



# Carbon Monoxide

## The "Silent Killer"



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## Carbon Monoxide

Contents of this paper compile information of several reports and studies from experts. Additional reading material is referenced at the end of this document.

This information is intended, as an alert, for real estate managers, designers, building engineers, housing administrators, maintenance personnel, and building occupants of the hazards, causes, and precautions that are necessary to avoid injury and loss of life due to carbon monoxide (CO) poisoning.

Carbon monoxide poisoning can go undetected, even though you might be experiencing the signs or symptoms every day. It is vital that we understand what CO is and where it comes from, how we are exposed and what steps can be taken to reduce exposures.

**Carbon Monoxide (the “silent killer”) sends 15,000 people to the hospital every year; it kills an average of 500 U.S. citizens. Information contained within this report is intended to increase awareness; it might even save your life, or the lives of friends or family members. Awareness is the key.**

*(CDC, Morbidity and Mortality Weekly Report (MMWR), Apr 2011)*

## Carbon Monoxide is a Poison

### CO is a By-product of Incomplete Combustion of Hydrocarbon Fuels (Referenced by the Chemical Symbols H and C)

These fuels include gasoline, natural gas, heating oil, propane, wood, charcoal and similarly familiar products.

The "silent killer" is odorless, tasteless and colorless. Although odorless, it is important to note that some common odors can contain harmful or deadly levels of CO.

Such odors are often present, and because of their familiarity might be overlooked as non-hazardous. They may, however, be a contributing factor to an illness symptom that you or family members may be experiencing.

The link between symptoms of illness and the possible effects of CO poisoning should be clearly understood and recognized. CO is a deadly poison and, in lower concentrations, can cause illness in any individual, particularly those with vulnerable health issues.

Everyone is vulnerable to CO poisoning. Exposure potential is not limited to residential, real estate or related markets. In the U.S., more than 800 construction worker fatalities occur on the job annually. Many of these deaths happen when workers breathe in harmful chemicals. CO poisoning is the number one cause of death from inhalation of harmful chemicals. It is particularly dangerous because individuals can neither smell, see nor taste it, and it can kill within minutes. However, many of these deaths can be prevented.

## How Does Carbon Monoxide Harm You?

### CO Prevents Oxygen from Being Absorbed by the Body

Every part of our body needs oxygen. Air is made up of approximately 20.9% oxygen and 79% nitrogen. The hemoglobin within our blood carries oxygen to every cell in our body.

The hippocampus is the part of the brain that is involved in memory forming, organizing and storing. It is a limbic system structure that is particularly important in forming new memories and connecting emotions and senses, such as smell and sound, to memories. CO poisoning disrupts function in the hippocampus and other areas of the brain.

When you breath harmful amounts of CO, the CO molecule displaces the oxygen molecule as it transfers to the blood through the respiratory system. This displacement of oxygen in your blood begins a process that generates a free radical or a disassociated molecule reaction. At lower poisonous levels, typical symptoms include slower reaction time, weak muscular movement and dexterity, hampered visual focus, headache or nausea. Symptoms may be immediate or sufficiently toxic to cause heart stress as it starts to compensate for the loss of oxygen. CO poisoning has the potential to harm the central nervous system (CNS) because of the insufficiency of oxygen delivery.

When CO is inhaled into the lungs and bonds with hemoglobin in blood, it forms carboxyhemoglobin (COHb). This displacement of oxygen in the blood stream also affects major organs and muscles. CO is a chemical asphyxiant, particularly dangerous because it is odorless.



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### CO is Present Within Common Everyday Gases from Combustion and Combustion Exhaust Systems

For instance, exhaust from a motor vehicle or other internal-combustion engine left running in a garage is especially dangerous. It is even more dangerous if the garage is attached to a house, apartment or building which the gas can penetrate. People have been sickened or died while keeping their motor vehicles running while talking, sleeping or being romantically occupied in an enclosed space.

