NIOSH

Current Intelligence Bulletin 20

JANUARY 20,1978

TETRACHLOROETHYLENE

(perchloroethylene)

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

The Current Intelligence Bulletin is the primary product of the Current Intelligence System. The purpose of the Current Intelligence System is to promptly review, evaluate, and supplement new information received by NIOSH on occupational hazards that are either unrecognized or are greater than generally known.

As warranted by this evaluation, the information is capsulized and disseminated to NIOSH staff, other government agencies, and the occupational health community, including labor, industry, academia, and public interest groups. With respect to currently known hazard information this system also serves to advise appropriate members of the above groups of recently acquired specific knowledge which may have an impact on their programs or perception of the hazard. Above all, the Current Intelligence System is designed to protect the health of American workers and to allow them to work in the safest possible environment.

Synonyms

Ankilostin
Antisal 1
CAS 127-18-4
Didakene
Ethylene tetrachloride
Fedal-Un
Nema
Perclene
PerSec
NIOSH-RTECS KX38500
Tetracap
Tetrachlorethylene
Tetrachloroethene
Tetraguer
Tetraleno
Tetropil
Tetlen
1,1,2,2-Tetrachloroethylene

DHEW (NIOSH) Publication No. 78-112

BIBLIOGRAPHIC DATA SHEET	1. Report No. NIOSH-78-112	2.	3. Recipient's Accession No. PB278055

4. Title and Subtitle

TETRACHLOROETHYLENE (PERCHLOROETHYLENE)

5. Report Date: *Jan. 20, 1978*

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

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10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

same as Box 9

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

Based on a recent study indicating that tetrachloroethylene causes liver cancer in mice, NIOSH recommends that it is prudent to handle the compound in the workplace as if it is a human carcinogen, while its carcinogenic potential at work is being further evaluated. The recommended NIOSH tetrachloroethylene exposure limit of 50 ppm and the OSHA standard for occupational exposure of 100 ppm, may not provide adequate protection from potential carcinogenic effects because they were selected to prevent toxic effects other than cancer. It is estimated that about 500,000 workers employed in dry cleaning establishments and other industries are currently at risk of exposure to the compound in the U.S. Suggested procedures for control of overexposure to tetrachloroethylene, and guidelines for personal protective equipment and personal hygiene are outlined.

17. Key Words and Document Analysis. 17a. Descriptors

Carcinogens
Industrial hygiene
Tetrachloroethylene
Chlorohydrocarbons
Halohydrocarbons
Preventive medicine
Safety
Toxicology
Solvents
Dry cleaning
Air pollution
Atmosphere contamination control
Occupational diseases

17b. Identifiers/Open-Ended Terms

Exposure limits
Air quality control
Chlorinated ethylenes

17c. COSATI Field/Group *06/J*

18. Availability Statement

Distribution unlimited

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21.

22. Price PC A02/MF A01

TETRACHLOROETHYLENE (PERCHLOROETHYLENE)

The National Institute for Occupational Safety and Health (NIOSH) recommends that it is prudent to handle tetrachloroethylene (perchloroethylene) in the workplace as if it were a human carcinogen. The recommendation is based on a recent study by the National Cancer Institute (NCI) indicating that tetrachloroethylene causes liver cancer in laboratory mice (1). This Bulletin is to advise you of the findings of the NCI study, other pertinent data, their implications for occupational health, and precautions for handling tetrachloroethylene.

Animal studies are valuable in helping identify human carcinogens. Substances that cause cancer in experimental animals must be considered to pose a potential cancer risk in man. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of cancer development is lowered with decreasing exposure to carcinogens. Thus NIOSH recommends that occupational exposure to tetrachloroethylene be minimized, and is providing suggested industrial hygiene practices. This is an interim recommendation, while the carcinogenic potential of tetrachloroethylene in the workplace is being further evaluated.

The current Occupational Safety and Health Administration (OSHA) standard for occupational exposure to tetrachloroethylene is 100 ppm, (8-hour time-weighted average). In July 1976 NIOSH (3) recommended an exposure limit of 50 ppm (time-weighted average for up to a 10-hour workday, 40-hour workweek). Neither of these levels may provide adequate protection from potential carcinogenic effects because they were selected to prevent toxic effects other than cancer.

