

NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND
SUPPORTING DOCUMENTATION FOR

*** CARBON MONOXIDE ***

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for CARBON MONOXIDE

The basic text of this document contains the draft technical standard approved by the Joint Review Committee of the NIOSH/OSHA Standards Completion Program and the supporting documentation for the substance CARBON MONOXIDE.

The SCP draft technical standards are recommendations to the Department of Labor for its consideration in rulemaking and have no legal status until final rules have been promulgated by that agency. This draft standard is provided for your information only.

The References and Sources, Respirator Table Documentation and Use/Exposure and Control Documentation are the working documents used by the various SCP working groups during the development of the draft technical standard and serve as the technical foundation for the standard. The classification for each substance and the regulatory statements were derived following a decision logic established for the various sections of the standard.

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(a) Definitions. (1) "Permissible exposure" means exposure of employees to airborne concentrations of carbon monoxide not in excess of 50 parts per million (ppm) (55 milligrams per cubic meter (mg/M3)) averaged over an eight-hour work shift (time weighted average), as stated in § 1910.1000, Table Z-1.

(2) "Action level" means one-half of the permissible exposure for carbon monoxide averaged over an eight-hour work shift.

(b) Initial determination and exposure measurement. (1) Each employer who has a place of employment in which carbon monoxide is released into the workplace air shall determine if there is any possibility that any employee may be exposed to airborne concentrations of carbon monoxide above the permissible level. The initial determination shall be made each time there is a change in production, process, or control measures which may result in an increase in airborne concentrations of carbon monoxide.

(2) A written record of the initial determination shall be made and shall contain at least the following information:

(i) Any information, observations, or calculations which may indicate employee exposure to carbon monoxide;

(ii) Any measurements of carbon monoxide taken;

(iii) Any employee complaints of symptoms which may be attributable to exposure to carbon monoxide; and

(iv) Date of initial determination, work being performed at the time, location within work site, and employees considered.

(3) If the employer determines that any employee may be exposed to carbon monoxide above the permissible exposure, the exposure of the employee in each work operation who is believed to have the greatest exposure shall be measured. The exposure measurement shall be representative of the maximum eight-hour time weighted average exposure of the employee.

(4) If the exposure measurement taken pursuant to paragraph (b) (3) of this section reveals employee exposure to carbon monoxide above the action level, the employer shall:

(i) Identify all employees who may be exposed above the permissible level; and

(ii) Measure the exposure of the employees so identified.

(5) If an employee exposure measurement reveals that an employee is exposed to carbon monoxide above the action level, but not above the permissible exposure, the exposure of that employee shall be measured at least every three months.

(6) If an employee exposure measurement reveals that an employee is exposed to carbon monoxide above the permissible exposure, the employer shall:

(i) Measure the exposure monthly of the employee so exposed; and

(ii) Institute control measures as required by paragraph (d) of this section; and

(iii) Individually notify, in writing, within five days, every employee who is found to be exposed to carbon monoxide above the permissible exposure. The employee shall also be notified of the results of the exposure measurements and of the corrective action being taken to reduce the exposure to below the permissible exposure.

(7) If two consecutive employee exposure measurements taken at least one week apart reveal that the employee is exposed to carbon monoxide below the action level, the employer may terminate measurement for the employee.

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(8) For purposes of this paragraph, employee exposure is that which would occur if the employee were not using a respirator.

(c) Methods of measurement. (1) An employee's exposure shall be obtained by any combination of long term or short term samples which represents the employee's actual exposure averaged over an eight-hour work shift (See Appendix B (IV) of this section).

(2) The method of measurement shall have an accuracy, to a confidence level of 95 percent, of not less than that given in Table 1.

Table 1

Concentration	Required Accuracy (Percent of True Value)
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Above permissible exposure	± 25
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At or below permissible exposure	
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and above the action level	± 35
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At or below the action level	± 50
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(d) Compliance. (1) No employee shall be exposed to carbon monoxide above the permissible exposure as defined in paragraph (a)(1) of this section.

(2) Employee exposures to airborne concentrations of carbon monoxide shall be controlled to at or below the permissible exposure by engineering and work practice controls.

(i) Engineering and work practice controls shall be instituted to reduce exposures to at or below the permissible exposure, except to the extent that such controls are not feasible.

(ii) Wherever engineering and work practice controls are not sufficient to reduce exposures to at or below the permissible exposure, they shall nonetheless be used to reduce exposure to the lowest level feasible and shall be supplemented by respirators in accordance with paragraph (d)(4) of this section.

(3) Engineering controls. When local exhaust is used to control exposure, measurements which demonstrate system effectiveness, for example, air velocity or static pressure shall be made at least every three months. Measurements of system effectiveness shall also be made within five days of any change in production, process, or control which might result in an increase in airborne concentrations of carbon monoxide.

(4) Compliance with the permissible exposure shall not be achieved by the use of respirators except:

(i) During the time period necessary to install or implement engineering or work practice controls; or

(ii) In work situations in which engineering and work practice controls are not feasible; or

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(iii) To supplement engineering and work practice controls when such controls fail to reduce airborne concentrations of carbon monoxide to at or below the permissible exposure; or

(iv) For operations which require entry into tanks or closed vessels; or

(v) In emergencies.

(5) Where respirators are needed and permitted under this paragraph to reduce employee exposure, the employer shall select and provide the appropriate respirator from Table 2 and shall ensure that the employee uses the respirator provided.

TABLE 2 RESPIRATORY PROTECTION FOR CARBON MONOXIDE

CONDITION	PERMISSIBLE RESPIRATORY PROTECTION
Gas Concentration	
500 ppm or less	Any supplied-air respirator. ----- Any self-contained breathing apparatus. -----
1500 ppm or less	Any supplied-air respirator with a full facepiece, helmet or hood. ----- A Type C supplied-air respirator operated in pressure - demand or other positive pressure mode. ----- Any self-contained breathing apparatus with a full facepiece. -----
Greater than 1500 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 gas mask providing protection against carbon monoxide. ----- Any escape self-contained breathing apparatus. -----

(6) Respirators shall be approved by the Mining Enforcement and Safety Administration (formerly Bureau of Mines) or by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

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(7) The employer shall institute a respiratory protection program in accordance with § 1910.134(b), (d), (e), and (f).

