharing of ERHMS data among various responder groups.

**Conclusions:** ERHMS creates a new paradigm that protects responders pre-, during, and post-deployment. All responder agencies should implement the ERHMS system to better protect their responders. Incident commanders should request that an ERHMS unit be included in the Incident Command Structure to perform these important functions.

## P0117 Regulatory and Communication Issues in Hazard Assessments

Wednesday, May 25, 2016, 10:00 AM - 12:00 PM

## SR-117-01 Experimental Measurements of the Interzonal Air Flow Parameter ( $\beta$ ) for Two- Zone Concentration Modeling

*C. Keil, Wheaton College, Wheaton, IL*

**Objective:** Historic, contemporary, and potential exposures to airborne chemicals can be modeled using a variety of approaches. For scenarios where a worker is close to a source, a two-zone model can be used to describe the higher concentrations near the point of pollutant release. The interzonal airflow rate ( $\beta$ ) is important in describing the mass flow between near and far zones.

**Methods:**  $\beta$  was measured in 74 experiments conducted in 13 indoor airspaces. The airspace ranged in volume from 79 to 1,000 m<sup>3</sup>. The air change rates ranged from 0.20 to 21 ACH. Tracer vapors were released at known rates and the resulting concentration were measured by 4 photoionization detectors in the near zone around the point of release. A robot arm was used to simulate worker motion in the near field. The tracer mass release rate and the measured vapor concentrations were used to solve mass balance equations for  $\beta$ .

**Results:** The mean value of  $\beta$  for all air spaces was 5.2 m<sup>3</sup>/min [95% CI 3.4 - 7.0] and the geometric mean was 3.4 m<sup>3</sup>/min [95%

CI 2.5 - 4.5].

**Conclusions:** These values will be useful in applying the two-zone model for estimation of workers' exposures near sources of air pollutants.

## CS-117-02 Managing Compliance to New N-Methyl Pyrrolidone (NMP) PEL: A Challenge for the IH Professional

*A. Torres, Northrop Grumman Corporation, Redondo Beach, CA; N. Mack, Northrop Grumman, Torrance, CA*

**Situation/Problem:** N-Methylpyrrolidone (NMP) is a highly effective solvent cleaner for various materials, making it a widely used chemical in many industries, including aerospace. NMP is currently listed as a California Proposition 65 chemical due to its reproductive/developmental toxicity and exposure may result in both short and long term adverse health effects to workers. In 2014, CalOSHA published a NMP PEL of 1.0 ppm. This new PEL poses challenges for some industries because many different chemicals and products contain NMP. The California Department of Public Health has developed regulations for material handling and use of NMP, as well as a list of alternative chemicals to substitute NMP. Despite all this, industries have continued to use NMP due to its high performance and effectiveness. Furthermore, any modifications altering the process could cause complications and potential extensive requalification procedures that could lead to additional losses such as time and other resources. In addition to the challenge of enforcement from a safety perspective, is the challenge of shifting the work culture. Due to this recent change in CalOSHA exposure regulations, Industrial Hygienist/ Safety Professionals are tasked to assist in managing industry compliance to the new standard without disrupting daily operations.

**Resolution:** Industrial Hygienist/Safety Professionals developed strategies to address the challenges associated with complying with the new NMP standard with existing processes. Addressing the task includes effectively identifying NMP usage, assessing exposure potential for each process, determining how to mitigate/minimize exposure to NMP through engineering controls/PPE, and educating affected personnel.

**Results:** Process activities which utilized NMP, successfully met the new compliance standards through collaborative efforts between Industrial Hygienists/Safety Professionals, employees, management, facilities and vendors.

**Lessons learned:** To achieve success in meeting the new compliance standards, it is essential that employees, management and facilities are fully engaged in their efforts. Although FedOSHA has not adopted this new standard, industries should take a pro-active approach in identifying NMP in their processes and deploy measures to mitigate exposure risks. This will help minimize potential production interruption if compliance standards become adopted.

## CS-117-03 Justification for an Occupational Exposure Limit for Shale Gas Mixture

*P. Haas, Ever Green Health and Safety Consulting LLC, Palm Beach Gardens, FL*

**Situation/Problem:** There is the potential for significant worker

exposures to hydrocarbon vapor from production equipment used to extract shale reserves at well sites. Emissions from storage tanks at well sites have also led to serious exposure risks. Emissions include a bolus or plume of released vapor in the form of pressurized gas and mist when a tank inspection hatch is opened for workers to check volumes of liquid. Reported exposures to massive amounts of the hydrocarbon mixtures in the plume have resulted in lightheadedness, shortness of breath and suffocation (arrhythmia, anoxia and death).

**Resolution:** Using data contained in environmental, health, marketability and research reports, a case can be made for an occupational exposure limit (OEL) for shale gas hydrocarbon vapors. An OEL-C (ceiling limit) for bolus exposures may be the safest alternative. Anecdotal information suggests the primary compounds are light-end aliphatic compounds including methane, butane, and propane up to hexane (C2-C7). Interim OEL's for controlling exposures exist on the basis of: industry practice API 18.1, interventions from recent governmental evaluations of reports of fatalities, and oil and gas industry requirements. NIOSH Current Intelligence Bulletin (CIB-66) recommends an OEL Ceiling limit (C-OEL) for compounds with health-based IDLH values which are greater than 10% of the lower explosive limit (10% LEL).

**Results:** Because of the compositional, mixture and toxicological variations in shale gas mixtures, there are many obstacles to providing a single limit, or even multiple provisional limits for worker health. There are hurdles to overcome in estimating what extent of the total amount of the gas vapor in a bolus exposure is potentially inhaled displacing oxygen and how this exposure causes effects to health. This invites controversy as to what portion of the total dose a worker should receive (5%, 10%... 40% of the LEL) before deciding a safe limit. This discussion does not intend to cover the great deal of toxicological research needed or decision making required to arrive at an OEL. This presentation offers relevant data and makes a case for consensus among the industry and scientific community concerned with limiting health effects to workers from exposures to shale gas mixtures.

**Lessons learned:** Recent reports of exposures suggest that the practice of tank gauging for shale gas warrants intervention. Government evaluations of the fatalities and allied oil and gas industry partners are considering changes to exposures by recommending an OEL. Obviously, across the far reaching shale plays in the U.S. and worldwide the composition of a production mixture could widely vary; so this estimate needs a great deal of research in order to bear out a common toxicological profile. Recent evidence from U.S. fatalities in the Bakken shale and reports of air samples from other locations bears out a commonality, on the basis of reported concentrations of methane, butane, propane up to n-hexane gas mixtures evolved which may be found in concentrations up to 40% of LEL in the bolus. Calculations of exposure limits for shale gas concentration using a method analysis as described by ACGIH® TLV® Appendix H. Reciprocal Calculation Method for Certain Refined Hydrocarbon Solvent Vapor Mixtures and others such as the British Health and Safety Executive Reciprocal calculation procedure for mixtures of hydrocarbon solvents are discussed as a means beyond using 10% of the LEL as an interim control step of worker safety and health.

## SR-117-04

### Premiering the NIOSH Manual of Analytical Methods, 5<sup>th</sup> Edition

*P. O'Connor, CDC/NIOSH, Cincinnati, OH*

**Objective:** The NIOSH Manual of Analytical Methods (NMAM) is a collection of methods for sampling and analysis of contaminants in workplace air, and in the blood and urine of workers who are occupationally exposed. In 2016, the NMAM will begin publishing the 5<sup>th</sup> Edition.

**Methods:** The 1<sup>st</sup> edition of the NMAM was published in 1975. For this 5<sup>th</sup> edition, there will not be a printed version of the NMAM. This will be a living document: meaning that as the methods and chapters are reviewed and approved they will be posted on the NMAM Website. The results of a survey of NMAM users helped shape the direction of the 5<sup>th</sup> edition, with new and updated chapters as well as new methods for air sampling, for biomonitoring and for wipe sampling. A number of the new methods were published in collaboration with our international partners. The webpage has a new look that uses a responsive design format to allow viewing of the NMAM on any electronic device. In addition to access of all the methods for the 5<sup>th</sup> edition, the "historical" 4<sup>th</sup> edition will still be available for use.

**Results:** Methods for assessment of workplace air quality were evaluated by using air samples taken in controlled laboratory atmospheres. These sample results were evaluated using the NIOSH Accuracy Criteria as well as determining the methods' bias and precision. Examples of some of the new methods are wipe methods for methamphetamines, elements using microwave digestion, and measuring such compounds as acetone or toluene in biological matrices such as urine or blood. A new method that combines a great number of the 4<sup>th</sup> Edition NMAM volatile organic compound (VOC) methods into one method (with all the evaluation data in one place) should allow industrial hygiene labs to be accredited now for just one method while retaining the ability to analyze many VOCs under their accreditation.

**Conclusions:** Harmonization of NIOSH methods with related voluntary consensus standards is a strategic goal for the 5<sup>th</sup> edition of NMAM. This 5<sup>th</sup> Edition NMAM is responsive to the current needs of the industrial hygiene community and the living nature of the document lends itself to adaption to meet any future needs in occupational exposure assessment.

## CS-117-05

### Assessment and Control of Low Observable Sanding Processes on F-22 Aircraft

*M. Ferreri and A. Pabon, Bioenvironmental Engineering, US Air Force, Hickam AFB, HI*

**Situation/Problem:** US Air Force F-22 aircraft use Chromium VI and silver paints as part of the low observable stealth coatings. As part of the maintenance of the aircraft along with maintenance of the stealth coatings, Low Observables (LO) workers hand and pneumatic sand aircraft to remove coatings to allow for reapplication. The 154 Wing LO shop needed to move to a new building due to renovations of their current facility. A new controls scheme needed to be developed in compliance with OSHA substance specific standards and Air Force Instructions (AFI).

**Resolution:** The Air Force Bioenvironmental Engineering flight

performed 4 sets of personal and area samples to determine the extent of the chromium VI and silver exposures. This data was used to develop a control scheme and housekeeping plan for the control of the chromium VI and silver exposure along with establishing regulated area extent.

**Results:** Statistical analysis for personal and area samples showed a 95<sup>th</sup> percentile personal exposure to chromium VI of 0.001 mg/m<sup>3</sup> with an exceedance fraction of 0.599%. Analysis of silver data showed a 95<sup>th</sup> percentile personal exposure of 0.181 mg/m<sup>3</sup> with an exceedance fraction of 55.3%. Area samples at the 20' distance also showed silver samples above the PEL for silver, but levels below the PEL at 40'. A 40' cordon from hazard point of generation was established for sanding processes. LO workers inside the cordon utilize ventilated sanders and full face respiratory protection. Additionally, a thorough contamination control plan was developed to support LO workers and reduce chromium VI and silver contamination.

**Lessons learned:** Sometimes the expected worst hazard is not the hazards that drives control actions. Worker practices are a dominant determinant of exposure. Different areas of the aircraft have different stealth coating layups and this will drive level of exposure to workers.

### CS-117-06

#### What Do You Mean My Laboratory Report May Have Errors? Successful Methods for Identifying, Mitigating, and Managing Data-Related Errors

S. Funk, R. Strode and A. Duane, *Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO*

**Situation/Problem:** All analytical data are subject to both random and systematic errors. Through deliberate efforts, the IH should try to minimize potential errors associated with data generation. Many IHs consider laboratory data ready for use and interpretation. However, laboratories are not infallible and errors associated with reported results should be anticipated and controlled. Some common issues associated with the laboratory data include rounding errors, transcription errors, and significant figure errors. Additionally, mistakes made by the IH in the field, or in reporting field related information to the laboratory, may also occur before and after sample submission, including transcription and statistical calculation errors. From a health protection and liability perspective, making exposure and risk assessments, or other data-based determination using inaccurate data can be a serious problem for both the exposed individual(s) and the IHs performing the work.

**Resolution:** As an IH you should be intimately familiar with your data and establish a QA/QC process to ensure data accuracy and completeness. All field generated data provided to the laboratory should be reviewed prior to laboratory receipt or analysis, and all laboratory generated data should be reviewed upon receipt of the laboratory work order notification, and after analysis. An approach was developed and implemented to ensure a thorough QA/QC procedure with tracking capabilities for all samples that are collected by field personnel. In this process, all data are reviewed at multiple levels, utilizing a systematic QA/QC approach. Implementation of these processes has reduced the errors associated with reported data, from sample collection through use of the data in assessing exposures and risks.

**Results:** Both personnel and laboratory errors associated with sample collection were identified that would have been missed. Reducing these errors is very important as any data errors are magnified during exposure and risk assessments, or other data-based calculations.

**Lessons learned:** The error associated with data collection and analysis can be significantly reduced with simple standardized QA/QC procedures, and by the IH taking ownership of the data they collect.

### P0118

#### Health and Safety Risk Assessments, Guidelines, Inspection Methods, and Other Current Topics

Wednesday, May 25, 2016, 1:30 PM - 3:50 PM

### SR-118-01

#### Developing Scaffold Use Risk Assessment Model for Construction Safety

K. Czarnocki and E. Czarnocka, *Lublin University of Technology, Lublin, Poland*; D. Byc, *St. John of Dukla Cancer Center, Lublin, Poland*

**Objective:** Problems in occupational health and safety commonly occur in the construction industry, including falling of materials or person from height, stepping on objects and injured by hand tools. Scaffold use is an important factor in construction occupational safety. All scaffolds used in construction, renovation, repair (including painting and decorating), and demolition shall be erected, dismantled and maintained in accordance with safety procedures. For safety professionals, it is crucial to have risk assessments for scaffold use. It has been found that some professionals are prone to rely heavily on their experience and knowledge, instead of using a systematic approach for a scaffold use risk assessment. There is also a lack of ways to check the reliability of the decisions made.

**Methods:** A Scaffold Use Risk Assessment Model (SURAM) has been developed for assessing risk levels at various construction process stages with various work trades. The SURAM is the result of a research project conducted at 60 construction sites. The 420 observations completed included: harmful physical and chemical factors, stress level, worker habits, as well as ex-post reconstruction of construction accident scenarios. ANN modelling tool has been used for the development of the SURAM.

**Results:** Common types of trades, accidents, and accident causes have been explored, in addition, to suitable risk assessment methods and criteria. We have found the initial stress level is a more direct predictor for developing of the unsafe chain leading to the accident than the work load, and concentration of harmful factors at the workplace.

**Conclusions:** Based on a set of historical accident data, the developed SURAM seems to be beneficial for predicting high-risk construction activities and thus preventing accidents.

## CS-118-02

### Facility Safety Guidelines for the Manufacture of Lithium Ion Battery Power Banks

*M. Andrew and J. Dankin, Sumerra, Portland, OR*

**Situation/Problem:** Small lithium ion battery power banks are nearly ubiquitous in the gadget central world that we currently inhabit. A single small battery poses minimal risk to the end user, but what about facilities producing high volumes of these battery packs for retailers. In our international work, we often observe inconsistent or lack of good safety practices at contract manufacturers, especially in small and medium size businesses that often escape the eye of regulators. The storage, handling, and use of large numbers of lithium ion battery cells present a real risk of fire or explosion if precautions are not taken. Based on our initial research, little industry specific guidance was available to these manufacturers.

**Resolution:** A literature review was conducted to identify studies or recommended best practices for the safe manufacture of these battery packs. General guidance regarding fire safety and material handling was available, however, minimal industry specific guidance could be located for manufacturers. Therefore, we set out to develop a simple to follow guideline of good practices that would address these concerns and provide a user friendly reference for manufacturers. Additionally, a site visit was conducted at a battery manufacturer to interview the management regarding their knowledge of safety practices and to identify specific hazards that may need additional guidance.

**Results:** An industry specific safety guideline was developed and distributed to interested stakeholders who in turn could then provide to suppliers and contract manufacturers. The guide provides basic and easy to follow best practices for manufacturing of lithium ion batteries, specifically addressing risks in receiving & storage, production & assembly, battery testing & inspection, emergency preparedness & response, and firefighting equipment & response.

**Lessons learned:** Industry and even product specific guidelines are useful in mitigating risk at small and medium sized businesses, especially in countries with developing economies that may have limited or rarely enforced safety regulations, or a general lack of institutional occupational safety knowledge. The mix of practical knowledge from the experience of working in factories and specific educational knowledge regarding occupational safety is key to providing an easy to understand guideline.

## CS-118-03

### Health and Safety Risks Associated with Craft Brewing: Characterization of Breweries within British Columbia

*P. Chua, WorkSafeBC, Burnaby, BC, Canada*

**Situation/Problem:** Craft breweries are small, independently-owned commercial breweries that employ traditional brewing methods. To classify as a craft brewery in British Columbia (BC), annual production must be less than 160,000 hectolitres.

Craft breweries within BC are growing at an exponential rate. The market share for craft beers has doubled in the past four years, from 9% of all beer sales in 2009 to more than 20% in 2014. Employers who start up craft breweries are often inexperienced and unsophisticated. These employers are typically small and often collaborate with other small employers to solve mutual issues such as health and safety.

**Resolution:** The purpose of this study is to: (1) characterize the extent of occupational health and safety (OHS) hazards and exposure risks within craft breweries; and (2) to probe employers within this industry on their knowledge depth of these hazards. Data was collected through publicly available and internal (government) databases. Brewery inspections, focus group discussions with industry representatives, and hygiene sampling of brewery activities were also performed.

**Results:** Brewery hazards are similar to those found in manufacturing operations. However, brewery hazards are primarily occupational hygiene hazards, which are less recognizable to unsophisticated employers. Industry identified hazards include: noise, boiling liquids, unprotected heated surfaces, exposure to caustic chemicals and chemical storage/containment, musculoskeletal strain, dust (explosion potential and respiratory susceptibility), confined spaces, carbon dioxide exposure and oxygen deficiency. Instantaneous carbon dioxide measurements for common brewery activities often approach the action limit. Worker exposures often exceed 25% TWA, and occasionally exceed the action limit. Areas of particular interest are cellar/tank farm(s), walk-in coolers, and barrel fermentation rooms. Post-secondary institutions with brewing programs in BC have a superficial health and safety component within the curriculum.

**Lessons learned:** Health and safety resources specific to the craft brewery industry are lacking. Industry-specific associations and organizations have different aims, with health and safety low in priority. Recommendations include increasing awareness of industry hazards through collaboration with stakeholders to guide development and communication of health and safety resources.

## CS-118-04

### Traffic Flow Risk Assessments: A Tool for Reducing Pedestrian/Vehicle Accidents

*N. Orr, Becton Dickinson, Franklin Lakes, NJ*

**Situation/Problem:** The interactions of pedestrians and vehicles, including powered industrial trucks, within industrial plants and on the surrounding property, present serious safety risks. These hazards are exacerbated by increased crowding in manufacturing spaces and unanticipated changes to machine layouts.

**Resolution:** Traffic Flow Risk Assessment (TFRA) is a relatively simple tool to identify where these overlaps occur and to develop recommendations to eliminate or reduce the potential for contact and possible incidents. The TFRA approach includes separately mapping pedestrian and vehicle traffic flows at a facility and identifying key overlaps that pose a risk to workers. This is best done with a cross-functional team of workers from warehouse, supply chain, material management and operations. Once problem areas have been identified, solutions

that align with the hierarchy of controls (eliminate, separate, control or minimize exposures) are developed.

**Results:** This presentation will review the results of several TFRAs conducted at multiple locations within a major paper company and a large medical device manufacturer. Significant reductions in the number of pedestrian/vehicle incidents occurred when this approach was implemented.

**Lessons learned:** Strategies for successful deployment of this tool, including lessons learned during the pilot phase, will be presented. Examples of effective engineering controls will also be shared.

## CS-118-05

### An Efficient Safety Inspection Method and System for Navy Installations

*P. Aysola, A. Harkins, and R. Maiello, Commander Navy in Command, Washington, DC*

**Situation/Problem:** An efficient, web-based global Occupational Health & Safety Management System with physical location identification capability is needed to monitor workplace safety requirements and workload at all Navy bases with host-tenant relationship responsibilities. Commander Navy Installations Command (CNIC) is the shore integrator for the United States Navy and provides Base Operating Support (BOS) Safety and related home port services for the Fleet across an enterprise consisting of 11 Regions, 70 bases and more than 3,000 assigned tenant command activities worldwide.

**Resolution:** A Mono-UIC (User Activity Title) is a term developed by CNIC HQ N35 Safety to identify the exact tenant location eligible to receive CNIC Base Operating Support (BOS) Safety services. A mono-UIC is the singular unit identification code of any Navy or non-Navy tenant activity of a CNIC installation that is currently on record as leasing real property facilities or facility spacels) assigned by the host installation. The web-based Safety Data Management System creates Inspection identification (ID) for every Mono-UIC ID workplace, scheduled safety inspection, types of safety inspection categories (OSH, Explosive, Traffic Safety, RODS, Unsafe Unhealthful Conditions, Radiation, and Industrial Hygiene etc.), safety training and several other workload parameters for each installation. This unique Safety Data Management System is also used by Public Safety (e.g., Security Force, Emergency Management, Fire and Emergency Services).

**Results:** Monthly data sets are analyzed using Excel Key Performance Indicator (KPI) pivot dash board and Visual Basic (VB) codes to: determine work load requirements; monitor safety inspection progress; and develop algorithms to optimally distribute the minimal amount of resources to ensure compliance with official, overarching guidance at varying levels of assurance.

**Lessons learned:** Data from Mono-UIC location based ID system is used by all Installation Safety Inspectors and Regional Program Directors (RPDs). It is populated with several safety and security related parameters and provides several opportunities for case control and cohort studies, remote auditing, monitoring of several safety related parameters. CNIC has been using Mono-UIC ID system for

three years. Instant access to safety inspection schedule ID, Mono-UIC ID, date, inspection type, completed date, inspector name, non-compliance warning and several other requirement parameters has made a tremendous impact on improving CNIC N35 safety inspection efficiency.

## CS-118-06

### Tick-Tock: Safety and Health Considerations Surrounding the Aging Worker

*P. Rice, ClickSafety/Ahtna Netiye, Walnut Creek, CA*

**Situation/Problem:** The aging workforce in the US and throughout the globe is one of the most significant trends employers face today and will continue to face in the decades to come. Americans are living and working longer and as a result, older employees constitute a larger segment of the workforce, especially the Baby Boomer generation who consistently state their plans to work well beyond the age of 65 (TIP: Everyday, 8,000 Baby Boomers turn 65).

**Resolution:** There are tremendous upsides to maintaining and hiring the older worker within your organization. There is no substitute for experience, a strong work ethic, loyalty, diversity, mentorship, lower absenteeism, team oriented and self-confidence of this demographic of worker. However, hiring and employing older workers may mean an increase in safety and industrial hygiene concerns for the safety and health professional. There are concerns of rising expenditures for various health-related benefits. Although work injury rates for older workers are lower, they are costlier to treat or compensate when they do occur. Chronic health conditions rise with age. As the workforce continues to age, employers can expect an increase in the number of workers with chronic conditions. Having an understanding of the aging process of these systems is important for the safety and industrial hygiene professional to recognize so that hazard evaluation and control strategies can be adopted. Smart strategies can be effective in mitigating incidents, reducing injury costs and promoting quality and production.

**Results:** This presentation will focus on the potential risks, evaluation and control techniques to promote safety and health among older workers, young workers and the entire workforce. Case studies will be presented how some progressive safety and health departments are taking the issue of older worker safety and health head on with training, medical and engineering interventions. Topics include common classifications of aging (Chronological vs. Biological vs. Functional, there are truly different shades of gray), incident statistics, body systems and the older worker challenges, discussion of how the interaction of lifestyle, work environment and genetics may impact workplace safety. Additionally, we will discuss tips and techniques for the safety professional (e.g. using BBS principals, motivation techniques, and communication programs). We will also discuss and offer up some suggestions relative to the importance of senior fitness and nutritional programs.

