



New Jersey State Firemen's Mutual Benevolent Association

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Carbon Monoxide

Introduction

Carbon monoxide (CO) is a poisonous and potentially lethal gas, produced as a by-product of incomplete combustion. It is present at all fire calls, and in some cases medical calls. CO is odorless, colorless and tasteless and the only way to detect the presence of it is with a gas monitor. The information provided in this data sheet is only a small representation of the knowledge currently available about CO. As an occupation, firefighting has a high frequency of exposure to CO. A firefighter is three times more likely to die of a heart attack at work than people in any other occupation in the US. Heart attacks account for over 44% of firefighter in-the-line-of-duty deaths annually. It is also a fact that CO exposure has the ability to induce a heart attack and go virtually undetected.

Listed below are some *commonly* known facts about CO:

- Potentially lethal
- Present during Overhaul Operations
- Slightly lighter than air, with a specific gravity of 0.97
- Explosive range of 12 to 75 %
- Odorless, colorless, and tasteless
- IDLH of 1200 PPM @ ½ hour*

Listed below are some *uncommonly* known facts about CO:

- CO is absorbed into blood at a 240 times greater rate than oxygen
- In most cases, CO poisoning goes undetected because it is not diagnosed in the first place. CO exposure statistics are vague at best.
- Individuals with occupations or lifestyles that have regular exposure to CO can become ASYMTOMATIC (will not show symptoms of exposure), i.e., firefighters, toll workers, tunnel workers, smokers.
- Auto ignition temperature 1128 degrees F. (Flashover hazard)

*OSHA Standard IDLH (Immediately Dangerous to Life and Health) of 1200 ppm reflects **healthy** individuals at **resting** respirations.

EFFECTS

The effects of CO exposure vary greatly and there is no absolute standard in how exposure to CO will affect individuals. There are many variables that come into play with individual tolerances, such as: weight/body mass, metabolism, age and pre-existing medical conditions.

SPECIAL GROUPS AT GREATEST RISK

- Embryos and fetuses
- People with coronary heart disease
- Young children
- Healthy senior citizens
- People at high altitude

COMMON SYMPTOMS

Being aware of a possible of CO poisoning is crucial, as acute high levels of CO poisoning can be fatal in just a few minutes. The symptoms are usually multiple, many are non-specific, and some are vague. They can involve many of the body systems.

The symptoms of low level CO poisoning include headaches, nausea, weakness, dizziness and confusion. CO exposure causes a victim's blood pressure to rise in an attempt to get more oxygen to the body. The symptoms at low levels are very similar to what a person might exhibit if affected by the flu or other common illnesses. Therefore, carbon monoxide is sometimes referred to as the "Great Imitator."

As CO exposure increases, more serious symptoms develop, such as lack of coordination, chest pain, vomiting and loss of consciousness. If a person is exposed to carbon monoxide long enough, coma and death can occur.

Symptoms in Order of Increasing Severity of CO Poisoning:

- Headache
- Dizziness and vertigo on exertion
- Fatigue, weakness
- Palpitations
- Tinnitus
- Nausea, vomiting
- Mental confusion, difficulty with thinking, speaking
- Fine manual dexterity abnormal
- Tachycardia
- Visual disturbances, blurry vision, double vision
- Hallucinations, confusion
- Tachypnea (increased ventilation), further tachycardia
- Coma, convulsions
- Pupils fixed, dilated
- Cardiac and ventilatory depression
- Cardio respiratory failure (death)

EXPOSURE LIMITS

- OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for carbon monoxide is 50 parts per million (ppm) parts of air (55 milligrams per cubic meter (mg/m³)) as an 8-hour time-weighted average (TWA) concentration [29 CFR Table Z-1].

- NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for carbon monoxide of 35 ppm (40 mg/m³) as an 8-hour TWA and 200 ppm (229 mg/m³) as a ceiling [NIOSH 1992].

- ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned carbon monoxide a threshold limit value (TLV) of 25 ppm (29 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 15].

- Rationale for Limits

The NIOSH limit is based on the risk of cardiovascular effects [NIOSH 1992].

The ACGIH limit is based on the risk of elevated carboxyhemoglobin levels [ACGIH 1991, p. 229].

Carbon Monoxide Level in ppm (Parts per Million)	Resulting Conditions/Effects on Humans
50	Permissible Exposure Level (PEL) for 8 hours (OSHA)
200	Possible mild frontal headache in 2 to 3 hours
400	Frontal headache and nausea after 1 to 2 hours; Occipital headache (back of head) after 2 to 3 hours
800	Headache, dizziness, and nausea in 45 minutes; Collapse and possible death in 2 hours
1,600	Headache, dizziness, and nausea in 20 minutes; Collapse and possible death in 1 hour
3,200	Headache and dizziness in 5 to 10 minutes; Unconsciousness and danger of death in 30 minutes
6,400	Headache and dizziness in 1 to 2 minutes; Unconsciousness and danger of death in 10 to 15 minutes

12,800	Immediate effects: unconsciousness; danger of death in 1 to 3 minutes
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TREATMENT

100% oxygen is recommended to be administered to an individual thought to have been exposed to CO.

