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Carbon Monoxide & Hydrogen Cyanide Make Today's Fires More Dangerous

What you need to know about the toxic chemicals released in today's fires



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By **Todd Shoebridge**
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Hypoxia, asphyxia, cardiac arrest and death—hopefully, this list has grabbed your attention. Modern technology has improved the way we fight fires, but due to the chemical make-up of many manufactured materials, today's fires reach hotter temperatures faster, flashovers occur more rapidly and the resulting smoke is much more toxic. As a result of these factors, firefighters have been dying at a greater rate than ever before from inhaling toxic chemical compounds, such as carbon monoxide (CO) and hydrogen cyanide (HCN).

In the mid-1970s, George Kimmerle developed a list of eight major factors that can cause death to those involved in structure fires¹:

1. Direct consumption by the fire (flame contact)
2. Very high temperature (thermal insult, burns)
3. Oxygen deficiency
4. Presence of CO
5. Presence of other toxic gases
6. Presence of smoke
7. The development of fear, shock and panic
8. Secondary fire effects because of mechanical reasons (trauma, fractures, etc.)

Two of the main players found in today's smoke and combustion are CO and HCN. Throughout this article, I'll focus on these gases, where they come from and what they do to our bodies, as well as the importance of using SCBA and practicing the rules of air management (ROAM) in today's fire service.

The Breath from Hell

Understanding CO and HCN is especially crucial to today's fire service, because the smoke that firefighters were exposed to 20 or 30 years ago is not the same as it is today. Wood, cellulose, cotton, silk, wool, etc., were bad decades ago, but they were nowhere near as toxic as the chemically-manufactured materials of today. When combined in a fire situation, these chemicals are often referred to as "the breath from hell"² and include compounds such as:



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- Acetyls—aerosol containers, combs, lighters and pens
- Acrylics—glues, food packages and skylights
- Nylons—various household containers, brushes, sewing thread and fishing line
- Polyesters—hair dryers, computers and kitchen appliances
- Polypropylene—bottles, diapers and furniture
- Polyurethanes—shoes and cushions
- Polyvinyl chlorides (PVC)—carpet, clothes, purses, records and shower curtains
- Thermo sets—TVs, coatings, toilets, buttons, flooring and insulation

Other chemicals that can be added to this toxic list include carbon monoxide, nitrogen dioxide, polynuclear aromatic hydrocarbons, formaldehyde, acid gases, phosgene, benzene and dioxins. In short, the smoke of today is a highly complex mixture of solids, liquids, fumes and gases that are produced when there's a thermal decomposition of materials, or in other words, when these materials burn.

As firefighters, we're exposed to these toxic compounds regularly, and although their effects are treatable at the time of onset, over a period of time, the compounds are compoundable, and can build up in our system and become life-threatening.

HCN & CO

Most firefighters are aware of the fact that where there's smoke, there's CO and HCN. But what's even more disturbing and not well known: HCN is 33–35% more dangerous than CO, because it can damage the systems of the body in many ways, such as through ingestion or inhalation, injections and skin exposures. Both are colorless gases, but CO is odorless, while HCN gives off a faint smell of almonds, which you would never pick up on during a fire.

And they work in different ways. CO attaches to the oxygen molecules in the body, preventing oxygen from reaching vital organs, which will cause you to suffocate after a short period of time. HCN, on the other hand, targets the central nervous system, cardiovascular system, thyroid and the blood, causing firefighters to become disoriented and agitated, and to lose focus on the task at hand. Some have even fought against RIT members attempting to rescue them. Others have run away from their rescuers, and at times, run deeper toward the seat of the fire until they become physically exhausted and overcome by smoke or thermal insult injuries. This is why you hear of so many firefighters who become lost and disoriented, and/or take off their masks once they've run out of air.

Signs & Symptoms

On average, we lose 100 firefighters a year, although that number has dropped slightly in recent years. Cardiac-related fatalities are still the number one cause of death in the fire service, with traumatic injuries number two, followed by asphyxiation. The key point, and the part that you need to remember, is that 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 as well.

Exposure to higher levels of CO, when combined with HCN, will mimic the signs and symptoms of cardiac-related emergencies. Acute exposure to HCN can result in symptoms such as weakness, headache, confusion, vertigo, dyspnea and, occasionally, nausea and vomiting. Respiratory rate and depth usually increase at the onset, and will eventually cause the victim to gasp for breath. Coma and convulsions occur in some cases. If a firefighter gets to the point where they lose color and become ashen, or cyanosis is present, it usually means that respirations have ceased or have been inadequate for an extended amount of time.

In the event that a high level of HCN has been absorbed into the body, collapse is usually instantaneous, followed quickly by

unconsciousness, convulsions and almost immediate death. This is why you sometimes hear of a firefighter walking out of a burning structure, taking off their mask and collapsing, or working a shift, going to bed and not waking up in the morning.

What the Fire Service Can Do

There are many things the fire service can do right now to decrease firefighters' chances of being exposed to or harmed by HCN and CO. The most important is to adopt ROAM, which simply states that if a firefighter is in an IDLH environment, then they will wear their SCBA.

Firefighters, company officers and chief officers need to change their mindset and give up on the "old school" ways of the past. They must educate themselves and the firefighters that they supervise about the new dangers that they face at every fire they respond to.

