HSDB: TETRACHLOROETHYLENE

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Tetrachloroethylene

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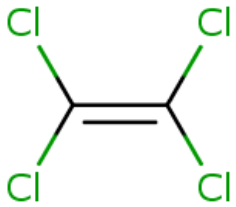

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Human Health Effects:

Evidence for Carcinogenicity:

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: (1) Although **tetrachloroethylene** is known to induce peroxisome proliferation in mouse liver, a poor quantitative correlation was seen between peroxisome proliferation and tumor formation in the liver after administration of **tetrachloroethylene** by inhalation. The spectrum of mutations in proto-oncogenes in liver tumors from mice treated with **tetrachloroethylene** is different from that in liver tumors from mice treated with trichloroethylene. (2) The cmpd induced leukemia in rats. (3) Several epidemiological studies showed elevated risks for esophageal cancer, non-Hodgkin's lymphoma and cervical cancer.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. 63 204 (1995)] **PEER REVIEWED**

A3: Confirmed animal carcinogen with unknown relevance to humans.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 55] **PEER REVIEWED**

Tetrachloroethylene: reasonably anticipated to be a human carcinogen.

[DHHS/National Toxicology Program; Eleventh Report on Carcinogens: Tetrachloroethylene (127-18-4) (January 2005). Available from, as of July 31, 2009: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s169tetr.pdf **PEER REVIEWED**

Human Toxicity Excerpts:

/HUMAN EXPOSURE STUDIES/ ... Subjects exposed for 7 hours at 101 ppm **tetrachloroethylene** had eye irritation and subjective symptoms such as headache, drowsiness, and sleepiness.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Irritation of the eyes, nose, or throat and central nervous system depression were experienced by 17 subjects, exposed to 685 mg of **tetrachloroethylene** per cu m air. Coordination was impaired within 3 hr of exposure.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Several studies of the effects of prolonged exposure to **perchloroethylene** vapors on human volunteers are avail. ... Prolonged exposure to 200 ppm results in early signs of CNS depression, while there was no response in men or women repeatedly exposed to 100 ppm for 7 hr/day. Clinical chemical studies indicate no liver or kidney effects at these levels but massive exposure to concentrations causing unconsciousness have resulted in proteinuria & hematuria.

[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986., p. 464] **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Sensory changes and mild elation were reported by volunteers exposed to **tetrachloroethene** vapor at 3250 mg/cu m for 130 min. Lassitude, mental fogginess, and exhilaration were experienced at 6280 mg/cu m for 95 min, and inebriation resulted when this was increased to 10 000 mg/cu m. Subjects found exposure to 13 400 mg/cu m intolerable.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ ... Six volunteers were exposed at 570-900 mg/cu m vapor for 1 hr /had eye irritation/. Dizziness and sleepiness were felt at 1420-1620 mg/cu m for 0.75-2 hr, while exposure to 1420-2450 mg/cu m for up to 2 hr caused lightheadedness, a sense of irresponsibility, nausea, and impaired motor coordination.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Eleven healthy adults were exposed at 690 mg/cu m for 7 hr, and a further five subjects were exposed daily for 5 days. Three subjects had difficulty in maintaining equilibrium in the Romberg test within the first 3 hr but performed normally when given a second chance. Performance on the other tests was not impaired. An additional subject, exposed during the 3rd day of testing, showed a slight deterioration in his Romberg

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test and complained of slight dizziness and slight impairment of his intellectual faculties after 1 hr of exposure.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ ... /In a/ 5-week study, 3-4 healthy men were exposed 1, 3, or 7.5 hr/day, 5 days/week, to **tetrachloroethene** at about 0, 140, 690, or 1000 mg/cu m ... EEG recordings made during exposure suggested altered patterns indicative of cortical depression in males and females exposed to **tetrachloroethene** at 690 mg/cu m for 7.5 hr. Recordings of visual evoked responses and equilibrium tests were normal in men and women. Men were given neurobehavioral tests of cognitive function, motor function, motor/cognitive function, and time estimation; performance was not statistically significantly affected by exposure. The performance of men on a second test of motor function (Flanagan coordination) was statistically significantly decreased ($P < 0.05$) when compared with the response at 0 mg/cu m on at least 1 day during the weeks of **tetrachloroethene** exposure at 690 and 1000 mg/cu m.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Five volunteers placed their thumbs in beakers of **tetrachloroethylene** for 30 minutes. Within 5-10 minutes, all subjects had a burning sensation. After the thumb was removed from the solvent, the burning decreased during the next 10 minutes. Marked erythema, which cleared l-2 hours after exposure, was present in all cases.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 86-87 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/HUMAN EXPOSURE STUDIES/ Researchers randomly allocated 22 healthy young male subjects to exposure to **tetrachloroethylene** at 10 ppm or 50 ppm in a chamber for 4 hours on 4 consecutive days, and blood samples were taken for **tetrachloroethylene** testing and visual and neurophysiologic tests were performed. All subjects had normal visual acuity and no previous solvent exposure. Increased latency in visual evoked potentials (VEPs) was observed in subjects exposed to **tetrachloroethylene** at 50 ppm, and decreased latency at 10 ppm; the greatest effect was observed on the last day of exposure. VEPs with the smallest visual angle and on the last day of exposure provided the greatest intergroup differences. VCS tests on five subjects (two at 50 ppm and three at 10 ppm) showed improvement at the low and intermediate spatial frequencies in the 10-ppm group but loss in the 50-ppm group. Brainstem auditory evoked potentials were not associated with **tetrachloroethylene** exposure. The lowest observed-adverse-effect level (LOAEL) appeared to be 10 ppm for VEP outcomes.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ Short Term Exposure: Inhalation: Irritates the eyes and respiratory tract causing coughing and/or shortness of breath. High exposure can cause headache, dizziness, lightheadedness, nausea, vomiting, and unconsciousness. Higher exposures can cause pulmonary edema, a medical emergency that can be delayed for several hours. This can cause death. Exposures of 220 ppm for 1 hr can cause irritation of the nose, mouth, and throat, dizziness, headaches, and lightheadedness. Exposures of 1000 ppm for 30 min can cause difficulty breathing, weakness, loss of muscle control, irritability, tremors, convulsions, paralysis, coma, heart irregularities, and death. Skin: Contact can cause irritation and burns. Can cause dry, scaly skin, a mild to moderate burning sensation, redness, and inflammation. Eyes: Can cause burning and irritation. Ingestion: Can cause nausea, vomiting, diarrhea, bloody stool, a reddening of face and neck, weakness, and loss of muscle control. Long Term Exposure: May affect

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the liver, kidneys, and nervous system. Exposures over 200 ppm during weeks or months can cause irritation of the respiratory tract, nausea, headache, sleeplessness, abdominal pain, constipation, dizziness, increased perspiration, fatigue, skin infection, kidney and liver damage, fluid in the lungs, and coma. Long term exposure can cause dermatitis, drying and cracking of the skin. **Tetrachloroethylene** has caused liver cancer and birth defects in mice. Whether it causes cancer in humans is unknown. May damage the developing fetus.

[Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 5th Edition Volume 1: A-H,Volume 2: I-Z. William Andrew, Norwich, NY 2008, p. 2389] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ **Perchloroethylene** has been reported to produce effects on the liver in humans. The concentration ... generally appeared to be in excess of 100 ppm.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values, 4th ed., 1980. Cincinnati, Ohio: American Conference of Governmmental Industrial Hygienists, Inc., 1980., p. 325] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ Acute exposure to **tetrachloroethylene** by inhalation results in central nervous system depression. Liver & kidney toxicity have been reported as effects of acute exposures to very high doses. In dry cleaners chronically exposed to **tetrachloroethylene**, increased levels of markers of early renal damage &/or dysfunction were attributed to the exposure.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ ... acute hepatic necrosis and oliguric uremia have followed human exposure.

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. II-165] **PEER REVIEWED**

/SIGNS AND SYMPTOMS/ ... /Oral/ doses of about 4.5-6 g have caused vertigo, inebriation, giddiness, nausea, sleepiness, and loss of consciousness ... In children, estimated intakes of 1.6-4.8 g/kg body weight have produced vomiting, gastrointestinal bleeding, shock, and even death ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/CASE REPORTS/ A pt is reported who had a connective tissue type of disease clinically similar to vinyl chloride disease, possibly caused by abnormal sensitivity to **perchlorethylene** to which he was exposed in his occupation.

[SPARROW GP; CLIN EXP DERMATOL 2 (1): 17-22 (1977)] **PEER REVIEWED** PubMed Abstract

/CASE REPORTS/ Six wk old breast-fed infant had obstructive jaundice & hepatomegaly. **Tetrachloroethylene** was detected in milk & blood. After discontinuance of breast-feeding rapid clinical & biochem improvement were noted.

