Orthogonal Detection for More Complete Protection from Toxic Gases and Vapors in Overhaul Operations

While long considered to be less toxic than firefighting suppression activities, overhaul and fire investigation activities do potentially represent both acute and chronic toxic atmospheric events. Carbon Monoxide (CO) and Hydrogen Cyanide (HCN) detectors, while appropriate for detection of CO and HCN respectively, are not good indicators of total toxicity in the post fire environment. New multisensory "orthogonal" technologies like the Environics' ChemPro100i provide the opportunity to detect a much more representative array of the toxic gases and vapors present in the overhaul environment and alert operators that a toxic event is happening that requires them to "mask up" or exit the overhaul environment.

What Is Overhaul?

Overhaul is the stage of firefighting where fire suppression is complete and firefighters search for and extinguish possible sources of reignition and fire investigators may begin the search for the source of the fire. It is during this stage of firefighting, where there is no fire and little to no smoke in the environment, that a firefighter is likely to remove his/her Self Contained Breathing Apparatus (SCBA) and work "barefaced." Because SCBAs can be heavy and bulky, it is common practice with many firefighters not to wear SCBAs during overhaul.

Overhaul Poses a Real Toxicity Threat

Building materials, furnishings, paints, plastics and the electronics found in today's buildings all have the potential to burn and decompose into acutely acting and chronically acting toxic gases and vapors. A number of studies have demonstrated that these toxic gases and vapors are not just present during suppression activities but also during the overhaul and investigation stages. This means that many potentially toxic and carcinogenic gas and vapors can be present during the overhaul process such as: Carbon Monoxide (CO), Hydrogen Cyanide (HCN), oxides of Nitrogen (NO and NO2), Sulfur Dioxide (SO2), Polycyclic Aromatic Hydrocarbons (PAHs), Aldehydes (like Formaldehyde), acids (like HCl), aromatics (like benzene) and Phosgene (from the thermal decomposition of refrigerants).

Even a small kitchen fire can off-gas many toxic vapors including PFIB (perfluoroisobutane, a chemical warfare agent) and HF (hydrofluoric acid) when Teflon thermally decomposes. Some of these chemicals found in overhaul have good warning properties but many do not.

Chronic Carcinogens Are Potentially Not Measured

Acutely toxic compounds produce effects immediately or soon after the exposure. CO and HCN represent two common acutely acting toxins found during overhaul. Chronic toxins can accumulate over time and symptoms may not present themselves for years after exposure. Bladder cancer in firefighters is often discussed as resulting from chronic, long term exposure to a variety of yet quantified toxins in the firefighting environment. The conclusion of ATF Health Hazard Evaluation Report 96-0171 by Gregory Kinnes and Gregg Hine demonstrates the potential for toxic atmospheres to be present during overhaul and fire investigations:

sales@environicsusa.com · www.environicsusa.com

"Although the environmental sampling conducted during this investigation indicated that most contaminant concentrations did not exceed the relevant evaluation criteria, it still indicated that the potential for exposure exists. In addition, the sampling indicated that the potential for exposure to carcinogens existed to some extent."

CO and HCN Don't Work as "Canaries

Carbon Monoxide (CO) and now Hydrogen Cyanide (HCN) sensors have been sold as "overhaul" sensors to provide firefighters with some sense of security that they are unmasking in a "clean" atmosphere.

However, in "Characterization of Firefighter Exposures During Fire Overhaul" Bolstad-Johnson et al found that "…CO concentrations did not predict concentrations of other products of combustion." This study was published in 2000, before the wide acceptance of HCN monitors for overhaul work. However, this study does provide an additional clue that HCN, like CO, does not predict concentrations of other products of combustion. In addition to CO detectors, HCN detectors were used in this study and "…Only 4 samples (out of 26 fires sampled-ed.) resulted in concentrations above the LOD (Limit Of Detection-ed.). None of these four samples had concentrations of HCN above 10 mg, hence, the concentrations could not be quantified, but were all well below 1 mg/m3." For reference the OSHA PEL (TWA) for HCN is 11mg/m3 (or 10 ppm) so the HCN levels monitored were well below potentially toxic levels. This isn't to say that CO and HCN may not be present during overhaul activities in significant and even toxic concentrations. Both CO and HCN have acute toxic effects. But CO and HCN concentrations do not correlate with total toxicity of either acute or chronically toxic compounds. Put another way, CO and HCN sensors are not appropriate "canaries" for judging total toxicity (acute and chronic) in an overhaul environment.

Cost of Ownership for CO & HCN

The electrochemical (EC) sensors used in CO and HCN detectors have a finite life and require periodic calibration. CO sensors last 2 years and HCN sensors last just one year.

Calibration gas for CO sensors is stable and inexpensive but calibration gas for HCN sensors is expensive and short-lived. Using the cost structure from a popular name brand company, the cost per year of owning a CO sensor is about $160/year factoring in sensor replacement and calibration gas costs. For an HCN sensor the comparable cost is $675/year. So the on-going yearly cost of using a CO and HCN detector for overhaul detection is $805/year.

An "Orthogonal" Solution

In gas detection the word "orthogonal" has come to be used to characterize detectors that use multiple, non-redundant sensors to solve a detection problem. The Environics ChemPro100i is just such an orthogonal detector. While at its heart there is an aspirated Ion Mobility Spectroscopy (IMS) sensor, it uses this sensor with additional sensors and "fuzzy logic" to classify chemicals. The ChemPro100i has the ability to demonstrate warning for more threatening chemicals in the overhaul environment than any handheld detection technology. While the ChemPro100i has a substantially higher purchase cost, it doesn't have the calibration and sensor replacement costs that EC sensors bring with them. With the Guaranteed Cost of Ownership (GCO) program that comes with the ChemPro100i maintenance costs are completely covered for the first 5 years of ownership (Ref: Environics SN-001 for more on the ChemPro100i GCO program). In the absence of wearing an SCBA the ChemPro100i represents a more systematic approach to monitoring the overhaul process for toxic gases and vapors. If a toxic gas or vapor is present it directs the operator to "mask up."

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