Summary of Overseas "Health Reports" on Perchloroethylene (PCE) (also known as Tetrachloroethylene)

(1) The International Agency for Research on Cancer (IARC) Monographs.

The International Agency for Research on Cancer is part of the World Health Organization. The IARC Monographs series contain authoritative independent assessments by international experts of the carcinogenic risks posed to humans by a variety of chemicals. IARC Monographs are well known for their thoroughness, accuracy and integrity.

Summary: There is "*limited evidence in humans*" for the carcinogenicity of tetrachloroethylene. There is "*sufficient evidence in experimental animals*" for the carcinogenicity of tetrachloroethylene. Tetrachloroethylene is probably carcinogenic to humans (Group 2A).

Web-site: http://193.51.164.11/htdocs/Monographs/Vol63/Tetrachloroethylene.htm

(2) US EPA's Integrated Risk Information System

The Integrated Risk Information System (IRIS) is an US EPA's database of scientific information that contains the Agency consensus scientific positions on the potential serious adverse health effects that may result from lifetime (chronic) exposure to substances found in the environment. IRIS currently provides health effects information on over 500 specific chemical compounds.

Summary: The US EPA has not established any limits for PCE. US EPA is currently reviewing the health effects of PCE.

Web-site: http://www.epa.gov/iris/subst/0106.htm

(3) The Ninth Report on Carcinogens prepared by the US Department of health and Human Services

It is a legal requirement (under Section 301 (b)(4) of the Public Health Service Act) that the Secretary of the Department of Health and Human Services publishes a biennial report with a list of all substances that are know to be human carcinogens or may reasonably be anticipated to be carcinogens. The Report is an informational scientific and public health document that identifies and discusses agents, substances, mixtures or exposure circumstances that may pose a carcinogenic hazard to human health.

Summary: There are no data available to evaluate the carcinogenicity of PCE in humans. PCE has been studied by observing laundry and dry-cleaning workers, who may also have been

exposed to other petroleum solvents, other than PCE. These studies suggest a possible association between long-term occupational exposure to PCE and increased lymphatic malignancies and urogenital cancers, the evidence must be regarded as inconclusive because workers were also exposed to other solvents (i.e. petroleum solvents) as well as PCE.

Web-site: http://ehis.niehs.nih.gov/roc/toc9.html

(4) The Public Health Statement of 1990 and the ToxFAQ for PCE of 1997 as prepared by the Agency for Toxic Substances and Disease Registry (ATSDR)'s

The US Department of Health and Human Services is the US Government's principal agency for protecting the health of all Americans and providing essential human services. The ATSDR is an agency of the US Department of Health and Human Services which is to prevent exposure and adverse human health effects and diminished quality of life associated with exposure to hazardous substances from waste sites, unplanned releases and other sources of pollution present in the environment. The ATSDR produces "toxicological profiles" for hazardous substances found at National Priorities List sites. The ATSDR ToxFAQs is a series of summaries about hazardous substances and is based on the Toxicological Profiles and Public Health Statements.

Summary: Exposure to high concentrations of PCE can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, and unconsciousness. The health effects of breathing low levels of PCE are not known. Some studies suggest that women who work in dry-cleaning industries where exposures of PCE can be quite high might have more menstrual problems and spontaneous abortions than women who are not exposed. However, it is not known if PCE was responsible for these problems because other possible causes were not considered.

Web-sites: http://www.atsdr.cdc.gov/ToxProfiles/phs8822.html
http://www.atsdr.cdc.gov/tfacts18.html

(5) The Chemical Information Fact Sheet provided by the New York State Department of Health (NYSDOH)

The fact sheet provides information on the health effects seen in humans and animals exposed to PCE in air. It also provides information about the NYSDOH guideline of 0.1 mg/m^3 (100 $\mu g/m^3$) for PCE in ambient air.

Summary: Exposure to high levels of PCE can damage many parts of the body where the major effects of exposure are on the central nervous system, kidney, liver and possibly the reproductive system. The health effects of PCE depend on the level and length of exposure and the sensitivity of the individuals. Some studies show a slightly increased risk of cancer and reproductive effects

among workers exposed to PCE. The cancers associated with exposure included cancers of the esophagus and cervix and non-Hodgkin's lymphoma. The reproductive effects associated with increased risks of spontaneous abortion, menstrual and sperm disorders, and reduced fertility. However, the data suggest, but do not prove, that the effects were caused by PCE and not by some other factor or factors.

The NYSDH recommended that the average air level in a residential area should not exceed 0.1 mg/m^3 (100 $\mu g/m^3$) with the consideration of continuous lifetime exposure and sensitive people. It should be noted that the guideline of 0.1 mg/m^3 is not a line between PCE levels that cause health effects and those that do not. The guideline is much lower than the air levels that caused either non-cancer or cancer effects. Thus the possibility of health effects is low even at air levels slightly above the guideline. PCE levels higher than the guideline value do not automatically cause for concern but suggest the need to consider actions to reduce exposure. The NYSDOH recommended that actions should be considered when ambient PCE level is above the guideline value. They also recommended that the need to take immediate action to reduce exposure should be considered when an air level is 10 times or more higher than the guideline. (In 1999, the annual ambient PCE level in Hong Kong recorded by the Environmental Protection Department was 2.34 $\mu g/m^3$.)

Web-site: http://www.health.state.ny.us/nysdoh/environ/btsa/fs_perc.htm

(6) Fact Sheet published by the Bureau of Environmental Investigations of the New York City Department of Health

The fact sheet provides information on the health effects seen in humans and animals exposed to PCE in air.

Summary: A single exposure to high level of PCE can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking and unconsciousness. Liver and central nervous system effects have been observed in workers in industries using PCE. Animal studies suggest that PCE has the potential to cause liver and kidney damage and developmental effects in the unborn. PCE can cause cancer in laboratory animals that were exposed to large amounts over their lifetimes. The currently available information is not sufficient to determine the health effects from low levels of PCE exposure and where PCE causes cancer in humans.

Web-site: http://www.ci.nyc.ny.us/html/doh/html/ei/eiperc.html

TETRACHLOROETHYLENE
(Group 2A)

For definition of Groups, see Preamble Evaluation.

VOL.: 63 (1995) (p.159)
CAS No.: 127-18-4
Chem. Abstr. Name: Tetrachloroethene

5. Summary of Data Reported and Evaluation

5.1 Exposure data

Tetrachloroethylene is one of the most important chlorinated solvents worldwide and has been produced commercially since the early 1900s. Most of the tetrachloroethylene produced is used for dry cleaning garments; smaller amounts are used in the production of chlorofluorocarbons and for degreasing metals. About 513 thousand tonnes were used in all applications in western Europe, Japan and the United States in 1990.

Tetrachloroethylene has been detected in air, water, food and animal and human tissues. The greatest exposure occurs via inhalation, and workers in dry cleaning and degreasing are the most heavily exposed. Individuals living or working in the vicinity of such operations have been shown to be exposed to lower concentrations.

5.2 Human carcinogenicity data

Results relevant to assessing the relationship between exposure to tetrachloroethylene and cancer risk are available from five cohort studies. In one study in Finland and one in four states of the United States, exposure was specifically to tetrachloroethylene; biological monitoring was conducted in the Finnish study. In a cohort study in Missouri, United States, in which follow-up was from 1948 to 1978, tetrachloroethylene was the chemical to which predominant exposure had occurred since about 1960. Data for a few cancer sites were reported in two other cohort studies, one in Louisiana and one in Utah, United States, in which exposure was to both tetrachloroethylene and other chemicals. Although data on different levels or duration of exposure were available in some of the cohort studies, the number of observed cases in each category was generally too small to allow adequate statistical power for testing for a dose-response relationship. Data from six relevant case-control studies have also been reported.

In the two cohort studies in which results for oesophageal cancer were reported, namely the four-state United States and Missouri studies, the relative risks were 2.6 and 2.1. Lack of data on smoking or alcohol consumption, both strong risk factors for this cancer, indicates caution in interpreting this observation.

The relative risks for cervical cancer were increased in three cohort studies in which such results were reported; however, potential confounding factors associated with socioeconomic status could not be adjusted for.

Elevated relative risks for non-Hodgkin's lymphoma were observed in all three cohort studies in which such results were reported.

With respect to cancer of the kidney, no consistent pattern of elevated risk was seen in the three cohort studies in which such results were reported. Although a case-control study conducted in Montreal, Canada, showed an odds ratio of 3.4, this was not statistically significant, and the exposure in question was to degreasing solvents and not specifically to tetrachloroethylene. In the cohort study in Missouri, the relative risk for urinary bladder cancer was elevated but not statistically significant; little or no information was available from other studies.

