Michigan Department of Labor and Economic Opportunity
Michigan Occupational Safety and Health Administration
Consultation Education and Training Division

Carbon Monoxide Hazards from Internal Combustion Engines

Properly Maintained Forklifts Cost Significantly Less to Operate

Employers are responsible to maintain air contaminant concentrations within the limits, as required by the following occupational health air contaminant standards:

1. Part 301 (General Industry), R325.51101 *et seq.*, and
2. Part 601 (Construction), R325.60151, *et seq*

Where employees have exposures to air contaminants, the employer must provide appropriate protections and hazard communication training.

Agriculture, construction, and general industry employees are exposed to carbon monoxide (CO) when using fuel-burning equipment indoors or in enclosed spaces. This toxic gas may become dangerously elevated if the equipment is not properly maintained and ventilation is inadequate. Industrial lift trucks, automobiles, aerial lifts, floor burnishers, generators, power washers, compressors, concrete cutters, and concrete trawlers are some examples of fuel-burning equipment that emit this toxic gas.

Employers are required to maintain employee exposures within established exposure limits and to conduct employee CO awareness training for employees who may be exposed to CO. By training employees on the symptoms of and medical responses to CO poisoning, employers can avoid an otherwise reversible illness from progressing to permanent neurological damage or death.

Legal employee exposure limits related to carbon monoxide (CO)

For General Industry, the primary limit is an eight hour Time-Weighted Average (TWA). Other limits are a Short Term Exposure Limit (STEL) and a Ceiling limit (C). For Construction, the primary limit is called the Maximum Allowable Concentration (MAC). The exposure limits for CO are listed below. Specific sampling equipment is necessary to test the air and determine an employee's exposure to air contaminants.

MIOSHA Part 301 Air Contaminants for General Industry, Rule 8, Table G-1-A
Time-Weighted Average (TWA) = 35 ppm (parts per million parts of air)

Ceiling limit (C) = 200 ppm

MIOSHA Part 601 Air Contaminants for Construction, Rule 5, Table 3
Maximum Allowable Concentration (MAC) = 50 ppm

The National Institute for Occupational Safety and Health (NIOSH) has recommended an immediately dangerous to life and health (IDLH) concentration as 1200 ppm CO.

With a combination of engine tuning (periodic equipment maintenance), mechanical exhaust ventilation, and exposure monitoring, employers are able to maintain exposures below established limits.

Warning Signs of CO Poisoning

This lethal poison is colorless, tasteless, odorless and non-irritating. Excessive exposures cause weakness and confusion and exposed individuals may have trouble seeking safely. Indoor air contamination levels may rise quickly, even in relatively open spaces with ventilation. Therefore, it is imperative that employers train employees to recognize sources and warning signs of CO poisoning; light-headedness, dizziness, nausea, headache, visual disturbances, changes in personality, and confusion.

In addition, employees who use fuel-burning equipment indoors should be made aware of the medical attention that may be required when employees become poisoned. Victims of CO poisoning should be removed from the exposure and given oxygen. Placement in a hyperbaric chamber may be necessary in cases of severe poisoning.

Maintaining Low CO Emissions

Carbon monoxide is one of many chemicals found in engine exhaust. Industrial lift trucks, because of their prevalence, are one of the main sources of CO in the workplace. Generation rates vary with vehicle power and fuel type. When feasible, electric-powered vehicles or tools can be used. Liquefied propane gas (LPG), compressed natural gas (CNG), and diesel are better fuel choices than gasoline, although all produce CO.

To achieve good vehicle performance while maintaining low CO emissions, vehicle engines should be in good working condition and properly maintained. Employers should request lift truck maintenance providers to tune their vehicles using an exhaust gas CO analyzer to limit CO emissions. Tuning fuel-burning equipment for substantial reductions in CO emissions can be accomplished with minimal reduction in power.

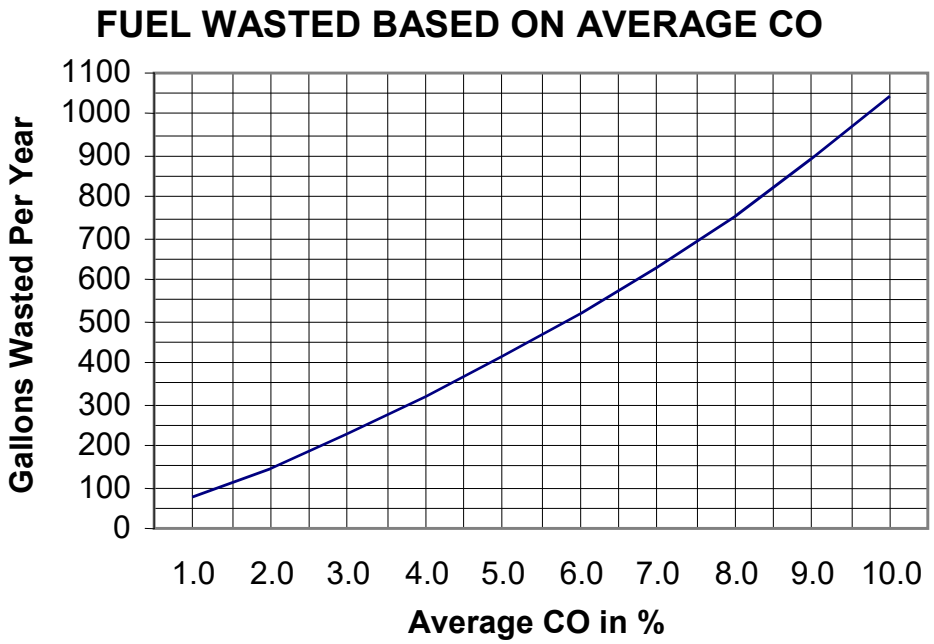
Specifically, periodic maintenance tuning for engines should include:

- Use properly-sized carburetors designed for optimum air and fuel mixture balance,
- Service the air cleaner regularly.
- Adjust engine timing per manufacturer's specifications.
- Use a CO analyzer designed for tailpipe exhaust sampling when adjusting the fuel system to approximately 0.4 to 0.7% CO.

Fuel Costs Are High with Excessive CO Emissions

Lowering CO will save fuel and operating dollars. Since fuel economy is best when CO is near 0.5%, any CO above this level indicates wasted fuel. A forklift with an average CO level of 5% to 8% can be wasting 400 to 750 gallons of fuel per year. It is not uncommon to see CO levels on older lift trucks in excess of 5% CO.

Below is a graph showing the gallons of propane wasted for different levels of CO in the exhaust. A forklift with an average CO level of 7.5% operating on a single shift will waste about 700 gallons of fuel per year. With fuel costs at approximately $3 per gallon, the user will save $2,100 per year - on a single shift. With properly adjusted CO emissions, there are immediate real savings in plant operating costs and long-term savings in employee health and related costs.



Preventing CO Poisoning

In 1996, NIOSH published an Alert, *Preventing Carbon Monoxide Poisoning from Small Gasoline-Powered Engines and Tools*, with the following recommendations for employers and equipment users:

- Do not allow the use of gasoline-powered equipment inside buildings or partially enclosed areas unless exhaust is located outside (where it will not be drawn indoors and away from air intakes).
- Learn to recognize the signs and symptoms of CO overexposure.
- Use personal CO monitors equipped with audible alarms to warn workers when CO is excessive.
- Substitute less hazardous equipment.
- If an employee has symptoms, turn off equipment and go outdoors. Call 911 for medical attention – **Do not drive a motor vehicle**.

In addition, the Alert recommends equipment manufacturers and rental agencies:

- Place warning labels on gasoline-powered tools. For example:

  WARNING – CARBON MONOXIDE PRODUCED DURING USE CAN KILL – DO NOT USE INDOORS OR IN OTHER SHELTERED AREAS.

- Tell customers the equipment should not be used indoors.
- Have portable, audible CO monitors available for rent or purchase and encourage their use.
- Provide recommendations for equipment maintenance to reduce CO emissions.
- Recommend safer tools for the intended use.

Limiting CO Concentrations

The hierarchy of Health and Safety controls lists elimination as the primary step in minimizing employee exposure. The American Conference of Governmental Industrial Hygienists (ACGIH) publication *Industrial Ventilation* recommends specific dilution rates to maintain CO exposures below the limits:

- 10,000 cfm/ propane-fueled lift truck,
- 16,000 cfm/gasoline-fueled lift truck,
- 10,000 cfm/operating automobile,
- 20,000 cfm (or more)/ operating truck,
- 100 cfm/horsepower for diesel-fueled vehicle.

These exhaust rates assume a regular periodic maintenance program that limits CO concentrations of gases to 1 percent for propane-fueled trucks and 2 percent for gasoline-fueled trucks. These rates also assume vehicles are only used for half of the work day, good distribution of air flow, space volume is greater than 150,000 ft^3/lift truck, and trucks are powered by engines of less than 60 HP. If operating conditions vary from these assumptions, the ventilation rate should be increased. Local exhaust ventilation that captures exhaust at the source is practical for service garages. Any ventilation system must have adequate make-up air to operate effectively.

Investigating CO Complaints

Health compliance investigations may result from an employee complaint or other reports of excessive CO exposure. Employers are required to perform hazard communication training when employees are exposed to any air contaminant. A typical CO investigation includes direct tailpipe measurements with a CO analyzer and employee exposure monitoring with toxic gas meters (dosimeters).

Air contamination levels associated with past exposure incidents may be estimated by analysis of an exposed individuals blood or breath. The Coburn equation has been used by industrial hygienists to calculate past theoretical airborne exposure level by considering variables (e.g. percent carboxyhemoglobin (%COHb), the time of the blood test, the time of the exposure event, etc.).

References:

Part 301 Air Contaminants for General Industry

Part 601 Air Contaminants for Construction

Note: This guide is intended for the benefit of the public and may not contain all of the information pertinent to a specific hazard and/or control of exposure. For further information, consult MIOSHA, Consultation Education and Training Division, 530 W. Allegan Street, P.O. Box 30643, Lansing, Michigan 48909-8143. Telephone: (517) 284-7720.

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530 W. Allegan Street, P.O. Box 30643
Lansing, Michigan 48909-8143

For further information or to request consultation, education and training services
call (517) 284-7720
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