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Searching for the Optimal Challenge Aerosol Size Distribution for Qualitative Fit Testing

Chih-Chieh Chen,
Wei-Chih Kuo,
Shen-Hsiu Huang, Chih-Wei Lin

Presenter's affiliation
Institute of Occupational Medicine and Industrial Hygiene,
National Taiwan University
17 Xu-Zhou Road, Room 718, Taipei, Taiwan, ZIP Code: 10055
E-mail: ccchen@ntu.edu.tw

Abstract

Several QLFT aerosol generators were commercially available, but the generated aerosol size distributions were not well defined and justified. The data on aerosol penetration through face seal leaks were still quite limited. Therefore, this study aimed to characterize the aerosol penetration through small diameter tubing, and to derive the appropriate range of size distribution of challenge aerosol particles for QLFT. Capillaries with different length and diameter were employed to simulate face seal leaks. An ultrasonic nebulizer was used to generate polydisperse NaCl particles. Aerosol number concentrations and size distributions upstream and downstream of the capillaries were measured by an Aerodynamic Particle Sizer. Aerosol penetration data were recorded at different leak flows and under leak orientation. Empirical models taking into account the aerosol aspiration efficiency and gravitational deposition were used to calculate the face seal leakage. The filter penetration was predicted based on the single fiber efficiency theory. Accordingly, fit factors, obtained by combining the filter penetration and face seal leakage, were shown as a function of mass medium diameter and geometric standard deviation. Experimental results agreed well with the modelled data, showing that aerosol penetration was significantly affected by aspiration efficiency which is a strong function of particle size. Aspiration effect increased with increasing leak flow through capillaries. Gravitational deposition loss in the capillaries was apparent, especially when the tube was placed horizontally and leak flow was low. Experimental data and modelled results all showed that leak size, leak length, leak orientation, breathing flow, filter properties all affected and contributed to the total inward leakage, and therefore, the fit factor. The upper limit of the size distribution of challenge aerosols was mainly determined by the aspiration loss and aerosol deposition due to gravitational settling in the face seal leaks, while the lower limit was driven by the filter penetration.