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INTERNATIONAL, INC.

CARBON MONOXIDE

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COMBUSTION PROCESS

In the presence of sufficient oxygen, the combustion (burning) of organic fuels results in each atom of carbon combining with two atoms of oxygen. This results in the carbon being oxidized to nontoxic carbon dioxide (CO_2). Most open flames such as gas ranges, campfires, etc., burn in an environment of surplus oxygen and thus emit carbon dioxide. However, with insufficient oxygen available, incomplete combustion results as carbon atoms each combine with only one oxygen atom to produce toxic carbon monoxide because the combustion occurs where the available oxygen is not sufficient for complete combustion.

The internal combustion engine, whether gasoline-fueled or diesel-fueled, also produces toxic carbon monoxide as one of its emission products. The only oxygen available for the combustion of the fuel is that trapped within the cylinder. Typically, there is insufficient oxygen in the cylinder for complete combustion of the fuel, and a portion of the carbon atoms in the fuel combine with only one oxygen atom to produce the carbon monoxide.

HEALTH EFFECTS

Carbon monoxide is orderless, colorless, and tasteless. These qualities make the gas particularly hazardous since an individual does not realize that it is present until the ill effect of exposure become obvious as symptoms of “carbon monoxide poisoning”. Blood hemoglobin-the red cells that transport oxygen from the lungs to the body tissues-are attracted to carbon monoxide approximately 210 to 270 times more strongly than the oxygen. As a result of this strong attraction, carbon monoxide is not easily expelled from the bloodstream once absorbed, and its presence completely “blocks” the oxygen carrying ability of the affected red blood cells. Although short-term exposures to limited concentrations of carbon monoxide are relatively harmless, long-term exposure to even low concentrations can have adverse effect on an individual’s health and well-being.

Up to 10% of the blood’s hemoglobin can be locked to carbon monoxide without the affected individual showing any noticeable symptoms of carbon monoxide poisoning. At levels between 10% and 20%, a slight headache is noticed, and a severe headache occurs at levels between 20% and 30%. Death generally results when more than 60% of the blood hemoglobin is locked to carbon monoxide.

For enclosed areas including parking garages, current specification of the Occupational Safety and Health Administration (OSHA) restrict concentrations of carbon monoxide to 50 parts per million (ppm) averages over an eight hour period, with maximum peak concentrations not to exceed 400 ppm at any time.

The 50 ppm average is intended to prevent an individual from attaining carboxyhemoglobin (hemoglobin plus carbon monoxide) levels greater than 10% when exposed to the gas over a full eight hour working shift. When the affected individual returns to fresh air, the carboxyhemoglobin level decreases at a rate of approximately 50% every four hours. For example, an individual attaining a carboxyhemoglobin level of

10% on the job would decrease the level to about 0.6% after 16 hours in fresh air. However, it should be noted that there is some evidence that carboxyhemoglobin levels as low as 5% are sufficient to impair an individual's judgment and manual skill, even though there may be no external symptoms of carbon monoxide poisoning.

The rate at which carbon monoxide is absorbed in the bloodstream depends upon three factors:

1) The concentration of the gas in the air; 2) The duration of exposure to the gas; and 3) The rate of breathing.

For any given concentration of carbon monoxide, an equilibrium level of carboxyhemoglobin in the blood is reached within four to eight hours of exposure. While rapid breathing shortens the time needed to reach equilibrium, it does not alter the equilibrium level which carboxyhemoglobin is safe. Depending upon the carbon monoxide concentration in the air, the equilibrium level may exceed the level necessary to cause severe health impairment or even death.

LONG-TERM EFECTS

There is little data available on the long-term effects of exposure to carbon monoxide. In some studies of humans and laboratory animals exposed to concentrations of 50 to 70 ppm no changes in physical or behavioral well-being have been noted. However, daily exposure to 100 ppm of carbon monoxide has been documented as producing mild but definite changes in the blood, central nervous system, heart muscle, and behavior pattern. It also has been claimed that exposure to excessive concentrations of carbon monoxide may cause a reduction in the sharpness of vision.

ALTITUDE

Altitude has a definite effect upon the toxicity of carbon monoxide. With 50 ppm of carbon monoxide in the air, the carboxyhemoglobin level in the blood is approximately 1% higher at an altitude of 1,220 meters (4,000 feet) then at sea level. The partial pressure of oxygen (the gas pressure causing the gas to pass into the blood) at the higher altitude is less than the partial pressure of carbon monoxide. Furthermore, the effects of carboxyhemoglobin in the blood at high altitudes are more pronounced. At an altitude of 4,570 meters (15,000 feet), a 3% carboxyhemoglobin level in the blood has the same effect as a 20% content at sea level.

CARBON MONOXIDE IN PARKING GARAGES

Whether underground or above ground, enclosed parking garages are subject to carbon monoxide emissions from the internal combustion engines of the vehicles using those structures. Without adequate ventilation, concentrations of this toxic gas can quickly rise to alarming levels. The primary purpose of ventilation systems in these structures is to expel carbon monoxide from the enclosed air in an amount and at time necessary to maintain concentrations at or below a "safe" level. The principal health hazard in these structures is not to the customers who merely pass through the area for a few minutes. Rather, the concern is for the attendants on duty and for people working in adjoining structures subject to possible seepage of the gas from the parking area. Since these people are or may be exposed to the carbon monoxide throughout their working day, considerations of the cumulative effects and equilibrium level of carboxyhemoglobin in the blood mandate controlling the atmospheric concentration of the gas within the range considered safe.

At present, OSHA specification requires that the carbon monoxide concentration in the air be limited to 50 ppm average over an eight hour period, with maximum peak concentration not exceeding 400 ppm.

REFERENCES

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