**Lessons learned:** The workforce is getting older The older worker has a tremendous upside for organizations. The older worker presents challenges to the IH professional in terms of chemical, physical, ergonomic exposure and response that can

be managed to promote a safer and more healthful workforce.

## CS-118-07

### Dust Explosions: The Nature of the Problem and Practical Measures for Its Control—Including the Requirements of the New NFPA 652 for “Dust Hazard Assessment”

*V. Ebadat, Chilworth Technology, Inc. - a DEKRA company, Princeton, NJ*

**Situation/Problem:** Many powders will burn slowly or with difficulty as a layer on a surface, but can explode if dispersed as a cloud. In fact, the vast majority of powders can form explosible dust clouds if the particle size is small, moisture content is low, and the dust cloud concentration (measured in g/m<sup>3</sup>) is above the Minimum Explosible Concentration (MEC).

**Resolution:** The size of the dust particle is a property which influences the explosibility of the dust cloud. The finer the particles, the greater the surface area per unit mass and thus, the more explosible a given dust is likely to be. The ease of ignition and the severity of the resulting explosion increases with a decrease in particle size. The moisture content of a product will also affect the explosion risk.

**Results:** A systematic approach to identifying dust cloud explosion hazards and taking measures to ensure safety against their consequences generally involves: 1. Understanding of the explosion characteristics of the dust(s); 2. Identification of locations where combustible dust cloud atmospheres could be present; 3. Identification of potential ignition sources that could be present under normal and abnormal conditions; 4. Proper process and facility design to eliminate and/or minimize the occurrence of dust explosions; and 5. Adequate maintenance of facilities to prevent ignition sources and minimize dust release

**Lessons learned:** This presentation will discuss a well-trying approach to identify, assess, and eliminate/control dust explosion hazards in facilities. Attendees will be provided information to screen the materials that they handle and aid in determining the precautions that should be taken in handling, processing, and storing combustible powders. This will include sensitivity to various types of ignition hazards (such as electrical arcs and electrostatic discharges) and the severity of combustion incidents (such as explosions and flash-fires). This presentation will also include the Dust Hazard Assessment (DHA) requirements of the New National Fire Protection Association (NFPA) 652: Standard on Fundamentals of Combustible Dusts. Attendees can expect to leave this presentation better equipped to respond to questions concerning the equipment and environment in which combustible dusts are handled and how to meet the requirements of the new NFPA 652.

## P0119

### IH Data: Tools for Exposure Assessment and Epidemiology

Wednesday, May 25, 2016, 1:30 PM - 4:10 PM

## SR-119-01

### Epidemiology of Hearing Impairment and Injuries in the U.S. Military

*D. Gimeno, J. Betancourt, and K. Whitworth, The University of Texas School of Public Health, San Antonio, TX; D. Tucker and N. Gorrell, The Geneva Foundation, San Antonio, TX; T. Hammill and M. Packer, Department of Defense Hearing Center of Excellence, San Antonio, TX; A. Senchak, Walter Reed National Military Medical Center, Bethesda, MD*

**Objective:** To provide an epidemiologic analysis of hearing impairment and injury among U.S. military personnel.

**Methods:** For the main epidemiological analysis, we included 15-64 year old Active Duty Armed Forces serving during fiscal years (FY) 2008 to 2012, and who have at least one clinical encounter with select hearing related ICD-9 diagnoses. Cases were identified from records from direct care (CAPER: Comprehensive Ambulatory/Professional Encounter Record, and SIDR: Standard Inpatient Data Record) and paid provider (TED-I: TRICARE Encounter Data-Institutional and TED-NI: TRICARE Encounter Data-Noninstitutional) data sources. We also identified cases using the Defense Occupational and Environmental Health Readiness System-Hearing Conservation database (DOEHRs-HC), which maintains hearing conservation and audiometric data across the DoD. The Defense Manpower Data Center provided data on at-risk denominators by the demographic and job-related characteristics.

**Results:** Demographics of the sample appeared stable over the study period, with an average annual population of approximately 1.4 million Service Members. The initial unadjusted overall incidence rate increased from 27 cases per 1000 persons to 27.6 cases per 1000 persons over the study period. The tinnitus incidence rate increased from 9.3 cases per 1000 persons in FY 2008 to 12.3 cases per 1000 persons in FY 2012. The rate of sensorineural hearing loss slightly decreased from 11.4 cases per 1000 persons to 10.7 cases per 1000 persons at the end of the study period. In general, rates of injury were highest in males, in the Army, in senior officers and in older service members. Rates will be presented for all analyzed ICD codes.

**Conclusions:** This study will lay the groundwork for comprehensive epidemiologic studies of hearing outcomes among U.S. military personnel. Results from this project will draw much needed attention to this critical issue, encouraging initiatives to improve the auditory health and wellbeing of Service Members and aiding in the development and implementation of prevention measures.

## SR-119-02

### Outpatient Costs of Hearing Loss in the U.S. Military: Direct Care and Paid Provider Care

*H. Alamgir, J. Betancourt, and C. Turner, The University of Texas School of Public Health, San Antonio, TX; D. Tucker and N. Gorrell, The Geneva Foundation, San Antonio, TX; T. Hammill and M. Packer, Department of Defense Hearing Center of Excellence, San Antonio, TX; A. Senchak, Walter Reed National Military Medical Center, Bethesda, MD*

**Objective:** The goal of this research is to comprehensively determine the economic impact of hearing impairment and noise-induced hearing injury (HINIH) among active duty U.S. Service Members from the perspective of the DoD

**Methods:** This study is a retrospective review of data collected on active duty military service members (SMs) during the January 1, 2007 to December 31, 2012 timeframe. Clinical data on military SMs who were diagnosed with one or more of the identified ICD-9 codes (associated with HINIH) from the Medical Data Repository (MDR) was received by the Military Health System Management Analysis and Reporting Tool for our analysis. This research reports findings from two M2/MDR clinical data sets: Tricare Encounter Data-Noninstitutional (TED-NI) which provides data on care provided by civilian paid providers outside a military treatment facility (MTF) and Comprehensive Ambulatory Encounter Record (CAPER) which provides data on direct care provided by military providers in an MTF.

**Results:** We obtained 8,251,109 encounter records from CAPER, representing 1,865,676 distinct patients, and 1,865,965 encounters from TED-NI, representing 243,349 distinct patients. Tympanic membrane disorders, males, and medical centers have relatively higher mean costs for HINIH in both TED-NI and CAPER. In both databases, fiscal year, diagnosis code, and age were significantly related to RVU dollars. Compared to other disorders of ear, CAPER and TED-NI revealed that patients with tympanic membrane disorders had a higher cost than those with other diagnoses. Patients  $\geq 65$  years-old in TED-NI cost more than the other age groups. Cost differences between males and females were not significant in CAPER, but females cost significantly less than males by an average of 57.34 RVU dollars (p-value = 0.0078) in TED-NI. Pay grade and facility size were only significant in CAPER (p-values < 0.0001).

**Conclusions:** Our estimates are a valuable decision making tool for DoD policymakers. These cost estimates may identify high burden groups, enable proactive measures for concerted education and training, identify best practices, and develop return-to-duty programs following HINIH, all of which may contribute to the retention of skilled, experienced, and mission-ready military personnel.

## CS-119-03

### Assessment of Dermatitis Among Chair Sanders

*N. Burton and L. Tapp, CDC/NIOSH, Cincinnati, OH*

**Situation/Problem:** NIOSH received a Health Hazard Evaluation (HHE) request from management of a chair manufacturing facility. They were concerned about skin rashes among sanders

in the clean-up (or sanding) department. Two employees had severe skin reactions at work and could no longer work in the department. The employees performed repairs using epoxy resins, sanded rough areas on wooden frames, and cleaned the frames using different chemicals including acetone. The work was done on downdraft benches, raised platforms, or the floor, depending upon the size of the piece. The screws used in the chair frames had been changed to a larger size that required angled holes to provide additional strength. The holes had to be filled with epoxy resin which was mixed by hand to match the color of the frame. The company required employees to wear either nitrile or vinyl gloves. This area of the facility did not have general ventilation.

**Resolution:** Several recommendations were made: installing local exhaust ventilation for the hand sanders; adding a vacuum system instead of compressed air to remove dust; using an epoxy gun to apply epoxy; using polyvinyl gloves when working with epoxies; using goggles or safety glasses when working with epoxies and other chemicals; reporting skin rashes to management when they occur; and referring employees with persistent rashes to a dermatologist with occupational medicine experience.

**Results:** Wipe sampling showed that dust from epoxy resins was found throughout the cleaning department. Air sampling for volatile organic compounds showed no over-exposures. The downdraft tables were not effective in controlling dust levels due to the size of some of the chair frames. The amount of epoxy used in the cleaning department was greatly increased after the change in frame design. Confidential medical interviews with employees showed that 8 of 18 employees reported current or recent skin irritation. Review of medical records confirmed that one employee showed an allergic skin reaction to epoxy resins when tested by skin patch testing.

**Lessons learned:** Epoxy resins were suspected to be the cause of the skin rashes. Engineering controls, improved work practices, and the use of personal protective equipment were needed to reduce the exposure to epoxy resins.

## CS-119-04

### Total Exposure Health

*R. Hartman, Planned Systems International, Arlington, VA; K. Phillips, Dept. of Defense, Alexandria, VA*

**Situation/Problem:** Through “total health” and Total Worker Health™, both private and public sector organizations have made strides toward achieving the President’s Precision Medicine Initiative. This initiative is an approach for disease prevention and treatment that takes into account an individual’s unique genes, environment, and lifestyles to provide personalized healthcare. However, they have overlooked one key factor that influences individual health risks: the exposure which drives both protective and clinical interventions.

**Resolution:** As industrial hygienists, we are positioned to effectively contribute to this fundamental change in our health care system as exposure scientists, linking our expertise not only to the occupational health of individuals but also to their overall well-being. Understanding that the impact of exposures are strongly related to sociocultural and economic status, occupational and environmental factors, and lifestyle choices, we created the Total Exposure Health (TEH) concept that incorporates workplace, environment with lifestyle exposure and provides a path to precision medicine.

**Results:** We will discuss various operational models and examples to show how TEH takes our existing knowledge of exposures and connects them to the individual's organ systems, cellular function, and DNA, along with classic industrial hygiene modeling (toxicokinetic modeling, cell toxicity, organ damage, etc.). As a new healthcare infrastructure to be defined and built, we will also show how TEH will position industrial hygienists as exposure scientists to improve the worker experience with a focus on individual exposures (unique and targeted).

**Lessons learned:** Exposure means different things to different people, so we conveniently packaged TEH into a simple brand. We revealed TEH as a catalyst to move exposure health away from animal data and population models to individual personalized effects of exposure. We also found TEH fosters innovations in research and technology development through programmatic support and can promote economic development, particularly in science, technology, engineering and mathematics (STEM) career fields. Lastly, we found TEH to be a system integrator between programs, policies, and disciplines that creates conversations and collaborations through a unified understandable goal to improve employee healthcare in the United States.

## CS-119-05

### Development of an Explosive Dust Screening App

*M. Rollins, Isosceles Group, Brooklyn, CT*

**Situation/Problem:** Dust explosions, despite all the research, recommendation, and regulations, continue to plague industry. Often times, the lack of recognition of the explosion potential is the reason the hazard goes unnoticed, and uncontrolled. One of the challenges is a way to rapidly assess and rank potential hazards, ranging from basic housekeeping to dust Kst value to material(s) processed.

**Resolution:** Creation of an expert system allowed for rapid screening of processes that could pose a dust explosion hazard. FileMaker was used to develop a custom iOS app for this purpose. Over 50 questions (e.g. depth of dust on surfaces) on 9 rubrics (materials, housekeeping, etc.) were developed. Questions are based on recommended screening from NFPA, OSHA, EU Directives, FM Global, and others. Each question is scored based on the multiple-choice answer from a drop-down menu, so that higher-risk answers result in a higher overall risk profile score. The score for each rubric is also tallied. The report generated in-situ from an iOS device provides a multi-page PDF document listing each question, with specific recommendation for deficiencies noted.

**Results:** Screenings for processes was completed, with higher hazard areas identified. These could be addressed by priority in a more efficient manner.

**Lessons learned:** The use of a properly designed, formatted and tested expert system app allowed dust hazard screening to be accomplished in hours as opposed to days.

## CS-119-06

### Developing a System to Track OSH Issues with Major Construction Projects

*D. Harman and T. Carraway, US Dept. of State, Aberdeen, MD*

**Situation/Problem:** The Department of State's Office of Safety, Health, and Environmental Management is involved in the planning and construction of new facilities (Embassies and Consulates), as well as major rehabs of existing buildings. One part of this process is to have an OSH professional conduct a site visit at approximately 85% completion. This site visit is to ensure that the completed project will meet applicable codes, DOS specifications, and the design drawings. In the past, the professional would produce a Word or Excel document with the issues and suggested resolution and leave it with the project management team for implementation. However, there was no process for follow up to ensure that the issues were addressed.

**Resolution:** DOS SHEM already has in place a software system to collect, track, and report on the results of visits to US Embassies and Consulates to ensure that any OSH hazard identified are addressed in a timely manner. That framework could be modified to perform similar collecting, tracking, and reporting of issues with construction projects. So a project was started with the same programming team that had done a recent rewrite of the other system.

**Results:** A new software development approach was used by the software team. Instead of writing a Requirements Document, the programmers would start programming, and there would be regular meetings to see the progress and provide feedback, and the Requirements Document would be produced on the fly, at the same pace the software development occurred. This approach caused a lot of moving 1 step forward then 1 or 2 steps back, and so forth. Programmers would start down a path, and then find they had gone a wrong direction. The system eventually was completed and is functional. Since, it was not replacing an existing system, it could go online in a less polished form. Also, there are a much smaller number of users, so the roll out is more like a Gamma (more than Beta) test and minor glitches would be acceptable.

**Lessons learned:** The big lesson learned is the traditional method of writing a Requirements Document makes for a smoother process to write the software. It is helpful to both sides, as it is a contract between the users and the programmers of what is expected at the end. It reduces the false paths and blind alleys of the more free flowing approach. But in the end, with close work between the user side and good programmers, you end up with a good system that does what you need it to do.

## SR-119-07

### Improving the Estimation of the Interzone Air Exchange Rate in the Near Field-Far Field Model by Computational Fluid Dynamic Simulations

*W. Chouchen and S. Halle, Ecole de technologie superieure, Montreal, QC, Canada; M. Debia and C. Castro Ruiz, University of Montreal, Montreal, QC, Canada; A. Bahloul, IRSST, Montreal, QC, Canada*

**Objective:** The two-zones, also called Near Field-Far Field (NF-FF) model, is commonly used by industrial hygienists for predicting occupational exposures to vapor of solvents. Input parameters in the NF-FF model include the near field volumes, the room supply air flow rate and the inter-zone air exchange rate between the NF and FF ( $\lambda$ ). The  $\lambda$ -parameter is determined from the averaged velocity at the zone interface and the available free surface area of the NF volume. However, the air velocity at the zone interface is generally unknown and important assumptions have to be made. The objective of this communication is to improve the determination of the  $\lambda$ -parameter by using computation fluid dynamic (CFD) simulations.

**Methods:** A simulated 54.5 cubic meters room with a constant acetone generation rate was investigated applying the NF-FF model (IHmod, V0.209). The NF was defined as a 1.8 m height cylinder with a radius ranging from 0.5 m to 1.5 m from the emission source. The average air velocity at the zone interface was determined, by CFD (FDS, V6.2), for two ventilation scenarios: air supplied from a ceiling square diffuser and from a sill wall grid. In each scenario, four room air supply rates were used: 2, 4, 6 and 8 air changes per hour (ACH).

**Results:** For a given air supply rate, the averaged air velocity is nearly constant for both ventilation scenarios regardless the distance from the contaminant source and depends only on the free surface area, hence the radial distance from the source. The average contaminant removal efficiency for the first and second ventilation scenario are 0.95 and 0.71 respectively. A linear relationship ( $R^2=0.94$ ) was found between the air change per hour and the averaged air velocity in the NF zone. For small free surface area, steady-state concentration in the NF zone is up to 20 times higher than the concentration obtained from the CFD simulations. However, NF concentration is only 2 to 3 times higher than CFD results, when the NF zone is defined as a 1.5m radius cylinder around the source. These results allowed us to determine an "optimal" free surface area for each ACH.

**Conclusions:** Estimation of the  $\lambda$ -parameter from CFD simulations can improve significantly NF concentrations in the two-zone model.

## CS-119-08

### Heat Stress and Monte Carlo Simulation—A Statistical Approach That Considers Uncertainty in Calculating Work/Rest Regimen

*P. Dessureault and D. Drolet, University of Quebec, Ste-Genevieve-de-Batiscan, QC, Canada*

**Situation/Problem:** The Wet Bulb and Globe Temperature (WBGT) has been the most frequently used heat stress index for decades. Its application is quite simple; one must make sure that the meeting point between the observed WBGT value ( $WBGT_{obs}$ ) and the estimated level of work metabolism (M) does not exceed the limit value ( $WBGT_{lim}$ ) curve on a graph, most often originating from ACGIH's<sup>®</sup> TLV<sup>®</sup>. In cases of overexposure, it is common practice to establish an hourly work/rest regimen that brings the time weighted average parameters ( $WBGT_{ave}$  and  $M_{ave}$ ) to an acceptable point. Of course, WBGT and work metabolism values have an inherent error that makes this practice quite risky whenever the meeting point nears the limit curve. Assessing the risk of overexposure is then clearly

desirable. At this time, no technique has been proposed to do so.

**Resolution:** A probabilistic distribution of the work/rest regimen considering each parameter's uncertainty would enlighten decision-making and make risk assessment possible. Monte Carlo Simulation (MCS) is a technique allowing a user to account for risk in quantitative decision making. Applied to heat stress assessment, it allows the user to define a probability distribution for WBGTs and M. The simulation process will run the model a chosen number of times, calculating the longest work period that meets the limit as TLV<sup>®</sup>. This iterative procedure produces an outcome defined by a probability distribution instead of a single point as  $WBGT_{ave}$  and  $M_{ave}$ . A MCS procedure was programmed into a regular worksheet using Visual Basic in Microsoft Excel.

**Results:** The Excel file includes a data entry form where the user has to enter the WBGT and M values at work and at rest, along with their uncertainty expressed as a distribution of probability (normal, uniform, triangular, log-normal). After running the chosen number of iterations, the result is displayed as a histogram of probabilities that the limit is met at each number of working minutes per hour.

**Lessons learned:** The histogram presentation of the work minutes per hour allows the user to determine the work/rest regimen with a given level of confidence considering the uncertainty associated with his readings and estimation. This tool does not only assist the risk manager in decision making but also in identifying the best measures to decrease the risk levels and ensure a safe exposure. In this presentation, a real-time demonstration will be presented.

## P0120

### Advances in Aerosol Technology

Wednesday, May 25, 2016, 1:30 PM - 4:30 PM

## SR-120-01

### Aerosol and Volatile Organic Compounds Emissions from a Low-Cost 3-D Printer

*J. Wang, E. Floyd, and J. Regens, Occupational & Environmental Health, University of Oklahoma Health Sciences Center, Oklahoma City, OK*

**Objective:** 3-D printing is an additive manufacturing process involving injection of melted thermoplastic polymers which are then laid down in layers to achieve a predesigned shape. The heated deposition process raises concern of potential aerosol and volatile organic compounds (VOCs) emission and exposure. The lowered cost of desktop 3-D printers brought more applications to places where sufficient ventilation is often lacking. Meanwhile, little is known about characteristics of 3-D printing fume. The objective of this study was to characterize the aerosol and VOCs generated from a low cost 3-D printer with various filaments in an environmental testing chamber.

**Methods:** A predesigned object was printed in 1.25 hours using eight types of filaments. A scanning mobility particle sizer and aerodynamic particle sizer were employed to measure

the particle size distribution in the fine (<0.5 µm) and coarse ranges (0.5–20 µm). Real-time VOCs concentration was monitored by a photoionization sensor and sampled on a thermal desorption tube and analyzed by thermal desorption gas chromatography mass spectrometry.

**Results:** The results showed a high number ( $7.4 \times 10^9$  to  $3.2 \times 10^{10}$  #/min) of ultrafine particles (41.4–83.0 nm) were found in the fume. VOC emission rates were between 20.4 to 30.6 µg/min, with predominant VOC species from breakdown and reaction products of the filaments, such as styrene for ABS-based filament and acrylic acid dimer for PLA-based filament.

**Conclusions:** The findings suggest that although the VOC concentrations were much lower than occupational exposure limits, ultrafine particles could still lead to health risks for low cost 3-D printer users.

## SR-120-02

### Estimation of Airborne Diesel Particulate Matter Concentrations Using Real-Time Aerosol Monitoring Instruments

*L. Pahler and R. Larson, University of Utah, Salt Lake City, UT*

**Objective:** Currently, there are limited real-time monitoring methods for estimating airborne diesel particulate matter (DPM) concentrations in the mining industry. This study investigated whether a Grimm 1.109 Aerosol Spectrometer, a Hazdust EPAM 5000, and a DustTrak 8520 could be used to estimate airborne DPM concentrations in hard rock mines when compared to SKC DPM cassette sampler results.

**Methods:** The objective of this study was accomplished by determining the correlation of DPM concentrations provided by GS-1 Cyclone - SKC DPM cassette samplers to simultaneously collected Grimm, HazDust, and DustTrak aerosol spectrometer particulate concentrations. Seven DPM sampling events resulted in the collection of 42 SKC DPM cassette samples following NIOSH Method 5040 sampling procedures and 7 blank SKC DPM cassette samples. The SKC DPM cassette sampler DPM concentrations were determined following NIOSH method 5040 analytical procedures. Linear regression equations were generated by comparing DPM concentrations collected by SKC DPM cassette samplers and particulate concentrations measured by the Grimm, Hazdust, and DustTrak aerosol instruments.

**Results:** Statistical results of the linear regression analysis of the Grimm, Hazdust, and DustTrak aerosol instrument concentration data and SKC DPM sampler concentration data obtained during seven sampling events (N=42) show a strong relationship between the aerosol instrument data and SKC DPM cassette data:  $R^2=0.86$ ,  $p=0.002$  (Grimm);  $R^2=0.96$ ,  $p=0.01$  (Hazdust); and  $R^2=0.97$ ,  $p<0.001$  (DustTrak).

**Conclusions:** Results of this study demonstrate that a strong correlation exists between Grimm, Hazdust, and DustTrak aerosol instrument data and SKC DPM cassette sample data for airborne DPM concentrations when sampling was carried out in hard rock mines.

## SR-120-03

### Performance Testing of a Handheld Nebulizer

*T. Yang, N. Yu, S. Huang, and C. Chen, Department of Public Health, National Taiwan University, Taipei, Taiwan; Y. Kuo, Chung Hwa University of Medical Technology, Tainan, Taiwan*

**Objective:** Vibrating mesh aerosol generators have been reported to have increased output efficiency, minimal residual volume, and high percentage of particles in the emitted respirable and fine particle fraction. This work aimed to thoroughly characterize a miniaturized vibrating mesh nebulizer, uniquely applying capillary force for solution delivery.

**Methods:** The miniaturized vibrating mesh aerosol nebulizer tested in this work consisted of a nebulization unit, a liquid reservoir and transport device. One AAA battery was used to power the nebulizer, in order to miniaturize the device and operate for long hours. The vibrating mesh plate was placed on top of the solution transport device which was composed of two circular tubes, designed to deliver solution by capillary force. The aperture size of vibrating mesh plate was 15 µm. There were 2375 tapered holes on the mesh and the aperture distance was 160 µm. The effect of the orientation, including vertical, horizontal, and up-side-down, of the nebulizer was also investigated. An aerosol size spectrometer (Welas 3000, Palas) was employed to measure the aerosol number concentration and size distribution. This nebulizer was mainly evaluated with 0.9% sodium chloride.

