



HCN and CO in Firefighting and EMS

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Smoke and gases generated in today's fires are more dangerous than they've ever been. Thankfully more knowledge and better equipment can help us deal with that increased danger.

Have you or members of your team experienced a headache, sore throat or nausea after a fire? The answer is likely yes, and if so, you have been warned, there's more you need to know. Today's fires involve burning plastics and polymers that can quickly cause permanent injury. The reality is in, near and after today's fires even minor symptoms can be an indication that harm has been done. Those small symptoms can even lead to significant long term damage. We must be proactive. We can no longer afford to assume that minor symptoms are not important or that EMS teams, Command teams, Pump operators, firefighters near an active fire, those cleaning up after the fire or even those investigating later are safe.

The intention of this is to share with you some of what we've learned from our customers and multiple other sources as our company has investigated and developed HCN monitoring equipment. It's obviously a complex topic so we'll attempt to address the more important things we all need to understand about HCN (hydrogen cyanide) and it's "evil twin" CO (carbon monoxide). We'll also be sharing sources for more information, training, sample HCN SOG's, etc.

Why is HCN so dangerous? The answer begins with the fact it is very likely to be in and around every fire today. It's readily assimilated by Inhalation, ingestion and absorption through the skin, eyes, etc. Small amounts do create harm and it's even more harmful when combined with Carbon Monoxide. Damage has been shown to be cumulative so every exposure matters. Actionable levels for CO are 30ppm – its 4.7ppm for HCN. HCN causes harm by killing organs either immediately or over time. Factor in that CO deprives those same organs of oxygen, often at the same time and you can see how the overall impact becomes even more sinister.

"Exposure to smaller concentrations can initially cause respiratory activation (manifested by rapid breathing and tachycardia) in an attempt to compensate for lack of oxygen. Early manifestations include headache, anxiety, blurry vision and loss of judgment. As cyanide accumulates further, signs and symptoms of poisoning reflect the effects of oxygen deprivation on the heart and brain. These include cardiac dysrhythmias, seizure, coma and death. The time between exposure and incapacitation or death is typically minutes, but varies depending on the concentration of cyanide and other toxicants. Obrien, DJ, Walsh, DW, Cyanide and Smoke inhalation, 2010

"Not all HCN and CO related fatalities are caused by asphyxiation. Many cardiac related fatalities that we're experiencing may very well be related to CO and HCN exposures over time. Todd Shoebridge, Carbon Monoxide and Hydrogen Cyanide Make Today's Fires More Dangerous, Firefighter Nation, Feb 14, 2012.

"Another underappreciated effect of exposure is the death of individual cells. Even if the entire organism is not killed by a given exposure, such exposures can kill individual cells in an organism. The cells most susceptible to this effect are those in the heart and brain. As time goes on, the cumulative effects of such cell death at repeated exposures can result in chronic heart and nervous system disease." Jean Marie McMahan, MD in Smoke Cyanide and Carbon Monoxide: The Toxic Twins of Smoke Inhalation, Cyanide Poisoning Treatment Coalition, 2009.

Is HCN really that prevalent? Natural sources of hydrogen cyanide are burning grass clippings, green wood, green weeds, tobacco, cotton, paper, wool, silk, even animal carcasses. Significantly higher levels come from combustion of manmade plastics and resins. Nylon, polyurethane, melamine and acrylonitrile are present everywhere in our world today, especially in buildings and vehicles. Foam insulation, furniture, carpet, drapes, appliances, most plastics and that includes most clothing today – all produce HCN when burning.

A burn study sponsored by the Fire Smoke Coalition and Tarrant County College, Fort Worth Texas in March of 2011 found significant levels of HCN were evident in open air sampling of an outdoor burn. The highest levels were recorded at incipient start of fire and smoke production and during the smoldering period as the fire wound down but were evident in harmful amounts throughout the burn and after. HCN was also found present in areas there was not smoke.

An eight month study in which monitoring for CO and HCN at fire calls responded to by the Columbia, SC Fire department was conducted in 2008. It resulted in air monitoring measurement results from approximately 40 structure fires. It found “staggeringly high HCN levels at almost every scene”. Worst offenders for HCN production in that study were; “Pot on a stove/cooking fires (average small kitchen fire produced 75 ppm of HCN), car Fires, dumpster fires and in overhaul operations. That study resulted in writing an SOG to address the problem which details the use of PPE, SCBA and metering in every fire response. That SOG is being shared and is available by on line search.

There’s more than HCN in Fire Smoke and proper SOGs can protect you from those other dangerous gases as well. Modern fire smoke contains things like Vinyl chlorides, formaldehyde, oxides of nitrogen, phosgene (sometimes used as a chemical warfare agent), hydrogen sulphide, chlorine and ammonia as well as carbon monoxide and Hydrogen Cyanide (HCN). Our understanding of HCN is maturing and as it does the danger from that gas stands out. We’ve known CO was responsible for many fire deaths and early retirements and now we’re discovering when combined with HCN they become “Toxic Twins” – together even more dangerous than either of them alone. The good news is protecting ourselves from those other dangerous gases is a side benefit of using PPE (personal protection equipment), SCBA (self contained breathing apparatus) and monitors that can tell you it’s safe to remove that equipment for CO and HCN.

