PO 107-1
Design, Development and Evaluation of a Noise Control Enclosure for a Model Jet Engine
J. Black, J. Rinker, R. Yon, C. Holder, U.S. Air Force, Wright-Patterson AFB, OH; J. Slagley, School of Aerospace Medicine, Wright-Patterson AFB, OH.

Situation/problem: A cart-mounted model jet engine used for educational demonstrations produced a sound pressure level (SPL) of 89.1 dB at a distance of 25’, the minimum safety distance determined for operating the jet engine at full power. Design, development and evaluation of an engineering noise control to lower the SPL attributable the jet engine to less than 80.0 dB at a distance of 25’ was requested by the jet engine’s owner. Resolution: A noise control enclosure (NCE) that would reduce the SPL of the jet engine to less than 80.0 dB at a distance of 25’ was designed, built and tested. The NCE is a wood frame rectangular box 27” x 48” x 24 1/8”, with 3/8” thick Plexiglas sides, special intake and ducted exhaust ports, a hinged side access window, and is directly attached to the existing jet engine cart with minimal modifications. The NCE’s predicted SPL reduction was based upon actual SPL frequency measurements, a blade pass frequency (BPF) analysis, and published transmission loss factors for the materials used to build to the NCE. Results: The NCE reduced the SPL attributable to the jet engine when operating at full power to 76.4 dB at a distance of 25’ and met all other owner desired use characteristics, such as ease of portability and not inhibiting viewing the jet engine. Lessons learned: NCEs are effective in reducing the SPL for hazardous noise sources and can be readily designed using basic noise control principals and published transmission loss factors. BPF analysis is of modest utility for predicting the dominant sound generating frequencies of devices that are not simple, rotating fans, and should be best regarded as a technical tool of interest for such cases. Actual SPL frequency data should be used to best design frequency-dependent NCEs

PO 107-2
Ensuring a Robust Industrial Hygiene Program by Maximizing Engineering Control Success by Implementing and Cultivating a Containment Culture and Soft Elements

Situation: Roche Colorado Corporation (RCC) continues to evaluate emerging technologies to target containment objectives for the handling of raw materials, isolated intermediates and active pharmaceutical ingredients. Containment technologies can represent significant investments where success relies on more than just engineering control installations for employee protection. In addition to technically feasible engineering controls, a containment culture and soft elements are required. Resolution: Integrate containment culture, soft elements and engineering controls in the site’s industrial hygiene program. Containment culture is the product of an organization’s individual and group values, attitudes, competencies and behavior patterns that determine the commitment to and the style and proficiency of the industrial hygiene program. These elements are demonstrated when the drivers for change are understood and accepted; management provides emphasis, support, and realistic expectations; and a structure for managing the change process exists. Containment culture strength relies on the effectiveness and presence of soft elements, which include innovative process development, occupational health pre-planning and containment execution cycles. Results: A strong industrial hygiene program drives the essential soft elements to achieve and sustain containment investment success. The soft
elements are essential and include trained and motivated industrial hygiene staff, monitoring equipment and instrumentation available, budgets and analytical methods allocated, aggressive data collection, operational refinement and timely, pervasive communication and operational procedures adherence. **Lessons Learned:** This integration of a containment culture, soft elements and engineering control applications has proven enhanced and repeatable containment for specific installations and is vital for the success of RCC’s robust industrial hygiene program. Maximizing engineering control investment success allows continued alignment to RCC’s responsible care commitment in providing a workplace free of recognized health and safety hazards.

**PO 107-3**

**Determination of Capture Velocities for Vapors and Gases by Schlieren Photography**

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**Objective:** With the aid of Schlieren Photography, we redetermined capture velocities for some gaseous contaminants, such as VOC vapors and sulfur hexafluoride, by instant visual observation. **Methods:** An experimental Schlieren Photography facility enables the observer to see if an interested gaseous contaminant is well captured by a miniature exterior exhaust hood suspended in front of a concave spherical mirror. A bull-eye color filter helps to enhance the observation sensitivity. Some pure VOC vapors (methanol, alcohol, isopropanol, toluene) and gases (carbon dioxide, sulfur hexafluoride) with different vapor/gas densities are chosen for comparison. **Results:** For vapors/gases chosen in this study, the larger the density of vapor/gas the higher the capture velocity needed. We also found that the capture velocity 0.5m/s (100fpm) is enough for all the vapors/gases mentioned above. **Conclusions:** We found that Schlieren Photography can be a quick, practical and inexpensive method to constantly monitor the overall efficacy of an exhaust hood capturing some certain gaseous contaminant with its density different from ambient air.