**Results:** The power consumption of this device was only 0.925 watt. It could continuously operate for over 6 hours. The feeding rate was around 0.15 mL/min and only negligibly affected by the device orientation. However, the residual was slightly influenced by the orientation, 7.0%, 5.6%, 2.6% for vertical, horizontal and upside down, respectively. The count median diameter of the aerosol output was around 0.55 µm, with geometric standard deviation about 2. The aerosol number concentrations were 6,878, 11,724, and 16,101 #/cm<sup>3</sup> for vertical, horizontal, and upside down, respectively.

**Conclusions:** The most significant feature of this handheld nebulizer was almost orientation independence. This made it ideal for medical use, especially for patients lying on bed. However, there are many applications in the field of occupational hygiene, such as qualitative fit testing, and smoke stream generation. It could also become an exceptionally energy saving humidifier. The aperture size and number on the vibrating mesh plate could be change to improve the aerosol size and concentration. The residual volume could be further reduced by adjusting the design of the solution transport device.

## CS-120-04

### Nearly Real-Time Particulate Counting During Remediation Projects

*A. Havics, PH2, LLC, Avon, IN*

**Situation/Problem:** Dust control is a common issue in remediation projects, both indoor and outdoor. Historically, sampling on sites has consisted of daily total, respirable dust, Total Suspended particulate (TSP), or PM10 using filters followed by gravimetric or lab-based analytical techniques. These techniques generally result in a delay of hours to days to

receive data upon which to assess particulate exposure.

**Resolution:** Optical Particle Counters (OPCs) can be used during these projects to directly assess particle aerosolization, fate & transport on a real-time or nearly real-time basis. This use provides relatively rapid turnaround to evaluate controls, processes, as well as determining more quickly whether an airborne limit has been exceeded.

**Results:** Sites for illustrative purposes include a hospital mold remediation project and a few excavation/building demo locations near residential or commercial properties involving metals and general dust.

**Lessons learned:** A few cases where OPCs have been used, including side-by-side filter sampling, will be used to illustrate the benefits and to show the assumptions and subsequent limitations.

## SR-120-05

### Real-Time Particle Size Distribution Measurements of Coarse Coal Dust

*T. Barone, C. Seaman, and S. Mischler, Dust, Ventilation and Toxic Substance Branch, CDC/NIOSH, Pittsburgh, PA; E. Hesse, University of Hertfordshire, Hertfordshire, United Kingdom*

**Objective:** Aerosols with strong light scattering properties and spheroidal morphology have previously been characterized by the cloud and aerosol spectrometer (CAS). However, the CAS response for strong light absorbing and irregularly shaped coal dust has not been studied. Real-time particle size distribution (PSD) measurements would facilitate assessments of control technologies for prevention of dust explosions in underground coal mines. The primary objective of this study was to estimate coarse coal dust PSDs using CAS real-time light scattering measurements.

**Methods:** Ray tracing diffraction on facets (RTDF) theory was used to compute PSDs from CAS single particle forward light scattering measurements. Coal dust morphology was approximated as fractal polyhedral crystals and refractive index was based on previous measurements for a given coal rank. PSDs were estimated for test coal dust (10 - 20  $\mu\text{m}$ , 20 - 32  $\mu\text{m}$ , 32 - 45  $\mu\text{m}$ ) generated by air jet sieving and characterized using computer controlled scanning electron microscopy (CCSEM). Test dust sedimentation was prevented by: (1) aerosolization and deagglomeration using a dust disperser with a linear flow path to avoid particle impaction on tubing walls, (2) vertically aligning the disperser outlet and CAS inlet; and (3) adding high velocity HEPA filtered sheath air to prevent particle settling.

**Results:** PSD estimates were consistent with size ranges of coal dust generated by air-jet sieving. Sieve size separation was not ideal, in that a small particle mode remained in the large particle test dust. This is probably because electrostatic properties of the test dust prevented deagglomeration during air-jet sieving. However, the dust could be fully deagglomerated by the dust disperser, and the absence of agglomerates was confirmed by CCSEM. Although the PSDs were bimodal, the modes were distinct and overlap did not interfere with size range comparisons. The 10 - 20  $\mu\text{m}$  and 20 - 32  $\mu\text{m}$  modal diameters were 7  $\mu\text{m}$  and 21  $\mu\text{m}$ , respectively. The 32 - 45  $\mu\text{m}$  test dust had a broad distribution that was confirmed by CCSEM.

**Conclusions:** Because estimated particle diameters agreed

well with sieve based sizing, the results suggest that CAS real-time measurements can be used to determine coarse coal dust PSDs. This was enabled through the RTDF model, which includes coal dust morphology and composition effects in estimating particle diameter from CAS forward light-scattering intensities.

## SR-120-06

### New Methodology for Achieving Inside the Hood Sampling for Welding Operations

*R. Aivazian, TCF Risk Management, Casper, WY*

**Objective:** To determine if a comprehensive study of a new methodology of inside the hood sampling for welding operations is warranted. Current methods for sampling within the welding hood create problems of discomfort for the user. This study was a preliminary test on a new method of sampling that would create less discomfort to see if the method is feasible and would warrant further testing.

**Methods:** Since this study was a preliminary feasibility study, it was limited in the size and scope. Two separate sampling events were included in the study at separate facilities. In each sampling event, 6 samples were taken on 6 individual welders using traditional sampling methodologies as control samples. Additionally, each welder had a sample collected using the new methodology. The samples were submitted to an AIHA accredited laboratory, along with blanks for quality control, to be analyzed for total particulates, Antimony, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron Oxide, Lead, Manganese, Molybdenum, Nickel, Vanadium Pentoxide, and Zinc Oxide. For each sampling event, the experimental samples were compared for statistical difference from the control samples using the Mann-Whitney U-Test calculated with 2-tails and a p value of 0.05.

**Results:** Based on the results of the samples from the two sampling events, there is no significant differences between the concentrations found in control samples and in experimental samples in either sampling event. The first sampling event provided U values of 1.15 to 2.7 times the critical U value. The second sampling event provided U values of 1.5 to 3.3 times the critical U value. While the sample sizes were small, significant statistical differences were not observed.

**Conclusions:** This experimental sampling was successful. Data was obtained to determine whether or not a larger analysis of the new sampling methodology would be warranted. Based on the sampling, it is feasible that the new methodology could provide data as accurate as current sampling method provide. Based on these results, more in depth analysis of this sampling method should be conducted.

## SR-120-07

### Effects of Pulse Parameters on Welding Fume Aerosol Size Distribution and Respiratory Deposition

*J. Wang, M. Bezerra, and J. Regens, Occupational & Environmental Health, University of Oklahoma Health Sciences Center, Oklahoma City, OK*

**Objective:** Welding fume contains various inhalation toxins such as hexavalent chromium and manganese. Occupational exposure to welding fume can cause various carcinogenic and

neurological effects. The high temperature welding process creates high concentrations of nano- to submicron-sized metallic aerosols composed of toxic metals. Pulse welding targets reducing the heat input to the welding arc zone by high-frequency voltage fluctuation, as opposed to the steady voltage in nonpulse welding. Pulse welding was hypothesized to improve the weld quality, while decreasing the metal vaporization. The objective of this study is to investigate the pulse parameters (voltage, frequency, and percentage) on formation and characteristics of welding fume aerosols.

**Methods:** A pulse metal inert gas welder was placed in a metal fume chamber. Welding with different combinations of pulse parameters as well as baseline (non-pulse) were conducted through beading on 308L stainless steel plates. Particle size distribution was measured by a scanning mobility particle sizer and an aerodynamic particle sizer for fine and coarse particles, respectively. Respiratory deposition fractions for head airways (HA), tracheobronchial (TB), and alveolar (AL) regions were estimated based on a simplified International Commission on Radiological Protection (ICRP) model.

**Results:** The results indicated the dominant parameter of particle emission characteristics was pulse voltage. Pulse welding did not drastically change the geometric distribution of the particle sizes comparing to the non-pulse welding. However, pulse welding reduced the particle emissions in both fine and coarse regimes, without compromising the weld quality. Use low pulse voltage can produce the least particle number concentrations ( $3.0E7 \text{ \#/cm}^3$  fine particles and  $0.7E4 \text{ \#/cm}^3$ ) and in favor of more upper respiratory tract deposition.

**Conclusions:** In sum, we suggest the welder should operate at a low pulse voltage to minimize the potential particle exposures.

## SR-120-08

### Study of the Effective Vortex Length of Cyclone

*H. Hung, S. Huang, C. Lin, and C. Chen, Department of Public Health, National Taiwan University, Taipei, Taiwan*

**Objective:** In a conventional cyclone, the outer vortex flow weakens and changes its direction at a certain axial distance from the vortex finder. This axial magnitude has been called the "natural vortex length" of the cyclone. Since the space below the vortex would not be used for particle collection, cyclone designs with a natural vortex length equal to or greater than the physical length of a cyclone were recommended. However, previous studies have shown contradictory results. Therefore, the main purpose of the present study was to experimentally investigate the effect of the 'effective vortex length' on the performance of cyclones with different configurations.

**Methods:** To characterize the performance of sampling cyclones, an ultrasonic atomizing nozzle was used to generate micrometer sized potassium sodium tartrate particles. An Am-241 radioactive source was employed to neutralize the particles to the Boltzmann charge equilibrium. Aerosol size distributions and number concentrations upstream and downstream of the cyclones were measured using an Aerodynamic Particle Sizer (APS). Each aerosol penetration measurement was repeated five times to assure data quality. The pressure drop across the cyclone was measured using an inclined manometer. All types of sampling cyclones developed in this work were variations from the base design of the Very Sharp Cut Cyclone. The

effective vortex length of a cyclone was analyzed by using the aerosol penetration and the pressure drop across the cyclone, and compared to the modeled data reported in previous studies.

**Results:** The results showed that both the 50% cut-off size and pressure drop were sensitive enough to illustrate the effect of cyclone configurations or the operation flow rate on the effective vortex length. The effective vortex length significantly increased with increasing sampling flow rate and decreasing cyclone body diameter. However, the inlet diameter, the outlet diameter, the length of vortex finder and the cyclone with or without cone had only minor influence on the effective vortex length.

**Conclusions:** The effective vortex length was normally in the range from 4 to 6 H/D, depending on the cyclone conformations and the power input entering the cyclone. As an indicator estimating the effective vortex length, the 50% cutoff size was more sensitive than the pressure drop. However, the pressure drop measurement was apparently easier to execute.

## P0121

### Evaluation of Airborne Contaminants

Wednesday, May 25, 2016, 5:30 PM - 7:30 PM

## SR-121-01

### Road Paving and Asphalt Fumes—What Affects Exposure Levels?

*M. Shum, L. Clements, L. Kimble, and P. Bergholz, Occupational Hygiene & Safety, AMEC Environment & Infrastructure, Burnaby, BC, Canada*

**Objective:** To determine factors that contribute to asphalt fume exposures during paving of hot asphalt mix such as job tasks/activities, type of paving, weather conditions, and time of year. To determine controls available that can help reduce exposures.

**Methods:** 61 benzene soluble fraction asphalt fume samples and 13 polycyclic aromatic hydrocarbon (PAH) full-shift personal samples were collected at various locations in the Lower Mainland of British Columbia over the course of two years during paving of hot asphalt mix. Personal samples for asphalt fume were collected in accordance with the NIOSH Method 5042. Benzene Soluble Fraction and Total Particulate (Asphalt Fume). Personal samples for PAHs were collected in accordance with NIOSH Method 5515. Polynuclear Aromatic Hydrocarbons were analyzed by GC. Additional sampling is expected to occur between the fall of 2015 and spring of 2016. The data will be analyzed to determine whether factors such as percent recycled asphalt product (RAP), cleaning of the paving machine prior to paving, and additional environmental conditions affect exposure levels.

**Results:** To date, the sampling results indicate that the exposures for the Paver Operator, Screedman, and Rakerman are often above the occupational exposure limits for benzene soluble fraction of asphalt fume in British Columbia, particularly during extended shifts (greater than eight hours).

Polycyclic aromatic hydrocarbon sampling results indicate low levels of exposure for the compounds specified in the NIOSH 5515 method. The job task and rate of paving (e.g., how many tonnes are paved per shift) are the best predictors of exposure.

**Conclusions:** Results indicate that asphalt road pavers are often overexposed to asphalt fumes during paving of hot asphalt mix. Length of shift and job task are predictors of exposure. Other factors affecting exposure and potential controls will be identified in the coming months.

## CS-121-02

### Formaldehyde Exposure Assessment During the Application of Professional Hair Smoothing Products

*M. Posson and R. Kalmes, Exponent, Inc., Oakland, CA*

**Situation/Problem:** Occupational exposures to formaldehyde associated with the use of hair smoothing products in professional salons have been the recent focus of media attention, government agencies, and NIOSH. Initial studies conducted by the authors indicated that short-term exposures above the ACGIH® Ceiling limit (0.3 ppm) occurred during the application and blow-drying stages of the treatment process. The objective of this study was to evaluate the effectiveness of practical administrative and engineering controls to reduce potential exposure to formaldehyde associated with the use of professional hair smoothing products under typical and representative salon conditions.

**Resolution:** A sampling approach was developed to characterize and evaluate controls to reduce formaldehyde exposures from professional hair smoothing products. Personal and area samples were collected at several commercial hair salons over a 3.5-year period. Samples were collected under typical salon conditions and during one to two treatments. Personal air samples were collected from the breathing zones of hair stylists during the treatments that were conducted in four distinct steps: pre-application preparation, application, blow-drying, and ironing. Task-based air samples were collected to evaluate potential exposure associated with each of the steps. Pre- and post-treatment samples were also collected. Samples were collected and analyzed using NIOSH Method 2016.

**Results:** A series of exposure controls were developed and evaluated. In some cases, task-specific formaldehyde concentrations were above the ACGIH® Ceiling limit (0.3 ppm), even when implementing controls. However, the treatment process was optimized during the study period and ultimately included a combination of practical administrative and engineering controls.

**Lessons learned:** The sampling methodology employed provides useful insight into characterizing formaldehyde exposures during treatments and identifying tasks for potential exposure control points during the treatment process. The amount of product used, the manner in which the product was applied and proximity of the stylist to the hair being treated were attributed to the measured formaldehyde exposures. Controls were optimized after several iterations.

## SR-121-03

### Application of a Novel Personal Air Sampler

*J. Herrington, M. Lininger, J. Konschnik, and S. Kozel, Innovations Group, Restek Corporation, Bellefonte, PA*

**Objective:** The AURA™ Personal Air Sampler (PAS) passively collects an 8-hour whole air sample via vacuum in a 400 mL canister. The sampler was developed to help environmental and occupational health experts monitor for personal exposures to airborne volatile organic compounds (VOCs). The PAS was designed as an alternative to diffusive sampling badges and/or active sampling with sorbent tubes. PAS was engineered to avoid some of the short-comings associated with said approaches. A field study applying the PAS and the most popular competing technologies has been executed to see how well it compares on multiple variables.

**Methods:** A field study was conducted in an occupational setting in which PAS were located on subjects along with diffusive sampling badges and/or sorbent tubes. Samples were collected over an 8-hour sampling duration and compared for VOCs applicable to both methods.

**Results:** Results indicate that the PAS results correlate very well with the results obtained from diffusive sampling badges and sorbent tubes. For example, thermal desorption (TD) tube results and PAS results for 13 subjects had a coefficient of determination of 0.92 for methylene chloride.

**Conclusions:** The AURA™ PAS is able to provide comparable results to diffusive sampling badges and active sampling with sorbent tubes. The PAS does this while avoiding some of the short-comings associated with the latter approaches. For example, the PAS does not require a pump and is therefore quiet; and manages variations in face velocity, temperature, and humidity better than traditional sampling approaches. In addition, the PAS is easy to operate with a simple quick connection to start and stop flow; and therefore does not require flow calibration. Lastly, the PAS is a whole-air sampling approach, which affords multiple analyses of over 100 VOCs; and is sensitive down to pptv levels, while not subject to sample breakthrough at ppmv levels.

## SR-121-04

### Association Between Personal and Area Fiber Concentrations in Brake Repair Shops: Analysis in a Real-Life Setting

*L. Méndez García, M. Cely-Garcia, M. Giraldo, and J. Ramos-Bonilla, Civil and Environmental Engineering, Universidad de Los Andes, Bogota, Colombia; P. Breyse, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD; M. Duran, C. Torres-Duque, M. Gonzales-Garcia, and P. Parada, Fundacion Neumologica Colombiana, Bogota, Colombia*

**Objective:** In the past, area asbestos concentrations were commonly used to estimate personal exposures to asbestos in occupational settings. Several studies have found this practice inadequate since personal fiber concentrations tend to be higher compared to area concentrations. However, other studies suggest that there is no difference and that a strong correlation exists between area and personal samples. This study evaluates the association between personal and area fiber samples, in brake repair shops that currently manipulate

asbestos containing friction products.

**Methods:** Personal and area samples were collected in two brake repair shops in Bogotá (Colombia) in September and December 2014. Personal samples were collected from one brake mechanic at each shop. In both shops, area and personal asbestos samples were collected simultaneously in time windows of 2-hours, during the 8 hours work shift for one week. Phase Contrast Microscopy (PCM) fiber concentrations were determined using NIOSH method 7400. A longitudinal based linear regression model was used to evaluate the association between personal and area asbestos concentrations.

**Results:** Important differences in work practices were observed between the workers sampled. In shop 1, the mechanic constantly left the manipulation area (i.e., which resulted in an intermittent exposure), while the mechanic in shop 2 remained most of the time at the manipulation area. The results of the model suggest that for the worker from shop 1, personal fiber concentration increases 61.14% ( $p = 0.073$ ) per each additional increase in area fiber concentration. For the worker from shop 2, fiber concentration in personal samples was expected to increase 550.08% ( $p = 0.012$ ) for each additional increase in fiber concentration in area samples. In both cases, the association was observed between fiber personal concentrations and fiber area concentrations collected at the source of the fibers (i.e., manipulation equipment). No significant associations were observed with area samples collected at other locations of the shop.

**Conclusions:** A significant association between area and personal fiber concentration was only observed in very specific circumstances. The association is highly dependent on the location of the area monitor and the time the worker spent at the manipulation area.

## CS-121-05

### Formaldehyde Emissions from Laminate Flooring: Is There a Proposition 65 Exposure Issue?

*P. Sheehan, A. Singhal, R. Kalmes, and K. Bogen, Exponent, Oakland, CA*

**Situation/Problem:** There has been much in the news recently about formaldehyde emissions from laminate flooring manufactured in China. The scientific literature has little information regarding the potential long term exposures of individuals who install this laminate flooring. California's Safe Drinking Water and Toxic Enforcement Act of 1986, commonly referred to as Proposition 65, lists formaldehyde as a chemical known to the State to cause cancer and requires that products that emit formaldehyde either be shown to pose an exposure below the safe harbor daily dose for formaldehyde (40  $\mu\text{g}/\text{day}$ ) or be properly labeled as a carcinogen.

**Resolution:** We have conducted a Proposition 65 exposure assessment for 26 types of Chinese manufactured laminate flooring. Samples of each type of laminate flooring were initially tested in a controlled environmental chamber to estimate formaldehyde emission rates. The emission rates were included in a probabilistic model of household exposure along with other parameters to estimate the distribution of formaldehyde concentrations in indoor air at initial steady-state levels after installation. A new evaluation of emissions

decay with time for particle board laminates was used to develop a decay curve for indoor formaldehyde concentration from laminate flooring. This decay curve was then applied to the initial concentration distribution to characterize the distribution of time-weighted average (TWA) concentrations over various time intervals during the expected use life of the product.

**Results:** From this analysis, the TWA indoor formaldehyde concentration experienced by a typical resident over the 10 year mean residency period is estimated to have an expected value of  $\sim 0.76 \mu\text{g}/\text{m}^3$ . Applying a conservative inhalation rate of 20  $\text{m}^3/\text{day}$  and accounting for the average fraction of the day spent at home (0.68), the daily dose of formaldehyde from laminate flooring is expected to be  $\sim 10 \mu\text{g}/\text{day}$ .

**Lessons learned:** This dose is only approximately 25% of the Proposition 65 safe harbor level for formaldehyde, indicating that this laminate manufactured in China poses a negligible risk under Proposition 65 and could be sold in California without a warning label.

## CS-121-06

### Conducting Smoke Testing for Placement of Near Real Time (NRT) Monitoring Utilizing the EPA DQO process

*J. Brooks, Bechtel, Pueblo, CO*

**Situation/Problem:** The Pueblo Chemical Agent Pilot Project is tasked with the destruction of the remaining US Army stockpile of assembled chemical weapons containing sulfur mustard agent (Bis-[2-chloroethyl] sulfide). The processing requires removal of the energetic (propellant and explosive) components from the munition. This is followed by munition cavity exposure for draining the sulfur mustard agent for treatment with high temperature water and sodium hydroxide. The resulting neutralized waste mixture is then biotreated for disposal. While much of the process is automated, potential employee exposure occurs through the munitions transport, energetic removal, and maintenance and repair of automated equipment cycles. NRT monitoring is conducted with MINICAMS<sup>®</sup> to detect potential agent exposures as early as possible to prevent exceedance of STEL and TWA established concentrations. The MINICAMS<sup>®</sup> NRT is an area air monitor which necessitates optimal placement based on potential process release points, ventilation characteristics of the facility, and location of the workers. Typically, NRT monitoring location siting has been conducted at nuclear and chemical demilitarization facilities by smoke testing using qualitative assessments by Industrial Hygiene and Health Physics professionals. The qualitative aspects (release and tracing to sample point collection end) has lacked the specificity to optimize the location for early detection.

**Resolution:** PCAPP has utilized the EPA Data Quality Objective (DQO) seven (7) step model process incorporating the variable of time to quantify optimal placement of NRT devices. Particular attention was given to step five (develop a decision rule) and step six (specify tolerable limits on the decision error) in developing detailed test plans and procedures. Successful testing was based not on adequacy but on optimization under this process to provide the best detection possible to prevent worker exposures.

**Results:** The application of the EPA DQO model has resulted in optimal placement of NRT sample collection points that may

have not been obvious using typical testing techniques.

**Lessons learned:** The use of DQO processes in siting NRT or Real Time air monitors provides for optimal placement in the protection of workers needing immediate notification of potential exposures.

## P0122

### Breathe Easier: Something for Everyone

Thursday, May 26, 2016, 8:00 AM - 11:00 AM

## SR-122-01

### Respirator Probe Bias Evaluation Using the Advanced Headform Respirator Test System

*M. Bergman, A. Rizer, E. Brochu, Z. Lei, and Z. Zhuang, CDC/NIOSH/NPPTL, Pittsburgh, PA*

**Objective:** Our lab has successfully used advanced manikin headforms in several studies to simulate respirator fit on humans. However, sampling probes may yield biased measurements due to imperfect mixing of test agents or streamlining within a respirator. This study used advanced headforms under different test conditions to evaluate factors that affect respirator probe bias in filtering facepiece respirators (FFR) and elastomeric half-mask respirators (EHR).

