OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CARBON TETRACHLORIDE

INTRODUCTION

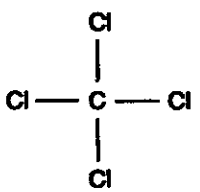
This guideline summarizes pertinent information about carbon tetrachloride for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

CCl_4

- **Structure**



- **Synonyms**

Tetrachloromethane; perchloromethane; methane tetrachloride; Nectorina; benzinoform; carbon chloride; Carbona; carbon tet

- **Identifiers**

1. CAS No.: 56-23-5
2. RTECS No.: FG4900000
3. DOT UN: 1846 55
4. DOT label: Poison

- **Appearance and odor**

Carbon tetrachloride is a noncombustible, colorless liquid with a sweet, aromatic, etherlike odor. The best estimate of the odor threshold for carbon tetrachloride is 250 parts per million (ppm) parts of air.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 153.84
2. Boiling point (760 mm Hg): 76.7°C (170°F)
3. Specific gravity (water = 1): 1.59 at 20°C (68°F)
4. Vapor density (air = 1 at boiling point of carbon tetrachloride): 5.3
5. Melting point: –23°C (–9.4°F)
6. Vapor pressure at 20°C (68°F): 91.3 mm Hg

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Education and Information Division

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

7. Solubility: Slightly soluble in water; miscible with alcohol, benzene, chloroform, ether, carbon disulfide, petroleum ether, and oils

8. Evaporation rate: Data not available

Reactivity

1. Conditions contributing to instability: None reported

2. Incompatibilities: Contact of carbon tetrachloride with fluorine gas, alkali metals, or aluminum may cause a violent reaction.

3. Hazardous decomposition products: Toxic gases (such as phosgene and hydrogen chloride) may be released in a fire involving carbon tetrachloride. When used to put out electrical fires, carbon tetrachloride may evolve phosgene gas.

4. Special precautions: None reported

Flammability

The National Fire Protection Association has assigned a flammability rating of 0 (no fire hazard) to carbon tetrachloride; this substance is not combustible.

1. Flash point: Not applicable

2. Autoignition temperature: Not applicable

3. Flammable limits in air: Not applicable

4. Extinguishant: Use an extinguishant that is appropriate for the materials involved in the surrounding fire.

Fires involving carbon tetrachloride should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of carbon tetrachloride may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Dikes should be used to contain fire-control water for later disposal. Fire fighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving carbon tetrachloride. Chemical protective clothing that is specifically recommended for carbon tetrachloride may not provide thermal protection unless so stated by the clothing manufacturer. Structural Fire fighters' protective clothing is not effective against fires involving carbon tetrachloride.

EXPOSURE LIMITS

- **OSHA PEL**

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for carbon tetrachloride is 10 ppm as an 8-hr time-weighted average (TWA) concentration with a ceiling concentration of 25 ppm that may not be exceeded during an 8-hr workday except for a 5-min period every 4 hours; the acceptable maximum peak during this 5-min period is 200 ppm [29 CFR 1910.1000, Table Z-2].

- **NIOSH REL**

The National Institute for Occupational Safety and Health (NIOSH) designates carbon tetrachloride a potential occupational carcinogen and has established a recommended exposure limit (REL) for this substance of 2 ppm (12.6 mg/m^3) as a 60-min short-term exposure limit (STEL) [NIOSH 1992a]. The STEL is a 60-min TWA exposure that shall not be exceeded at any time during a workday.

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) has designated carbon tetrachloride an A2 substance (suspected human carcinogen) and has assigned carbon tetrachloride a threshold limit value (TLV) of 5 ppm (31 mg/m^3) as a TWA for a normal 8-hr workday and a 40-hr workweek. The ACGIH has also assigned carbon tetrachloride a "Skin" notation, which indicates that the cutaneous route of exposure (including mucous membranes and eyes) contributes to overall exposure [ACGIH 1993].

- **Rationale for limits**

The NIOSH and ACGIH limits are based on the risk of cancer associated with exposure to carbon tetrachloride [ACGIH 1993; NIOSH 1992a].