[BAGNELL PC, ELLENBERGER HA; CAN MED ASSOC J 117 (9): 1047-8 (1977)] **PEER REVIEWED** PubMed Abstract Full text: PMC1880184

/CASE REPORTS/ After ingestion of 12-16 g **tetrachloroethylene**, a 6 year old boy was admitted to the clinic in coma. In view of the high initial **tetrachloroethylene** blood level, hyperventilation therapy was performed. Under this therapeutic regimen, the clinical condition of the patient improved considerably. The **tetrachloroethylene** blood level profile which was determined under hyperventilation therapy could be computer fitted to a two compartment model. Elimination of **tetrachloroethylene** from the blood compartment occurred via a rapid and a slow process with half-lives of 30 min and 35 hours, respectively. These values compared favorably with the half-lives of 160 min and 33

hours under normal respiratory conditions. During hyperventilation therapy, the relative contribution to the fast elimination process increased from 70% for physiological minute volume to 99.9%. A minor fraction of the ingested dose was excreted with the urine (integral of 1% during the first 3 days). In contrast to previous results, trace amounts of unchanged **tetrachloroethylene** were detected in the urine besides trichloroacetic acid and trichloroethanol.

[Koppel C et al; J Toxicol Clin Toxicol 23 (2-3): 103-15 (1985)] **PEER REVIEWED** PubMed Abstract

/CASE REPORTS/ A 68 year old launderette worker was anesthetised & suffered erythema & 30% superficial burns after spilling a container of **tetrachloroethylene** over his clothes. The defatting property of **tetrachloroethylene** ... lead to cracking of damaged skin.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

/CASE REPORTS/ A 21 year old man who had been exposed to fumes of **tetrachloroethylene** developed acute pulmonary edema & became comatose. He received isoprenaline ..., furosemide ..., aminophylline ..., & dexamethasone ... /through iv/. Oxygen was admin. After 6 hr, improvement was noted. No evidence of liver or kidney damage was seen.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

/CASE REPORTS/ A man accidentally exposed to 1860 mg/cu m for 3 hr, followed by 7460 mg/cu m for 30 min, experienced light-headedness and eye irritation and finally became unconscious reversibly after the first 3 hr. Liver damage was indicated by the clinical report.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

/CASE REPORTS/ Acute renal failure occurred in a man who accidentally ingested 75 g **tetrachloroethene**. Renal biopsy 19 days later revealed acute tubular necrosis with aggregation of calcium-rich crystals in the tubular lumen. Following repeated dialysis, renal function gradually returned to normal.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/CASE REPORTS/ A 33-year-old man was found unconscious after performing work on a plugged line in a commercial dry cleaning establishment and died on the way to the hospital. Exposure to **tetrachloroethylene** was presumably by inhalation since an autopsy revealed no **tetrachloroethylene** in the stomach contents but high levels of the compound in the blood and brain (4.4 mg/l00 mL and 36 mg/l00 g, respectively).

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 13 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/CASE REPORTS/ A case report describes a 24-year-old man who experienced cardiac arrhythmia (frequent premature ventricular beats). The patient had been employed for 7 months in a dry cleaning facility where he used **tetrachloroethylene**. Plasma **tetrachloroethylene** was measured at 0.15 ppm on his 5th day of hospitalization. The patient was discharged the next day but returned in 2 weeks for outpatient evaluation with a recurrence of skipping of heartbeats, headache, and dizziness. At that time, plasma **tetrachloroethylene** was measured at 3.8 ppm. Since the biological exposure index associated with an 8-hour exposure of 25 ppm is 0.5 mg/L **tetrachloroethylene** in blood, this subject was exposed to relatively high concentrations. The patient was reported to be asymptomatic 1 month after finding different employment.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for

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Number 18: Tetrachloroethylene p. 34-35 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/CASE REPORTS/ One case of occupational asthma was reported after regular exposure for short periods of time to **tetrachloroethylene** originating from dry-cleaned linen. After complete recovery, the patient was challenged again with **tetrachloroethylene**, and he presented cough and dyspnea.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 144 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ Researchers conducted a well-designed study of the relationship between acute and cumulative **tetrachloroethylene** exposure in dry-cleaning shops in Detroit, Michigan, and performance on a neuropsychologic battery. There was no "unexposed" group, but the referent group (lowest exposed; mean air **tetrachloroethylene** concentrations, not greater than 11.4 ppm) was in the same cohort of dry-cleaning shops as the "exposed" group (mean air **tetrachloroethylene** concentrations, not greater than 40.8 ppm). Using an internal referent group reduced the potential for the types of selection bias present in many other studies. In the analyses, several potential confounders were considered, including, age, education, verbal skill, alcohol consumption, and prior intoxicant exposure. The authors used a stepwise selection procedure for adjustment, but it is not clear which variables were ultimately used. After adjustment for the covariates, performance on tests for Wechsler Memory Scale Visual Reproduction, NES Pattern Memory, and NES Pattern Recognition was significantly poorer in workers who had a high index of lifetime **tetrachloroethylene** exposure than in workers who had a low index of lifetime **tetrachloroethylene** exposure. Estimated lifetime **tetrachloroethylene** exposure was positively associated with self-reported "tension" (on the Profile of Mood States) and inversely associated with NES Pattern Recognition scores. Subanalysis demonstrated some similarity in the test results affected by **tetrachloroethylene** and alcohol consumption: Visual Reproduction, Pattern Memory, and Pattern Recognition. This similarity underscores the importance of adjusting for alcohol use in analyses of effects of **tetrachloroethylene**. The study is not without limitations in that recruitment was influenced by the lowering of the permissible exposure limit from 50 ppm to 25 ppm and by owners' emphasizing the cost of such a change for relatively little effect on health status; therefore, only 23 of a potentially eligible 125 shops participated, for a total of 65 exposed workers.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ ... Two cohort mortality studies of drycleaner union members and a large (N = 77,965) cohort mortality study of aerospace workers report no association with hepatic-cancer mortality. A sizable subcohort (N = 2,631) of the aerospace workers routinely exposed to **tetrachloroethylene** had a standardized mortality ratio of 2.05 (95% confidence interval [CI], 0.83-4.23) on the basis of seven observed deaths. However, an analysis that used an internal cohort referent population to reduce confounding yielded no overall association and no exposure-response relationship. Because hepatic cancer is fatal, assessments of mortality represent the burden of the disease in the population. Essentially null associations are reported in studies of incident cancers in laundry workers residing in Nordic countries. In ... one study ... that reported an increased standardized incidence ratio (SIR) for hepatic cancer in women (2.7; 95% CI, 1.5-4.5; 14 observed cases, all cases were in laundry workers, and no cases were observed in dry-cleaning workers, whose exposure to **tetrachloroethylene** is more likely.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ /Investigators/ conducted a population-based case-control study in Germany that estimated **tetrachloroethylene** exposure with a job-exposure matrix (JEM) and a job-task exposure matrix (JTEM). ...

FPL-049-006

The data were acquired in in-person interviews, so information on occupational history was obtained and confounding covariates (such as smoking) were well measured. An increased odds ratio (OR) for **tetrachloroethylene** exposure was observed in men who had a medium exposure index (OR, 1.4; 95% confidence interval [CI], 1.1-1.7) or a substantial exposure index (OR, 1.4; 95% CI, 1.1-2.0) on the basis of the JEM. However, the results based on the JTEM were less convincing (OR, 1.2; 95% CI, 0.9-1.7 and OR, 1.3; 95% CI, 0.7-2.3 for medium and substantial exposure, respectively). In contrast, no association was observed in women on the basis of the JEM, but a positive albeit imprecise association was observed on the basis of the JTEM for medium and substantial exposure (OR, 2.2; 95% CI, 0.9-5.2 and OR, 2.0; 95% CI, 0.5-7.8, respectively).

