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Total Inward Leakage of Nanoparticles Through Filtering Facepiece Respirators

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Nanoparticle (<100 nm size) exposure in workplaces is a major concern because of the potential impact on human health. Human exposure to particulates is primarily reduced by implementing engineering and administrative controls. When these measures are insufficient or not installed, respiratory protection is required to reduce inhalation of particulates to acceptable levels. When respiratory protection is required, NIOSH-approved particulate respirators are recommended. Data is available on the filtration performance of NIOSH approved particulate respirators against a wide range of particles, including nanoparticles as small as 3 nm, but little information is available related to face seal leakage of nanoparticles. In this study, we hypothesized that total inward leakage for nanoparticles would be similar to leakage from larger particles. Filter penetration and total inward leakage through artificial leaks were measured for N95, and other filtering facepiece respirator classifications sealed to a breathing manikin kept inside a closed chamber. Polydisperse NaCl or monodisperse sucrose (8-80 nm size) aerosols were passed into the chamber. Filter penetration and total inward leakage were measured at 20, 30 and 40 l/min breathing flow rates. As expected, filter penetration for 50 and 100 nm size particles were markedly higher than the penetrations for 400 nm size particles and increased with increasing flow rates. With artificial leaks (at the smallest leak sizes only), the total inward leakage measured for 50 and 100 nm size particles was <2-fold higher than the value for 400 nm size particles. In general, the total inward leakage values for 50, 100 and 400 nm size particles increased with increasing leak sizes. The total inward leakage/penetration ratio consistently increased with increasing particle size at the three different flow rates and leak sizes indicating that face seal leakage for nanoparticles (<100 nm size) is less than the levels for 400 nm size particles. Further studies on face seal leakage of nanoparticles for respirator users in workplaces are needed to better understand the respiratory protection against nanoparticle exposure.