

Occupational Health Guideline for Carbon Monoxide

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CO
- Synonyms: Monoxide
- Appearance and odor: Colorless, odorless gas.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for carbon monoxide is 50 parts of carbon monoxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 55 milligrams of carbon monoxide per cubic meter of air (mg/m³). NIOSH has recommended that the permissible exposure limit be reduced to 35 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 200 ppm. The NIOSH Criteria Document for Carbon Monoxide should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Carbon monoxide can affect the body if it is inhaled or if liquid carbon monoxide comes in contact with the eyes or skin.

• Effects of overexposure

Exposure to carbon monoxide decreases the ability of the blood to carry oxygen to the tissues. Inhalation of carbon monoxide may cause headache, nausea, dizziness, weakness, rapid breathing, unconsciousness, and death. High concentrations may be rapidly fatal without producing significant warning symptoms. Exposure to this gas may aggravate heart disease and artery disease

and may cause chest pain in those with pre-existing heart disease. Pregnant women are more susceptible to the effects of carbon monoxide exposure. The effects are also more severe in people who are working hard and in people who are working in places where the temperature is high or at altitudes above 2,000 feet. Skin exposure to liquid carbon monoxide may cause frost-bite-type burns.

• Reporting signs and symptoms

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to carbon monoxide.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to carbon monoxide at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of coronary heart disease, anemia, pulmonary heart disease, cerebrovascular disease, thyrotoxicosis, and smokers would be expected to be at increased risk from exposure. Pregnant women have an increased sensitivity to the effects of carbon monoxide. Examination of the cardiovascular system, the pulmonary system, the blood, and the central nervous system should be stressed.

—A complete blood count: Carbon monoxide affects the ability of the blood to carry oxygen. A complete blood count should be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, with the exception that a carboxyhemoglobin determination should be performed at any time overexposure is suspected or signs or symptoms of toxicity occur.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

• Summary of toxicology

Carbon monoxide (CO) gas causes tissue hypoxia by preventing the blood from carrying sufficient oxygen. CO combines reversibly with the oxygen-carrying sites on the hemoglobin molecule with an affinity ranging from 210 to 240 times greater than that of oxygen; the carboxyhemoglobin thus formed is unavailable to carry oxygen. In addition, carboxyhemoglobin interferes with the release of oxygen carried by unaltered hemoglobin. With exposure to high concentrations such as 4000 ppm and above, transient weakness and dizziness may be the only premonitory warnings before coma supervenes; the most common early aftermath of severe intoxication is cerebral edema. Exposure to concentrations of 500 to 1000 ppm causes the development of headache, tachypnea (rapid breathing), nausea, weakness, dizziness, mental confusion, and in some instances, hallucinations, and may result in brain damage. The affected person is commonly cyanotic. Concentrations as low as 50 ppm result in blood COHb levels up to 10% in an 8-hour day. This greatly increases the risk of angina pectoris and coronary infarctions by decreasing the oxygen supply in the blood and also in the myoglobin of the heart muscle. These effects are aggravated by heavy work, high ambient temperatures, and high altitudes. Pregnant women are especially susceptible to the effects of increased CO levels. Smoking also increases the risk: cigarette smoke contains 4% CO, which results in 5.9% COHb if a pack a day is smoked. The blood of persons not exposed to CO contains about 1% CO, probably as a result of normal heme metabolism. The diagnosis of CO intoxication depends primarily on the demonstration of significantly increased carboxyhemoglobin in the blood. Levels over 60% are usually fatal; 40% is associated with collapse and syncope; above 25% there may be electrocardiographic evidence of a depression of the S-T segment; between 15% and 25% there may be headache and nausea. The reaction to a given blood level of carboxyhemoglobin is extremely variable: some persons may be in coma with a carboxyhemoglobin level of 38% while others may maintain an apparently clear sensorium with levels as high as 55%. The blood of cigarette smokers contains 3 to 10% carboxyhemoglobin, and nonexposed persons have an average level of 1%, probably as a result of normal heme metabolism. Several investigators have suggested that the results of behavioral tests such as time discrimination, visual vigilance, choice response tests, visual evoked responses, and visual discrimination thresholds may be altered at levels of carboxyhemoglobin below 5%.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 28
2. Boiling point (760 mm Hg): -191.5 C (-313 F)
3. Specific gravity (water = 1): 0.79 (liquid at boiling point)
4. Vapor density (air = 1 at boiling point of carbon

monoxide): 0.97

5. Melting point: -199 C (-326 F)

6. Vapor pressure at 20 C (68 F): Greater than 1 atmosphere

7. Solubility in water, g/100 g water at 20 C (68 F): 0.004

8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity

1. Conditions contributing to instability: Elevated temperatures may cause cylinders to explode.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: None

4. Special precautions: None

• Flammability

1. Flash point: Not applicable

2. Autoignition temperature: 609 C (1128 F)

3. Flammable limits in air, % by volume: Lower: 12.5; Upper: 74

4. Extinguishant: Dry chemical. If flow of gas cannot be stopped, let fire burn.

• Warning properties

1. Odor Threshold: The AIHA *Hygienic Guide* points out that carbon monoxide is odorless.

2. Eye Irritation Level: Grant states that carbon monoxide is a non-irritating gas.

3. Evaluation of Warning Properties: Carbon monoxide is an odorless, non-irritating gas. It has no warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of carbon monoxide. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of carbon monoxide vapors using an adsorption tube with a subsequent chemical analysis of the adsorption

tube. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure carbon monoxide may be used. An analytical method for carbon monoxide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent the skin from becoming frozen from contact with liquid carbon monoxide or from contact with vessels containing liquid carbon monoxide.
- Any clothing which becomes wet with liquid carbon monoxide should be removed immediately and not reworn until the carbon monoxide has evaporated.
- Employees should be provided with and required to use splash-proof safety goggles where liquid carbon monoxide may contact the eyes.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to carbon monoxide may occur and control methods which may be effective in each case:

Operation

Liberation from emissions in enclosed places from exhaust fumes of internal combustion engines; from metallurgic industry and foundries; from chemical industry for synthesis and emission as result of incomplete combustion

Liberation during acetylene welding; from enclosed areas as mines or tunnels; from fire-damp explosions

Liberation from industrial heating

Controls

Local exhaust ventilation; respiratory protective device

Local exhaust ventilation; respiratory protective device

Local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Breathing

If a person breathes in large amounts of carbon monoxide, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

LEAK PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of leaks or releases until cleanup has been completed.
- If carbon monoxide is leaked or released in hazardous concentrations, the following steps should be taken:
 1. Ventilate area of leak or release to disperse gas.
 2. Stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair the leak or allow the cylinder to empty.

REFERENCES

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RESPIRATORY PROTECTION FOR CARBON MONOXIDE

Condition	Minimum Respiratory Protection* Required Above 50 ppm
Gas Concentration 500 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
1500 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 1500 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against carbon monoxide. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.