

swabs showed 36% personnel to be colonized with nosocomial pathogens. **Conclusion.** While the systematic profile of location-influenced bioaerosols such as *E. coli* in the laundry (soiled linen) and effluent treatment areas was expected, the isolation of *Shigella* from the biomedical waste site is a major concern.

The pilot study results indicate that bioaerosols in health care facilities in India may be a significant occupational safety and health concern. It also points out the need for generating a more comprehensive profile for implementing interventions.

Engineering Controls and Technology

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A HOT TOPIC: IMPROVING VENTILATION EQUATIONS FOR EXOTHERMIC PROCESSES. J. McKernan, CDC/NIOSH, Cincinnati, OH; M. Ellenbecker, University of Massachusetts-Lowell, Lowell, MA.

Exothermic processes create potentially unsafe work environments for an estimated 5–10 million American workers. These processes are present in a multitude of industries including chemical, plastic, rubber, glass, and primary metals. Although excessive heat and process contaminant exposure have the potential to cause adverse health effects in workers, insufficient attention has been given to improving engineering control technologies for these processes. The objective of this research was to investigate this knowledge gap. A review of historic and modern heat transfer and meteorological theory were conducted, leading to the development of new ventilation equations to provide improved control of exothermic processes. Subsequently, laboratory data were collected to validate the new and currently accepted ACGIH equations. In laboratory experiments, axisymmetric centerline velocity data were collected using a hot-wire anemometer at varying heights above a model exothermic process. Laboratory results were compared to predicted results from both the new and ACGIH equations. Statistical analyses were conducted for the difference between the laboratory velocity results and predicted velocity results from both the ACGIH and new equations using a one-sample t-test. Mean difference, variance of the difference, and t-test p-values when comparing the ACGIH equations with laboratory data were 0.016 m/s, 0.005, < 0.0001. Mean difference, variance of the difference, and t-test p-values when comparing the new equations with laboratory data were -0.006 m/s, 0.006, 0.298. Analyses indicate that the new equations have the potential to more accurately predict ventilation rates to capture the entire potential thermal plume flow.

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A STUDY OF THE REMOVAL EFFICIENCY OF BERYLLIUM OXIDE DUST FROM CONTAMINATED CLOTHING USING AIR SHOWERS. M. McCawley, McCawley Consulting, Morgantown, WV; T. Frigon, Brush Wellman, Tucson, AZ; M. Kent, Brush Wellman, Elmore, OH.

A study was done at a beryllium oxide ceramics operation to determine the efficiency of the air showers at removing beryllium from workers' clothing. Workers were issued new shirts that were worn over their regular uniforms for a period of up to three days before they were taken through the air showers. Multiple sections of the shirts were analyzed for the concentrations of beryllium before and after using the air shower.

The removal efficiency of the air showers ranged from approximately 18 to 28%. The coefficient of variation between samples was 41%, and ranged from approximately 18 to 79% within single shirts. Workers had one of the back center sections of their shirts vacuumed through a mixed cellulose ester filter to collect the mechanically removable material from the shirt. At best only 10% of the beryllium that could be chemically dissolved from the samples could be vacuumed off, a result similar to the air showers' efficiency. This means that individual characteristics, could make a considerable difference in the measured removal efficiency from any single garment. These results were strongly influenced by the removal efficiency of the shirts that were most heavily loaded. The conclusion that could be drawn is that the air showers are effective at removing some beryllium from clothing samples if the loading is "high," unlikely on a daily basis. For normal activity, then, the air showers may be of little use in reliably removing measurable quantities of beryllium. This may be because it is difficult to detect the small amounts of beryllium that are removed or because small amounts of beryllium are not easily removed. In the latter case, this beryllium may then not be available for cross contamination of other surfaces.

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THE EFFECTS OF DILUTION VENTILATION ON CONCENTRATIONS OF FORMALDEHYDE AND PHENOL IN A GROSS ANATOMY LABORATORY. M. Osborne, K. Hahn, D. Butgereit, D. Englund, C. Rice, University of Cincinnati, Cincinnati, OH.

