

Respirators were modified to include a mid-line sampling probe between the nose and mouth for quantitative fit-testing with a TSI7 PortaCount7. A second modification included the introduction of a shortened 14-gauge intravenous catheter at the bridge of the nose. The fixed leak was designed to produce fit factors <100 when unplugged, with an average fit factor of 67 among 26 respirator wearers. A complete fit-test was not performed, since one purpose of this study was to determine the ability of respirator wearers to detect a known fixed leak during a single normal breathing exercise, without introducing unknown and potentially variable size leaks. Sensitivity threshold screening included a placebo and requirement to correctly characterize the taste of the agent used. This step was introduced after a separate field study of emergency room personnel provided unreliable responses to sensitivity threshold screening with saccharin.

Quantitative fit factors without leaks ranged from 96 to >20,000 and 22 to 160 with the leak present. Twenty-four of 26 subjects had fit factors <100 (92%) when fixed leaks were induced. All subjects correctly detected Bitrex with fixed leaks (sensitivity = 100%). Nine of 26 subjects (35%) were unable to detect saccharin in the presence of a known fixed leak even though the average fit factor for these subjects was 77. When the two subjects with fit factors >100 were excluded, saccharin only identified 16 of 24 respirators with known leaks (sensitivity = 67%).

There were several important aspects of our study design worth noting, including the introduction of a placebo during sensitivity threshold test, limiting the subject response time to a single maneuver, using a higher concentration of Bitrex than reportedly used by others, and requiring the subjects to characterize the taste of the qualitative test agent. In conclusion, leak detection was correctly identified with Bitrex, but not saccharin.

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FIELD PERFORMANCE MEASUREMENTS OF HALF-FACEPIECE RESPIRATORS CORRELATION BETWEEN WORKPLACE PROTECTION FACTORS AND FIT FACTORS. Z. Zhuang, C. Coffey, NIOSH, Morgantown, WV; W. Myers, West Virginia University, Morgantown, WV

Current standards, regulations, and recommendations regarding the selection and use of respirators require that individual users be fit-tested as part of the selection process. However, no correlation between workplace protection factors (WPFs) and quantitative fit factors (FFs) has been previously reported. A series of field studies was conducted to collect ambient and in-facepiece samples on workers in foundry, aircraft-painting, and steel-manufacturing operations to evaluate the protection provided by negative-pressure, half-facepiece respirators. Protection was assessed by WPFs (i.e., the ratio of ambient concentration C_o to in-facepiece concentration, C_i and reported previously. As a part of these studies, quantitative fit-tests were performed on workers wearing elastomeric respirators. A worker could wear a respirator only if he or she met the fit-test pass/fail criteria (FF=100) with that particular respirator. A systematic correlation analysis of C_o , C_i , WPF, and FF data was conducted to identify any correlations and evidence supporting the standards

and regulations. The log-transformed WPF data and C_i data were strongly correlated in all three operations (P-values are <0.01 and R^2 values = 0.42, 0.54, and 0.55). The log-transformed WPF data and C_o data were significantly correlated in two operations (R^2 = 0.11 and 0.28). The log-transformed C_i data and C_o data were significantly correlated in two operations (R^2 = 0.24 and 0.26). No significant correlation was found between WPF and FF when all data were analyzed and fit factors (overall fit factor and fit factors for each exercise) were the only independent variables. However, significant correlations between WPF and FF were found in some facility-respirator combinations (R^2 ranged from 0.18 to 0.82). Both positive and negative correlation coefficients were found. It is concluded that WPFs were correlated with FFs when fit factors, facility, and respirator were independent variables.

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A NEW METHOD FOR FIT-TESTING RESPIRATORS USING SIZE SELECTED AEROSOL. T.G. Halvorsen, TSI, Inc., Shoreview, MN

A new method has been developed for quantitative fit-testing N95 respirators using the particle counting method. This technique avoids the problem of counting particles that penetrate the respirator media and mix with particles coming from face-seal leaks. By limiting the particle counts to a size spectrum where the filter media is inherently very efficient, this method results in a more accurate measure of fit factor. Two aerosol samples, ambient and mask, first pass through a differential mobility classifier before being counted by a CPC. The classifier is set to operate at 0.04 microns, a size where even the least efficient of the N95 respirators are greater than 99.5% efficient. The quantitative fit factor calculation now becomes a comparison of 0.040 micron aerosols.

