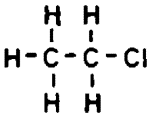
NIOSH

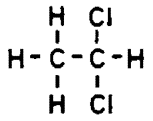
Current Intelligence Bulletin 27

August 21, 1978

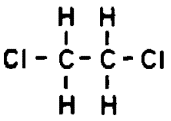
CHLOROETHANES:
REVIEW OF TOXICITY



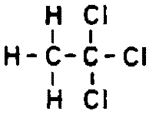
Chloroethane
(Ethyl Chloride)



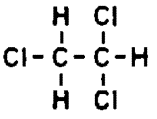
1,1,-Dichloroethane



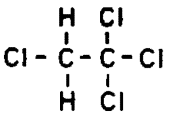
1,2-Dichloroethane
(Ethylene Dichloride)



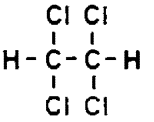
1,1,1-Trichloroethane
(Methyl Chloroform)



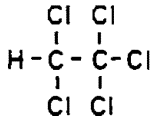
1,1,2-Trichloroethane



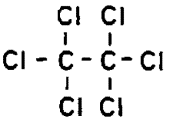
1,1,1,2-Tetrachloroethane



1,1,2,2-Tetrachloroethane



Pentachloroethane



Hexachloroethane

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

The NIOSH 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 appropraate 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.

IDENTIFIERS AND SYNONYMS FOR THE NINE CHLOROETHANES ARE LISTED

IN THE REAR PORTION OF THIS BULLETIN

ERRATA

In Bulletins #22 through #25 it was stated that the NIOSH National Occupational Hazard Survey (NOHS) had included "over 500,000 employees at 4,775 facilities." Actually the Survey included nearly 900,000 employees at 4,636 facilities.

In Bulletin #23 NIOSH erroneously listed Dowfume® MC-2 as a synonym for ethylene dibromide. Dow Chemical USA has advised NIOSH that Dowfume®MC-2 actually is 98% methyl bromide and 2% chloropicrin.

DHEW (NIOSH) Publication No. 78-181

BIBLIOGRAPHIC INFORMATION

PB85-119196

Current Intelligence Bulletin 27. Chloroethanes: Review of Toxicity.

21 Aug 78

PERFORMER: National Inst. for Occupational Safety and Health, Cincinnati, OH.
DHEW/PUB/NIOSH-78/181

The National Institute for Occupational Safety and Health (NIOSH) recommends that it would be prudent to handle 1,2-dichloroethane (ethylene dichloride); 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; and hexachloroethane in the workplace as if they were human carcinogens. This recommendation is based primarily on consideration of National Cancer Institute (NCI) data indicating that laboratory animals administered these compounds experienced a statistically significant excess of cancer as compared to control animals (1-4). Additionally, NIOSH recommends that five other chloroethane compounds: chloroethane (ethyl chloride); 1,1-dichloroethane; 1,1,1-trichloroethane (methyl chloroform); 1,1,1,2-tetrachloroethane; and pentachloroethane be closely monitored for carcinogenic effects in humans and/or laboratory animals. These five should also be treated in the workplace with caution because of their relation to the four chloroethanes shown to be carcinogenic in laboratory animals.

KEYWORDS: *Environmental surveys, *Industrial medicine, *Chloroethanes, *Toxic substances, *Occupational safety and health.

Available from the National Technical Information Service, SPRINGFIELD, VA. 22161

NIOSH CURRENT INTELLIGENCE BULLETIN

CHLOROETHANES: REVIEW OF TOXICITY

The National Institute for Occupational Safety and Health (NIOSH) recommends that it would be prudent to handle 1,2-dichloroethane (ethylene dichloride); 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; and hexachloroethane in the workplace as if they were human carcinogens. This recommendation is based primarily on consideration of National Cancer Institute (NCI) data indicating that laboratory animals administered these compounds experienced a statistically significant excess of cancer as compared to control animals (1-4). Additionally, NIOSH recommends that five other chloroethane compounds: chloroethane* (ethyl chloride); 1,1-dichloroethane; 1,1,1-trichloroethane (methyl chloroform); 1,1,1,2-tetrachloroethane; and pentachloroethane be closely monitored for carcinogenic effects in humans and/or laboratory animals. These five should also be treated in the workplace with caution because of their relation to the four chloroethanes shown to be carcinogenic in laboratory animals.

This Current Intelligence Bulletin summarizes information on some of the similarities and dissimilarities within the chloroethane group. NIOSH is concerned about the carcinogenic potential of chloroethanes based on emerging data from the NCI bioassay program. Concern for the carcinogenic potential of all members of the chloroethane series is based upon structural similarities within the group as well as the structural similarities to other carcinogenic organochlorine compounds. Extreme care must be used when selecting possible substitutes, and the alternatives should be fully evaluated with regard to human effects.