**PO 107-4**

**Utilization of Computational Fluid Dynamics (CFD) in the Design of Engineering Controls to Reduce the Exposure to Airborne Lead Particulate Matter and Volatile Organic Compounds in an Armory**

D. Hall, C. Strode, R. Strode, Chemistry & Industrial Hygiene, Inc., Wheat Ridge, CO.

**Situation/problem:** Armorists cleaning weapons at two tables in a small armory room without personal protective equipment and non-task specific engineering controls were assessed for exposure to airborne heavy metal particulates and volatile organic compounds (VOCs) associated with the weapon cleaning process and products. The employer desired to incorporate a task-specific local exhaust ventilation (LEV) control to address the potential exposures. **Resolution:** Several iterations of CFD modeling were used to assist in the design of local exhaust ventilation that was subsequently installed and tested for efficacy. The armorists’ workstation, air supply register, hood locations and hood types were modeled at positions and configurations to arrive at an optimal solution. Due to the small volume characteristic of the room, controls were required to operate the LEV and general HVAC system to maintain only a slight negative pressure within the Armory. The CFD-optimized design was then contracted, installed, tested and utilized. **Results:** The hood’s capture effectiveness and the CFD results were validated by flow measurements and qualitative particulate tests performed on the commissioned system, substantiating the hood’s capture efficiency. **Lessons learned:** CFD provided a beneficial three-dimensional representation of the hoods’ capture effectiveness and the flow characteristics within the room.

**PO 107-5**

**Preliminary Results from Tests on Two Tracer Gas Protocols Developed to Determine Ventilation Flow Rates and Patterns in Naturally Ventilated Munitions Storage Bunkers**

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**Objective:** Since World War II, the Army has stored chemically filled munitions in large, naturally ventilated structures known as bunkers. Most of these bunkers were designed and built in the 1940s and 1950s. The Army would like to reliably monitor these bunkers without first entering them to ascertain if any munitions are leaking by measuring agent concentration within the bunkers. Ventilation is provided using the natural properties of air such as pressure, temperature and density; no mechanical ventilation systems are used. The ventilation in these large semicircular structures is provided by a vent located in the front door of the structure and a rear vent connected to a stack. **Method:** The Army assembled a team to develop and test tracer gas protocols to determine if this would provide more reliable information on the airflow rates within the bunkers. The team developed two protocols: one using n-dibutyl sulfide (BS) as the tracer gas and the second using carbon dioxide (CO2). The BS gas protocol has six sampling points within the bunker, and the measurements are made using a portable gas chromatograph. The CO2 protocol utilizes
15 sample points, each monitored by a portable instrument equipped with an infrared sensor to measure the concentration. **Result:** Results from releasing the gas at two or three release points within the test bunkers during three of the four seasons will be presented. Measurements for each protocol were collected using two bunkers (one equipped with a set of passive filters on the vents and the other without filters) and two internal storage configurations. Each release point was measured under each of these conditions for a minimum of eight sampling periods. **Conclusion:** Early test results suggest that both protocols together provided the best data on air movement within the bunkers.

**PO 107-6**

**Field Effectiveness of Portable HEPA-Equipped Air Filtering Devices (Pilot Study)**

D. Walsh, Walsh Certified Consultants, Inc., Las Vegas, NV.

**Objective:** Evaluate whether portable HEPA-equipped air filtering devices (devices) are performing at or near an efficiency of 99.97% for 0.3 microns or greater-sized particles when used under field conditions. **Methods:** Three devices (one back-pack vacuum and two high-volume negative air machines) were exhausted into an approximately eight-foot cube plastic-lined chamber where the exhaust air was tested and compared to device intake air. Testing was done twice for each device using laser particle counters, an ultrafine (<0.1 microns) particle counter and laboratory aerosol analysis of Air-O-Cell cassettes. The aerosols included molds, pollens, dander, opaque particles, etc. **Results:** The testing indicated that none of the three devices met HEPA filtration criteria. Most of the data indicated less than 90% efficiency for the devices tested with some much less. In the case of one device, the ultrafine particles were removed with high efficiency while the larger particles were removed with low efficiency. **Conclusions:** Additional studies in a more controlled environment (e.g., University research lab) should be conducted to confirm the results of this and other pilot studies in a more defensible manner. Also, a method for field assessment of devices should be developed to assure proper functioning of these important health protection devices.