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ /Researchers/ ... conducted a nested case-control study in four Scandinavian countries in a cohort of about 47,000 persons employed in the laundry and dry-cleaning industry as of 1970 and followed through 1997-2001 to identify incident cancers. Multiple cancers were assessed, including 56 renal cell cancer (RCC) cases in men and 154 in women. The cohort was divided into those who were not exposed to the dry-cleaning process, dry-cleaners and other exposed workers, and others working in dry-cleaning. Risk was also estimated by duration of employment in dry-cleaning occupations. **Tetrachloroethylene** was the most commonly used solvent in dry-cleaning during the study interval; the mean concentration over the interval of the study was estimated as 24 ppm. The adjusted relative risk of RCC for dry-cleaners compared with unexposed workers was 0.67 (95% CI, 0.43-1.05) on the basis of 29 cases in the exposed.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ /Investigators/ pooled data from a multicenter international case-control study of renal cell cancer (RCC); the study was conducted in six centers in five countries (Australia, Denmark, Germany, Sweden, and the United States) and included 1,732 cases and 2,309 controls. Occupational histories, collected in in person interviews, were used to estimate exposures to specific chemicals or tasks. The study reported an increased OR of 1.4 (95% CI, 1.1-1.7) associated with exposure to dry-cleaning solvents, but no exposure response was observed on the basis of duration of exposure. /Dry cleaning solvents/

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ Few human data are available for assessing the relationship between **tetrachloroethylene** exposure and the risk of specific cell types of lymphohematopoietic cancers. Several studies have assessed the risk of chronic lymphocytic leukemia in humans, but otherwise the finest classification of outcomes used was "leukemia," "lymphoma," "non-Hodgkin lymphoma" (NHL), and "Hodgkin disease" (HD) ... The epidemiologic data "suggested an association between lymphoma and **tetrachloroethylene**" ... but ... the data are relatively weak and inconsistent. Associations between those cancers and exposure to **tetrachloroethylene** are based on very small numbers and thus are statistically unstable. The positive associations with **tetrachloroethylene** are sometimes observed only for lymphomas in women; ... Other large cohort studies ... found no association in either women or men, and no dose-response effects have been observed.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW

Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ ... A retrospective cohort mortality study was conducted of workers employed for at least 1 year at a large aircraft manufacturing facility in California on or after 1 January 1960. The mortality experience of these workers was determined by exam of national, state, & company records to the end of 1996. Standardised mortality ratios (SMRs) were evaluated comparing the observed numbers of deaths among workers with those expected in the general population adjusting for age, sex, race, & calendar year. The SMRs for 40 cause of death categories were computed for the total cohort & for subgroups defined by sex, race, position in the factory, work duration, yr of first employment, latency, and broad occupational groups. Factory job titles were classified as to likely use of chemicals, & internal Poisson regression analyses were used to compute mortality risk ratios for categories of yr of exposure to chromate, TCE, PCE, & mixed solvents, with unexposed factory workers serving as referents. The study cohort comprised 77,965 workers who accrued nearly 1.9 million person-years of follow up (mean 24.2 yr). Mortality follow up, estimated as 99% complete, showed that 20,236 workers had died by 31 December 1996, with cause of death obtained for 98%. Workers experienced low overall mortality (all causes of death SMR 0.83) & low cancer mortality (SMR 0.90). No significant increases in risk were found for any of the 40 specific cause of death categories, whereas for several causes the numbers of deaths were significantly below expectation. Analyses by occupational group & specific job titles showed no remarkable mortality patterns. Factory workers estimated to have been routinely exposed to chromate were not at increased risk of total cancer (SMR 0.93) or of lung cancer (SMR 1.02). Workers routinely exposed to TCE, PCE, or a mixture of solvents also were not at increased risk of total cancer (SMRs 0.86, 1.07, & 0.89, respectively), & the numbers of deaths for specific cancer sites were close to expected values. Slight to moderately increased rates of non-Hodgkin's lymphoma were found among workers exposed to TCE or PCE, but none was significant. A significant incr in testicular cancer was found among those with exposure to mixed solvents, but the excess was based on only six deaths & could not be linked to any particular solvent or job activity. Internal cohort analyses showed no significant trends of increased risk for any cancer with increasing years of exposure to chromate or solvents. The results from this large scale cohort study of workers followed up for over 3 decades provide no clear evidence that occupational exposures at the aircraft manufacturing factory resulted in increases in the risk of death from cancer or other diseases. Our findings support previous studies of aircraft workers in which cancer risks were generally at or below expected levels. /Chromate, trichloroethylene, **perchloroethylene**, and mixed solvents/

[Boice JD Jr et al; Occup Environ Med 56 (9): 581-597 (1999)] **PEER REVIEWED** PubMed Abstract Full text: PMC1757791

/EPIDEMIOLOGY STUDIES/ /No/ significant differences /were found/ in the incidence of liver and kidney malfunctions between a group of 112 railway workers, exposed to **tetrachloroethylene**, and a control group of 101 workers, over an average period of 11.5 years. Three-quarters of all 8 hr measurements revealed concentrations below 340 mg/cu m. Liver dysfunction after short-term **tetrachloroethylene** exposure was found in a number of case studies. In two of these cases, liver cell necrosis was found and, in one case, pulmonary edema. One case of liver cirrhosis was reported. They examined a total of 7 men, exposed for 2-6 years. Three of the men, including the cirrhosis case, showed significantly changed clinical chemistry measurements, indicative of liver disease.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ A collaborative European cross-sectional study assessed renal effects in 50 dry cleaning workers (41 women, 9 men) who had been exposed to **tetrachloroethene** for an average of 10 years. **Tetrachloroethene** was measured in blood samples collected during the working day and in air samples collected during 4-hr periods randomly selected over the working week. Atmospheric concentrations ranged from traces to about 590 mg/cu m, with a mean of 100 mg/cu m. Blood concentrations ranged from 9 to 900 ug/L (mean 143 ug/L). The control group consisted of 50 blood donors, matched for sex and age, who had no history of **tetrachloroethene** exposure. Renal function was assessed using markers in blood (creatinine, beta2-microglobulin, antiglomerular basement membrane antibodies, and laminin fragments) and urine (total protein, albumin, transferrin, immunoglobulin G, beta2-microglobulin, retinol binding protein, brush border antigens BBA, BB50, HF5, prostaglandins PGF1alpha, PGE2, PGF2alpha, thromboxane B2, Tamm-Horsfall glycoprotein, glycosaminoglycans, N-acetyl-beta-D-

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glucosaminidase activity, alkaline phosphatase activity, and fibronectin). Mean values of virtually all urinary markers were higher in the exposed group, and statistically significant increases were observed for albumin and transferrin (high molecular weight proteins), the three brush border antigens, fibronectin, and alkaline phosphatase. The increases in excreted glycoprotein and glycosaminoglycans also approached significance. In serum, there were statistically significant increases in laminin fragments and antiglomerular basement membrane antibodies. Serum creatinine and beta2-microglobulin values overlapped in the two groups, indicating the absence of major impairment of kidney function. In the control group, only 3/50 had >3 abnormal values, compared with 13/50 exposed workers. Increased high molecular weight proteins associated with markers of tubular alterations were seen in 17/50 exposed workers compared with 1/50 controls. ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ A case-control study further evaluating earlier suggested associations between breast cancer and **tetrachloroethene** exposure from drinking-water ... The cases (n = 672) were women from eight towns in the Cape Cod region of Massachusetts, USA, who had been diagnosed with breast cancer between 1987 and 1993. Controls (n = 616) were demographically similar women from the same towns. Women were exposed to **tetrachloroethene** when it leached from the vinyl lining of water distribution pipes during the late 1960s through the early 1980s. A relative delivered dose of **tetrachloroethene** that entered a home was estimated using an algorithm that considered residential history, water flow, and pipe characteristics. Small to moderate elevations in risk were observed among women whose exposure levels were above the 75th and 90th percentiles when 0-15 years of latency were considered (adjusted ORs, 1.5-1.9 for the 75th percentile; 1.3-2.8 for the >90th percentile).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ A ... population-based case-control study evaluated the relationship between cancer of the colon-rectum (n = 326), lung (n = 256), brain (n = 37), and pancreas (n = 37) and drinking-water exposure to **tetrachloroethene** among residents of five upper Cape Cod towns (Barnstable, Bourne, Falmouth, Mashpee, and Sandwich) in Massachusetts, USA, who were diagnosed during 1983-1986. Adjusted ORs for lung cancer were elevated among subjects whose exposure level was above the 90th percentile whether or not a latency period was assumed (ORs and 95% CIs: 3.7 (1.0-11.7), 3.3 (0.6-13.4), 6.2 (1.1-31.6), and 19.3 (2.5-141.7) for 0, 5, 7, and 9 years of latency, respectively). The adjusted ORs for colon-rectum cancer were moderately elevated among exposed subjects, as more years of latency were assumed (ORs and 95% CIs: 1.7 (0.8-3.8) and 2.0 (0.6-5.8) for 11 and 13 years of latency, respectively).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ The pregnancy outcome in 1973-1983 among 5700 female Finnish dry cleaning and laundry workers, identified from union membership files and employers' records for employees /has been studied/. Out of 247 spontaneous abortion cases, 130 finally were included in the analysis, together with 289 controls. Dry cleaning was associated with an increased risk of spontaneous abortion (OR 4.9, 95% CI 1.3-20). High exposure (exposure assessed by questionnaire) to **tetrachloroethene** was also associated with an increased risk of spontaneous abortion (OR 3.4, CI 1.0-11.2, adjusted for use of other solvents, heavy lifting at work, and alcohol use) ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ Another large population-based case-control study was conducted in Germany on renal cell carcinoma. Exposure assessment was done by expert rating with two job exposure matrices. Response rates