(e) Fire and safety. (1) The employer shall familiarize himself with the information contained in the Substance Technical Guidelines (Appendix B of this section) for carbon monoxide.

(2) For the purpose of compliance with § 1910.309, locations classified as hazardous locations due to the presence of carbon monoxide shall be Class I, Group C.

(3) For the purpose of compliance with § 1910.178, locations classified as hazardous locations due to the presence of carbon monoxide shall be Class I, Group C.

(4) For the purpose of compliance with § 1910.157, carbon monoxide is classified as a Class B fire hazard except that loaded stream or foam shall not be permitted.

(5) Where a fan is located in ductwork and where carbon monoxide is present in the ductwork in concentrations greater than 30,000 ppm (approximately 25% of the lower flammable limit), the fan rotating element shall be of nonsparking material or the casing shall consist of, or be lined with, nonsparking material. There shall be sufficient clearance between the fan rotating element and the fan casing so as to prevent contact.

(6) Sources of ignition such as smoking or open flames are prohibited where carbon monoxide presents a fire or explosion hazard.

(7) Carbon monoxide shall be stored so as not to come in contact with strong oxidizers.

(8) Cylinders containing carbon monoxide shall be stored in accordance with § 1910.101.

(f) Personal protective equipment. (1) Employers shall provide and ensure that employees use appropriate protective clothing and equipment necessary to prevent the skin from becoming frozen from contact with liquid carbon monoxide or from contact with vessels containing liquid carbon monoxide.

(2) Employers shall ensure that clothing which becomes wet with liquid carbon monoxide be removed immediately and not reworn until the carbon monoxide has evaporated.

(3) Employers shall provide and ensure that employees use splash-proof safety goggles which comply with § 1910.133(a)(2)-(a)(6) where liquid carbon monoxide may contact the eyes.

(g) Spills and disposal. In the event that carbon monoxide is inadvertently released the employer shall immediately provide available ventilation.

(h) Sanitation. (Reserved).

(i) Training and information. (1) Each employer who has a workplace in which carbon monoxide is present shall keep a copy of this regulation with Appendixes A, B and C at the workplace. This material shall be made readily available to affected employees.

(2) Each employer who has employees exposed to carbon monoxide above the action level without regard to the use of respirators, or employees who may have skin contact with liquid carbon monoxide or vessels containing liquid carbon monoxide, or who may have eye contact with liquid carbon monoxide, or employees who work where a potentially hazardous release of carbon monoxide may occur shall annually:

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(i) Inform affected employees of the information contained in the Substance Safety Data Sheet for carbon monoxide (Appendix A of this section);

(ii) Advise affected employees as to the signs and symptoms of exposure to carbon monoxide.

(iii) Instruct affected employees to advise the employer of the development of signs and symptoms of overexposure to carbon monoxide which are listed in Appendix A of the section; and

(iv) Provide training to ensure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to carbon monoxide.

(j) Medical surveillance. (1) The employer shall provide medical procedures as required by this paragraph. All medical procedures shall be performed by or under the supervision of a physician at no cost to the employee.

(2) Preplacement medical examination. The employer shall make available to each employee who is exposed, or will be exposed, to airborne concentrations of carbon monoxide above the action level, without regard to the use of respirators, a preplacement medical examination which must include the following:

(i) A medical history and physical examination with emphasis on the heart, lungs, blood and central nervous system;

(ii) A complete blood count to include at least red and white cell count, a differential smear, hemoglobin and hematocrit.

(3) Periodic medical examination. The employer shall make available to each employee exposed to airborne concentrations of carbon monoxide above the action level, without regard to the use of respirator, twelve months from the date of the employee's first exposure, and every twelve months thereafter, a periodic medical examination which must include the following:

(i) A medical history and physical examination with emphasis on the heart, lungs, blood and central nervous system;

(ii) A complete blood count to include at least red and white cell count, a differential smear, hemoglobin and hematocrit.

(4) Alternative medical procedures. If the examining physician chooses to use alternative medical procedures to those specified in paragraphs (j)(2) and (j)(3) of this section, the employer may accept such alternative medical procedures as meeting the requirements of this section provided that the employer:

(i) Obtains a statement from the examining physician setting forth the alternative medical procedures, the rationale for substitution, and evidence that they will be equally effective;

(ii) Informs each exposed worker of the fact that alternative medical procedures to those required in paragraphs (j)(2) and (j)(3) of this section are to be made available.

(5) Interim medical examination. The employer shall provide an interim medical examination including a determination of carboxyhemoglobin in the blood for the employee if the employee informs the employer of any of the signs or symptoms of exposure to carbon monoxide which are listed in Appendix A or at any time overexposure to carbon monoxide is suspected.

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(6) Informing the physician. The employer shall provide to the physician performing any medical examination required by this section the following information:

- (i) A copy of this regulation with Appendixes A, B, and C for carbon monoxide;
- (ii) A description of the affected employee's duties as they relate to his exposure to carbon monoxide;
- (iii) A description of any personal protective equipment and respirators required to be used;
- (iv) The results of any measurements which may indicate the affected employee's exposure;
- (v) The affected employee's anticipated exposure level; and
- (vi) Upon request of the physician, any available information from previous medical examinations of the affected employee.

(7) Where a medical examination is required by paragraphs (j)(2), (j)(3), or (j)(5) of this section, following such examination the employer shall obtain from the examining physician a written opinion which conforms with paragraph (j)(8) of this section.

