

DISPATCH



Carbon Monoxide and Fire Fighters

Introduction

Tasteless, colorless, and odorless, carbon monoxide (CO) is widely known as the "silent killer". CO is rapidly absorbed by the lungs into the bloodstream. Once in the blood it crosses into the red blood cell and binds to hemoglobin, forming carboxyhemoglobin. When CO binds to hemoglobin, it prevents hemoglobin oxygen binding and causes the hemoglobin that remains bound to oxygen to hold the oxygen more tightly, consequently lowering the amount of oxygen delivered to the tissues and organs of the body. Effects are felt first by parts of the body with higher metabolic rates. Like the canaries whose higher metabolic rates earned them jobs as early warning devices for CO in coal mines, the heart and brain are most sensitive to the effects of oxygen deprivation. If the accumulation of CO in the body is not reversed, it can cause progressive heart problems and brain dysfunction and may ultimately lead to coma and death.

Carbon monoxide is formed wherever fuels, wood products or other carbon-containing materials are burned. The number one cause of increased CO in the general environment is car exhaust, which contains on average 2/3 of a pound of CO for every mile the car travels. The most significant personal factor in CO exposure is cigarette smoking. Cigarette smokers have been proven to have significantly elevated levels of CO in their blood compared to non-smokers, and any further exposure to CO is added on top of the baseline exposure from cigarettes.

Essentially all fire fighting environments can be expected to contain high levels of carbon monoxide. Depending on the fire, levels may range from 50 parts per million (ppm), which might be expected to cause some mild neurological impairment after several hours exposure, to several thousand parts per million, which would be fatal after several minutes exposure. The highest levels occur during the knockdown phase of fire fighting, but CO levels are also substantially elevated during the overhaul phase as well.

The carboxyhemoglobin level, measured as the percentage of hemoglobin that is bound to carbon monoxide, is the most commonly used indicator of CO exposure. The rate of formation of carboxyhemoglobin depends on the concentration of CO in inhaled air and the level of exertion of the person breathing it in. At rest, a person breathing 500 ppm CO would reach a carboxyhemoglobin level of 32% (a level associated with severe neurologic symptoms) in about 200 minutes. At 50 ppm atmospheric CO for 200 minutes, the same person would reach a carboxyhemoglobin level of about 4%. With exertion, the time to reach a given carboxyhemoglobin level for a given air concentration is much less than at rest.

Health Effects of Acute Exposure

Like the carboxyhemoglobin level, the symptoms of carbon monoxide poisoning depend on the level of carbon monoxide in the air, the length of exposure, and the exertional level of the subject. An actively exercising fire fighter in a high CO environment may suffer collapse and sudden death without any warning symptoms. With exposure to more moderate levels of CO, a progression of neurologic symptoms is usually encountered, from headache to confusion to unconsciousness. Early cardiac symptoms include decreased exercise tolerance and rapid heart beat. With continued exposure, arrhythmias and exacerbation of chest pain may result. Ultimately, severe heart ischemia (inadequate oxygenation) and fatal arrhythmias may occur.

Carbon monoxide is an especially harmful agent for the fetus. Short-term moderate to high level exposure to CO can cause severe injury fetal or death. More chronic, lower level exposure to CO may increase the child's risk of low birth weight, behavioral problems, and perinatal mortality. It is again worth noting that exposure to cigarette smoke adds to any risk from occupational exposure to CO.

Health Effects of Chronic Exposure

The health effects of repeated exposure to low levels of CO are less clear. Persons with underlying heart disease are more susceptible to exacerbation of their condition, including heart attacks and sudden arrhythmias. There is some evidence that chronic low level exposures to CO may actually cause atherosclerosis and promote blockage of heart arteries, but this has not been proven.

Neurologic damage from CO can occur long after the actual exposure. There have been numerous case reports of memory loss, poor balance and personality changes occurring weeks after high level exposures. It is less clear whether lower level exposures may cause similar neuropsychiatric symptoms over a period of many years.

Prevention of Carbon Monoxide Exposure and Illness

The medical treatment of CO poisoning involves removal from the source of exposure and administration of oxygen. Oxygen speeds the body's normal clearance of carbon monoxide from the blood. While 100% oxygen given by mask is always used first and is usually sufficient for most cases, serious cases of CO poisoning are treated with administration of oxygen in special hyperbaric chambers.

For fire fighters, it is important to remember that CO is present in just about all fire environments, and that levels high enough to cause significant illness are present in the smoldering fires of the overhaul phase. Studies have shown that consistent use of SCBA lowers the amount of CO in the blood of exposed fire fighters.

Fire fighters should be aware of non-occupational sources of CO as well to prevent a higher baseline exposure level. Indoor sources of importance include cigarettes, indoor gas and kerosene appliances, and wood or charcoal burning stoves. Numerous accidental CO poisonings are also caused by faulty automobile exhaust systems, especially in old cars with corroded floor boards.

Carbon monoxide detectors for use in the home were released for the first time in late 1993. These units respond to an 8 hour level of 15 parts per million with an intermittent alarm and a 90 minute level of 100 parts per million with a continuous alarm.

Summary

- Carbon monoxide is tasteless, odorless, colorless and deadly.
- Carbon monoxide is present at high concentrations in most fires, during knockdown and overhaul.
- The main health effects of carbon monoxide exposure are neurological (headache, dizziness, loss of balance, loss of consciousness, coma and death) and cardiac (worsening of pre-existing heart disease, fatal and non-fatal arrhythmias.) Carbon monoxide is also very harmful to the fetus.
- Cigarette smoking doubles the amount of carbon monoxide normally present in your blood.
- Use of SCBA lowers exposures to carbon monoxide.