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were 81% (cases) and 75% (controls). Overall, 935 incident renal cell carcinoma cases and 4298 controls were interviewed. An OR of 1.4 (95% CI 1.1-1.7) was observed in men with medium levels of exposure to **tetrachloroethene**, whereas ORs of 1.1 (95% CI 0.9-1.4) and 1.4 (95% CI 1.0-2.0) were observed for high levels and for substantial levels, respectively (... exposure categories medium, high, and substantial were defined as the 30th, 60th, and 90th percentiles of the exposure index among exposed controls). No association was observed in women.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ In a cross-sectional study of dry cleaners, a subgroup was exposed to **tetrachloroethene** at a mean concentration of 335 mg/cu m (range 84-750 mg/cu m). This group had a higher total leukocyte count compared with blood donors as a possible expression of an inflammatory process. An increased total leukocyte count is an established risk indicator for ischemic heart disease (IHD).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ ... This study was carried out on 80 adult males. Subjects designated as controls (n = 40) were healthy persons and others were **tetrachloroethylene**-exposed dry-cleaning workers (n = 40). The controls and **tetrachloroethylene**-exposed workers were then divided into four equal groups (20 individuals/group): group I, control group never smoking; group II, smoking control group; and groups III and IV, **tetrachloroethylene**-exposed nonsmoking and smoking workers, respectively. Blood level of **tetrachloroethylene**, complete blood count, immunoglobulins (IgA, IgM, IgG, and IgE), the total numbers of white blood cells (WBC), and leukocyte differential counts, as well as interferon gamma (IFN-gamma) and interleukin-4 (IL-4), were measured. The immunotoxicity of **tetrachloroethylene** appeared in the form of an increase in serum immunoglobulin E in nonsmoking and smoking **tetrachloroethylene**-exposed workers, while the serum immunoglobulins A, M, and G levels showed no significant change in all studied groups. In addition, our results demonstrated a significant increase in white cell count, lymphocytes, natural killer (NK; CD3+CD16CD56+) cells, and B (CD19+) lymphocytes. ... Moreover, serum and lymphocytic interlukin-4 levels were significantly increased in nonsmoking and smoking **tetrachloroethylene**-exposed workers. **Tetrachloroethylene** exposure is associated with immunotoxicity ...

[Emara AM et al; Inhal Toxicol 22 (2): 117-24 (2010)] **PEER REVIEWED** PubMed Abstract

/EPIDEMIOLOGY STUDIES/ ... This retrospective cohort study examined whether PCE contamination of public drinking water supplies in Massachusetts influenced the occurrence of congenital anomalies among children whose mothers were exposed around the time of conception. The study included 1,658 children whose mothers were exposed to PCE-contaminated drinking water and a comparable group of 2,999 children of unexposed mothers. Mothers completed a self-administered questionnaire to gather information on all of their prior births, including the presence of anomalies, residential histories and confounding variables. PCE exposure was estimated using EPANET water distribution system modeling software that incorporated a fate and transport model. Children whose mothers had high exposure levels around the time of conception had an increased risk of congenital anomalies. The adjusted odds ratio of all anomalies combined among children with prenatal exposure in the uppermost quartile was 1.5 (95% CI: 0.9, 2.5). No meaningful increases in the risk were seen for lower exposure levels. ...

[Aschengrau A et al; Environ Health 8: 44 (2009)] **PEER REVIEWED** PubMed Abstract Full text: PMC2761868

/EPIDEMIOLOGY STUDIES/ This population-based retrospective cohort study examined the association between developmental disorders of learning, attention and behavior and prenatal and early postnatal drinking water exposure to **tetrachloroethylene** (PCE) on Cape Cod, Massachusetts. Subjects were identified through birth records from 1969 through 1983. Exposure was modeled using information from town water departments, a PCE leaching and transport algorithm, EPANet water flow modeling software, and a Geographic Information System (GIS). Mothers completed a questionnaire on disorders of attention, learning and behavior in their children and on potential confounding variables. The final cohort consisted of 2086 children. Results of crude and multivariate analyses showed

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no association between prenatal exposure and receiving tutoring for reading or math, being placed on an Individual Education Plan, or repeating a school grade (adjusted Odds Ratios (OR)=1.0-1.2). There was also no consistent pattern of increased risk for receiving a diagnosis of Attention Deficit Disorder (ADD) or Hyperactive Disorder (HD), special class placement for academic or behavioral problems, or lower educational attainment. Modest associations were observed for the latter outcomes only in the low exposure group (e.g., adjusted ORs for ADD were 1.4 and 1.0 for low and high exposure, respectively). (All ORs are based on an unexposed referent group). Results for postnatal exposure through age five years were similar to those for prenatal exposure ...

[Janulewicz PA et al; Neurotoxicol Teratol 30 (3): 175-85 (2008)] **PEER REVIEWED** PubMed Abstract Full text: PMC2494864

/EPIDEMIOLOGY STUDIES/ Using proportional hazard methods, ... the relationship between parental occupation as a dry cleaner and risk for schizophrenia /was studied/ in a prospective population-based cohort of 88,829 offspring born in Jerusalem from 1964 through 1976, followed from birth to age 21-33 years. Of 144 offspring whose parents were dry cleaners, 4 developed schizophrenia. We observed an increased incidence of schizophrenia in offspring of parents who were dry cleaners (RR=3.4, 95% CI, 1.3-9.2, p = 0.01) ...

[Perrin MC et al; Schizophr Res 90 (1-3): 251-4 (2007)] **PEER REVIEWED** PubMed Abstract Full text: PMC2739584

/EPIDEMIOLOGY STUDIES/ A retrospective cohort mortality study based on standardized mortality ratios (SMRs) was conducted to investigate the possible association between exposure to chlorinated organic solvents and various types of cancer deaths. Vital status and causes of death of study subjects were determined from January 1, 1985 to December 31, 1997 by linking cohort data with the National Mortality Database. Person-year accumulation began on the date of entry to the cohort, or January 1, 1985 (whichever came later), and ended on the closing date of the study (December 31, 1997), if alive; or the date of death. This retrospective cohort study examined cancer mortality among 86,868 workers at an electronics factory in the northern Taiwan. Using various durations of employment and latency and adjusting for age and calendar year, no significantly elevated SMR was found for any cancer in either male or female exposed workers when compared with the general Taiwanese population. In particular, the risk of female breast cancer was not found to be increased. Although ovarian cancer suggested an upward trend when analyzed by length of employment, ovarian cancer risk for the entire female cohort was not elevated ...

[Chang YM et al; Ann Epidemiol 13 (9): 652-60 (2003)] **PEER REVIEWED** PubMed Abstract

/EPIDEMIOLOGY STUDIES/ ... The International Agency for Research on Cancer (IARC) currently finds sufficient evidence to designate PCE as carcinogenic in animals, with limited evidence in humans. With regard to occupational exposure through dry-cleaning, PCE is considered to be possibly carcinogenic to humans. This review was conducted to assess the current epidemiological literature on PCE and specific cancers. A comprehensive search was conducted to identify all available epidemiological literature pertaining to the carcinogenic effects of PCE. Forty-four papers that provided reasonable data on up to 17 cancer sites were critically reviewed in the context of the available background literature for each cancer site and were assessed on the basis of specified methodological and scientific quality criteria. While all the epidemiological studies selected for review investigated similar exposure-health outcome relationships, there was a broad diversity of proxy measurements of exposure to PCE, as well as numerous specific cancer outcomes of interest. The widespread lack of valid exposure measurements or other adequate indicators of potential for exposure were consistent limitations. We found no evidence of an association between breast, prostate, skin or brain cancer and exposure to PCE. A relationship between PCE and cancer of the following sites was considered unlikely: oral cavity, liver, pancreas, cervix, lung. Scientific evidence was inadequate for laryngeal, kidney, esophageal and bladder cancers. The current epidemiological evidence does not support a conclusion that occupational exposure to PCE is a risk factor for cancer of any specific site.

[Mundt KA et al; Int Arch Occup Environ Health 76 (7): 473-91 (2003)] **PEER REVIEWED** PubMed Abstract

/EPIDEMIOLOGY STUDIES/ GGT isoenzyme patterns in 141 **tetrachloroethene**-exposed workers and 130 controls /has been studied/. The exposed group (124 females, 17 males, aged 20-58 years; mean 43.0 years) were employed for a mean of 12.3 years in 47 small laundries and dry cleaning shops in Bologna, Italy, exposed only to