Five studies of people exposed to drinking-water contaminated with tetrachloroethylene have been reported. In four of these, no consistent pattern of risk for any specific cancers was observed. In the fifth study, in Massachusetts, United States, although the increase in the relative risk for leukaemia was significant, the result was based on only two cases. No consistent evidence for an elevated risk for leukaemia was seen in the cohort studies.

In summary, there is evidence for consistently positive associations between exposure to tetrachloroethylene and the risks for oesophageal and cervical cancer and non-Hodgkin's lymphoma. These associations appear unlikely to be due to chance, although confounding cannot be excluded and the total numbers in the cohort studies combined are relatively small.

5.3 Animal carcinogenicity data

Tetrachloroethylene was tested for carcinogenicity by oral administration in one experiment in mice, and a significant increase in the incidence of hepatocellular carcinomas was observed in animals of each sex. A study in rats treated orally was inadequate for an evaluation of carcinogenicity. Tetrachloroethylene was tested for carcinogenicity by inhalation in one experiment in mice and in one experiment in rats. The incidence of hepatocellular adenomas and carcinomas was significantly increased in mice of each sex, and the incidence of mononuclear-cell leukaemia was significantly increased in rats of each sex. A nonsignificant increase in the incidence of uncommonly occurring renal-cell adenomas and adenocarcinomas was also observed in male rats. Tetrachloroethylene did not induce skin tumours in mice after administration by topical application in one study.

A presumed metabolite of tetrachloroethylene, tetrachloroethylene oxide, did not increase the incidence of local tumours in mice when given by topical application or subcutaneous injection.

5.4 Other relevant data

Tetrachloroethylene is rapidly absorbed after inhalation and from the gastrointestinal tract, but dermal absorption from the gaseous phase is negligible. The biotransformation of tetrachloroethylene is species-and dose-dependent; mice consistently had a greater capacity to biotransform tetrachloroethylene than rats. Two metabolic pathways have been demonstrated in rodents: cytochrome P450-catalysed oxidation and, as a minor route, glutathione conjugation.

Tetrachloroethylene shows only low acute toxicity in humans and in experimental animals. After repeated administration, the major target organ is the liver in mice and the kidney in rats. Tetrachloroethylene induced peroxisome proliferation in mouse liver after oral administration; a marginal response was observed in mouse kidney and rat liver.

Disturbances of sperm quality and fertility have been observed among dry cleaners exposed to tetrachloroethylene in a few studies of limited size. The results of studies of women exposed to tetrachloroethylene in dry cleaning shops and other settings are generally consistent in showing an increase in the rate of spontaneous abortions; however, other solvents were also present in most of

these workplaces. Effects on other reproductive outcomes such as stillbirths, congenital malformations and low birth weight could not be evaluated in these studies.

Tetrachloroethylene can cross the placenta of rats and is metabolized in the placenta or fetus to trichloroacetic acid. Tetrachloroethylene appears to have little toxicity in developing rats and rabbits; high atmospheric concentrations produced delayed fetal development in mice in one study.

The frequencies of gene conversion and gene mutation were not increased in yeast recovered from mice treated with tetrachloroethylene *in vivo*. Tetrachloroethylene increased the frequency of DNA single-strand breakage/alkaline-labile sites in the liver and kidney of mice *in vivo* in one study, but binding to DNA was not demonstrated in mouse liver.

It did not induce gene mutation (in a single study), chromosomal aberrations, sister chromatid exchange (in a single study) or DNA damage in mammalian cells *in vitro*. In single studies, it induced morphological transformation in virus-infected rat embryo cells but not in BALBc/3T3 cells. The only study available showed no induction of gene mutation by tetrachloroethylene in insects. Tetrachloroethylene did not usually induce gene conversion in yeasts; the results with regard to induction of aneuploidy in one study were inconclusive. Tetrachloroethylene did not increase the frequency of mutations in bacteria, except in one study in which a metabolic activation system consisting of liver and kidney fractions, which favours glutathione conjugation and further activation, was used. The metabolites formed from tetrachloroethylene in rats by minor biotransformation pathways, S-1,2,2-trichloroglutathione and derived sulfur conjugates, were genotoxic in bacteria and cultured renal cells.

The frequency of H-*ras* mutations was lower in hepatocellular tumours from tetrachloroethylene-treated mice than in tumours from control animals, whereas the frequency in hepatocellular tumours from trichloroethylene-treated mice was not significantly different from that in controls. The frequency of K-*ras* mutations was higher in liver tumours from tetrachloroethylene-treated mice than in tumours from control animals.

5.5 Evaluation

There is *limited evidence* in humans for the carcinogenicity of tetrachloroethylene.

There is *sufficient evidence* in experimental animals for the carcinogenicity of tetrachloroethylene.

Overall evaluation

Tetrachloroethylene is *probably carcinogenic to humans (Group 2A).*

In making the overall evaluation, the Working Group considered the following evidence:

(i) Although tetrachloroethylene is known to induce peroxisome proliferation in mouse liver, a poor quantitative correlation was seen between peroxisome proliferation and tumour formation in the liver after administration of tetrachloroethylene by inhalation. The spectrum of mutations in proto-oncogenes in liver tumours from mice treated with tetrachloroethylene is different from that in liver tumours from mice treated with trichloroethylene.

(ii) The compound induced leukaemia in rats.

(iii) Several epidemiological studies showed elevated risks for oesophageal cancer, non-Hodgkin's

lymphoma and cervical cancer.

For definition of the italicized terms, see Preamble Evaluation.

Previous evaluation: Suppl. 7 (1987) (p.355)

Synonyms

- Ethylene tetrachloride
- PCE
- 'per'
- PER
- Perchlorethylene
- Perchloroethene
- Perchloroethylene
- Tetrachlorethylene
- 1,1,2,2-Tetrachloroethene
- 1,1,2,2-Tetrachloroethylene

Last Updated 05/20/97

Letterhead of U.S. EPA IRIS

Tetrachloroethylene
CASRN 127-18-4

Contents

0106
Tetrachloroethylene; CASRN 127-18-4

Health assessment information on a chemical substance is included in IRIS only after a comprehensive review of chronic toxicity data by U.S. EPA health scientists from several Program Offices and the Office of Research and Development. The summaries presented in Sections I and II represent a consensus reached in the review process. Background information and explanations of the methods used to derive the values given in IRIS are provided in the Background Documents.

STATUS OF DATA FOR Tetrachloroethylene

File On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	03/01/1988
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)

Substance Name -- Tetrachloroethylene
CASRN -- 127-18-4
Last Revised -- 03/01/1988

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. ORAL RfD SUMMARY

Critical Effect	Experimental Doses*	UF	MF	RfD
Hepatotoxicity in mice, weight gain in rats	NOAEL: 20 mg/kg/day (converted to 14 mg/kg/day)	1000	1	1E-2 mg/kg/day
6-Week Mouse Gavage Study	LOAEL: 100 mg/kg/day (converted to 71 mg/kg/day)			

Buben and
O'Flaherty, 1985
*Conversion Factors: Doses have been adjusted for treatment schedule (5 days/week)

I.A.2. PRINCIPAL AND SUPPORTING STUDIES (ORAL RfD)

Buben, J.A. and E.J. O'Flaherty. 1985. Delineation of the role of metabolism

in the hepatotoxicity of trichloroethylene and perchloroethylene: a dose-effect study. Toxicol. Appl. Pharmacol. 78: 105-122.

Buben and O'Flaherty (1985) exposed Swiss-Cox mice to tetrachloroethylene in corn oil by gavage at doses of 0, 20, 100, 200, 500, 1500, and 2000 mg/kg, 5 days/week for 6 weeks. Liver toxicity was evaluated by several parameters including liver weight/body weight ratio, hepatic triglyceride concentration, DNA content, histopathological evaluation, and serum enzyme levels. Increased liver triglycerides were first observed in mice treated with 100 mg/kg. Liver weight/body weight ratios were significantly higher than controls for animals treated with 100 mg/kg. At higher doses, hepatotoxic effects included decreased DNA content, increased SGPT, decreased levels of G6P and hepatocellular necrosis, degeneration and polyploidy.

A NOEL of 14 mg/kg/day was established in a second study, as well (Hayes et al., 1986). Groups of 20 Sprague-Dawley rats of both sexes were administered doses of 14, 400, or 1400 mg/kg/day in drinking water. Males in the high-dose group and females in the two highest groups exhibited depressed body weights. Equivocal evidence of hepatotoxicity (increased liver and kidney weight/body weight ratios) were also observed at the higher doses.