(8) Physician's written opinion. (i) The physician's written opinion by the examining physician shall specifically state:

- (A) Whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to carbon monoxide;
 - (B) Any recommended limitations upon the employee's exposure to carbon monoxide, including limitations upon the use of personal protective equipment and respirators;
 - (C) That the employee has been informed by the physician of any detected medical conditions which require further medical examination or treatment.
- (ii) The physician's written opinion shall not reveal specific medical findings or diagnoses unrelated to the employee's employment.

(iii) The employer shall provide the employee with a copy of the physician's written opinion.

(9) Results of tests. Where a preplacement or periodic medical examination is required by paragraphs (j)(2) or (j)(3) of this section, following such examination the employer shall obtain from the examining physician for inclusion in the employee's medical record:

- (i) A recording of the results of the blood tests and the carboxyhemoglobin determination;
- (ii) Where alternative medical procedures have been performed in accordance with paragraph (j)(4) of this section, a recording of such alternative procedures.

(10) No employee shall be exposed to carbon monoxide in such a way as would put the employee at increased risk of material impairment of his health from such exposure. The employer shall base this decision on any information available including the physician's written opinion.

(11) No medical procedure which would be performed pursuant to paragraphs (j)(2) or (j)(3) of this section need be performed if records of a previous such procedure performed within the past six months are acceptable to the examining physician.

(12) If an employee refuses any required medical examination, the employer shall inform the employee of the possible health consequences of

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such refusal and obtain a signed statement from the employee indicating that the employee understands the risk involved by refusal to be examined.

(13) The employer shall provide emergency medical treatment for any employee injured through exposure to carbon monoxide.

(k) Recordkeeping. (1) Exposure determination. (i) The employer shall keep an accurate record of all determinations required to be made pursuant to paragraph (b)(1) of this section.

(ii) This record shall include the written determination required in paragraph (b)(2) of this section.

(iii) This record shall be maintained until replaced by a more recent record.

(2) Exposure measurements. (i) The employer shall keep an accurate record of all measurements taken to determine employee exposure to carbon monoxide.

(ii) This record shall include:

(A) The date of measurement;

(B) Operations involving exposure to carbon monoxide which are being monitored;

(C) Sampling and analytical method used and evidence of their accuracy;

(D) Number, duration, and results of samples taken; and

(E) Name, social security number and exposure of the employee monitored.

(iii) This record shall be maintained until replaced by a more recent record but in no event for less than one year.

(3) Mechanical ventilation. (i) When mechanical ventilation is used as an engineering control, the employer shall maintain an accurate record of the measurements demonstrating the effectiveness of such ventilation required by paragraph (d)(3) of this section.

(ii) This record shall include:

(A) Date of measurement;

(B) Type of measurement taken;

(C) Result of measurement.

(iii) These records shall be maintained for at least one year.

(4) Employee training and information. (i) The employer shall keep an accurate record of all employee training and information required by paragraph (i) of this section.

(ii) This record shall include:

(A) Date of training;

(B) Name and social security number of employee trained;

(C) Content or scope of training provided.

(iii) This record shall be maintained until replaced by a more recent record.

(5) Medical surveillance. (i) The employer shall keep an accurate record of employee medical surveillance required by paragraph (j) of this section.

(ii) This record shall include:

(A) The name and social security number of the employee;

(B) Results of tests required by paragraph (j)(2) and (j)(3) of this section and results of any tests conducted pursuant to paragraphs (j)(4) of this section;

(C) Any employee medical complaints relative to exposure to carbon monoxide;

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(D) A copy of information provided to the physician pursuant to paragraph (j)(6)(ii), (iii), (iv), (v), and (vi) of this section.

(E) Physician's written opinion; and

(F) A signed statement of any refusal to be examined.

(iii) This record shall be maintained for the duration of and for five years after termination of the employment of the affected employee.

(6) Access to records. (i) All records required to be maintained by this section shall be made available upon request to authorized representatives of the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health.

(ii) Each employee or former employee shall have access to the exposure determination and exposure measurement records required to be maintained by this section which indicate his own exposure to carbon monoxide.

(iii) Employee medical records required to be maintained by this section shall be made available upon written request to a physician designated by the employee or former employee.

(1) Employee observation of measurement. (1) The employer shall give each employee or his representative an opportunity to observe any measurement of his exposure to carbon monoxide which is conducted pursuant to this section.

(2) When observation of measurement of employee exposure to carbon monoxide requires entry into an area where the use of personal protective devices, including respirators, is required, the observer shall be provided with and required to use such equipment and comply with all other applicable safety procedures.

(3) Without interfering with the measurement, observers shall be entitled to:

(i) Receive an explanation of the measurement procedure.

(ii) Visually observe all steps related to the measurement of the airborne concentration of carbon monoxide that are being performed at the place of exposure; and

(iii) Record the results obtained.

NOTE: The information contained in the following appendix for carbon monoxide is neither intended, by itself, to create any additional obligations not otherwise imposed, nor detract from any existing obligations. To the extent the information supplements this regulation for carbon monoxide, it is advisory in nature.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET
FOR CARBON MONOXIDE

I. SUBSTANCE IDENTIFICATION

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- A. Substance: Carbon monoxide
- B. Permissible Exposure: 50 parts of carbon monoxide per million parts of air (ppm) (55 milligrams of carbon monoxide per cubic meter of air (mg/M3)) averaged over an eight-hour work shift.

C. Appearance and Odor: Colorless, odorless gas

II. HEALTH HAZARD DATA

A. Ways in which the chemical affects your body: Carbon monoxide can affect your body if you inhale it or if liquid carbon monoxide comes in contact with your skin or eyes.