At present, NIOSH is not aware of any evidence associating chloroethane compounds with an increased risk of cancer in man. However, animal studies are valuable in helping identify human carcinogens. Substances that cause cancer in experimental animals must be considered a potential cancer risk in man. Safe levels of exposure to carcinogens have not been demonstrated, but lowered exposure to carcinogens decreases the probability of cancer development.

NIOSH issued Current Intelligence Bulletin #25 (April 1978), recommending that ethylene dichloride (1,2-dichloroethane) be handled in the workplace as if it were a human carcinogen (5). NIOSH is now distributing Bulletin #27 to advise of additional findings of the NCI chloroethane bioassays, other pertinent data, and possible implications for occupational health. Also included are "Suggested Guidelines for Controlling Employee Exposure to Chloroethanes." NIOSH requests that producers, distributors, professional associations, and unions transmit the information in this Bulletin to their customers, employees, associates and members.

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*to be referred to as monochloroethane in this Bulletin

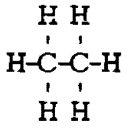
Table 1. Summary of Some of the Industries and Occupations Which Use Chloroethanes.[a]

Chemical	Industries[b]	Occupations[c]
monochloroethane	medical and other health services; automotive dealers and service stations; wholesale trade; electric, gas and sanitary services; machinery, except electrical; special trade contractors; fabricated metal products; printing and publishing; rubber and plastics products not elsewhere classified; food and kindred products	registered nurses; automobile mechanics; physicians, medical and osteopathic; office machine mechanics and repairmen; garage workers and gas station attendants; not specified mechanics and repairmen; household appliance and accessory installers; assemblers; heavy equipment mechanics, including diesel; plumbers and pipe fitters
1,1-dichloroethane	chemicals and allied products; miscellaneous business services; stone, clay and glass products not elsewhere classified; petroleum and coal products	janitors and sextons; not specified clerical workers; electricians; assemblers; agricultural and biological technicians
1,2-dichloroethane	medical and other health services; automotive dealers and service stations; machinery, except electrical; wholesale trade; printing and publishing; eating and drinking places; primary metal industries; chemicals and allied products; miscellaneous business services; transportation equipment; electrical equipment and supplies; special trade contractors; fabricated metal products; stone, clay and glass products; food and kindred products; paper and allied products; rubber and plastics products not elsewhere covered; communication; water transportation; instruments and related products	automobile mechanics; janitors and sextons; heavy equipment mechanics, including diesel; registered nurses; miscellaneous specified machine operatives; miscellaneous operatives; assemblers; machinists; pressmen and plate printers, printing; cooks, except private household; garage workers and gas station attendants; cleaners and charwomen; electricians; telephone installers and repairmen; vehicle washers and equipment cleaners; secretaries not elsewhere classified; nursing aides, orderlies and attendants; checkers, examiners and inspectors, manufacturing; not specified mechanics and repairmen: painters, manufactured articles
1,1,1-trichloroethane	medical and other health services; automotive dealers and service stations; machinery, except electrical; wholesale trade; transportation equipment; printing and publishing; primary metal industries; electrical equipment and supplies; fabricated metal products; communication; special trade contractors; chemicals and allied products; eating and drinking places; miscellaneous services; transportation by air; stone, clay and glass products; retail general merchandise; instruments and related products; apparal and accessory stores; electric, gas and sanitary services; food and kindred products; rubber and plastics products not elsewhere classified; personal services; paper and allied products	auto mechanics; janitors and sextons; heavy equipment mechanics, including diesel; registered nurses; secretaries not elsewhere classified; machinists; machine operatives; miscellaneous specified; assemblers; not specified clerical workers; cleaners and charwomen; miscellaneous operatives; electricians; pressmen and plate printers, printing; garage workers and gas station attendants; telephone installers and repairmen; manufacturing checkers, examiners and inspectors; cooks, except private household; tool and die makers; administrators and managers, not elsewhere classified; nursing aides, orderlies and attendants; dishwashers; vehical washers and equipment cleaners; millwrights; miscellaneous mechanics and repairmen; office machine
1,1,2-trichloroethane	primary metal industries; wholesale trade; auto repair, services and garages; transportation equipment; communication; electrical equipment and supplies; special trade contractors; miscellaneous retail stores; machinery, except electrical; stone, clay and glass products; chemicals and allied products; medical and other health services; instruments and other related products	electricians; heavy equipment mechanics, including diesel; miscellaneous mechanics and repairmen; upholsterers; janitors and sextons; electrical and electronic engineering technicians; office machine mechanics and repairmen; radio and television; not specified mechanics and repairmen; air conditioning, heating and refrigeration; telephone installers and repairmen; miscellaneous operatives; assemblers; manufacturing checkers, examiners and inspectors; printing pressmen and plate printers
1,1,2,2-tetrachloroethane	electrical equipment and supplies; chemicals and allied products; electric, gas and sanitary services; miscellaneous business services; stone, clay and glass products	assemblers; janitors and sextons; not specified clerical workers; electricians; manufacturing checkers, examiners and inspectors
hexachloroethane	real estate; paper and allied products; lumber and wood products; amusement and recreation services not elsewhere classified	cleaners and charwomen; millwrights; machine operatives, miscellaneous specified; plumbers and pipefitters; electricians