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tetrachloroethene, while the control group was drawn from among staff and students of the University of Bologna. Based on measurement of trichloroacetic acid in urine after at least 5 consecutive days of exposure, **tetrachloroethene** exposure in the exposed group was estimated to be below 340 mg/cu m (mean 76 +/- 27 mg/cu m). Total GGT activity was higher in the exposed group ... When total GGT was ranked by activity ... the frequency distribution was significantly different, more of the controls being distributed among the lower ranks. One GGT fraction (GGT-4), considered to reflect hepatobiliary impairment, was seen only in the exposed group.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ ... The underlying and contributing causes of death among 5,369 members of a dry cleaning union in St. Louis were determined through December 31, 1993. The mortality experience of the cohort was compared to that of the US population adjusted for age at entry, year of death, race and gender. Results: The total mortality was about as expected (SMR = 1.0, N = 2351, 95% CI = 1.0-1.1). Excesses were observed for emphysema (SMR = 1.7, N = 21, 95% CI = 1.0-2.5), Hodgkin's disease (SMR = 2.0, N = 5, 95% CI = 0.6-4.6) and cancers of the esophagus (SMR = 2.2, N = 26, 95% CI = 1.5-3.3), larynx (SMR = 1.7, N = 6, 95% CI = 0.6-3.7), lung (SMR = 1.4, N = 125), 95% CI = 1.1-1.6), and cervix (SMR = 1.6, N = 27, 95% CI = 1.0-2.3). These excesses occurred among men and women and blacks and whites. Bladder cancer was elevated among white men and women and kidney cancer among black men and women, but not significantly so. None of these causes of death showed strong relationships with duration or estimated level of exposure to dry cleaning solvents, although relative risks for cancers of the larynx, lung and kidney were larger among subjects estimated to have higher levels of exposure and risks from bladder cancer and chronic nephritis were greater among persons who entered the union after 1960 ... /Dry cleaning solvents/

[Blair A et al; Ann Epidemiol 13 (1): 50-56 (2003)] **PEER REVIEWED**

/EPIDEMIOLOGY STUDIES/ ... A literature search was performed to identify all peer-reviewed epidemiological and toxicologial studies examining outcomes from early lifestage exposure to perc, and reviewed by developmental stage for both exposure and outcome. Exposure scenarios to perc unique to early lifestages include transplacental and breast milk intake, along with inhalation, ingestion, or dermal exposure. Toxicokinetics factors that may influence early lifestage susceptibility to perc, along with existing physiologically based pharmacokinetic (PBPK) models, are described. Adverse outcomes examined include: reproductive outcomes examined prior to conception including reduced fertility, adverse effects on sperm, or altered reproductive hormones; prenatal outcomes examined after exposure prior to conception or prenatally including fetal death, birth defects, and decreased birth weight; postnatal outcomes examined after exposure prior to conception, prenatally, or during childhood including neurotoxicity, immunotoxicity, cancer, hepatotoxicity, congential anomalies and mortality; and adult schizophrenia examined after exposure prior to conception. The limited evidence on early lifestage exposure to perc does not provide sufficient evidence of this sensitive period as being more or less important than exposure at a later lifestage, such as during adulthood. However, there are a number of adverse health effects observed uniquely in early lifestages, and increased sensitivity to visual system deficits is suggested in children. ...

[Brown Dzubow R et al; Birth Def Res B Dev Reprod Toxicol 89 (1): 50-65 (2010)] **PEER REVIEWED** PubMed Abstract

/EPIDEMIOLOGY STUDIES/ The literature concerning the neurobehavioral and neurophysiological effects of long-term exposure to **perchloroethylene** (PERC) in humans was meta-analyzed to provide a quantitative review and synthesis in the form of dose-effect curves. The useable database from this literature comprised studies reporting effects of long-term exposure to PERC, effects that included slowed reaction times, cognitive deficits, impaired color vision, and reduced visual contrast sensitivity. For the meta-analyses, dose was defined as the product of the concentration inhaled PERC and the duration of exposure, expressed in units of ppm-hr/1000 (for numerical convenience). Dose-related results were highly variable across studies. Reports involving low exposure concentrations characteristic of nonoccupational exposures consistently produced effects of a magnitude that were comparable to those reported for higher concentration occupational studies. If this finding is reliable and general, studies of occupationally exposed persons may underestimate the magnitude of effects of PERC and other chemicals in the total population. ...

[Benignus VA et al; J Toxicol Environ Health A 72 (13): 824-31 (2009)] **PEER REVIEWED** PubMed Abstract

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/EPIDEMIOLOGY STUDIES/ A possible effect of **tetrachloroethene** exposure on vocal reaction times was assessed by examining 35 dry cleaners and 39 unexposed controls, matched for age and education. Exposure was assessed only by a grab sample technique and indicated a median concentration of **tetrachloroethene** of 55 mg/cu m (range 14-940 mg/cu m). An index of cumulative exposure to **tetrachloroethene** was also developed. The exposed group had statistically significantly longer mean reaction times and/or vocalization durations, and statistically significant positive correlations were observed between cumulative **tetrachloroethene** exposure and immediate and delayed tasks (r = 0.69 and r = 0.73, respectively).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/SURVEILLANCE/ /Researchers/ examined color-vision loss in 35 dry-cleaning workers in 12 small dry-cleaning shops in Modena, Italy, and in controls who had no solvent exposure and were matched by age, sex, alcohol use, and cigarette- smoking. Inclusion criteria were apparently healthy, average daily alcohol intake under 50 g/day, smoking fewer than 30 cigarettes/day, and corrected visual acuity of at least 6/10. Color vision was evaluated with the Lanthony 15 Hue desaturated panel, which was repeated 10 times. Few exposed or control workers were able to perform the test without error. Results were expressed as a color-confusion index (CCI) with errors in blue-yellow color vision. Tests were performed monocularly, and the mean CCI for both eyes was used in the analyses, although CCI may be affected in only one eye after **tetrachloroethylene** exposure. Air **tetrachloroethylene** concentrations obtained with personal passive sampling for 1 day produced a mean time-weighted average (TWA) for drycleaners of 7.27 +/- 8.19 ppm (range, 0.38-31.19 ppm). The mean CCI for the drycleaners was significantly higher (1.192 +/- 0.133) than that of controls (1.089 +/- 0.117). The statistically significant relationship between TWA of **tetrachloroethylene** exposure and CCI depended on two extreme values. CCI was not related to duration of exposure or to an integrated index of exposure; only current exposure was known, and there were no data on **tetrachloroethylene** concentrations in previous years.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/SURVEILLANCE/ /Investigators/ re-examined 33 of the workers from the ... study for color-vision loss after an interval of 2 years. This study was unique in that it examined the same workers at two times. Overall, **tetrachloroethylene** concentrations remained unchanged for the whole group, but 19 workers (group A) had exposure to significantly increased **tetrachloroethylene** concentrations at the time of the second assessment, and the remainder (group B) had exposure to significantly lower concentrations because of changes in the processes used in their dry-cleaning shops. Demographic information was provided on the group as a whole but not the two subgroups. The mean color-confusion index (CCI) increased significantly over the 2 years in group A (from 1.16 +/- 0.15 to 1.26 +/- 0.18) but remained unchanged in group B (1.15 +/- 0.14 and 1.15 +/- 0.13). In comparison, the control group from the Cavalleri et al. study, which was not re-examined in the Gobba et al. study, had a mean CCI of 1.08 +/- 0.10. The clinical significance of these CCI changes is uncertain.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/SURVEILLANCE/ /Researchers/ studied oxidative damage (measured as 8- hydroxydeoxyguanosine [8-OHdG]) in leukocyte DNA of 18 female dry cleaners exposed to **tetrachloroethylene** and compared it with oxidative damage in 20 female laundry workers who were not exposed to **tetrachloroethylene**. Blood concentrations in the exposed workers were greater than in unexposed workers by two orders of magnitude. There was a statistically significant

reduction in 8- OHdG in the exposed workers and no difference in urinary 8-OHdG or in urinary lipid peroxidation biomarkers between the two groups. The data from this small sample provide no evidence of oxidative DNA damage under the conditions of the study.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/SURVEILLANCE/ Examination of 113 dry-cleaning workers, revealed that 35% of them experienced symptoms of central nervous system depression, while the autonomic nervous system was affected in 40%. Slight liver function disturbances were revealed. Out of 326 measurements, 75% revealed average 8-hr concentrations below 678 mg/cu m.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/SURVEILLANCE/ Six pseudoneurotic syndrome cases and 4 subjects with pathological EEG recordings among 16 factory employees exposed to **tetrachloroethylene** concentrations ranging from 400 to 3000 mg/cu m for periods of 2 years to more than 20 years. The altered EEG was accompanied by a reduced cholinesterase activity in the serum of 3 workers and an increased alanine aminotransferase activity in the serum of 2 workers, which could point to liver damage. Subjective complaints of irritation and neurological disorders were related to length of exposure. Adrenal gland damage was also noted.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

/SURVEILLANCE/ Color vision in 33 of the 35 dry cleaners and ironers (two had retired) ... was re-examined after 2 years. **Tetrachloroethene** concentration had increased during the 2-year period for 19 subjects, identified as Group A, and had decreased for 14 subjects. For the 33 workers overall, exposure was only slightly changed over the 2-year period (geometric mean, from 17 to 13 mg/cu m). Color vision had deteriorated between the two surveys for the entire group, a reflection of the color vision loss among Group A subjects, whose exposure had increased in the second survey. Perception of the blue-yellow range of color was most affected. Color vision performance for the entire group was related significantly to age (r = 0.45) and **tetrachloroethene** concentration (r = 0.39). For subjects who experienced lower exposure concentrations by the second survey, the error score had not changed

