Particle Penetration and Breathing Resistance Evaluation of Uncertified Dust Masks

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Background

Recently, Uncertified Dust Masks (UDMs) are being advertised as a potential alternative to NIOSH-certified filtering face-piece respirators (FFR) for use in agricultural settings.

Few studies have been conducted to determine particle penetration and breathing resistance (BR) of UDMs.

However, new technologies and designs of UDMs have been developed and their properties are not well known.

Studying UDMs to identify their properties is essential to determine the feasibility of UDMs as a way to reduce worker exposure to dust in agricultural settings.

Objective

Determine the effects of particle size on the particle penetration of uncertified dust masks (UDMs)

Evaluate the increase in breathing resistance (BR) with particle loading over time in an attempt to compare BR between UDMs and FFRs.

Methods

Five models of commercially available UDMs were selected for this study.

- UDMs were from different manufacturers

UDMs were sealed on a manikin face with rope caulk and tested inside a 55-L chamber.

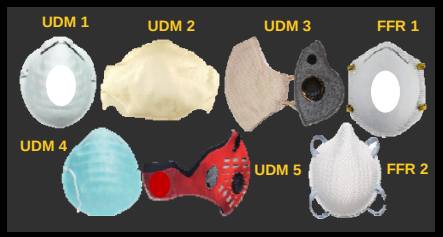
A scanning mobility particle sizer (SMPS) was used to measure the particle size distribution during a penetration test.

- Particle penetration test was performed following NIOSH protocol described in 42 CFR 84.181 except the UDMs were not preconditioned.
- A 2% NaCl charge-neutralized aerosol was used to challenge particle penetration.
- Particle size distribution was measured within the range of 10 – 700 nm.

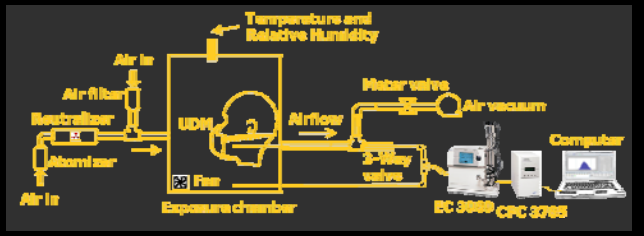
A second test was performed with Arizona road dust (ARD) as the challenge aerosol to evaluate the BR of new UDMs and FFRs.

- BR test was evaluated at 55 L min^{-1} air flow for 2 hours.
- BR ($P-P_0$) versus mass loading (W) was plotted for all UDMs and FFRs.
- Scanning electron microscopy (SEM) micrographs were taken to show the top layer of each filter loaded with dust

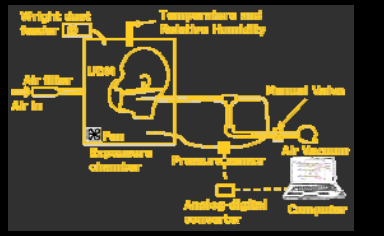
Experimental Setup



Images of tested UDMs and FFRs

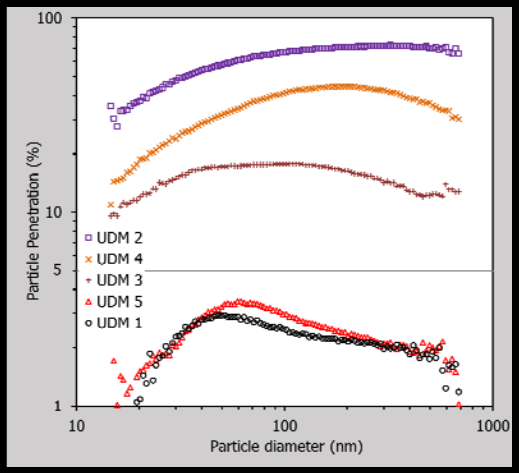


Schematic of particle penetration test.

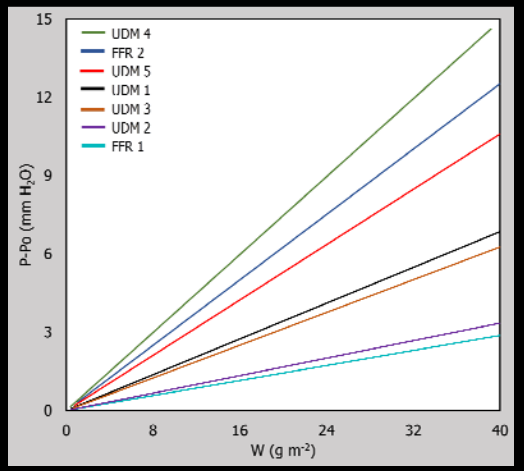


Schematic of BR test.

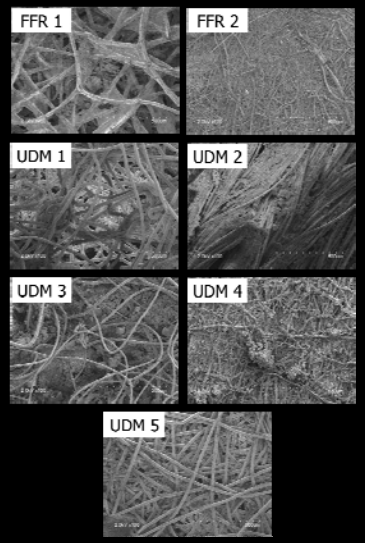
Results



NaCl aerosol penetration was significantly different at the MPPS among tested UDMs ($p < 0.001$).



Variation in the BR slopes for UDMs and FFRs with loading with ARD ($p < 0.001$).



SEM images of UDMs and FFRs top layer loaded with ARD.

Conclusions

A very wide range of particle penetrations was observed among the UDMs tested in this study (3 – 75% at the most penetrating particle size).

There was a significant difference between the slopes of the positive linear relationships developed between BR and mass loading for the UDMs and FFRs.

Despite using the same challenge dust, different BR vs W slopes were obtained. It is assumed that the different structures of the top layer may influence particle deposition and affect BR differently between the tested models.

Future Research

Evaluate face-seal leakage among the tested UDMs to better asses the particle penetration.

Evaluate other respiratory protection devices to observe how rapidly the BR increases.

Acknowledgements

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