
Respirator Article Abstracts

We review the articles published in the American Industrial Hygiene Association Journal (AIHJ) and the Applied Occupational and Environmental Hygiene Journal for information that is applicable to the field of respiratory protection, and we publish the abstracts of these articles. We appreciate the cooperation of the American Industrial Hygiene Association and the American Conference of Governmental Hygienists in allowing us to do this.—Ed.

"Collection of Silica and Asbestos Aerosols by Respirators at Steady and Cyclic Flow," L. M. Brosseau, M. J. Ellenbecker, and J. S. Evans, *AIHJ*, August, 51(8): 420–426, 1990.

Air-purifying dust/mist respirators are presently tested using a silica aerosol under conditions of steady flow. In experiments, the predictive value of such tests was evaluated by testing respirators using silica and asbestos aerosols under conditions of both steady and cyclic flow. Silica penetration at steady flow was reasonably predictive of silica penetration under cyclic flow. However, asbestos penetration under cyclic flow was not predicted well by penetration of either silica or asbestos at steady flow. Furthermore, the potential for exhalation valve failure under cyclic flow was identified. Current NOISH protocols for evaluating respirator performance should be reconsidered in light of these findings.

"Thermal Discomfort of Respiratory Protective Devices," A. B. Dubois, Z. F. Harb, and S. H. Fox, *AIHJ*, October, 51(10): 550–554, 1990.

Respiratory protective devices that would protect the wearer against noxious material and gases are not worn in many of the appropriate circumstances. They have been said to feel uncomfortable and hot. In the present study, six men and six women in a 25°C room reported on facial discomfort, thermal sensation, and sweating while wearing three different types of half-facepiece respirators requiring tidal airflow. Skin temperature of the face was measured using a thermocouple taped to the nasolabial fold. The subjects reported that the face felt comfortable when the skin temperature was 34°C or below. However, at skin temperatures above 34.5°C, the face felt increasingly warm, uncomfortable, and sweaty. This finding is similar to that reported previously when subjects wore a half-facepiece respirator supplied continuously with warm, humid air. The conclusion is that thermal conditions of the face contributed to, and may possibly dominate, the discomfort of wearing respiratory protective devices.

"Aerosol Penetration Through Respirator Exhalation Valves," Peter Bellin and William C. Hinds, *AIHJ*, October, 51(10): 555–560, 1990.

Exhalation valves are a critical component of industrial respirators. They are designed to permit minimal inward leakage of air contaminants during inhalation and provide low resistance during exhalation. Under normal conditions, penetration of aerosol through exhalation valves is minimal. The exhalation valve is, however, a vulnerable component of a respirator and under actual working conditions may become dirty or damaged to the point of causing significant leakage. Aerosol penetration was measured for normal

exhalation valves and valves compromised by paint or fine copper wires on the valve seat. Penetration increased with increasing wire diameter. A wire 250 μm in diameter allowed greater than 1% penetration into the mask cavity. Dirt or paint accumulated on the exhalation valve allowed a similar level of penetration. Work rate had little effect on observed penetration. Penetration decreased significantly with increasing aerosol particle size. The amount of material on the valve or valve seat necessary for significant (greater than 0.5%) inward leakage in a **half-mask** respirator could be readily observed by careful inspection of the exhalation valve and its seat in good lighting conditions.

"Development of a Field Method for Evaluating the Service Lives of Organic Vapor Cartridges: Results of Laboratory Testing Using Carbon Tetrachloride—Part II: Humidity Effects," Howard J. Cohen, Edward T. Zellers, and Richard P. Garrison, *AIHJ*, November, 51(11): 575–580, 1990.

Results of further studies on the use of small carbon-filled glass tubes, referred to as respirator carbon tubes (RCTs), for predicting the service lives of organic vapor respirator cartridges, are presented. Organic vapors are drawn through the RCT using a personal sampling pump until breakthrough is detected. This breakthrough time is then used in conjunction with a bed-residence adsorption model to predict the breakthrough time of a cartridge containing carbon identical to that in the RCT. Previous work demonstrated that accurate prediction of cartridge breakthrough time was possible for exposure to carbon tetrachloride in dry air. This report examines the effects of relative humidity (RH) and **prehumidification** of the RCT and cartridge carbon beds on the predictive accuracy of the method. The effect of varying the flow rate through the RCT is also examined. The RCT method predicted cartridge breakthrough times to an accuracy of $\pm 9\%$ at the 95% confidence level for moderate and high humidity conditions and to an accuracy of $\pm 20\%$ for **prehumidified** carbon beds. **Flow rate** had no effect on the performance of the bed-residence model over a range of values corresponding to breathing rates typical of respirator users. Estimates of both the kinetic adsorption rate and kinetic adsorption capacity constants were statistically similar for cartridges and RCTs under all test conditions. A linear relationship was found between RH and the inverse of the relative breakthrough time normalized to 50% RH, consistent with results reported by the other researchers.

"Variability in Protection Afforded by Half-Mask Respirators Against Styrene Exposure in the Field," Kit Galvin, Steve Selvin, and Robert C. Spear, *AIHJ*, December, 51(12): 625–631, 1990.