**Methods:** Three N95 FFR models, one P100 FFR model, and one P100 EHR model were tested on two sizes of static headforms (medium and large) connected to a breathing simulator. Respirators were probed with a flush probe. Three samples of each model were tested. Sodium chloride aerosol was used as the challenge agent. Two PortaCount® units (model: 8038+; TSI, Inc.) were used to measure manikin fit factor ( $FF_{man}$ ) of the respirator (mask location) and  $FF_{man}$  at a location directly downstream of the headform (reference location). Three test conditions were evaluated: 1) cyclic breathing only (CB); 2) cyclic breathing with heated/humidified exhaled air (100% RH, 34.5 ± 2 C) (H1); and 3) cyclic breathing with heated/humidified exhaled air and heated PortaCount sample lines to reduced humidity condensation (H2). Each test condition was conducted at two different minute ventilations (25 and 40 L/min), each for one minute. Analysis of variance (ANOVA) was used to test independent variables (HF (i.e., headform size), CONDITION, FLOWRATE, CLASS (i.e., N95 or P100), and STYLE (i.e., FFR or EHR) and their interactions for significant effects on probe bias. Duncan's Multiple Range Test was used to test significant differences in mean probe bias for each independent variable.

**Results:** Significant ( $P < 0.05$ ) variables and interactions were: CLASS, STYLE, CONDITION, HF\*STYLE, CONDITION\*STYLE, and CONDITION\*CLASS. The mean bias for the condition CB (1.2%) was significantly different than H2 and H1 which were 3.2% and 3.6%, respectively. The significantly different mean biases for CLASS were -2.1% and 5.8% for P100 and N95 classes, respectively. The significantly different mean biases for STYLE were -0.1% and 3.5% for EHR and FFR styles, respectively.

**Conclusions:** The test procedures evaluated show small probe bias (< 4%) and may be considered as candidates for developing standardized test methods using advanced headforms.

## SR-122-02

### Field of View Respirator Certification Standards Comparison

*K. Coyne, US Army, Aberdeen Proving Ground, MD*

**Objective:** Visual field may be decreased while wearing an air-purifying respirator (APR). The United States' National Institute for Occupational Safety and Health (NIOSH), the European Standard (EN136), and a committee draft (CD) International Standards Organization (ISO) method use the same equipment to assess visual field, but each analyzes the results differently. NIOSH uses a Visual Field Score grid with 110 points along 10 meridians. NIOSH requires a minimum Visual Field Score (VFS) of 90 to pass certification for commercial chemical, biological, radiological, and nuclear (CBRN) APRs. The CD ISO standard adds 8 additional points to the NIOSH VFS grid and requires that 96 of those points be within the peripheral isopter. Additionally, this draft standard identifies the four points on the 85° meridian as critical points and requires that a minimum of two critical points be included in the visual field. For EN 136, the effective field of vision and effective overlapped field of vision are expressed as a percentage of the natural field of vision and overlapped field of vision, respectively. A passing score requires an effective field of vision greater than or equal to 70% and an overlapped field of vision of 80%. The goal of this effort was to assess and compare the visual field of eleven NIOSH certified CBRN APRs using the NIOSH, EN 136, and CD ISO standards.

**Methods:** Each respirator was mounted on the headform that accompanies the apertometer and the headform placed in position. The eye lights were illuminated and the shadow on the apertometer was checked to ensure that it was symmetric about the origin. The outline of the shadow on the apertometer was recorded and the field of view was determined according to each method. The overall score for a respirator was determined by averaging the scores for three separate fittings of each respirator.

**Results:** As expected, all respirators exceeded the NIOSH minimum. Three respirators failed the CD ISO standard due to the fact that less than two of the critical points were within the peripheral limits. Two of these respirators had dual eye lenses. These three respirators also failed the EN136 standard as did one additional respirator. The additional respirator had a single lens.

**Conclusions:** A respirator that passes the NIOSH standardized test may not pass the CD ISO or EN 136 standards. The EN 136 standard was the most stringent of the three certification standards.

## CS-122-03

### Comparison of Methods Suggested in 29CFR1910.134 for Determining Change Schedules for Air Purifying Respirators

*G. Wood, Consultant, Los Alamos, NM; C. Manning, Assay Technology, Livermore, CA*

**Situation/Problem:** An employer desires to use an air-purifying respirator (APR) to protect workers against organic vapors,

(e.g. hexane, chloroform, etc.) in a workplace. A specific respirator and applicable cartridge (manufacturer & model) were selected. The use environment was characterized for primary vapor concentration, co-vapors, temperature, atmospheric pressure, relative humidity, and average breathing rate (APR) or total flow (PAPR). The maximum acceptable breakthrough concentrations (MACs) for setting cartridge change schedules have been decided. Now, how does one get the corresponding breakthrough times to set change schedules?

**Resolution:** Several methods were suggested in 29CFR1910.134 to get breakthrough times for setting change schedules: 1) Review manufacturer's recommendations; 2) Use the manufacturer's Service Life Calculator; 3) Review recommendations and Service Life Calculator on OSHA website; 4) Use the NIOSH MultiVapor service life estimation program; 5) Search the literature for measured breakthrough times; and 6) Measure cartridge breakthrough times in a laboratory.

**Results:** An MSA Safety Works half-mask, with pairs of Multi-Purpose cartridges, was selected and purchased from an online supplier for use against 1000 ppm hexane (MAC = 50 ppm) or 500 ppm chloroform (MAC = 10 ppm). Each of the methods suggested in 29CFR1910.134 produced breakthrough times that are compared with those measured in the laboratory.

**Lessons learned:** Certain of the suggested methods require more effort and expense to gain greater accuracy. For common chemicals, all six methods are available, while for rare chemicals, some methods (manufacturer's recommendations and/or service life calculators) may not be available. Ultimately, one must decide how accurate a result is required based on the safety factor that is selected. The accuracy required in the service life will suggest how much effort one should expend to obtain it.

## CS-122-04

### Can the SWPF Study be the New WPF Study?

*C. Colton, 3M PSD, St. Paul, MN*

**Situation/Problem:** To determine respirator assigned protection factors (APF), workplace protection factors (WPF) have been used to measure respirator workplace performance. For many reasons (cost, workplace logistics and reproducibility between worksites, among other things), the simulated workplace protection factor (SWPF) has been considered a good substitute for the WPF. To use an APF of 1000 for a respirator with a loose-fitting hood, OSHA states the employer must have evidence that testing of these respirators demonstrates performance at a level of protection of 1000. This can be demonstrated by performing a WPF, SWPF or equivalent testing. These types of testing can be very different; one is done in the workplace and the other in the laboratory. However, no one has determined with precision the correlation of the results between the two types of tests.

**Resolution:** WPF and SWPF studies performed on various respirator types were reviewed. Six WPF studies indicate the performance of one respirator type was always different from laboratory results. Review of recent SWPF studies indicates they can also be different from each other, perhaps in part due to the fact that SWPF protocols can use different exercises,

testing equipment and aerosol challenges, among other things. A search of the literature for definitions of WPF, SWPF and equivalent testing was conducted.

**Results:** A thorough understanding of the differences between these studies needs to be understood. To date these differences have not been identified in the published definitions. Some studies had different steps for simulating work than others. Some studies used a "safety factor." No guidance or standards exist for establishing a safety factor for all respirator types or the type of testing. The review of laboratory testing protocols identified several factors that may contribute to differences including: aerosol particle size, work rate, environmental conditions, work activities and test duration.

**Lessons learned:** WPF studies appear to be the most direct measurement of respirator performance in the workplace. SWPF studies have used a wide range of exercises and test conditions which may account for differences between laboratory and workplace results. Some SWPF studies use test protocols that more closely resemble certain workplaces than others. Stricter definitions or use of SWPF may help define more relevant SWPF studies. The use of a safety factor, its level, or other statistical approaches could then be dependent on the protocol.

## SR-122-05

### Efficacy for Using Facepiece Embedded Fans for PAPR Like Protection

*D. Caretti, D. Barker, and D. Wilke, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD*

**Objective:** For reasons related to size, weight, logistics and blower operating restrictions, commercially available powered air-purifying respirators (PAPR) are not conducive for use by tactical first responders. A recent attempt was made to circumvent these issues by mounting two small fans within the facepiece of an air-purifying respirator (APR) to independently supply air to the eye and nose cup regions. This investigation compared respiratory protection levels afforded by this design to those obtained with a traditional PAPR blower system.

**Methods:** Simulated workplace protection factors (SWPFs) were obtained from 7 volunteers aged 33 ± 5 yr. (mean ± SD) who completed 14 min wear trials with an Avon Protection C50 facepiece modified with embedded fans (EF-APR) and a commercially available C420 PAPR (CA-PAPR). The EF-APR modifications also segmented the eye and nose cup regions of the facepiece so breathing air exchange only occurred in the nose cup cavity. Flow rates for the EF-APR nose cup and eye fans were 32 L/min and 11 L/min, respectively; the CA-PAPR system also used a C50 facepiece and supplied air at 105 L/min. In addition to quantifying SWPFs in the nose and eye regions of the facepiece, eye cavity pressure data and subjective feedback on comfort and facial thermal sensation were obtained.

**Results:** Although the CA-PAPR produced the highest average nose and eye cavity SWPFs within each task, no significant differences were observed between EF-APR and CA-PAPR conditions at any time. Pressure data showed that the eye cavity went negative relative to atmosphere more frequently with the CA-PAPR compared to the EF-APR during the Crawl (13.5% vs. 9.4%), Shovel (15.4% vs. 4.9%) and Stair Climb (10.8% vs. 0.7%) tasks. No differences in comfort or thermal

sensation responses were observed between conditions.

**Conclusions:** These findings suggest that the EF-APR concept provided respiratory protection levels comparable to a commercial PAPR system without compromising comfort and thermal sensation advantages associated with PAPRs. Additionally, the EF-APR design was better at maintaining positive pressures within the respirator facepiece at all times despite the substantially lower air flow rates compared to the CA-PAPR. The primary advantage of the facepiece-embedded fan design is a significant reduction in size, weight, required fan power and bulkiness compared to traditional PAPR motor-blowers and hoses.

## SR-122-06

### Respiratory Protection for Firefighters— Evaluation of CBRN Canisters for Use During Overhaul II: In Mask Analyte Sampling with Integrated Dynamic Breathing Machine

*L. Jones, E. Lutz, and J. Burgess, University of Arizona, Tucson, AZ*

**Objective:** This study expands on previous work by introducing the use of a dynamic breathing machine that accurately simulates the rate, volume, and oscillation of normal breathing patterns. It is hypothesized that the introduction of the breathing machine combined with in-mask analyte sampling will better demonstrate the protectiveness of CBRN canisters and their potential use as an alternative to SCBAs to protect firefighters during post fire operations.

**Methods:** To determine analyte reduction effectiveness of CBRN canisters/cartridges a series of 12 burns with associated sampling durations was conducted at the Northwest Fire Districts training center. Measured quantities of common household items were used during burns to simulate actual overhaul environments. Three commercially available NIOSH approved CBRN canisters and one non-CBRN cartridge were used during testing. Each head form was drilled to allow insertion of five Tygon tubes around the nose and mouth area to allow for in-mask sampling, as well as a large stainless steel pipe for attachment to the breathing machine. The sampling system was placed inside the burn room via a wheeled cart approximately one meter from the smoldering materials in a position that approximated a firefighters working breathing zone. Sampling durations were randomized for each test iteration (15 minutes or 60 minutes).

**Results:** Sampling indicated the presence of 10 of the 55 analytes were detected above the level of quantification. Of the 10 analytes detected above the LOQ in the post-fire overhaul ambient environment, acetaldehyde and formaldehyde were the only analytes to be detected downstream of any filters on a fairly consistent basis. Benzene was detected downstream of one filter on the last burn cycle. All filters appreciably reduced concentrations of acetaldehyde and formaldehyde during all test iterations.

**Conclusions:** At the ambient analyte concentrations generated during this study, the CBRN filters evaluated effectively reduced levels of hazardous chemicals and respirable particulates to below occupational exposure limits during simulated overhaul. Although reduced to below occupational exposure limits at the currently tested ambient

levels, the carcinogenicity of formaldehyde combined with breakthrough observed at higher concentrations, warrants the recommendation that firefighters continue to use SCBAs during post-fire activities.

## SR-122-07

### Inter-Laboratory Comparison of the Performance of Firefighting Self-Contained Breathing Apparatus

*J. Parker, CDC/NIOSH, Pittsburgh, PA*

**Objective:** The objective of this study is to compare the performance of all available NIOSH and NFPA approved firefighting SCBAs in two NIOSH laboratories when tested against the major NIOSH certification tests and the NFPA air flow performance test.

**Methods:** Testing was performed on eight NIOSH approved SCBAs that also meet the requirements of NFPA 1981 Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, 2007 edition. NIOSH certification tests for positive pressure, rated service time (duration), exhalation resistance, static pressure, remaining service-life indicator, and gas flow at zero facepiece pressure were conducted. The NFPA air flow performance test at maximum work rate was also performed. For comparing the Morgantown Laboratory measurements to the Pittsburgh Laboratory measurements, the difference measured within each “Run” was used for statistical analysis. Because of the small sample sizes ( $n=3$ ) for each system, the Wilcoxon Signed Rank (WSR) test was used to test if the difference is zero, and p-values were calculated. The Kruskal-Wallis test and the sign test were also used to test if the results are different.

**Results:** For the rated service time test, no statistically significant differences comparing Morgantown to Pittsburgh results were found. For the positive pressure test, the results indicated that Morgantown results are higher than the Pittsburgh results. For the remaining service-life indicator test, the static pressure test and the exhalation resistance test, the results indicated no statistically significant differences between the Morgantown results and the Pittsburgh results. For the positive pressure, gas flow and NFPA tests, the results indicated a statistically significant difference between the Morgantown results and the Pittsburgh results.

**Conclusions:** There is good agreement between the test labs for all tests except for positive pressure, gas flow and NFPA tests. The differences in the positive pressure test were attributed to differences in the equipment, which have been eliminated, and further testing has shown no significant differences. New equipment has been ordered for the gas flow and NFPA tests. Agreement in test results between the laboratories contributes to the validation of the test methods.

## SR-122-08

### Do P100 FFRs Perform Better than N95 FFRs When Faceseal Leakage Presents?

*X. He, J. Zhu, R. Dodrill, and S. Guffey, West Virginia University, Morgantown, WV*

**Objective:** The NIOSH approved P100 Filtering Facepiece Respirators (FFRs) have a higher filter efficiency than that of N95 FFRs. However, P100 filters are typically associated with higher flow resistance than N95 filters. Consequently, when

a leak occurs, the proportion of total air flow through the faceseal leakage of P100 FFRs may exceed that of N95 FFRs, which may result in a higher particle penetration through the P100 FFRs. The objective is to compare the particle penetration between an N95 FFR and a P100 FFR when faceseal leakage is present.

**Methods:** The tested N95 and P100 FFRs were mounted on a manikin headform placed inside an exposure chamber (1.2m×1.2m×1.2m). The filters' efficiency and flow resistance were measured when the two FFRs were sealed. Two artificially fixed faceseal leaks were created: 1) a needle with a diameter of 0.8mm inserted in-between the respirator and the lower cheek of the head form, and 2) two needles with a diameter of 0.8mm inserted at the lower cheek of the headform. Three constant (15, 50, and 85 L/min) and three cyclic breathing flows (mean inspiratory flow, MIF = 15, 50, and 85 L/min) were tested. Sodium chloride (NaCl) was used as the challenge aerosol. The concentrations inside ( $C_{in}$ ) and outside the respirator ( $C_{out}$ ) were measured with a NanoScan SMPS Nanoparticle Sizer (Model 3910, TSI Inc.). The total particle penetration was determined as  $C_{in}/C_{out}$ .

**Results:** When fully sealed, the filter efficiency of the P100 FFR was much higher than that of the N95 FFR, but a significantly higher flow resistance was also observed for the P100 respirator. In most conditions the P100 FFR was associated with a significantly ( $p < 0.05$ ) lower total particle penetration than the N95 FFR. One exception was when the lowest flow rate (15 L/min) and the larger artificial leak (two needles) were introduced. In that case the N95 FFR produced lower penetration values (0.42±0.06% under constant flow, 1.73±0.02% under cyclic flow) than the P100 FFR (3.42±0.19% under constant flow, 1.93±0.03% under cyclic flow).

**Conclusions:** Overall, the findings suggest that when significant faceseal leakage occurs and these two respirators are used by workers performing low work activities, the P100 FFR with higher flow resistance may not be as protective as the low-flow-resistance N95 FFR. This study will have an impact on manufacturers to design P100 FFRs with low flow resistance.

## SR-122-09

### Searching for the Optimal Challenge Aerosol Size Distribution for QLFT

*K. Yang, S. Huang, and C. Chen, National Taiwan University, Taipei, Taiwan; W. Kuo, Chung Hwa University of Medical Technology, Tainan, Taiwan; C. Chen, Institute of Labor, Occupational Safety and Health, Ministry of Labor, New Taipei City, Taiwan*

**Objective:** Several QLFT aerosol generators have been commercially available, but the generated aerosol size distributions have not been well defined and justified. In addition, the data on aerosol penetration through face seal leaks is still quite limited. Therefore, this study aimed to characterize the aerosol penetration through small diameter tubing, and to derive the appropriate range of size distribution of challenge aerosol particles for QLFT.

**Methods:** Microtubes with different length and diameter were employed to simulate faceseal leaks. An ultrasonic nebulizer was used to generate polydisperse NaCl particles with various size distributions as the challenging aerosol. Aerosol number concentrations and size distributions upstream and downstream of the microtubes were measured by an

Aerodynamic Particle Sizer. Aerosol penetration data were taken at different flow rate through microtubes and under tube orientation (horizontal and perpendicular). Empirical models taking into account the aerosol aspiration efficiency and gravitational deposition were used to calculate the faceseal leakage, and to compare with experimental results. The filter penetration was predicted based on the single fiber efficiency theory. Accordingly, fit factors, obtained by combining the filter penetration and faceseal leakage, were shown as a function of mass medium diameter and geometric standard deviation.

**Results:** Experimental results agreed well with the modelled data, showing that aerosol penetration was significantly affected by aspiration efficiency which was a strong function of particle size. Aspiration effect increased with increasing leak flow through microtubes, given in the calm air environment. Gravitational deposition loss in the microtubes was apparent, especially when the tube was placed horizontally and leak flow was low. Experimental data and modelled results all showed that leak size, leak length, leak orientation, breathing flow, filter properties all affected and contributed to the total inward leakage, and therefore, the fit factor.

**Conclusions:** The upper limit of the size distribution of challenge aerosols was mainly determined by the aerosol deposition in the faceseal leaks, while the lower limit was governed by the filter penetration. The optimal challenge aerosol size distribution for QLFT was found to be  $0.4 < MMD < 2.0 \mu\text{m}$  and  $GSD < 2$ , with 25% error. When a more accurate (10% error) fit factor was desired, the aerosol size distribution should be  $0.5 < MMD < 1.3 \mu\text{m}$  and  $GSD$  around 1.5.

## P0123

### Real Time Detection Systems

Thursday, May 26, 2016, 8:00 AM - 11:00 AM

## SR-123-01

### Field—portable Gas Chromatography—Mass Spectrometry Used to Identify Unknown and Unexpected Airborne Stressors

*P. Smith and J. Lodwick, U.S. Department of Labor - OSHA, Sandy, UT*

**Objective:** To understand the processes and mechanisms that generate air contaminants. To identify causative stressors when unexplained medical conditions are observed; especially in situations where the presence of specific important contaminants is unknown and unexpected.

**Methods:** Person portable gas chromatography-mass spectrometry (GC-MS) instrumentation was used in the laboratory to develop sampling methods compatible with the instrument for use in field investigations. These methods were then used in the field to complete two investigations where worker medical conditions raised important exposure questions. Both solid phase microextraction (SPME) and needle trap (NT) sampling are compatible with solventless sample introduction into the heated injector of the GC-MS instrument

used. Methods were developed for both sampling approaches to screen materials, for general area air samples to identify or rule out expected stressors, and to identify unknown/unexpected airborne stressors.

**Results:** Both SPME and NT sampling ruled out exposure to toluene, although several materials with other solvents (methylene chloride, perchloroethylene, and Stoddard solvent) were identified in a fabric printing shop. Both sampling methods identified and unexpected exposure to aniline and p-toluidine an exposure scenario where a worker spent <1 hour cleaning out a tank that held solidified material derived from methylene diphenyl isocyanate (MDI). Worker suffered a rapid onset methemoglobinemia.

**Conclusions:** The use of both sampling approaches with the person portable GC-MS instrument used in the field was instrumental in identifying or ruling out important airborne stressors in cases where medical outcomes implicated workplace exposures. Prior to the field work, there was no information on the causative exposure that produced the near-fatal medical condition in the worker who cleaned the MDI tank, nor was there any understanding of a process or mechanism that may have led to the formation of methemoglobinemia inducing agents within the tank. The identification of the likely causative airborne stressors allowed further work to understand the underlying chemical processes. The new sampling methods developed in the laboratory differentiate the field work completed from a simple case study, and the field work validated the usefulness of the sampling and field analysis approaches used.

## CS-123-02

### Evaluating the Usefulness of Gaseous FTIR Spectroscopy

*L. Knoch, Army Public Health Center (Provisional), Aberdeen Proving Ground, MD*

**Situation/Problem:** When industrial hygienists monitor exposures, real-time sampling can be critical to detecting overexposures. Instantaneous overexposures often are undetected when sampling industrial processes and operations using traditional industrial hygiene sampling methods. The ability to quantify contaminants real-time during workplace monitoring offers significant advantages. Real-time gas/vapor monitoring is especially relevant due to the number of chemicals that have short term exposure and/or ceiling limits. In addition, cross interferences can create an exhaustive nuisance for industrial hygienists in complex sampling environments.

**Resolution:** Innovative Fourier Transform Infrared (FTIR) spectrometers are becoming more accurate, tough, and convenient to use. Due to molecular fingerprinting abilities, FTIR technology is emerging as the cutting edge solution to workplace monitoring problems. Comparable to direct-reading single-beam infrared spectrophotometers, FTIR spectrometers can analyze up to fifty gases simultaneously and detect unknowns. Due to the ruggedness of the instrument and particle filters, the FTIR can be used to sample in most types of environments.

**Results:** Toxic gas sampling methodologies for a variety of workplace environments will be compared. Sampling capabilities and limitations of an array of instruments and examples of real-life sampling methods will be presented.

Pros and cons of various portable, direct-reading instruments and rationale for instrument selection will be presented. The capabilities and accuracy of gas-phase FTIR spectroscopy proves to be superior to other direct-reading instrumentation.

**Lessons learned:** Instantaneous short-term exposure monitoring for gases/vapors is achievable using state of the art FTIR technology. Future research on instrument design should continue to focus on shrinking the overall instrument size, increasing the accuracy, and improving the signal to noise ratio.

## CS-123-03

### Evaluation of Personal Breathing Zone and Area Airborne Diacetyl and Other Volatile Organic Compounds (VOCs) at a Commercial Coffee Roasting Facility via Real-Time Fourier Transformed Infrared Spectroscopy (FTIR)

*M. McCoy and K. Parr, GZA GeoEnvironmental, Inc., Waukesha, WI; J. Cornish, Gasmot, Bellingham, WA; J. Greivell, RAECO, Butler, WI; M. Haapala, Gasmot Technologies Oy, Helsinki, Finland*

**Situation/Problem:** Recent scientific literature has identified the airborne presence of diacetyl and 2,3-pentanedione at concentrations nearing or potentially exceeding the current ACGIH® Threshold Limit Values (TLVs®) at commercial coffee roasting facilities. A large commercial coffee roaster wished to determine its employee breathing zone exposures to these VOCs during various work activities including large-scale coffee bean roasting and grinding, as well as in the general work environment. The coffee roaster was concerned about potential worker inhalational exposure and the potential for adverse health effects.

