

Particle Penetration into Filtering Facepiece Particulate Respirators: Quantification of Primary Pathways and Novel Design Approaches

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The aerosol particle penetration into a filtering facepiece particulate respirator (FFPR) occurs through the filter medium and faceseal leaks. In this study, the contributions of the two penetration pathways were differentiated under actual breathing conditions. Conventional N95 FFPRs were tested on 25 subjects using an OSHA fit testing protocol, which was modified to measure aerosol concentrations inside and outside the respirator particle size selectively with an ELPI (Dekati Ltd., Tampere, Finland). In addition, the subject's breathing pattern was recorded for each fit test exercise using a Breathing Recording and Simulation System (Koken Ltd., Tokyo, Japan) and reproduced with the respirator sealed to a manikin. The overall penetration through the filter medium and the leak was obtained from the subject-based tests; the filter penetration was obtained from the manikin-based tests. The number of particles penetrating through the FFPR's faceseal leakage exceeded the filter penetration (on average, approx. 10-fold), which indicates that the former was the primary penetration pathway. The findings suggest that the priority in improving respirator design should be shifted toward reducing the faceseal leakage through introducing a better contact between the respirator periphery and the wearer's face. To address this, a novel strapless FFPR with a medical-grade adhesive was developed by Wein Products Inc. (Los Angeles, USA). We conducted a follow-up performance evaluation study with human subjects and found that all subjects passed fit testing with fit factors ranging from 241 to 7088 (median = 3370), which is significantly greater than levels we typically observe for conventional FFPRs.