Gross anatomy laboratories have long been known to be the sources of potential exposures to formaldehyde and phenol—both components of the embalming solution used to preserve cadavers. While faculty may be monitored and protected under the OSHA Act, students participating in these laboratories remain an underrepresented population. The purpose of this study was to evaluate potential exposures to phenol and formaldehyde vapors that may be encountered by students and faculty working in a

gross anatomy laboratory. The study included an evaluation of air concentrations for both chemicals as well as an evaluation of the dilution ventilation system in the laboratory. A total of 24 samples were collected during the three-day evaluation period. Phenol and formaldehyde concentrations were evaluated with the ventilation system turned off and with the ventilation system operating. Additionally, background levels were evaluated in order to gather information for exposures that may be encountered by cleaning and maintenance staff. Airborne concentrations of phenol ranged between 0.19 and 0.48 ppm (mean = 0.27, SD = 0.12) and formaldehyde concentrations ranged between 0.26 and 0.65 ppm (mean = 0.37, SD = 0.16) with the ventilation system operating. When the ventilation system was turned off, the concentrations of phenol ranged between 0.31 and 0.87 ppm (mean = 0.54, SD = 0.27) and formaldehyde concentrations ranged between 0.59 and 0.89 ppm (mean = 0.72, SD = 0.13). The background concentration for phenol was below the limit of detection (0.005 ppm) and the background formaldehyde concentration was measured at 0.02 ppm. All results were compared to occupational exposure limits. The dilution ventilation system was determined to be operating below design specifications. Therefore, while concentrations of both airborne contaminants were noticeably lower when the ventilation system was operating, concentrations would likely be lower if the ventilation system were operating at design specifications.

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EVALUATION OF A HIGH-EFFICIENCY FILTER-BANK SYSTEM. S. Martin, E. Moyer, CDC/NIOSH, Morgantown, WV; B. Beamer, University of Wisconsin-Stout, Menomonie, WI.

In November 2001, the United States Postal Service (USPS) asked the National Institute for Occupational Safety and Health (NIOSH) for technical assistance in evaluating new USPS ventilation and filtration systems (VFSs). These prototype VFSs were developed by outside vendors and had been installed on critical mail processing equipment in response to the 2001 bioterrorist attacks, when the USPS unknowingly processed letters laden with *B. anthracis* spores. In response to the USPS request for assistance, NIOSH investigators evaluated the overall filtration efficiencies of these VFSs at three USPS processing and distribution centers. The new VFS units included high-efficiency particulate air filters and were required by USPS contract specifications to provide an overall filtration efficiency of 99.97% or better. Because no testing standards or procedures existed to meet the USPS requirements, the USPS evaluation involved a modification of an American Society of Agricultural Engineers methodology used to test total filtration efficiency in agricultural tractor cab enclosures. Optical particle counters, that were carefully calibrated and matched as a set, were placed

upstream and downstream of the filter banks within the VFS housing. This modified sampling strategy proved effective for monitoring the filtration component of VFS performance. The results clearly showed that this testing method is capable of monitoring overall filtration efficiencies of 99.97% and higher. The method was also effective as a tool to distinguish between filtration units performing to the high USPS performance criteria and those needing repair, redesign, or replacement. Further, the modified methodology used for the USPS study is readily adaptable to any workplace wishing to evaluate air filtration systems, including high-efficiency systems.

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Aerosols

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PARTICLE BOUNCE AND ENDOTOXIN LEVELS IN A MARPLE CASCADE SAMPLER WITH PVC FILTERS. S. Kirychuk, N. Koehncke, University of Saskatchewan, Saskatoon, SK, Canada; S. Reynolds, J. Nakatsu, J. Mehaffy, Colorado State University, Fort Collins, CO.

