REFERENCE DATA SHEET ON CARBON MONOXIDE (CO)

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Potential Problem Areas:

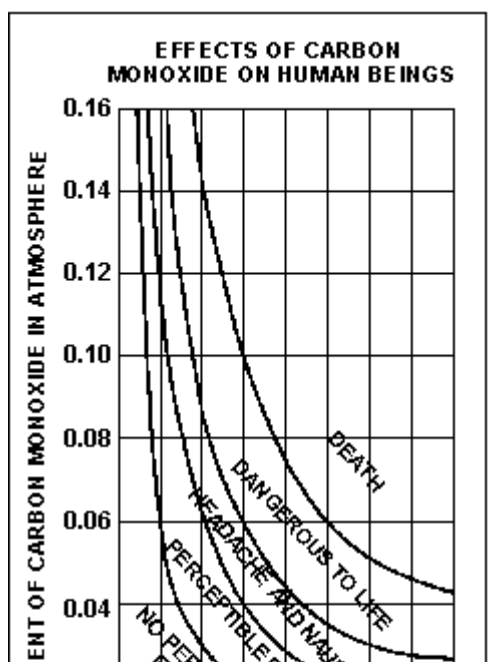
- Disconnected chimney flue
- Failure of heat exchanger
- Tight buildings/down drafts/low chimneys
- Restricted air intake/furnaces installed in closets
- Misadjusted burners
- Incorrect gaseous fuel usage
- Malfunctioning flue damper
- Use of oven/stove for area heating
- Smoldering charcoal/unvented hydrocarbon fuel heaters
- Blast-furnace operations
- Failure of carbon monoxide monitors
- Forklift truck/vehicle operation indoors
- Heating trailers with cooking appliances
- Water gas generation equipment

PHYSICAL DATA

A gas at normal conditions: odorless; colorless; tasteless; approximately the same density as air; slightly soluble in water; supports combustion at concentrations of greater than 12% by volume.

IMPLICATIONS:

There are few sensory indicators to over-exposure. CO generally diffuses or mixes evenly in air. Leaks from blast-furnace operations might be an exception.

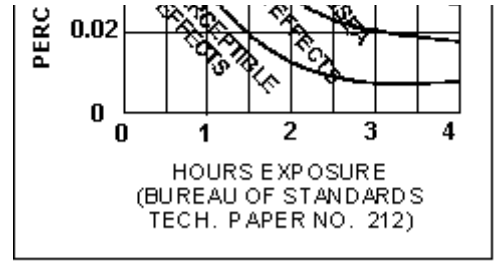


HEALTH EFFECT DATA:

Hemoglobin has 300 times the affinity for CO as it does for oxygen. The proposed OSHA allowable 8-hour/day exposure level is 35 ppm with a "ceiling" limit of 200 ppm. Short-term effects are related to concentration levels and duration. Minimum doses above allowable levels result in such symptoms as headache, nausea, and dizziness. Exposures of 1000 ppm for two hours will cause more than half of an exposed group to lose consciousness, death will quickly occur for most at 10,000 ppm. Smokers and individuals working around vehicular traffic have elevated carboxyhemoglobin levels, breathing oxygen enriched air is a common treatment.

IMPLICATIONS:

Not all exposures to CO are harmful at elevated levels. CO can quickly affect a person, and the concentration and duration are needed to determine degree of exposure. Breathing oxygen can quickly lower the blood carboxyhemoglobin level. Smokers and others can have elevated levels of carboxyhemoglobin.



CARBON MONOXIDE EFFECTS
How concentration and exposure affect human beings.

CO SOURCES:

Carbon monoxide comes primarily from incomplete combustion of carbon containing fuels. Increased generation rates result from insufficient oxygen levels or poor fuel/air mixing. The rate of generation can change substantially depending on several variables.

Examples:

1. **Furnaces:** blocked exhausts, restricted air intakes, plugged burner orifices, cracked heat exchangers, down-drafts in chimneys, tight-house effects, fuel rich conditions.

2. **Automobiles/vehicles:** leaks in exhaust systems, overly rich fuel/air ratios, non- operating catalysts and emission systems, operation in a confined area, leaks into occupancy compartments, restricted forced or natural ventilation.

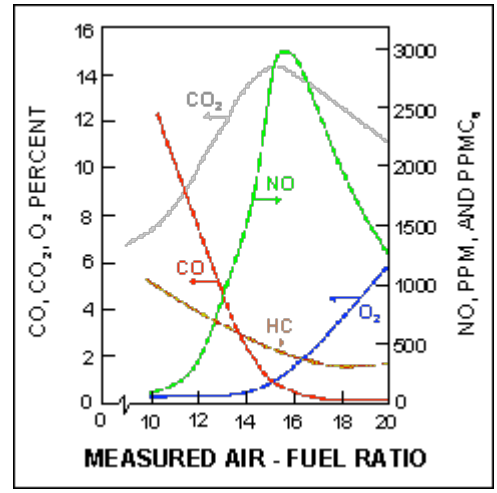
3. **Ovens:** unvented gas stoves and ovens operated for heating purposes in confined area, ovens used in trailers, restricted orifices, debris in a combustion zone, incorrect fuel, improper pressure, blocked exhaust flow on vented units.