**PO 107-7**

**Quantitative Assessment on the Effectiveness of Different Exposure Control Strategies for Hexavalent Chromium Mitigation in Stainless Steel Welding**

S. Caporali-Filho, R. Aviles, University of Puerto Rico, San Juan, PR.

**Objective:** Hexavalent Chromium (CrVI) is among the most common welding hazards in construction. Its airborne concentration depends on the welding process and task, the base metal and the metal being added from the electrode. Although engineering controls are required in most situations where exposure to CrVI exists, control strategies such as portable Local Exhaust Ventilation Systems (LEVs) are not yet a common practice in construction and still represent an untested and unfamiliar innovation for many employers. The objective of this project was to compile evidence-based data addressing the effectiveness of portable LEVs in mitigating CrVI exposure in a welding task similar to those performed in construction. **Methods:** The study methodology involved a laboratory-based experiment where outdoor welding on stainless steel was conducted under controlled environmental and welding conditions. This experiment was designed to test with air samples the effect of four different exposure control strategies (750 cfm LEV, 230 cfm LEV, half mask with high efficiency particulate air filters, and powered air purifying respirator, PAPR) on the worker’s exposure to CrVI while welding at three different working heights (overhead, eye height, waist height). **Results:** Data was submitted to an analysis of variance and results identified a significant effect (5%) of working height, exposure control strategy and their interactions on workers’ CrVI exposure. Hypothesis testing identified the PAPR and the 750 cfm LEV as being the most effective control strategies across all working heights, with average exposures significantly (5%) lower than 2.5 μm/m3, while waist height was associated with the highest exposures for all exposure control strategies (5%). **Conclusions:** In conclusion, findings from this research study can be used to develop intervention activities to educate construction employers and employees on the practical advantage of using PAPRs and/or large LEVs, instead of half mask respirators, to properly control employees’ exposure to CrVI

**PO 107-8**

**Mercury Exposure Assessment and Control at Third-Party Lighting Manufacturing Sites in China**


Mercury is listed in the Highly Toxic Chemical Inventory by China Ministry of Health. Liquid or solid mercury is used in compact fluorescent lamp and metal halide lamp production. Potential for mercury exposure exists if exposure controls are not provided or the controls are not effective, especially at third-party manufacturing sites where hazard awareness is not significant and resources
to control exposures are limited. Qualitative exposure assessments (QLEA), Quantitative Exposure Assessment (QNEA) and a regulatory compliance audit were conducted at three third party lamp manufacturing sites in China. QLEA was conducted using a model that considered chemical hazards, frequency/duration of chemical used, airborne potential, exposure control, skin absorption and ingestion potential. QNEA was conducted with a direct reading mercury vapor analyzer. Activities with potential mercury exposure including: mercury receiving and distribution, mercury weighing, mercury dosing, exhausting, aging, housekeeping, maintenance, mercury waste disposing were reviewed to determine the degree of health risk. Biological monitoring data for mercury were evaluated. Recommendations were made on reducing mercury exposure and determining compliance status with regulatory requirements. Improvements in exposure controls, work practices, respiratory protection and personal protective equipment were recommended. One of the three sites replaced liquid mercury with solid mercury and the process significantly reduced potential mercury exposure. The exposure assessment and the compliance audit conducted assisted the sites in reducing mercury exposures.

**Poster Session 404**
**Engineering and Control Technology**

*Tuesday, May 17, 2011*
*1:00 p.m.–3:00 p.m.*
*Papers PS 404-1 - PS 404-5*

**PS 404-1**
**Characterizing Ventilation in Collision Repair Spray Painting Booths**
K. Broadwater, M. Yost, D. Ceballos, University of Washington, Seattle, WA; C. Whitaker, Washington State Department of Labor and Industries, Olympia, WA.

