Assessment of Faceseal Leakage in a Half-mask Respirator Used by Firefighters

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Objective

- To evaluate the fitting characteristics of an elastomeric half-mask respirator worn by a 25-subject panel being fit-tested while exposed to a NaCl-based surrogate of the combustion aerosol.

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Introduction

- Studies have shown that firefighters as well as first responders are heavily exposed to smoke particles during fire suppression and other activities (*NIOSH, 2007*).
- Ultrafine particles (<100 nm) accounted for more than 70% of particle numbers during fire knockdown and overhaul (*Baxter et al., 2010*).
- During fire overhaul, firefighters use elastomeric half-mask or filtering facepiece respirators or no respirators at all (*Bolstad-Johnson et al., 2000; Burgess et al., 2001*). Elastomeric respirators are also used in non-firefighting activities.

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Introduction (cont'd)

- Respiratory protection offered by negative pressure respirators significantly depends on the faceseal fit (*Grinshpun et al., 2009; Cho et al., 2010*).
- According to the U.S. OSHA, every worker required to wear a tight fitting respirator such as the elastomeric half-mask, which shall be fit tested prior to initial use of the respirator (OSHA 2006).
- Respirator fit-testing studies have usually been conducted under normal skin conditions (dry and clean-shaved). Thus, there are less data on respirator performance using other challenge conditions such as wet and/or unshaved skin.

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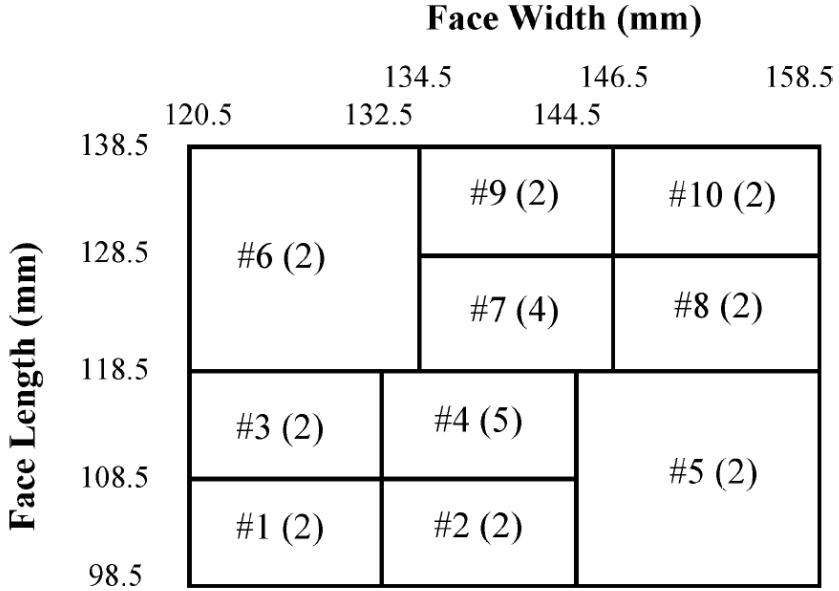
Methods

Respirators

An elastomeric half-mask

- equipped with P100 filters

The NIOSH bivariate 25-subject panel



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Methods

OSHA respiratory fit testing exercises:

1) normal breathing
2) deep breathing
3) turning head side to side
4) moving head up and down
5) talking
6) grimace
7) bending over
8) returning to normal breathing.

$$FF_i = \frac{C_{out}}{C_{in}}$$

i = 1, 2, 3, etc.

$$FF_{overall} = \frac{7}{\frac{1}{FF_1} + \frac{1}{FF_2} + \frac{1}{FF_3} + \frac{1}{FF_4} + \frac{1}{FF_5} + \frac{1}{FF_7} + \frac{1}{FF_8}}$$

