

assessments included comfort, visual and respiratory discomfort, ease to put on and maintain in place, protection efficiency, and a summary evaluation of respirator use.

Worker judgment of an acceptable wearing duration was also evaluated. Assessment parameters were contained in a booklet with each on a separate page. Each parameter was presented on a 5- or 6-point vertical scale. Subjects were asked to mark a place on the scale. The distance (in millimeters) between the lower end of the scale and the point marked by the subject was measured and averaged for each parameter and compared among types of RPDs and workers.

Results showed that supplied-air respirators had the highest ratings with good comfort, minimal breathing and visual discomfort, ease to put on and maintain, and perceived good protection. Half-masks with organic cartridges and paint filters were considered by the workers as even easier to put on and maintain, but they were perceived as providing less protection efficiency and comfort. They were also reported as causing slight visual and breathing discomfort.

N95 dust masks were perceived as easy to put on and maintain, but workers regarded their protection as less efficient than the other respirators. Workers judged the acceptable duration of wear for cartridge respirators and dust masks as 107 and 152 minutes, respectively.

These results may be considered in setting up a respiratory protection program for autobody shop workers.

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EXPOSURE PROFILE EFFECTS ON QUANTITATIVE FIT-FACTOR ASSESSMENT. D. Dalamagas, Harder Mechanical Contractors, Portland, OR; C. Coffey, Z. Zhuang, NIOSH, Morgantown, WV

The purpose of this study was to correlate quantitative fit-factors to specific exposures by measuring Freon-113 in a wearer's exhaled breath. This was done by determining whether identical exposures, occurring at different times during a 30-minute simulated workplace test (SWPT), would result in different end-exhaled air concentrations (EACs) of Freon-113.

The study consisted of three phases, each with four different subjects. End-exhaled air samples were collected 30 minutes after the SWPT and analyzed by gas chromatography. The first phase consisted of four exposure scenarios: 1) 500 ppm during the first minute of the SWPT; 2) 500 ppm during the last minute of the SWPT; 3) 33 ppm during the first 15 minutes of the SWPT; and 4) 33 ppm during the last 15 minutes of the SWPT.

The second phase consisted of 1) 500 ppm during the first six minutes of the SWPT; and 2) 500 ppm during the last six minutes of the SWPT. The third phase consisted of 1) 500 ppm during the first two minutes, between 15 and 16 minutes, and between 28 and 30 minutes of the SWPT; and 2) continuous exposure of 100 ppm during the entire SWPT.

No significant difference was found between the means for these scenarios except that the means of scenario 2 of phase 1 was higher for two subjects. A significance level of 0.05 was used for all analyses.

It was concluded that exposures of the same magnitude produced the same EACs regardless of when they occurred. Freon-113 EAC can be used to determine the actual level of protection provided by an air-purifying respirator.

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COMPARISON OF SIX RESPIRATOR FIT-TEST METHODS WITH AN ACTUAL MEASUREMENT OF EXPOSURE USING FULL-FACEPIECE RESPIRATORS. C. Coffey, Z. Zhuang, R. Lawrence, P. Jensen, NIOSH, Morgantown, WV

A recent study found that some quantitative fit-test (QNFT) methods may be predictive of actual half-mask respirator performance. The purpose of this study was to determine whether the same degree of predictability could be found using full-facepiece respirators.

Fit-factors from six QNFT methods performed under laboratory conditions were compared with the exposure to 1,1,2 trichloro-1,2,2 trifluoroethane (Freon-113) assessed by exhaled breath analysis. The six QNFT methods were 1) low flow, flush probe corn oil (CLF); 2) high flow, deep probe corn oil (CHD); 3) controlled negative pressure (CNP); 4) ambient aerosol, 10 minutes, six exercises (AA1); 5) ambient aerosol, 30 minutes, 17 exercises (AA2); and 6) high flow, deep probe ambient aerosol (AAHD).