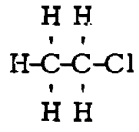
(a) 1,1,1,2-tetrachloroethane and pentachloroethane were not mentioned in the NOHS survey (6)
(b) These are standard industrial titles from the Standard Industrial Classification Manual (7)
(c) These are standard occupational titles from the Bureau of the Census (8)

BACKGROUND

Chloroethanes are chlorinated organic compounds structurally related to ethane in which one or more of the hydrogen atoms have been replaced by a chlorine atom or atoms. Monochloroethane, for example, is shown to result from the replacement of one hydrogen atom in ethane by a chlorine atom.



ethane



monochloroethane

At room temperature monochloroethane is a gas, hexachloroethane is a solid, and the seven other chloroethanes are liquids. Some of the chloroethanes are manufactured on a large scale and used extensively because of their low cost and excellent solvent properties. They are used as solvents and in degreasing agents, cutting fluids, fumigants, and in the manufacture of plastics, textiles, and other chemicals. Table 1 (opposite page) summarizes the major industries and occupations in which workers are potentially exposed to chloroethanes.

From 1972-1974, NIOSH conducted the NIOSH National Occupational Hazards Survey (NOHS), on a sample of about 900,000 employees at 4,636 facilities, in order to determine the potential for worker exposure to chemicals and physical agents. NOHS algorithms used Bureau of the Census 1970 population counts to permit extrapolation from the sample to the United States worker population of 1970. A total of over 3 million workers were estimated to be potentially exposed to one or more chloroethanes. Table 2 presents a summary of NOHS estimates of worker exposure to chloroethanes and some production figures (6,9, 40).

Table 2. Chloroethane Exposures and Production (6,9, 40).

Chemical	Estimated number of workers exposed	Annual Production quantities (pounds)
monochloroethane	113,000	670 million (1976)
1,1-dichloroethane	4,600	b
1,2dichloroethane	1,900,000	8 billion (1976)
1,1,1-trichloroethane	2,900,000	630 million (1976)
1,1,2-trichloroethane	112,000	c
1,1,1,2-tetrachloroethane	a	b
1,1,2,2-tetrachloroethane	11,100	c
pentachloroethane	a	b
hexachloroethane	1,500	b,d

[a] NOHS estimates not available
[b] does not appear to be commercially produced in the United States
[c] direct production information not available
[d] 730,000 kg were imported in 1976

Summaries of the current Department of Labor - Occupational Safety and Health Administration (OSHA) exposure standards (10) and NIOSH recommended exposure standards for the chloroethane compounds are given in Table 3.

Table 3. Chloroethane Exposure Standards.

Chemical	OSHA Exposure Standard (ppm)	NIOSH Recommended Exposure Standard (ppm)
monochloroethane	1000	none
1,1-dichloroethane	100	none
1,2-dichloroethane	50	5
1,1,1-trichloroethane	350	350
1,1,2-trichloroethane	10	none
1,1,1,2-tetrachloroethane	none	none
1,1,2,2-tetrachloroethane	5	1
pentachloroethane	none	*
hexachloroethane	1	*

* NIOSH has tentative plans for a Criteria Document for a Recommended Standard for this substance

The OSHA exposure standards and the NIOSH recommended standards and control measures for the chloroethanes were developed before the carcinogenic potential of these compounds was recognized. Therefore, an assessment of the carcinogenicity of these compounds was not included. The levels currently recommended or adopted may not provide adequate protection from potential carcinogenic effects.

LABORATORY ANIMAL STUDIES

Carcinogenicity

As of July 1978, four of the eight chloroethanes selected by NCI for testing have been shown to be carcinogenic in laboratory animals. The results of the bioassays (1-4,14) are summarized in Table 4. Each compound was studied separately in male and female Osborne-Mendel rats and male and female $B_6C_3F_1$ mice. Each experiment consisted of a high dose and a low dose group of 50 animals each. Twenty animals of each species/sex combination served as untreated controls and 20 animals of each species/sex combination served as vehicle controls. The chloroethane compounds were administered to the test animals in a corn oil vehicle by gastric intubation (stomach tube) five days a week for 78 weeks. The vehicle controls were intubated with pure corn oil at the same rate as the high dose animals.

Table 4. Summary of NCI Chlorothane Bioassay Results as of July 1978 (1-4,14).