Potential Occupational Exposures

Tetrachloroethylene is a volatile liquid with an odor detectable at about 50 ppm. It is a solvent widely used in dry cleaning, fabric finishing, metal degreasing, and other applications. NIOSH estimates that approximately 500,000 workers are currently at risk of exposure to tetrachloroethylene in the United States. Over 20,000 dry cleaning establishments and a large number of other industries manufacture or use this substance. About 700 million pounds of tetrachloroethylene are currently produced in the United States each year.

Two-thirds of the domestically consumed tetrachloroethylene is used for dry cleaning and for the processing and finishing of textiles. Tetrachloroethylene is used by three-quarters of the dry cleaners in the United States because it is an excellent cleaner of most fabrics, is easily recycled, and is not flammable.

Metal cleaning accounts for approximately fifteen percent of the domestic consumption of tetrachloroethylene, where exposures can occur during degreasing and cold cleaning. Tetrachloroethylene also serves as a chemical

intermediate in the synthesis of trichlorotrifluoroethane (fluorocarbon 113), dichlorotetrafluoroethane (fluorocarbon 114), chloropentafluoroethane (fluorocarbon 115), and hexafluoroethane (fluorocarbon 116). Tetrachloroethylene exposures may also occur in extraction processes, during its use as an industrial solvent, as a heat exchange fluid, and as a drug in treatment of internal parasite infestations.

Laboratory Animal Studies for Carcinogenicity

The long term animal study reported by NCI demonstrates tetrachloroethylene to be carcinogenic in laboratory mice. In the study, B6C3F1 mice were force fed tetrachloroethylene for 78 weeks. Male mice were treated at two dose levels (536 or 1072 mg/kg/day) and female mice were treated at two different dose levels (386 or 772 mg/kg/day). A significant increase of hepatocellular carcinoma (liver cancer) was observed in both sexes of treated mice when compared with control animals. At both dose levels more than 50% of the male mice and 40% of the female mice (each from groups of approximately 50 animals) developed liver cancer. By comparison, cancer developed in 12% or less of the groups of untreated or vehicle-matched controls. This NCI report is the first definitive association of tetrachloroethylene with cancer. To relate some of the above information to the work environment, a 70 kg man breathing a typical 10 cu m/day (over an 8-hour work shift) of air contaminated with 100 ppm of tetrachloroethylene would have an inhalation exposure of about 100 mg/kg/day.

In the same NCI report, Osborne-Mendel rats showed no significant increase of liver cancer under the same experimental procedure. Because many of the rats died early in the study, this bioassay was considered inadequate for the carcinogenicity testing of tetrachloroethylene. However there was a high incidence of kidney damage observed in both the rats and mice treated with tetrachloroethylene.

A study by The Dow Chemical Company (2) found many tumors in Sprague-Dawley rats exposed by inhalation to 300 or 600 ppm tetrachloroethylene, but for most tumors there was no statistically significant difference in tumor incidence between exposed and control rats. Some tumors were found in higher incidence in control animals. The only tumor seen at higher incidence in exposed animals was adrenal pheochromocytoma in female rats at the lower exposure level only. Pheochromocytoma is a tumor which gives rise to high blood pressure and hyperglycemia due to release of adrenalin and noradrenalin into the blood. Increased mortality occurred in male rats exposed to 600 ppm tetrachloroethylene.

Section references: 1,2

Other Laboratory Animal Studies

The liver is a principal target organ of tetrachloroethylene exposure in

animals. Typical toxic effects are fatty liver, liver enlargement, and abnormal liver function tests. Tetrachloroethylene has also been shown to cause kidney damage in mice following intraperitoneal injection and in rats and rabbits following inhalation.

Neurophysiological effects of tetrachloroethylene are reflected in the distinct alterations of the electroencephalogram (EEG) in rats. Central nervous system (CNS) depression, including abnormal weakness, handling intolerance, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness have been observed in exposed animals.

Tetrachloroethylene has been shown to be a primary eye and skin irritant in rabbits. Other effects of tetrachloroethylene exposure in laboratory animals include lung damage (excessive fluid accumulation, inflammation, congestion, or hemorrhage), cardiac depression, decreased blood pressure, depressed respiration, decreased oxygen consumption, and depression in growth rate.

