

The Effect of Simulated Air Conditions on N95 Respirator Performance

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Background

- Respirators are recognized personal protective equipment (PPE) used by workers to provide protection against airborne particulates.
- Many studies have assessed the effect of constant airflow and particle size on the efficiency of respirators.
- Few studies have been conducted to determine whether air humidity affects respirator performance under constant flow.
- Recent studies have been using cyclic flow to evaluate respirators performance.

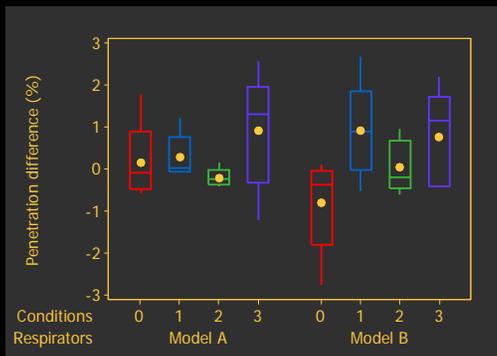
Objective

Determine the effect of different simulated air conditions on the resistance to flow and the efficiency of N95 Filtering Face-piece Respirators (FFRs).

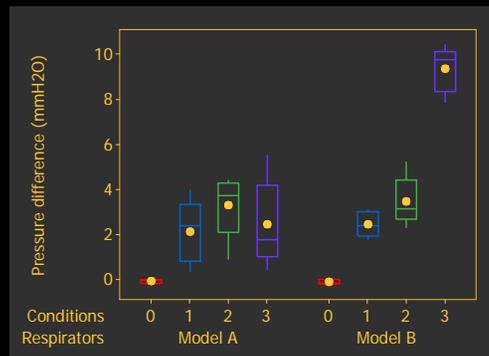
Methods

- Two models of NIOSH-approved N95 respirators were evaluated on particle penetration and resistance to flow.
- Respirators were from different manufacturers and were referred to as Model A and Model B
- A 55 L chamber was constructed to evaluate the respirator.
- A scanning mobility particle sizer (SMPS) was used to measure particle size penetration.
- A 2% Sodium Chloride charge neutralized aerosol was used to challenge particle penetration through the respirator.
- Penetration was tested before and after a 2-hr resistance to flow test at the most penetrating particle size (MPPS).
- Resistance to flow test was performed under cyclic flow and four simulated air conditions as shown in Table 1.
- Resistance to flow was measured every 30 minutes with a pressure sensor as shown in Figure 1.
- A minute volume of 55 L min⁻¹ was chosen to represent inhalation and exhalation under heavy work.
- An indoor air quality monitor was utilized to measure temperature and relative humidity inside the chamber.
- A second round of tests included the addition of inorganic dust to determine the effect of mass loading on resistance to flow.

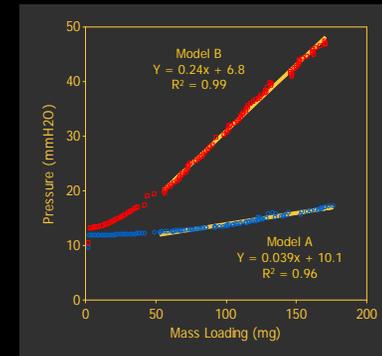
Results



The effect of penetration difference at MPPS was not significantly different in Model A and Model B ($p=0.853$).



The effect of resistance to flow was significantly different in Model A and Model B ($p<0.001$).



For every unit increase in mass loading, the pressure level will on average increase by 0.04 mm H2O for Model A and 0.24 mm H2O for Model B.

Experimental Setup

Table 1: Simulated conditions for resistance to flow test

Conditions	Inhalation		Exhalation	
	T (°F)	RH (%)	T (°F)	RH (%)
0	70	40	70	40
1	70	40	98	95
2	50	90	98	95
3	50	100	98	95

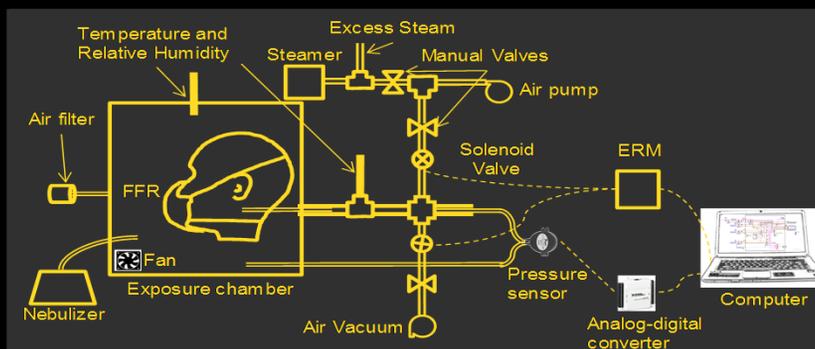


Figure 1: Schematic of resistance to flow test

Conclusions

- Results show that simulated air conditions that involve high humidity in air increase resistance to flow of a N95 respirator.
- There is a difference in the slope of the positive linear relationship between resistance to flow and mass loading for the two models of N95 respirator.
- No difference was observed in particle penetration in both N95 respirator models.
- Development of new FFR design should consider FFR performance under high humidity conditions.

Future Research

- Evaluate FFR's resistance to flow in a work setting with high humidity conditions.
- Incorporate air pollution control theory to estimate the resistance to flow of a N95 respirator.
- Evaluate other respiratory protection devices to observe how rapidly the resistance to flow increases.

Acknowledgements

This research was supported (in part) by a pilot project research training grant from the Heartland Center for Occupational Health and Safety at the University of Iowa. The Heartland Center is supported by Training Grant No. T42OH008491 from the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health.

Slide 1

BJL3 effects not affects

Butler-Dawson, Jaime L,
4/15/2014

BJL6 have you defined "mass loading". Not sure what that is

Butler-Dawson, Jaime L,
4/15/2014

BJL12 not sure what this is?

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