Prevailing winds, deep snow, mud, ditches and walls can contribute to this type of poisoning by restricting exhaust flow away from the vehicle, thereby bringing exhaust inside the vehicle.

Potential exposure to small amounts of CO may occur when you:

- burn charcoal, lamp oil or alcohol while camping
- are exposed to or inhale cigar, cigarette or pipe tobacco smoke
- are exposed to garbage, leaf, brush or forest fires which can produce sickening to deadly levels of CO, as can combustion gases from propane or gasoline fueled forklifts, floor buffers and power washers

Danger exists when levels of CO are allowed to accumulate in closed or confined spaces.

Most people have oil, gas or wood furnaces, water heaters, space heaters, cooking systems or fireplaces that are capable of producing amounts of CO. If not properly maintained or serviced, or if improperly vented, exposure may occur. Does your home or office have CO detectors? Are they in proper working order? When was the last time they were examined?

The misuse of gasoline powered electrical power generators can cause death or injury to people at work and during power outages. Use them cautiously, safely and far away from inhabited or enclosed buildings, campers and air conditioning.

#### CO Warnings

- Never use outdoor barbecues inside
- Never use gas or gasoline powered tools inside
- Be careful with unvented portable heaters

## How Much CO is Too Much?

### The Health Effects of CO Depend on the Concentration and Length of Exposure, as Well as Each Individual's Health Condition

CO concentrations are measured in parts per million (ppm). Most people will not experience typical symptoms from prolonged exposure to CO levels of less than 50 ppm; however, patients with cardiovascular disease might experience an increase in chest pain.

Air sampling in and around busy city streets has shown concentrations around 9 ppm. Marginal exposures (10 – 35 ppm) can affect small children, elderly and those suffering respiratory or heart problems.

The health effects can vary significantly due to age, sex, weight and an individual's overall state of health.

### When Does CO Become a Major Risk Factor?

Percent CO in Blood	Typical Symptoms
< 10	<ul style="list-style-type: none"> <li>• None</li> </ul>
10 – 20	<ul style="list-style-type: none"> <li>• Slight headache</li> </ul>
21 – 30	<ul style="list-style-type: none"> <li>• Headache</li> <li>• Slight increase in respirations</li> <li>• Drowsiness</li> </ul>
31 – 40	<ul style="list-style-type: none"> <li>• Headache</li> <li>• Impaired judgement</li> <li>• Shortness of breath</li> <li>• Increasing drowsiness</li> <li>• Blurring of vision</li> </ul>
41 – 50	<ul style="list-style-type: none"> <li>• Pounding headache</li> <li>• Confusion</li> <li>• Marked shortness of breath</li> <li>• Marked drowsiness</li> <li>• Increasing blurred vision</li> </ul>
> 51	<ul style="list-style-type: none"> <li>• Unconsciousness</li> <li>• Eventual death if victim is not removed from source of CO</li> </ul>

## Who is Responsible for the Air You Breathe?

### Your Awareness is Key

A CO alarm or detector should be used whenever a combustion system is used. The choice of alarms, detectors and monitors may be a matter of life, better health or death.

There are approximately 50,000 Emergency Room visits for CO poisoning in the U.S. annually. Increasingly, states and communities are requiring CO alarms in living quarters, including motels. Though many of these laws are limited in scope, they mark the start of greater societal recognition of and safety practices against the "silent killer." Sadly, several of these laws are named after children and other loved ones who have died from CO exposure.

Every day, CO news reports from around the world underscore the prevalence and commonality of accidental poisonings. Often these illnesses and/or deaths could have been prevented if the people affected were more aware or better educated to the dangers of this deadly gas. Had the building had a CO alarm, perhaps the injury could have been avoided.



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## Always be Prepared for CO

### Residential Carbon Monoxide Detection and Alarms

CO detectors and alarms can provide potentially life-saving early warning of CO exposure and allow building occupants to move to a safe, well-ventilated area before being overcome.