**Objective:** Exposure to isocyanates, a component in automotive paints, causes sensitization and occupational asthma in spray painters. The first line of preventing exposure is the use of engineering controls, such as adequate booth ventilation. The objective of this project is to assess spray booth ventilation in local collision repair shops. **Methods:** Nineteen booths were evaluated at eleven auto body shops, including eleven downdraft booths and eight semi-downdraft booths. A rotating vane anemometer was used to measure EFV (exhaust face velocity) as well as breathing zone velocities, which were taken at waist-level. Instrument error was ±20 lfm (linear feet per minute). **Results:** Semi-downdrafts had a significantly (p=0.004) higher mean EVF, 201 lfm, than downdraft booths, 105 lfm. This is due to smaller exhaust faces in semi-downdraft booths; the average exhaust area was 34 ft² for semi-downdraft and 150 ft² for downdraft booths. One hundred percent of semi-downdraft and 45% downdraft booths met the NIOSH recommended mean 100 lfm EFV. The mean ACM (air exchanges per minute) for downdrafts was 3.6, which is significantly higher (p=0.01) than that of the semi-downdrafts at 2.3 ACM. The average reported filter age was 18.5 days for all booths. An average of 2.5% of semi-downdraft and 26% of downdraft EFV measurements were zero lfm. Only one booth, a semi-downdraft, met the NIOSH breathing zone recommendation of 80 lfm. On average, 38% semi-downdraft and 58% downdraft breathing zone measurements were zero lfm. **Conclusions:** These data suggest that while most booths met ventilation government recommendations, there are multiple measures that must be considered to support advice for improvements or additional maintenance. Painters should be aware of dead zones in their booths (zero lfm) to assure protection while spray painting. More investigation is needed to determine the relationship between maintenance, booth age, filter age and velocity.

**PS 404-2**
**Local Exhaust Ventilation: Excellent for the Effective Reduction and Control of Combustible Dust**
K. Housman, Liberty Mutual Group, Birmingham, AL.

**Situation/Problem:** A quantitative IH assessment was completed to determine employee 8-hr TWA exposures to total particulate during routine grass seed mixing and bagging activities. The initial survey determined employee exposures that were approximately 2.4 times the OSHA PEL. However from a risk assessment standpoint, the accumulation of a combustible dust on the surrounding surfaces was considered to be of greater concern. **Resolution:** The accumulation of a combustible dust meant that the total particulate exposures had to be reduced through engineering controls. Management decided to pursue the IH’s recommendation of installing local exhaust ventilation (LEV) so to capture the particulate at the sources as it was generated; thus reducing employee
exposure, while also reducing the accumulation of the combustible dust. In-house staff installed the LEV. The $9,000 cost included slot ventilation at the seed dumping area, two back-draft hoods at the bagging stations, a cyclone, and all duct work. Results: Follow-up air monitoring documented an 80 times reduction in the highest 8-hr TWA employee exposure. The installed LEV also adequately reduced the accumulation of combustible dust in the area. Lesson Learned: The NCCI estimates that the average cost of an occupational disease injury claim is $58,422 (in direct and indirect costs); thus the cost savings and return on the investment for implementation of these controls would already be significant. If we examine both the direct and indirect costs associated with just one claim, a company would have to generate an additional $1,162,640 in sales to recover these costs. However the cost associated with a combustible dust explosion, not even considering the possibility of the lost of life, would be even greater. Based on this information, it is easy to see the value in the installation of LEV as a control method in this specific case and for the associated employee exposures

PS 404-3
Resolution of Halovision Cases by Substitution of Reactive Amines in a Poly Urethane Foaming Industry