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to carbon tetrachloride can occur through inhalation of the vapor, eye or skin contact, absorption through the skin of the liquid, or ingestion.

- **Summary of toxicology**

1. *Effects on Animals:* In animals, carbon tetrachloride is an eye and skin irritant, a liver and kidney toxin, and a carcinogen. This chemical is a mild eye and skin irritant in rabbits [NIOSH 1992b]. Monkeys demonstrated little dermal absorption from ambient exposures. Likewise, rats dermally exposed to the liquid required large doses to induce lethality [Clayton and Clayton 1981]. The dermal LD_{50} in rats is 5,070 mg/kg [NIOSH 1992b]. The maximum exposures that caused no effects in male rats were: 3,000 ppm for 6 min, 800 ppm for 30 min, and 50 ppm for 7 hr [Clayton and Clayton 1981]. The highest airborne concentrations in which rats survived were 12,000 ppm for 15 min and 3,000 ppm for 8 hr [Clayton and Clayton 1981]. The LC_{50} in rats and mice are 8,000 ppm for 4 hr and 9,526 ppm for 8 hr, respectively [NIOSH 1992b]. The oral LD_{50} in rats is 2,350 mg/kg [NIOSH 1992b]. Rats, guinea pigs, rabbits, and monkeys were exposed to carbon tetrachloride vapors for 7 hr/day, 5 days/week for up to 4 months. Rats, guinea pigs, and rabbits all showed histologic damage to the liver after exposures of 10 ppm or higher but not after exposure to 5 ppm; monkeys exhibited histologic damage to the liver at concentrations of 100 ppm or above but not at lower levels [Clayton and Clayton 1981]. Carbon tetrachloride was embryotoxic and fetotoxic but not teratogenic in rats exposed to 300 to 1,000 ppm for 7 hr/day on days 6 to 15 of gestation [IARC 1979; NIOSH 1992b]. This chemical also increased fetal mortality when pregnant mice were given a single 150 mg dose [IARC 1979]. Carbon tetrachloride is weakly mutagenic in a wide variety of test systems [NIOSH 1992b]. This chemical produced liver tumors as well as cancers in mice, rats, and hamsters following administration by several routes, including inhalation and ingestion [ACGIH 1991; IARC 1979]. The International Agency for Research on Cancer (IARC) has determined that there is sufficient evidence of carbon tetrachloride's carcinogenicity in animals and that it is a Group 2B carcinogen (possibly carcinogenic in humans) [IARC 1987].

2. *Effects on Humans:* In humans, carbon tetrachloride is a mild eye and skin irritant, a central nervous system depressant, and a liver and kidney toxin. NIOSH, ACGIH, and other organizations classify carbon tetrachloride as a potential human carcinogen. The vapor of carbon tetrachloride is mildly irritating to the eyes [Grant 1986]; and has also caused visual disturbances (concentric restriction of color fields) [NLM 1991]. Prolonged or repeated contact of the liquid with the skin can cause pain, erythema, hyperemia, weal formation, tissue defatting and blistering [Grant 1986; Hathaway et al. 1991; NLM 1991]. The estimated no-observed-effect level for acute human exposure is 10 ppm for 3 hr [Hathaway et al. 1991]. A TC_{Lo} (lowest concentration causing an effect) exposure of 20 ppm (duration undefined) or 317 ppm for 30 min has produced nausea and vomiting [NIOSH 1992b]. Acute symptoms can include abdominal cramps, nervousness, dyspnea, cyanosis, oliguria, proteinuria, hepatomegaly, and optic neuritis [NIOSH 1992b]. Polycythemia, anemia, and hemodilution also may follow acute exposure [Hathaway et al. 1991]. Mild acute poisoning can result in renal injury, and decreased renal blood flow and filtration, which may require up to 200 days for complete recovery. In severe acute poisoning, anuria and terminal uremia require active restoration of renal function, or death occurs [NLM 1991]. In humans, the majority of fatalities caused by inhalation of carbon tetrachloride have been the result of renal injury with secondary cardiac failure. Liver damage occurs more often from ingestion of the liquid than from inhalation of the vapor [Hathaway et al. 1991]. Persons consuming alcohol, those with poor nutritional status, and persons with pre-existing liver or kidney disease are more susceptible to poisoning by carbon tetrachloride [Gosselin et al. 1984]. Human fatalities caused by acute renal failure have resulted from exposure to carbon tetrachloride concentrations of 50,000 ppm for 5 min [NLM 1991], 1,000 to 2,000 ppm for 30 min to 1 hr [Hathaway et al. 1991], or oral doses that exceed 1,500 mg/kg [NIOSH 1992b]. Although repeated exposure of workers to 10 ppm did not induce signs or symptoms of toxicity, 25 to 30 ppm caused nausea, vomiting, dizziness, drowsiness, and headache [NLM 1991]. Ten out of 17 workers exposed for an unspecified period to a 45- to 97-ppm concentration of carbon tetrachloride reported experiencing headache and giddiness, and several of these workers also had symptoms of liver dysfunction [ACGIH 1991]. Workers exposed to carbon tetrachloride at unspeci-

