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DETERMINATION OF KNOWN EXHALATION VALVE DAMAGE USING NEGATIVE PRESSURE USER SEAL-CHECK METHODS ON FULL-FACE RESPIRATORS. L. Delaney, NIOSH, Cincinnati, OH; R. McKay, University of Cincinnati, Department of Environmental Health, Occupational Medicine, Cincinnati, OH

Employees wearing respirators in industrial settings rely on users' positive- and negative-pressure seal checks to assess respirator fit. However, few studies have been performed to determine the adequacy of user seal checks in detecting poor-fitting or damaged respirators.

In this study, the negative-pressure user seal check (NPUSC) method was evaluated for its ability to adequately detect known exhalation valve damage. The damage included a warped valve, a valve with three slits, and a valve with a small amount of glue. Twenty-six test subjects, wearing full-facepiece respirators, were asked to perform a NPUSC. Their responses as to whether they passed or failed the NPUSC were compared with fit-testing results from two quantitative fit-test methods. In addition, in-mask pressure differentials were measured during the performance of NPUSCs using equipment developed in the UC respirator laboratory.

This method was developed as a more reliable technique to assess the ability of respirator wearers to properly conduct user seal checks. The data were analyzed to determine whether the NPUSC procedure is an effective method for detecting known exhalation valve damage.

All test subjects reported passing the NPUSC with the undamaged valve. With the respirator equipped with the warped valve, 95% of test subjects reported passing NPUSCs. With the respirator equipped with the valve with adhesive, 65% reported passing.

All fit factors were below the OSHA recognized pass/fail criteria, except one test with the respirator equipped with the slit valve. Results from the in-mask pressure measurements confirmed that 98% of all user seal checks were properly conducted. It was unable, however, to detect respirator leakage. In conclusion, NPUSC performed by the user rarely identified damaged exhalation valves.

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WORK PERFORMANCE WHEN BREATHING THROUGH VARIOUS RESPIRATOR EXHALATION RESISTANCES. D. Caretti, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD; A. Johnson, W. Scott, University of Maryland, College Park, MD

Recent research efforts that have optimized experimental designs to elicit respiratory stress have shown that respirator inspiratory resistance has a profound effect on performance. The performance–resistance relationship established by these studies indicate that a best value inspiratory resistance design goal does not exist. To what extent the findings for the inspiratory performance–resistance relationship apply to respirator expiratory resistance is unknown.

For this reason, a study was conducted to assess performance of individuals exercising at a fixed workload and wearing a full-facepiece respirator modified to provide different expiratory airflow resistances. Fifteen volunteers exercised to a voluntary end-point on a treadmill at fixed speeds and grades chosen to elicit 85% of maximal aerobic capacity for an unencumbered condition on six separate occasions. Test conditions consisted of a U.S. Army M40 respirator modified to yield expiratory resistances of 0.27, 0.47, 1.81, 4.43, 12.27, and 27.35 cm H2O sec/L at a constant airflow of 1.42 L/sec.

Subject heart rates, oxygen consumption, ratings of perceived exertion (RPE), and breathing apparatus comfort (BAC) were recorded throughout each test session. Exercise performance time was recorded at the cessation of each test. Exercise termination RPE and BAC values did not differ between resistance conditions, indicating that subjects exerted the same amount of effort for each condition and experienced similar levels of respirator comfort.

Results also showed that average performance times generally decreased linearly with expiratory resistance. Average performance times differed significantly between the 0.47 and 27.35 cm H2O sec/L resistance conditions (21.4+/-10.1 vs. 7.2+/-5.0 minutes, respectively). A threshold value below which expiratory resistance had no effect on performance time was not found.

These results suggest that, as for inspiratory resistance, there is no best value for expiratory resistance to be used as a respirator design goal.

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USE OF THE AIRFLOW PERTURBATION DEVICE TO MONITOR RESPIRATORY RESISTANCE OF WORKERS REQUIRED TO WEAR RESPIRATORS. A. Johnson, University of Maryland, College Park, MD

The airflow perturbation device (APD) is a new means to monitor resistance to airflow in the respiratory system. The APD determines resistance by superimposing a periodic signal onto spontaneous breathing with a variable resistance device. The APD is handheld, inexpensive, noninvasive, lightweight, and requires no particular breathing maneuvers. It also directly measures respiratory resistance without confounding with additional variables such as muscle strength.