The half-life of CO in normal air (21% oxygen) is approximately 4-5 hours.

Breathing 100% oxygen reduces the half-life in approximately 80 minutes.

Hyperbaric chamber treatment reduces the half-life in approximately 23 minutes.

EFFECTS OF SHORT-TERM EXPOSURE

CO has detrimental effects to the cardiovascular system and central nervous system. Exposure at high levels may result in lowering of consciousness and death.

EFFECTS OF LONG-TERM OR REPEATED (CHRONIC) EXPOSURE

CO affects the nervous system and cardiovascular system, resulting in neurological and cardiac disorders. CO is suspected to cause reproductive effects such as neurological problems, low birth weight, increased still births, brain damage and congenital heart problems.

SUMMARY

The effects of carbon monoxide poisoning are still not clearly understood. There are many variables to consider. Continuing studies will enable us to better understand the long term health risks. The vulnerability is quite clear with regard to firefighters.

Heavy gear, heavy workload, and elevated respirations combined together can be dangerous, even when levels CO are low.

Researched by Kevin Reilly, FMBA Local #47

Organizations

New Jersey Firemen's Mutual Benevolent Association

www.njfmba.org

New Jersey State Department Health, Public Employees Occupational Safety and Health

<http://www.state.nj.us/health/eoh/peoshweb/>

New Jersey State Department Health, Division of Environmental and Occupational Health
Services Right to Know Program

<http://www.state.nj.us/health/eoh/rtkweb/>

American Conference of Governmental Industrial Hygienists

<http://www.acgih.org/>

Carbon Monoxide Headquarters

<http://www.coheadquarters.com/index.htm>

National Fire Protection Association

www.nfpa.org

National Institute of Occupational Safety and Health

<http://www.cdc.gov/niosh/homepage.html>

Occupational Safety and Health Administration

<http://www.osha.gov/>

National Safety Council

<http://www.nsc.org/>

Carbon Monoxide Headquarters

<http://www.coheadquarters.com>

U.S. Consumer Product Safety Commission

<http://www.cpsc.gov>

APPENDIX*

CO EXPOSURES AND SCALE OF EFFECTS FROM ZERO TO ONE MILLION PARTS PER MILLION (ppm)

(Modified from Donnay, 2001)

<<<1 ppm (20-30 nanomoles/L tissue water; 0.56 ul/L) - Naturally/normally found in human tissues; a concentration 3-4 orders of magnitude smaller than would be possible based on its solubility in water (at body temp. & 760 mmHg max. solubility = 18.3 ml/L.). CO appears to play a physiological role in vasomotion, etc.

<1 ppm - Amount of CO in clean air.

0.4 - 1.6 ppm - Range of average ambient outdoor CO exposure over which asthma prevalence among middle schoolers was linearly correlated, and more significantly than with any other pollutant studied (NO_x, SO_x, Ozone, or particulates of any size) (Hajat et al., Thorax, 1999; Norris et al., Environ. Health Perspectives, 1999).

1 ppm = 0.0001% - Increase in average ambient outdoor CO was associated with a 30% increase in the odds of unmedicated asthmatic children reporting symptoms the next day - stronger association than with any other pollutant studied: (Environ. Health Perspectives, Dec., 2000).

See the page on relationship between ppm and % of CO

0 - 2 ppm - Range of CO found in end-tidal breath (ETCO_b) of healthy non-smokers due to systemic but variable endogenous CO production.

2 ppm (+/-2.5) - Level of CO found in U.S. homes.

3 - 4 ppm - Borderline range for ETCO_b in non-smokers.

5 ppm - Lowest level of CO displayed by first-AIM low-level CO monitors (not approved by UL or CPSC).

3 - 7 ppm - A 6% increase in the rate of admission of non-elderly for asthma was associated with a change in CO in Seattle, Washington (Sheppard et al., Epidemiology, 1999).

>5.5 ppm (3-month average) - CO level above this value during the last trimester of pregnancy was associated with a significantly increased risk for low birth weight in Los Angeles study of 125,573 pregnancies (Ritz & Yu, Environ. Health Perspectives, 1999).

5 - 10 ppm - Range of increase in average outdoor CO found associated with a significant increase in heart disease deaths and hospital admissions for congestive heart failure.

5 - 25 ppm - Normal range of ETCOb in smokers who have not recently smoked.

9 ppm - US EPA's national ambient air quality standard 8-hour average (TWA) limit for CO exposure outdoors (rarely ever exceeded now in U.S. cities).

