

# Occupational Health Guideline for Carbon Dioxide

## 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<sub>2</sub>
- Synonyms: Carbonic acid gas; "Dry Ice"; CO<sub>2</sub>
- Appearance and odor: Primarily a colorless, odorless gas; however, it can be a liquid or a solid.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for carbon dioxide is 5000 parts of carbon dioxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 9000 milligrams of carbon dioxide per cubic meter of air (mg/m<sup>3</sup>). NIOSH has recommended that the permissible exposure limit be changed to 10,000 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 30,000 ppm averaged over a 10-minute period. The NIOSH Criteria Document for Carbon Dioxide should be consulted for more detailed information.

## HEALTH HAZARD INFORMATION

- Routes of exposure  
Carbon dioxide can affect the body if it is inhaled. Solid carbon dioxide (dry ice) and compressed carbon dioxide gas from a cylinder can affect the body if it comes in contact with the eyes, skin, or mouth.
- Effects of overexposure  
Inhaling carbon dioxide may cause rapid breathing, rapid beating of the heart, headache, sweating, shortness of breath, dizziness, mental depression, visual disturbances, shaking, unconsciousness, and death. Skin,

eye, or mouth contact with solid carbon dioxide (dry ice) may cause frostbite. Similar effects may occur from carbon dioxide as it is being released from a cylinder.

- 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 dioxide.
- Recommended medical surveillance  
Routine medical examinations should be provided to each employee who is exposed to carbon dioxide at potentially hazardous levels.

- Summary of toxicology  
Carbon dioxide gas is an asphyxiant, a potent respiratory stimulant, and both a stimulant and depressant of the CNS. Respiratory volume is doubled at 4% CO<sub>2</sub> and redoubled at 5%. Increases in heart rate and blood pressure have been noted at 7.6% and dyspnea, headache, dizziness, and sweating occur if exposure at that level is prolonged. At 10% and above, prolonged exposure can result in unconsciousness. Above 11%, unconsciousness occurs in 1 minute or less. Numerous human fatalities have occurred after persons entered fermentation vats, wells, and silos where oxygen had been largely replaced by carbon dioxide. Exposure to very high concentrations, 25 to 30%, may cause convulsions. Carbon dioxide at room temperature will not injure the skin, but frostbite may result from contact with the solid or the liquid phases.

## CHEMICAL AND PHYSICAL PROPERTIES

- Physical data
  1. Molecular weight: 44
  2. Boiling point (760 mm Hg): -78.5 C (-109 F) (sublimation point)
  3. Specific gravity (water = 1): 1.02 (liquid)
  4. Vapor density (air = 1 at boiling point of carbon dioxide): 1.52
  5. Melting point: -78.5 C (-109 F) (sublimation point)
  6. Vapor pressure at 20 C (68 F): Greater than 1

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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.

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Public Health Service Centers for Disease Control  
National Institute for Occupational Safety and Health

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atmosphere

7. Solubility in water, g/100 g water at 20 C (68 F): 0.14

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

• **Reactivity**

1. Conditions contributing to instability: None  
2. Incompatibilities: Contact with chemically active metals such as sodium, potassium, or hot titanium may cause fire.

3. Hazardous decomposition products: None

4. Special precautions: Liquid or solid carbon dioxide will attack some forms of plastics, rubber, and coatings. See 29 CFR 1910.101 for specific regulations on storage of compressed gas cylinders.

• **Flammability**

1. Not combustible

• **Warning properties**

1. Odor Threshold: The AIHA *Hygienic Guide* states that carbon dioxide is an odorless gas.

2. Irritation Levels: Grant states that "carbon dioxide at high concentration in air causes a stinging sensation in the eyes, nose, and throat . . ."

3. Evaluation of Warning Properties: Since carbon dioxide has no odor, and since no quantitative information is available relating its irritant effects of to air concentrations, this gas has been treated as a material with poor 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 dioxide. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) 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 dioxide in a gas sampling bag, followed by gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure carbon dioxide may be used. An analytical method for carbon dioxide is

in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

## 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 solid carbon dioxide or from contact with vessels containing carbon dioxide.

## COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Liberation from fermentation in manholes, mine floors, wells, shipwells, brewery vats, garbage dumps, and fruit storage facilities	General dilution ventilation; local exhaust ventilation; personal protective equipment

Operation	Controls
Use in cooling and refrigerating for storage, preparation and transfer of foods; use as an inert gas in fire extinguishers; for protection of flammable materials during manufacture; in shielded arc welding; and in canned food production	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as an inert pressure medium for aerosol packaging; pressure spraying, spray painting, gas-operated firearms, purging tanks and pipelines, inflating liferafts, manufacture of plastic foam	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use in manufacture of carbonated beverages	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a neutralizing agent in textile processing and treatment of leather hides; use as shattering agent for coal mining; in fracturing and acidizing treatment of oil and gas wells	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use during water treatment for neutralizing alkaline waste waters; carbonating water to prevent scaling; use for chemical synthesis and pH control in manufacture of urea, aspirin, carbonates and bicarbonates, beer, and sugar	General dilution ventilation; local exhaust ventilation; personal protective equipment

Operation	Controls
Use in miscellaneous operations for enrichment of greenhouse air, antiseptic, industrial solvent extraction, medical use, in foundries, cement curing, and in animal slaughter	General dilution ventilation; local exhaust ventilation; personal protective equipment

## EMERGENCY FIRST AID PROCEDURES

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

- **Eye Exposure**

If solid carbon dioxide (dry ice) or carbon dioxide as it is being released from a cylinder gets into the eyes, get medical attention.

- **Skin or Mouth Exposure**

If solid carbon dioxide (dry ice) or carbon dioxide as it is being released from a cylinder comes in contact with the skin or mouth, stop the exposure immediately. If frostbite has occurred, get medical attention.

- **Breathing**

If a person breathes in large amounts of carbon dioxide, 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 until cleanup has been completed.

- If carbon dioxide is leaked, the following steps should be taken:

1. Ventilate area of leak 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 DIOXIDE

Condition	Minimum Respiratory Protection* Required Above 5000 ppm
Gas Concentration  50,000 ppm or less	Any supplied-air respirator.  Any self-contained breathing apparatus.
Greater than 50,000 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 escape self-contained breathing apparatus.

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