Such a device should have advantages over traditional pulmonary function measures normally used in clinics on workers required to wear respirators. Tests of the APD have shown that the instrument is sensitive to changes in resistance, gives consistent results, and can detect added resistance. The APD can prove useful for annual monitoring of worker health, detection of respiratory abnormalities, and as a real-time aid for allergy detection using bronchochallenge.

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ASSIGNED PROTECTION FACTORS OF SINGLE-USE DUST MASKS UNDER SIMULATED WORK CONDITIONS — PART II: METHODS AND RESULTS. B. Samimi, R. Welch, J. Muni, San Diego State University, San Diego, CA

A robotic system has been used for quantitative evaluation of respirators, including single-use filtering facepiece respirators commonly known as "dust masks." In view of the historical fact of widespread use of dust masks for protection against nuisance as well as toxic dusts, we found it appropriate to re-examine the conditional protection factors (PF) recently assigned by NIOSH to respirators in this category using our robotic mannequin system and breathing machine.

We applied a combination of test conditions (i.e., breathing minute volumes and cycles of 24 L/16 bpm vs. 36 L/24 bpm, head and body motion vs. static under high [50–60 mg/m^3] dust concentrations). The AFRD test dust (55% respirable) and Wright Dust Generator were used to create the desired dust concentrations within the chamber. Real-time dust concentrations were continuously monitored inside and outside the test respirators by means of two MIE DATA RAM along with the negative pressure within the respirator using the Setra Systems pressure transducer.

Data were monitored and stored using the Lab View Data Acquisition System. Eleven models of single-use respirators (Gerson: 1730 and 2737; Moldex: 2200 and 2207; 3M: 8500, 8210, and 8710; MSA Affinity Plus; Wilson Dalloz Saf-T-Fit; and AO: N9500C and N9501C) and two models of elastomeric respirators (MSA Comfo and Wilson Dalloz both with P100 HEPA cartridge) were tested in the study.

Three test runs, each for a period of 90 minutes, were conducted on each of the three respirators purchased from each model (N = 9). The results were analyzed by Two-Way ANOVA and Quantile Test as well as graphically and visually by photography.

For single-use respirators, the mean PF for all testing modes were: 5.368, 3.466, 3.832, 5.200, 2.096, 4.804, and 7.284, 4.731, 2.800, 3.267, and 2.300 in the order of brands and models stated above. MSA Comfo and Wilson Dalloz elastomeric respirators showed mean PFs of 80.300 and 14.580, respectively.

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THE EFFICACY OF FOUR FIT-TEST METHODS WITH N95 FILTERING-FACEPIECE RESPIRATORS. C. Coffey, Z. Zhuang, R. Lawrence, D. Campbell, NIOSH, Morgantown, WV

The OSHA regulations on respirators (29 CFR 1910.134) allow respirator wearers to use four fit-test methods to screen out poorly fitting N95 filtering-facepiece respirators: 1) the Bitrex™ (Denatonium benzoate) solution aerosol qualitative fit test; 2) the Portacount Test Instrument with the N95-Companion™ accessory (Companion); 3) the Portacount Test Instrument without the N95-Companion™ accessory (PortaCount); and 4) the generated aerosol quantitative fit-test.

In this study, the results of these four tests were compared with total penetration factors, an indicator of whether a respirator provided an adequate facepiece fit to its wearer using the PortaCount Plus™. Total penetration, as defined in this study, comprises face-seal leakage and filter penetration. A respirator was determined to provide adequate protection if the 95th percentile of the total penetration calculated from six tests was less than or equal to 10 percent, which is equivalent to a protection factor greater than 10 - the level of protection often expected for a half-mask respirator.

A panel of 25 subjects with varying face sizes tested 10 models of N95 half-mask filtering-facepiece respirators. The order in which the tests were performed was randomized. Redonning occurred between the tests. Four statistics: sensitivity, predictive value of a pass, specificity, and predictive value of a failure were computed. The sensitivity values ranged from 0.87 to 0.98, the predictive value of a pass from 0.86 to 0.95, the specificity from 0.22 to 0.44, and the predictive value of a failure from 0.33 to 0.43.

The best screening test was the corn oil, with 2% of the subjects receiving a false adequate conclusion, followed by the PortaCount (3%), the Companion (13%), and the Bitrex (13%). The Companion and Bitrex methods might not adequately screen out poorly fitting respirators.

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