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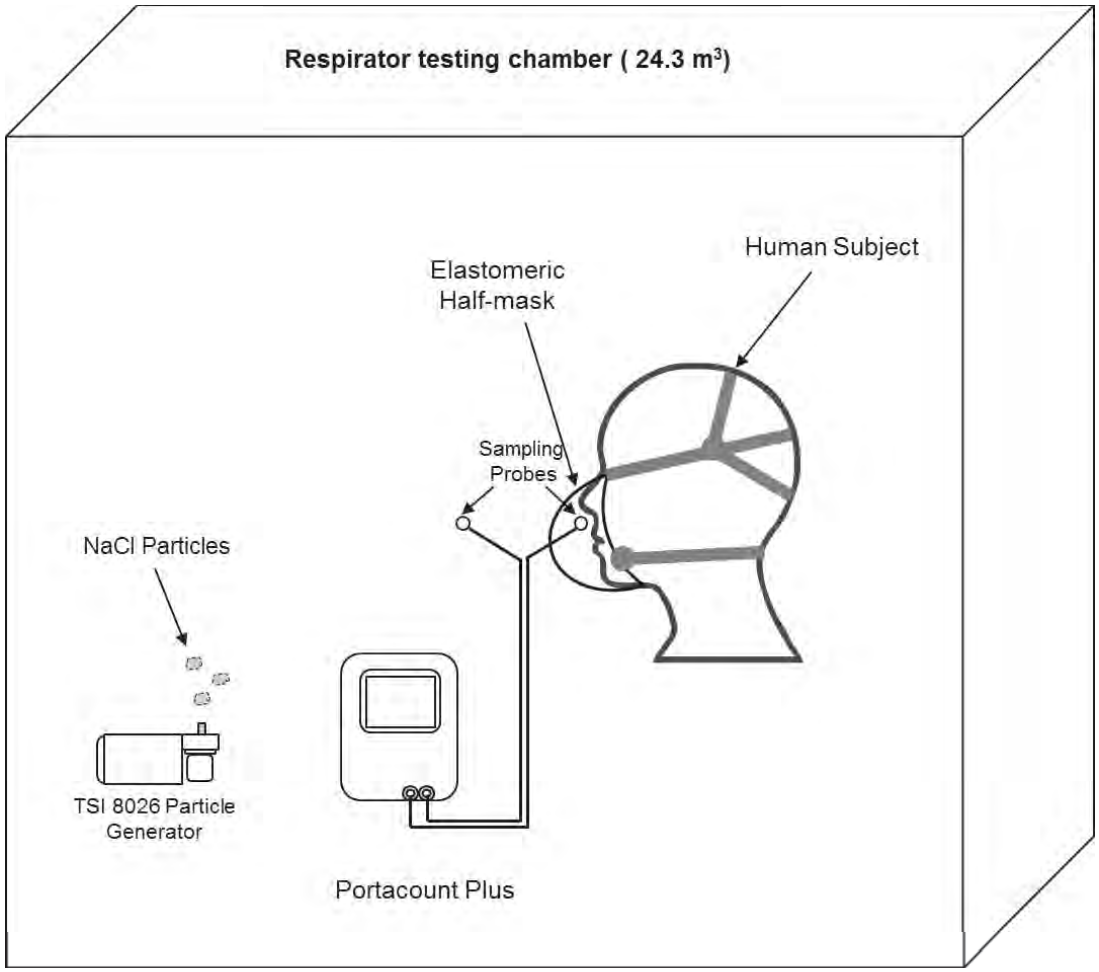
Methods



- The respirator was fit tested on a NIOSH bivariate (face length and width) 25-subject panel using the standard OSHA fit testing protocol.
- One of these 25 subjects then participated in a pilot study designed to investigate the fitting characteristics of the respirator with less than ideal facial conditions.