Compound	Species/sex	Tumor site	Statistically significant tumors
monochloroethane	no testing planned		
1,1-dichloroethane	retesting recommended because initial results inconclusive		
1,2-dichloroethane	rats/female	mammary gland	adenocarcinomas
	rats/male	forestomach	squamous cell carcinomas
		circulatory system	hemangiocarcinomas
		subcutaneous tissue	fibromas
	mice/female	mammary gland	adenocarcinomas
		endometrium	stomal sarcomas
		lungs	adenomas
	mice/male	lungs	adenomas
1,1,1-trichloroethane	retesting in progress		
1,1,2-trichloroethane	mice/female	liver	hepatocellular carcinomas
	mice/male	liver	hepatocellular carcinomas
	mice	adrenal glands	pheochromocytomas
1,1,1,2-tetrachloroethane	testing in progress, no report available		
1,1,2,2-tetrachloroethane	mice/female	liver	hepatocellular carcinomas
	mice/male	liver	hepatocellular carcinomas
pentachloroethane	testing in progress, no report available		
hexachloroethane	mice/female	liver	hepatocellular carcinomas
	mice/male	liver	hepatocellular carcinomas

The National Cancer Institute has concluded that under the conditions of the bioassay 1,2-dichloroethane; 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; and hexachloroethane are carcinogenic in mice, inducing liver cancer in both sexes (1-4). Additionally, results of the NCI bioassay of 1,2-dichloroethane indicate that this compound also causes cancer in male and female rats. In mice 1,1,2-trichloroethane was also associated with increased adrenal pheochromocytoma, a tumor which gives rise to high blood pressure and hyperglycemia. Toxic kidney damage was observed in all groups of both mice and rats treated with hexachloroethane (4).

Although the occurence of cancer in mice is highly significant, the results do not provide conclusive evidence that 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; or hexachloroethane cause cancer in rats. A statistically significant association between increased dosage and accelerated mortality was observed in rats treated with hexachloroethane. NCI has concluded that early mortality may have obscured a carcinogenic effect in these animals.

The National Cancer Institute is currently conducting bioassays of pentachloroethane and 1,1,1,2-tetrachloroethane (14). They are also retesting 1,1-dichloroethane and 1,1,1-trichloroethane because the previous tests were inconclusive; low survival rates complicated the interpretation of the bioassay results. Monochloroethane has not yet been tested.

Other Adverse Effects

All of the chloroethane compounds are known to cause central nervous system (CNS) depression in laboratory animals. This is usually expressed as abnormal weakness, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsiousness. Chloroethanes are generally irritating to the eyes and skin. Damage to the liver and/or kidney has been demonstrated in various animal species following exposure to these compounds (15).

It has been reported that some of the chloroethanes and their metabolites are mutagenic in bacterial systems (3,16). Mutagenic activity, per se, should be considered a substantial liability. In addition, research suggests a correlation between mutagenicity in some bacterial strains and carcinogenicity in higher animals. Other adverse effects of the chloroethanes may vary from one compound to another. Table 5 summarizes some of the toxicological studies in animal systems.

Table 5. Some Adverse Effects of Chloroethanes Reported in Animal Studies (5,11-13,17-37).

Chemicals	Species	Adverse Effect
monochloroethane	unspecified	kidney damage; fatty changes in liver, kidney, and heart
1,1-dichloroethane	cat	kidney damage
	dog	liver injury
	rat	liver injury; retarded fetal development
1,2-dichloroethane	bacterium	mutagen
	cat	retarded growth rate, fatty changes in liver; heart dilation; lung hyperemia
	dog	corneal clouding; fatty changes in liver; liver enlargement; weight loss
	fruit fly	mutagen
	guinea pig	fatty changes in liver; liver enlargement; weight loss
	monkey	fatty changes in liver
	rabbit	fatty changes in liver; hypotension; respiratory paralysis; EKG changes; anemia; bone marrow changes; liver dysfunction, hemorrhage and degeneration; kidney degeneration and dysfunction
	rat	embryotoxin; pulmonary congestion; fatty changes in liver
1,1,1-trichloroethane	cat	neuromuscular reflex changes
	dog	sudden death; respiratory failure
	guinea pig	fatty changes in liver; lung irritation
	mouse	cardiac arrythmias; liver dysfunction; pulmonary congestion
	monkey	cardiac arrythmias; myocardial depression; respiratory failure; staggering gait; tachycardia; tremors
	rat	cardiac failure; pulmonary congestion; pneumonitis; staggering gait; weakness; respiration; semiconsciousness; respiratory failure
1,1,2-trichloroethane	dog	liver and kidney injury
	guinea pig	liver and kidney injury
1,1,1,2-tetrachloroethane	rabbit	embryotoxin
	rat	embryotoxin; liver dysfunction; mutagen
1,1,2,2-tetrachloroethane	bacterium	mutagen
	dog	ascites; diarrhea; jaundice; liver enlargement; intestinal hemorrhage
	guinea pig	convulsions; weight loss; death
	monkey	anorexia; diarrhea; blood cell fluctuation; weight loss
	mouse	staggering gait; breathing difficulty; fatty degeneration of liver and kidney; death
	rabbit	altered immune system; altered blood chemistry; liver and kidney degeneration; fatty degeneration of liver and kidney; corneal reflex changes; liver enlargement; paralysis; death
	rat	blood cell changes; fatty degeneration of liver; liver dysfunction; death
pentachloroethane	cat	liver, kidney, and lung changes
	dog	fatty degeneration of liver; kidney and lung injury
	sheep	liver dysfunction
hexachloroethane	cattle	liver and kidney damage
	mouse	liver and kidney damage
	rat	liver and kidney damage
	sheep	liver and kidney damage

