A Quantitative Approach to Understanding Protection Factor

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Experimental evidence shows that respirator protection factor (PF) is a complex function of challenge concentration, measuring technique and the size distribution of the challenge aerosol. Traditionally, respirator PF is defined as the ratio between the challenge concentration and the penetration concentration. It is believed that as this ratio is defined by bulk parameters of the response function of the measuring technique it does not provide a basis for a full understanding of PF. This is because the definition assumes a linear signal mapping between the challenge and the penetration aerosol for all aerosol particle sizes. This paper presents a method to determine PF that considers the challenge concentration as the sum of the partial components of the aerosol distribution and the penetration concentration as the sum of fractions of the partial components of the challenge. The fraction of the challenge aerosol that penetrates the respirator can then be represented by a penetration function that is a function of the aerosol size. In addition, by considering an additional noise term for the in-mask concentration, the effect of in-mask particle generation for particle counting techniques can be examined through applying a Monte Carlo methodology. This method for defining PF correctly predicts PF as a function of challenge concentration, technique and particle size distribution. The approach also enables a direct comparison of particle counting and mass measuring methods as a function of concentration and particle size. From this study an improved understanding of PF is provided that enables a better understanding of the challenge properties required for counting and flame photometry, as well as an improved understanding of each technique and comparison of the two.