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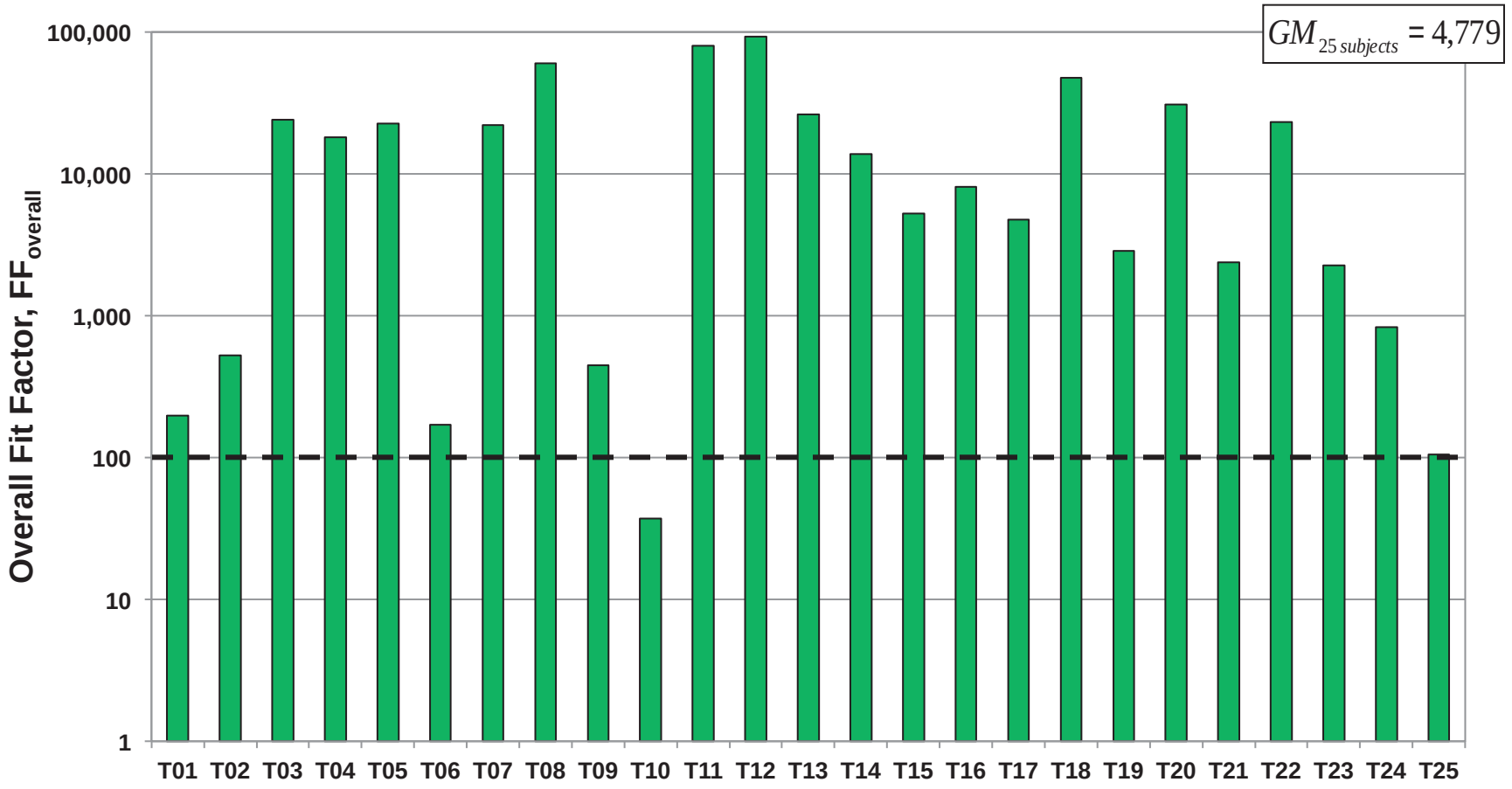
Results



25 subjects, dry-shaved facial condition.

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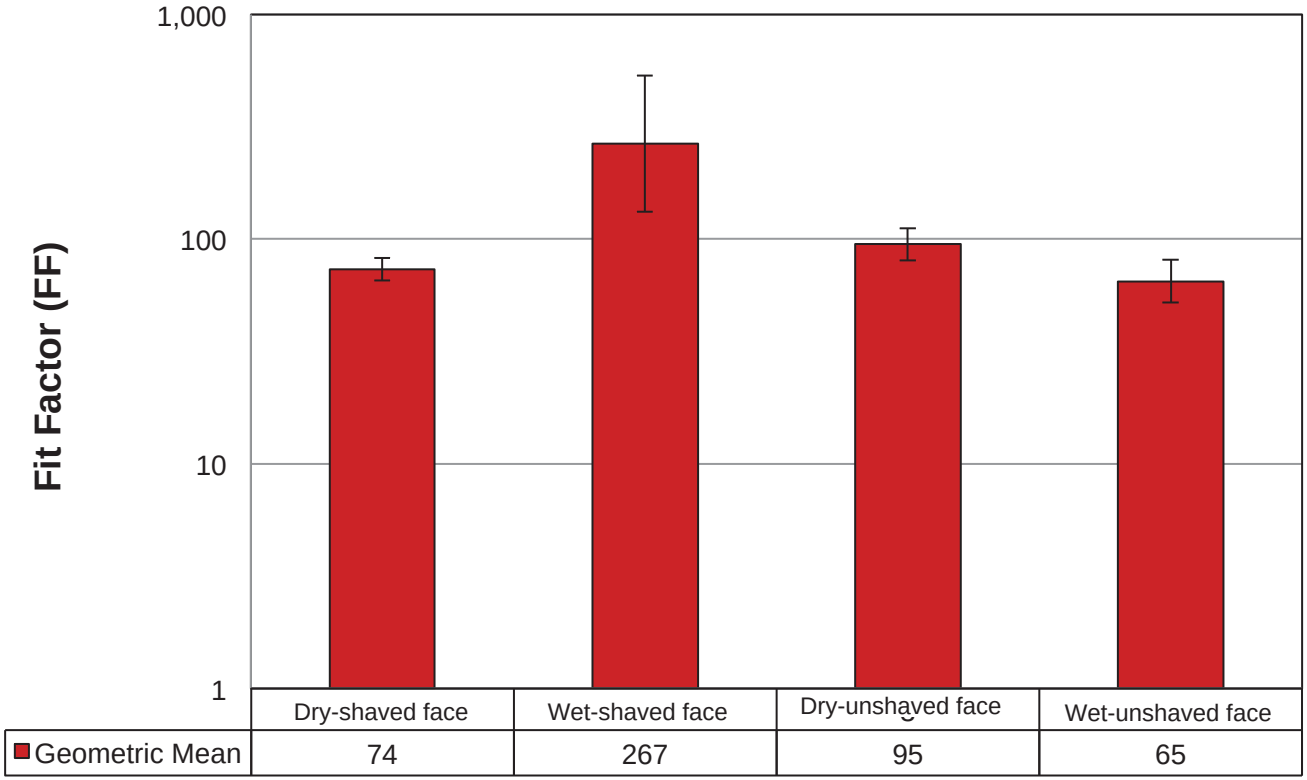
Results