Situation/problem: There happened eye-related complaints in a urethane forming industry during a summer season. Symptoms included blurred eyes, narrow sight, dry eyes, eye redness, difficulty in eye focusing. Nearly 80% of workers in a newly expanded process with a mezzanine to remove burs and to fill up crack holes for foam products suffered from the eye disturbance. The employer introduced a new local ventilation system with little effect. Resolution: One NIOSH HHE report pointed out organic amines for halovision suspects. Several catalyst amines were detected in a raw chemical named Polyol then. The air concentrations of triethylamine (TEA), triethylenediamine (TEDA), tetramethyl hexanediamine (TMHDA), TDI, MDI, formaldehyde, acetaldehyde, propionaldehyde were ND, 0.060 ppm, 0.070 ppm, 0.024 ppm, 0.011 ppm, 0.0016ppm, 0.209 ppb and ND for 2 days consecutive area monitoring, respectively. The TLV for TEA, TDI, MDI, formaldehyde acetaldehyde are 2 ppm, 5 ppb, 5 ppb, 0.5 ppm and 50 ppm respectively. TEDA, TMHDE and propionaldehyde do not have TLV yet. Results: As the concentrations of isocyanates and aldehydes were low compare to TLVs, TEA and MDI were not detected, and TEDA and TMHDE has no OELs, we just could not recommend to renovate the local ventilation system. Polyol chemical supplier and employer discussed the issue for months and decided to change amines from non-reactive to reactive ones. Reactive amines combine to PU during chemical reaction of TDI/MDI with Polyol. After the substitution of old Polyol, the areas were monitored again. The concentrations of amines and aldehydes were reduced by 60-85%. Next summer halovision among workers reduced to less than 20%. Lessons learned: Organic amines could cause eye disturbance at low concentrations. Aldehydes and TDI may generate synergistic effects on eyes. OELs for TEDA and TMHDA might be less than 50 ppb to preventing halovision among PU forming workers

PS 404-4
Crystalline Silica Exposure During Trenching Activities
S. Al Rawahi, Petroleum Development Oman, Muscat, Oman.

Situation/problem: Full assessment was undertaken to assess the exposure of the inhalable dust, respirable dust and crystalline silica concentration. Resolution: Ten inhalable dust samples and eighteen respirable dust samples were taken by personal air monitoring using GLA 5000 PVC filters. Crystalline silica content was measured in eight of the collected respirable dust samples in the filters by using XRD to examine the potential heath hazard from the silica. Results: The result showed average exposure was below the Occupation Exposure limit (OEL) for crystalline silica. However, exposure to inhalable and respirable dust are above the OEL. Lessons learned: The study recommended that the conveyor belt design should be covered and lowered downward to decrease the generation of the dust
**Situation/Problem:** Certain aviation parts require the removal of serial numbers to eliminate identifiable or distinguishing characteristics before the parts are sent for scrap metal processing. Because the aviation parts are “scrap” from a variety of sources, MSDSs are not readily available. Manual grinding of serial numbers off aviation parts was employed to accomplish this task. In the grinding process, one manual grinder operator and the grinding helper were exposed to excessively high airborne concentrations of cadmium and beryllium. Excessive cadmium exposure has been linked to kidney damage. Excessive beryllium exposure has been linked to sensitization and berylliosis. Sampling revealed exposures that could represent acute as well as chronic health hazards. The grinder operator’s cadmium exposure was 100 times the OSHA PEL and the beryllium exposure was 50 times the OSHA PEL. The helper’s cadmium exposure was 4 times the PEL with the beryllium exposure approximating the PEL. Worker protection was limited to Tyvek® suits, gloves, eye protection and NIOSH approved N95 filtering facepieces. Industrial hygiene recommendations emphasized the need for management to act expeditiously to reduce/eliminate these exposures following the hierarchy of control methods. **Resolution:** Management actions included ceasing all grinding operations until decisions were made regarding the feasibility of continuing the grinding operation with appropriate engineering and personal protective equipment and comprehensive program controls. Simultaneously, management investigated suitable alternative means of disguising the serial numbers without the use of abrasive grinding. An acceptable means of covering the serial numbers with a masking compound was identified and adopted, eliminating the grinding operation. Results: Cadmium and beryllium exposures were eliminated. **Lessons Learned:** In the absence of MSDSs, efforts should be made to test aviation parts to determine their composition prior to grinding. As grinding produces significant airborne dust, alternative means of disfiguring distinguishing characteristics such as serial numbers should be explored.

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