

# TerranearPMC Safety Share

## Week of March 19, 2012 – Detecting Volatile Organic Compounds

Volatile Organic Compounds (VOCs) comprise a wide range of chemicals. By definition, they contain carbon and are considered to be quite volatile, which means they can readily evaporate and become airborne at room temperature. As a class of chemicals they have a wide range of toxic effects on humans, from affecting our central nervous system and losing coordination (ah, ethyl alcohol) to causing dysfunction and deterioration of a number of organs. Such is the case with carbon tetrachloride and chloroform affecting the liver and brain. This is because the liver is designed to metabolize non-water soluble materials and transform them into being hydrophilic (water soluble); thus allowing them to be removed from the body through the blood, followed by excreta routes. This makes the liver to be a major target organ for VOCs. Many VOCs have the ability to readily cross the blood brain barrier while disrupting the ability of neurotransmitters to function properly: the result being mental impairment including mood changes, short and long-term memory loss, and altered motor functions. One group of organic compounds, pesticides, can actually cause such severe dysfunction to the nervous system to the point of affecting our ability to breathe and result in suffocation.

Other VOCs have been directly linked to causing a number of serious diseases including cancer. Such is the case with a common group of chemicals known as BTEX. This is an acronym for benzene, toluene, ethyl benzene and xylenes (note that *xylenes* is plural due to having a number of isomers). BTEX is strongly associated within the environmental field being prevalent contaminants of concern.

Gasoline, kerosene, and jet fuel; typical contaminants of concern at many remediation sites, are a class of chemicals that contain multiple types of VOCs. Depending on the manufacturer and even time and place of manufacturer, the concentrations of the various compounds within these substances can vary significantly. This is why such chemical and physical characteristics as boiling points, lower explosive limits and molecular weights for these materials are not listed (sometimes approximations or ranges are presented).

As we can surely understand from the health concerns associated with VOCs, exposures from these materials need to be controlled. This includes understanding their potential ability to become airborne during our work activities and therefore, having the ability to be inhaled and enter into our bodies. While there are a number of sampling techniques that can be used, they require laboratory analysis which can be costly while getting results days after the specific activity have already caused possible employee exposures. Therefore, industrial hygienists typically employ real-time, directing instrumentation to help assess potential exposures to VOCs - while a specific activity is being performed. Thus determining if personnel are properly protected or if additional controls are necessary; all done at the time of exposure and therefore, help prevent an exposure from exceeding the occupational exposure limit: the limit deemed to be the point at which personnel need to be protected.

There two commonly used pieces of equipment that are used to accomplish real time readings of VOCs: one is the photoionization detector (PID) and the other is the flame ionization detector

(FID). While both instruments operate by ionizing various contaminants (such as VOCs), their method of how they achieve this process are quite different.

Ionization is the process by which certain materials are subjected to an energy source that causes those materials to separate into positive and negative particles and thus create electrical charges. Once electrical charges have been created, a signal can be generated. Based upon the number of contaminant-based molecules that were ionized, the strength of that signal would directly correspond to the amount of contaminants in the instrument, which is a direct indication of the amount of contamination in the atmosphere being monitored. For the PID, ionization is created by introducing energy, in the form of ultra violet (UV) light so that incoming airborne contaminants are drawn into the instrument and absorb the UV energy, causing molecules to excite to the point where electrons are lost; thus positive and negative ions are created. The FID, actually burns the materials that are drawn into the instrument. The burning is caused by an electric ignition component (using hydrogen gas as its combustion source) that ignites and causes a flame. The subsequent combustion of hydrogen and oxygen creates a charged current between the flame jet, which acts as an electrode, and another electrode in the chamber. In both cases, once an electric potential is created, the electronic signal is amplified and can be read on a display screen (typically an LED or LCD read-out).

While both the FID and PID offer an immediate response for which one may receive information pertaining to potential contaminant concentrations, they both have the disadvantage in that they are not selective; meaning that they cannot identify specific contaminants as they ionize all materials that are capable of being ionized. In addition, both the FID and PID have their own advantages/disadvantages when compared to each other. Because the PID ionizes without destroying contaminants, the exhaust stream can be a potential exposure for the equipment operator (FID actually burns/destroys materials so its exhaust does present the same concern). In addition the PID can only ionize materials that have a molecular bonding energy low enough that can be “broken” by the UV energy introduced by the PID. This energy is referred to as a material’s ionization potential or IP. And while the PID may have various strengths of UV sources (known as lamps), there are some VOCs that are so tightly bound that no amount of energy from available lamps can cause ionization. Such is the case with methane; a common product associated with landfills as well as other environmental sites. Therefore, one may be working in a methane-rich environment to the point of being in an explosive atmosphere (methane is odorless) and a PID would not indicate a danger. Conversely, FIDs are only effective for combustible materials and therefore would be ineffective for such materials as carbon disulfide (common laboratory contaminant), as well as nitrogen dioxide and nitric oxide.

Complicated? Maybe a little. The important point is that FIDs and PIDs are can help determine potential VOC health exposures. While they cannot replace traditional sampling methodology for precision and accuracy, they are, indeed, valuable tools to help assess worker exposure and to develop immediate controls to ensure employees are properly protected.

**Life is like a ten-speed bicycle. Most of us have gears we never use.**

- Charles Schulz