One study suggests the teratogenic potential of tetrachloroethylene. Fetal and maternal toxicity was observed in mice and rats exposed to tetrachloroethylene on days 615 of gestation. In this study a decrease in the maternal weight gain in rats, an increase in the relative weight of the liver in pregnant mice, an increase of fetal reabsorption in rats, a decrease in fetal body weight and an increase of subcutaneous edema in fetal mice, were all associated with exposure to tetrachloroethylene. Delayed ossification of skull bones and split sternebrae were possible teratogenic effects observed in mice.

Section references: 3,5,6,7,8,13

Human Toxicity

Clinical evidence accumulated over the years clearly demonstrates that tetrachloroethylene is toxic to the liver and kidneys in humans. Liver impairment has been noted in cases of exposure to tetrachloroethylene as evidenced by abnormal liver function tests. Also, toxic chemical hepatitis, and enlargement of the liver and spleen have been associated with exposure to tetrachloroethylene. Tetrachloroethylene vapor is irritating to the eyes and upper respiratory tract, and may cause frontal sinus congestion and headache. Direct contact with skin can cause burns, blistering, and erythema due to the "degreasing" effect of tetrachloroethylene on the skin. Over a period of time this can result in extreme skin dryness with cracking and associated infection.

Altered physiological and behavioral responses observed in subjects exposed to tetrachloroethylene include vague nonspecific complaints generally attributed to CNS depression. These symptoms include vertigo, impaired memory, confusion, fatigue, drowsiness, irritability, loss of appetite, nausea

and vomiting. Motor coordination following tetrachloroethylene exposure requires additional mental effort, which along with memory impairment and fatigue have important implications for worker safety. Various disturbances of the peripheral nervous system such as tremors and numbness have also been associated with exposure to tetrachloroethylene. Excessive absorption of tetrachloroethylene can cause severe depression of the CNS leading to coma; ultimately death may occur from respiratory paralysis or circulatory failure.

Tetrachloroethylene is most commonly absorbed through the lungs and can be absorbed from the intestines if ingested. The skin is a less important absorption site. Physical exercise can significantly increase the amount of tetrachloroethylene absorbed through the lungs because of greater respiration and increased blood flow.

Metabolism and elimination of tetrachloroethylene is relatively slow. It is deposited in body fat and the biologic halflife of tetrachloroethylene in man is estimated at six days.

Section references: 3,4,8,9,10,11,12,14

NIOSH Action on Tetrachloroethylene

1. NIOSH has contracted for a retrospective mortality study of persons employed in dry cleaning establishments where there had been exposure to tetrachloroethylene. The contract will be monitored by the Biometry Section of the NIOSH Industry-wide Studies Branch.

2. The NIOSH Industrial Hygiene Section of the Industry-wide Studies Branch plans an industrial hygiene assessment of dry cleaning workers exposed to tetrachloroethylene.

3. The NIOSH Behavioral and Motivational Factors Branch is undertaking a tetrachloroethylene behavioral teratology study. The study results should be available in late 1978.

4. NIOSH has contracted for a control technology assessment of the dry cleaning industry. The contract will be monitored by the NIOSH Control Technology Research Branch.

5. NIOSH will coordinate research on tetrachloroethylene with the National Cancer Institute (NCI) which is also examining the mortality experience of persons employed in dry cleaning establishments.

6. NIOSH has contracted for a study to evaluate the potential teratogenicity and the mutagenicity of tetrachloroethylene. This contract will be monitored by the NIOSH Experimental Toxicology Branch.

7. Currently available NIOSH publications on tetrachloroethylene include:

a) Criteria for a recommended standard....Occupational Exposure to Tetrachloroethylene (Perchloroethylene). HEW Publication No. (NIOSH) 76-185.

b) Health and Safety Guide for Laundries and Dry Cleaners. HEW Publication No. (NIOSH) 75-151.

c) Effects of Perchloroethylene/Drug Interaction on Behavior and Neurological Function HEW Publication No. (NIOSH) 77-191.

d) A Behavioral and Neurological Evaluation of Dry Cleaners Exposed Perchloroethylene. HEW Publication No. (NIOSH) 77-214.