I.A.3. UNCERTAINTY AND MODIFYING FACTORS (ORAL RfD)

UF -- The uncertainty factor of 1000 results from multiplying factors of 10 to account for intraspecies variability, interspecies variability and extrapolation of a subchronic effect level to its chronic equivalent.

MF -- None

I.A.4. ADDITIONAL COMMENTS (ORAL RfD)

Other data support the findings of the principal studies. Exposure of mice and rats to tetrachloroethylene by gavage for 11 days caused hepatotoxicity (centrilobular swelling) at doses as low as 100 mg/kg/day in mice (Schumann et al., 1980). Mice were more sensitive to the effects of tetrachloroethylene exposure than rats. Increased liver weight was observed in mice at 250 mg/kg, while rats did not exhibit these effects until doses of 1000 mg/kg/day were reached. Relative sensitivity to man cannot be readily established but the RfD of 1E-2 mg/kg/day is protective of the most mild effects observed in humans [diminished odor perception/modified Romberg test scores in volunteers exposed to 100 ppm for 7 hours; roughly equivalent to 20 mg/kg/day (Stewart et al., 1961)].

The principal studies are of short duration. Inhalation studies have been performed which indicate that the uncertainty factor of 10 is sufficient for extrapolation of the subchronic effect to its chronic equivalent. Liver enlargement and vacuolation of hepatocytes were found to be reversible lesions for mice exposed to low concentrations of tetrachloroethylene (Kjellstrand et al., 1984). In addition, elevated liver weight/body weight ratios observed in animals exposed to tetrachloroethylene for 30 days were similar to those in animals exposed for 120 days. Several chronic inhalation studies have also been performed (Carpenter, 1937; NTP, 1985; Rowe et al., 1952). None are

inconsistent with a NOAEL of 14 mg/kg/day for tetrachloroethylene observed by Buben and O'Flaherty (1985) and Hayes et al. (1986).

I.A.5. CONFIDENCE IN THE ORAL RfD

Study -- Low
Data Base -- Medium
RfD -- Medium

No one study combines the features desired for deriving an RfD: oral exposure, large number of animals, multiple dose groups, testing in both sexes and chronic exposure. Confidence in the principal studies is low mainly because of the lack of complete histopathological examination at the NOAEL in the mouse study. The data base is relatively complete but lacks studies of reproductive and teratology endpoints subsequent to oral exposure; thus, it receives a medium confidence rating. Medium confidence in the RfD follows.

I.A.6. EPA DOCUMENTATION AND REVIEW OF THE ORAL RfD

U.S. EPA. 1985. Health Assessment Document for Tetrachloroethylene (Perchloroethylene). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC for the Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA 600/8-82/005F.

U.S. EPA. 1987. Quantification of Toxicological Effects for Tetrachloroethylene. Prepared from the Health Assessment Document for Tetrachloroethylene (Perchloroethylene). Office of Drinking Water, Washington, DC.

Agency Work Group Review -- 05/20/1985, 08/05/1986, 09/17/1987

Verification Date -- 09/17/1987

I.A.7. EPA CONTACTS (ORAL RfD)

Please contact the Risk Information Hotline for all questions concerning this assessment or IRIS, in general, at (513)569-7254 (phone), (513)569-7159 (FAX) or RIH.IRIS@EPAMAIL.EPA.GOV (internet address).

I.B. REFERENCE CONCENTRATION FOR CHRONIC INHALATION EXPOSURE (RfC)

Substance Name -- Tetrachloroethylene
CASRN -- 127-18-4

Not available at this time.

II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- Tetrachloroethylene
CASRN -- 127-18-4

Not available at this time.

VI. BIBLIOGRAPHY

Substance Name -- Tetrachloroethylene
CASRN -- 127-18-4
Last Revised -- 07/01/1989

VI.A. ORAL RfD REFERENCES

Buben, J.A. and E.J. O'Flaherty. 1985. Delineation of the role of metabolism in the hepatotoxicity of trichloroethylene and perchloroethylene: A dose-effect study. Toxicol. Appl. Pharmacol. 78: 105-122.

Carpenter, C.P. 1937. The chronic toxicity of tetrachloroethylene. J. Ind. Hyg. Toxicol. 19(7): 323-336.

Hayes, J.R., L.W. Condie, Jr. and J.F. Borzelleca. 1986. The subchronic toxicity of tetrachloroethylene (perchloroethylene) administered in the drinking water of rats. Fund. Appl. Toxicol. 7: 119-125.

Kjellstrand, P., B. Holmquist, M. Kanje, et al. 1984. Perchloroethylene: Effects on body and organ weights and plasma butyrylcholinesterase activity in mice. Acta Pharmacol. Toxicol. 54(5): 414-424.

NTP (National Toxicology Program). 1985. NTP Technical Report on the Toxicology and Carcinogenesis Studies of Tetrachloroethylene (perchloroethylene). U.S. Dept. Health and Human Services, NIH Publ. No. 85-2567.

Rowe, V.K., D.D. McCollister, H.C. Spencer, E.M. Adams and D.D. Irish. 1952. Vapor toxicity of tetrachloroethylene for laboratory animals and human subjects. Arch. Ind. Hyg. Occup. Med. 5: 566-579.

Schumann, A.M., J.F. Quast and P.G. Watanabe. 1980. The pharmacokinetics and macromolecular interaction of perchloroethylene in mice and rats as related to oncogenicity. Toxicol. Appl. Pharmacol. 55: 207-219.

Stewart, R.D., H.H. Gay, D.S. Erley, C.L. Hake and A.W. Schaffer. 1961. Human exposure to tetrachloroethylene vapor. Arch. Environ. Health. 2: 40-46.

U.S. EPA. 1985. Health Assessment Document for Tetrachloroethylene (perchloroethylene). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC for the Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA 600/8-82-005F. Office of Drinking Water, Washington, DC.

U.S. EPA. 1987. Quantification of Toxicological Effects for Tetrachloroethylene. Prepared from the Health Assessment Document for Tetrachloroethylene (perchloroethylene). Office of Drinking Water, Washington, DC.

VI.B. INHALATION RfC REFERENCES

None

VI.C. CARCINOGENICITY ASSESSMENT REFERENCES

None

VII. REVISION HISTORY

Substance Name -- Tetrachloroethylene

CASRN -- 127-18-4

Date	Section	Description
12/23/1987	I.A.	RfD withdrawn pending further review
03/01/1988	I.A.	Revised Oral RfD sumary added - RfD changed
03/01/1988	III.A.	Health Advisory added
07/01/1989	VI.	Bibliography on-line
05/01/1990	II.	Carcinogen assessment now under review
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.	Regulatory action section withdrawn
08/01/1995	II.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III.,IV.,V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.

VIII. SYNONYMS

Substance Name -- Tetrachloroethylene
CASRN -- 127-18-4
Last Revised -- 01/31/1987

127-18-4
Ankilostin
Antisal 1
Antisol 1
Carbon bichloride
Carbon dichloride
Czterochloroetylen
Dee-Solv
Didakene
Didokene
Dowclene EC
Dow Per
ENT 1,860
Ethene, tetrachloro-
Ethylene tetrachloride
Ethylene, tetrachloro-
Fedal-Un
NCI-C04580
Nema
PCE
PER
Perawin
PERC

U.S. EPA IRIS Substance file - Tetrachloroethylene; CASRN 127-18-4 第 8 頁，共 8 頁

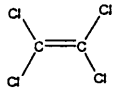
Perchloorethyleen, per
Perchlor
Perchloraethylen, per
Perchlorethylene
Perchlorethylene, per
Perchloroethylene
Perclene
Percloroetilene
Percosolv
Percosolve
PERK
Perklone
Persec
Tetlen
Tetracap
Tetrachlooretheen
Tetrachloraethen
Tetrachlorethylene
Tetrachloroethene
Tetrachloroethylene
1,1,2,2-Tetrachloroethylene.
Tetracloroetene
Tetraguer
Tetraleno
Tetralex
Tetravec
Tetroguer
Tetropil
WLN: GYGUYGG

IRIS Home Page | Substance File List

Send Comments | Search | NCEA Home Page | ORD Home Page | EPA Home Page

Last updated: 5 May 1998
URL: http://www.epa.gov/iris/subst/0106.htm

TETRACHLOROETHYLENE (PERCHLOROETHYLENE)
CAS No. 127-18-4
First Listed in the *Fifth Annual Report on Carcinogen*



CARCINOGENICITY

Tetrachloroethylene (perchloroethylene) is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (IARC V.20, 1979; NTP 311, 1986; IARC S.7, 1987). When administered by inhalation, tetrachloroethylene increased the incidences of hepatocellular adenomas and carcinomas in male mice and hepatocellular carcinomas in female mice. By the same route of administration, the compound increased the incidences of mononuclear cell leukemia in rats of both sexes and rare renal tubular cell neoplasms in male rats. When administered by gavage, tetrachloroethylene increased the incidence of hepatocellular carcinomas in mice of both sexes.

