Effect of High Relative Humidity on OV Cartridge Performance

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Background: The severity of the effect of high relative humidity on the performance of chemical cartridges against organic vapors is often underestimated. The early work by Nelson et al. established a breakthrough time multiplier (correction factor) of about 0.83 for OV cartridges conditioned at 50% RH and tested at 90% RH relative to cartridges conditioned at 50% RH and tested at 50% RH (correction factor 1.00). However, these tests were conducted at a challenge concentration of 1000 ppm. Nelson's observation that humidity has a greater effect on cartridge performance at lower concentrations has been widely ignored. Workplace concentrations are often considerably lower than 1000 ppm. Humidity correction factors at these lower concentrations are much more significant than is often realized.

Method: A number of "as received" commercially available OV cartridges were tested to 1% breakthrough against a 2.5 ppm n-pentane challenge at 32 L/min (equivalent to 64 L/min for a pair of cartridges in a dual-cartridge configuration). Test RH values ranged from 50 to 90%.

Results: Time to 1% breakthrough of n-pentane was considerably shortened as the test RH was increased. For example, a NIOSH approved OV cartridge that exhibited breakthrough after about 74 hours at 50% RH lasted about 9.6 hours at 65% RH, 5.0 hours at 75% RH, 3.3 hours at 85% RH, and 2.9 hours at 90% RH.

Conclusions: (1) Experimentally determined OV cartridge breakthrough times for water-immiscible organic vapors at low concentrations and high RH are much shorter than calculated by a number of cartridge service life prediction programs available to respirator users on the web. (2) When the observed humidity correction factor at a given RH is plotted against the experimentally determined 50% RH W_e/d parameter from the Wood equation {AIHAJ, 55(1) pg 11-15, 1994} for that cartridge and fit to a power law, the characteristic curve obtained can be used to estimate the humidity correction factor at that RH for any water immiscible solvent vapor at any concentration. However, at very low values of W_e/d, the correction factor reaches a limiting value that is determined by the time required for the cartridge to equilibrate with water vapor.