B. Effects of Overexposure:

1. Exposure to carbon monoxide decreases the ability of the blood to carry oxygen to the tissues. Inhalation of carbon monoxide may cause headache, nausea, dizziness, weakness, rapid breathing, unconsciousness and death. High concentrations may be rapidly fatal without producing significant warning symptoms. Exposure to this gas may aggravate heart disease and artery disease and may cause chest pain in those with pre-existing heart disease. Pregnant women are more susceptible to the effects of carbon monoxide exposure. The effects are also more severe in people who are working hard and in people who are working in places where the temperature is high or at altitudes above 2,000 feet. Skin exposure to liquid carbon monoxide may cause frostbite-type burns.
2. Reporting Symptoms: You should inform your employer if you develop any signs or symptoms and suspect that they are caused by exposure to carbon monoxide.

III. EMERGENCY FIRST AID PROCEDURES

A. Breathing: If you or any other person breathes in large amounts of carbon monoxide 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.

B. Rescue: Move 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 yourself. Understand your emergency rescue procedures and know the locations of the emergency rescue equipment before the need arises.

IV. RESPIRATORS AND PROTECTIVE CLOTHING

A. Respirators: Respirators are not the best way to control exposure to carbon monoxide. You can only be required to wear them for routine use if your employer is in the process of installing controls or control measures prove inadequate. You may be required to wear respirators for non-routine activities or in emergencies. If respirators are worn, they must have a Mining Enforcement and Safety Administration (MESA) or National Institute for Occupational Safety and Health (NIOSH) approval label. (Older respirators may have a Bureau of Mines approval label.) For effective protection,

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respirators must fit your face and head snugly. Respirators should not be loosened or removed in work situations where there use is required. If you experience difficulty breathing while wearing a respirator, tell your employer.

- B. Protective Clothing: You must wear appropriate protective clothing and equipment to prevent skin contact with liquid carbon monoxide when skin contact may occur.
- C. Eye Protection: You must wear splash-proof safety goggles where liquid carbon monoxide may contact your eyes.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

- A. Carbon monoxide is a flammable gas. It can easily form explosive mixtures with air.
- B. Carbon monoxide must not come in contact with with strong oxidizers.
- C. Sources of ignition such as smoking and open flames are prohibited wherever carbon monoxide is handled, used or stored in a manner that could create a potential fire or explosion hazard.
- D. You must immediately remove any clothing that becomes wet with liquid carbon monoxide and this clothing must not be reworn until the carbon monoxide is removed from the clothing.
- E. Fire extinguishers, where provided, must be readily available and you should know where they are and how to operate them.
- F. Ask your supervisor where carbon monoxide may be used or inadvertently released in your work area and for any additional safety and health rules.

VI. ACCESS TO INFORMATION

- A. Each year your employer is required to inform you of the information contained in this Substance Safety Data Sheet for carbon monoxide. In addition, your employer must instruct you in the safe use of carbon monoxide, emergency procedures, and the correct use of protective equipment.
- B. Your employer is required to determine whether you are being exposed to carbon monoxide. You or your representative have the right to observe employee exposure measurements and to record the results obtained. If your employer determines that you are being overexposed, he is required to inform you of the exposure and the actions which are being taken to reduce your exposure.
- C. Your employer is required to keep records of your exposure and medical examinations. Your employer is required to keep exposure data for at least one year and to keep medical data during your employment, and for a period of five years following your termination of employment. Your employer is required to make the exposure data available to you upon your request. Your employer is also required to release your medical records to your physician upon your written request.
- D. Your employer must give you a copy of the physicians written opinion for any physical examination required by this standard.

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APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES
FOR CARBON MONOXIDE

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: Monoxide
2. Formula: CO
3. Molecular weight: 28

B. Physical Data

1. Boiling point (760 mm Hg): -191.5 C (-313 F)
2. Specific gravity (water = 1): 0.79 (liquid at boiling point)
3. Vapor density (air = 1 at boiling point of carbon monoxide): 0.97
4. Melting point: -199 C (-326 F)
5. Vapor pressure at 20 C (68 F): Greater than 1 atmosphere
6. Solubility in water, grams of carbon monoxide per 100 grams of water at 20 C (68 F): 0.004
7. Evaporation rate (butyl acetate = 1): Not applicable
8. Appearance and odor: Colorless, odorless gas

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: Not applicable
2. Autoignition temperature: 610 C (1128 F)
3. Flammable limits in air, % by volume: Lower: 12.5; Upper: 74
4. Extinguishing media: Dry chemical. If flow of gas cannot be let fire burn.
5. Special fire-fighting procedures: Use water spray to keep fire-exposed containers cool and to protect men fighting fire. Do not extinguish flame in an enclosed area since unburnt gas may form explosive mixtures with air.
6. Unusual fire and explosion hazards: Carbon monoxide is a flammable gas. It can readily form explosive mixtures with air. All ignition sources must be controlled where carbon monoxide is used, handled and stored in a manner that could create a potential fire or explosion hazard.

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7. One-fourth of the lower flammable limit, approximately 30,000 ppm, is one situation in which carbon monoxide is considered to be a potential fire and explosion hazard.
8. For purposes of complying with 29 CFR 1910.309, the classification of hazardous locations as described in Article 500 of the National Electrical Code for carbon monoxide shall be Class I, Group C.
9. Cylinders containing carbon monoxide shall be stored in accordance with § 1910.101.

B. Reactivity

1. Conditions contributing to instability: Elevated temperatures may cause cylinders to explode.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None.
4. Special precautions: None.

III. LEAK PROCEDURES

- A. If carbon monoxide is leaked or released in hazardous concentrations, the following steps should be taken:
 1. Ventilate area of leak or release 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 leak or allow cylinder to empty.
- B. Persons not wearing protective equipment should be restricted from areas of leaks or releases until cleanup has been completed.