There are no data available to evaluate the carcinogenicity of tetrachloroethylene in humans. (IARC S.7, 1987; ATSDR, 1995k). Tetrachloroethylene has been studied by observing laundry and dry-cleaning workers, who may also have been exposed to other solvents, especially trichloroethylene, but also petroleum solvents. In several cohort and proportionate mortality studies, excesses have been reported of lymphosarcomas; leukemias; and cancers of the skin, colon, lung and urogenital tract. Some excess of lymphomas and of cancers of the larynx and urinary bladder was seen in a large cohort of dry cleaners. A familial cluster of chronic lymphocytic leukemia has also been related to dry cleaning. Although these studies suggest a possible association between long-term occupational exposure to tetrachloroethylene and increased lymphatic malignancies and urogenital cancers, the evidence must be regarded as inconclusive because workers were exposed to petroleum solvents and other dry cleaning agents as well as tetrachloroethylene.

PROPERTIES

Tetrachloroethylene is a colorless, nonflammable liquid with an ether-like odor. It is miscible with alcohol, ether, chloroform, oils, and benzene but is practically insoluble in water. When heated to decomposition, tetrachloroethylene emits toxic fumes of hydrochloric acid and other chlorinated compounds. It is oxidized by strong oxidizing agents. It is slowly decomposed by light and is sensitive to prolonged exposure to air

USE

Tetrachloroethylene is used primarily in dry cleaning and textile processing (56% of the tetrachloroethylene produced), as a chemical intermediate, mostly in the production of chlorofluorocarbons F-113 and F-114 (29%), and as a metal degreasing agent (11%) (Chem. Mktg. Rep., 1986a; Chem. Week, 1987c). Tetrachloroethylene is also used as an insulating fluid and cooling gas in electrical transformers, as a solvent with various applications, as an extractant for pharmaceuticals, as a pesticide intermediate, and as an anthelmintic agent (IARC V.20, 1979;

ATSDR, 1995k). To a lesser extent, it is used in the production of adhesives, aerosols, paints, and coatings (Morgan et al., 1985).

PRODUCTION

Chemical and Engineering News estimated that 384 million lb of tetrachloroethylene were produced in the United States in 1990 (Chem Eng. News, 1991). The USITC reported that 479 million lb of tetrachloroethylene were produced domestically in 1989 (USITC, 1990). The USITC reported that 497 million lb of tetrachloroethylene were produced domestically in 1988 and 473 million in 1987 (USITC, 1989, 1988). In 1986, the USITC reported that domestic production of tetrachloroethylene was 405 million lb and in 1985, domestic production was 464 million lb (Chem. Week, 1986c; Chem. Mktg. Rep., 1986a). In 1984, estimated production by 5 producers was 573 million lb, of which 434 million lb were sold (USITC, 1985). In 1983, 547 million lb of tetrachloroethylene were produced (Chem. Prod., 1985c).

Total tetrachloroethylene imports were 119 million lb for 1988, 136 million lb for 1987, and 159 million lb for 1986 (Chem Prod, 1989). Tetrachloroethylene exports for those same years were 60 million, 54 million, and 45 million lb (Chem. Prod., 1989). Tetrachloroethylene imports exceeded 102 million lb in 1989 (USDOC, Imports, 1990). This represented a decrease from the 1988 total of 119 million lb (Chem Prod, 1989). Total tetrachloroethylene imports were 136 million lb and 159 million lb for 1987 and 1986, respectively (Chem Prod, 1989). In 1985, the United States imported 140 million lb of tetrachloroethylene and exported approximately 22 million lb (Chem. Week, 1986; USDOC Exports, 1986). Estimated 1984 United States imports were reported as 133 million lb, and exports exceeded 28.8 million lb (Chem. Prod., 1985c; USDOC exports, 1985). In 1983, 55 million lb were imported, and 54 million lb of tetrachloroethylene were exported (Chem. Prod. 1985c).

From 1980 to 1984, tetrachloroethylene demand declined by roughly 30%, and the present decline in demand is expected to continue through 1990 (Chem. Mktg. Rep., 1986a; Chem. Prod., 1985c). This decline in demand has been attributed to an increase in product recycling, rather than decreased product use (Chem. Eng. News, 1987b).

EXPOSURE

The primary routes of potential human exposure to tetrachloroethylene are inhalation and dermal contact, but the chemical is also absorbed after ingestion. About 85% of the tetrachloroethylene used annually in the United States is lost to the atmosphere. In 1974, this amount was estimated to be 550 million lb. Numerous studies have found tetrachloroethylene in the air in the United States at concentrations ranging from 30 ppt in rural areas to 4.5 ppb in metropolitan or industrial areas. Tetrachloroethylene may be formed in small quantities during chlorination of water. It has also been detected in rainwater, sea water, rivers, and subterranean water, and in commercial deionized charcoal-filtered water. Tetrachloroethylene has been found in foods, such as dairy products, meats, oils and fats, beverages, fruits and vegetables, and fresh bread, and in the tissues of fish, shellfish, marine mammals, and algae (IARC V.20, 1979; ATSDR, 1995k). The Toxic Chemical Release Inventory (EPA) listed 394 industrial facilities that produced, processed, or otherwise used tetrachloroethylene in 1996 (TRI, 1999). In compliance with the Community Right-to-Know Program, the facilities reported releases of tetrachloroethylene to the environment which were estimated to total 7.9 million lb.

Potential consumer exposure to tetrachloroethylene may occur through use of coin-operated laundromats containing dry cleaning machines and freshly dry-cleaned clothing. In a limited study, six coin-operated facilities in the Washington, DC, area were sampled. The highest 7-day average tetrachloroethylene level of 8,600 ppb was reported for the only air-conditioned facility where air was recirculated. The 7-day average values in the five facilities that were not air-conditioned ranged from 130 to 1,500 ppb. Since these values were 8-hr time-weighted averages (TWAs), much higher peak levels may have occurred (Howie & Elfers, 1981). In another limited study conducted by the Michigan Department of Public Health (1979) an average tetrachloroethylene concentration of 1,300 ppb was detected during the summer in four coin-operated laundry facilities in the counter area and breathing zone of the counter attendant. During the winter, average levels of 4,500 ppb and 3,500 ppb were measured in the counter area and breathing zone of the counter attendant, respectively. In one very limited study, the tetrachloroethylene levels were measured in the bedroom of one house in which freshly dry-cleaned clothing was hung in the closet for 1 week. Levels decreased from a high of 102 ppb on the first day of exposure to 6.2 ppb on the seventh day. The average level over the 7-day period was 29 ppb (Howie & Elfers, 1981).

The National Occupational Exposure Survey (1981-1983) indicated that 395,882 workers, including 129,221 women, potentially were exposed to tetrachloroethylene in the workplace (NIOSH, 1984). Approximately 200,000 dry cleaning establishments use tetrachloroethylene. Over half of the domestically consumed tetrachloroethylene is used for dry cleaning and one-quarter is used in fluorocarbon production; therefore, workers in these two industries account for most of the potential occupational exposure to tetrachloroethylene (Morgan et al., 1985; Chem. Eng. News, 1987b; NIOSH 20, 1978). An analysis of 44 dry cleaning establishments in the United States determined geometric mean TWA exposures ranging from 3.0 to 22 ppm (ATSDR, 1995k). NIOSH reported that nearly 500,000 workers in 1978 and 275,000 workers in 1979 potentially were exposed to tetrachloroethylene (NIOSH 20, 1978; NIOSHb, 1979d). The National Occupational Hazard Survey, conducted by NIOSH from 1972 to 1974, estimated that 1,597,072 workers were potentially exposed to tetrachloroethylene in the workplace (NIOSH, 1976).

