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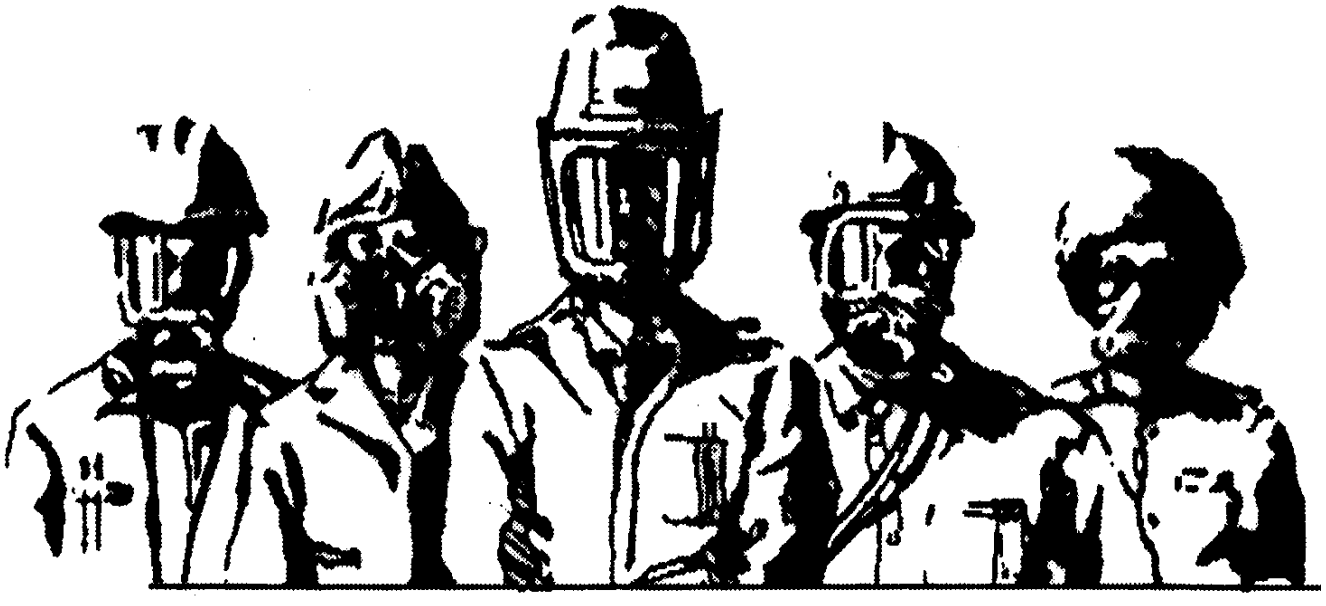

Effects of Respirator Inhalation Resistance on Low-to-Moderate Intensity Task Performance

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ABSTRACT

This study assessed physical and subjective performance decrements resulting from wearing air-purifying respirators with different levels of inhalation breathing resistances during wear trials of low-to-moderate intensity activities. Twenty-four volunteers completed 4 trials of No Mask and full-facepiece air-purifying respirator (APR) wear involving 3 inhalation resistance (P_{IN}) conditions (1.23 ± 0.16 cm H_2O, 2.61 ± 0.05 cm H_2O, and 4.29 ± 0.43 cm H_2O measured at 85 $L \cdot min^{-1}$ flow rate). Test sessions comprised 3 hr of continuous APR wear while performing both fine and gross motor physical tasks for various durations; both objective measures of performance and subjective feedback of user comfort were obtained throughout testing. No significant differences were observed among P_{IN} conditions for any of the dependent variables assessed for the hand-tool dexterity task. No interactive effects between P_{IN} and task loads used for the gross motor physical activities were found, but box lift rates decreased linearly as P_{IN} increased for each load task. Independent of task load, a significant linear decrease in lift rate performance rating was found with increased P_{IN} ($R^2 = 0.96$; $p < 0.01$). Physiological and subjective responses indicated that neither the P_{IN} nor the physical tasks invoked significant amounts of physiological stress from the test participants. These findings suggest use of respirators with inhalation resistances equal to or less than those used in this investigation will not significantly impact performance of fine or gross motor activities of low to moderate intensities.

Keywords: APR, respirator, inhalation resistance, physiology, performance

Penetration of N95 Filtering-facepiece Respirators by Charged and Charge-Neutralized Nanoparticles

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ABSTRACT

Aerosol-based quantitative respirator fit testing relies on the assumption that all particles detected inside the mask arrived there through a face seal leak. When less efficient media is used, this assumption may no longer be valid since a significant number of particles may penetrate the filter media. To address this issue, TSI developed an accessory for the PortaCount called the Model 8095 N95-Companion™, which uses electrostatic principles to select a specific size range of particles that are far from the most penetrating particle size (MPPS). The narrow size range selected by the N95-Companion is centered nominally at 55 nm. Recent studies indicate that the MPPS for commercially available N95 filters is now between 40-60 nm and particle penetrations can exceed 5%. This caused concerns to be raised that the N95-Companion method is not valid for N95 filtering facepiece respirators that use charged fibers. To further quantify the amount of aerosol that penetrates through the N95 filter media and its effect on the fit factor, TSI conducted a study to measure the fractional penetration efficiencies of several commercially available N95 filtering-facepiece respirators using charge-neutralized, positively charged, and negatively charged monodisperse aerosols.

