

Carbon monoxide and hydrogen sulfide: the leading toxic hazards in confined space entry

1. Toxic contaminants in the workplace

Many toxic substances are commonly encountered in industry. The presence of the toxic contaminants may be due to materials being stored or used, the work being performed, or may be generated by natural processes. Exposure to toxic substances can produce disease, bodily injury, or death in unprotected workers. Many toxic gases are dangerous in very low concentrations. In some cases a concentration of only a few parts per million can be quickly lethal.

Carbon monoxide and hydrogen sulfide are the two most widely occurring toxic gases, especially in confined space entry. Carbon monoxide is a byproduct of incomplete combustion, and will always be present whenever combustion occurs. Hydrogen sulfide is another very common and very dangerous toxic gas. It is generally produced by bacterial action on materials which contain sulfur. It is especially associated with raw sewage, crude oil, animal products, and the pulp and paper industry, but can be encountered occasionally in almost any confined space. All it takes is a small amount of organic material which contains sulfur (such as a dead animal) and bacterial action will produce this very dangerous contaminant.

Airborne toxic substances are typically classified on the basis of their ability to produce physiological effects on exposed workers. Toxic substances tend to produce symptoms in two time frames. Higher levels of exposure tend to produce immediate (acute) effects, while lower levels of long-term (chronic) exposure may not produce physiological symptoms for years.

2. Hydrogen sulfide

Hydrogen sulfide (H₂S) is a good example of an acutely toxic substance which is immediately lethal at relatively low concentrations. Exposure to a concentration of only 300 PPM (parts per million) for a period of 30 minutes is enough to render a worker unconscious. Exposure to a 1,000 PPM concentration of H₂S in air produces rapid paralysis of the respiratory system, cardiac arrest, and death within minutes.

Hydrogen sulfide is readily produced by the action of anaerobic sulfur fixing bacteria on materials which contain sulfur. Hydrogen sulfide smells like rotten eggs at low concentrations. At high concentrations it desensitizes the sense of smell, and is no longer detectable by the nose. H₂S is colorless, heavier than air, corrosive, flammable (LEL is 4.3 %), soluble in water, and extremely toxic!

Toxic effects of hydrogen sulfide exposure:

Concentration Effect

Concentration	Effect
1 PPM	Smell
10 PPM	8 hr. TWA
15 PPM	15 min. STEL
100 PPM	Loss of smell
300 PPM	Loss of consciousness with time (~ 30 min.)
1000 PPM	Immediate respiratory arrest, loss of consciousness, followed by death

3. Carbon monoxide

Carbon monoxide is a colorless, odorless, tasteless gas produced as a byproduct of incomplete combustion. It is strongly associated with internal combustion engine exhaust, leaky heating systems, and many other common processes which involve combustion.

Carbon monoxide (CO) is a good example of a chronically toxic gas. Carbon monoxide bonds to the hemoglobin molecules in red blood cells. Red blood cells contaminated with CO are unable to transport oxygen. Although very

high concentrations of carbon monoxide may be acutely toxic, and lead to immediate respiratory arrest or death, it is the long term physiological effects due to chronic exposure at lower levels that take the greatest toll of affected workers. This is the situation with regards to smokers, parking garage attendants, or others chronically exposed to carbon monoxide in the workplace. Exposure levels are too low to produce immediate symptoms, but small repeated doses reduce the oxygen carrying capacity of the blood over time to dangerously low levels.

This partial impairment of the blood supply may lead over time to serious physiological consequences.

The only way to be sure that carbon monoxide is not present in dangerous concentrations is to look for it with an atmospheric monitor designed to detect it. Since carbon monoxide is encountered so frequently in so many settings, there is sometimes a tendency not to take it seriously as a hazard. **Don't make that mistake!**

High concentrations of carbon monoxide can saturate a person's blood in a matter of minutes, and quickly lead to respiratory arrest or death. Constant monitoring is the *only* way to ensure that the air is safe from this invisible hazard.

Toxic effects of carbon monoxide exposure:

Concentration Effect

Concentration	Effect
35 PPM	8 hr. TWA
200 PPM	Ceiling
600 PPM	Headache, discomfort (1 hr.)
2500 PPM	Unconsciousness (30 min)
4000 PPM	Quickly fatal

4. Permissible exposure limits

OSHA permissible exposure limits (PELs) are defined in three ways; as an instantaneous ceiling, as a short term exposure limit (STEL) or as an 8 hour time weighted average (TWA). Permissible exposure limits for gases and vapors are usually given in part-per-million concentration. OSHA's PEL for a particular gas may consist of one, two, or in a few (usually transitional) cases all three terms. You can't pick and choose which parts of the definition you are going to comply with: If a particular gas has a multi-part permissible exposure limit it is equally important to comply with all parts of the limit.

The current OSHA permissible exposure limit for carbon monoxide is a TWA of 50 PPM. Although it is no longer officially part of the OSHA requirement, many states also enforce a ceiling level of 200 PPM for carbon monoxide. (OSHA's 1989 requirement for CO was a dual limit including a ceiling level of 200 PPM and a TWA of 35 PPM.) The OSHA permissible exposure limit for hydrogen sulfide remains a two part definition. OSHA's PEL for H₂S consists of an 8 hour TWA of 10 PPM, and a STEL of 15 PPM.

Biosystems instruments are equipped with three independent alarm setpoints for each sensor installed; ceiling (instantaneous), STEL and TWA. With Biosystems instruments there's no guessing; the instrument automatically sounds the alarm whenever the concentration exceeds *any* part of the permissible exposure limit definition.

Please call Biosystems Technical Service at (860) 344-1079 if you have any additional questions.