REGULATIONS

CPSC is currently coordinating activities with EPA to address problems associated with tetrachloroethylene in the Chlorinated Solvents Integrated Strategy. EPA regulates tetrachloroethylene under the Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Food, Drug, and Cosmetic Act (FD&CA), Resource Conservation and Recovery Act (RCRA), and Safe Drinking Water Act (SDWA). Tetrachloroethylene is a toxic pollutant of air, a pollutant of water with carcinogen and oncogen designations, and a hazardous waste. Effluent guidelines, standards of performance, and water quality criteria have been published. A reportable quantity (RQ) of 1 lb was established for tetrachloroethylene under CERCLA and CWA. The RQ was adjusted from 1 lb to 100 lb. Tetrachloroethylene is exempted under FD&CA from tolerances for pesticide chemicals. FDA regulates tetrachloroethylene as an indirect food additive. NIOSH has recommended to set the REL for tetrachloroethylene at the lowest feasible concentration. OSHA established a transitional permissible exposure limit (PEL) of ≤ 100 ppm as an 8-hr TWA, and a 200-ppm ceiling not to exceed 300 ppm for over 5 minutes in 3 hr. The OSHA final rule adjusted the PEL to 25 ppm with no STEL or ceiling permitted. OSHA also regulates tetrachloroethylene under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table B-137.

Letterhead of ATDSR - Public Health Statement: Tetrachloroethylene (1990)

Agency for Toxic Substances and Disease Registry

Public Health Statement

Tetrachloroethylene

ATSDR Public Health Statement, January 1990

What is tetrachloroethylene?

Tetrachloroethylene is a man-made substance widely used for dry cleaning fabrics and textiles and for metal-degreasing operations. It is also used as a starting material (building block) for the production of other man-made chemicals. Other names that may be used for tetrachloroethylene include perchloroethylene, perc, PCE, perclene, and perchlor. Although tetrachloroethylene is a liquid at room temperature, some of the liquid can be expected to evaporate into the air producing an ether-like odor; evaporation increases as temperature increases.

How might I be exposed to tetrachloroethylene?

Humans can be exposed to tetrachloroethylene from environmental, consumer product, and occupational sources. Common environmental levels of tetrachloroethylene (often called background levels) are usually several thousand times lower than levels found in some workplaces. Background levels found in the air we breathe and in the food and water we consume probably result from evaporation from industrial or dry-cleaning operations or from releases from areas where chemical wastes are stored. Tetrachloroethylene has been found in at least 330 of the 1117 National Priorities List (NPL) hazardous waste sites.

In general, tetrachloroethylene levels in air are higher in urban and industrialized areas than in more rural or remote areas. Higher-than-background concentrations of tetrachloroethylene have occasionally been measured in air close to chemical waste sites and in water taken from nearby wells.

Exposure to tetrachloroethylene may also occur from some consumer products. Products that may contain tetrachloroethylene include auto brake quieters and cleaners, suede protectors, water repellants, silicone lubricants, belt lubricants and dressings, specialized aerosol cleaners, ignition wire driers, fabric finishers, spot removers, adhesives, and wood cleaners. Although uncommon, small amounts of tetrachloroethylene have been found in food.

The levels of tetrachloroethylene in air in dry-cleaning shops, textile and chemical processing operations, and degreasing operations can result in exposures that are much higher than those found in the outside environment. Levels of tetrachloroethylene in the workplace are usually measured in parts of tetrachloroethylene per million parts of air (ppm), while common environmental levels are usually

measured in parts per billion (ppb) or parts per trillion (ppt).

How does tetrachloroethylene get into my body?

Because tetrachloroethylene evaporates quickly, the most common exposure to tetrachloroethylene comes from breathing air containing it. This is certainly true for individuals who work with the chemical, but it is probably also true for those who live in industrial and commercial areas where large amounts of the compound are used or disposed of. Tetrachloroethylene may also enter the body through drinking contaminated water or eating contaminated food. Because tetrachloroethylene does not pass through the skin to any significant extent, entry into the body by this path is of minimal concern, although skin irritation may result from repeated or prolonged contact with the undiluted liquid. Scientific reports indicate that tetrachloroethylene is present (and may in fact be concentrated) in the breast milk of mothers who have been exposed to the chemical.

How can tetrachloroethylene affect my health?

In high concentrations in air, particularly in closed, poorly ventilated areas, single exposures to tetrachloroethylene can cause central nervous system (CNS) effects leading to dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, and possibly unconsciousness and death. As might be expected, these symptoms occur almost entirely in work (or hobby) environments. The potential long-term health effects that might occur in humans from breathing lower levels of tetrachloroethylene than those that produce CNS effects or from ingesting very low levels of the chemical found in some water supplies have not been identified. The effects of exposing infants to tetrachloroethylene through breast milk are unknown.

Animal studies, conducted with amounts much higher than typical environmental levels, have shown that tetrachloroethylene can cause liver and kidney damage, liver and kidney cancers, and leukemia (cancer of the tissues that form the white blood cells). Developmental effects in fetuses have been observed but only at tetrachloroethylene exposure levels that also produce toxicity in the maternal animal.

The U.S. Department of Health and Human Services has determined that tetrachloroethylene may reasonably be anticipated to be a carcinogen. Based on evidence from animal studies, tetrachloroethylene is thought to be capable of causing cancer in humans. It should be emphasized, however, that currently available information is not sufficient to determine whether tetrachloroethylene causes cancer in humans.

Is there a medical test to determine if I have been exposed to tetrachloroethylene?

One way of testing for tetrachloroethylene exposure is to measure the amount of the chemical in the breath. This procedure has been used to measure levels of the chemical in persons living in areas where the air has been contaminated with tetrachloroethylene or in individuals occupationally exposed to the chemical. This procedure is only useful, however, if the exposure is recent (within weeks or less) because tetrachloroethylene is rapidly eliminated from the body. It is also possible to detect tetrachloroethylene in the blood. In addition, samples of blood and urine can be used to identify breakdown products of the chemical in persons suspected of being exposed to tetrachloroethylene. Although these procedures are relatively simple to perform, most physicians do not have the proper equipment and must rely on special laboratories to collect and analyze the samples. It should be noted

that exposure to other chemical agents can produce the same breakdown products in the urine and blood. Therefore, these methods cannot be regarded as specific for tetrachloroethylene.

What levels of exposure have resulted in harmful health effects?

The graphs on the following pages show the relationship between exposure to tetrachloroethylene and known health effects. In the first set of graphs (Fig.1.1) labeled "Health effects from breathing tetrachloroethylene," exposure is measured in parts of tetrachloroethylene per million parts of air (ppm). In all graphs, effects in animals are shown on the left side and effects in humans on the right side.

In the second set of graphs (Fig.1.2), the same relationship is represented for the known "Health effects from ingesting products containing tetrachloroethylene." Exposures are measured in milligrams of tetrachloroethylene per kilogram of body weight per day (mg/kg/day).

The first column on the graphs, labeled "Short-term exposure," refers to known health effects in laboratory animals and humans from exposure to tetrachloroethylene for 14 days or less. The column labeled "Long-term exposure" refers to tetrachloroethylene exposures of more than 14 days. The levels marked on the graphs as "Minimal risk for effects other than cancer" show estimates of levels of exposure at which no adverse effects are expected to occur. Because these levels are based largely on animal studies, some uncertainty still exists.

Toxic Effects Other Than Cancer--Figure 1.1 shows that short-term exposures to air containing more than 100 ppm of tetrachloroethylene have produced harmful effects in both humans and animals, and more prolonged exposures to approximately 9 ppm caused harmful liver effects in mice. It should be pointed out that some of the highest environmental levels of tetrachloroethylene ever recorded (at waste disposal sites, for example) were still 150 times smaller than the concentrations shown to produce symptoms of toxicity in animals after repeated exposure.

Figure 1.2 shows that drinking (or eating) the equivalent of approximately 60 to 80 mg (less than a spoonful) of undiluted tetrachloroethylene per kg of body weight (1 kg = 2.2 pounds) has produced effects similar to drinking alcohol. Tetrachloroethylene was used in the past as a medicine to eliminate worms in humans, but safer and more effective drugs are now available. More prolonged exposures in animals have produced harm to the liver at doses of approximately 100 mg/kg/day. These levels of exposure are more than 1,000 times higher than would be expected even if humans ingested the most contaminated drinking water ever reported.

Cancer--From data in animals, EPA has estimated that if people breathe air containing 1 ppm tetrachloroethylene all day every day for 70 years, there would be an added risk of 66 additional cases of cancer in a population of 10,000 people (or 65,500 additional cases in a population of 10,000,000) over the number of cases that would be observed in a population not exposed to tetrachloroethylene. If people consume 1.0 mg tetrachloroethylene/kg/day in food and water every day for 70 years, there would be at the most a risk of 510 additional cases of cancer in a population of 10,000, or 510,000 additional cases in a population of 10,000,000. It should be noted that these risk values are plausible upper-limit estimates. Actual risk levels are unlikely to be higher and may be lower.