Concentrations of **styrene** were measured in the breathing zone and inside the facepiece of air-purifying half-mask respirators of 13 workers for three to six 1-hour periods while they were engaged in the production of fiberglass-reinforced products. These data were used to estimate the protection afforded by the respirators. In arriving at these estimates, it was necessary to correct the concentration measured inside the mask for pulmonary retention of styrene by the workers. Workers were classified as sprayers or as other production line workers not directly carrying out spraying operations. An analysis of variance showed no evidence of differences in the level of protection afforded by the respirators between the two job classes. A **second** analysis of variance showed that protection varied between workers as well as for a single worker during different wearing periods. The geometric standard deviation (GSD) between workers was 1.92, the common **within-worker** GSD was 2.93, and the total GSD was 3.51. One-half of a population of wearers with similar protection would be expected to experience long-term average workplace protection factors in excess of 44 and one-half below that value. The observation of **between-worker** and within-worker variability in protection indicates that both sources of variability have to be taken into account in the specification of maximum use concentrations.

"Filter and Leak Penetration Characteristics of a Dust and Mist Filtering Facepiece," C. C. Chen, J. Ruuskanen, W. Pilacinski, and K. Willeke, *AIHJ*, December, 51(12): 632–635, 1990.

The filtering facepiece, also referred to as a disposable respirator, is an extensively used type of respirator without an officially accepted fit-testing method. This study describes an aerosol generator and a sampling train, that have been developed for investigating the aerosol penetration characteristics through the filter element and the face seal. Electrostatic attraction and impaction are the two primary filtration mechanisms for micrometer- and supermicrometer-sized aerosols, respectively. Filtration and flow dynamics were found to affect aerosol penetration in distinct ways that allow for the differentiation of the face seal leakage from the filter penetration. The slope of the aerosol size-dependent penetration curve potentially may differentiate the face seal leakage from filter penetration.

"Development of a Field Method for Evaluating the Service Lives of Organic Vapor Cartridges—Part III: Results of Laboratory Testing Using Binary Organic Vapor Mixtures," Howard J. Cohen, Dale E. Briggs, and Richard P. Garrison, *AIHJ*, January, 52(1): 34–43, 1991.

Results of a third study on the use of small, carbon-filled glass tubes, referred to as respirator carbon tubes (RCTs), for predicting the service lives of organic-vapor respirator cartridges are presented. Previous work demonstrated that accurate prediction of cartridge breakthrough time was possible for exposure to carbon tetrachloride in atmospheres containing 5–94% relative humidity (RH) with both "as-received" and prehumidified carbon beds. This report examines the effects of binary organic vapor mixtures and intermittent testing on the predictive accuracy of the method. Results of this study demonstrated the RCT method predicted cartridge breakthrough times to an accuracy of $\pm 17\%$ at the 95% confidence level for n-hexane, pyridine, and binary mixtures of each with carbon tetrachloride in an approximately 50% RH environment. Estimated kinetic adsorption capacities for each adsorbate-carbon bed system tested were reduced when a second adsorbate was introduced at the same concentration. There was no evidence that n-hexane, carbon tetrachloride, or their mixtures exhibited migration through cartridges when exposed to a regime of testing to 50% of the breakthrough time, followed by a resting cycle of four days, and then a resumption of testing to breakthrough. However, a small, statistically insignificant reduction in breakthrough time was observed when cartridges were tested intermittently with pyridine. Results suggest that simple treatment of mixtures based on data from single-component testing may predict incorrect breakthrough times and support the need for a field method to estimate cartridge service lives.

"A Theoretical Interpretation of the Service Life of Respirator Cartridges for the Binary Acetone/m-Xylene System," Young Hee Yoon, James H. Nelson, Jaime Lara, Cherif Kamel, and Daniel Fregeau, *AIHJ*, February, 52(2): 65–74, 1991.

A theoretical model introduced previously describes the adsorption of individual organic compounds on activated carbon. This model was modified to investigate binary assault systems composed of two different compounds. The breakthrough characteristics of binary systems are different from those of single-component systems. The study reported here addresses the development of a theoretical model for binary systems and the application of the model to a specific binary system—acetone and m-xylene. For binary mixtures of acetone and m-xylene, the breakthrough curves of m-xylene are similar to those observed for corresponding single-component m-xylene systems. The breakthrough properties of acetone in the presence

of **m-xylene** are, however, considerably **different** from those observed for acetone alone. This difference is attributed to the displacement of adsorbed acetone molecules by the more strongly adsorbed m-xylene. A theoretical expression was derived that defines the breakthrough curve for acetone in the presence of **m-xylene**. This expression applies for varying assault concentrations of both acetone and m-xylene in the binary **system**. Values of required theoretical parameters were determined. The values of the parameters were used to calculate breakthrough curves for acetone in the binary **acetone/m-xylene** system. These curve were compared with corresponding experimental data at several different assault concentrations (acetone: 100 to 1000 ppm; m-xylene: 100 to 1000 ppm). For each binary system, the total concentration of acetone and m-xylene added together was 1000 ppm. For the **acetone/m-xylene** binary system, one must consider the breakthrough time of acetone to estimate the service life of a cartridge simultaneously exposed to both vapors.

"A Comparison of Respirator Fit Factors Determined by Portable Condensation Nuclei Counting and Forward Light-Scattering Photometric Methods," John C. Rose, Riedar K. Oostenstad, and **Vernon E. Rose**, *Applied Occupational and Environmental Hygiene*, November, 5(11): **792–797**, 1990.

The purpose of this study was to compare fit factors determined by a recognized photometer quantitative fit test system (Model 264, **Dynatech-Frontier** Corp.) and a portable condensation nuclei counter respirator fit test instrument (**Portacount**, **TSI**, Inc.). The study was performed by conducting sequential fit tests with the two methods on human subjects wearing the same respirator at the same fitting. The fit factors obtained by the two methods were compared by several statistical tests. The results of these analyses indicated that there was good agreement in determining **pass/fail** at a critical fit factor. It was further concluded that fit factors for groups of wearers measured by the condensation nuclei counter instrument are comparable to those obtained by the photometer method.