**Resolution:** Workers were monitored for 8-TWA exposures to alpha diketones, as well as for task-based, short-term exposures for 15 minute periods during specific roasting and grinding processes. Airborne temperature and relative humidity were also evaluated during the study. The authors utilized an AIHA certified laboratory for the analysis via modified OSHA method 1012 for the sensitive and specific quantification of diacetyl and 2,3-pentanedione by gas chromatography with electrochemical detection (ECD). Additionally, the authors performed real-time FTIR analysis of breathing zone and area workplace air for VOCs to determine the sources, as well as quantify and identify various VOCs in the close proximity of roasting and grinding activities. Real-time FTIR provided both identification and quantification of both diacetyl and 2,3-pentanedione, as well as other VOCs generated during coffee bean roasting and released during grinding operations.

**Results:** Airborne concentrations of diacetyl in the worker's breathing zone for 8-hour TWAs were less than the ACGIH® TLV® for diacetyl, and 2,3-pentanedione was non-detectable by standard laboratory methods. Two short-term breathing zone samples revealed airborne concentrations for diacetyl exceeded the ACGIH® STEL of 0.02 ppm. FTIR analysis of air collected from both the breathing zone and the workplace area air samples revealed low concentrations of various VOCs. Diacetyl and 2,3-pentanedione were detected in breathing zone and area samples at concentrations less than the limit

of detection for the FTIR methods. However, when air samples were collected for FTIR analysis from the headspace of bags of freshly ground beans, elevated concentrations of diacetyl, acetaldehyde, carbon monoxide, carbon dioxide as well as other VOCs were detected. Concentrations of these gases rapidly decreased with increasing distance from the freshly ground beans, and neither breathing zone or area workplace air samples reflected hazardous atmospheres in these conditions.

**Lessons learned:** Coffee roasting and grinding, with adequate ventilation and proper roasted bean handling and grinding, appear to generate minimal worker breathing zone exposure to diacetyl and 2,3-pentanedione. It appears from this study that roasted coffee beans naturally generate alpha diketones and other VOCs as naturally occurring compounds resultant of the roasting process. Real-time FTIR proved to be both beneficial in quantifying as well as identifying various VOCs during coffee roasting and grinding operations. Small scale and micro roasting operations, based on their individual ventilation conditions, may need to consider monitoring for alpha diketones as well as other VOCs during roasting and grinding operations.

## SR-123-04

### Handheld Non-Dispersive Infrared (NDIR) Sensing for Field Detection of Light Hydrocarbon Gases

*J. Hill and P. Smith, USDOL/OSHA, Sandy, UT*

**Objective:** When assessing airborne light hydrocarbon concentrations, handheld multi-gas meters are often used to quantify exposures and assess potentially flammable environments. During oilfield activities, hydrocarbon concentrations greater than the LEL may be encountered and proper LEL assessments are essential to worker protection. When detectors are not accurately calibrated or calibrated with a gas dissimilar to the environment being tested, knowledge of potential hazards isn't reliable. Field users may make decisions resulting in hazardous working conditions. To better understand the impacts of gas detection when calibrated to a different gas, tests conducted in a laboratory setting provided valuable information for field personnel when determining multi-gas meter response in varying conditions.

**Methods:** Due to limitations of catalytic combustion sensors to values below the LEL, non-dispersive infrared (NDIR) detection was selected as a means to evaluate hydrocarbon gas concentrations ranging from 0 to 100 vol%. Instruments with NDIR sensors were exposed to methane, propane and butane to determine response accuracy when calibrated to one gas but exposed to a different flammable gas. A wide range of concentrations were generated in 5 layer bags for methane, propane, and butane ranging from 10 to 100 vol% to determine NDIR sensor response.

**Results:** Analysis of the data indicated loss of accuracy for scenarios when calibration to methane occurs but detection of propane or butane is necessary. Strong linearity was identified when meters are calibrated to methane and methane was monitored (slope=1.0,  $r^2 > 0.99$ ). In addition, in low concentrations (less than 6 vol%), propane was linearly detected using a meter calibrated to methane but higher propane concentrations caused the meter to read out "over limit" results due to the greater molecular IR absorptivity of

propane compared to methane.

**Conclusions:** This demonstrates a need to determine the composition of potential flammable gases to be encountered when calibrating handheld portable multi-gas meters for detection of gas concentrations greater than LEL values. For reliable results in the field, one must use a sensor that measures the gas to be encountered and that sensor must be calibrated to the appropriate gas to ensure results are accurate and representative of the actual airborne concentrations.

## SR-123-05

### A Portable Colorimetric Biosensor for Real-Time Personal Exposure Assessment to Bisphenol A in Indoor Environments

*R. Alkasir, A. Rossner, and S. Andreescu, Clarkson University, Potsdam, NY*

**Objective:** Bisphenol A (BPA) is a phenolic compound commonly used in the plastics industry that can result in human exposure and potentially lead to behavioral, reproductive, developmental, and neurological disorders. While relatively high concentrations of BPA are released in the living environment, there is a lack of temporal and spatial resolution data to characterize BPA exposure. An improved understanding of the exposure response effects requires field deployable instrumentation that can be used for rapid multisite monitoring in the living environment.

**Methods:** To facilitate spatiotemporal measurements of BPA exposure, we have designed a compact portable colorimetric paper based biosensing device with integrated sampling/analysis units for field-based measurements of BPA. The system employs interchangeable BPA responsive paper sensors as a colorimetric test zone for BPA. Sample analysis through measurement of color intensity was made directly on the sensing pad, immediately following sample aspiration. The sensor was validated with the conventional Gas Chromatography (GC) method and used to detect BPA exposure in household dust.

**Results:** The sensor enabled selective detection of BPA with a detection limit of 0.28  $\mu\text{g/g}$ . Sensor data was gathered as a visual color change with the naked eye and by using common image analysis software such as Adobe or Image J, or with an iPhone. BPA concentrations in household dust samples ranged from 0.05 to 3.87  $\mu\text{g/g}$ . Side-by-side comparison of BPA concentrations in the household dust samples shows excellent correlation between the two methods: portable biosensor and GC.

**Conclusions:** This study demonstrates the feasibility of low cost paper based devices with biomolecular recognition as reliable detection tools for field based assessment of BPA exposure in dust samples. Advantages include on-site measurements, ease of use, real-time detection and reagentless operation with all in one sampling, extraction and analysis. The system could be adapted to other chemicals such as volatile organic compounds (VOCs), phthalates and pesticides, and can be used in homes, day care centers, schools and the work environment.

## SR-123-06

### Real-Time Particulate and Toxic-Gas Sensors for Firefighters

*F. Takahashi and C. Liu, Chemical Engineering, Case Western Reserve University, Cleveland, OH; P. Greenberg, G. Hunter and M. Kulis, NASA Glenn Research Center, Cleveland, OH; G. Hunter, NASA Glenn Research Center, Cleveland, OH; S. Carranza and D. Makel, Makel Engineering, Inc., Chico, CA*

**Objective:** Removal of respiratory protection during fire overhaul activities can expose firefighters to unknown toxicants, but current practice relies solely on the Carbon Monoxide concentration. Wildland firefighters do not even wear respiratory protection despite low-level but long-term exposure to smoke. Simultaneous monitoring of particulates, aldehydes (formaldehyde and acrolein), and hydrocarbons are needed as they include carcinogens and exceed frequently the exposure limits during fire overhaul and wildland firefighting. The purpose of this project is to develop prototypes of compact, highly sensitive, real-time particulate/gas detection systems to reduce the number of firefighter fatalities and injuries.

**Methods:** This study endeavors to: (1) combine the NASA developed compact particulate and gas (O<sub>2</sub>, CO, and hydrocarbons) sensors, (2) micro fabricate and integrate new sensitive aldehyde sensors, and (3) test prototypes in the laboratories, burn rooms, fire overhaul, and wildland fire environments.

**Results:** The preliminary testing of existing particulate and micro fabricated gas sensors was conducted in a controlled burn room using different fuels and in the laboratory using smoke from wood samples being pyrolyzed in a tube furnace. The preliminary testing resulted in further understanding of the device responses and room for improvement.

**Conclusions:** The preliminary testing of the previously developed particulate and gas sensors demonstrated their performance and potential. Additional micro fabricated sensors for the aldehydes are being developed. Compact real-time particulate and toxic-gas detectors to be derived from the prototypes under development can be adopted by fire services eventually in the future.

## CS-123-07

### Practicalities & Early Lessons: Small Unmanned Aerial Platforms for Monitoring Stressors

*R. Eninger, Air Force Institute of Technology, WPAFB, OH; K. Fullerton, US Air Force School of Aerospace Medicine, WPAFB, OH*

**Situation/Problem:** Rapidly developing unmanned aerial technologies are offer the potential for a novel, mobile sensing platform for use by environment, safety & occupational health professionals and in related disciplines. Employment of small unmanned aerial systems (SUAS) for these purposes is nascent and has yet to develop standard practices and specifications. In particular, improvements in sensor design, employment, and interoperability are needed to foster wider adoption. Currently, sensor solutions tend to be customized for a chosen airframe.

**Resolution:** The literature was reviewed and two distinct pilot efforts were undertaken to develop airborne platforms for chemical and aerosol monitoring. The first effort pursued a design to locate chemical emissions using micro aerial vehicles. The second effort attempted to design and fly a platform for monitoring combustion emissions. Through these efforts, practical lessons were garnered across the planning, design, development, and attempted employment phases.

**Results:** Observations were made on operator/pilot requirements, controls, sensor employment, and platform characteristics which impacted the feasibility of operations. Claims for UAS efficacy for use in environmental monitoring should be viewed with some skepticism based upon complexities that are yet to be worked out.

**Lessons learned:** An interdisciplinary approach is required to effectively design, plan, and employ small unmanned aerial systems for monitoring of stressors. The technology is not sufficiently mature to consider these capabilities for routine employment but does have promise to do so in the future. A trade-off occurs between payload, flight time, and sensor detection limit/sophistication. These are additional considerations when formulating data quality objectives.

## CS-123-08

### Lessons Learned in Selecting an All-Hazards Equipment Suite of Direct Reading Instruments

*C. Baker, Alliance Solutions Group, Inc., Helotes, TX; R. Campbell, Alliance Solutions Group, Inc., Newport News, VA; W. Weisman, Consulting, Newport News, VA*

**Situation/Problem:** Any organization purchasing direct reading equipment knows the challenges of selecting the right tool for the job, even if the hazards are known. Take this situation and apply it to an organization with one hundred seventy branches in nine countries responsible for protecting workers and the surrounding communities from known and unknown hazards; the combination of challenges skyrocket. This presentation will cover the process used to select a comprehensive, standardized package of direct reading equipment for teams of occupational health and emergency response specialists engaged in global operations.

**Resolution:** The effort focused on identifying best of breed instruments that addressed global and local risks, satisfied the technological capability needs, and balanced the selection based on life-cycle cost and ease of user interface. An organization wide equipment list was stratified by target capability (e.g., radiological, VOC, high volume air sampler, biological agent, etc.) and if it could detect, identify, and/or quantify hazards. From this, a set of instruments with similar capabilities was scored on its ability to address the risks and satisfy the technical criteria (e.g., instant quantification of gamma radiation). These factors included: life-cycle cost, operations and maintenance schedule, anticipated lifespan, supply-chain availability, consumable and accessory shelf life, power source, value, user feedback, training time required for proficiency, and other practical considerations—are the buttons big enough to push when in Level A PPE?

**Results:** Each item selected filled a specific need in the teams' all-hazards direct reading equipment suite. Some duplication of capabilities was intentionally incorporated into

the final equipment suite to ensure field teams had redundant capability.

**Lessons learned:** Thousands of hours of real world responses and all-hazards exercises, using the recommended equipment set, provided lessons learned about the equipment, how well users were able to choose the best instrument based on time constraints and available information, and how standardization improved cost, logistical support and streamlined training efforts.

## CS-123-09

### The Role of Data Science on the Industrial Hygiene Team

*R. Reed, University of Arizona, Tucson, AZ*

**Situation/Problem:** Advances in data collection (such as sensors), data storage, and data processing technologies have opened the hypothetical data flood gates. Today, data science drives marketing, political campaigns, and it even drives cars. Data science could and should be utilized for improving industrial hygiene, but our field has yet to embrace it. The objective of this presentation is to deepen understanding of data science, its impact on health and safety, and help quicken the pace at which IHS see utilization and improvement.

**Resolution:** Data science is simply the aggregation of 1) field expertise (Industrial Hygiene), 2) some statistical knowledge, and 3) some computer programming skills. Certain predictive data science techniques were developed with human brain physiology in mind and are a form of 'machine learning'. Machine learning techniques can continue to model and improve their predictions, sometimes without human supervision.

**Results:** Data science has already invaded occupational health and safety. Some companies use it to predict when workers are too fatigued to operate heavy equipment based on wearable monitors or anomalies in every day, measurable behaviors. Other applications for data science include predicting measures that are otherwise too difficult or costly to collect. Further insight and predictive capabilities can be gleaned from data already collected, such as machine health. Future wearable, real-time sensors will measure several contaminants at once and predict risk based on a host of inputs.

**Lessons learned:** Several barriers will slow the application of data science to industrial hygiene. While sensor technology, data integration and processing power continue to be barriers in some cases, they will quickly be overcome. Other issues include the ethical premise of activity monitoring, and the effect risk prediction could have on individual risk aversion. While many questions remain unanswered, for now, industrial hygienists should 1) understand the benefits and challenges that data science will bring, 2) be proactively involved in the discussions and actions that will shape the future of health and safety, and 3) think outside of the box, integrate ideas from other life and work experiences, and apply them to the work of improving health and safety.

## P0124

### Biological Monitoring & Bleeding Edge

Thursday, May 26, 2016, 1:00 PM - 3:20 PM

## CS-124-01

### Exposure to Lead from Industrial Paints and Coatings: Is This Still a Potential Hazard in Workplaces?

*D. Radnoff, Alberta Jobs, Skills, Training and Labour, Edmonton, AB, Canada*

**Situation/Problem:** Historically, lead has been used as a pigment in paints and also to improve the qualities of the product. Under the current federal legislation in Canada, a lead paint is considered a product that contains more than 90 mg/kg lead. Employers may not be aware that products with applied industrial coatings can still contain lead. There is no labeling required for such products on which the coating has already been applied. Moreover, there is very little guidance for employers on the potential for an occupational hazard when coatings containing low levels of lead are disturbed.

**Resolution:** Alberta Jobs, Skills, Training and Labour conducted a literature review and some limited sampling to better quantify the potential for a workplace hazard.

**Results:** Lead was found in new industrial coatings above the Canadian standard. Employers where these results were found were not aware of the lead content. Studies in the published literature show that workers may still be exposed to lead in excess of occupational standards, even when the lead content is low, but this data is very limited. Further, the relationship between the amount of lead in the coating and how much becomes airborne is not established. Regardless of the lead content in the coating, the lead can still become airborne and contaminate surfaces over time.

**Lessons learned:** More work is required to improve employer awareness of this potential hazard and to better quantify the potential exposure hazard to workers when disturbing coatings containing low levels of lead.

## SR-124-02

### Legionella in Residential and Commercial Properties: Routine Monitoring and Prevention

*J. Birkebak, C. Lively, M. Reed, and E. Sobek, Assured Bio Labs, LLC, Oak Ridge, TN; P. Riccobono, Conditioning and Control Systems, Inc., Englewood, NJ; J. Leitner and M. Borello, Environmental Building Solutions, LLC, New York, NY*

**Objective:** Legionella has received increased media recognition recently due to several large scale lethal outbreaks, including the Pittsburgh Veterans' Affairs clinic in 2012 and the New York City Bronx outbreak of 2015. Despite the seemingly intermittent diagnosis of Legionellosis, routine monitoring reveals that Legionella is commonly and consistently recovered in cooling towers as well as potable water. The CDC estimates that Legionellosis is greatly under reported, partly due to the current medical techniques for diagnosis. The best way to

ensure a healthy environment for tenants and employees and liability free operations for owners is to implement a schedule for routine testing and response actions when Legionella is detected. Here we set out to illustrate the increasing need for a Legionella monitoring program and provide guidelines for testing methodologies and response actions.

**Methods:** Over four years of results for routine Legionella testing of properties in New York City and other areas are presented. Both culture and qPCR were used in some settings.

**Results:** Over the past three years we have found that Legionella is frequently recovered from water samples in residential and commercial properties in New York City. Over half of projects were found to contain Legionella. Despite the recently expanded testing of cooling towers, the bacterium was more commonly found in potable hot water systems than in cooling towers. Some buildings consistently test positive for Legionella while others implement treatment protocols in order to control Legionella contamination. Even though Legionella is found, often no illness or outbreak is reported. This may be primarily due to the current medical methods that only screen for one serogroup of one species. Research has shown that many people do produce antibodies indicative of past Legionellosis. There are two main options for Legionella testing currently available: the traditional culture method and quantitative polymerase chain reaction (qPCR). Each option has benefits and drawbacks and which to use may seem unclear. While the culture method remains the “gold standard” for detection for environmental Legionella detection, it requires a long turnaround time which may not be feasible while combating or tracking an ongoing outbreak or immediately following response actions to ensure proper decontamination. QPCR, while it can be run with same day turnaround for immediate results, cannot distinguish between living and nonliving Legionellae and inter-lab comparison of results can be difficult given that there is no established and universally accepted methodology. Guidelines on which method will best fit a given circumstance will be presented.

**Conclusions:** The increased media attention will likely lead to an increase in monitoring requirements, social attention, and raise the legal stakes for owners and managers of cooling towers and potable water systems. With the increasing social and medical relevance of Legionella infection and the prevalence of Legionella recovered from cooling towers and potable water systems, a routine monitoring program is strongly advisable.

## SR-124-03

### Passive Wristband Sampler Technology Used to Build Bridges: Pilot Study Examples

*K. Anderson, Oregon State University, Corvallis, OR*

**Objective:** Accurately assessing the breadth of a person’s exposures to environmental toxicants is central to the challenge of studying environmental health effects. The lack of low cost, easy to use personal sampling technology hinders many situations where sampling is challenging.

**Methods:** Personal sampling wristband technology (BRIDGES: Biological Response Indicator Devices for Gauging Environmental Stressors) was developed specifically because Public Health researchers and Community partners were enthusiastic about its broad potential to fill a key gap in

Public Health. The wristbands can provide a foundation to measure organic chemicals that are a crucial component of the exposome. Volatile and semi-volatile organic chemicals (chemical with a boiling point less than 450°C) can be quantified from the wristband.

**Results:** The wristband can be screened, in a single method, for over 1,400 organic compounds. We can quantify several 100 analytes such as PAHs, pesticides, flame retardants, PCBs, and many consumer products. The extracts can be used to assess the bioactivity of the actual exposure mixture of the individual wearing the wristband. Several pilot studies have been completed. Polycyclic aromatic hydrocarbons (PAHs) were detected and quantified, and two oxygenated PAHs were quantified on journeymen who wore the wristband while roofing and pre-apprentices at a training center. All participants. Thirty-one PAHs were detected, including large PAHs such as benzo[e]pyrene (mp 178°C, bp 493°C) and total PAHs ranged from 230 to 4,600 ng/wristband. In another study, young children’s exposure to flame retardants was investigated. Wristband recoveries averaged 98%, 103% for brominated diphenyl ethers, and phosphate ester flame retardants, respectively. The between day precision of spiked wristbands was < 9%. Some children’s wristbands had 20 quantifiable flame retardants. In a western Africa study, we found that wristbands contained 2 to 10 pesticides, with deltamethrin and cypermethrin most frequently detected in 99 and 94% respectively.

**Conclusions:** We have found that people are actually eager to wear the wristband and we have 85-100% compliance in studies to date. Our passive sampling technology can be deployed in hours to disaster areas in a way that synergizes with NIEHS’s programs to develop effective analyses of the human health impacts of disasters. Individuals and communities can be empowered with this chemical exposure information which helps build community resilience.

## SR-124-04

### Piloting Development of a Wearable, Real-Time Heat Strain Monitor

*R. Reed, University of Arizona, Tucson, AZ*

**Objective:** The objective of this study is to develop a real-time, wearable heat strain monitor that can predict core body temperature and potential heat related incidents. Because of the barriers associated with monitoring heat strain, its individualized nature, and the lack of regulatory limits, few employers regularly perform personal heat strain monitoring. The ACGIH® Threshold Limit Value (TLV®) for heat stress utilizes a method that combines metabolic and environmental heat sources to determine one’s risk of excessive heat strain. This work attempts to assess these heat sources in real-time using sensor technologies and predict core body temperature (CBT).

**Methods:** Physiologic (heart rate, activity, skin temperature) and environmental (dry bulb temperature, relative humidity) measures were collected for approximately five subjects using real-time, wearable sensors. CBT were measured using the CorTemp® ingestible temperature sensor (HQ Inc., Palmetto, FL). A type of machine learning technique called artificial neural networks (ANN) is being utilized to develop models capable of predicting core body temperature using sensor inputs. If ANN proves ineffective, prediction will be attempted using vector auto-regressive time series methods. MATLAB

(MathWorks, Natick, MA) will be used for data cleaning, filtering, smoothing, and analysis.

**Results:** The average HR is 157 bpm, the average calorie expenditure is 14.4 calories per minute, while the average steps per minute is 170. Preliminary CBT data required substantial cleaning and smoothing, while HR and other sensor data are comparatively noise free. After initial model training, we anticipate excluding 1-2 inputs because they do not contribute to CBT prediction. We hope to successfully predict CBT in real-time for working individuals with a wearable monitor. Potential limitations include a lack of inputs for hydration status, perspiration, precipitation, and convective and radiant heat sources. In addition, the small sample size does not allow for machine learning across a variety of body types, races, ethnicities, or other modifiers such as personal protective equipment.

**Conclusions:** We aim to reduce the barriers associated with heat strain monitoring in the workplace and at sporting events. We believe a wearable, real-time heat strain monitor with alerting system can accomplish this, and this project lays the groundwork for such a device.

### SR-124-05

## Analysis of Los Angeles Taxi Drivers' Urinary PAH Metabolites and Their Associations with Occupational Exposure to Traffic Pollutants

*N. Yu, University of California Los Angeles, Los Angeles, CA*

**Objective:** Polycyclic aromatic hydrocarbons (PAHs) is one of the major hazardous traffic emission constituents. Many PAH species have been identified as carcinogens, mutagens, and teratogens, and their metabolites can cause damage to human DNA. About 4,000 taxi drivers are working in Los Angeles area with potentially high occupational particulate matter and PAH exposures, however, there is a data and knowledge gap on quantifying their PAH exposure levels and the associated health impacts.

**Methods:** In this study, 22 never smoked Los Angeles taxi drivers were recruited and monitored for 4 consecutive work days, a 6-hour work shift/day, for their ultrafine particles and PM<sub>2.5</sub> exposures. In the last two monitored days, each driver's taxi will be installed with a high efficiency particulate cabin air filter for exposure intervention. The taxi driver urine samples were also collected both just before (pre shift) and right after (post shift) their daily work shift. Nine different urinary monohydroxylated PAH metabolites were analyzed, which included 1- and 2-hydroxynaphthol (1- and 2-NAP), 1-, 2-, 3- hydroxyphenanthrene (1-, 2- and 3-PHE), 2-, 3-, 9-hydroxyfluorene (2-, 3-, and 9-FLU), and 1-hydroxypyrene (1-PYR). Urinary malondialdehyde (MDA) was also analyzed and used in this study as an oxidative stress marker. Four UCLA never smoked researchers served as a control group. Their urine samples were also collected and analyzed following the same procedure that was administered to the taxi driver group.