What recommendations has the federal government made to protect human health?

The government has made recommendations to limit the exposure of the general public to tetrachloroethylene in drinking water and the exposure of workers to tetrachloroethylene in the workplace.

The Environmental Protection Agency (EPA) has developed the following health advisories to describe concentrations of tetrachloroethylene in drinking water at which no adverse effects are anticipated to occur: 2.0 milligrams per liter of water (mg/L) for short-term exposure of children, 1.4 mg/L for longer term exposure of children, and 5.0 mg/L for long-term exposure of adults. In addition, a drinking water equivalent level (DWEL) of 0.5 mg/L has been established.

The Occupational Safety and Health Administration (OSHA) has a legally enforceable exposure limit of 25 ppm tetrachloroethylene in air for an 8-hour workday, 40-hour workweek based on noncancer health considerations. The National Institute for Occupational Safety and Health (NIOSH) has classified tetrachloroethylene as a potential occupational carcinogen and recommends that workplace exposure be limited to the lowest possible level.

Where can I get more information?

If you have more questions or concerns, please contact your state health or environmental department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road, E-29
Atlanta, Georgia 30333

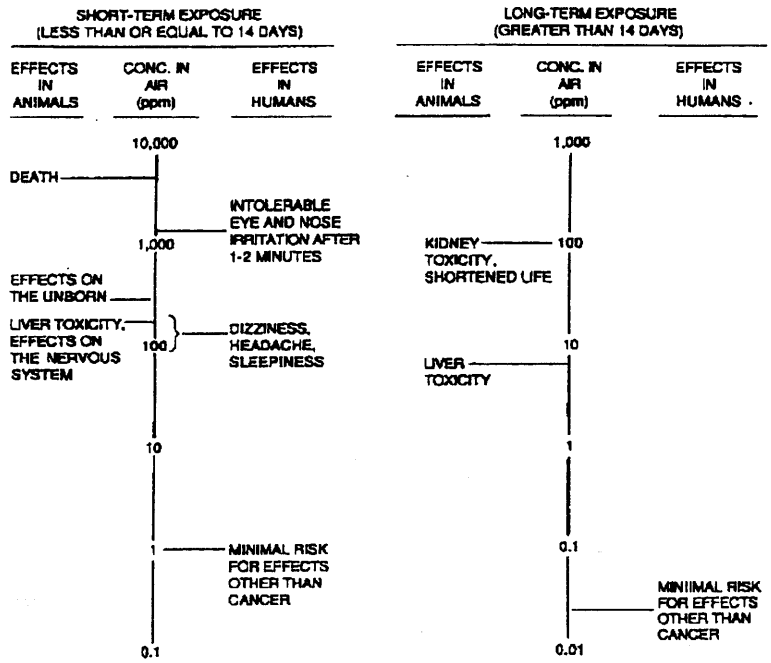


Fig. 1.1. Health effects from breathing tetrachloroethylene.

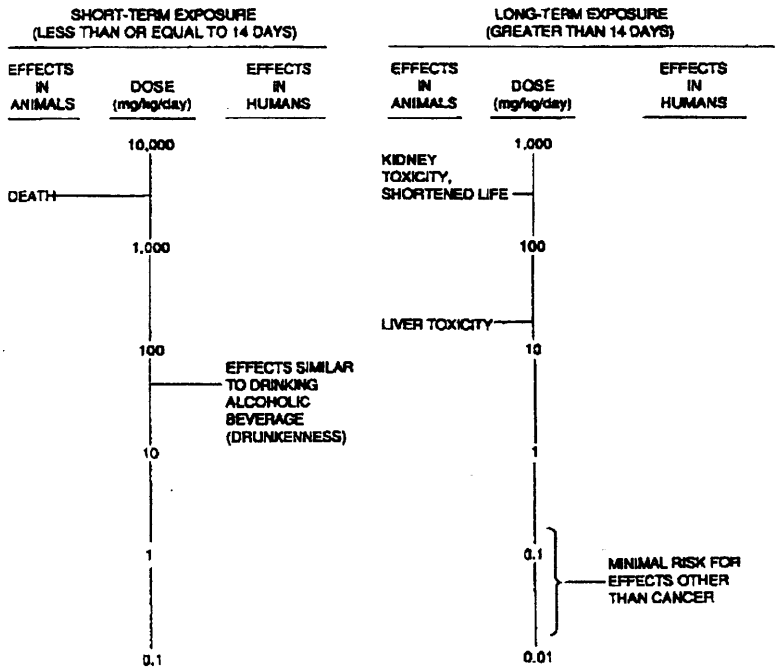


Fig. 1.2. Health effects from ingesting tetrachloroethylene.

ATSDR ToxFAQs

Tetrachloroethylene

CAS# 127-18-4

September 1997

Tetrachloroethylene
C_2Cl_4
Stereo Image
XYZ File

NFPA Label Key

Vermont SIRI MSDS Archive

Agency for Toxic Substances and Disease Registry

This fact sheet answers the most frequently asked health questions (FAQs) about tetrachloroethylene. For more information, call the ATSDR Information Center at 1 -800-447-1544. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Tetrachloroethylene is a manufactured chemical used for dry cleaning and metal degreasing. Exposure to very high concentrations of tetrachloroethylene can cause dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, and unconsciousness. Tetrachloroethylene has been found in at least 771 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is tetrachloroethylene?

Tetrachloroethylene is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is also used to make other chemicals and is used in some consumer products.

Other names for tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell tetrachloroethylene when it is present in the air at a level of 1 part tetrachloroethylene per million parts of air (1 ppm) or more, although some can smell it at even lower

levels.

What happens to tetrachloroethylene when it enters the environment?

- Much of the tetrachloroethylene that gets into water or soil evaporates into the air.
- Microorganisms can break down some of the tetrachloroethylene in soil or underground water.
- In the air, it is broken down by sunlight into other chemicals or brought back to the soil and water by rain.
- It does not appear to collect in fish or other animals that live in water.

How might I be exposed to tetrachloroethylene?

- When you bring clothes from the dry cleaners, they will release small amounts of tetrachloroethylene into the air.
- When you drink water containing tetrachloroethylene, you are exposed to it.

How can tetrachloroethylene affect my health?

Animal testing is sometimes necessary to find out how toxic substances might harm people or to treat those who have been exposed. Laws today protect the welfare of research animals and scientists must follow strict guidelines.

High concentrations of tetrachloroethylene (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death.

Irritation may result from repeated or extended skin contact with it. These symptoms occur almost entirely in work (or hobby) environments when people have been accidentally exposed to high concentrations or have intentionally used tetrachloroethylene to get a "high."

In industry, most workers are exposed to levels lower than those causing obvious nervous system effects. The health effects of breathing in air or drinking water with low levels of tetrachloroethylene are not known.

Results from some studies suggest that women who work in dry cleaning industries where exposures to tetrachloroethylene can be quite high may have more menstrual problems and spontaneous abortions than women who are not exposed. However, it is not known if tetrachloroethylene was responsible for these problems because other possible causes were not considered.

Results of animal studies, conducted with amounts much higher than those that most people are exposed to, show that tetrachloroethylene can cause liver and kidney damage. Exposure to very high levels of tetrachloroethylene can be toxic to the unborn pups of pregnant rats and mice. Changes in behavior were observed in the offspring of rats that breathed high levels of the chemical while they were pregnant.

How likely is tetrachloroethylene to cause cancer?

The Department of Health and Human Services (DHHS) has determined that tetrachloroethylene may reasonably be anticipated to be a carcinogen. Tetrachloroethylene has been shown to cause liver tumors in mice and kidney tumors in male rats.

Is there a medical test to show whether I've been exposed to tetrachloroethylene?

One way of testing for tetrachloroethylene exposure is to measure the amount of the chemical in the breath, much the same way breath-alcohol measurements are used to determine the amount of alcohol in the blood.

Because it is stored in the body's fat and slowly released into the bloodstream, tetrachloroethylene can be detected in the breath for weeks following a heavy exposure.

Tetrachloroethylene and trichloroacetic acid (TCA), a breakdown product of tetrachloroethylene, can be detected in the blood. These tests are relatively simple to perform. These tests aren't available at most doctors' offices, but can be performed at special laboratories that have the right equipment.