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/SURVEILLANCE/ A number of neuropsychological tests /were administered/ to 44 German dry cleaning workers with high **tetrachloroethene** exposure (39 women, 5 men), 57 dry cleaners with low exposure (50 women, 7 men), and 84 controls (employees of department stores and hotels) without exposure (64 women, 20 men). Air monitoring revealed that mean **tetrachloroethene** concentrations (8-hr TWA) for the low and high exposure groups were approximately 83 +/- 55 mg/cu m and 370 +/-120 mg/cu m, respectively. The mean durations of occupational exposure for the low and high exposure groups were 11.8 and 10.6 years, respectively. Subjects were administered standardized tests of symptoms and personality, tests of sensorimotor function (including finger tapping and aiming), and dexterity tests. Threshold of perceptual speed was assessed by recognition of stimuli flashed briefly on a screen. Choice reaction time was determined using nine light and tone stimuli. Subtests of the Wechsler Intelligence Test (digit span, digit symbol, and cancellations) were used, as was recognition of words, faces, and digits. Intelligence was assessed using a logical thinking subtest. Stratified analysis was used to control for various group differences. Both exposed groups performed significantly (P < 0.01) worse than controls in tests for the threshold of perceptual speed and choice reaction times and had lower scores in tests of attention (digit reproduction and digit symbol) and visual scanning and memory (cancellation), but there were no significant differences between the low and high exposure groups. Exposed

groups reported more neurological signs and emotional liability, but the scores were statistically significantly different only in the low exposure group. There were no differences between groups on the other tests. Controlling for group differences in alcohol consumption did not alter any test results.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/SURVEILLANCE/ CNS effects were assessed in 56 workers (27 women, 29 men; mean **tetrachloroethene** exposure time 3 years) from three dry cleaning shops in China and in 69 unexposed workshop controls (37 women, 32 men). Passive air sampling revealed a geometric mean 8-hr TWA **tetrachloroethene** concentration of 140 mg/cu m and a TWA concentration range of about 28-670 mg/cu m. Five symptoms (dizziness, drunken feeling, floating sensation, heavy feeling in head, facial flushes) were significantly more prevalent among the dry cleaning workers.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/SURVEILLANCE/ Urinary beta2-microglobulin, albumin, and retinol binding protein levels were similar in 24 female and 2 male dry cleaning shop workers in Belgium, when compared with unexposed subjects (31 females, 2 males). The TWA **tetrachloroethene** exposure (estimated by personal air monitoring, analysis of breath and blood for **tetrachloroethene**, and urine analysis for trichloroacetic acid) in the dry cleaning workers varied from 61 to 260 mg/cu m, with a mean for all samples of 143 mg/cu m. The study suggested that if the blood concentration of **tetrachloroethene** does not exceed 1 mg/L, 16 hr after the end of exposure, the TWA exposure is likely to have been below 340 mg/cu m. It was suggested that exposure to such levels for an average of 6 years did not seem to exert any adverse effect on the CNS, liver, or kidneys.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/SURVEILLANCE/ **Tetrachloroethylene** (also called **perchloroethylene**, or perc), a volatile organic compound, has been the predominant solvent used by the dry-cleaning industry for many years. The U.S. Environmental Protection Agency (EPA) classified perc as a hazardous air pollutant because of its potential adverse impact on human health. Several occupational studies have indicated that chronic, airborne perc exposure adversely affects neurobehavioral functions in workers, particularly visual color discrimination and tasks dependent on rapid visual-information processing. A 1995 study ... extended these findings, indicating that environmental perc exposure at a mean level of 4,980 ug/cu m (median = 1,360 ug/cu m) alters neurobehavioral functions in residents living near dry-cleaning facilities. Although the U.S. EPA has not yet set a reference concentration guideline level for environmental exposure to airborne perc, the New York State Department of Health set an air quality guideline of 100 ug/cu m. In the current residential study, the potential for perc exposure and neurologic effects /was investigated/ using a battery of visual-system function tests among healthy members of six families living in two apartment buildings in New York City that contained dry-cleaning facilities on the ground floors. In addition, a day care investigation assessed the potential for perc exposure and effects among workers at a day care center located in the same one-story building as a dry-cleaning facility. Results from the residential study showed a mean exposure level of 778 ug/cu m perc in indoor air for a mean of 5.8 years, and that perc levels in breath, blood, and urine were 1-2 orders of magnitude in excess of background values. Group-mean visual contrast sensitivity (VCS), a measure of the ability to detect visual patterns, was significantly reduced in the 17 exposed study participants relative to unexposed matched-control participants. The groups did not differ in visual acuity, suggesting that the VCS deficit was of neurologic origin. Healthy workers in the day care investigation were chronically exposed to airborne perc at a mean of 2,150 ug/cu m for a mean of 4.0 years. Again, group-mean VCS, measured 6 weeks after exposure cessation, was significantly reduced in the nine exposed workers relative to matched controls, and the groups did not differ significantly in visual acuity. These results suggested that chronic, environmental exposure to airborne perc adversely affects neurobehavioral function in healthy individuals. ...

[Schreiber JS et al; Environ Health Perspect 110 (7): 655-64 (2002)] **PEER REVIEWED** PubMed Abstract Full text: PMC1240911

/SURVEILLANCE/ In a study of 22 dry cleaning workers (primarily women) in Belgium exposed to a TWA concentration of 21 ppm **tetrachloroethylene** over an average of 6 years, no significant alterations were detected in neurological symptoms or psychomotor performances compared to 33 unexposed controls. However, 17 of 22 subjective neurologic symptoms were more prevalent in the exposed group, particularly memory loss and difficulty in falling asleep. Exposure assessment included measurement of urinary trichloroacetic acid daily for 1 week, measurement of air **tetrachloroethylene** concentrations with personal air samplers and badges, and measurement of breath and blood concentrations of **tetrachloroethylene**. All measurements were completed during 1 work week ... An increase in subjective symptoms including dizziness and forgetfulness in workers exposed to trichloroethylene at a geometric mean concentration of 20 ppm for l-120 months relative to unexposed controls /was reported/. Exposure was measured using a diffusive sampling with carbon cloth. Additional details, including frequency of measurements were not reported.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 46 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/BIOMONITORING/ ... 44 workers (exposed to TETRA during automated, continuous cloth-degreasing operations), & ten non-exposed subjects volunteered to participate in the study. The exposure to vapor was monitored by diffusive sampling. The amounts of TETRA & TCA in end-of-shift blood & urine samples were measured by either head-space gas chromatography (HS-GC) or automated methylation followed by HS-GC. The correlation was examined by regression analysis. The maximum time-weighted average (TWA) concentration for TETRA-exposure was 46 ppm. Regression analysis for correlation of TETRA in blood, TETRA in urine & TCA in urine, with TETRA in air, showed that the coefficient was largest for the correlation between TETRA in air & TETRA in blood. The TETRA in blood, in urine & in air correlated mutually, whereas TCA in urine correlated more closely with TETRA in blood than with TETRA in urine. ... The biological marker levels at a hypothetical exposure of 25 ppm TETRA were substantially higher in the present study than were the levels reported in the literature. ... Blood TETRA is the best marker of occupational exposure to TETRA, being superior to the traditional marker, urinary TCA.

[FURUKI K et al; INTERNATIONAL ARCHIVES OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH 73 (4): 221-227 (2000)] **PEER REVIEWED**

/BIOMONITORING/ Measurements of **tetrachloroethylene** in exhaled air were used to determine exposure in children attending a school near a factory and in occupants of a senior citizens home located near a former chemical waste dump. A control group of children had a mean **tetrachloroethylene** level in their exhaled air of 2.8 ug/cu m, whereas exposed children had a mean **tetrachloroethylene** level of 24 ug/cu m. In the senior citizens group, people living on the first floor of the home had a mean **tetrachloroethylene** level of 7.8 ug/cu m, whereas people living on the second floor and above had a mean tetra-chloroethylene level of 1.8 ug/cu m

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 144 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/BIOMONITORING/ In a study of occupationally exposed individuals, measurements of **tetrachloroethylene** and TCA in the blood 15-30 minutes after the end of the workday at the end of the week were judged to be the best parameters for estimating exposure to the chemical. The best noninvasive method for determining **tetrachloroethylene** exposure was to measure the concentration of the parent compound in exhaled air. After exposure to a TWA concentration of 50 ppm of **tetrachloroethylene**, the estimated concentrations of **tetrachloroethylene** and TCA in blood were 2.2 and 5.4 mg/L, respectively; the concentration of **tetrachloroethylene** in exhaled air was estimated to be 22.5 ppm.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 145 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/GENOTOXICITY/ **Tetrachloroethylene**'s effects on unscheduled DNA synthesis were studied in human fibroblasts (WI-38), in primary hepatocytes from rats and mice, and in human lymphocytes; the results were mostly negative.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/GENOTOXICITY/ Cytogenic and cytokinetic studies of lymphocytes were performed on 10 factory workers, who had been exposed to **tetrachloroethylene** vapor concentrations between 68 and 270 mg/cu m air or between 200 and 1490 mg/cu m air for periods ranging from 3 months up to 18 years. No significant dose-related changes were found in chromosome aberrations, sister-chromatid-exchange rates, the proportion of M2 + M3 metaphases, and the mitotic index.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/ALTERNATIVE and IN VITRO TESTS/ ... PCE modulates the expression of some genes implicated in cancer induction, cell differentiation, cell-cycle progression, and the survival and clonogenic potential of human cord blood cells. After exposure to the compound, the modulated genes were involved in inflammatory responses as with the mitogen-activated protein kinase 14 (MPK 14), or in tumor and metastasis progression as with the matrix metalloproteinase 17 (MMP 17), in cell proliferation as with c-jun and c-fos, and moreover in the apoptotic process as with interferon alpha-inducible protein (IFI), BAX and BCL-2. Analysis of cord blood cells via flow cytometry showed that PCE treatment induced a statistically significant increase in necrosis after 24 hr, while the clonogenicity of Human Colony-Forming Unit-Granulocyte/Macrophage (CFU-GM) and Burst-Forming Unit-Erythrocyte (BFU-E) progenitors did not change.