4. **Space Heaters:** incorrect fuel, improper ventilation, tight house, use in tents, combustion related problems, cool operating conditions.

   (Note: 9.5 ft³ air required to burn 1 ft³ of natural gas, 23.8 ft³ of air required to burn 1 ft³ of propane; therefore the fuel-to-air ratio changes, and CO production levels change.)

5. **Hot Water Tanks:** broken or disconnected flue, debris in combustion zone, fuel pressure problems, tanks installed in air-tight areas, horizontal flue installations, vent height inadequate or too small in diameter.

6. **Cigarette Smoke:** normal cigarette smoke contains enough CO to result in carboxyhemoglobin levels in smokers of 4% to 20%, with a one-pack-per day smoker having an average of about 5%.



Summary of Exhaust-Gas Constituent

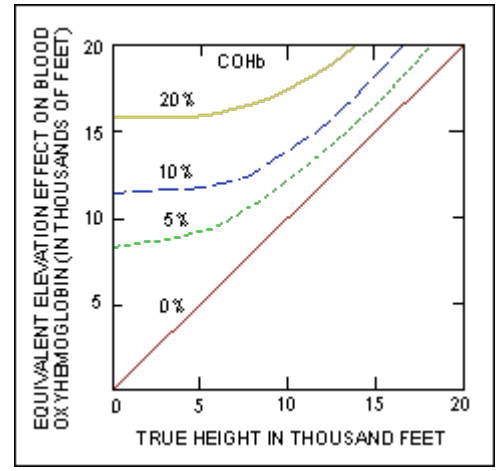
AIR FUEL	PERCENT BY VOLUME				
	CO_2	O_2	CO	N_2	H_2O
11	8.76	0.15	9.14	77.08	13.78
12	10.18	0.44	6.65	79.13	13.93
13	11.60	0.59	4.31	81.09	14.16
14	13.02	0.63	2.09	82.99	14.46
15	13.23	1.35	0.99	83.72	14.09
16	12.62	2.49	0.68	83.65	13.30
17	12.00	3.55	0.48	83.51	12.54
18	11.45	4.49	0.30	83.39	11.88
19	10.90	5.36	0.20	83.23	11.25
20	10.40	6.15	0.11	83.07	10.68
21	9.92	6.86	0.08	82.90	10.16
22	9.44	7.55	0.06	82.71	9.65
23	9.00	8.18	0.05	82.53	9.19
24	8.60	8.74	0.06	83.37	8.78

(Fuel is gasoline)

IMPLICATIONS:

Although there are several sources for CO exposure, there are a

few common problems related to combustion, such as inadequate ventilation, tight buildings, and fuels which allow CO to be released, causing over-exposure conditions.