HUMAN TOXICITY

Although chloroethanes have been associated with cancer in laboratory animals, NIOSH is unaware of any definitive evidence indicating that chloroethanes are carcinogenic in humans. However, the chloroethanes have long been known to be capable of producing harmful local and systemic effects. As summarized in Tables 6 and 7, the chloroethanes may affect a variety of human organs or systems. The effects of chloroethane exposure vary from one compound to another, but, most are known to effect the central nervous system (CNS). In many instances, the clinical manifestations and laboratory findings associated with chloroethane toxicity are similar for the major routes of entry: inhalation, skin absorption, and ingestion. Liver and/or kidney injury, pulmonary irritation, and damage to the blood-forming system have been associated with inhalation of chloroethanes. Repeated or prolonged skin exposure can defat the skin and cause dermatitis.

In addition to the toxic effects of chloroethanes and their metabolites, the oxidative decomposition of products produced in the presence of open flames, hot metals, or lighted cigarettes should be taken into account. The chloroethane compounds may degrade to phosgene, hydrogen chloride and dichloroacetylene. Phosgene is considered to be dangerous to life in 30 to 60 minutes at 12.5 ppm (37).

Table 6. Adverse Effects of Chloroethanes on Human Organs and Systems (5,11-13,39-41).*

CHEMICAL	IMMUNOLOGICAL, ALLERGIC	HEMATOLOGICAL	CARDIOVASCULAR	PULMONARY	RENAL, UROLOGIC	GASTROINTESTINAL	HEPATIC, BILIARY	MUSCULOSKELETAL	NEUROLOGIC	DERMATOLOGIC	OPTHALMOLOGIC	OTHER
monochloroethane	●		●	●		●			●	●	●	●
1,1-dichloroethane				●					●	●		
1,2-dichloroethane		●	●	●	●	●	●	●	●	●		●
1,1,1-trichloroethane		●	●			●	●		●	●	●	●
1,1,2,2-tetrachloroethane		●	●	●	●	●	●		●	●		●
hexachloroethane									●		●	

*adverse human health effects have not been reported to NIOSH for 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, and pentachloroethane

Table 7. Specific Adverse Effects of Chloroethanes on Humans, by System (5,11-13,37-39).

Chemical	System	Adverse Effect
monochloroethane	neurologic	central nervous system depression, headache, dizziness, incoordination, feeling inebriated, unconsciousness
	gastrointestinal	abdominal cramps
	respiratory	respiratory tract irritation, respiratory failure
	cardiovascular	cardiac arrhythmias, cardiac arrest
	dermatological	skin irritation, frostbite, allergic eczema
	other	eye irritation, death
1,1-dichloroethane	neurologic	central nervous system depression
	respiratory	respiratory tract irritation
	dermatologic	skin burn
1,2-dichloroethane	neurologic	headache, dizziness, unconsciousness, vertigo, hand tremors, generalized weakness, sleepiness, nervousness, mental confusion
	hepatic	liver function abnormalities, cellular damage, toxic chemical hepatitis, jaundice, liver enlargement
1,1,1-trichloroethane	neurologic	central nervous system depression, headache, dizziness, incoordination, feeling inebriated, unconsciousness; impaired perceptual speed, manual dexterity and equilibrium; increased reaction time, lightheadeness, drowsiness, sleepiness, generalized weakness, ringing sound in ears, unsteady gait, burning and/or prickling sensation in hands and/or feet
	hepatic	cellular damage, liver function abnormalities
	gastrointestinal	nausea, vomiting, diarrhea
	cardiovascular	drop in blood pressure (hypotension), decrease in heart rate (bradycardia), cardiac arrhythmias
	hematologic	blood clotting changes
	dermatologic	dryness, cracking, scaliness, inflammation
	other	eye irritation, fatigue, death
1,1,2-trichloroethane		NIOSH is unaware of reports of adverse occupational exposure (see Table 5)
1,1,1,2-tetrachloroethane		NIOSH is unaware of reports of adverse occupational exposure (see Table 5)
1,1,2,2-tetrachnoroethane	neurologic	central nervous system depression, headache, feeling inebriated, unconsciousness, drowsiness, unsteady gait, vertigo, hand tremors, numbness in limbs, prickling sensation of fingers and tows, pain in sole of feet, loss of knee jerk, paralysis of some muscles of the hands and feet, inflammation of the peripheral nerves slight paralysis of the soft palate, loss of the gag refles, irritability, mental confusion, delirium, convulsions, stupor, coma
	hepatic	liver function abnormalities, massive cell damage toxic chemical hepatitis, jaundice, liver enlargement, sensation of pressure in the liver area
	gastrointestinal	abdominal pain, nausea, vomiting, unpleasant taste in the mouth, loss of appetite (anorexia), vomiting of blood (hematemesis), increased flatulence, diarrhea, constipation, pale stools
	urologic	kidney damage, presence of bile pigments, albumen, and casts in the urine
	respiratory	excessive fluid in the lungs (pulmonary edema), respiratory paralysis
	cardiovascular	fatty degeneration of the heart muscle (in lab animals)
	hematologic	anemia, increase in white blood cells, (and blood platelets)
	dermatologic	dryness, cracking, scaliness, inflamation, purpuric rash
	other	insomnia, general malaise, fatigue, excessive sweating, weight loss
pentachloroethane		NIOSH is unaware of reports of adverse occupational exposure (see Table 5)
hexachloroethane	neurologic	inability to close eyelid
		eye irritation, tearing of eyes, inflamation of delicate membrane lining the eye, visual intolerance to light, (photophobia)

