cartridges was then determined by passing through an airflow with a $CS_2$ concentration of 10 ppm for the time required to reach 5 ppm $CS_2$. The used cartridges exhibiting stain tube concentrations of greater than 5 ppm were found to possess no residual adsorption capacity for $CS_2$.

In conclusion, the use of a stain tube was found to be useful for work site detection of the breakthrough time of the used cartridges.

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PERSONAL AEROSOL GENERATION DURING THE RAINBOW PASSAGE EXERCISE AND THE EFFECT ON COMPUTED QUANTITATIVE FIT FACTORS. R. McCleery, D. Lillquist, D. Wallace, T. Aldrich, Rocky Mountain Center for Occupational and Environmental Health, Salt Lake City, UT

The Rainbow Passage speaking exercise is standard in quantitative fit-testing. This QNFT exercise is intended to emulate worker facial movements while speaking. With the use of a condensation nuclei counter (CNC) and a full-face respirator, the lowest consistent fit factor of all the exercises performed is the Rainbow Passage exercise. The purpose of this study was to investigate the impact of personal aerosol generation on the fit factor of this speaking exercise. Fifty subjects were quantitatively respirator fit-tested according to the OSHA Lead Standard Protocol with the exception of one added nonspeaking exercise. The nonspeaking exercise was mouthing the Rainbow Passage instead of speaking out loud. Comparing the fit factors of these two exercises indicated that the nonspeaking had a significantly larger fit factor than the speaking exercise (38825+1-43529 and 6124+/12174, respectively). The ambient particle concentration readings (particles/cc) for the two exercises were significantly correlated, r=0.98. The ratio of the two fit factors and the ambient particle concentration was not correlated, r=0.20. The ambient particle concentration does not have an effect on the fit factors of these two exercises. In conclusion, personal aerosol generation is a variable that plays a role in the magnitude of the Rainbow Passage speaking exercise fit factor. This is an important variable to keep in mind, especially when a subject fails this exercise leading to an insufficient overall QNFT fit factor. With a low ambient particle concentration and a high internal mask particle concentration a low, possibly failing fit factor will be observed, thus indicating a poor respirator fit.

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CARBON DIOXIDE CONCENTRATIONS INSIDE SURGICAL HELMETS AND POWERED AIR-PURIFYING RESPIRATORS. A.S. Echt, G. Burroughs, S. Lenhart, D. Booher, NIOSH, Cincinnati, OH; M. Rubman, Northern New Jersey Orthopedics, Madison, NJ

This poster presents the results of carbon dioxide ($CO_2$) measurements performed inside surgical helmets and powered air-purifying respirators (PAPRs) while test subjects performed an exercise protocol designed to simulate the work of orthopedic surgery.

Four types of surgical helmets in a total of 11 configurations were tested from among those manufactured by 3 companies. In addition, two NIOSH-approved PAPRs were evaluated. Test subjects wore typical surgical clothing while performing light exercise (<4 kilocalories/minute) while standing at an upper extremity ergometer set at a workload of 20 watts. Subjects were asked to maintain an exercise rate of 60 revolutions per minute on the ergometer's hand cranks. $CO_2$ measurements were made using a portable infrared indicator. The range of the assembled instrumentation package was extended from 4950 to 49,500 ppm by diluting the contaminant air stream in a ratio of 9:1 with ambient air scrubbed to remove $CO_2$. $CO_2$ concentration in room air was monitored continuously during all testing using a second, nondiluted $CO_2$ analyzer.

Mean $CO_2$ concentrations from four 15-minute tests of each of 11 surgical helmet configurations and 2 PAPRs tested ranged from 5500 to 11,700 ppm. $CO_2$ concentrations in room air ranged from 375 to 575 ppm, with a mean of 450 ppm. These results indicate that if these surgical helmets and PAPRs are used during operations lasting 8 hours or more, the users will be exposed to $CO_2$ levels exceeding the time-weighted average exposure limit (NIOSH REL, OSHA PEL, and ACGIH TLV) of 5000 ppm. Studies should be conducted to evaluate $CO_2$ exposures during actual orthopedic procedures.