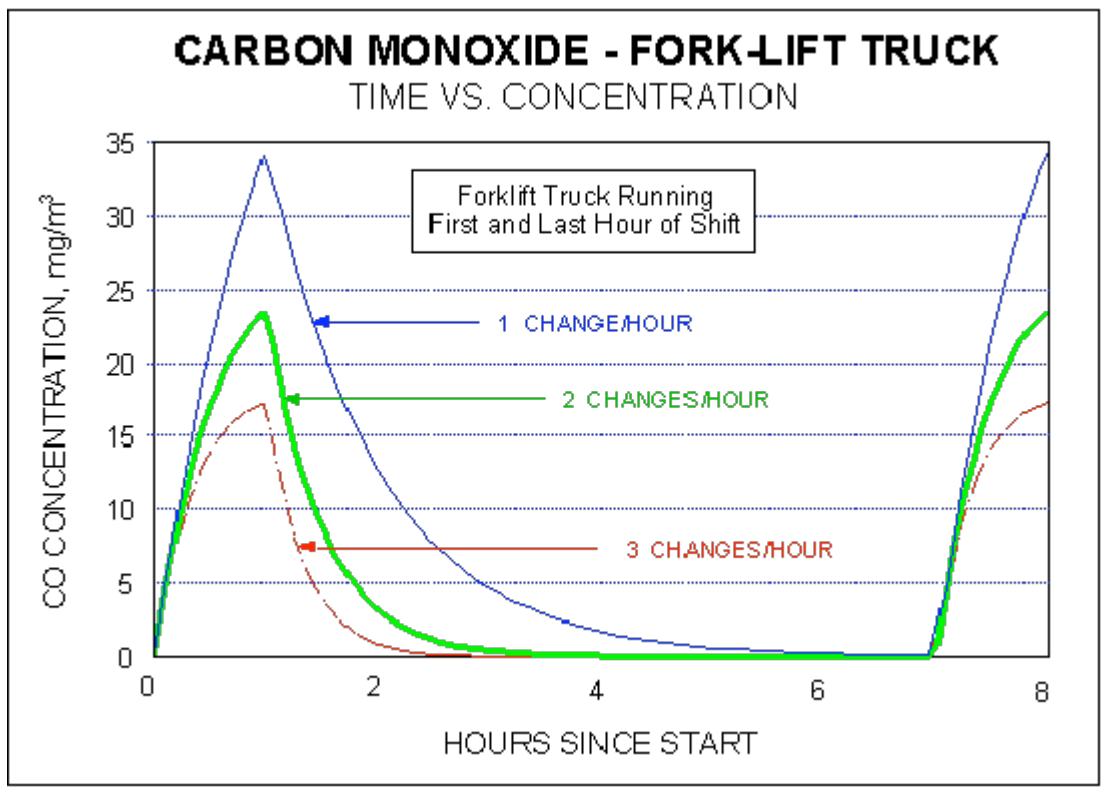


Mitigating And Aggravating Conditions:

- Blood carboxyhemoglobin levels are often a poor indicator of CO exposure levels, unless measured soon after cessation of CO exposure. Treatment with oxygen-enriched breathing air reduces the blood level more quickly. Often the quantity and duration of treatment is undocumented and insufficient to determine prior maximum levels. Smokers will naturally have elevated levels. Ambient levels of CO, especially in heavy traffic conditions, can also result in elevated blood levels. Altitude can effect exposure and exposure levels can be expressed in terms of equivalent altitude.

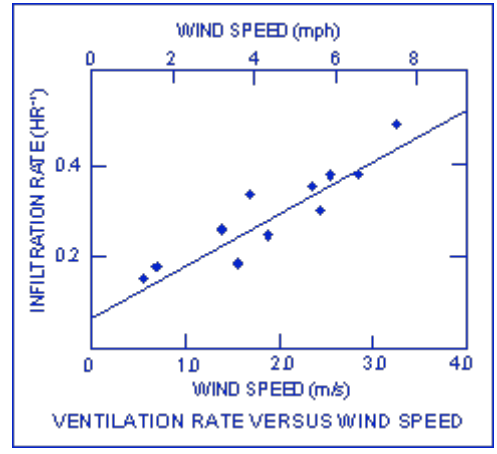
- Extremes in ambient weather conditions can contribute to variations in CO generation and release rates. Down drafts and inversions may enhance releases of CO in buildings. Frequent cycling on and off of combustion equipment may enhance CO generation. Natural infiltration into buildings may substantially reduce CO levels within the structure. Tests indicate many older buildings have a complete air exchange in half an hour.

- Tight buildings may restrict the availability of combustion air causing an increased generation of CO. Tight buildings may also reduce the amount of infiltration, increasing the rate and maximum level of CO concentration. Placement of combustion sources in closets requires additional considerations.



Effects of three different air exchange rates on CO levels from forklift truck operation.

- Under some combustion conditions, there may be odors resulting from other companion emissions.
- If the gases from the combustion source are sufficiently hot, they may initially act as a buoyant gas and move upward.
- Heavy work activities will increase the rate of uptake of CO and cause earlier onset of symptoms. Preexisting adverse health conditions may also aggravate the effects of exposure.
- The concurrent exposure to methylene chloride can increase the potential exposure to CO as it is metabolized to CO within the body.



- Smokers have initial carboxyhemoglobin levels of 4% to 20%, and will reach dangerous levels more quickly than non-smokers.

Measurement Of Carbon Monoxide:

The easiest method of measurement of carbon monoxide levels is the use of length-of-stain detector tubes. These are available from several manufacturers, including Draeger, MSA, and Sensidyne/Gastec. Tubes are available for low and high ranges of CO. In most cases, a tube with a lower range, such as 5 to 700 ppm CO, is suitable for measurement in inhabited areas. These tubes usually have an accuracy of ± 25% or better and have a limited shelf life. Interfering gases may be acetylene, petroleum distillates, benzene, hydrogen sulfide, or trichloroethylene; but most are absorbed in a precleanse layer in the tube. The manufacturer's instructions should be consulted for the tube that is being used. A hand-operated pump is required for these tubes. The tubes should always be used with a pump from the same manufacturer.

Documentation:

There are several OSHA, ACGIH, and NIOSH documents concerning allowable exposure levels. The effects of exposure based on concentration and duration of exposure are well documented. Emission factors from various sources already exist which allow the estimation of generation rates. Computer models allow calculation, overtime, of the concentration of exposures. Data on infiltration rates for various buildings have been determined by tests and can be verified for specific building configurations.