NIOSH Recommendation

Animal studies are valuable in helping identify human carcinogens. Substances that cause cancer in experimental animals must be considered a potential cancer risk in man. Although safe levels of exposure to carcinogens have not yet been demonstrated, decreasing exposure to carcinogens does reduce their probability of initiating cancer development.

As an interim and prudent measure while the carcinogenicity of chloroethanes is being further evaluated, NIOSH recommends that occupational exposure to 1,2-dichloroethane; 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, and hexachloroethane be minimized. Exposures should be limited to as few employees as possible, while minimizing workplace exposure levels with engineering and work practice controls. Additionally, monochloroethane; 1,1-dichloroethane; 1,1,1-trichloroethane; 1,1,1,2-tetrachloroethane; and pentachloroethane should be treated in the workplace with caution.

J. Michael Lane, M.D.
Acting Director

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SUGGESTED GUIDELINES FOR CONTROLLING EMPLOYEE EXPOSURE TO CHLOROETHANES

NIOSH recommends that it would be prudent to handle 1,2-dichloroethane (ethylene dichloride); 1,1,2-trichloroethane; 1,1,2,2-tetrachloroethane; and hexachloroethane in the workplace as if they were human carcinogens. Exposure to these chloroethanes should be limited to as few employees as possible, and workplace exposure levels should be minimized. The areas in which they are used should be restricted to only those employees essential to the process or operation and these employees should be adequately protected.

Additionally, NIOSH recommends that the other five chloroethane compounds: monochloroethane (ethyl chloride); 1,1-dichloroethane; 1,1,1-trichloroethane (methyl chloroform); 1,1,1,2-trichloroethane; and pentachloroethane should be treated in the workplace with caution because of their relation to the four chloroethanes shown to be carcinogenic in laboratory animals. These five chloroethanes should be closely monitored for carcinogenic effects in humans.

EXPOSURE MONITORING

Detailed sampling and analytic methods for most of the chloroethane exposure measurements are described in the NIOSH Manual of Analytical Methods, Second Edition (1). These are:

Chemical	NIOSH Method
monochloroethane	not available
1,1-dichloroethane	S123
1,2-dichloroethane	P&CAM 127 and S122
1,1,1-trichloroethane	P&CAM 127 and S328
1,1,2-trichloroethane	P&CAM 127 and S134
1,1,1,2-tetrachloroethane	not available
1,1,2,2-tetrachloroethane	S124
pentachloroethane	not available
hexachloroethane	S101

Initial and routine employee exposure surveys should be made by competent industrial hygiene and engineering personnel. These surveys are necessary to determine the extent of employee exposure and to ensure that controls are effective.

The NIOSH Occupational Exposure Sampling Strategy Manual (2) may be helpful in developing efficient programs to monitor employee exposures to chloroethanes. The manual discusses determination of the need for exposure measurements, selection of appropriate employees for exposure evaluation and selection of sampling times.

Employee exposure measurements should primarily consist of 8-hour TWA (time-weighted average) exposure estimates calculated from personal or breathing zone samples (air that would most nearly represent that inhaled by the employees). In addition, short term samples should be taken during periods of maximum expected exposure by using all available knowledge regarding the area, employee work procedures, and process. Area and source measurements may be useful to determine problem areas, processes, and operations.

CONTROLLING EMPLOYEE EXPOSURE

There are four basic methods of limiting employee exposure to chloroethanes. None of these is a simple industrial hygiene or management decision and careful planning and thought should be used prior to implementation.

o Product Substitution

The substitution of an alternative material with a lower potential health risk is one method. However, extreme care must be used when selecting possible substitutes. Alternatives to chloroethanes should be fully evaluated with regard to possible human effects. Unless the toxic effects of the alternative have been thoroughly evaluated a seemingly safe replacement, possibly only after years of use, may be found to induce serious health effects.

o Contaminant Controls

The most effective control of chloroethanes, where feasible, is at the source of contamination by enclosure of the operation and/or local exhaust ventilation. Guidelines for selected processes and operations can be found in the NIOSH Recommended Industrial Ventilation Guidelines (3).

