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Numerical studies on the performance of an aerosol respirator with faceseal leakage

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Abstract

© Published under licence by IOP Publishing Ltd.We studied the efficiency of a facepiece filtering respirator (FFR) in presence of a measurable faceseal leakage using the previously developed model of a spherical sampler with porous layer. In our earlier study, the model was validated for a specific filter permeability value. In this follow-up study, we investigated the effect of permeability on the overall respirator performance accounting for the faceseal leakage. The Total Inward Leakage (TIL) was calculated as a function of the leakage-to-filter surface ratio and the particle diameter. A good correlation was found between the theoretical and experimental TIL values. The TIL value was shown to increase and the effect of particle size on TIL to decrease as the leakage-to- filter surface ratio grows. The model confirmed that within the most penetrating particle size range (~50 nm) and at relatively low leakage-to-filter surface ratios, an FFR performs better (TIL is lower) when the filter has a lower permeability which should be anticipated as long as the flow through the filter represents the dominant particle penetration pathway. An increase in leak size causes the TIL to rise; furthermore, under certain leakage-to-filter surface ratios, TIL for ultrafine particles becomes essentially independent on the filter properties due to a greater contribution of the aerosol flow through the faceseal leakage. In contrast to the ultrafine fraction, the larger particles (e.g., 800 nm) entering a typical high- or medium-quality respirator filter are almost fully collected by the filter medium regardless of its permeability; at the same time, the fraction penetrated through the leakage appears to be permeability- dependent: higher permeability generally results in a lower pressure drop through the filter which increases the air flow through the filter at the expense of the leakage flow. The latter reduces the leakage effect thus improving the overall respiratory protection level. The findings of this study provide valuable information for developing new respirators with a predictable actual workplace protection factor.

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