IV. MONITORING AND MEASUREMENT PROCEDURES

- A. EXPOSURE ABOVE THE ACTION LEVEL: Measurements taken for the purpose of determining employee exposure under this section are best taken such that the eight-hour exposure may be determined from a single eight-hour sample or 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). Sampling and analyses may be performed by instruments such as detector tubes certified by NIOSH under 42 CFR part 84, portable direct-reading instruments, dosimeters, or gas and vapor adsorption tubes with subsequent chemical analysis. The method of measurement must determine the concentration of carbon monoxide to plus or minus 35%.
- B. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring and measurements under this section should be essentially the same as described under paragraph IV. A. Laboratories performing chemical analyses should be accredited in Industrial Hygiene Chemistry by the American Industrial Hygiene Association. The method of measurement must determine the concentration of carbon monoxide to plus or minus 25%.

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C. METHODS: Methods meeting these accuracy requirements are available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161 under the title "NIOSH Analytical Methods for Set W" (Order number XXXXXXXXXX).

D. QUALIFIED PERSONS: Since many of the duties relating to employee protection are dependent on the results of monitoring and measuring procedures, employers should assure that the evaluation of employee exposures is performed by a competent industrial hygienist or other technically qualified person.

V. MISCELLANEOUS PRECAUTIONS

A. Do not use flame to detect leaks.

B. Employers should advise employees of all plant areas and operations where their exposure to carbon monoxide could occur.

VI. COMMON OPERATIONS

Common operations in which exposure to carbon monoxide is likely to occur are: During its formation in the incomplete combustion of all carbonaceous fuels; during the use or manufacture of water gas or other fuel mixture containing it; during its use as a reducing atmosphere in metal treating; during its use in the preparation of metal carbonyls (as in the refining of nickel); during its use as a reagent in the manufacture of alcohols, aldehydes, acids, esters and other organic compounds; during emission in enclosed places from exhaust fumes of internal combustion engines; during acetylene welding; and during its use in industrial heating.

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APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. ROUTE OF ENTRY

Inhalation.

II. TOXICOLOGY

Carbon monoxide (CO) gas causes tissue hypoxia by preventing the blood from carrying sufficient oxygen. CO combines reversibly with the oxygen-carrying sites on the hemoglobin molecule with an affinity ranging from 210 to 240 times greater than that of oxygen; the carboxyhemoglobin thus formed is unavailable to carry oxygen. In addition, carboxyhemoglobin interferes with the release of oxygen carried by unaltered hemoglobin. With exposure to high concentrations such as 4000 ppm and above, transient weakness and dizziness may be the only premonitory warnings before coma supervenes; the most common early aftermath of severe intoxication is cerebral edema. Exposure to concentrations of 500 to

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1000 ppm causes the development of headache, tachypnea, nausea, weakness, dizziness, mental confusion, and in some instances, hallucinations; the person is commonly cyanotic. Although an occasional individual will exhibit the unusual combination of hypoxia associated with a bright-red color of the fingernails, mucous membranes, and skin, this "cherry-red cyanosis" is usually only seen at autopsy. Exposure to 50 ppm may cause aggravation of angina pectoris after 90 minutes at carboxyhemoglobin levels of about 5%; exposed anginal patients may show a negative inotropic effect (weakened force of myocardial contraction); 50 ppm for 120 minutes may cause aggravation of intermittent claudication. The clinical effects of CO exposure are aggravated by heavy labor, high ambient temperature, and altitudes above 2000 feet; pregnant women are more susceptible to the effects of CO. The diagnosis of CO intoxication depends primarily on the demonstration of significantly increased carboxyhemoglobin in the blood. Exposure to 50 ppm for 6 to 8 hours results in carboxyhemoglobin levels of 8 to 10 percent. Levels of carboxyhemoglobin over 60 percent are usually fatal; 40 percent is associated with collapse and syncope; above 25 percent there may be electrocardiographic evidence of a depression of the S-T segment; between 15 to 25 percent there may be headache and nausea. The reaction to a given blood level of carboxyhemoglobin is extremely variable and some persons may be in coma with a carboxyhemoglobin level of 38 percent while others may maintain an apparently clear sensorium with levels as high as 55 percent. The blood of cigarette smokers contains 2 to 10 percent carboxyhemoglobin and nonexposed persons have an average level of 1 percent; heme metabolism is an endogenous source of CO. Several investigators have suggested that the results of behavioral tests such as time discrimination, visual vigilance, choice response tests, visual evoked responses, and visual discrimination thresholds may be altered at levels of carboxyhemoglobin below 5 percent.

III. SIGNS AND SYMPTOMS

Headache, tachypnea, nausea, weakness, dizziness, mental confusion, hallucinations; cyanosis; depression of the S-T segment of electrocardiogram; anginal pain in those with pre-existing heart disease; syncope.

IV. SPECIAL TESTS

Analysis of the blood for the level of carboxyhemoglobin is useful in evaluating the extent of intoxication.

V. TREATMENT

Remove from exposure. Give artificial resuscitation and administer oxygen if indicated. With 100 percent oxygen and a tightly fitting mask, the elimination half-time of carbon monoxide is 80 minutes. If a

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hyperbaric chamber is available, it is the preferred method of treatment in severe intoxication. Exposure at 3 atmospheres must be limited to no more than 90 minutes to prevent signs of oxygen toxicity such as convulsions; at this level the elimination half-time of carbon monoxide is 23 minutes.

VI. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. GENERAL

Carbon monoxide intoxication is one of the most common of all poisonings in industry. Exposure to high concentrations can be rapidly fatal with little or no warning. Premonitory symptoms at lower levels include headache, dizziness, and nausea which are easily confused with the onset of a cold or stomach influenza. Since pregnant women are more susceptible to the effects of CO, the advisability of exposing women of child bearing capacity should be considered. It is important that the physician become familiar with plant operating conditions in which exposure to carbon monoxide occurs. Those with skin disease may not tolerate the wearing of protective clothing and those with chronic respiratory disease may not tolerate the wearing of negative pressure respirators.