fied levels have experienced dizziness, vertigo, mental confusion, and incoordination, all signs and symptoms of central nervous system depression, and some have developed loss of visual acuity, convulsions, and cardiac arrhythmias [Hathaway et al. 1991]. Carbon tetrachloride has been confirmed as a weak mutagen in a variety of assays [NIOSH 1992b]. In the preamble of the 1989 *Air Contaminants; Final Rule,* OSHA concluded that an "occupational exposure to carbon tetrachloride at the 10-ppm PEL presents a significant risk of cancer to workers" [54 Fed. Reg. 2681 (1989)]. IARC has concluded that there is insufficient human data to directly classify carbon tetrachloride's carcinogenic risk to humans [IARC 1987].

- **Signs and symptoms of exposure**

1. *Acute exposure:* Carbon tetrachloride can induce mild irritation of the eyes and skin, with redness and inflammation, and central nervous system depression, with symptoms of malaise, headache, dizziness, incoordination, confusion, stupor, coma, and convulsions; nausea, vomiting, abdominal pain, and diarrhea are also frequent. Acute exposures can lead to ventricular fibrillation (rapid, irregular heartbeat) and death from cardiac failure. Acute oral exposures have primarily caused liver damage, as evidenced by an ehlarged and tender liver and jaundice, as well as acute nephritis, with a decrease in the volume of urinary output and the presence of blood, pus, or protein in the urine. Acute renal failure can result in coma and death.

2. *Chronic exposure:* Repeated contact of the skin with carbon tetrachloride may cause defatting of the skin and dermatitis, with redness and blister formation. Chronic exposure has also been associated with nausea, vomiting, dizziness, drowsiness, headache, visual disturbances, and loss of visual acuity. The IARC classifies carbon tetrachloride as possibly carcinogenic to humans based on sufficient animal data.

- **Emergency procedures**

> WARNING!
>
> **Seek immediate medical attention for severely affected victims or for victims with signs and symptoms of toxicity or irritation!**

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. *Eye exposure:* Irritation may result from exposure to concentrated solutions, vapors, mists, or aerosols of carbon tetrachloride. ***Immediately and thoroughly*** flush eyes with large amounts of water, occasionally lifting the upper and lower eyelids.

2. *Skin exposure:* Irritation may result. ***Immediately*** remove contaminated clothing and ***thoroughly*** wash contaminated skin with soap and water.

3. *Inhalation exposure:* Move the victim to fresh air ***immediately.***

   If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure:* Take the following steps if carbon tetrachloride or any material containing it is ingested:

   —Have the victim rinse the contaminated mouth cavity several times with a fluid such as water.

   —Have the victim drink a glass (8 oz) of fluid such as water.

   —Induce vomiting by touching the back of the throat with a finger until productive vomiting ceases. Do ***not*** give syrup of ipecac because of possible onset of respiratory depression and seizures.