Because exposure to other chemicals can produce the same breakdown products in the urine and blood, the tests for breakdown products cannot determine if you have been exposed to tetrachloroethylene or the other chemicals.

Has the federal government made recommendations to protect human health?

The EPA maximum contaminant level for the amount of tetrachloroethylene that can be in drinking water is 0.005 milligrams tetrachloroethylene per liter of water (0.005 mg/L). The Occupational Safety and Health Administration (OSHA) has set a limit of 100 ppm for an 8-hour workday over a 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) recommends that tetrachloroethylene be handled as a potential carcinogen and recommends that levels in workplace air should be as low as possible.

Glossary

Carcinogen:
: A substance with the ability to cause cancer

CAS:
: Chemical Abstracts Service

Milligram (mg):
: One thousandth of a gram

Nonflammable:
: Will not burn

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Toxicological profile for tetrachloroethylene (update). Atlanta, GA.: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more

questions or concerns.

For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Phone: 1-800-447-1544
Fax: 404-639-6359

U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry

Link to ToxFAQs Home Page

Link to ATSDR Science Corner

Link to ATSDR Home Page

Return to Info for Consumers

Return to Toxic Substances Main Page

Home Page

Info for Researchers

Tetrachloroethylene (PERC) in Indoor and Outdoor Air

Chemical Information Fact Sheet

This fact sheet answers a few questions about a chemical called tetrachloroethene (PERC), which is widely used to dry-clean clothes. It provides information on health effects seen in humans and animals exposed to PERC in air. It also provides information about the New York State Department of Health (NYSDOH) guideline of 0.1 milligrams of PERC per cubic meter of air (0.1 mg/m^3) or 100 micrograms per cubic meter of air (100 ug/m^3). The fact sheet focuses on the health risks from air exposures because most of the PERC released into the environment goes into air.

1. **What is tetrachloroethene (PERC)?**

   Tetrachloroethene is a manufactured chemical that is widely used in the dry-cleaning of fabrics, including clothes. It is also used for degreasing metal parts and in manufacturing other chemicals. Tetrachloroethene is found in consumer products, including some paint and spot removers, water repellents, brake and wood cleaners, glues, and suede protectors. Other names for tetrachloroethene include PERC, tetrachloroethylene, perchloroethylene, and PCE. PERC is a commonly used name and will be used in the rest of the fact sheet.

   PERC is a nonflammable, colorless liquid at room temperature. It readily evaporates into air and has an ether-like odor. Because most people stop noticing the odor of PERC in air after a short time, odor is not a reliable warning signal of PERC exposure.

2. **How can I be exposed to PERC?**

   People are exposed to PERC in air, water, and food. Exposure can also occur when PERC or material containing PERC (for example, soil) gets on the skin. For most people, almost all exposure is from PERC in air.

   PERC gets into outdoor and indoor air by evaporation from industrial or dry-cleaning operations and from areas where chemical wastes are stored or disposed. Groundwater near these areas may become polluted if PERC is improperly dumped or leaks into the ground. PERC may get into indoor air after PERC-products, such as spot removers, are used. Indoor air levels in air may get high if PERC-products are used in poorly ventilated areas. It can also evaporate from polluted drinking water into indoor air during cooking and washing.

3. **How does PERC enter and leave my body?**

   When people breathe air containing PERC, the PERC is taken into the body through the lungs and passed into the blood, which carries it to all parts of the body. A large fraction of this PERC is breathed out, unchanged, through the lungs into the air. Some of this PERC is stored in the body (for example, in fat, liver, and brain) and some is broken down in the liver to other compounds and eliminated in urine. PERC can also be found in breastmilk. Once exposure stops, most of the PERC

and its breakdown products leave the body in several days. However, it may take several weeks for all of the PERC and its breakdown products to leave the body.

4. What kinds of health effects can be caused by exposure to PERC in air?

The strength (potency) of PERC to cause health effects is low, but breathing air with high levels of PERC can damage many parts of the body. In humans and animals, the major effects of exposure are on the central nervous system, kidney, liver, and possibly the reproductive system.

The health effects of PERC depend on the level and length of exposure. Figure 1 (Portable Document Format (PDF) file - help for PDF) shows the types of health effects seen in humans and animals and the lowest levels of PERC in air at which the effects were seen. The diagram on the right side of the figure shows the effects of long-term exposures in humans and animals whereas the diagram on the left side shows the same information for short-term exposures. Because there is a large amount of information on the human effects of PERC, the rest of the fact sheet will discuss only the human data.

Not all humans exposed showed effects at the levels given in Figure 1. Some did and some did not. This difference was due, in part, to the individual differences among humans. People, for example, differ in age, sex, diet, family traits, lifestyle, and state of health. These differences can affect how people will respond to a given exposure. One person may feel fine during and after an exposure while another person may become sick. This is known as sensitivity. Differences in sensitivity should be kept in mind when examining the following information on the human health effects of PERC.

Studies with volunteers show that short-term exposures of 8 hours or less to 700 mg/m^3 cause central nervous system symptoms such as dizziness, headache, sleepiness, lightheadedness, and poor balance (Figure 1). Exposures to 350 mg/m^3 for 4 hours affected the nerves of the visual system and reduced scores on certain behavioral tests (which, for example, measure the speed and accuracy of a person's response to something they see on a computer screen). These effects were mild and disappeared soon after exposure ended.

Studies of dry-cleaning workers indicate that long-term exposure (9 - 20 years, for example) to workplace air levels averaging about 50 mg/m^3 to 80 mg/m^3 reduces scores on behavioral tests and causes biochemical changes in blood and urine (Figure 1). The biochemical changes indicate liver and kidney damage. The effects were mild and hard to detect. How long the effects would last if exposure ended isn't known.

There is only one study of long-term exposure to air levels lower than in the workplace. The study reported reduced scores on behavioral tests in healthy adults living (for 10.6 years, on average) in apartments near dry-cleaning shops (Figure 1). The effects were small; the average test scores of the residents were slightly lower than that of unexposed people. The average air level in all apartments was 5 mg/m^3 and the median was 1.4 mg/m^3 (that is, half the measured air levels were above 1.4 mg/m^3 and half were below it).

Some studies show a slightly increased risk of cancer and reproductive

effects among workers exposed to PERC, including dry-cleaning workers. The cancers associated with exposure included cancers of the esophagus and cervix and non-Hodgkin's lymphoma. The reproductive effects associated with exposure included increased risks of spontaneous abortion, menstrual and sperm disorders, and reduced fertility. The data suggest, but do not prove, that the effects were caused by PERC and not by some other factor or factors. These studies provided some (cancer studies) or no data (studies on reproduction) on workplace air levels; however, workplace air levels are often considerably higher than those found in outdoor air or indoor air of homes or apartments.

5. What is the New York State Department of Health's (NYSDOH) guidelines for PERC in air?

NYSDOH recommends that the average air level in a residential community not exceed 0.1 milligrams of PERC per cubic meter of air (0.1 mg/m^3), considering continuous lifetime exposure and sensitive people. Three other ways of expressing the guideline are 100 micrograms per cubic meter of air (100 $\mu g/m^3$), 0.015 parts per million (ppm) and 15 parts per billion (ppb).

The guideline can be used to guide decisions about actions to reduce human exposures to PERC. NYSDOH recommends, for example, that actions to reduce exposure should be considered when an air level is above the guideline. NYSDOH also recommends that the need to take immediate action to reduce exposure should be considered when an air level is ten times or more higher than the guideline (that is, when the air level is 1 mg/m^3 or higher). The specific corrective actions to be taken depends on a case-by-case evaluation of the situation. In all cases, however, the NYSDOH also recommends that simple, common sense actions to reduce exposure (such as covering open containers of PERC) should be taken even if an air level is below 0.1 mg/m^3.

6. Should I be concerned about health effects if I am exposed to an air level slightly above the guideline?

The guideline of 0.1 mg/m^3 is not a line between air levels that cause health effects and those that do not. The guideline is much lower than the air levels that caused either non-cancer or cancer effects (see Figure 1). Thus, the possibility of health effects is low even at air levels slightly above the guideline.

In addition, the guideline is based on the assumption that people are continuously exposed to PERC in air all day, every day for as long as a lifetime. This is rarely true for most people, who are more likely to be exposed for a part of the day and part of their lifetime. This difference between assumed exposure and actual exposure should also be considered when air levels are slightly above the guideline.

In summary, measured air levels that are slightly higher than the guideline are not automatically cause for concern, but suggest the need to consider actions to reduce exposure.