Each method was conducted on a sample of 30 subjects with three replications. Each subject randomly selected 3 of 10 organic vapor/P100 full-facepiece respirators. The exhaled breath of each subject exposed to 500 ppm of Freon-113 was first evaluated at 30 minutes post-exposure. This characterization was then used to estimate the actual exposure to Freon-113 during correlation testing. Fit-factors resulting from the QNFT protocols were then individually correlated with the Freon-113 exposures using the coefficient of determination, R<sup>2</sup>.

Statistically significant correlation between fit-factors and actual exposure doses of Freon-113 was found with some QNFT methods. But the highest R<sup>2</sup> value was only 0.20. The correlations were not as strong as those observed with the half-mask respirators in the previous study.

The results of this study suggest that some QNFT methods can predict actual performance of full-facepiece respirators.

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SUGGESTING THE DIRECTION FOR DEVELOPMENT OF SOME RESPIRATOR FILTERS IN KOREA. D. Han, Inje University, Kimhae, Republic of Korea

Most manufacturers try to produce the most efficient filter for respirators with the lowest breathing resistance. Filter performance depends on the low aerosol penetration (i.e., high efficiency [%] and pressure drop [mmH<sub>2</sub>O]). Performance of mechanical respirator filters depends considerably on the proportion of mixing of raw materials, such as glass fiber, mini fiber, activated carbon fiber, and pulp, which is very important to produce a good quality filter.

This study was performed to suggest the direction for development of some mechanical filters and filtering facepieces that performed well in Korea. Two mechanical filters, S and K (made in Korea) and three filtering facepieces (S made in China, C in Korea, and M in the United States) - all of which are widely used in Korean workplaces - were chosen to be tested for aerosol penetration and pressure drop.

Twenty filters of each were tested with TSI Incorporated's Automated Filter Tester Model 8110A using polydisperse NaCl for types of test particles. Aerosol penetration and pressure drop were measured for four constant airflow rates at 10, 32, 64, and 85 L/min. Mechanical filter S showed that aerosol penetration rates were very low at all airflow

rates compared with Korean standards (<5% at airflow rate 30 L/min), but pressure drops increased dramatically at airflow rates of more than 32 L/min, even though its pressure drop was in compliance with Korean standards 6 mmH<sub>2</sub>O at the 30 L/min airflow rate.

Mechanical filter K showed that penetration rates and pressure drops were higher than those of S, and increased linearly with airflow rates. The results indicated that mechanical filter S should decrease pressure drop without increasing efficiency, but K should decrease pressure drop and increase efficiency simultaneously for better quality. While filtering facepiece M performed well compared with Korea standards, S and C were improved for both efficiency and pressure drop.

## Case Studies 401 Papers 423-432 423

REDUCING TOTAL OWNERSHIP COSTS IN THE UNITED STATES AIR FORCE THROUGH ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH IMPROVEMENTS. J. Garland, K. Grant, T. Joachim, E. England, B. Blazicko, U.S. Air Force, Brooks AFB, TX; L. Pazyra, U.S. Air Force, Randolph AFB, TX

Situation: Cost and risk containment are U.S. Air Force concerns. This case study demonstrates how an activity-based cost study was used to spur environment, safety and occupational health (ESOH) improvements in aircraft corrosion control facilities at Randolph Air Force Base, Texas.

Problems: An activity-based cost study of the six-year strip-and-paint cycle for the T-38 aircraft revealed that 26% of costs associated with this process are driven by ESOH policies and requirements.