We can’t afford to relax when the smoke is gone. The same dangerous gases can still be a factor – and now we can’t see them so here’s where knowledge and training really count. Both gases are long lived and not easy to break up so they tend to be present in dangerous amounts for some time after the active fire has been eliminated and the smoke is gone. That creates the need to keep PPE and SCBA equipment intact until metering can show neither HCN nor CO are present – even after the smoke is gone! It’s important to note studies have shown that while frequently found in the same places the presence of CO or HCN doesn’t necessarily predict the presence of the other.

The soot and particulate matter we get covered with also present a danger. Lightly hosing off your outer gear should be a standard practice - especially before going into a rehab or other “clean” environment. Be aware that a person being rescued from a fire or to whom you are providing medical services may be off-gassing an unacceptable amount of HCN that has been absorbed into the soot and

particulate matter covering them – or even from their clothing and skin. Use a monitor to be safe – or don PPE and SCBA proactively. A spray of water will help to remove contaminants. Wash face, hands and any other area that might have been exposed in the fire as soon as you are out and shower as soon as practical. Thorough washing of PPE should also be done as soon as practical and never allow PPE to remain in living or sleeping areas.

How long after a fire do we need to be concerned? Only monitoring can tell you. A firefighter recently shared they found only CO in an apartment building after the fire was out but found HCN in the next four adjacent apartments. HCN is very stable. While its evil twin CO breaks down eventually to become CO₂, HCN needs to be washed or blown away - it doesn't break down. It's also readily absorbed by many materials – including our skin, from which it continues to off gas for some time after the fire and smoke are gone.

How much is too much? The numbers for acceptable exposure keep coming down as scientists gain more knowledge about HCN. We also have to consider that when combined with CO both gases are more dangerous. The current Short Term Exposure limit (STEL) recommended by NIOSH is 4.7ppm. This is also the ceiling limit of exposure recommended by the American Conference of Industrial Hygienists. OSHA still uses 10ppm as their short term exposure limit but EPA lists 10ppm as creating possible adverse medical impacts in as little as 30 minutes. HCN is estimated to be 26 to 35 times more toxic than CO.

There is a significant perimeter around an active fire that is not safe. We have many crews that carry our portable carbon monoxide monitors as passive screening and personal protection devices so they are with them all the time. Those users have reported sensing CO in command and rehab centers that were set up near active fires but were not being continually monitored. CO and HCN are often in the same locations. The only way to know you are outside the perimeter of danger from those gases is to use a monitor that can tell you the air is clear. Live air sampling is the only safe way to pick a spot to set up Command, EMS, Rehab, etc. Continuous monitoring is the only way to know it continues to be safe. Note the CO monitor that is wall mounted in many EMS and rehab trailers is going to report a time weighted average – they won't alarm in smaller (20 to 60 ppm) amounts of CO until the alarm has been exposed for several hours. One of our customers reported his CO monitor reporting 40ppm in a trailer being used for rehab several hours after set up while the wall mounted device had not responded.

We need to address this increased risk! Metering and using SCBA and PPE that limits the exposure of eyes and skin should be considered a minimum while working in and around any active fire, see Air Management (NFPA 1404). Atmospheric monitoring to determine when the air is safe for all-clear to doff SCBA should include HCN. Air monitoring should be used to be sure areas set up for rehab, command and other operations are outside – and stay outside – of the perimeter of danger for those gases at any active fire. Only metering can confirm pump operators and others near an active fire are safe. We need to be aware that off-gassing from gear worn into a fire or victims rescued from an active fire may put you in danger. The bottom line is your crews safety, as well as your own requires that constant air monitoring be conducted any time you are out of SCBA and PPE at any active fire scene and on into overhaul, clean up and investigation.

Promote standard operating guidelines (SOGs or SOPs) for your department if yours doesn't already address these two very dangerous "toxic twins" (CO and HCN). One resource is an organization called the Fire Smoke Coalition. They offer web based education, training programs – even an "ask the expert"

service. This is what they have to say about the management of dangerous gases including HCN; “In the end, implementation is up to department leaders. Many leaders have attended *Know Your Smoke*, became believers and ultimately made wide-sweeping departmental changes in standard operating procedures for the sole purpose of saving firefighter lives. **If your department is struggling through the process of implementing new SOG's to prevent firefighter exposure to fire smoke, and, just as important, changes in treatment for exposure, the Coalition maintains a database of departments and contacts who have gone through the process who are willing to share information.**” They are available at www.FireSmoke.org.

There are some new technologies available in monitors. Our company has developed an HCN monitor that does not need to be calibrated and offers several years of warranted service. There are also several brands of HCN detectors as standalone devices or in combination with other gases that can be considered.

Knowledge regarding HCN is relatively new but it is compelling and ignoring the inherent danger it presents has the potential to shorten our lives. Knowledge is your basic defense. Learn more at the conferences, through the Fire Smoke Coalition, NFPA and others. Make sure your SCBA and PPE equipment is intact and up to date. Check into monitoring devices to protect yourself and your team. Your successful and long life may depend on it!

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