7. When should I or my children see a physician?

If you believe you or your children have symptoms that you think are caused by PERC exposure, you and your children should see a physician. You should tell the physician about the symptoms and about

when, how, and for how long you think you and/or your children were exposed to PERC.

8. Where can I get more information?

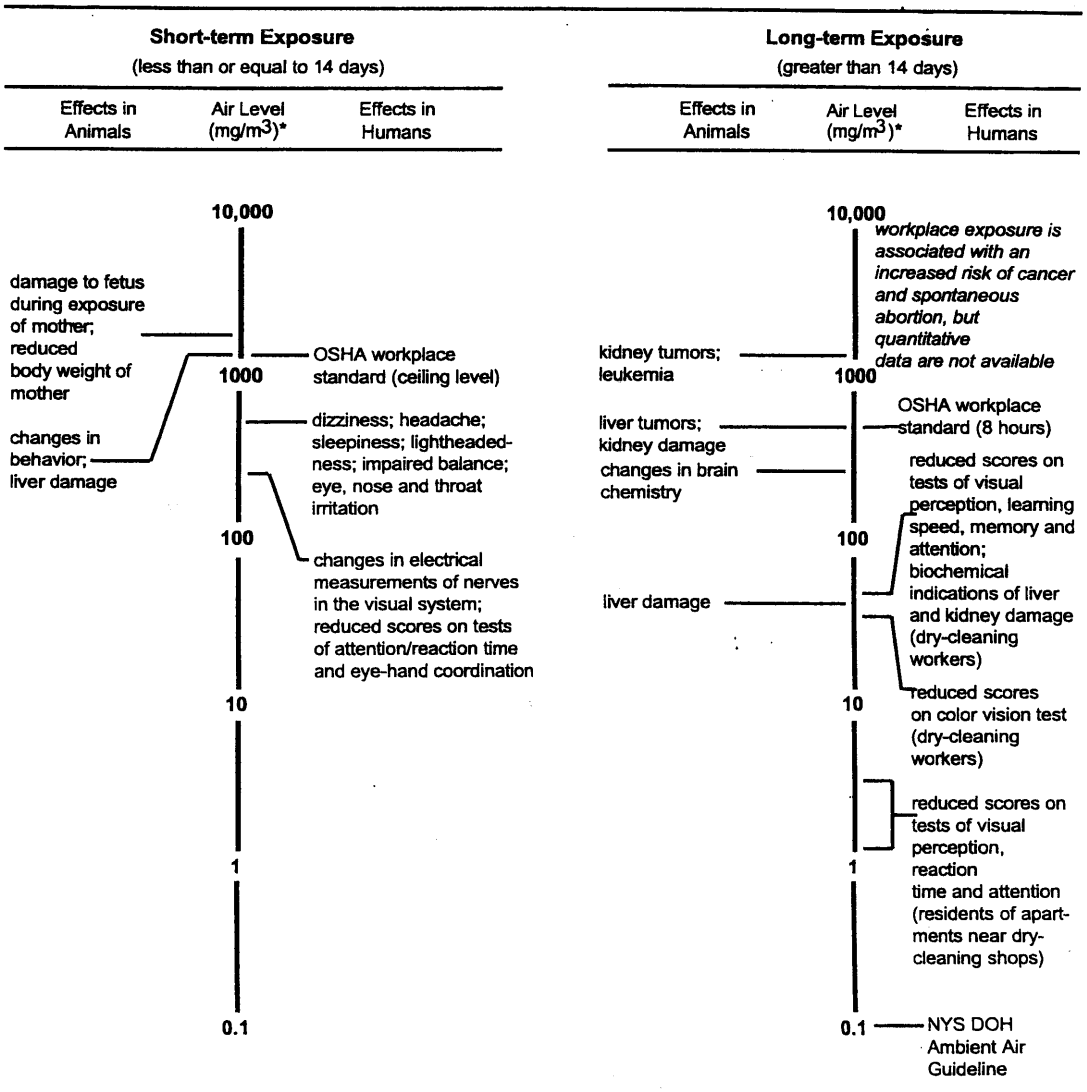
If you have any questions about the information in this fact sheet or would like to know more about PERC, please call the New York State Department of Health at 1-518-402-7800 or 1-800-458-1158 (extension 27800) or write to the following address.

New York State Department of Health
Bureau of Toxic Substance Assessment
Flanigan Square
547 River Street
Troy, NY 12180-2216

Send questions or comments to: btsa@health.state.ny.us
Revised: August 1999

What's This Month/HELP!

Figure 1. Health Effects from Breathing Tetrachloroethene (Perc). The diagram shows the effects observed in humans and animals exposed to specific measured levels of tetrachloroethene in air. The diagram contains information on the effects observed after short-term (left-side of figure) and long-term (right side of figure) exposure. Federal workplace standards (set by the Occupational Safety and Health Administration or OSHA) are also shown on the diagram.



*Effects are listed at the lowest level (milligrams per cubic meter of air (mg/m^3)) at which they were first observed. They may also be seen at higher levels.

***1 mg/m^3 = 1000 $\mu g/m^3$ (micrograms/m^3) = 0.15 ppm (parts per million) = 150 ppb (parts per billion)**

Letterhead of New York City Department of Health Bureau of Environmental Investigations

Tetrachloroethylene (Perchloroethylene - "PERC") Fact Sheet

Q1: What is Tetrachloroethylene?

Tetrachloroethylene (also known as perchloroethene or "PERC") is a synthetic chemical. It is a colorless, nonflammable and stable liquid at room temperature. Although it is liquid at room temperature, it tends to evaporate into the air producing an ether-like odor that may be detected at low concentrations. However, after a short period of time the odor may become inconspicuous, thereby becoming an unreliable warning signal.

Q2: Where is PERC used?

PERC is widely used in dry cleaning fabrics and for metal-degreasing operations. It is also used as a starting material for making other chemicals and some consumer products such as auto brake cleaners, suede protectors, water repellants, silicone and belt lubricants. Specialized aerosol cleaners, ignition wire driers, fabric finishers, spot removers, adhesives and wood cleaners also use PERC as an ingredient.

Q3: How might I be exposed to PERC?

Humans can be exposed to PERC from environmental and occupational sources and from consumer products. Background levels of PERC are found in the air we breathe, in the water we drink, and in the food we eat. Nevertheless, PERC is found most frequently in air and less often in the water and food. Air close to dry cleaning shops and chemical waste sites may have levels of PERC higher than background levels. The main route of exposure to PERC for residents in the vicinity of such facilities is inhalation.

Q4: How does PERC enter and leave my body?

PERC can enter the human body through inhalation, ingestion and skin contact. Very little PERC in the air can pass through the skin into the body. Most PERC leaves the human body from the lungs when breathed out. A small amount of PERC is changed by the body and eliminated from the body in urine within a few days. Some of the PERC that entered the body can be found in the blood and other tissues, especially body fat. Part of the PERC that is stored in fat may stay in the body for several days or weeks before it is eliminated.

Q5: How can PERC affect my health?

The health effects of PERC depend on the level and duration of exposure. PERC has been used safely as a general anesthetic agent, since at high concentrations it is known to produce loss of consciousness. When concentrations in the air are high - particularly in closed, poorly ventilated areas - a single exposure to PERC can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Skin irritation may result from repeated or extended contact with PERC. By far the most significant exposure to PERC occurs in industrial environments. Liver and central nervous system effects have been observed in workers in industries using PERC.

Animal studies suggest that PERC has the potential to cause liver and kidney damage and developmental effects in the unborn. PERC can cause cancer in laboratory animals that were exposed to large amounts over their lifetimes.

The currently available information is not sufficient to determine the health effects from low levels of PERC exposure and whether PERC causes cancer in humans.

Q6: Is there a medical test to determine whether I have been exposed to PERC?
Currently there is no readily available medical test to determine the amount of PERC in a person's body. The best way to determine if an individual has recently been exposed to PERC is to measure the amount of PERC in the air of their residence.

Q7: Should I or my children see a doctor?
If you believe you or your children are experiencing symptoms which you think might be related to PERC exposure, you and your children should see your physician. You should explain to the physician when, how and for how long you think you were exposed to PERC.

In an emergency, call the Poison Control Center at (212) POISONS, (212) VENENOS, or (212) 340-4494.

For more information call the New York City Health Department:

- Bureau for Environmental Investigations, (212) 442-3372
- Bureau for Environmental and Occupational Disease Prevention, (212) 788-4290

April 2000

For more information on Environmental Investigations, call 212-442-3372.