Six different models of NIOSH-certified N95 filtering-facepiece respirators from five different manufacturers were used in this study. Each respirator was mounted on a manikin head and sealed using a silicone sealant applied to the edges to prevent face seal leakage. The manikin was then placed in the center of a 47x24x28 inch test chamber. Charge-neutralized, negatively charged, and positively charged monodisperse aerosols (40, 50, 65, 80, and 100 nm) were introduced into the chamber one at a time. The aerosol concentrations inside and outside the respirators were measured with a TSI 3772 Condensation Particle Counter (CPC). The fractional penetration efficiency of the respirator was calculated as the ratio of Cmask and Cchallenge: [1 - (Cmask/Cchallenge)]x100. Percent penetration = 100xCmask/Cchallenge. The penetrations of positively charged and negatively charged aerosols were very similar to each other for all respirators, and were much lower than the penetration of charge neutralized particles. Using charged aerosol (N95-Companion method), all respirators showed penetrations below approximately 0.25% indicating a maximum (with zero face seal leakage) fit factor of 400.

This study showed that the N95-Companion method is a valid method for performing quantitative fit testing on any respirator using NIOSH series-95 or similar filter media.

Keywords: Fit Test, N95 Respirator, Nanoparticles, PortaCount, N95 Companion

Physical Fabrication and Verification of New NIOSH Digital Headform Designs with Skin-analog for Use in Fit Testing

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ABSTRACT

In order to ensure adequate respiratory protection for the US workforce, NIOSH has developed a new fit test panel and corresponding headform designs. These headform designs, combine three-dimensional data collected during the large anthropometric survey conducted to construct the new panel. Between the novelty of these new headform designs and the high cost of prototyping them, little testing has been performed to evaluate commercially available respirator facepieces. This study aims to develop silicone-skinned prototypes of the new NIOSH headforms for use in respirator fit testing. The silicone skin is used to better replicate the interaction between the respirator facepiece and the human face. The only complete set of headform prototypes were lent from Texas Tech to make molds. These molds were used for casting the prototypes tested in this study using methods adapted from the special effects industry. These test casts of the molds were then verified for anthropometric accuracy against the original NIOSH digital models and Texas Tech prototypes. After the mold dimensions were verified, silicone-skinned prototypes were constructed for use in controlled negative pressure fit testing. Commonly used, commercially available respirators will then be fit tested on the generated prototypes. Preliminary fit testing results indicate that facepieces tested do not adequately fit the headform prototypes developed in this study. Further evaluation is needed to determine if this indicates poorly fitting respirators, an issue with the prototyping methods used, or the design of the headforms themselves.

Keywords: respiratory protection, new NIOSH fit panel, respirator testing, ppe testing, facial anthropometry, respirator, fit testing

Use of Speech Transmission Index (STI) for Voice Intelligibility Testing of Respiratory Protection Devices and Proposed Measurement Method

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ABSTRACT

Voice intelligibility of respiratory protection devices is a key metric of communication effectiveness. The Modified Rhyme Test is the current standard for measuring this key metric; the method is known to be cumbersome, time consuming, and subjective. The study being described evaluates the Speech Transmission Index method for use in measuring voice intelligibility of respiratory protection. The Speech Transmission Index is used in multiple industries to determine intelligibility and has been standardized by the International Electrotechnical Commission. In contrast to the Modified Rhyme Test, it is an objective test with a significantly reduced setup and test time. The study uses the Speech Transmission Index method developed by the National Fire Protection Agency for their 1981:2013 standard. Using three of Scott Safety's AV3000 facepieces, 313 data points were generated. The test operator and equipment remained the same throughout the testing. The operator was familiar with both Speech Transmission Index and donning respiratory protection facepieces. The repeatability and reproducibility of the National Fire Protection Agency method was evaluated by comparing the measurements gathered within and between test runs. It was found that within each test run an average of 70% of the measurements were equivalent with respect to the test system error. Between test runs it found that 90% of the sample populations were equivalent with respect to the test system error. Thus the method was found to be a robust way of objectively assessing voice intelligibility of the facepieces tested. However, it was noted that the National Fire Protection Agency method only assessed intelligibility directly in front of the user. To address practical usage scenarios a method is proposed using the Speech Transmission Index to assess voice intelligibility in 360 degrees around the user.

Keywords: Voice Intelligibility, Speech Transmission Index, Modified Rhyme Test