1. Standard operating guidelines (SOGs) and standard operating procedures (SOPs) need to be put in place and strictly adhered to. When writing your SOPs/SOGs, please remember to include what you want to accomplish or what you want as the end result. Guidelines leave room for individual interpretation, while procedures are set, step-by-step instructions that shall be followed each and every time. Below is a sample section of an SOP that will help protect your firefighters from the toxic twins:

General Guidelines—Self contained breathing apparatus (SCBA) shall be used by all personnel operating in an area where the potential for a hazardous atmosphere exists, including but not limited to:

- Interior structural firefighting operations
- Exterior structural firefighting operations where the potential for breathing smoke exists
- Overhaul operations (even in the absence of visible smoke)
- Car fires
- Dumpster and rubbish fires
- Hazardous materials incidents in the hot and warm zones
- Confined-space entry
- CO emergencies where the CO concentration exceeds the LEL (35 ppm)
- Any time the incident commander or safety officer deems it necessary

Individual Air Management Program—All personnel shall follow the Rules of Air Management (ROAM)³, which state: "Know how much air you have in your SCBA cylinder and manage that air so you can leave the hazardous environment before your low-air alarm activates." The low-air alarm activates when the SCBA cylinder has 25% of its capacity remaining. This 25% is the emergency reserve and should not be used for exiting the hazard area.

Using the Rule of Air Management (ROAM)—Conduct a READY check before entering:

- Radio = turned on, battery charged, correct channel
- Equipment = PPE, proper tools for the assignment
- Air = full cylinder, SCBA functioning properly
- Duties = everyone knows their assignment
- Yes = if answers to above are yes, you may enter

2. Departments must train their members on the hazards of these potentially deadly gases and offer refresher courses once a year at minimum. During these classes, training officers should explain why CO and HCN are more significant today than they were 20 or 30 years ago. Explain the chemistry of the two compounds when they're found in a fire, and identify the chemical make-ups and materials when HCN is found.

3. Educate your members about decontamination practices. Ensure that every firefighter washes their turnout gear, boots, helmet, gloves and hood after each fire they encounter. Because HCN can be absorbed, firefighters can become contaminated over and over again by simply not washing their turnout gear. It's no longer "cool" to have the nastiest turnout gear and the blackest helmet in the western world. With the chemical compounds out there today, continued exposure through contaminated turnout gear will eventually make you sick or worse.

4. During training, identify all the medical concerns related to cyanide poisoning and why firefighters can't merely rely on their past experiences to determine whether or not an atmosphere is safe from these gases.

5. Educate your members on where the closest medical assistance is in the event of an exposure, and which, if any, medical facilities in your area have CynoKits on the premises.

6. Train personnel on the proper ways of monitoring hazardous atmospheres for dangerous gases, how to correctly use monitoring equipment and what to look for, such as lower explosive limits (LEL levels), part per million concentration levels (PPM), CO and HCN levels.

7. Adopt NFPA 1404: Standard for Fire Service Respiratory Protection Training, 2006 edition, and use it as a guide in the training of your members.

Don't Forget About SCBA

It is the company officer's job to focus on the protection and safety of their crewmembers. Therefore, they need to ensure that any time their crew is working in or around an IDLH environment, all crewmembers are wearing SCBA, and that the only time their facepieces are removed is when they are well outside any contaminated area.

This does not just pertain to structure fires, although that is the focus of this article. Vehicle fires, trash fires and dumpster fires are included in this as well. All of the same chemically manufactured materials found in a structure fire (PVC, plastics, synthetic leathers, aerosols, etc.) can also be found in vehicles and the materials that we throw away. Why risk your life for a trash-filled dumpster or a vehicle that some insurance company is going to pay for anyway? Take the time to put on your SCBA.

A Final Note

As firefighters, our job is just that—fighting fires—but we need to change our way of thinking and start doing it in a safer way. The fires you fight today may not kill you today, but what about those exposures you faced 15 or 20 years ago? Repeated exposure to toxic chemicals can and does have a negative effect on the human body. And what about the fire you'll face in the months and/or years to come?

The bottom line: We need to educate ourselves on the dangers that these chemical compounds expose us to; we need to educate our personnel on how to determine their presence in a fire environment and how to protect ourselves in an IDLH atmosphere; we need to wear our SCBA any time we are in an IDLH environment; and we need to learn to recognize the signs and symptoms of toxic exposures, and realize that if one of our own suffers from smoke inhalation, they need to be treated as if they've been exposed to HCN.

Additionally, departments should adopt mandatory annual wellness programs. *Note:* Those members who have health concerns need to have them addressed by a licensed physician, treated and cleared before returning to duty.

Doing all of these things could mean saving a life—your own—and

ensuring that everyone goes home.

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3. Gagliano M., Phillips C., Jose P., et al. *Air Management for the Fire Service*. Fire Engineering Books: 2008.

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Todd Shoebridge is a 30-year fire service veteran and captain/EMT with the Hickory (N.C.) Fire Department, where he has served for 20 years. He also serves as North Carolina's lead advocate for the Everyone Goes Home program, and he holds certifications as a National Registry (PROBOARD) Fire Officer III, rapid intervention and NFA mayday instructor, hazmat technician, level II fire service instructor, basic VMR rescue technician, and fire/arson investigator (CFI) through the North Carolina Fire and Rescue Commission. Shoebridge holds associate's degrees in biology and ecology from Montreat College, and is completing his bachelor's degree in fire science at the University of Maryland. [Read Full Bio](#)

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