B. PREPLACEMENT

The following medical procedures must be made available to each employee who is exposed to carbon monoxide:

1. A complete history and physical examination -- The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of coronary heart disease, anemia, pulmonary heart disease, cerebrovascular disease, thyrotoxicosis, and smokers would be expected to be at increased risk from exposure. Pregnant women have an increased sensitivity to the effects of carbon monoxide. Examination of the cardiovascular system, the pulmonary system, the blood, and the central nervous system should be stressed.
2. A complete blood count -- Carbon monoxide affects the ability of the blood to carry oxygen. A complete blood count must be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

C. PERIODIC EXAMINATIONS

The above medical examinations are to be repeated on an annual basis, with the exception that a carboxyhemoglobin determination

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shall be performed at any time overexposure is suspected or signs or symptoms of toxicity occur.

VII. REFERENCES

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3. National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: Criteria for a Recommended Standard...Occupational Exposure to Carbon Monoxide, HSM 73-11000, U.S. Government Printing Office, Washington, D.C., 1972.
4. American Conference of Governmental Industrial Hygienists: "Carbon Monoxide," Documentation of the Threshold Limit Values for Substances in Workroom Air (3d ed., 2d printing), Cincinnati, 1974, pp. 41-43.
5. Hygienic Guide Series: "Carbon Monoxide," American Industrial Hygiene Association Journal, 26:431-434, 1965.
6. Patty, Frank A.: Industrial Hygiene and Toxicology, Vol. II - Toxicology (2d ed. revised), Interscience Publishing Company, New York, 1963, pp. 924-936.
7. Community Air Quality Guides: "Carbon Monoxide," American Industrial Hygiene Association Journal, 30:322-325, 1969.
8. Goodman, Louis S. and Alfred Gilman: The Pharmacological Basis of Therapeutics (5d ed.), The Macmillan Publishing Company, New York, 1975, pp. 900-904, 910-911.

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REFERENCES AND SOURCES
CARBON MONOXIDE
1910.1000

- (f) Personal Protective Equipment, (h) Sanitation
Eye: Grant, "Toxicology of the Eye"
Skin: Sax, "Dangerous Properties of Industrial Materials"
Ingestion: None

COMMENTS

Eye - Classification: 2

Output statement numbers: 10

Exceptions: None

Carbon monoxide has a boiling point of -313 degree F.
According to Grant, "local external effects of carbon monoxide gas on the eyes are essentially nil."

Although CO is predominantly shipped and used as a non-liquefied gas, the author is aware of industrial consideration of liquid shipments and use. It is, therefore, treated as a low-boiling liquid which might cause frostbite type burns.

Skin - Classification: Low-boiling liquid

Output statement numbers: Special statements

Exceptions: None

Sax indicates that carbon monoxide gas has no local effects.

Since CO has a boiling point of -313 degrees F, and since it may be utilized in liquid form, it is treated as a low-boiling liquid which might cause frostbite type burns.

Ingestion - Classification: 0

Output statement numbers: None

Exceptions: None

Carbon monoxide has a boiling point of -313 degrees F.
Ingestion of this compound would obviously not present a hazard in the industrial environment.

SUBSTANCE TECHNICAL GUIDELINES

The references cited for this document include:

National Fire Protection Association, "Fire Protection Guide on Hazardous Materials," 5th edition, 1975 (NFPA)

Air Products and Chemicals, Inc., Data Sheet (Air)

Matheson Gas Products, "Matheson Gas Data Book," 5th edition, p. 99 (Math)

Sources of data items used:

- | | | | |
|-----|----|----|-------------------------------------|
| I. | A. | 1. | Synonyms: ADL |
| | | 2. | Formula: NFPA-325M |
| | | 3. | Molecular weight: Air |
| | B. | 1. | Boiling point: Math |
| | | 2. | Specific gravity: Math |
| | | 3. | Vapor density: Math |
| | | 4. | Melting point: Air |
| | | 5. | Vapor pressure: Math, Air |
| | | 6. | Solubility in water: Air, Math |
| | | 7. | Evaporation rate: Not applicable |
| | | 8. | Appearance and odor: Math |
| II. | A. | 1. | Flash point: Not applicable |
| | | 2. | Autoignition temperature: NFPA-325M |

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3. Flammable limits: NFPA-325M, Air, Math
4. Extinguishing media: NFPA-325M, ADL
5. Special fire fighting procedures: ADL
6. Unusual fire and explosion hazards: ADL
- B. 1. Conditions contributing to instability: Air
2. Incompatibilities: NFPA-491M
3. Hazardous decomposition products: None
4. Special precautions
- III. A. Steps if released or spilled: ADL
- C. Waste disposal method: ADL
- V. Miscellaneous precautions: Air, Math