[Diodovich C et al; Arch Toxicol 79 (9): 508-14 (2005)] **PEER REVIEWED** PubMed Abstract

Skin, Eye and Respiratory Irritations:

Eye exposure can lead to conjunctivitis; Skin exposure can lead to inflamation; Inhalation can lead to respiratory tract irritation.

[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982., p. 507] **PEER REVIEWED**

Tetrachloroethylene vapor is a mucous membrane & upper resp irritant at levels above 75 to 100 ppm.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

Neat **tetrachloroethene** is irritating to human skin.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Drug Warnings:

VET: At one time it was used fairly extensively against gi parasites of ruminants. Its disadvantage in ruminants is necessity of stimulating closure of esophageal groove so that medication is delivered directly to abomasum rather than passing into rumen which ... reduces effectiveness of drug. ... No food or water should be allowed for 12-18 hr before & for 4 hr after dosing. ... /It/ is contraindicated in tapeworm-infected animals since irritation of these worms may result in their balling up & occluding digestive passage. It is ... contraindicated in animals with distemper ... & should not be admin to nursing animals or those weighing less than 2 lb (approx 1 kg). /Former/

[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 839] **PEER REVIEWED**

VET: Restrict dietary fat within 2 days before and after use to avoid enhanced absorption of this fat sol liver toxicant. Contraindicated in febrile diseases or in debilitated animals. Strong mucosal irritant. Breaking capsules in mouth has produced ataxia, convulsions, and anesthesia. /Former/

[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974., p. 587] **PEER REVIEWED**

Medical Surveillance:

Nine unrelated groups (659 males) working in plastic boat, chemical, plastic button, paint, and shoe factories were studied. Urine samples were collected at the beginning of the workshift and at the end of the first half of the shift. A close relationship (correlation coefficient always above 0.85) between the average environmental solvent concentration (mg/cu m) measured in the breathing zone and the urinary concentration of unchanged solvent (ug/L) was observed. The authors recommended a biological equivalent exposure limit of 101 ug/L. biological exposure data for urine collected over 4 hr during random sampling for at least 1 yr could be used to evaluate long-term exposure and probability of non-compliance for individual or groups of workers.

[Ghittori S et al; Am Ind Hyg Assoc J 48 (9): 786-90 (1987)] **PEER REVIEWED** PubMed Abstract

Periodical exam of the liver and kidneys.

[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982., p. 508] **PEER REVIEWED**

Exhaled air was analyzed for **tetrachloroethene** in teachers and 4-5 year old pupils of a kindergarten situated near a factory, and in residents of an old folks home situated near a former chemical waste dump. The **tetrachloroethene** concentrations were higher in the exhaled air of children living near the factory (mean 24 ug/cu m, n= 6) than in control children (mean 2.8 ug/cu m, n= 11). In the old folks home, the **tetrachloroethene** concentrations in the exhaled air of people living on the first floor were higher (mean 7.8 ug/cu m, n= 10) than in the exhaled air of the people living on the second floor and higher (mean 1.8 ug/cu m, n= 19). From the results of this study, it is clear that in environmental exposure to **tetrachloroethene**, biological monitoring of exhaled air is a simple, efficient, effective, and convenient method of assessing total ambient exposure of both young and aged subjects.

[Monster AC, Smolders JF; Int Arch Occup Environ Health 53 (4): 331-6 (1984)] **PEER REVIEWED** PubMed Abstract

PRECAUTIONS FOR "CARCINOGENS": ... in relation specifically to cancer hazards, there are at present no health monitoring methods that may ensure the early detection of preneoplastic lesions or lesions which may precede them. Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning additional tests that might become useful or mandatory. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No.

33. Lyon, France: International Agency for Research on Cancer, 1979., p. 23] **PEER REVIEWED**

Probable Routes of Human Exposure:

Currently at risk of exposure are more than 500,000 workers, primarily in the dry cleaning and textile industries, which use more than 2/3 of the domestically produced **tetrachloroethylene**.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

According to the 2006 TSCA Inventory Update Report, the number of persons reasonably likely to be exposed in the industrial manufacturing, processing, and use for **tetrachloroethylene** is 1000 or greater; the data may be greatly underestimated(1).

[(1) US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Nov 10, 2010: http://cfpub.epa.gov/iursearch/index.cfm **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 688,110 workers (177,342 of these were female) were potentially exposed to **tetrachloroethylene** in the US(1). Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used. **Tetrachloroethylene** was detected, not quantified in blood samples from New York City firefighters who had responded to the World Trade Center fire and collapse(2). Mean levels inside and outside a tollbooth at the Baltimore Harbor Tunnel during the summer of 2001 were reported as 1.95 and 0.39 ug/cu m, respectively; the median indoor/outdoor ratio a the tollbooth is 8.3, compared to 1.3, 1.1, and 1.8 for homes in New York City, Los Angeles, and Baltimore, respectively(3). Concentration ranges in three photocopy centers 0.2-0.32, 0.1-0.2, and not detected to 0.2 ppb; detection limit not specified(4). The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking water(SRC).

[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available from, as of Nov 19, 2010: http://www.cdc.gov/noes/ (2) Edelman P et al; Environ Health Perspect 111: 1906-1911 (2003) (3) Sapkota A et al; Environ Sci Technol 39:2 936-2943 (2005) (4) Stefaniak AB et al; Environ Res 83: 162-73 (2000)] **UNREVIEWED**

Body Burden:

Tetrachloroethylene was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2). **Tetrachloroethylene** was detected in expired breath and blood from 9 individuals living in Love Canal, NY at 600-4,500 ng/cu m and 0.35-260 ng/mL, respectively(3). The mean concentration of **tetrachloroethylene** in alveolar air in 136 residents living near 12 dry-cleaning stores were: living equal to or <5 floors above the stores 5 mg/cu m, adjacent houses 1 mg/cu m, one house away 0.2 mg/cu m, across street <.1 mg/cu m, whereas the mean concentration in 18 workers from these stores was 73 mg/cu m(4).

[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)] **PEER REVIEWED**

Breath samples (ug/cu m, weighted statistics), Elizabeth and Bayonne, NJ, 1981, 295-339 samples, 93% pos, 280

max, 13.0 avg, 6.8 median(1). Alveolar air in children and teachers in school situated near factory were 24 ug/cu m avg for children and 11 and 47 ug/cu m for the teachers(2). The mean concentration of **tetrachloroethylene** in the classroom was 13 ug/cu m(2). Alveolar air of residents of a nursing home situated near a former chemical waste dump averaged 7.8 ug/cu m first floor and 1.8 ug/cu m on the second floor, where ambient concentrations averaged 8.2 and 1.6 ug/cu m, respectively(2). Breathing zone samples collected in three photocopy centers were reported as 0.5, 0.2, and 0.1 ppb; the compound was not identified as a building background contaminant(3). A positive correlation has been identified between the incidence of asthma symptoms in children and presence of **tetrachloroethylene** in air of the Huntington Park region, Los Angeles, CA studied in 1999/2000(4). The mean personal air concentration was 7.98 and 9.18 ug/cu m in winter and summer, respectively, for 47 high school students from northern Manhattan and the South Bronx, Queens, and Brooklyn, New York City, NY, tested in 1999(5).

[(1) Wallace L et al; J Occup Med 28: 603-7 (1986) (2) Monster AC, Smolders JFJ; Int Arch Environ Health 53: 331-6 (1984) (3) Stefaniak AB et al; Environ Res 83: 162-73 (2000) (4) Delfino RJ et al; Environ Health Perspect 111: 647-656 (2003) (5) Kinney PL et al; Environ Health Perspect 110: 539-546 (2002)] **PEER REVIEWED**

Whole blood, USA survey of 250 (121 males, 129 females), 0.7-23 ppb, 2.4 ppb avg(1). The geometric mean concentration in 43 blood samples from children living in a socioeconomically disadvantaged area of Minneapolis was 0.04 ng/L, in a study conducted from January through April 2002(2). USA FY82 National Human Adipose Tissue Survey specimens, 46 composites, 61% pos (>3 ppb, wet tissue concentration), 94 ppb max(3). **Tetrachloroethylene** was detected in human body fat (8 subjects) 0.4-29.2 ppb and various human organs less than 6 ng/g(4).