Several studies indicate distortion related to particle bounce when utilizing cascade impactors with certain filter media. To reduce the effect of particle bounce and the related effect on size distribution, it is often recommended to utilize impaction grease on filter media in cascade impactors. The effect of particle bounce with polyvinyl chloride (PVC) filters in a Marple® cascade impactor were unknown as was the effect of impaction grease on endotoxin levels. A pilot study was undertaken utilizing six-stage Marple cascade impactors and 5.0 µm PH-PVC 34-mm filters with radial slits. Poultry dust was run through a wind tunnel in which four six-stage samplers were stationed. For each of the three runs that were carried out, the filters of two of the samplers were treated with impaction grease and two of the samplers were not treated. Levels of total dust (mg/m³) and endotoxin (EU/m³ and EU/mg) were analyzed to determine if there was any effect from utilizing impaction grease. The results indicate that when utilizing the PVC filters in the Marple impactor running at 2.0 litres/minute there was no significant difference in total dust between filters treated with impaction grease (0.20 mg/m³) and those not treated (0.24 mg/m³) when controlling for the impaction stages. There was a significant difference ($p = 0.01$) in airborne endotoxin between filters treated with impaction grease (5.61 EU/m³) and those not treated (6.00 EU/m³), but no significant difference in endotoxin concentration (EU/mg). The results indicate that there is no difference in particle bounce utilizing impaction grease or no impaction grease on 5.0 µm PVC filters in a Marple impactor, but the impaction grease does appear to inhibit the endotoxin assay.

Furthermore, utilizing impaction grease with PVC filters had some negative practical issues such as filter tearing and inaccurate impaction grease application rates.

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DIFFERENCES IN DISSOLUTION BEHAVIOR IN A PHAGOLYSOSOMAL SIMULANT FLUID FOR SINGLE-COMPONENT AND MULTICOMPONENT BERYLLIUM MATERIALS ASSOCIATED WITH BERYLLIUM SENSITIZATION AND CHRONIC BERYLLIUM DISEASE.

A. Stefaniak, G. Day, M. Hoover, NIOSH, Morgantown, WV; P. Breysse, Johns Hopkins University, Baltimore, MD; R. Scripsick, Los Alamos National Laboratory, Los Alamos, NM.

Dissolved beryllium is the hypothesized input to the cell-mediated immune reaction associated with development of beryllium sensitization and chronic beryllium disease (CBD). Particle dissolution within the macrophage phagolysosome is thought to be an important source of dissolved beryllium. Using a phagolysosomal simulant fluid in a static dissolution technique, we measured dissolution rates for single- and multicomponent beryllium aerosol materials associated with elevated prevalence of beryllium sensitization and CBD. The observed dissolution rates were normalized to measured values of specific surface area (SSA) to calculate a chemical dissolution rate constant (k) for each material. The values of k , in g/(cm²·day), for single-component beryllium oxide released from a screener unit operation ($1.3 \pm 1.9 \times 10^{-8}$) and for single-component finished product beryllium oxide powder ($1.1 \pm 0.5 \times 10^{-8}$) were similar ($p = 0.45$). The value of k observed for single-component finished product beryllium metal powder ($1.1 \pm 1.4 \times 10^{-7}$) was significantly greater than observed for the beryllium oxide materials ($p < 0.0003$). For multicomponent aerosol material collected from an arc furnace during processing of copper-beryllium alloy, k ($1.6 \pm 0.6 \times 10^{-7}$) was significantly greater than observed for single-component beryllium oxide ($p < 0.00001$), despite the fact that the chemical form of beryllium in the aerosol was beryllium oxide. Thus, knowledge of the SSA of the particles and the k value of the chemical form of beryllium was not sufficient to characterize beryllium dissolution from the multicomponent material. Additional studies of the dissolution behavior of beryllium alloy materials, as well as beryllium minerals, metal, oxide, and composite materials in a variety of mixture configurations (uniform mixtures, nonhomogeneous mixtures, surface coatings, etc.) are needed to aid in developing exposure-response models to improve understanding of the risk of beryllium sensitization and CBD.

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EMISSION CHARACTERISTICS OF SIDESTREAM CIGARETTE SMOKES.

C. Chen, F. Chiang, T. Yang, C. Hsu, Y. Lin, National Taiwan University, Taipei, Taiwan Republic of China.

Tobacco smoke is formed by a complex series of processes, including combustion, pyrolysis, evaporation, distillation, and condensation. This complex matrix is composed of several thousand constituents. Numerous studies have been conducted to investigate the health effect. Historically, smoking-control efforts have focused on smoking prevention and cessation through individual and group counseling efforts, reflecting a reliance on the individual-based medical model. Compared to the policy-oriented control, the technology-oriented control measures do not receive as much attention as they deserve. Therefore, the ultimate goal of this work was to develop or improve the current commercial air cleaners designed for removing sidestream cigarette smokes.