A sample of N95 respirators were quantitatively fit-tested under no-leak conditions. Simultaneous fit-tests were conducted using both classified and unclassified aerosol. Very efficient N95 respirators showed less discrepancy in the two methods, with classified aerosol producing fit factors in excess of 7000, and unclassified aerosol yielding fit factors around 2500. Less efficient N95 respirators had the same classified fit factor of 7000, with an unclassified fit factor of approximately 150. Controlled leakage studies across a range of fit factors produced a 1:1 correlation between the two methods. The particle classification method resulted in more variability, however, due to lower counts. At an ambient concentration of 8000 pt/cc, the classified concentration was approximately 250 pt/cc, and had a standard deviation three times that of the unclassified. The classification method clearly avoids the unfair bias from filter penetrating particles. Statistical limitations suggest the method should be limited to fit factors not to exceed 200.

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PRELIMINARY DEVELOPMENT AND TESTING OF A PERSONAL SAMPLING SYSTEM FOR MEASURING RESPIRATOR WORKPLACE PROTECTION FACTORS FOR GASES AND VAPORS. W.A. Groves, C. Conrad, S. Reynolds, University of Iowa, Iowa City, IA

A sampling system for measuring respirator

workplace protection factors for gases and vapors was investigated. Methods for measuring the concentration of contamination inside respirators have previously been described; however, these studies have typically involved continuous sampling of aerosols. Our work focuses on the development of an intermittent sampling system designed to measure the concentration of gases and vapors inside the respirator during inspiration. This approach addresses two potential problems associated with continuous sampling: biased results due to lower contaminant concentrations in exhaled air, and high humidity. The system consists of a pressure transducer circuit designed to activate a pair of sampling pumps during inspiration based on differential pressure measured inside the respirator. The circuit assembly measures approximately 2.5 x 2.75 x 1.75 inches, weighs less than 6 oz., and draws 20 mA of current, yielding more than 8 hours operation from a 9 volt-battery. Two Sipin7 model SP-1 personal sampling pumps were modified to allow the transducer circuit to turn the pumps on and off. One pump draws air from inside the respirator while the second samples outside air. Sample volumes are determined using the pump stroke-counter. Solid granular adsorbent tubes are used to trap the contaminant making the approach applicable to a large number of gases and vapors. Preliminary testing was performed using a respirator mounted on a head form that was connected to a breathing machine producing a sinusoidal flow pattern with a peak flow rate of 25 L/min and a period of 3 seconds. The sampling system was adjusted to activate the pumps when the pressure inside the respirator was less than 0.1 inch H_2O . Results showed that the system quickly and consistently activated the sampling pumps during inspiration, thus demonstrating the feasibility of using this personal sampling system to measure workplace protection factors.

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PROBABILITY OF OVEREXPOSURE AND ADEQUACY OF THE ASSIGNED PROTECTION FACTOR FOR HALF-FACEPIECE RESPIRATORS. Z. Zhuang, NIOSH, Morgantown, WV; W. Myers, West Virginia University, Morgantown, WV

A number of field studies have been conducted over the last 10-13 years to evaluate the worker protection provided by negative pressure, half-facepiece respirators. Protection was assessed by workplace protection factors (WPF). The appropriateness of the assigned protection factor (APF) for negative pressure half-mask respirators has generally been evaluated based on the fifth percentile estimate of a WPF distribution. No evaluation has been based on the comparison of in-facepiece concentration and an exposure standard. A new approach based on probability of overexposure was developed to use the combined WPF data published in peer-reviewed journals to evaluate the appropriateness of the APF for half-facepiece respirators. The new approach first utilized a graphical representation of WPF data and hazard ratios (ambient concentration divided by permissible exposure limit). The adequacy of the APF was then evaluated from binomial statistics based on the number of successes (no overexposure) and failures (overexposure). In the studies reviewed, the probability of over-

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