## 382

PERMEATION TESTING OF GLOVE CANDIDATES FOR USE IN HANDLING DIMETHYLMERCURY. C.R. Dodgen, B. Brown, Intertek Testing Services, NA, Inc., Cortland, NY; M. Blayney, Dartmouth College, Hanover, NH

The selection of chemically resistant gloves when handling dimethylmercury has been limited by the lack of empirical information on permeation resistance. Dimethylmercury is an uncommon compound with no practical use, less its role as a standard in mercury NMR spectroscopy. The recent death of an organometallic chemist from a single exposure to dimethylmercury led to a series of tests done in accordance with ASTM F739-96 to help identify potential routes of exposure and gloves that may (or may not) be protective.

Six common laboratory/examination-style gloves were initially tested using 15-minute sampling intervals, with an exposure time of 3 hours. Since all six glove types exhibited substantial breakthrough at the first 15-minute sample, the tests were repeated using shorter sampling intervals (15 seconds). All six glove types had average breakthrough times of less than 2 minutes, indicating a strong possibility for dermal exposure. A second series of test was conducted to determine whether readily available commercial gloves (labeled as "chemical resistant" rather than examination-style) would provide adequate protection. A relatively thin, unsupported elastomeric glove, a multilayer laminate glove, and a combination of the laminate and the elastomeric glove were tested. The laminate glove and the laminate/elastomer combination exhibited very good permeation resistance (breakthrough times >4 hours), while the elastomeric glove tested alone had much lower resistance (breakthrough times <10 minutes).

While the use of any elastomeric glove may seem to prevent skin contact with liquids, gloves with poor permeation resistance may afford little or no protection from exposure, particularly for chemicals readily absorbed through the skin. Gloves specifically touted as "chemically resistant" may create a false sense of protection. In all cases, it is essential that the selection of glove and other personal protective equipment (PPE) be based on as much information as possible. Ideally, all PPE recommendations should be based on accepted, empirically derived information.

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EFFECTS OF A COMMERCIAL UNDERGARMENT UNDER IMPERMEABLE ENCAPSULATING CLOTHING IN THREE ENVIRONMENTS. P. A Bishop; A. Clapp, D. Gu, University of Alabama, Tuscaloosa, AL

It is generally accepted that improving comfort increases worker productivity in encapsulating protective clothing (EPC). However, little attention has been given to determining the most effective undergarment to be worn with EPC to maximize heat loss or comfort during rest. The purpose of this study was to compare a commercial undergarment (Oasis (r), Kimberly Clark Corp.) with the typically worn cotton T-shirt and jeans. Heat acclimated subjects (n=16) completed two sets of tests (one in cotton, one in Oasis (r) in counterbalanced order) in each of three WBGTs: 18, 23 and $27^0$ C. Subjects worked for 30 min at 300 Kcal/hr wearing a coated Tyvek (r) (Saranex 23P(r)) hooded coverall with gloves, boot covers and full-face gas mask then rested in the same environment with 1m/sec of wind for 30 min. with the coverall removed to the ankles, continuing this work-rest for 4 hours total. Rectal temperature, skin temperatures, heart rate, rating of perceived exertion and thermal and comfort rating were obtained every five minutes. Subjective assessment of garment selection, and rating score (1-5 scale with 5 as "extreme difference") was ascertained by survey after each pair of tests within the same environment. The physiological and comfort rating responses during work and rest were not significantly different (p>.05); however, the post-test survey scores and selection ratings for the commercial garment were significantly (p<.05) higher for: comfort, feeling, bulkiness, dryness, and coolness. Subjects overwhelmingly selected the commercial garment as the undergarment of choice.

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*Paper Withdrawn by Author*

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HOSPITAL OPERATING ROOM AIR QUALITY INVESTIGATION. S.D. Parkhurst, Environmental Diagnostics, Inc., Lake Zurich, IL

A major metropolitan hospital experienced a cluster of human health effects in their operating rooms (ORs). Of the 27 functioning ORs, 7 OR personnel experienced symptoms including dizziness, lightheadedness, nausea, and fatigue to the degree that one staff member fainted and several reported to the emergency room. An air quality investigation was conducted to identify potential environmental factors affecting well-being and performance.

**Abstracts**

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