USE/EXPOSURE AND CONTROL DOCUMENT

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- American Welding Society, "The Welding Environment," 1973 (Welding)
- Baskin, A. D. (ed.), "Handling Guide for Potentially Hazardous Commodities," Railway Systems and Management Assoc., Chicago, 1972 (Baskin)
- Bates, C. E. and L. D. Scheel, "Processing Emissions and Occupational Health in the Ferrous Foundry Industry," AIHAJ 35 (8), 452-62 (1974) (Bates)
- Breysse, P. A. and H. H. Bovee, "Use of Expired Air - Carbon Monoxide for Carboxyhemoglobin Determination in Ensulating Carbon Monoxide Exposures Resulting from the Operation of Gasoline Fork Lift Trucks in Holds of Ships," AIHAJ 30 (5), 477-83 (1969) (Breysse)
- Buchwald, H., "Exposure of Garage and Service Station Operators to Carbon Monoxide: A Survey Based on Carboxyhemoglobin Levels," AIHAJ 30 (6), 570-5 (1969) (Buchwald)
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- Carbon Monoxide: American Industrial Hygiene Association, Hygienic Guide Series August, 1965 (Guide)
- Carbon Monoxide: "Effects of Carbon Monoxide," Fire Journal 61, 46-7 (1967) (NIOSH Technical Information Service NIOSH 29385)
- Carbon Monoxide: Mass. Dept. Labor and Industries, Div. Occup. Hyg., Chemical Data Sheet No. 6, April, 1974 (Mass #6)
- Carbon Monoxide: National Academy of Sciences, "Effects of Chronic Exposure to Low Levels of Carbon Monoxide on Human Health, Behavior, and Performance," 1969 (NAS)
- Carbon Monoxide: National Safety Council, Industrial Safety Data Sheet 415, 1952 (NSC)
- Carbon Monoxide: Commonwealth of Pennsylvania, Dept. Natural Resources, Occupational Health, Hygienic Information Guide No. 5, July, 1971 (Penna # 5)
- Chinn, H. I., "Carbon Monoxide - Hemoglobin Levels of Workers Employed in Airplane Engine Repair Shops," J. Indust. Hyg. & Toxic. 31 (5), 258-60, (1949) (Chinn)
- Cook, W. A., "The Occupational Carbon Monoxide Hazard of Commercial Vehicle Drivers," Indust. Med. and Surg., 118-20 (march 1964) (Cook)
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- Hall, D. A., F. A. Miller, E. C. Riley, and R. F. Scherberger, "Carbon Monoxide Hazard from Indoor Use of Propane-Fueled Fork Lift Trucks," Indust. Hyg. Quar. pp. 355-9, Dec., 1957 (Hall)
- Hama, G. M. and K. E. Butler, "Design Airflows for Proper Ventilation of Service Garages," Air Eng. 9, 20-25 (1967) (NIOSH Tech. Info. Service NIOSH 12103)

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- Hamilton, A. and H. L. Hardy, "Industrial Toxicology," Pub. Sci. Group, 3rd ed. (H/H)
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- International Labour Office, "Encyclopedia of Occupational Health and Safety, Geneva, 1972 (ILO)
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2. "Industrial Lift Trucks: Reducing Carbon Monoxide and Operating Costs," Michigan's Occupational Health 16 (4), Summer, 1971 (Lift Trucks 2)
3. "The Industrial Truck/Help Mate of Health Hazard," Michigan's Occupational Health 12 (1), Fall, 1966 (Lift Trucks 3)
4. "Lift Truck Hazards," Michigan's Occupational Health 1 (2), Winter, 1956 (Lift Trucks 4)
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- Rispler, L. and C. R. Ross, "Ventilation for Engine Exhaust Gases," Occup. Health Rev. 17, 19-22 (1965) (NIOSH Technical Information Service NIOSH 9114)
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- Sammons, J. H. and R. L. Coleman, "Firefighters' Occupational Exposure to Carbon Monoxide," Jour. Occup. Med. 16 (8), 543-6 (1974) (Sammons)
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- Von Oettingen, W. F., "Carbon Monoxide: Its Hazards and the Mechanism of Its Action," Public Health Bulletin #290, 1944 (Von Oettingen)

References for Specific Use/Exposure were:

1. Mass #6, Penna #5, NSC, Patty, Von Oettingen, K-O, ILO, H/H, Hama (12103)
Lift Trucks 1, 2, 3, 4, Hall, Breysse, Buchwald, Howlett, First, Summerson (21195), Ramsay, NAS, Chinn, Cook
2. Air Prod, Von Oettingen, Reichenbach, NSC, Bates, Patty, Schmauch
3. K-O, ILO, Von Oettingen, Penna #5, Guide, NSC
4. Welding Environ, deKretser, Guide
5. K-O, NAS, Von Oettingen, NSC
6. K-O, Air Prod, Baskin, NSC, Von Oettingen, Schmauch
7. K-O, Air Prod, Baskin, Schmauch
8. Sammons, Effects of CO (29385), Rossnagel (32200)
9. Schmauch, Patty

References for Control Methods

- Schmauch, Air Prod, Penna #5, Mass #6, Guide, Reichenbach, NSC, ILO, Lift Trucks
Rispler (9114)

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SUBSTANCE: Carbon monoxide

D. O. L. STANDARD: 50 ppm

WARNING PROPERTIES:

Odor Threshold: The AIHA Hygienic Guides point out that carbon monoxide is odorless.

Eye Irritation Level: Grant states that carbon monoxide is a non-irritating gas.

Evaluation of Warning Properties: Since carbon monoxide is an odorless, non-irritating gas, gas sorbent respiratory equipment is not permitted. Carbon monoxide has no warning properties.

IDLH: 1500 ppm

Basis for IDLH Value: The chosen IDLH is based upon the information given in Patty that a 1-hour exposure to 1000 - 1200 ppm would cause "unpleasant, but no dangerous, symptoms." Patty also reports that 1500 - 2000 ppm might be a "dangerous concentration for exposure of 1 hour."

Other Toxicological Information: The AIHA Hygienic Guides state that "the acute effects of carbon monoxide are related to the percentage saturation of hemoglobin with carbon monoxide, which is dependent on the degree of activity, duration of exposure, ambient temperature, health status and metabolic efficiency of the worker.

"Exposure to concentrations of 500 - 1,000 ppm results in a gradually increasing series of symptoms occurring as a result of the progressive asphyxia which develops. Respiration is increased, and is followed by headaches, nausea, mental confusion and in some instances hallucinations. The individual at first appears pale, but, as the condition progresses, the skin and mucous membranes sometimes may appear cherry red even after respiration has ceased."

Concerning the short exposure tolerance to carbon monoxide, the Hygienic Guides state that "approximately 20% saturation of blood causes initial symptoms of poisoning and will result from exposure to 1000 ppm for 30 minutes or 500 ppm for one hour. One hour at 1500 ppm is dangerous to life. Short exposures (one hour) should not exceed 400 ppm."

Concerning the atmospheric concentration immediately hazardous to life, the Hygienic Guides state that "a concentration of 5000 ppm causes rapid collapse, unconsciousness and death within a few minutes."