- WHO 8-hour average (TWA) limit for CO exposure outdoors.
- ASHRAE recommended indoor CO limit.
- "Action" level with regard to CO for many public safety organizations.
- Level above which many public safety organizations (fire departments, etc.) red-tag and prevent further use of combustion devices.
- Lowest CO level producing significant effects on cardiac function (ST-segment changes, angina) during exercise in subjects with coronary artery disease. (Allred et al., Environ. Health Persp., 1991, and others).

10 ppm = 0.001%

11 ppm - Health Canada's 8-hour average legal limit for any CO exposure.

15 - 35 ppm - Range of ETCOb found in non-smokers recently and chronically exposed to high levels of CO indoors from inadequately vented combustion appliances in their homes.

20 ppm - US OSHA heat exposure standard: maximum allowable ETCOb post shift in non-smokers.

25 ppm - WHO 8-hour average limit for any CO exposure.

25 ppm - 150 ppm - ETCOb of smokers immediately after smoking.

30 ppm - Lowest CO level that US CPSC and UL/CSA allow home CO alarms to display (based on UL standard #2034, 3rd revision, OCT., 1998). The health reasons for this are obscure.

35 ppm - US EPA's national ambient air quality standard 1-hour average limit for CO exposure.

- US NIOSH recommended 8-hour average limit for occupational CO exposure
- Level above which Baltimore City fire fighters use self-contained breathing apparatus.

50 ppm = 0.005% CO - US OSHA 8-hour average legal limit for occupational CO exposure (the highest occupational CO limit in the world)

70 ppm - Lowest CO level at which US CPSC and UL/CSA allow home CO alarms to alarm, but only after 1 - 4 hours of exposure. The health reasons for this are also obscure.

100 ppm = 0.01% CO - Level at which Baltimore City F.D. orders evacuation of any building (12-14% COHb at equilibration). Many safety agencies will often do so at far lower CO concentrations.

100 - 1,000 ppm = 0.01%-0.1% CO - Range of CO found in exhaust of gasoline-powered motor vehicles with hot (working) catalytic converters.

200 ppm - Level at which US NIOSH recommends immediate evacuations of any building - level above which US CPSC and UL approved home CO alarms must sound after 30-60 min. - Level of CO (air-free) allowed inside water heater flues by an American gas association (now ANSI) standard.

200 - 300 ppm - Range of CO in exhaled (diluted) cigarette smoke (exceeds water heater limit!).

400 ppm - Level above which CPSC and UL approved home CO alarms must sound after 5-15 min.

- Level of CO (air-free) allowed inside furnace flues by an American gas association (now ANSI) standard.

500 ppm = 0.05% CO - Roughly the level of CO thought to be lethal in humans exposed over a period of many hours (42-45% COHb at equilibration).

800 ppm - (air-free) Level of CO allowed inside oven flues by an American gas association (now ANSI) standard, # Z21.1. [This level is unchanged since 1921 when oven flues were still vented outdoors like woodstoves, instead of directly into the kitchen as they have since 1950s!]

1,000 ppm = 0.1% CO - Level of CO commonly considered rapidly lethal in humans (approx. 62% COHb at equilibration).

1,000 - 5,000 ppm - Level of CO in exhaust gases from "well-tuned" diesel engines.

1,200 ppm = 0.12% CO - Level of CO declared by US NIOSH to be immediately dangerous to life and health (potentially lethal within minutes, certainly within a few hours).

3,000 - 10,000 ppm - Level of CO in exhaust gases from "well-tuned" propane-powered forklift trucks (i.e. hilos) without functioning catalytic converters. Dangerous!

5,000 ppm = 0.5% CO - CO level in coal gas used almost exclusively for gas lighting in the USA from 1819-1865 (thereafter until widespread introduction of natural gas in the 1950's, coal gas was usually mixed with other gases containing even higher concentrations of CO).

10,000 - 100,000 ppm = 1% - 10% CO - Range of CO found in exhaust of gasoline-powered vehicles without catalytic converters or with converters that are cold or otherwise not working. Dangerous!

220,000 - 300,000 ppm - CO concentration undiluted blast furnace (steel-making) gases.

250,000 - 350,000 ppm = 25% - 35% CO - Range of CO in mixed or utility gas made from 1870s until 1940s by mixing coal gas (5% CO) and water gas (50% CO).

500,000 ppm = 50% CO - Water gas (made by spraying water onto hot coals, $C + H_2O = H_2 + CO$). Invented in Paris, but banned there in 1854 as too deadly. Introduced in the USA in 1858 and widely used in mixtures with coal and/or other gases until 1940s for lighting, heating, cooking and in industry. Banned only in Massachusetts from 1880 - 1890.

1,000,000 ppm = 100% CO - pure CO: one breath is instantly lethal; at this level, CO kills neurologically, not via hypoxia, and COHb remains normal.

* Referenced from www.coheadquarters.com