**Results:** Paired t tests were conducted to compare pre and post work shift samples from the taxi drivers, and the results showed no significant differences ( $p < 0.05$ ) between pre and post work shift urinary PAH metabolites and MDA levels. Taxi driver urinary MDA didn't show significant correlations with any analyzed urinary PAH metabolites. Comparing urinary

MDA and monohydroxylated PAH metabolite levels, within the total of nine analyzed metabolites, four of the metabolite mean levels in the driver group were higher than the control group significantly with group t tests ( $p < 0.05$ ). These four metabolites were 1- and 2-NAP, 1-PYR and 9-FLU. No differences were detected for urinary MDA levels between the taxi driver and control groups.

**Conclusions:** A mixed effect longitudinal model results showed the taxi driver 1-PYR levels were significantly affected by their work time ultrafine particle and PM<sub>2.5</sub> exposure levels.

### CS-124-06

## Application of a Systems Approach to Link Safety and Productivity to Power Hand Tool Evaluation and Procurement

*M. Geiger, Naval Safety Center, Fairfax, VA; D. Wasserman, Consulting Engineer, Frederick, MD*

**Situation/Problem:** Powered hand tools have become essential in the industrial environment since their introduction in the late 1870s. Risks linked to this technology include noise, segmental vibration, and a range of ergonomic/repetitive motion risks. While exposures and potential health outcomes are commonly correlated with well described dose response relationships, regulatory controls are not consistently imposed on procurement and support activities. This is a major issue in the US, where OSHA regulatory standards lag significantly behind current scientific knowledge. Standards for hand-arm vibration are advisory rather than mandatory. Procurement often considers initial purchase costs as the primary factor in product selection. The result has been use of tools and work practices inconsistent with best available technology and related persistence of poorly controlled occupational exposures.

**Resolution:** A team of health and safety professionals from the US Department of Defense (DOD) and NIOSH and procurement/logistics experts from the General Services Administration and DOD was formed in 2008. This group developed procurement guidelines considering vibration and other safety and health factors. Collaboration with industry and SAE International led to development of a process standard. Aerospace Standard AS 6228, for power tool evaluation and procurement considers life-cycle costs, productivity, noise, vibration and other ergonomic considerations in a semi-quantitative rating scale.

**Results:** The US Government's commodity manager for powered hand tools has adapted this standard in evaluation and product selection. Approximately 130 new tools have been introduced into the supply system. Outreach is being made within DOD and to allied industries.

**Lessons learned:** A standardization approach may be considered where process improvements and selection of best available technology benefit productivity, cost and safety. A multidisciplinary team and persistent outreach, was needed to reach the various customers and product managers. This methodology focused upon power tools, but could also be applied to help overcome the absence of strong safety and health regulatory criteria for other commodities and processes.

## SR-124-07

### Estimating the Dermal Exposure of Synthetic Musks from Personal Care Products by Using Vertical Diffusion Cell

*Y. Hsu, W. Tseng, and S. Tsai, National Taiwan University, Taipei, Taiwan*

**Objective:** Emerging environmental pollutants have caused concerns in recent years. For example, a variety of chemical components such as synthetic musks (e.g., galaxolide (HHCB) and tonalide (AHTN)), from personal care products (PCPs), may cause exposures through skin contact. To assess the possible health effects, the dermal exposures of synthetic musks were estimated in this research.

**Methods:** The vertical diffusion cell (VDC), an in vitro method, was used to simulate skin exposures in this study. Porcine skin was selected as the substituted skin for human exposure, while phosphate buffered saline (PBS) solution was used as the receptor media. The flow rate of the VDC system was about 10.13 ml/hr., and the temperature was set at 37 degrees Celsius. Samples from the VDC system were taken periodically to determine the permeation profiles. The 65µm PDMS/DVB solid-phase microextraction (SPME) fiber was exposed to the headspace over the samples. After adsorption equilibrium has been reached, the SPME fiber was inserted into the injector of the gas chromatography with tandem mass spectrometry (GC/MS/MS) for thermal desorption and further analysis.

**Results:** The SPME procedure coupled with GC/MS/MS analysis for the determinations of synthetic musk in PBS solution was established in this study. No carry over effect was observed from the thermal desorption of the sample. The detection range for nitro and polycyclic musk were 0.1 ng/ml-20 ng/ml and 0.01 ng/ml -2 ng/ml, respectively. The skin permeation profiles of synthetic musks from different PCPs were estimated. Health risks associated with the possible exposures were also assessed.

**Conclusions:** VDC system was applied in this study to estimate the skin exposures of synthetic musks from PCPs. With SPME procedure, advantages over conventional methods, such as solvent-free and time-saving, were reached. The sensitivities of the method for different musk compounds were low enough to determine the concentrations after skin permeation.

## P0125

### Intriguing Unknown and Known IH Hazards

Thursday, May 26, 2016, 1:00 PM - 3:20 PM

## CS-125-01

### Cold Storage of Fumigated Fruit: Worker Illnesses Uncover an Unforeseen Route of Pesticide Poisoning

*H. Fong and P. Tehrani, California Department of Pesticide Regulation, Sacramento, CA*

**Situation/Problem:** In 2010, the California Department of Pesticide Regulation's (DPR) noted two workers at a cold

storage facility in Long Beach had been diagnosed with methyl bromide poisoning. The Worker Health and Safety Branch of DPR investigated the situation, since methyl bromide (MBR), a fumigant, was not normally associated with cold storage facilities. These facilities stored Chilean grapes. Fumigation is required by USDA for imported grapes. Six large cold storage facilities (CSF), that were known to receive fumigated grapes, were investigated using colorimetric tubes. All showed unacceptably high levels (as high as 24 ppm, California PEL = 1 ppm) in the cold storage chillers. As more CSFs were discovered to be accepting fumigated fruit, the monitoring program expanded and in all cases MBR was detected.

**Resolution:** Two CSFs were selected for intensive monitoring using charcoal tube sampling. One was tested during the first three hours after receiving fruit, the other three days after receiving. Additionally, different mitigation strategies were employed, including extended dockside aeration, in transit venting, predelivery aeration, facility ventilation, filtration, and real-time MBR monitoring.

**Results:** Overall sampling results indicated that without active control measures, unacceptable levels occur in the chillers, but drop off after 72 hours. Sampling also found that MBR had infiltrated into rooms within the building envelope distant from the chillers holding the fumigated fruit. Some mitigation measures were of little use (extended aeration), while others reduce build-up of MBR in cold storage rooms.

**Lessons learned:** A state mandated program, designed to mitigate the off-gassing hazard, has been developed in cooperation with the CSFs. Key elements include ventilation, worker education, real-time monitoring of MBR and worker exposure time management. Only CSFs that have this program are allowed to receive and store freshly fumigated grapes. And although the greatest bulk imported fruit required to be fumigated is grapes, other fruits, including kiwis and blueberries, are also fumigated and have been folded into this program.

## CS-125-02

### Protecting Workers Who Manufacture the Insensitive Munitions that Protect the Warfighter

*L. Kneten, Army Public Health Center, Bel Air, MD*

**Situation/Problem:** The safety and health of workers in manufacturing the new insensitive munitions IMX is of concern. Three of the four main ingredients of IMX, 2,4-dinitroanisole (DNAN), 3-Nitro-1,2,4-triazol-5-one (NTO) and nitroguanidine (NQ) do not have established occupational exposure levels (OELs). Without OELs and exposure assessment methodology, it is unclear whether the workers in IMX Army Ammunition Plants are properly protected.

**Resolution:** 1. Establish OELs for IMX. The Army Public Health Center (Provisional) conducted toxicology studies and submitted results to the Toxicology Excellence for Risk Assessment (TERA) Occupational Alliance for Risk Science (OARS) to publish Workplace Environmental Exposure Levels (WEELs) for DNAN, NTO and NQ. 2. Establish Sampling and Analytical Methodology. The analytical laboratory at the Army Public Health Center (Provisional) developed procedures for sampling and analysis of DNAN, NTO, and NQ. 3. Conduct Worker Exposure Assessments at IMX Army Ammunition Plants. Comprehensive Industrial Hygiene assessments were

conducted at several IMX Army Ammunition Plants. Over 240 personal samples and 620 wipe samples were collected. Personal exposures were measured for each of the explosive compound constituents. Results were compared to recently published OARS WEELs. Controls (engineering and personal protective equipment) at plants were assessed and work practices were observed to identify opportunities to control or eliminate exposures.

**Results:** Personal air monitoring results and observations from work practices indicate the potential exists for workers to be exposed above the OARS WEELs for three out of the four chemical constituents of the new insensitive munitions explosives. Exposure to NQ was not significant. Poor work practices and improper use of personal protective equipment often contribute to exposure. Production area work surfaces contained high levels of the chemical compounds and validates the need to wear gloves to reduce skin contact.

**Lessons learned:** Environmental conditions and requirements for intrinsic safety make implementing controls difficult. All equipment must be grounded or classified as intrinsically safe for Class 1, Division 1, Group D. Due to the concentrations of chemicals present workers are wearing flame retardant coveralls and respirators. In addition, the atmosphere temperature must be maintained to at least 85 degrees Fahrenheit in order for the mixture to maintain necessary temperature, which adds to the workers' heat stress burden. Until engineering controls can be retrofitted into the operation to reduce and/or control exposures, interventions such as improved personal hygiene, reduced exposure duration, improved housekeeping and work practices, and use of respiratory protection can be used to protect the workers during production operations.

### SR-125-03

#### Hazard Assessment of High-Nitrogen Explosive Compounds: A Novel In Vitro Multi-Cellular Approach

*T. Maurais, C. Gellasch, and M. Bruggemeyer, DoD, Uniformed Services University of Health Sciences, Bethesda, MD; K. Donohue, N. Garcia-Reyero, E. Perkins, and K. Gust, USACE Engineer Research and Development Center, Vicksburg, MS*

**Objective:** The energetic properties of high-nitrogen (high-N) content materials have increased the interest towards the development of high-N compounds for use in insensitive munitions. However, the use of such compounds is known to lead to an increase risk of adverse health effects towards munition factory workers and the general population. While chemical hazard assessment with live animals has many advantages, the high cost of in vivo testing, in terms of resource consumption, animal usage, and time, only allows for the testing of a limited number of compounds. Current in vitro systems are limited by screening cells in isolation, underestimating the cytotoxicity of metabolites. In order to address these limitations, the objective of this research is to develop a rapid and efficient in vitro model capable of assessing the toxicological impact of high-N compounds.

**Methods:** The Integrated Discrete Multiple Organ Co-Culture (IdMOC) system allows for the co-culture of up to 6 discrete organ cell types; demonstrating cell-specific toxicity of parent compounds and of metabolites generated by other cells. In

this research, 5 cell lines were used: kidney, liver, lung, heart and vascular endothelium. The high-N compounds assessed through this system were 2,4,6-trinitrotoluene (TNT) and 2,4-dinitroanisole (DNAN). TNT, with its well documented cytotoxicity, served as a comparative model, while the assessment of DNAN led to a better understanding of its less known toxicity. Cytotoxicity was assessed by viability and functional assays as well as by functional analysis of common regulated genes following microarray analysis.

**Results:** Following viability assays with the cell lines used in the IdMOC system, the toxicity of DNAN was found to be less than the toxicity of TNT by a factor of 10. Furthermore, results from the functional assays and microarray analysis indicate the effects of TNT and DNAN on the gene expression profiles of the different cell lines as well as the impact of metabolites, leading to a better understanding of the in vitro multi-tissue dynamic of high-N metabolism.

**Conclusions:** The IdMOC system is expected to play an increasing role in the hazard assessment of high-nitrogen compounds in order to facilitate their safe development and use in insensitive munitions, with the potential for an extended use of the system with other contaminants, natural or industrial.

### SR-125-04

#### Occupational Exposure Assessment of 1-Bromopropane

*Y. Lin, H. Lee, and C. Ko, Fu-Jen Catholic University, New Taipei City, Taiwan; J. Wu, C. Chang, and Y. Dai, Chang Jung Christian University, Tainan, Taiwan*

**Objective:** 1-Bromopropane (1-BP) has been applied as a metal cleaning agent in manufacture industries since the ozone-depletion substances were banned. Exposure of 1-bromopropane has been reported in relation to peripheral neuropathy. The ACGIH® has classified 1-BP as an A3 chemical. Several occupational disease cases due to the 1-BP exposure have been reported in Japan, the USA and Taiwan. No official PEL and occupational exposure profile of 1-BP are established in Taiwan. This study investigated the exposure profiles of workplaces using 1-BP.

**Methods:** The 1-BP sampling protocol was modified from OSHA Method 1017 and NIOSH Method 1025. Active samples were collected by drawing workplace air through coconut shell charcoal tubes with personal sampling pumps at flowrate 200 mL/min for 6 hours. All samples were analyzed by GC/MS with a method detection limit of 0.84 ppb. At the time of collection of the personal samples, urine samples were collected. The 1-BP metabolite, n-acetyl-S-(n-propyl)-L-cysteine (AcPrCys) was selected as the biological exposure index (BEI) and quantified by HPLC-MS/MS. The limit of quantitation was 0.023 ng/mL. A total of 100 area and personal air samples and 76 urine samples (before and after the work shift) were collected from three plants.

**Results:** The 1-BP concentrations of the 95th percentiles of exposure group (cleaning operation) ranged from 31.44 to 41.96 ppm for personal samples. The 95th percentile 1-BP concentrations of area samples air ranged from 20.43 to 41.84 ppm. The AcPrCys concentrations in urines were between 11.58 mg/g cre and 4,945.71 mg/g cre before shifts, and the AcPrCys concentrations in urines were from 3.72 mg/g cre to 7,818.26 mg/g cre after shift. The correlation between

the after-shift urine AcPrCys concentrations and the 1-BP concentrations of personal air samples was significant ( $r = 0.679$ ,  $p = 0.05$ ). This implied that after-shift is a better specimen collecting time for 1-BP BEI, AcPrCys. Meanwhile, an enclosure process was implemented in one of the survey plants and the 1-BP air concentration in the working area was reduced by 70%.

**Conclusions:** The sampling results exceeded Cal OSHA PEL 5 ppm and ACGIH® TLV® 0.1 ppm. The occupational exposures of 1-BP should receive a high level of attention in Taiwan. Effective engineering controls, respiratory protection program and dermal protection program should be implemented to limit exposures.

## CS-125-05

### Isocyanate Exposure Assessment When a Paint Brush and Roller Are Used to Apply Moisture-Cure Polyurethane Paint

*T. Schoonover, Washington State Department of Labor & Industries, Olympia, WA*

**Situation/Problem:** A public mass transit agency established a maintenance program to paint metal surfaces at bus and light rail stations. The agency was concerned about worker and public exposure to airborne isocyanates, chemicals that irritate mucus membranes and are well known to cause occupational asthma. The paint system most compatible with the previously painted shelter frames, doors, and light poles was an isocyanate based moisture-cure primer and paint. Isocyanate exposure is known to be hazardous when polyurethane paints are applied with a spray gun, but less is known of exposure when paint is applied with a paint brush and roller.

**Resolution:** To guide the agency's on-site exposure control plan, airborne isocyanate concentrations were assessed under two scenarios. The first scenario was an indoor test environment in which isocyanate concentrations were evaluated in an enclosed non-ventilated test room followed by application in an outdoor test setting. The second scenario was the in situ application of the paint to an outdoor transit station in the public domain. Concentrations of 1,6-hexamethylene diisocyanate (HDI) monomer and three HDI polymers were assessed when two moisture-cure polyurethane paints containing 31-35% isocyanates were applied with a paint roller and brush. Short-term 15-minute samples were taken during paint application in an indoor test environment with no ventilation ( $n=12$ ); in an outdoor test environment ( $n=11$ ); and in an outdoor in situ assessment ( $n=22$ ).

**Results:** All isocyanates were below analytical limits of detection during the initial test condition in a closed room with no ventilation. Furthermore, all isocyanates were below detection limits in the subsequent outdoor test and during in situ station painting. This is primarily attributed to the roller and brush application method which generate low aerosol and therefore low exposure.

**Lessons learned:** The paint formulation studied here contains a very low fraction of HDI monomer (0.10%). Thus, there is a low reservoir of isocyanate available to naturally vaporize from the paint can, tray, or from uncured applied paint. If a paint formulation has a higher concentration of isocyanate monomer, isocyanate exposure during roller application may be higher. The non-detectable airborne isocyanate concentrations

attributed to the use of roller and brush do not infer that workers do not need proper respiratory or skin protection when doing similar work.

## CS-125-06

### Use of Aggressive Air Sampling for Assessing the Sufficiency of Indoor Firing Range Cleaning for Lead (Pb) Removal

*A. Weber and R. Seymour, Army Public Health Center (Provisional), Aberdeen Proving Ground, MD; B. Grace, Public Health Command-Pacific, Camp Zama, Japan*

**Situation/Problem:** In indoor firing ranges, ongoing weapon firing can deposit lead on walls and floors. These surfaces must be periodically cleaned to maintain surfaces "as free as practicable" of accumulations of Pb as required by the OSHA standard 29CFR1910.1025, Lead. Presently, there are no quantitative occupational exposure limits for Pb on surfaces that can be used to evaluate the adequacy of cleaning. Current lead surface wipe methods for Pb can yield highly variable results which may be inconclusive with respect to showing cleaning effectiveness, particularly when surfaces are porous. **Resolution:** Aggressive air sampling, modeled after asbestos post-abatement clearance sampling, was implemented as a more meaningful and practical measure of the effectiveness of indoor range cleaning and the inhalation hazard posed by settled Pb containing dust. Pb air concentrations were measured using National Institute for Occupational Safety and Health (NIOSH) 7300 method.

**Results:** The Pb air concentrations measured during aggressive air sampling prior to range cleaning were at or above the OSHA permissible exposure limit. The precleaning results exceeded the proposed criteria of  $5 \mu\text{g}/\text{m}^3$  or less for a thirty-minute sample collected at 4 L/min. After cleaning, Pb air concentrations were found to be below the method limit of quantitation. Non-detectable concentrations were measured regardless of the porosity of the surface material.

**Lessons learned:** Using surface wipe sample results to demonstrate the effectiveness of cleaning in shooting ranges is challenging, and the results are difficult to interpret with respect to quantifying hazards. Aggressive air sampling may be a more meaningful tool because it provides a more homogeneous measure of Pb present on surfaces and can quantify Pb which has the potential to become airborne and thus become an inhalation hazard.

## CS-125-07

### Material Substitution of Methylene Chloride/Phenol Paint Stripper

*K. Walter, T. Harper, F. Blount, V. Sackmann, and T. Nelsen, Hill AFB, US Air Force, Layton, UT*

**Situation/Problem:** In 2011, the Occupational Safety and Health Administration (OSHA) visited and cited the Air Force Depots for methylene chloride overexposure during paint stripping of aircraft flight controls. Material substitution had been attempted many times, but had failed due to lack of treatability of the waste water or high disposal costs.

**Resolution:** Several engineering controls were implemented, however, the controls were unable to reduce the exposure below the Permissible Exposure Limit/Action Level. After four rounds of material substitution trials with undesirable results,

a new formulation of a non-methylene chloride containing paint stripping product was tested and passed all of the test requirements.

**Results:** This new formulation passed all three important tests for implementation: It was listed on the Air Force Corrosion Prevention and Control Office Qualified Products List, it removed multi-layer paint systems, and it was treatable by the Industrial Wastewater Treatment Plant at Hill AFB. Through testing, the new paint stripper removed coatings in a similar timeframe as the previous stripper. Rinse water was collected and a treatability test was performed at the wastewater treatment plant. This test was performed at 5% of total plant flow and showed no adverse effects. Furthermore, this material substitution significantly reduces chemical loading at the Industrial Wastewater Treatment Plant, which would reduce environmental regulatory risk and treatment costs. Finally, the new material did not contain an OSHA's Expanded Standards chemical, providing a reduced exposure to employees, and OSHA regulatory risk.

**Lessons learned:** Integrating the entire implementation team to include engineering, EHS, and subsidiary processes allowed for validating the entire process from cradle to grave. In addition, the team's effective communication with the material manufacturer has aided in the successful process substitution. As a result of this project, these efforts have reduced chemical exposures to personnel and decreased our regulatory risk.

## P0126

### Spectrum of Legal Issues

Thursday, May 26, 2016, 1:00 PM - 3:20 PM

## CS-126-01

### A Review of the New York City and New York State Legionella Regulations for Cooling Tower Management—Are They Enough to Prevent Legionellosis Cases?

*D. Miskowski, EMSL Analytical Inc., Cinnaminson, NJ*

**Situation/Problem:** Both New York State and New York City passed groundbreaking regulations in the US requiring Legionella monitoring of cooling tower and potable water in response to the largest outbreak of Legionnaires disease in the Bronx that occurred in August 2015. The New York State regulation specifically mentions retaining Industrial Hygienists, as well as other professions, to help building owners with industrial cooling towers meet these regulations. This presentation will compare these regulations to the new ASHRAE 188 standard practice guidelines for the prevention of Legionellosis accepted by ANSI in 2015, to determine if they really accomplish what they claim.

**Resolution:** Both the ASHRAE guidelines and the New York regulations are historic measures in the US as a first step in preventing additional Legionnaires disease cases. Since these measures are live documents that will be undergoing routine updates, this presentation will also include thought topics on additional changes that can be made to strengthen them.

**Results:** Suggestions will be made that will help Industrial Hygienists understand why it is so difficult to control legionellosis outbreaks as well as provide suggestions to help their clients obtain compliance with these new regulations.

**Lessons learned:** A discussion will be included on the competition between New York State and New York City to be the first to pass historic Legionella regulations and how it impacted the outcome.

## CS-126-02

### An Update on USDOL-OSHA's Efforts to Reduce Heat Deaths and Illnesses

*G. Lamson, OSHA Salt Lake Technical Center, Sandy, UT; M. Hodgson and S. Arbury, OSHA Office of Occupational Medicine and Nursing, Washington, DC*

**Situation/Problem:** After five years of enhanced enforcement and outreach by the USDOL-OSHA to reduce heat illness and fatalities, exposure to heat continues to kill workers in the United States. The campaign to reduce injuries and fatalities included: training for compliance officers; a coordinated outreach program to inform employers and workers of the dangers of working in hot environments; and the steps that can be taken to work safely in heat. As part of the campaign, OSHA's Health Response Team (HRT) and Office of Occupational Medicine and Nursing (OOMN) have reviewed fatality and illness cases looking for lessons that employers can use to develop heat stress prevention programs that reduce workplace heat illnesses and fatalities.

**Resolution:** Lacking a specific standard for heat exposure OSHA is required to use the "General Duty Clause" of The OSH Act which states that employers are to ensure that workers are furnished a place of employment which is free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees. Compliance officers use the OSHA Technical Manual, the ACGIH® TLV® booklet and guidance from the HRT and OOMN as investigation guidelines and blueprints for prescribing suitable controls.

**Results:** Over five years, numerous inspections have been performed. Many of those inspections lead to citations and hazard alert letters being issued to employers. We have also seen some exemplary heat stress prevention programs that we need to recognize. Sharing these success stories and model heat stress programs will help employers know what USDOL-OSHA is looking for in an employer's heat stress program.

**Lessons learned:** We have found areas to improve our investigative process and have addressed them in an updated OSHA Technical Manual chapter which incorporates the 2007 ACGIH® Heat Stress and Heat Strain TLV®. We have also updated our outreach message to emphasize the need for worker acclimatization which was not included in the original "Water. Rest. Shade." campaign. Finally, we have updated the OSHA.GOV website and the official OSHA heat application to bring them in line with these lessons learned.

## CS-126-03

### The Impact of Key Global Personal Protective Equipment Selection Criteria on Standard Development

*J. Tremblay, 3M OHESD, St. Paul, MN*

**Situation/Problem:** Product performance, selection and use standards and regulations are evolving to include requirements and test methods that help encourage personal protective equipment to fit better, be more comfortable, and better align the protection afforded with the amount of protection needed.