### Placement and Maintenance

Below are recommendations on the optimal placement and maintenance of residential CO detection and alarms:

- Always follow the manufacturer's instructions for placement, maintenance and testing of CO detection and alarms in residential buildings
- Install at least one CO alarm on every floor and in sleeping areas
- Make sure CO alarms are at least 15 feet away from cooking or heating appliances to prevent false alarms
- Don't cover or obstruct the unit
- Test the CO alarm monthly
- Replace batteries at recommended intervals
- Replace CO alarms every seven years to benefit from the latest technology upgrades

In addition to residential areas of buildings, it is a good idea to provide CO detection and alarms in areas of buildings that are adjacent to garages, restaurants, boiler rooms, HVAC rooms with gas or oil-fired equipment or other areas that could house CO producing equipment.

### Summary

There is a significant potential for exposure to CO in the real estate industry. Real estate managers, designers, building engineers, housing administrators, maintenance or construction personnel and building occupants must be made aware of the hazards, causes, precautions and controls that are necessary to avoid injury and loss of life due to CO poisoning.

## General References

### Information Readily Available for Download from the Internet Includes the Following

- **Department of the Navy**  
Naval Facilities Engineering Command — Carbon Monoxide White Paper:  
[https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac\\_ww\\_pp/navfac\\_hq\\_pp/navfac\\_sf\\_pp/navfac\\_sf\\_topics/sf\\_carbon/carbonmonoxide.pdf](https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_hq_pp/navfac_sf_pp/navfac_sf_topics/sf_carbon/carbonmonoxide.pdf)
- **CDC: Centers for Disease Control and Prevention**  
<http://www.cdc.gov/co/faqs.htm>
- **Carbon Monoxide: A fact sheet**  
[http://www.cdnsafety.com/articles/co\\_fact\\_sheet.htm](http://www.cdnsafety.com/articles/co_fact_sheet.htm)
- **EPA: United States Environmental Protection Agency**  
<http://www.epa.gov/iaq/co.html>
- **OSHA Occupational Safety and Health Guidelines for Carbon Monoxide**  
<http://www.osha.gov/SLTC/healthguidelines/carbonmonoxide/recognition.html>
- **National Fire Protection Association: Carbon Monoxide**  
<http://www.nfpa.org/categoryList.asp?categoryID=280&URL=Safety%20Information/For%20consumers/Fire%20&%20safety%20equipment/Carbon%20monoxide&cookie%5Ftest=1>
- **ASHRAE: Ventilation for Acceptable Indoor Air Quality**  
<http://www.ashrae.org/home/search?k=carbon+monoxide>
- **American Conference for Governmental Industrial Hygienist**  
<http://www.acgih.org>
- **Environmental Protection Agency Publications: Introduction to Indoor Air Quality — Carbon Monoxide**  
<http://www.epa.gov/iedweb00/co.html>
- **Carbon Monoxide Safety Association**  
<http://cosafety.org/Default.aspx>
- **Center for Hyperbaric Medicine; Section of Pulmonary and Critical Care Medicine, Virginia Mason Medical Center, Seattle, WA, USA; Reference: Undersea and Hyperbaric Medical Society**  
<http://membership.uhms.org/?page=CM>
- **Washington State**  
<http://www.ini.wa.gov/Safety/Topics/AtoZ/CarbonMonoxide/>
- **Occupational Safety and Health Guideline for Carbon Monoxide**  
<http://www.osha.gov/SLTC/healthguidelines/carbonmonoxide/recognition.html>



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## Addendum

### Sources of Carbon Monoxide

NAVFAC Criteria Office Carbon Monoxide 20 OCT 1999 White Paper

#### Source — Flue Gases; Controls

Proper design, installation, preventive maintenance and repair of gas exhaust flues are essential to the prevention of CO exposure from flue gasses. Design, installation, maintenance and repairs should only be performed by qualified, trained personnel who are familiar with the potential dangers of improper exhaust of flue gasses.

#### Source — Fuel-fired Air Furnace Heat Exchanger Leakage; Controls

Proper maintenance of fuel-fired heating systems should be performed to ensure that heat exchangers remain in good condition. A qualified person should test the system regularly with a CO detection instrument to ensure that gases from fuel combustion are not leaking into the heated building air supply.