   —Do ***not*** force an unconscious or convulsing person to drink fluid or to vomit.

5. *Rescue:* Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve carbon tetrachloride and result in worker exposures to this substance:

—Manufacture of fluorocarbons for aerosols, refrigerants, and fire extinguishants (these uses of fluorocarbons have been largely phased out or banned)

—Use as a solvent in dry cleaning and in industry to dissolve resins, oils, fats, varnishes, and rubber waxes

—Use as an agricultural grain fumigant, pesticide, and anthelmintic and as an agent to extract oil from flowers and seeds

—Use in polymer technology as a reaction medium, catalyst, and chain transfer agent

—Use in organic synthesis for the chlorination of organic compounds and in the soap and perfume industries

—Use as a laboratory solvent

—Use in tin recovery and catalyst regeneration and as a cleaning agent for machinery and electrical equipment

The following methods are effective in controlling worker exposures to carbon tetrachloride, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

  Before a worker is placed in a job with a potential for exposure to carbon tetrachloride, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the liver, kidneys, and nervous system.

  A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to carbon tetrachloride at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history of excessive alcohol intake and other findings consistent with diseases of the liver, kidney, or nervous system.

- **Periodic medical examinations and biological monitoring**

  Occupational health interviews and physical examinations should be performed at regular intervals during the

employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to carbon tetrachloride exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of carbon tetrachloride on the liver, kidneys, or nervous system. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Although carbon tetrachloride can be detected in the breath of exposed workers, data on the correlation between breath concentrations and airborne concentrations of carbon tetrachloride are not available. Therefore, no biological monitoring test acceptable for routine use has yet been developed for carbon tetrachloride.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to carbon tetrachloride may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne carbon tetrachloride is determined by using a charcoal tube (100/50-mg sections, 20/40 mesh). Samples are collected at a recommended flow rate of 0.2 liter/min until a maximum air volume of 15 liters is collected. Analysis is conducted by gas chromatography using a flame ionization detector. The limit of detection for this procedure is 0.01 mg, and the method is described in NIOSH Method No. 1003 [NIOSH 1984].

PERSONAL HYGIENE

This substance can be absorbed through the skin in toxic amounts. Therefore, if carbon tetrachloride contacts the skin, workers should flush the affected areas immediately with plenty of water for 15 min, and then wash with soap and water.

Clothing contaminated with carbon tetrachloride should be removed immediately, and provisions should be made for safely removing this chemical from these articles. Persons laundering the clothes should be informed of the hazardous properties of carbon tetrachloride, particularly its potential to cause severe central nervous system effects on acute exposure.

A worker who handles carbon tetrachloride should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where carbon tetrachloride is handled, processed, or stored.

STORAGE

Carbon tetrachloride should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of carbon tetrachloride should be protected from physical damage and direct sunlight and should be stored separately from aluminum, barium, dimethyl formamide, magnesium, potassium, sodium, triethylaluminum, calcium disilicide decaborane, ethylene, heat, sparks, and open flame. Because containers that formerly contained carbon tetrachloride may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving carbon tetrachloride, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a spill or leak:

1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.

2. Notify safety personnel.

3. Ventilate the area of the spill or leak.

4. Use water spray to reduce vapors.

5. For small dry spills, use a clean shovel and gently place the material into a clean, dry container, creating as little dust as possible; cover and remove the container from the spill area.

6. For small liquid spills, absorb with sand or other noncombustible absorbent material and place into closed containers for later disposal.

7. For large liquid spills, build dikes far ahead of the spill to contain the carbon tetrachloride for later reclamation or disposal.

SPECIAL REQUIREMENTS

Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

  Carbon tetrachloride is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

- **Reportable quantity requirements for hazardous releases**

  A hazardous substance release is defined by EPA as any spilling, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers). In the event of a release that is above the reportable quantity for that chemical, employers are required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the proper Federal authorities.