If feasible, the process or operation should be enclosed with a slight vacuum so that any leakage will result in the flow of external air into the enclosure.

The next most effective means of control would be a well designed local exhaust ventilation system that physically encloses the process as much as possible, with sufficient capture velocity to keep the contaminant from entering the work atmosphere.

To ensure that ventilation equipment is working properly, effectiveness (e.g., air velocity, static pressure, or air volume) should be checked at least every three months. System effectiveness should be checked soon after any change in production, process, or control which might result in significant increases in airborne exposure to chloroethanes.

o Employee Isolation

A third alternative is the isolation of employees. It frequently involves the use of automated equipment operated by personnel observing from a closed control booth or room. The control room is maintained at a greater air pressure than that surrounding the process equipment so that air flow is out of, rather than into, the room. This type of control will not protect employees who must do process checks, adjustments, maintenance, and related operations.

o Personal Protective Equipment

The least preferred method is the use of personal protective equipment. This equipment, which may include respirators, goggles, gloves, etc., should not be used as the only means to prevent or minimize exposure during routine operations.

Exposure to chloroethanes 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
- For maintence; or
- For operations which require entry into tanks or closed vessels; or
- In emergencies.

Only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of Federal regulations 30 CFR 11 should be used. Refer to Cumulative Supplement June 1977, NIOSH Certified Equipment (4) for a listing of NIOSH-approved respirators. Note that the use of faceseal coverlets or socks with respirators voids NIOSH approvals.

Quantitative faceseal fit test equipment (such as sodium chloride, dioctyl phthalate, or equivalent) should be used. Refer to NIOSH's A Guide to Industrial Respiratory Protection (5) for guidelines on appropriate respiratory protection programs.

In addition, proper maintenance procedures, good housekeeping in the work area, and employee education are all vital aspects of a good control program. Employees should be informed as to the nature of the hazard, its control, and appropriate personal hygiene procedures.

REFERENCES FOR SUGGESTED GUIDELINES

1) NIOSH Manual of Analytical Methods, 2nd Edition, Vol. 1: GPO #017-033-00267-3, $8.75: Vol. 2: GPO #017-033-00260-6, $9.75; Vol. 3: GPO #017-033-0247-9, $9.00.

2) NIOSH Occupational Exposure Sampling StrategyManual, GPO #017-033-00247-9, $2.75.

3) NIOSH Recommended Industrial Ventilation Guidelines, GPO #017-033-00136-7, $3.90.

4) NIOSH Cummulative Supplement June 1977, NIOSH Certified Equipment, NIOSH #77-195, no charge.

5) A Guide to Industrial Respiratory Protection, GPO #017-033-00153-7, $2.30.

GPO publications must be ordered from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Reference #4 can be ordered from:

Publications Dissemination, DTS
NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45226

IDENTIFIERS AND SYNONYMS FOR CHLOROETHANE

Chemical Abstracts Service Registry Number 75-00-3
NIOSH RTECS Number KH75250
Chemical Formula C_2H_5Cl

Aethylis
Aethylis Chloridum
Anodynon
Chelen
Chlorene
Chlorethyl
Chloridum
Chloroethane
Chloryl
Chloryl Anesthetic
Cloretilo
Dublofix
Ethane, Chloro-
Ether Chloratus
Ether Hydrochloric
Ether Muriatic
Ethyl Chloride
Hydrochloric Ether
Kelene
Monochloroethane
Muriatic Ether
Narcotile

IDENTIFIERS AND SYNONYMS FOR 1,1-DICHLOROETHANE

Chemical Abstracts Service Registry Number 75-34-3
NIOSH RTECS Number KI01750
Chemical Formula $C_2H_4Cl_2$

Chlorinated Hydrochloric Ether
1,1-Dichlorethane
1,1-Dichloroethane
Ethane, 1,1-Dichloro-
Ethylidene Chloride
Ethylidene Dichloride
NCI-C04535

IDENTIFIERS AND SYNONYMS FOR 1,2-DICHLOROETHANE

Chemical Abstracts Service Registry Number 107-06-2
NIOSH RTECS Number KI05250
Chemical Formula $C_2H_4Cl_2$

1,2-Bichloroethane
Brocide
Borer Sol
Destruxol Borer-Sol
Di-Chlor-Mulsion
Dichloremulsion
1,2-Dichlorethane
1,2-Dichloroethane
α,β-Dichloroethane
sym-Dichloroethane
Dutch Liquid
EDC
ENT 1,656
Ethane, 1,2-Dichloro-
Ethane Dichloride
Ethylene Chloride
Ethylene Dichloride
Glycol Dichloride

IDENTIFIERS AND SYNONYMS FOR 1,1,1-TRICHLOROETHANE

Chemical Abstracts Service Registry Number 71-55-6
NIOSH RTECS Number KJ29750
Chemical Formula $C_2H_3Cl_3$

