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Performance Comparison of Breathing and Metabolic Simulators

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ABSTRACT

A study was undertaken to compare the performance of the various types of breathing and metabolic simulators (BMSs) in current use by government agencies and breathing apparatus manufacturers around the world. BMSs are used for quantitative testing of closed-circuit breathing apparatus (CCBA). Different methods of achieving simulation of breathing and metabolism are used by the various BMSs. There have been no studies comparing the performance of apparatus tested by BMSs of different designs. In order to do so, two standardized CCBA were tested on the various BMSs at the same work load in the laboratories of the participating companies or agencies. The two major types of CCBA – compressed-oxygen and chemical-oxygen – were represented in this study by the CSE/Faser AU-9A1, a refillable compressed-oxygen apparatus, and the Dräger OXYBOKS K, a chemical-oxygen apparatus, a batch of which were made in a single production run by Dräger for this study. A metabolic work load able to be reproduced by all the BMSs was used. Identical breathing apparatus tested at the same work load on each BMS enabled side-by-side comparison of the BMSs.

The most notable differences between the simulators included in this study are 1) the lower average inhaled CO_2 concentrations measured by the simulators having uni-directional versus bi-directional internal flow paths; and 2) the lower DB inhalation temperatures measured on chemical-oxygen apparatus by the simulators having large water reservoirs. Users will experience higher average inhaled CO_2 concentrations and higher DB inhalation temperatures than predicted by testing on BMSs of the above-mentioned respective BMS designs.

Keywords: closed-circuit breathing apparatus (CCBA), breathing and metabolic simulators, compressed-oxygen and chemical-oxygen, PPE, CO_2 concentrations

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Investigation of Potential Affecting Factors on Performance of N95 Respirator

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ABSTRACT

With the exponential growth of the nano-technological products and their potential impact on the workers' health and safety, the N95 filtering face-piece respirators (FFRs) are commonly recommended to protect them from the exposure to nano-particles in workplaces. This paper reports the outcomes of a series of experiments carried out to characterize the performance of NIOSH approved N95 filtering face-piece respirators against particles in nano-range: poly-dispersed and mono-dispersed sodium chloride (NaCl) particles were used in this study. In the first experimental set-up, a methodology was developed to test a N95 respirator model, sealed on a manikin head, against 15 to 200 nm poly-dispersed NaCl aerosols as function of flow rate (85, 135, 270 and 360 liters/min), loading time (up to 5 hours), and relative humidity (RH) (10, 30 and 70%). In the second phase, the experimental set-up was adapted to test N95 respirators against mono-dispersed particles (at twelve particle sizes) with a size range between 20 to 200 nm at a constant flow rate of 85 liters/min.

The results from the poly-dispersed aerosol test (PAT) method indicated that the inhalation flow rate had a strong impact on the initial particle penetration; the maximum penetration level through the N95 respirator dramatically exceeded the 5% NIOSH certification criterion at flow rates higher than 85 liters/min. The particle penetrations at the Most Penetrating Particle Size (MPPS), occurring between 30 to 50 nm, were respectively 6.6, 11.7 and 15.3% for the airflow rate of 135, 270 and 360 liters/min. The outcomes of the effect of particle loading on the filter performance showed that, the particle penetration decreased through the N95 respirator for particle sizes below 100 nm. Also, with the increase of the (RH) level, lower filtration performance was also observed at nano-sized particles.

The mono-dispersed aerosol test (MAT) method was performed at 85 liters/min constant flow rate; the initial particle penetration at the MPPS was below 5% NIOSH certification criterion. Moreover, the initial particle penetration value, measured with (MAT) method was higher than the one measured with (PAT) method at each corresponding particle size.

Keywords: N95 respirator; nano-particle; filter; penetration; exposure

ISRP members can read the full paper in the members-only section.

Improved Prediction of Minute Volume Flow Rates

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ABSTRACT

The ability to predict respiratory minute volumes while wearing respirators can be important to the design, specification, testing, and use of respirators. Starting with minute volume data and equations previously appearing in the paper by Caretti and Coyne (2006), a power transformation was made to improve the linearity of the fit. The resulting transformed data improved the agreement between measured and predicted values of minute volumes. The equation is:

$$V_E = (0.00366\ W - 0.392\ R_{in} + 0.173\ m - 7.586)^{1.382}$$

where V_E is minute volume in L/min, W is specific work rate in Watts/m^2, R_{in} is inhalation resistance in cm H_20•sec/L, and m is body mass in kg.

Using this equation, values of minute volumes may be predicted for 95% of the population of data points by multiplying by 1.5. Peak flows can also be calculated based upon these minute volumes.

Keywords: minute volumes, peak flows, prediction equations, respirator masks

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Impact of Three Cycles of Decontamination Treatments on Filtering Facepiece Respirator Fit

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ABSTRACT

Decontamination and reuse of N95 filtering facepiece respirators (FFRs) may be a strategy for mitigating a supply shortage during an influenza pandemic. The objective was to determine if multiple decontamination treatments affect respirator fit. Quantitative fit tests were performed on three different surgical N95 FFR models before and after multiple applications of ultraviolet germicidal irradiation (UVGI), moist heat incubation (MHI), or microwave-generated steam (MGS). Ten test subjects initially qualified for each FFR model by passing (fit factor (FF) ≥ 100) a standard OSHA-accepted quantitative fit test. Fit was then evaluated over multiple consecutive donnings using an abbreviated fit test protocol: first on an untreated FFR and then on the same sample following one, two, and three decontaminations. FFRs were visually examined for physical degradation following each decontamination cycle. MGS and MHI treatments caused one FFR model to experience a slight separation of the inner foam nose cushion. MGS caused a melted headstrap in one FFR sample. UVGI did not cause any physical degradation. Fit test passing rate ranged from 90% to 100% for the four donnings and varied by respirator model/decontamination method combination. Mean faceseal leakage (FSL) for each donning for all FFR models was < 1 % (i.e., corresponding to FF > 100). Tests were non-significant ($p > 0.05$) comparing the mean FSL of each of the four donning trials for all FFR model / decontamination method combinations. Three applications of the decontamination methods studied did not cause significant changes in respirator fit. Further research is needed before specific recommendations employing these methods can be made.

Keywords: filtering facepiece respirator, fit test, healthcare workers, N95, decontamination, N95 fit, pandemic influenza, respirator reuse

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