**Resolution:** ISO, EN, and key country standards will be reviewed to determine what requirements and test methods seem to help assess fit, comfort, and optimized protection, how those requirements and test methods compare and contrast with one another, and what are the growing trends.

**Results:** For respiratory protection: (1) fit testing requirements and test methods are increasing globally with mandatory fit testing standards in US, Australia, Canada, Brazil, Singapore, UK, and most recently France; (2) comfort continues to be a challenge to quantify with breathing resistance as a key indicator in many standards; and (3) optimized protection seems to be addressed with more choices (for example, ISO respiratory protection standard with 6 protection classes). For hearing protection: (1) fit testing recommendations are starting to appear in Canadian and EN standards; (2) comfort is generally not well defined; and (3) optimized protection is reflected in developing EN standards with requirements for low attenuation hearing protectors.

**Lessons learned:** Fit testing is becoming more and more pervasive in standards and regulations, particularly with more methods becoming available to assess fit. Comfort is not well defined in standards. Optimized protection with more options seems to be a growing trend with more choices for selection as seen in the ISO respiratory protection standard and the EN hearing protection standard.

## CS-126-04

### The Eyes Have It! Occupational Vision Is More Than Just Making Certain Workers Use Their PPE Correctly.

*M. Pattison, Army Institute of Public Health, Aberdeen Proving Ground, MD*

**Situation/Problem:** In today's high tech environment, the visual demands required by the worker for safety and efficiency are much more than just using eye protection. Today's worker needs to be able to see clearly and comfortably. Often they are performing tasks that are often a lot different from what their predecessors had to do and what their job description now states.

**Resolution:** When doing a worksite assessment, in addition to determining the appropriate PPE, you need to: (1) Assess the visual demands of the task at hand; (2) Determine if there should be a Vision Standard put in place; and (3) Gain concurrence from those involved including Occupational Health, Safety, Supervisors, etc.

**Results:** This discussion will include: (1) Performing a worksite assessment including visual demands such as illumination and acuity as well as use of the appropriate PPE. (2) Vision

Standards: current requirements and requirements for creating new standards.

**Lessons learned:** Job Descriptions often do not match the actual tasks required of today's workers, especially in the high tech environment. Individuals responsible for worksite assessments must be able to determine if the written standards meet the actual job requirements observed in the site visit and what to do if they feel that the requirements do not meet the demands.

## CS-126-05

### Evaluation of Occupational Exposure Limits: Lessons Learned from the Alberta Process

*D. Radnoff, Alberta Jobs, Skills, Training and Labour, Edmonton, AB, Canada*

**Situation/Problem:** Section 16 of the Alberta Occupational Health and Safety (OHS) Code requires employers to ensure that worker exposure to substances does not exceed Occupational Exposure Limits (OEL). An OEL is the airborne concentration of a substance for which it is believed that nearly all workers may be repeatedly exposed on a day to day basis without suffering adverse health effects. OELs are based on review of data from experimental animal and human studies and from industrial experience from studies of workers. The majority of the OELs in the OHS Code are, for the most part, based on Threshold Limit Values (TLVs<sup>®</sup>) developed by the American Conference of Governmental Industrial Hygienists (ACGIH<sup>®</sup>).

**Resolution:** Each year, ACGIH<sup>®</sup> reviews a number of TLVs<sup>®</sup> and makes revisions based on current science and knowledge regarding the effects of these chemicals on the body. In Alberta, the OHS legislation does not automatically adopt the most current version of the TLVs; rather a process of review and consultation is followed to ensure that the exposure limits are appropriate for Alberta workplaces.

**Results:** Alberta has developed a process to directly involve affected stakeholders in the review and adoption of OELs. As a result, OELs in the OHS Code are typically amended on about a five-year cycle. This process, which has evolved over the years, is somewhat different than that taken by other Canadian jurisdictions and will be discussed in this presentation.

**Lessons learned:** It is possible and achievable to amend OELs on a regular schedule with the support of stakeholders. However, this process needs to be flexible, inclusive and comprehensive. In addition, this process must be reviewed and evaluated on a regular basis.

## CS-126-06

### The Evolution of PricewaterhouseCoopers' Office Ergonomics and Reasonable Accommodation Process

*T. Silva, Atlas Injury Prevention Solutions, Grand Haven, MI*

**Situation/Problem:** PricewaterhouseCoopers is one of the world's largest, multinational professional services networks with a large percentage of the work population using hoteling stations and working remotely from client and home office locations. In addition to these challenges, the firm must provide reasonable accommodations to qualified individuals

with disabilities who are staff or candidates for employment. Examples include but are not limited ergonomic furniture (i.e., office chairs) interior and exterior PwC office facilities adjustments (i.e., ADA doors, special parking space, etc.).

**Resolution:** Launched in August 2012 (reengineered in 2014), the AbilityWorks solution is a centralized approach where staff requests involving reasonable accommodations are referred to and managed through the firm's Human Resources Management System. This presentation will examine how PricewaterhouseCoopers utilized Six Sigma methodologies to develop and subsequently improve their AbilityWorks solution.

**Results:** Improved the firm's organizational processes and approach to determining reasonable accommodation requests. Establishment of Service Level Agreements (SLA's) for all deliverables in the Ergonomic Work Stream, resulting in data driven approach to better measure program performance. Standardized approach to evaluating and controlling ergonomic hazards. Significant reductions in errors in the office ergonomics recommendation process through the creation of SOPs and detailed equipment guidelines.

**Lessons learned:** PricewaterhouseCoopers' standard practices for making requests for reasonable accommodations and purchasing ergonomic equipment. Strategies for hoteling (shared) stations and working in client environments. Classification of portable, non-portable and prohibited equipment. How to use different Six Sigma methods to collect Voice of the Customer and determine Critical to Quality characteristics. How to use process flow diagrams to document the work flow.

## CS-126-07

### Fire and Smoke Damage Investigations and Testing Options

*E. Mirica, EMSL Analytical, Cinnaminson, NJ*

**Situation/Problem:** Fire and smoke damage is a covered peril in most homeowner policies. Disputes with the insurance companies often arise over the need for cleaning versus the need for replacing the items that have been exposed to smoke. Successful insurance claims are typically associated with analytical results that use sound scientific methods to evaluate the extent of damage or to determine the suitable remediation measures.

**Resolution:** This presentation provides a systematic description of the target analytes in fire debris analysis, the sampling procedures, and the applicable analytical techniques. The capabilities and limitations of each analytical method for characterization and quantification of the combustion by-products (char, soot/black carbon, and ash) are also evaluated.

**Results:** The comprehensive characterization of the combustion by-products is best supported by the use of an array of techniques involving light and electron microscopy, both in scanning and transmission mode, with energy dispersive x-ray analyzers to determine the elemental composition of the particles. Light microscopy is best used for screening purposes. Advanced electron microscopy techniques are important for the confirmation of the analytes. When even more in-depth information is required, employment of Gas Chromatography-Mass Spectroscopy can be used to determine the residual semi-volatile components, information critical to further characterize the fire event (including the presence

of accelerants). The results of the analytical package can be successfully used for cleaning assessment or insurance claims.

**Lessons learned:** The selection of the appropriate analytical methodologies is an essential step for the characterization of the analytes associated with fire debris. The results obtained following the comprehensive analytical approach that combines the light and electron microscopy, with the additional valuable information supplied by the analysis of the semi-volatile components, provide the most valuable and legally defensible analytical package used to assess the extent of the damage produced by the fire, the magnitude of the remediation effort, and the post-remediation cleaning assessment.

## P0127

### Novel Approaches in Industrial Hygiene Sampling and Analysis

Thursday, May 26, 2016, 1:00 PM - 3:40 PM

## SR-127-01

### Evaluation of Sampling Bias During VOC Exposures Involving Peaks Using Capillary Flow Controllers Coupled with Evacuated Canisters

*R. LeBouf, CDC/NIOSH, Morgantown, WV*

**Objective:** NIOSH is in the process of evaluating canister methods for sampling of a wide range of VOCs. Capillary flow controllers have a well-defined drop in flow rate over the sampling period as the pressure in the canister rises closer to atmospheric pressure. Peak exposures during this period will give rise to a positive or negative bias in sampling results. This study was conducted to assess the influence of the time of occurrence of the peak on the performance of the method.

**Methods:** Six flow controllers coupled with 400 mL evacuated canisters were tested in a small chamber (32 L) to evaluate sampling bias with respect to grab samples using canisters. All samples were pressurized with ultra-high purity nitrogen and analyzed with a 1 mL gas sample loop and a gas chromatograph/flame ionization detector. Toluene was used as a representative chemical of indoor/industrial contaminants. A 2 ppm concentration of toluene was generated in a chamber using a Dynamic Dilution System. Peaks of 200 ppm (100x) were generated at either the beginning of the sampling period to assess positive sampling bias or at the end of the sampling period to assess negative sampling bias. A photoionization detector was used to monitor the stability of the concentration of toluene throughout the sampling period. Two sampling periods were assessed: 4 hours and 8 hours representing 25% and 50% volume filled in the canister. Three experiments were run for each sampling period with six replicate canisters per experiment. The reference concentration was established using a series of canisters drawn directly from the chamber with no flow control device (grab sampler). Comparison of the reference values to the concentrations collected by the capillary flow controllers allowed for an assessment of the capillary flow controller bias.

**Results:** The bias for all experiment trials ranged from 0.01% to -25% as compared to the reference concentrations. Relative standard deviations ranged from 1.0% to 16.3%. Reducing the volume filled in the canister from one-half to one-quarter decreased sampling bias from -25% to -16% for a peak at the end of the sampling period.

**Conclusions:** Full-shift and half-shift sampling with small, evacuated canisters were found to provide results comparable to the reference values. Sampling bias can be reduced by filling the canister to a smaller percentage of the canister volume.

## SR-127-02

### Determinations of Bisphenol A and Bisphenol A Analogues by Solid-Phase Microextraction with On-Fiber Derivatizations

*F. Hsu and S. Tsai, Environmental Health, Taipei, Taiwan*

**Objective:** Bisphenol A (BPA) is widely used in consumer products, such as the lining in various types of cans. The leaching of BPA from such products can result in adverse human exposures. For example, BPA could be released into canned foods and cause possible adverse effects, especially for infants. Many countries have prohibited the use of BPA in food packaging. The common substitutes of BPA include Bisphenol S (BPS), Bisphenol F (BPF) and Bisphenol E (BPE). However, previous studies have shown that exposure to those substitutes might still cause the same or more serious health concerns. Therefore, to assess the health risk from these possible sources of exposures, there is a need to determine the concentrations of BPA and BPA analogues.

**Methods:** BPA and BPA analogues were extracted by using solid phase microextraction (SPME) with direct sample immersions. The analytes adsorbed on the SPME fiber were then derivatized with the derivatizing reagent: N,O-Bis(trimethylsilyl)trifluoroacetamide (BSTFA). Afterwards, the derivatives were determined by gas chromatograph and mass spectrometry (GC/MS). Canned foods and infant formula were purchased from the markets for method validations. The food samples were mixed with water before filtration and the SPME procedures.

**Results:** The results showed that the desorption efficiency was 100% when the desorption time was 4 min under 240 degrees Celsius. The best suitable fiber coating was 65µm Polyethylene Glycol (PEG) and the optimum condition of derivatization was 30 minutes at 50 degrees Celsius by adding 50 µL BSTFA. The working range for the analysis was between 0.01 - 10 µg/L. Different levels of BPA and BPA analogues were found in commercially available canned foods and infant formula.

**Conclusions:** Compared with conventional extraction methods, the SPME provides a time saving and solvent free procedures. In addition, the sensitivities of the method for BPA and BPA analogues were low enough to determine the concentrations from various types of samples.

## CS-127-03

### A Review of PCB Analytical Methods for Industrial Hygiene Sampling and Recommended Practices

*W. Mills, Northern Illinois University, Sycamore, IL*

**Situation/Problem:** Indoor air exposure to polychlorinated biphenyls (PCBs) from building materials, such as caulk and joint sealants, has been recognized as an issue in Europe for a number of years and more recently in the United States (US). The US Environmental Protection Agency (USEPA) and several state agencies have issued guidance on the sampling and analysis of air and solids. Many investigators are often not aware of a number of issues and limitations with the sampling and analysis of air and solids for PCBs, which are not addressed by these guidance documents.

**Resolution:** The available sampling and analysis methodologies for PCBs with applicability to indoor air and solids samples, with their associated uncertainties were reviewed. The analytical methods identified include high resolution gas chromatography (HRGC) with various detectors such as electron capture detection (ECD), low resolution mass spectrometry (LRMS) and high resolution mass spectrometry (HRMS). A review of worldwide guidelines for PCB air concentration guidelines and basis (i.e. Aroclor, congener, homolog) was completed. Dynamic flux chamber experiments to investigate changes in PCB patterns, due to volatilization were carried out. The data is analysed by congener and homolog and Aroclor. Predictive models were developed which matched the observed congener patterns quite closely.

**Results:** The USEPA, NIOSH and OSHA sampling documents for PCBs are all based on work originally carried out during the 1970's and 1980's. Occupational exposures to Aroclor mixtures were at much higher concentrations than current guidelines. As a result of changing exposure scenarios and analytical advances, Aroclor™ analysis of indoor air samples is no longer an acceptable methodology. The use of congener or homolog specific PCB analysis is required in order to provide accurate, usable data. In addition, passive air sampling methods under development may offer less intrusive, longer term monitoring data for the same or lower costs. A predictive model for vapor phase congener patterns was developed. Using this data, the observed air sample pattern (congener or homolog) can be fit with predicted vapor phase and original Aroclor™ patterns to determine if the air sample is vapor phase vs. aerosol, and predict the source profile using data analysis techniques.

**Lessons learned:** Sampling and analysis of PCBs in indoor air and solids, has a number of potential sources of errors and limitations, of which the investigator and unwary data user need to be aware. This presentation provides recommended practices to avoid, or at least recognize and/or minimize, these sources of error.

## SR-127-04

### Sampling and Analysis of Airborne Hazardous Chemicals in Bakeries in Taiwan

*P. Chang and S. Tsai, Department of Public Health & Institute of Environmental Health, College of Public Health, National Taiwan University, Taipei City, Taiwan; P. Hung, Institute of Labor, Occupational Safety and Health, Ministry of Labor, Executive Yuan, Taipei City, Taiwan*

**Objective:** Baker's Asthma, the most frequently reported occupational asthma makes occupational health a critical issue in bakeries. Flour dust, an airborne allergen, has been recognized as the primary risk factor. In addition, it has been reported that a wide variety of food flavorings are constantly used in the bakeries and the concentrations of hazardous airborne chemicals might be enhanced during the blending and heating processes. To assess the associated health risks for bakers in Taiwan, the airborne concentrations of flour dust, ketones and aldehydes were determined.

**Methods:** Silica gel tube, XAD-2 tube, and IOM inhalable dust sampler were used for the air sampling, and the flow rates were 50ml min<sup>-1</sup>, 50ml min<sup>-1</sup>, and 1000ml min<sup>-1</sup>, respectively. After 6-hour sampling, the filters were weighed and the samplers were desorbed by ethyl alcohol:water (95:5) or toluene followed by the analysis with gas chromatograph and mass spectrometer (GC/MS). In addition, questionnaires were administered to the bakers to collect the information regarding the disease history of asthma, work conditions and related symptoms.

**Results:** From questionnaires, the symptoms of respiratory and dermal irritation were significantly higher for the exposure group, and only a few bakers wore personal protection equipment. It was found that various compounds and high concentration of flour dust existed in the air of the bakeries. In some work groups, especially for dough making, the environmental concentration of flour dust exceeded the ACGIH® TLV®-TWA (0.5 mg/m<sup>3</sup>). In addition, other airborne chemicals, such as 2,3-butanedione, 2,3-pentanedione, furfural, and acetaldehyde, were also detected around ovens and bakeries with various levels.

**Conclusions:** The results indicated that airborne chemical exposure is a problem worthy of attention in the bakeries. Although the permissible exposure limits of some detected chemicals have not been set, the respiratory symptoms were still observed. Therefore, monitoring the indoor air quality and improving the ventilation systems are both crucial to preventing work related exposures in the bakeries.

## SR-127-05

### Development of a Pre-Filter for Thermal Desorption Tubes

*C. Chang, K. Yang, C. Lin, S. Huang, N. Yu, and C. Chen, Department of Public Health, National Taiwan University, Taipei, Taiwan; Y. Kuo, Chung-hwa University of Medical Technology, Tainan, Taiwan; C. Chen, Institute of Labor, Occupational Safety and Health, Ministry of Labor, New Taipei City, Taiwan*

**Objective:** Thermal desorption tubes are commonly used to quantify trace amounts of volatile organic compounds in air. Previous studies have demonstrated that the aerosol loading

on the sorbent could significantly influence the adsorption and desorption characteristics. Normally, a piece of glass wool is placed in front of the sorbent, but filtration efficiency data can be limited. This study aimed to evaluate the filtration characteristic of the glass wool, and to design a pre-filter for the better performance of thermal desorption tubes.

**Methods:** A constant output aerosol generator and an ultrasonic atomizing nozzle were used to generate sub-micrometer sized and micrometer sized aerosol particles, respectively. A scanning mobility particle sizer and an aerodynamic particle sizer were employed to measure the aerosol concentration and size distribution upstream and downstream of the test filter. The pressure drop across the filter was simultaneously monitored. Glass wool, stainless steel mesh (#400, #1500), polyurethane foam (110 ppi) and filter disc cut from N95 filtering facepieces were tested in this work.

**Results:** The experimental results showed that the most penetrating particle size (MPPS) of the glass wool was 0.3-0.5 µm and the aerosol penetration of MPPS was about 60-75%, under the sampling flow of 0.2 L/min. To reach the same level of performance of glass wool, it took 60 layers of #400 stainless steel mesh. Higher aerosol collection efficiency (90%) could be achieved by increasing the mesh number and disc size (to reduce face velocity). The use of stainless steel mesh was too clumsy because of the size. For 110 ppi foam, the total height of the foam disc was estimated to be 30 cm to attain the required collection efficiency (90%). The aerosol collection efficiency could be enhanced by increasing the foam packing density. However, there was no guarantee of the packing quality to gain stable performance. The use of N95 filter disc appeared quite promising. The aerosol penetration was 5% and pressure drop was only 9.8 mmH<sub>2</sub>O, the lowest among all tested materials.

**Conclusions:** The glass wool pieces did not provide stable and sufficient filtration efficiency to protect the sorbents from aerosol contamination. Among the filter materials tested, the N95 filter worked best, for low cost, low pressure drop and stable quality. The oil-resistant P95 filter could be used when oil aerosol particles were present in the workplace.

## SR-127-06

### IOM Inhalable and Respirable Sampling Compared to Conventional Total and Respirable Sampling for Assessing Welders Exposure to Manganese

*F. Akbar-Khanzadeh, M. Shomody, S. Milz, A. Ames, and M. Valigosky, UT HSC College of Medicine, Toledo, OH*

**Objective:** Total and respirable concentrations of airborne manganese (Mn) are conventionally determined by using two separate sampling devices/methods. The Institute of Occupational Medicine (IOM) technique can be used to determine inhalable and respirable concentrations of airborne Mn by using only one device. There are currently no known published studies that compared these methods during welder's exposure to Mn.

**Methods:** In this study, the OSHA sampling method was compared with IOM dual fraction for assessing occupational exposure to airborne Mn during Shielded Metal Arc Welding (SMAW). Welding was performed in a barge at a marine facility.

Using OSHA Method, an aluminum cyclone was loaded with a 25 mm Mixed Cellulose Ester (MCE) filter to sample respirable Mn contaminant. A filter cassette loaded with a 25 mm MCE filter was used to sample total Mn contaminant. The IOM sampler was used to sample inhalable and respirable fractions simultaneously by a foam insert with specific porosity to trap inhalable particles, and respirable size particles are allowed to pass through and be collected on a 25 mm MCE filter. All monitoring was performed by area sampling. A total of 20 side by side samples were collected for respirable Mn and 18 side by side samples were collected for inhalable and total Mn.

**Results:** The volume of air sampled ranged from 202.2-1077 liters. Concentration (mg/m<sup>3</sup>) of respirable Mn by IOM method ranged from 0.00-0.41 (mean±sd; 0.13±0.14) and by conventional method from 0.00-0.51 (0.19±0.18). Inhalable Mn ranged from 0.01- 0.52 (0.20±0.19) and total Mn from 0.01-0.41 (0.21±0.18). Conventional respirable readings, except one, were consistently higher than those of the IOM respirable readings (slope = 0.746; r<sup>2</sup> = 0.943) and the difference of the means was significant (p < 0.01). The mean concentration of inhalable Mn was not significantly different from the mean of total Mn (slope=1.02; r<sup>2</sup>=0.921).

**Conclusions:** The findings of this study suggest that for sampling airborne Mn during SMAW welding: (1) the IOM respirable sampler may not be suitable as an alternative method to the conventional respirable sampler; and (2) the IOM inhalable sampler may be used as an alternative method to conventional total sampler.

## SR-127-07

### Treated and Untreated Rock Dusts: Silica Content and Physical Characterization

*J. Soo, T. Lee, W. Chisholm, D. Farcas, D. Schwegler-Berry, and M. Harper, CDC/NIOSH/HELD/EAB, Morgantown, WV*

**Objective:** To assess the free silica content and physical characteristics of four selected rock dusts consisting of calcium and/or magnesium carbonate, in both treated and untreated form.

**Methods:** Four selected rock dusts were investigated: AMC (untreated), AMC with X-10 (treated), Micro-White 100 (untreated) and Imerys Phase IV (treated blend of 87.5% Micro-White 100 and 12.5% Kotamite). For each rock dust, two different size fractions (bulk and respirable size fractions) were tested to determine quartz content (%). The selected rock dusts were aerosolized and introduced into an aerosol chamber. A total of 72 individual samples of respirable dust were collected using FSP10 cyclones. Particle size segregating samplings were conducted using a Micro-Orifice Uniform Deposit Impactor (MOUDI). Silica measurement was performed according to NIOSH Method 7603. Particle morphology was examined with a combination of scanning electron microscopy and energy-dispersive x-ray spectroscopy analysis (EDX).

**Results:** The silica content of AMC in respirable dust (0.84%) was the largest but not significantly different from that of AMC X-10 (0.68%). The Micro-White 100 had significantly lower silica content than the other rock dusts but was not significantly different from Imerys Phase IV. The respirable fraction of AMC dust, treated and untreated, had a significantly higher silica content than did the bulk material. Silica is enriched in the respirable fraction but not above the Mine Safety and Health Administration (MSHA) limit for silica in bulk dust. All particle

size distributions showed log-normal distributions, with the mass median aerodynamic diameters between 1.2 and 5.3 µm and geometric standard deviations less than 2.8. The dust spectra from EDX analysis are predominantly from limestone, clay particles and gypsum particles. No free quartz particles were observed, but that is reasonable considering the low quantity of silica and the number of particles studied.

**Conclusions:** All four dusts contained respirable silica. Treated rock dusts had slightly lower silica content than untreated ones. Silica can be elevated in the respirable fraction compared to the bulk, but this enrichment is not likely to lead to silica concentrations above the MSHA Permissible Exposure Limit (PEL), provided there is compliance with the PEL for respirable dust.

## CS-127-08

### Vermiculite Containing Asbestos & Zonolite Insulation

*D. Ewert, RJ Lee Group, Monroeville, PA*

**Situation/Problem:** Since the association between asbestos related disease and Libby, Montana vermiculite mining was first proven, products containing vermiculite have consistently been classified as a hazard. In fact, since 2013 all vermiculite insulating materials have been regulated under New York State laws as Asbestos Containing Material (ACM). Further, the EPA states clearly in its homeowner outreach that "YOU SHOULD ASSUME THE VERMICULITE CONTAINS ASBESTOS AND DO NOT DISTURB IT!" Obviously, these approaches to vermiculite insulation are real and impact the lives of property owners and contractors every day.