1 subjects, challenge facial conditions.

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Conclusions

- The respirator produced a geometric mean fit factor of 4,779 (GSD = 9.1).
- Among the challenge conditions, wet-shaved face was associated with higher fit factor (GM = 267) than dry-shaved face (GM = 74).
- No significant difference was found between other challenge conditions.
- Future studies are needed to include more subjects with various face dimensions along with different shaving and wetting/sweating conditions.

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Future Directions

- The workplace protection factor (WPF) set-up will be developed and used for testing the elastomeric respirators during field studies when firefighters perform training activities as well as the actual firefighting (the fire overhaul phase).

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Outcomes

Peer-reviewed Publications

He X, Grinshpun SA, Reponen T, McKay RT, Bergman MS, and Zhuang Z: Effect of Breathing Frequency and Flow Rate on the Total Inward Leakage of an Elastomeric Half-Mask Donned on an Advanced Manikin Headform. *Annals of Occupational Hygiene.* Accepted. 2013

He X, Reponen T, McKay RT, and Grinshpun SA: Effect of Particle Size on the Performance of an N95 Filtering Facepiece Respirator and a Surgical Mask at Various Breathing Conditions. *Aerosol Science & Technology*. Accepted. 2013

He X, Reponen T, McKay RT, and Grinshpun SA: How does breathing frequency affect the performance offered by an N95 filtering facepiece respirator and a surgical mask against surrogates of viral particles? *Journal of Occupational and Environmental Hygiene.* Accepted. 2013

He X, Grinshpun SA, Reponen T, McKay RT, Lu J, and Soroushian P: Performance Characteristics of an Elastomeric Half-mask Respirator Modified with a Polymer Micro-Patterned Adhesive. *Journal of the International Society for Respiratory Protection.* Submitted. 2013

Conference Proceedings

He, X., Grinshpun, S.A., Reponen, T. “Effects of Breathing Frequency on the Performance of an Elastomeric Half-mask Against Combustion Aerosols Using an Advanced Manikin Headform”, Student Poster #35. American Industrial Hygiene Conference & Exposition (AIHce), Montréal, Canada, 18-23 May, 2013, (awarded “Best Student Poster”)

He, X., Grinshpun, S.A., Reponen, T. “How Does Breathing Frequency Affect the Filter Efficiency of an N95 Filtering Facepiece Respirator?”, Podium 111. American Industrial Hygiene Conference & Exposition (AIHce), Montréal, Canada, 18-23 May, 2013.

He, X., Yermakov, M., Reponen, T., Grinshpun, S.A. “Performance Evaluation of an Elastomeric Half-mask Respirator on a Manikin with Combustion Aerosol”, International Society for Respiratory Protection 16th International Conference, Boston, USA, 23-27 September, 2012.

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Acknowledgement

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Thank You!

Questions?

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