The following table is given in Patty:

PHYSIOLOGICAL RESPONSE TO VARIOUS CONCENTRATIONS
OF CARBON MONOXIDE

Response	CO in Air	
	ppm by vol.	Vol. %
Concentration allowable for an exposure of several hours	100	0.01
Concentration inhaled for 1 hour without appreciable effect	400 - 500	0.04 - 0.05
Concentration causing just appreciable effects after 1 hour of exposure	600 - 700	0.06 - 0.07

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Concentration causing unpleasant, but not dangerous, symptoms after 1 hour of exposure	1000 - 1200	0.1 - 0.12
Dangerous concentration for exposure of 1 hour	1500 - 2000	0.15 - 0.2
Concentrations fatal in exposure of less than 1 hour	4000 and above	0.4 and above

The Documentation of TLV's states that "a threshold limit value for carbon monoxide of 100 ppm has been extant for many years, but no substantial justification for its validity under ordinary circumstances of work can be found. The often quoted work of Henderson and Haggard, states that a three-hour exposure at 100 ppm produces no effect, but six hours' exposure produces a perceptible effect and nine hours' exposure causes headache and nausea. Drinker states that the safety constant must be reduced to 1/3 or less under exercise or work. The committee believes that the apparent success of 100 ppm value was due to inurement and accumulation of individuals of low degree of susceptibility. A great deal of confusion has resulted over the years from the summation of thousands of publications on the effects of carbon monoxide on man because of serious difficulty in the determination of low levels of the compound in air and blood. It now seems reasonably certain that an equilibrium exposure of man at 50 ppm of carbon monoxide will result in a HbCO value of 8 - 10%, and that under usual conditions of work and rest periods an 'end of work day' level of 5 - 6% would be expected. A crew of workers in the Holland Tunnel who worked two hours in, and two hours out, for eight-hour 'swing' shifts in an average tunnel CO concentration of 70 ppm showed an average of 5% HbCO with no one above 10%. Under this average exposure of 25 - 50 ppm, no symptoms or health impairments were found, or would be expected.

"Men exposed continuously for many days in a submarine at 50 ppm CO complained of headache but a 60-day exposure at 40 ppm CO was without effect.

"Schulte stated that exposure at 100 ppm of CO for over four hours is excessive and recommends a maximal exposure at 50 ppm CO for over four hours' duration.

"Studies made upon a group of healthy young men exposed for a prolonged period at 44 ppm CO produced no adverse reactions on their general health . . .

"It would appear to the Committee that for conditions of heavy labor, high temperatures or work 5000 - 8000 feet above sea level, the threshold limit value should be appropriately reduced to 25 ppm. No further benefit under any circumstances could be expected by reducing the level below 5 - 10 ppm since at this concentration one is practically in equilibrium with the normal blood level of around 1% HbCO.

"The recommended TLV for CO of 50 ppm is thus based on an air concentration that should not result in blood CO levels above 10%, a level that is just below the development of signs of borderline effects."

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LFL: Not applicable

VAPOR PRESSURE AT 20 C: Carbon monoxide is a gas at room temperature.

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Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1. Inhalation of gas during emission in enclosed places from exhaust fumes of internal combustion engines (may contain up to 38% CO): traffic tunnels (policemen, maintenance crew); parking garages (attendants); garages (automotive and aircraft maintenance and repair); industrial lift loading areas, ships' holds, arenas (industrial lift trucks, payloaders, sweepers, ice-finishing machinery - exposure to operator and other personnel during loading, unloading, transport, or use).	A	Local exhaust ventilation; respiratory protective devices when needed
2. Inhalation of gas during use or emission in the metallurgic industries: foundries (emission from blast and Bessemer furnaces); use as reducing agent for purification of metals (smelting of copper, lead, silver, zinc); use for production of metal carbonyls (as in Mond process for nickel recovery - CO is recycled).	A	Local exhaust ventilation; respiratory protective devices when needed
3. Inhalation of gas emitted from industrially used heaters, ovens, boilers, or burners (produced by incomplete combustion of fuel): oil refineries (emission from forges and coking ovens); textiles (emission from singeing, pressing, calico printing); ceramics (emission from kilns); printing (emission from linotype melting pots); burner and chimney maintenance and repair; industrial kitchens and bakeries (emission from stoves and ovens).	A	Local exhaust ventilation; respiratory protective devices when needed
4. Inhalation of gas evolved	A	Local exhaust ventilation;

respiratory protective
devices when needed

- | | | | |
|----|--|---|---|
| 5. | Inhalation of gas evolved in mines, tunnels, and other enclosed areas: CO resulting from fire damp explosions; CO emission from explosive devices in mines (incomplete combustion): CO from gas pipe leaks in manholes (danger to repairmen); CO emission from explosives in gun turrets, tanks, and gun emplacements. | A | Local exhaust ventilation; respiratory protective devices when needed |
| 6. | Inhalation of gas in chemical industry during use for synthesis and during emission as a result of incomplete combustion: ammonia production; production of phosgene; methane, methanol, and many other organic compounds (acids, esters, hydroxides, higher aldehydes and alcohols); manufacture of carbon black, illuminated gas, coke, and coal tar products. | A | Process enclosure and local exhaust ventilation; respiratory protective devices when needed |
| 7. | Inhalation of gas during manufacture, distribution, and maintenance of equipment. | A | Local exhaust ventilation; respiratory protective devices when needed |
| 8. | Inhalation of gas during emission (fires) from incomplete combustion of oil, wood, gas, coal, explosives, plastics (danger to fire-fighters). | A | Respiratory protective devices when needed |
| 9. | Inhalation of gas during use for industrial heating (furnaces, space heaters). | A | Local exhaust ventilation |

- A -- Inhalation
B -- Skin and eye contact resulting
in localized irritation
C -- Ingestion
D -- Skin contact resulting in
absorption and subsequent
systemic poisoning