Nanoparticle penetration through filter media and through face seal leakage of N95 filtering facepiece respirators

Samy Rengasamy[1] and Benjamin C. Eimer[2]

[1]Policy and Standard Development Branch, National Personal Protective Technology Laboratory, National Institute for Occupational Safety and Health, Pittsburgh PA USA
[2]URS Corp., Pittsburgh PA USA

Background: NIOSH-approved particulate respirators are recommended for protection against nanoparticles (<100 nm size). Protection afforded by a filtering facepiece particulate respirator (FFR) is a function of the filter efficiency and the leakage through the face-to-facepiece seal. However, the interaction between particle penetration through filter media and particle leakage through face seal in the total inward leakage (TIL) is not well studied.

Methods: Filter penetration at sealed conditions and TIL with artificially introduced leaks were measured using a manikin test system. Filter penetration and TIL were measured using 20–800 nm NaCl particles at 8 to 40 L breathing minute volumes for four N95 FFR models.

Results: The most penetrating particle size (MPPS) was ~45 nm for all four respirator models. Filter penetration for ~45 nm size particles were significantly ($p<0.05$) higher than the values for 400 nm size particles. With increasing leak sizes and breathing minute volumes, the TIL values for 45 nm size particles increased and were higher than the TIL values for 400 nm size particles. This suggested that face seal leakage allows the test aerosols, regardless of particle size, inside the FFR, while filter penetration determines the TIL for different size particles. Higher efficiency N95 models showed lower TIL values than the models with higher filter penetrations at smaller leak sizes indicating the dependence of TIL values on filter penetration. When the electrostatic charge was removed, the N95 FFRs showed a shift in the MPPS to ~150 nm with the same test aerosols (mode size, ~75 nm) at different hole sizes and breathing minute volumes, confirming the interaction between filter penetration and face seal leakage processes.

Conclusions: The results suggest that among the different size particles that enter inside the N95 respirators, relatively high concentration of the MPPS particles in the breathing zone of respirators can be expected in nanoparticle workplaces. Overall, the data obtained in the study suggest that good fitting respirators with lower filter penetration values would allow fewer nanoparticles inside the filtering facepiece respirators.