#### Source — Dirty Furnace Air Filters and Blockages; Controls

Licensed building Heating, Ventilation and Air Conditioning (HVAC) maintenance personnel or contractors should inspect HVAC filters regularly to ensure that they are clean. They should further inspect supply and return air ducts regularly to ensure that there are no kinks, obstructions or other restrictions that could cause increased pressures and cracks in the heat exchangers.

#### Source — Hot Water Boiler; Controls

Licensed Building Engineers should ensure that boiler chemicals are maintained within proper operating levels and that preventive maintenance is performed on the equipment at proper intervals. Boiler inspections should be performed by licensed as required by state regulatory authorities.

#### Source — Gas-fired Natural-draft Water Heaters and Hot Air Furnaces; Controls

Repairs, maintenance, relocation or other changes to gas-fired water heaters should only be made by qualified contractors.

#### Source — Attached Laundry Room or Garage Installation; Controls

Do not start, warm up, tune up or operate any automobile, motorcycle, snowmobile, boat, personal watercraft, lawn mower, generator or other internal-combustion engine powered machine inside. Also, such equipment should not be operated near the open door of an attached garage or laundry room since CO can penetrate these spaces. CO concentrations may build up quickly, especially if there are other fuel-burning appliances operating in the laundry room or garage. If operating an engine outdoors, make sure the exhaust is not entering the residence through open doors, windows or outside air intakes, including window air conditioners.

#### Source — Fireplaces and Wood Stoves; Controls

Always ensure that the fireplace or wood stove flue damper is open and unobstructed before lighting a fire. Do not close the flue damper before a fire is completely out since this may divert the carbon monoxide in the flue gasses into the room.

**Source — Smokers; Barbecues and Grills; Controls**

Gas, charcoal or wood-fired smokers, barbecue appliances and grills should never be used indoors or in a confined, unventilated area.

**Source — Gas-fired Clothes Dryers; Controls**

Clean the dryer air filter before every load, and clean the dryer flue or exhaust duct every month. This is also good practice for electric-heat clothes dryers, in order to reduce the accumulation of highly combustible lint which creates a fire hazard.

**Additional Factors**

The operation of exhaust fans in kitchens, laundry rooms, and bathrooms, as well as window fans and clothes dryer fans may result in increasing the potential for CO in the residence. All may remove more air from the residence than can be readily replaced from outside — especially from new, tightly constructed energy-efficient residences.

**Source — 800 Construction Worker Fatalities**

[http://www.dol.gov/dol/media/webcast/20111031-oshacarbonmonoxide\\_fnl\\_eng\\_web-captions.htm](http://www.dol.gov/dol/media/webcast/20111031-oshacarbonmonoxide_fnl_eng_web-captions.htm)

**Source — “Silent Killer”**

Underwriters Laboratories, *Protect Your Family from the ‘Silent Killer’*

<http://www.ul.com/global/eng/pages/offerings/perspectives/consumer/stories/carbonmonoxide/>

**Source — Approximately 50,000 Emergency Room**

Hampson NB, Weaver LK. *Undersea Hyperb Med* 2007; 34(3):163-8.

Affiliation: Center for Hyperbaric Medicine; Section of Pulmonary and Critical Care Medicine, Virginia Mason Medical Center, Seattle, WA, USA; Reference: Undersea and Hyperbaric Medical Society)

**Source — In Vitro Absorption of Atmospheric Carbon Monoxide and Hydrogen Cyanide in Undisturbed Pooled Blood**

FAA (Federal Aviation Administration) report dated September 2012 titled: “In Vitro Absorption of Atmospheric Carbon Monoxide and Hydrogen Cyanide in Undisturbed Pooled Blood” with heading “DOT/FAA/AM-12/13 Office of Aerospace Medicine Washington, DC 20591” <http://library.erau.edu/find/online-full-text/faa.html#11>



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