length of the shift. Data from four workplace protection factor studies on four disposable and two elastomeric half facepiece respirators were analyzed. Each study measured WPFs for three or four sampling periods during the shift on 60 different workers. All studies were conducted in a similar manner: respirators properly selected, fit tested and worn, maintained with respiratory protection programs that met the requirements of 29 CFR 1910.134. When possible the WPF from the first sampling period was compared to the last sampling period. Using a Student's t-test of paired data, the results showed no significant difference in WPFs between sampling periods for all respirators studied ($p = 0.21$ to 0.99). The assumption that wearing a respirator at different times during the day does not cause deterioration in performance appears to be correct.

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WORKPLACE PROTECTION FACTOR STUDY ON A CONTINUOUS FLOW SUPPLIED AIR RESPIRATOR DURING AIRCRAFT SANDING. C. Colton, J. Bidwell, 3M, St. Paul, MN.

The National Institute for Occupational Safety and Health (NIOSH) has recommended an assigned protection factor (APF) of 25 for all loose fitting supplied air respirators. This study evaluated the performance on a continuous flow supplied air respirator equipped with a helmet against zinc in dust during aircraft sanding. Zinc was the most abundant metal. Workplace protection factor (WPF) measurements were determined by simultaneous sampling inside and outside the respirator during the 10-hr work shift. Twenty-seven measurements were collected over four days on four different workers. Inside respirator samples were analyzed for metals by proton induced x-ray emission (PIXE) analysis. Due to the potential for sample overloading, outside respirator samples were analyzed by inductively coupled plasma (ICP) emission spectroscopy. Outside respirator zinc concentrations ranged from 81 ug/m3 to 415 ug/m3. No zinc was detected on any of the inside respirator samples. Using the PIXE detection limit for zinc for inside respirator mass, the geometric mean WPF was greater than 4000 and the fifth percentile WPF was greater than 827. A Monte Carlo simulation, using the sampling data from this study and an assumption that 15% of the in-respirator samples were above the zinc detection limit, predicts a geometric mean WPF greater than 20,000. These results support an APF much greater than the 25 assigned by NIOSH.

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NUMERICAL INVESTIGATION OF BREATHING ZONE EXPOSURE TO A REMOTE PARTICULATE SOURCE. J. Richmond-Bryant, M. Flynn, University of North Carolina, Chapel Hill, NC.

Computational fluid dynamics (CFD) can allow the ventilation engineer to predict breathing zone (BZ) concentrations from various constituent sources. In this study, CFD was employed to examine the impact of a remote source on a worker's BZ exposure. A Lagrangian particle-tracking algorithm was combined with a discrete vortex method airflow model to demonstrate the effect of time-dependent vortex shedding on the concentration of particulate matter in the BZ of a worker. Convective and diffusive airflow behavior was considered. 3.4 micron particles having density of 2.5 kg/m3 were released from a line source located ten diameters upstream of the "worker," which was represented by a circular cylinder. A Reynolds number of 5000 was selected for the airflow; this value is appropriate for the low-turbulence environment typical of an industrial setting. The aerosol, having Stokes number on the order of 10-3, was expected to follow the pattern of air movement. Time-averaged particle concentration was computed throughout the computational domain, and the BZ was defined as the square region extending one diameter from the cylinder center.

Analysis of the time-averaged concentration at various times during the simulation reveals that the particles first convect past the near-wake region, which forms directly behind the cylinder. At this time, a void can be seen in the BZ. Particles first collect in a downstream eddy at a high concentration of approximately 7 concentration units, made nondimensional by the upstream particle concentration. Subsequently, the particles diffuse across the wake and back upstream. This diffusion causes the maximum particle concentration to decrease slightly to approximately 5 units; this maximum level is distributed over the mid-wake region. Because the recirculating region encompassing the BZ allows little material to infiltrate, the BZ concentration contains approximately the same amount of material as that found upstream; i.e. a concentration of roughly 1 unit.

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REPLICATION OF HUMAN TRACHEOBRONCHIAL HOLLOW AIRWAY MODELS USING A SELECTIVE LASER SINTERING RAPID PROTOTYPING TECHNIQUE. R. Clinkenbeard, D. Johnson, University of Oklahoma Health Science Center, Oklahoma City, OK; R. Parthasarathy, C. Altan, K. Tan, University of Oklahoma, Norman, OK; R. Crawford, S. Park, University of Texas, Austin, TX.

Exposures to toxic or pathogenic aerosols are known to produce adverse health effects. The nature and severity of these effects are often governed in large part by the location and amount of aerosol deposition within the respiratory tract. Morphologically detailed replica hollow lung airway casts are widely used in aerosol deposition research; however, techniques are not currently available which allow replicate deposition studies in identical, morphologically detailed casts produced from a common reference anatomy. The aim of this project was to develop a technique for the precision manufacture of morphologically detailed human tracheobronchial airway models based on high-resolution anatomical imaging data. Detailed physical models were produced using the selective laser sintering (SLS) Rapid Prototyping process. Input to the SLS process was a 3D computer model developed by boundary-based 2D to 3D conversion of anatomical images from the original NIH/NLM Visible Human male data set. The SLS process produced replicate models that were identical to one another and corresponded exactly with the anatomical section images, within the limits of the measurement. At least five airway generations were achievable, corresponding to airways less than 2 mm in diameter. It is anticipated that rapid prototyping manufacture of respiratory tract structures based on reference anatomies such as the Visible Male and Visible Female may provide 'gold standard" models for inhaled aerosol deposition studies. Adaptations of the models to represent various disease states may be readily achieved, thereby promoting exploration of pharmaceutical research on targeted drug delivery via inhaled aerosols.