**Resolution:** A new method was developed for the sample preparation and analysis of vermiculite containing materials to accurately speciate and quantify the asbestiform mineral which exists in vermiculite containing ores and finished products. This achievement is possible via a technique which chemically dissolves vermiculite and other interfering substances. Scanning Electron Microscopy and Energy Dispersive Spectroscopy speciate and quantify any amphibole species which occur. This technique achieves a detection limit of 0.01%.

**Results:** The method accurately detects and quantifies asbestiform minerals embedded in vermiculite. In July of 2014, the method (LAB.055.1) received New York State Dept. of Health certification for the analysis of asbestos in Spray-On Fireproofing Containing Vermiculite (SOF-V). Numerous samples have been analyzed including amphibole-spiked fireproofing materials as well as pure Zonolite based insulating products originating from Libby, Montana. The resulting data will demonstrate the unique ability of this technique to not only make 100% of the amphibole species available for inspection, but also to consistently and reproducibly determine the asbestos content in vermiculite containing materials.

**Lessons learned:** Given the impact and importance of accurately characterizing the amphibole asbestos content of Libby-based vermiculite containing materials, methods capable of accurately and precisely defining the asbestos content are a critical to any health assessments being performed. This work describes the results of one such method and builds awareness of the true asbestos content which exists in those vermiculite containing materials we now treat as asbestos.

# Author Index

## A

- Abelmann, A. SR-404-02, SR-107-02, SR-404-01, SR-403-03, SR-107-04  
Acker, R. CS-403-02  
Acosta, L. SR-114-04  
Adams, K. SR-106-09  
Ahn, K. SR-110-02, SR-110-05  
Aivazian, R. SR-120-06  
Akbar-Khanzadeh, F. SR-127-06, SR-113-02, SR-403-10, SR-403-11, SR-403-14  
Alamgir, H. SR-119-02  
Alkasir, R. SR-123-05  
Allard, C. SR-401-09  
Allenbrand, R. SR-113-01  
Ames, A. SR-127-06, SR-113-02, SR-403-10, SR-403-11, SR-403-14  
An, H. SR-401-12  
Anderson, K. SR-124-03  
Anderson, L. CS-102-01  
Andreescu, S. SR-123-05  
Andrew, M. CS-118-02  
Arbury, S. CS-126-02  
Armstrong Gibbs, J. SR-402-09  
Arrandale, V. SR-401-05  
Aysola, P. CS-118-05

## B

- Baetz, L. CS-111-03  
Bahloul, A. SR-119-07  
Baker, C. CS-123-08  
Banerjee, S. SR-113-06  
Barber, C. SR-403-11  
Bare, J. SR-404-02, SR-107-02, SR-404-01, SR-107-04  
Barker, D. SR-122-05  
Barone, T. SR-120-05  
Barrey, E. SR-403-01  
Barton, T. CS-104-02, CS-105-03  
Barzan, C. SR-403-13  
Basham, J. CS-116-02  
Battista, G. SR-403-12  
Beall, R. CS-104-05  
Beard, S. CS-116-04  
Beckett, E. SR-404-02, SR-107-02, SR-404-01, SR-107-04  
Bégin, D. SR-402-08  
Bergholz, P. SR-121-01  
Bergman, M. SR-122-01  
Betancourt, J. SR-119-01, SR-119-02, SR-106-03  
Bethel, B. CS-105-01  
Bezerra, M. SR-120-07

- Bhattacharya, A. SR-106-04  
Bingham, G. SR-403-14  
Birkbak, J. SR-124-02  
Biyeyeme Bi Mve, M. SR-401-04  
Blair, A. SR-113-06  
Blount, F. CS-125-07  
Boelter, F. CS-103-02, CS-109-02  
Bogen, K. CS-121-05, CS-403-06  
Bohgard, M. SR-401-10  
Borello, M. SR-124-02  
Bowers, J. SR-401-13  
Bowman, J. CS-111-01  
Boyle, T. CS-110-03  
Boylstein, R. SR-402-09  
Brand, J. CS-112-06  
Brazile, W. SR-106-09  
Breyse, P. SR-121-04  
Brochu, E. SR-122-01  
Brooks, J. CS-121-06  
Brown, J. SR-403-01  
Brueggemeyer, M. SR-125-03  
Bui, D. SR-109-06  
Bujak, K. CS-402-03  
Bunker, K. CS-108-03  
Burge, H. CS-114-02, CS-107-05, CS-101-01  
Burgess, J. SR-122-06, SR-109-06  
Burns, D. SR-401-13  
Burton, N. CS-119-03  
Byc, D. SR-118-01

## C

- Cahill, E. CS-103-06  
Calvert, G. CS-111-01  
Campbell, R. CS-105-02, CS-123-08  
Capuzzi, J. SR-402-06  
Caretti, D. SR-122-05  
Carranza, S. SR-123-06  
Carraway, T. CS-119-06  
Casey, M. SR-111-05  
Castro Ruiz, C. SR-402-08, SR-119-07  
Casuccio, G. CS-108-03  
Catto, C. SR-401-09  
Cauda, E. SR-113-04, SR-401-03  
Ceballos, D. CS-402-01  
Cely-Garcia, M. SR-121-04  
Cena, L. SR-108-04  
Chambers, M. SR-113-02  
Chan, C. SR-401-07  
Chang, C. SR-404-14, SR-125-04, SR-127-05  
Chang, P. SR-404-14, SR-127-04  
Chen, A. SR-404-07

- Chen, C. SR-127-05, SR-120-08, SR-127-05, SR-120-03, SR-122-09, SR-122-09  
Chisholm, W. SR-127-07  
Cho, S. CS-404-04  
Choi, K. SR-401-12  
Choi, S. SR-110-05  
Chouchen, W. SR-402-08, SR-119-07  
Chua, P. CS-118-03  
Chubb, L. SR-113-04  
Chute, D. CS-106-08  
Cikalo, J. SR-113-05  
Clark, N. SR-114-04  
Clarke, S. CS-112-05  
Clements, L. SR-121-01  
Cloutier, Y. SR-401-04  
Cochran, J. CS-402-03  
Cole, K. CS-110-01  
Colton, C. CS-122-04  
Comerford, C. SR-403-03  
Cooper, C. CS-101-04, SR-107-06  
Cornish, J. CS-123-03  
Cox-Ganser, J. SR-111-05  
Coyne, K. SR-122-02  
Crowne, F. CS-105-05  
Cyrs, W. SR-103-03  
Czarnocka, E. SR-118-01  
Czarnocki, K. SR-118-01

## D

- D'Andrea, C. SR-114-04  
D'Angelo, R. SR-113-05  
Dai, Y. SR-125-04  
Dakin, J. CS-118-02  
DaSilva, M. CS-109-03  
Davis, W. CS-402-10  
Dawson, B. CS-102-02  
De Guzman, A. CS-401-02  
Debia, M. SR-401-04, SR-402-08, SR-119-07, SR-401-09  
DeHart, R. CS-112-06  
DeJoy, D. SR-104-04  
Demers, P. SR-404-05  
Dessureault, P. CS-119-08  
Deutsch, D. CS-403-02  
DiMaggio, A. CS-402-04  
Divjan, A. SR-114-04  
Dodrill, R. SR-122-08  
Doney, B. SR-113-05, SR-403-04  
Donohue, K. SR-125-03  
Dotson, S. CS-116-05  
Drolet, D. SR-402-08, CS-119-08  
Duane, A. SR-404-08, CS-117-06  
Duffy, D. CS-402-02  
Duran, M. SR-121-04

Dusseix, D. SR-103-03  
Dyal, A. SR-104-04

## E

---

Ebadat, V. CS-118-07  
Eitniew, S. SR-403-14  
Engel, L. SR-113-06  
Eninger, R. CS-123-07  
Enomoto, T. SR-404-03  
Erdely, A. SR-108-04  
Espenschied, K. SR-403-01  
Esposito, P. CS-109-05  
Estill, C. SR-106-04  
Ewert, D. CS-127-08

## F

---

Farcas, D. SR-127-07, SR-108-04  
Feeley, T. SR-113-05  
Felker, L. CS-402-04  
Ferreri, M. CS-117-05  
Finley, B. SR-403-03, SR-404-12  
Floyd, E. SR-120-01, SR-108-02  
Fong, H. CS-125-01  
Fritz, H. SR-404-02, SR-107-02, SR-404-01, SR-107-04  
Fullerton, K. CS-123-07  
Funk, R. SR-116-06  
Funk, S. CS-112-01, CS-117-06

## G

---

Gaffney, S. SR-103-04  
Gallagher, S. SR-115-04  
Gao, P. SR-111-06  
Garcia-Reyero, N. SR-125-03  
Garnick, L. SR-103-04  
Gauthier, A. SR-103-04  
Gay, R. SR-107-03  
Geiger, M. CS-124-06  
Gellasch, C. SR-125-03  
Geltman, E. SR-114-01  
Gimeno, D. SR-119-01, SR-106-03  
Giraldo, M. SR-121-04  
Girard, G. CS-111-01  
Glynn, M. SR-103-03  
Golla, V. CS-116-02  
Gonzalez-Garcia, M. SR-121-04  
Gorrell, N. SR-119-01, SR-119-02  
Gowrisankaran, G. SR-109-06  
Grace, B. CS-125-06  
Green, B. SR-114-04  
Greenberg, P. SR-123-06  
Greivell, J. CS-123-03

Grespin, M. SR-103-04  
Griffin, S. SR-109-06  
Groth, C. SR-113-06  
Gruenwald, G. CS-403-08  
Grzywacz, C. SR-107-03  
Gudmundsson, A. SR-401-10  
Guffey, S. SR-402-14, SR-122-08  
Gust, K. SR-125-03

## H

---

Haapala, M. CS-123-03  
Haas, P. CS-117-03  
Hall, D. CS-112-01  
Halle, S. SR-402-08, SR-119-07  
Halpenny, M. SR-403-01  
Hammill, T. SR-119-01, SR-119-02  
Han, I. SR-404-11  
Hardos, J. SR-404-11  
Harkins, A. CS-118-05  
Harman, D. CS-119-06  
Harper, M. SR-401-01, SR-127-07, SR-402-14, SR-401-06, SR-401-03, SR-401-13  
Harper, T. CS-125-07  
Hartman, R. CS-119-04  
Havics, A. CS-120-04, CS-109-01, CS-108-05  
Hawks, C. SR-107-03  
Hawley, B. SR-111-05  
He, C. SR-109-06  
He, X. SR-122-08  
Heckman, B. CS-109-02  
Hedmer, M. SR-401-10  
Henneberger, P. SR-403-04  
Herrington, J. SR-121-03  
Hess, A. SR-114-01  
Hesse, E. SR-120-05  
Higgins, E. CS-108-06  
Higley, R. CS-403-08  
Hill, J. SR-123-04  
Hodgson, M. CS-126-02  
Hon, C. SR-403-13, SR-404-05  
Horiuchi, K. SR-107-03  
Horvatin, M. SR-111-06  
Houseman, E. SR-403-07  
Hsu, F. SR-404-14, SR-127-02  
Hsu, Y. SR-404-14, SR-124-07  
Hu, C. SR-109-06  
Huang, S. SR-120-08, SR-127-05, SR-120-03, SR-122-09  
Huang, Y. SR-115-05  
Hubka, V. SR-114-05  
Hudson, N. CS-116-05  
Humann, M. SR-403-04

Hummer, J. SR-401-03  
Hung, H. SR-120-08  
Hung, P. SR-127-04  
Hunt, D. CS-115-06  
Hunter, G. SR-123-06  
Huynh, T. SR-113-06

## I

---

Isaxon, C. SR-401-10

## J

---

Jachak, A. CS-108-01  
Janke, B. CS-108-01  
Jarecha, R. CS-116-01  
Jayjock, M. CS-105-07  
Jelley, E. SR-404-05  
Joe, P. CS-404-13  
Johnson, R. CS-104-07  
Jones, E. CS-106-06  
Jones, L. SR-122-06  
Judd, G. CS-404-13  
Jung, M. SR-401-12  
Jurjevic, Z. SR-114-05

## K

---

Kalenge, S. SR-401-05  
Kalmes, R. CS-121-02, CS-121-05, CS-403-06  
Kang, J. SR-108-04  
Karlsson, J. CS-404-10  
Kashon, M. SR-401-01, SR-402-14  
Keeton, K. SR-403-03  
Keil, C. SR-117-01, CS-105-04  
Kelly, K. SR-403-04  
Kenny, J. CS-402-03, CS-402-05  
Keppta, S. CS-109-04  
Kim, T. SR-110-02, SR-110-05  
Kimble, L. SR-121-01  
Knepper, T. CS-403-08  
Kneten, L. CS-125-02  
Knoch, L. CS-123-02  
Ko, C. SR-125-04  
Koehn, J. CS-403-02  
Kolarik, M. SR-114-05  
Kominsky, J. CS-112-02  
Konschnik, J. SR-121-03  
koo, J. CS-404-04  
Kozel, S. SR-121-03  
Krishnamoorthy, K. SR-113-03  
Kroeger, J. SR-401-09  
Kubátová, A. SR-114-05  
Kulis, M. SR-123-06

Kuo, A. SR-401-08, SR-401-07, SR-401-11  
Kuo, W. SR-122-09  
Kuo, Y. SR-127-05, SR-120-03  
Kwok, R. SR-113-06

## L

---

L'Espérance, G. SR-401-09  
Lacombe, N. SR-401-04  
Lai, C. SR-401-08, SR-401-07, SR-401-11  
Lamson, G. CS-126-02  
Larson, R. SR-120-02  
Leamont, J. CS-102-01  
Leasure, J. CS-106-05  
LeBouf, R. SR-127-01, SR-401-13  
Lee, E. SR-402-14  
Lee, H. SR-125-04  
Lee, L. SR-401-03, CS-104-06  
Lee, T. SR-401-01, SR-127-07, SR-401-06, SR-401-03, SR-401-13  
Lee, W. SR-401-07  
Lee, Y. SR-401-11  
Lee, S. CS-404-04, CS-404-04  
Lei, Z. SR-122-01  
Leitner, J. SR-124-02  
Leonard, S. SR-106-03  
Light, E. SR-107-03  
Lilley, P. CS-103-05, CS-104-03  
Lim, S. CS-404-04  
Lin, C. SR-120-08, SR-127-05  
Lin, Y. SR-401-08, SR-125-04  
Lininger, M. SR-121-03  
Little, M. SR-114-04  
Liu, C. SR-123-06  
Lively, C. SR-124-02  
Lo, E. SR-404-07  
Lodwick, J. SR-123-01  
Lohkamp, J. CS-402-04  
Long, R. SR-106-02, SR-106-01  
Lotter, J. SR-404-02, SR-107-02, SR-404-01, SR-403-03, SR-107-04  
Ludvigsson, L. SR-401-10  
Lungu, C. SR-108-02, CS-404-13  
Lutz, E. SR-122-06, SR-109-06, SR-113-04

## M

---

Maberti, S. CS-108-01  
Mack, N. CS-117-02  
Magrm, R. SR-402-14  
Maiello, R. CS-118-05  
Maier, A. CS-116-05  
Makel, D. SR-123-06  
Makos, K. SR-107-03  
Mancini, J. CS-104-03  
Manning, C. CS-122-03  
Marchand, G. SR-401-04  
Martinez, L. SR-113-05  
Mathew, T. SR-113-03  
Maurais, T. SR-125-03  
McCoy, M. CS-123-03  
McCoy, T. CS-109-04

McGowan, B. CS-115-02  
McKelvey, L. CS-403-02  
McNamara, K. SR-102-03  
Mead, K. CS-402-01  
Meeds, H. CS-402-07  
Meijster, T. CS-102-01  
Meisenzahl, L. SR-104-01  
Mele, W. CS-112-01  
Méndez García, L. SR-121-04  
Messing, M. SR-401-10  
Meyer, M. CS-108-03  
Middendorf, P. SR-113-05  
Miller, W. SR-113-05  
Mills, W. CS-127-03  
Milz, S. SR-127-06, CS-402-12, SR-113-02, SR-403-11, SR-403-10, SR-403-14  
Mirica, E. CS-126-07  
Mischler, S. SR-120-05  
Miskowski, D. CS-126-01  
Monnot, A. SR-103-03  
Morata, T. SR-106-04  
Morrison, R. SR-403-12  
Mugford, C. SR-402-09  
Murphy, P. CS-106-07

## N

---

Neitzel, R. SR-106-02, SR-106-01  
Nelsen, T. CS-125-07  
Newport, M. CS-402-05  
Nguyen Weekes, L. CS-101-03  
Niese, J. SR-403-14  
Niezgoda, G. SR-111-06  
Nilsson, P. SR-401-10  
Noguchi, M. SR-404-03  
Novak, D. SR-401-13

## O

---

O'Connor, P. SR-117-04  
Oh, J. SR-108-02, CS-404-13  
Oishi, G. SR-403-01  
Orr, N. CS-118-04  
Ott, D. SR-404-11  
Owens, P. CS-101-05

## P

---

Pabon, A. CS-117-05  
Packer, M. SR-119-01, SR-119-02  
Pagel, J. SR-401-10  
Pahler, L. SR-120-02  
Parada, P. SR-121-04  
Park, J. SR-404-15  
Parker, J. SR-122-07  
Parr, K. CS-123-03  
Pattison, M. CS-126-04  
Paustenbach, D. SR-103-04  
Paz, J. CS-112-03  
Penniall, C. CS-108-01  
Perez, C. SR-121-04  
Perkins, E. SR-125-03  
Persky, J. CS-103-02, CS-109-02  
Perzanowski, M. SR-114-04

Phalen, R. SR-115-03  
Phillips, K. CS-119-04  
Pierce, J. SR-404-02, SR-107-02, SR-404-01, SR-403-03, SR-404-12, SR-107-04  
Pierrero, J. CS-102-05  
Pomerence, C. CS-403-05  
Posson, M. CS-121-02

## R

---

Radnoff, D. CS-124-01, CS-126-05  
Ramachandran, G. SR-113-06  
Ramdas, S. SR-106-02, SR-106-01  
Ramos-Bonilla, J. SR-121-04  
Ramsey, J. CS-402-01  
Ranpura, S. CS-112-07  
Rao, M. SR-106-04  
Reed, M. SR-124-02  
Reed, R. CS-123-09, SR-113-04, SR-124-04  
Regens, J. SR-120-01, SR-120-07  
Riccobono, P. SR-124-02  
Rice, C. SR-106-04  
Rice, P. CS-110-06, CS-118-06  
Rickabaugh, K. CS-108-03  
Riddar, J. CS-404-10  
Rissler, J. SR-401-10  
Rizor, A. SR-122-01  
Robbins, W. SR-102-03  
Roberts, B. SR-106-02, SR-106-01  
Robertson, R. CS-402-10  
Rollins, M. CS-119-05  
Rosen, J. CS-116-04  
Rossner, A. SR-123-05  
Ruestow, P. SR-404-02, SR-107-02, SR-404-01, SR-404-12, SR-107-04

## S

---

Sackmann, V. CS-125-07  
Saleh, M. SR-101-06  
Sanchez, M. CS-102-01  
Sandle, D. SR-113-06  
Sauter, A. CS-401-02  
Sawicki, E. CS-112-04  
Schall, M. SR-115-04  
Schoepp, R. CS-105-06  
Schoonover, T. CS-125-05  
Schwegler-Berry, D. SR-127-07  
Seaman, C. SR-120-05  
Senchak, A. SR-119-01, SR-119-02, SR-106-03  
Seymour, R. CS-125-06  
Shaffer, R. SR-111-06  
Sheehan, M. SR-403-12  
Sheehan, P. CS-121-05, CS-403-06  
Sherrick, B. SR-403-14  
Shimelis, O. SR-403-01  
Shin, M. SR-102-04  
Shomody, M. SR-127-06  
Shugart, J. CS-116-03  
Shum, M. SR-121-01  
Silva, T. CS-126-06, CS-115-01

Simmons, B. SR-103-04, SR-404-06  
Singhal, A. CS-121-05, CS-403-06  
Skulinova, M. SR-401-09  
Sleight, T. CS-402-15  
Smith, A. CS-402-07  
Smith, P. SR-123-01, SR-123-04  
Smith, T. SR-104-04  
Sobek, E. SR-114-04, SR-124-02  
Soffer, N. SR-114-04  
Soo, J. SR-401-01, SR-127-07, SR-401-03, SR-401-13  
Stenzel, M. SR-113-06  
Stewart, P. SR-113-06  
Strange, M. CS-105-01  
Stratton, G. CS-402-05  
Strode, C. CS-112-01  
Strode, R. CS-112-01, CS-117-06  
Sulyok, M. SR-404-15  
Sun, K. SR-106-02, SR-106-01  
Susi, P. CS-110-04  
Suzuki, Y. SR-404-03

## T

---

Takahashi, F. SR-123-06  
Tapp, L. CS-119-03  
Tarver, W. CS-109-04  
Taylor, J. SR-403-10  
Taylor, R. CS-116-02  
Tehrani, P. CS-125-01  
Tinnerberg, H. SR-401-10  
Torres, A. CS-117-02  
Torres-Duque, C. SR-121-04  
Tortora, M. CS-111-02  
Tremblay, J. CS-126-03  
Tsai, S. SR-404-14, SR-127-02, SR-124-07, SR-127-04  
Tsekhanovskaya, N. CS-402-13  
Tseng, W. SR-124-07  
Tucker, D. SR-119-01, SR-119-02, SR-106-03  
Turner, C. SR-119-02

## U

---

Unice, K. SR-404-02, SR-107-02, SR-404-01, SR-107-04

## V

---

Valigosky, M. SR-127-06, SR-113-02, SR-403-11, SR-403-10, SR-403-14  
Van Baalen, M. CS-109-04  
Virji, M. SR-111-05, SR-403-07

## W

---

Waller, D. SR-404-11  
Walter, K. CS-125-07  
Wang, J. SR-120-01, SR-120-07  
Wang, M. SR-401-07  
Wang, Y. SR-401-11  
Wasserman, D. CS-124-06  
Weber, A. CS-125-06  
Weber, D. CS-403-09  
Weible, R. SR-111-06  
Weisman, W. CS-105-02, CS-123-08  
Whitehead, L. SR-404-11, SR-106-03  
Whitworth, K. SR-119-01, SR-106-03  
Wiley, J. CS-403-02  
Wilke, D. SR-122-05  
Williams, P. SR-103-01, SR-404-09  
Witters, D. CS-111-01  
Woldu, H. SR-104-04  
Wood, G. CS-122-03  
Woollen, N. CS-111-04  
Wu, J. SR-125-04  
Wu, N. SR-401-08  
Wurzelbacher, S. SR-106-04

## Y

---

Yanagisaway, Y. SR-404-03  
Yang, K. SR-127-05, SR-122-09  
Yang, T. SR-120-03  
Ye, M. SR-403-01  
Yen, Y. SR-114-06, SR-107-01, SR-101-02, SR-114-03  
Yong, L. CS-102-06  
Yu, N. SR-127-05, SR-120-03, SR-124-05

## Z

---

Zagagi, Y. CS-402-11, CS-102-01  
Zamuco, R. CS-112-06  
Zgodzinski, E. SR-403-14  
Zhang, A. SR-106-03  
Zhu, J. SR-122-08  
Zhuang, Z. SR-122-01  
Zisook, R. SR-404-06  
Zouak, M. CS-101-04

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