POF023: General platform presentation

Integrating a Toxicological Approach for Breakthrough Curves of Vapor Mixtures in the Estimation of Respirator Cartridge Service Life

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Abstract

The estimation of cartridge service life (CSL) for mixtures of contaminants is a complex task. OSHA-CPL-02-00-158 recommends the use of the additive principle where cartridge service life is determined from the sum up of the concentration in ppm of the components in the mixture to the most volatile contaminant breakthrough time.

Here we present a quantitative risk assessment framework to predict potential human health risk when estimating CSL to avoid gas breakthrough inside the mask, premature change schedules, and unnecessary costs. Simulations using the IAST-Langmuir model combined with the modified Wheeler-Jonas equation allowed the calculation of breakthrough curves for vapor mixtures. Acetone was used as an example of a volatile organic contaminant with m-xylene, o-xylene, styrene, and toluene.

Simulations of exposures to acetone (10-700 ppm) and the other contaminant of lower volatility (500 ppm) through a respiratory cartridge with 50 g of carbon at 25°C and a flow rate of 24 L/min were performed. Outlet concentrations were used to determine the Hazard Index (HI) throughout the exposure.

The HI is defined as the sum of concentrations for each mixture component normalized by its Occupational Exposure Limit (OEL) Value (HI > 1 indicates a health risk). Cartridge service life estimations based on the 10% breakthrough times of acetone and the 10% of HI for the mixture were compared. Simulations of breakthrough curves were in agreement with experimental data previously published. At lower acetone concentrations (< 50 ppm), the simulated CSL using 10% HI of the vapor mixture were up to two times greater, than the 10% Breakthrough time approach. At higher concentrations of acetone, both approaches gave similar results.

The breakthrough time of HI is inversely proportional to the ratio of contaminant 1 (C1) to contaminant 2 (C2), suggesting that using the HI approach can be useful when C1/C2 < 2.