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LABORATORY EVALUATION OF VENTILATED SHROUDS FOR MORTAR GRINDING. W. Heitbrink, D. Watkins, NIOSH, Cincinnati, OH.

As brick buildings age, mortar deteriorates and needs to be replaced. Before replacing the mortar, the existing mortar is removed to a depth of 1.5 to 3 cm. Typically, an 11-cm diameter grinder, operated at 10,000-12,000 rpm, is used to remove mortar, causing worker exposures to respirable crystalline silica concentrations as high as 10 mg/m3. Also, a tool resembling a router can be used to remove mortar. For four different shrouds, the effect of exhaust flow rate upon respirable dust emissions was experimentally evaluated. To conduct this testing, a small brick wall was built and enclosed in a hall-shaped, ventilated test chamber. The grinder was mounted on a mechanical trolley which moved the grinder horizontally down the wall at constant velocity of approximately 1 m/min and the mortar was removed at a fixed depth cut of 1.2 or 2 cm. A vacuum cleaner equipped with high efficiency filters exhausted air from the shrouds to a location outside of the enclosure. The vacuum cleaner's exhaust air flow was varied by controlling the voltage applied to the vacuum cleaner. An air flow rate of 1.3 m3/sec was drawn through the test chamber and past mixing baffles and into an exhaust duct. A time-of-flight aerosol spectrometer was used to measure the respirable dust concentration in the duct. Dust emissions per volume of mortar removed were plotted as a function of exhaust flow rate. For uncontrolled grinding, respirable dust emissions were 20 mg/cm3 of mortar removed. As flow rates increased, respirable dust emissions were reduced to under 0.2 mg of respirable dust per cm3 of mortar removed. For the 11-cm diameter grinding wheel and the router, 80 and 40 cfm, respectively, were the minimum exhaust volumes which provided this emission reduction. Further flow rate increases did not provide useful emission reduction.

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THE EFFECT OF TWO VENTILATION METHODS ON WELD FUME EXPOSURE IN A SHIPYARD CONFINED-SPACE WELDING TASK. S. Wurzelbacher, O. Johnston, S. Hudock, L. Blade, S. Shulman, NIOSH, Cincinnati, OH.

Recent NIOSH studies have indicated that shipyard confined-space welding presents unique fume exposure control problems. Limited options for worker positioning (in reference to the air flow direction) and posture (in regards to the weld fume plume) can significantly affect weld fume exposure, resulting in eight-hour TWAs for PBZ concentrations that exceed evaluation criteria for welding fume and individual metals. To determine the effectiveness of available ventilation options for a specific shipyard, two ventilation methods were studied on three volunteer welders (2 male, 1 female) who performed confined-space stick welding as part of their typical work. The first method, which was currently being employed at the shipyard for this task, was a type of forced turbulence which directed air into the confined space with an electric blower. The second method, which was suggested by NIOSH, involved

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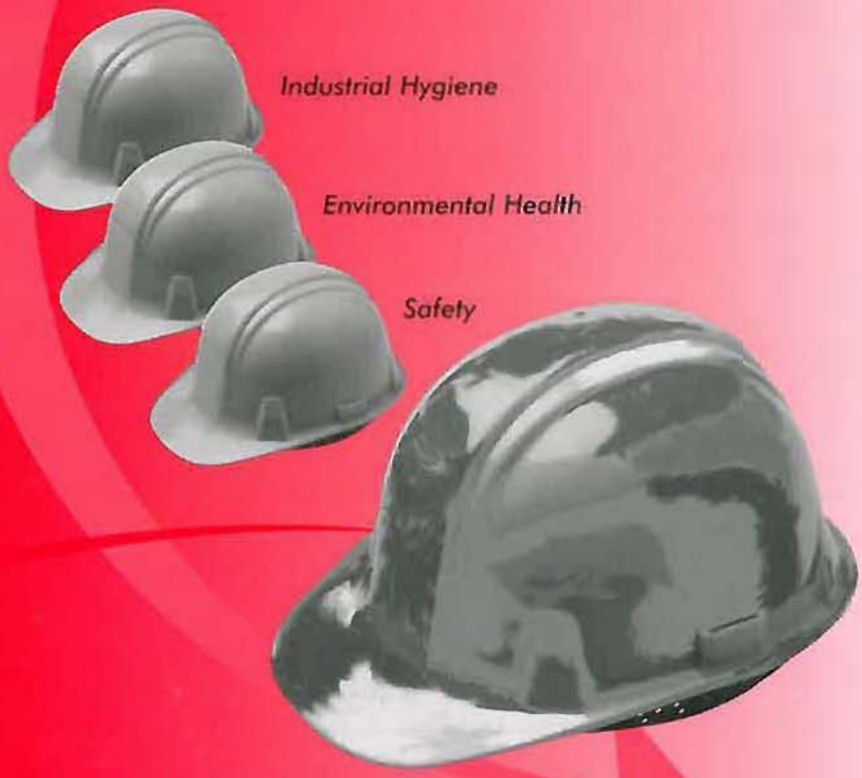

ABSTRACTS