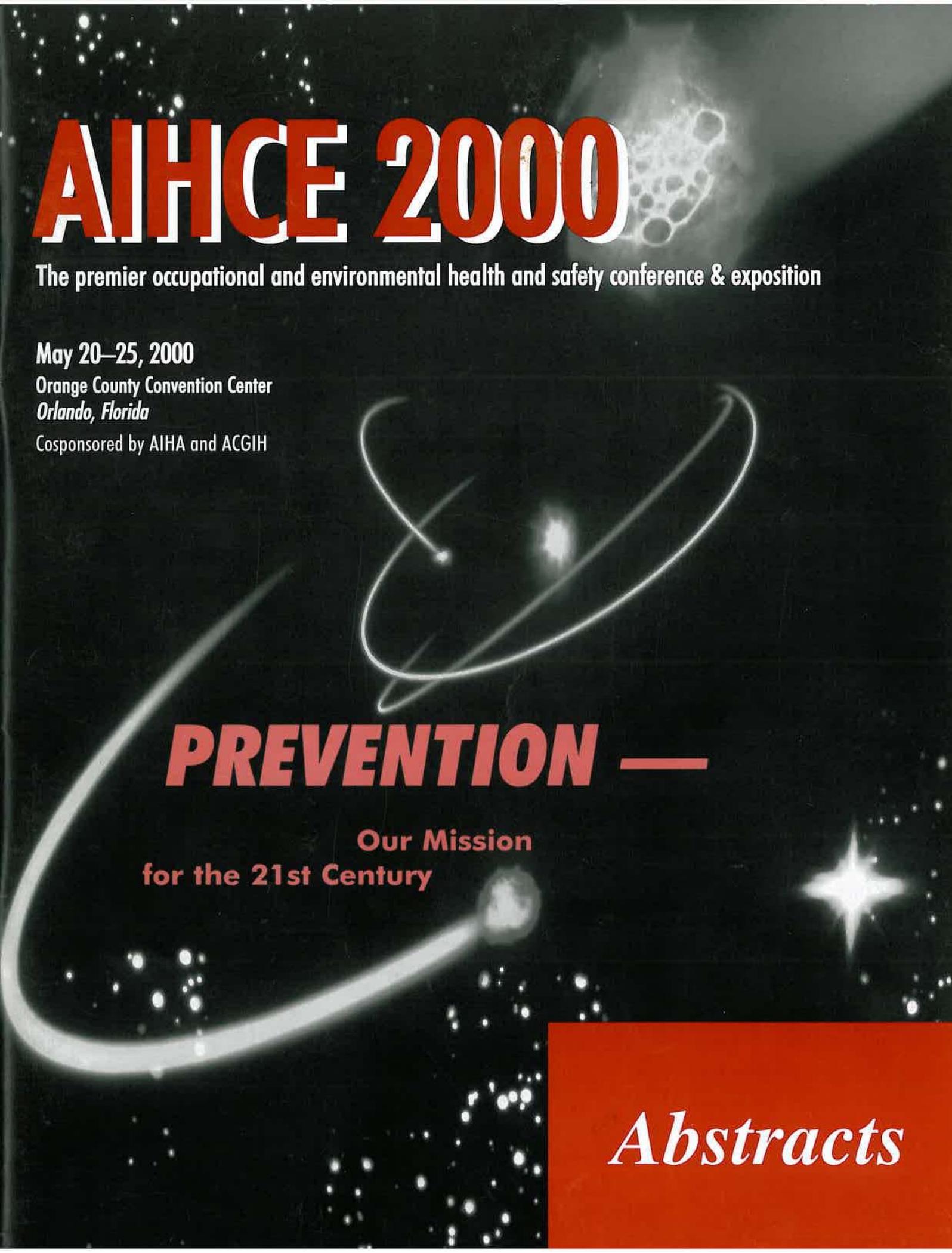
Resolution: ESOH professionals met with process owners and shop workers to brainstorm potential improvements in personal protective equipment use, hazardous waste disposal, noise control, and ergonomics. Fifteen ideas were targeted for further examination. Of these, five were judged to have outstanding potential for reducing costs, eight had possible cost benefits, and two were discarded due to high capital costs or a long payback period.

Proposals with immediate cost-saving potential included 1) improving noise control near air compressors; 2) implementing a shop towel rental contract to eliminate hazardous waste disposal costs; 3) recycling solvents through distillation; 4) providing operators with support stands to reduce fatigue; and 5) substituting high-speed stripping nozzles for conventional blast nozzles.

A recent change in Air Force policy could also allow the shops to switch from supplied-air respirators to powered air-purifying respirators, with significant savings to the respiratory protection program.

How will sharing this work experience benefit other industrial hygiene practitioners? This case study demonstrates how ESOH professionals, working with process owners and shop workers, can increase organizational productivity and reduce costs. Recognition of the benefits of ESOH activities on performance and cost is critical to ensuring that ESOH is fully integrated into organizational planning and capital investment decision-making activities.

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