
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.

"Development of a Field Method for Determining the Service Lives of Respirator Cartridges—Part IV: Result of Field Validation Trails," Howard J. Cohen, Steven P. Levine, and Richard P. Garrison, *AIHJ*, July, 52:263–267, 1991.

Results of a fourth 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. Organic vapors are drawn through the RCT by 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 laboratory 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 dry and prehumidified carbon beds and with n-hexane, pyridine, and binary mixtures of each with carbon tetrachloride. This report examines the performance of the RCT method in a workplace environment where carbon tetrachloride concentrations varied from 101 to 855 ppm, pyridine levels varied from 0 to 29 ppm, temperatures ranged from 28 to 39° C, and RH varied from 19 to 49%. The RCT method predicted cartridge breakthrough times to an accuracy of $\pm 8\%$ at a 95% confidence level, which equaled or exceeded results of previously reported laboratory studies. Actual breakthrough time averaged within $\pm 5\%$ of times predicted with previous laboratory data. A plot of bed-residence time versus breakthrough time yielded a coefficient of determination of 0.71 when ambient concentrations were standardized.

"Simplified Pressure Method for Respirator Fit Testing," D. Han, M. Xu, S. Foo, W. Pilacinski, and K. Willeke, *AIHJ*, August, 52:305–308, 1991.

A simplified pressure method has been developed for fit testing air-purifying respirators. In this method, the air-purifying cartridges are replaced by a pressure-sensing attachment and a valve. While wearers hold their breath, a small pump extracts air from the respirator cavity until a steady-state pressure is reached in 1 to 2 seconds. The flow rate through the face seal leak is a unique function of this pressure, which is determined once for all respirators, regardless of the respirators' cavity volume or deformation because of pliability. The contaminant concentration inside the respirator depends on the degree of dilution by the flow through the cartridges. The cartridge flow varies among different brands and is measured once for each brand. The ratio of cartridge to leak flow is a measure of fit. This flow ratio has been measured on human subjects and has been compared to fit factors determined on the same subjects by means of photometric and particle count tests. The aerosol tests gave higher values of fit.

"Physiologic and Subjective Effects of Respirator Mask Type," Philip Harber, John Beck, Carol Brown, and John Luo, *AIHJ*, September, 52:357-361, 1991.

The effect of alternate airflow path designs on full-face mask air-purifying respirators was assessed in 14 health volunteers during submaximal exercise. Respirator designs included no respirator (N), full-face mask, dual-cartridge with no nasal deflector (FN), full-face mask respirator with nasal deflector (FD), and a powered air-purifying respirator (PA). Physiologic effects were measured by using respiratory inductive plethysmography and subjective responses by two visual analog scales. There were significant effects of airflow path design upon the physiologic parameters of ventilation, tidal volume, and mean flow rate. There were no significant physiologic or subjective differences between the full-face mask respirators with and without the nasal deflector in place. The PA had less physiologic impact than the nonpowered models but did not show significant subjective benefit. The study suggests that both subjective and objective physiologic responses must be utilized in assessing respirator design.

"Comparisons of Air and Liquid Personal Cooling for Intermittent Heavy Work in Moderate Temperatures," Philip A. Bishop, Sarah A. Nunneley, and Stefan H. Constable, *AIHJ*, September, 52:393-397, 1991.

Personal microenvironmental cooling has been used to enhance safety and extend the work capacity of laborers wearing protective clothing. Previous studies of air and liquid cooling have used either very low work rates or high environmental temperatures. Emergency work tasks frequently require high work rates and occur in moderate ambient temperatures. The purpose of this research was to examine the efficacy of intermittent personal cooling during rest and to compare liquid and air cooling systems in subjects engaged in hard work. Fourteen volunteers wearing chemical protective clothing performed treadmill walking at a metabolic rate of 430 W for 45 minutes followed by a 15 minute rest at a wet-bulb globe temperature of 25°C. During rest, volunteers received either no cooling, air cooling, or liquid cooling. Both cooling systems partially alleviated heat strain and increased work time with the air system offering slightly more effective cooling.

"A Prototype Active End-of-Service-Life Indicator for Respirator Cartridges," G. J. Maclay, C. Yue, M. W. Findlay, and Joseph R. Stetter, *Applied Occupational and Environmental Hygiene Journal*, August, 6:677-682, 1991

Respirator cartridges are used to allow workers to remain in an environment that contains gases that would be harmful to breathe. One of the problems users face is determining when the cartridge service life has ended. Air-purifying respirators for use with vapors are certified by the National Institute for Occupational Safety and Health (NIOSH). When the cartridge is no longer reducing the toxic gas concentration below the minimum permissible level, a "warning" may take the form of an odor; an irritation to the eyes, nose, or throat; or perhaps dizziness.

From the viewpoint of a user, the most desirable cartridge should have an indicator that actively and unambiguously notifies the operator when the cartridge's useful service life is almost ended. In 1984, NIOSH published standards for certification of Active-End-of-Service-Life Indicators (AESLI) to encourage the development of AESLI systems. AESLI should provide advance warning to the user that the cartridge is 90% expended. To this date, development efforts have not been extensive, and no AESLI has been certified in an air-purifying respirator.

This article presents a prototype AESLI designed to be used with organic vapors. The prototype device consists of a sensor that is to be located within the bed of the cartridge and is electrically connected to a signal-processing module located on the facemask. The small, low-power module causes an LED alarm to flash when the gas concentration reaches a preset threshold value. The LED is mounted on the mask,

directly in front of the user, and is clearly visible when flashing; however, it does not obstruct vision. Locating the sensor within the filter protects the sensor from species in the ambient air that do not pass directly through the cartridge bed during use, thus reducing the demand for sensor selectivity and protecting the sensor from exposure to the breath of the user.

The active element is a **chemiresistor**, a device whose resistance changes with the concentration of the toxic species. Important features of the sensor are 1) a generic response to many of the contaminants that the cartridge is designed to remove, and 2) room-temperature operation, which results in a very low power consumption and safe operation even in a flammable or explosive atmosphere. The sensors were tested for response to cyclohexane in air mixtures (100–4000 ppm). Further, initial tests of the sensors in a compensating bridge circuit suggest that the effects of changing relative humidity and temperature may be minimized.

"A Comparison of Fit Provided by Natural and Silicone Rubber Facepieces of the Same Brand of Half-Mask Respirator," Riedar K. Oestenstad and Angela M. Zwissler, *Applied Occupational and Environmental Hygiene Journal*, September, 6:785–789, 1991

The fit provided by natural and silicone rubber facepieces of the same brand and size of half-mask respirators were compared by performing multiple fit tests in random order with both facepieces on 45 subjects. The tests consisted of a six-exercise protocol while measuring the penetration of ambient room aerosols with a condensation nuclei counter fit-test device. Fit factors obtained by the two facepieces were compared by **nonparametric** statistical methods because fit factors for the silicone rubber facepiece were not log-normally distributed. The fit factors for the silicone rubber facepiece were found to be significantly greater than those of the natural rubber facepiece. Although the difference was statistically significant, it was not of the same magnitude as reported in previous studies. It was noted that the maximum and minimum fit factors obtained with the natural rubber facepiece were higher than those for the silicone rubber facepiece. The variability of fit factors for the silicone rubber facepiece was also found to be higher than that of the natural rubber facepiece. This would affect the calculation of fit factor lower tolerance limits and should be considered in estimating the lowest likely fit provided by a respirator for an individual or a group of wearers.