  The reportable quantity for carbon tetrachloride is 10 lb. If an amount equal to or greater than this quantity is released within a 24-hr period in a manner that will expose persons outside the facility, employers are required to do the following:

  —Notify the National Response Center ***immediately*** at (800) 424-8802 or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6].

  —Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40].

  —Notify the community emergency coordinator of the local emergency planning committee (or relevant local emergency response personnel) of any area likely to be affected by the release [40 CFR 355.40].

- **Community right-to-know requirements**

  Employers who own or operate facilities in SIC codes 20 to 39, who employ 10 or more workers, and who manufacture 25,000 lb or more or otherwise use 10,000 lb or more of carbon tetrachloride per calendar year are required by EPA [49 CFR Part 372.30] to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of carbon tetrachloride emitted or released from their facility annually.

- **Hazardous waste management requirements**

  EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Carbon tetrachloride is listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 CFR 355.40], and has been assigned EPA Hazardous Waste No. U211. This chemical is approved for land disposal as long as the concentration of carbon tetrachloride in the waste or treatment residual does not exceed 5.6 mg/kg. Carbon tetrachloride also may be disposed of in an organometallic or organic lab pack that meets the requirements of 40 CFR 264.316 or 265.316.

  Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of carbon tetrachloride exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent any skin contact with carbon tetrachloride. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. The following materials have been recommended for use against permeation by carbon tetrachloride and may provide protection for periods greater than 8 hr: polyvinyl alcohol, Viton, Barricade®, and Responder®. Materials that may withstand permeation for more than 4 but fewer than 8 hr are Teflon and a polyethylene/ethylene vinyl laminate. Protective clothing made of butyl rubber, natural rubber, neoprene, nitrile rubber, polyethylene, or polyvinyl chloride are not recommended for protection against permeation by carbon tetrachloride.

If carbon tetrachloride is dissolved in water or an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which carbon tetrachloride might contact the eyes (e.g., through splashes of solution). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with carbon tetrachloride. Contact lenses should not be worn if the potential exists for carbon tetrachloride exposure.

REFERENCES CITED

ACGIH [1991]. Documentation of the threshold limit values and biological exposure indices. 6th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

ACGIH [1993]. 1993-1994 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Clayton G, Clayton F [1981]. Patty's industrial hygiene and toxicology. 3rd rev. ed. New York, NY: John Wiley & Sons.

CFR. Code of Federal regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

54 Fed. Reg. 2681 [1989]. Occupational Safety and Health Administration: air contaminants; final rule. (29 CFR 1910).

Gosselin RE, Smith RP, Hodge HC [1984]. Clinical toxicology of commercial products. 5th ed. Baltimore, MD: Williams & Wilkins.

Grant WM [1986]. Toxicology of the eye. 3rd ed. Springfield, IL: Charles C. Thomas.

Hathaway GJ, Proctor NH, Hughes JP, and Fischman ML [1991]. Proctor and Hughes' chemical hazards of the

workplace. 3rd ed. New York, NY: Van Nostrand Reinhold.

IARC [1979]. IARC monographs on the evaluation of carcinogenic risk of chemicals to humans: some halogenated hydrocarbons. Vol. 20. Lyon, France: World Health Organization, International Agency for Research on Cancer.

IARC [1987]. IARC monographs on the evaluation of carcinogenic risk of chemicals to humans. Suppl. 7. Lyon, France: World Health Organization, International Agency for Research on Cancer.

NIOSH [1984]. Hydrocarbons, halogenated: Method No. 1003. In: Eller PM, ed. NIOSH manual of analytical methods. 3rd ed. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

NIOSH [1987a]. NIOSH guide to industrial respiratory protection. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-116.

NIOSH [1987b]. NIOSH respirator decision logic. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-108.

NIOSH [1992a]. NIOSH recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

NIOSH [1992b]. Registry of toxic effects of chemical substances database: carbon tetrachloride. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, Technical Information Branch.

NLM [1991]. The hazardous substances data bank: carbon tetrachloride. Bethesda, MD: National Library of Medicine.