An experimental system, composed of a sidestream cigarette smoke generator, a mixing and test chamber, and a sampling train, was set up to investigate the chemical and physical characteristics of the sidestream cigarette smokes. Real time instruments, such as Q-Trak, were used to monitor the concentrations of CO and CO₂; PID was used to measure the concentration of VOCs. Filter samples were collected for estimating the mass concentration. We also measured the particle size distribution (by using a scanning mobility particle sizer) and temperature of cigarette burning tip, by using a homemade thermocouple with 79-µm nickel-aluminum and chrome wires.

The results showed that cigarette combustion rate increased with decreasing packing density of cigarette due to less mass and therefore relatively higher oxygen transfer. The emission factors and emission rates of CO, CO₂, aerosol mass concentration, VOCs, and the surface temperature of the smoldering cone all increased with increasing passing air flow. The thermal conductivity of the ashtray played an important role in both aerosol and gas emission. The design of the trench holding the cigarette was particularly critical. The cigarette smoldering rate decreased with increasing contact area, until the combustion ceased due to not enough heat generation.

Hexavalent Chromium Issues

Papers 285–288

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INDUSTRY AND EXPOSURE PROFILES FOR INDUSTRIES AFFECTED BY THE PROPOSED OSHA HEXAVALENT CHROMIUM STANDARD. L. Verdier,

R. Krishnan, D. Schupp, Shaw Environmental Inc., Cincinnati, OH.

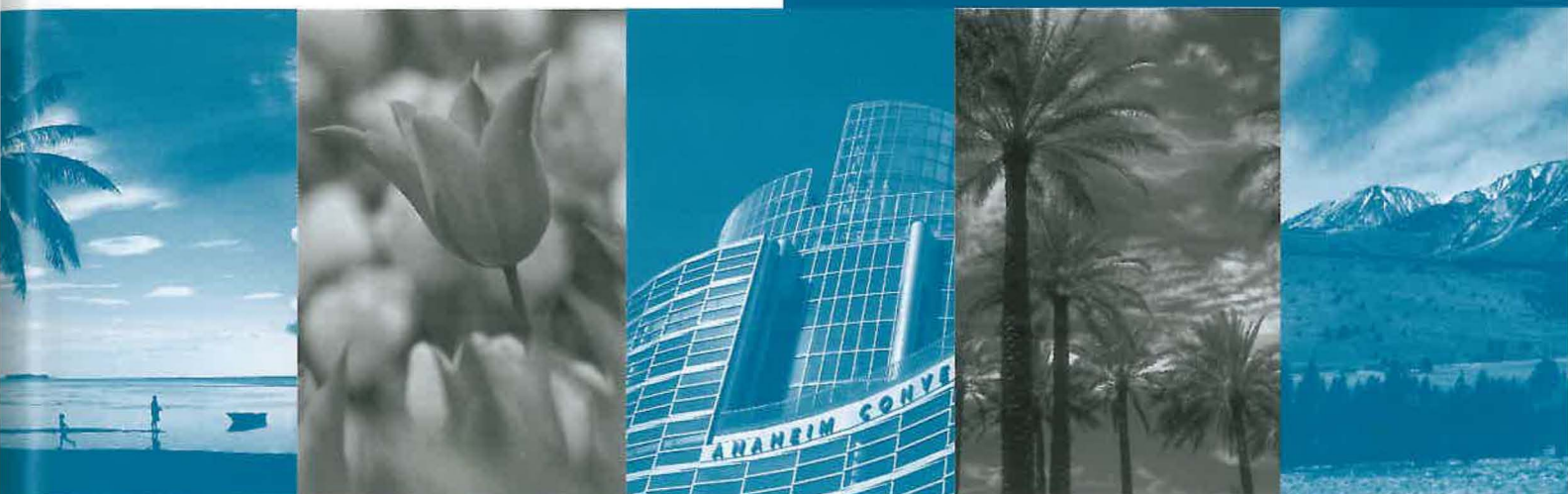
The Occupational Safety and Health Administration (OSHA) published a proposed rule for occupational exposure to hexavalent

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