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SUGGESTED PROCEDURES FOR MINIMIZING EMPLOYEE EXPOSURE TO TETRACHLOROETHYLENE (PERCHLOROETHYLENE)

CONTROL OF OVEREXPOSURES

NIOSH recommends that it is prudent to handle tetrachloroethylene in the workplace as if it were a human carcinogen and that occupational exposure to tetrachloroethylene be minimized. Exposure to tetrachloroethylene should be limited to as few employees as possible, while minimizing workplace exposure levels. The area in which it is used should be restricted to those employees necessary to the process or operation. Furthermore, consideration should be given to isolating the tetrachloroethylene exposure area so that adjacent workers are not also exposed.

1. Exposure monitoring

The NIOSH Occupational Exposure Sampling Strategy Manual, NIOSH publication #77-173, may be helpful in developing efficient programs to monitor employee exposures to tetrachloroethylene. The manual discusses determination of the need for exposure measurements, selection of appropriate employees for sampling, and selection of sampling times.

Employee exposure measurement samples can be obtained and analyzed using the guidelines in NIOSH method #P&CAM 127 in the second edition of the NIOSH Manual of Analytical Methods, NIOSH publication #77-157. Exposure measurements should consist of 8-hour TWA exposure estimates calculated from personal or breathing zone samples (air that would most nearly represent that inhaled by the employees).

2. Engineering controls

Engineering and work practice controls should be used to minimize employee exposure to tetrachloroethylene.

To ensure that ventilation equipment is working properly, it is advised that effectiveness be checked at least every three months (e.g., air velocity, static pressure or air volume). System effectiveness should also be checked within five days of any change in production, process, or control which might result in significant increases in airborne exposures to tetrachloroethylene.

3. Respiratory protection

Exposure to tetrachloroethylene should not be controlled with the use of respirators except:

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

In work situations in which engineering and work practice controls are technically not feasible; or

To supplement engineering and work practice controls when such controls fail to adequately control exposure to tetrachloroethylene; or

For operations which require entry into tanks or closed vessels; or

In emergencies.

Respirators should be approved by the National Institute for Occupational Safety and Health (NIOSH) or by the Mining Enforcement and Safety Administration (MESA). Refer to NIOSH Certified Equipment, December 15, 1975, NIOSH publication #76-145 and Cumulative Supplement June 1977, NIOSH Certified Equipment, NIOSH Publication #77-195. The use of faceseal coverlets or socks with any respirator voids NIOSH/MESA approvals.

Quantitative faceseal fit test equipment (such as sodium chloride or PDOP) should be used. Refer to A Guide to Industrial Respiratory Protection, NIOSH publication #76-189 for guidelines on appropriate respiratory protection programs.

Where respirators are used under the preceding guidelines, NIOSH recommends that for routine use the employer provide either a) Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode (30 CFR 11.70(a)) or b) 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 positive pressure mode (30 CFR 11.70(b)). For firefighting, the employer should provide a) Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode (30 CFR 11.70(a)). For escape the employer should provide a) Any gas mask providing protection against organic vapors (30 CFR 11.90) or b) Any escape self-contained breathing apparatus (30 CFR 11.70(a)).

PERSONAL PROTECTIVE EQUIPMENT

Employers should provide impervious, gloves, face shields (8-inch minimum) and other appropriate clothing necessary to prevent repeated or prolonged skin contact with liquid tetrachloroethylene.

Employers should see that employee clothing wet with liquid tetrachloroethylene is placed in closed containers for storage until it can be discarded or until the employer provides for the removal of tetrachloroethylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetrachloroethylene, the employer should inform the person

performing the operation of the hazardous properties of tetrachloroethylene including the fact that it is a possible human carcinogen.

Employers should see that permeable clothing which becomes contaminated with liquid tetrachloroethylene be removed promptly and not reworn until the tetrachloroethylene is removed from the clothing.

PERSONAL HYGIENE

Employers should see that employees who handle liquid tetrachloroethylene wash their hands thoroughly with soap or mild detergent before eating, smoking, or using toilet facilities.

Employers should see that employees whose skin becomes contaminated with liquid tetrachloroethylene promptly wash or shower with soap and mild detergent and water to remove any tetrachloroethylene from the skin.

* U.S. GOVERNMENT PRINTING OFFICE: 1978— 757-090/61