Aerothene TT
Chloroethene NU
Chlorotene
Chlorothane NU
Chlorothene
Chlorothene NU
Chlorothene VG
Chlorten
Ethane, 1,1,1-Trichloro-
Inhibisol
Methyl Chloroform
Methyltrichloromethane
NCI-C04626
Alpha-T
Trichloroethane
1,1,1-Trichloroethane
α-Trichloroethane

IDENTIFIERS AND SYNONYMS FOR 1,1,2-TRICHLOROETHANE

Chemical Abstracts Service Registry Number 79-00-5
NIOSH RTECS Number KJ31500
Chemical Formula $C_2H_3Cl_3$

Ethan Trichloride
Ethane, 1,1,2-Trichloro-
NCI-C04579
Beta-T
1,1,2-Trichlorethane
1,1,2-Trichloroethane
β-Trichloroethane
Vinyl Trichloride
Vinyltrichloride

IDENTIFIERS AND SYNONYMS FOR 1,1,1,2-TETRACHLOROETHANE

Chemical Abstracts Service Registry Number 630-20-6
NIOSH RTECS Number KI8450000
Chemical Formula $C_2H_2Cl_4$

Ethane, 1,1,1,2-tetrachloro-
NCI-C52459
1,1,1,2-Tetrachloroethane

IDENTIFIERS AND SYNONYMS FOR 1,1,2,2-TETRACHLOROETHANE

Chemical Abstracts Service Registry Number 79-34-5
NIOSH RTECS Number KI85750
Chemical Formula $C_2H_2Cl_4$

Acetylene Tetrachloride
Bonoform
Cellon
1,1-Dichloro-2,2-Dichloroethane
Ethane, 1,1,2,2-tetrachloro-
NCI-C03554
Tetrachloroethane
1,1,2,2-Tetrachloroethane
sym-Tetrachloroethane
TCE

IDENTIFIERS AND SYNONYMS FOR PENTACHLOROETHANE

Chemical Abstracts Service Registry Number 76-01-7
NIOSH RTECS Number KI63000
Chemical Formula C_2HCl_5

Ethane Pentachloride
Ethane, Pentachloro-
NCI-C53894
Pentachloroethane
Pentalin

IDENTIFIERS AND SYNONYMS FOR HEXACHLOROETHANE

Chemical Abstracts Service Registry Number 67-72-1
NIOSH RTECS Number KI40250
Chemical Formula C_2Cl_6

Avlothane
Carbon Hexachloride
Distokal
Distopan
Distopin
Egitol
Ethane Hexachloride
Ethane, Hexachloro-
Falkitol
Fasciolin
Hexachlorethane
1,1,1,2,2,2-Hexachloroethane
Hexachloroethylene
Mottenhexe
NCI-C04604
Perchloroethane
Phenohep

CUMULATIVE LIST OF NIOSH CURRENT INTELLIGENCE BULLETINS

*	1.	Chloroprene	- January 20, 1975
*	2.	Trichloroethylene (TCE)	- June 6, 1975
*	3.	Ethylene Dibromide (EDB)	- July 7, 1975
*	4.	Chrome Pigments	- June 24, 1975
			- October 7, 1975
			- October 8, 1976
*	5.	Asbestos	- August 8, 1975
*	6.	Hexamethylphosphoric Triamide (HMPA)	- October 24, 1975
*	7.	Polychlorinated Biphenyls (PCBs)	- November 3, 1975
			- August 20, 1976
	8.	4,4-Diaminodiphenylmethane (DDM)	- January 30, 1976
*	9.	Chloroform	- March 15, 1976
	10.	Radon Daughters	- May 11, 1976
	11.	Dimethylcarbamoyl Chloride (DMCC) Revised	- July 7, 1976
	12.	Diethylcarbamoyl Chloride (DECC)	- July 7, 1976
	13.	Explosive Azide Hazard	- August 16, 1976
	14.	Inorganic Arsenic - Respiratory Protection	- September 27, 1976
*	15.	Nitrosamines in Cutting Fluids	- October 6, 1976
*	16.	Metabolic Precursors of a Known Human Carcinogen, Beta-Naphthylamine	- December 17, 1976
*	17.	2-Nitropropane	- April 25, 1977
*	18.	Acrylonitrile	- July 1, 1977
*	19.	2,4-Diaminoanisole	- January 13, 1978
*	20.	Tetrachloroethylene (Perchloroethylene)	- January 20, 1978
	21.	Trimellitic Anhydride (TMA)	- February 3, 1978
*	22.	Ethylene Thiourea (ETU)	- April 11, 1978
*	23.	Ethylene Dibromide and Disulfiram Toxic Interaction	- April 11, 1978
*	24.	Direct Black 38, Direct Blue 6, and Direct Brown 95 BenzidineDerived Dyes	- April 17, 1978
*	25.	Ethylene Dichloride (1,2-Dichloroethane)	- April 19, 1978
	26.	NIAX® Catalyst ESN	- May 22, 1978
*	27.	Chloroethanes: Review of Toxicity	- August 31 ,1978

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*Cancer related alerts