[(1) Antoine SR et al; Bull Environ Contam Toxicol 36: 364-71 (1986) (2) Sexton K et al; Environ Health Perspect 114: 453-459 (2005) (3) Stanley JS; Broad Scan Analysis of the FY82 National Human Adipose Tissue Survey Specimens Vol. I Executive Summary p. 5 USEPA-560/5-86-035 (1986) (4) McConnell G et al; Endeavour 34: 13-8 (1975)] **PEER REVIEWED**

... **Tetrachloroethylene** ... in the blood and brain (4.4 mg/l00 mL and 36 mg/l00 g, respectively). /fatal/

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 13 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

Average Daily Intake:

The AVDI of **tetrachloroethylene** measured in 8 urban areas of Japan was reported as 21 ug (inhalation) and 0.84 ug (ingestion)(1).

[(1) Yoshida K; Chemosphere 27: 621-30 (1993)] **PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **TETRACHLOROETHYLENE** ***, is relevant for this HSDB record chemical.

Life Support:

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o   This overview assumes that basic life support measures
       have been instituted.
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Clinical Effects:

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0.2.1 SUMMARY OF EXPOSURE
   0.2.1.1 ACUTE EXPOSURE
     A)  Tetrachloroethylene is irritating to the eyes, skin and
         mucous membranes. Signs and symptoms of exposure may
         include CNS depression, malaise, dizziness, headache,
         lightheadedness, disorientation, seizures, respiratory
         tract irritation, non-cardiogenic pulmonary edema,
         nausea, vomiting and diarrhea.
     B)  Eye contact may cause pain, lacrimation and burning.
         Dermal exposure can cause dermatitis, erythema, burns
         and vesiculation.
     C)  Long-term exposure may cause liver, kidney and heart
         damage.
   0.2.1.2 CHRONIC EXPOSURE
     A)  Chronic exposure may affect the liver and kidneys and
         may cause dysrhythmias, reduced color perception,
         contact dermatitis and defatting dermatitis, impaired
         memory; numbness of the extremities, peripheral
         neuropathy and impaired vision.
     B)  Chronic inhalation exposure has been associated with
         the development of peripheral neuropathies.
     C)  Chronic occupational exposure has resulted in
         hepatitis, confusion, disorientation, muscle cramps,
         fatigue and agitation.
  0.2.4 HEENT
   0.2.4.1 ACUTE EXPOSURE
     A)  Eye, nose and throat irritation may occur.
  0.2.5 CARDIOVASCULAR
   0.2.5.1 ACUTE EXPOSURE
     A)  Cardiac dysrhythmias may develop with high exposures.
  0.2.6 RESPIRATORY
   0.2.6.1 ACUTE EXPOSURE
     A)  Upper respiratory tract irritation and non-cardiogenic
         pulmonary edema may occur.
  0.2.7 NEUROLOGIC
   0.2.7.1 ACUTE EXPOSURE
     A)  CNS depression, coma and peripheral neuropathies may
         develop. Optic neuritis has been reported.
  0.2.8 GASTROINTESTINAL
   0.2.8.1 ACUTE EXPOSURE
     A)  Nausea, vomiting and anorexia may be noted acutely.
         Diarrhea and bloody stools may result from ingestion.
         Long-term exposure has been associated with abdominal
         pain and constipation.
  0.2.9 HEPATIC
   0.2.9.1 ACUTE EXPOSURE
     A)  Hepatotoxicity with increased enzyme levels may be
         seen.
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0.2.10 GENITOURINARY
0.2.10.1 ACUTE EXPOSURE
A) Proteinuria, hematuria and oliguric renal failure have occurred.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A) Dermatitis, a burning sensation and erythema may be seen after dermal exposure. Toxic epidermal necrolysis has occurred after ingestion.
0.2.18 PSYCHIATRIC
0.2.18.1 ACUTE EXPOSURE
A) Psychosis, hallucinations and distorted perceptions have been reported with inhalation exposure to **tetrachloroethylene**. Drug dependence may occur.
0.2.20 REPRODUCTIVE HAZARDS
A) Fetotoxicity and developmental abnormalities have been described in experimental animals only.
0.2.21 CARCINOGENICITY
0.2.21.1 IARC CATEGORY
A) IARC Carcinogenicity Ratings for CAS127-18-4 (International Agency for Research on Cancer, 2015; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2010a; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2008; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2007; IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2006; IARC, 2004):
1) IARC Classification
a) Listed as: **Tetrachloroethylene**
b) Carcinogen Rating: 2A
1) The agent (mixture) is probably carcinogenic to humans. The exposure circumstance entails exposures that are probably carcinogenic to humans. This category is used when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals. In some cases, an agent (mixture) may be classified in this category when there is inadequate evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals and strong evidence that the carcinogenesis is mediated by a mechanism that also operates in humans. Exceptionally, an agent, mixture or exposure circumstance may be classified in this category solely on the basis of limited evidence of carcinogenicity in humans.
0.2.21.2 HUMAN OVERVIEW
A) **Tetrachloroethylene** is probably carcinogenic to humans. Epidemiologic data suggest a possible increased incidence of liver, esophageal and urinary tract tumors and leukemia in humans, but data are limited.
0.2.21.3 ANIMAL OVERVIEW
A) **Tetrachloroethylene** is carcinogenic in experimental animals.
0.2.22 GENOTOXICITY
A) Chromosome abnormalities were seen in lymphocytes from exposed workers.

Laboratory:

A) Monitor liver and renal function tests and urinalysis in patients with significant exposure.
B) **Tetrachloroethylene** is radiopaque, abdominal radiographs

may be useful to assess decontamination following ingestion.

C) Expired air **tetrachloroethylene** or urinary metabolite measurements may be useful for monitoring chronically exposed workers.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A) EMESIS: Ipecac-induced emesis is not recommended because of the potential for CNS depression.

B) GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in the head down left lateral decubitus position or by endotracheal intubation. Control any seizures first.

1) CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C) ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

D) Monitor level of consciousness, EKG, adequacy of respirations and oxygenation, and liver and renal function tests.

1) Endotracheal intubation and ventilatory assistance with supplemental oxygen may be required if CNS and respiratory depression are present.

E) ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gases and/or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

F) Some halogenated hydrocarbons sensitize the myocardium to catecholamines, but this effect has not been substantiated for **tetrachloroethylene**. Epinephrine or other beta-adrenergic agents should be used only with caution and only when clearly indicated. Careful EKG monitoring for the possible induction of arrhythmias should be done, and resuscitation medications and equipment should be readily available. Beginning therapy with the lowest effective doses of these agents is advisable.

G) Koppel et al (1985) have demonstrated that controlled hyperventilation enhanced pulmonary elimination of **tetrachloroethylene** in a child who had ingested 8 to 10 mL.

1) While there is little clinical experience with this treatment modality, it is physiologically attractive and most likely safe in patients requiring endotracheal intubation and mechanical ventilation for CNS and respiratory depression. Monitor arterial blood gases and avoid pH> 7.55.

0.4.3 INHALATION EXPOSURE

A) INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with an inhaled beta2-adrenergic agonist. Consider systemic

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        corticosteroids in patients with significant
        bronchospasm.
    B)  Monitor level of consciousness, EKG, adequacy of
        respirations and oxygenation, and liver and renal
        function tests.
     1)  Endotracheal intubation and ventilatory assistance with
         supplemental oxygen may be required if CNS and
         respiratory depression are present.
    C)  ACUTE LUNG INJURY: Maintain ventilation and oxygenation
        and evaluate with frequent arterial blood gases and/or
        pulse oximetry monitoring. Early use of PEEP and
        mechanical ventilation may be needed.
    D)  Some halogenated hydrocarbons sensitize the myocardium
        to catecholamines, but this effect has not been
        substantiated for tetrachloroethylene. Epinephrine or
        other beta-adrenergic agents should be used only with
        caution and only when clearly indicated. Careful EKG
        monitoring for the possible induction of dysrhythmias
        should be done, and resuscitation medications and
        equipment should be readily available. Beginning therapy
        with the lowest effective doses of these agents is
        advisable.
  0.4.4 EYE EXPOSURE
    A)  DECONTAMINATION: Remove contact lenses and irrigate
        exposed eyes with copious amounts of room temperature
        0.9% saline or water for at least 15 minutes. If
        irritation, pain, swelling, lacrimation, or photophobia
        persist after 15 minutes of irrigation, the patient
        should be seen in a healthcare facility.
  0.4.5 DERMAL EXPOSURE
    A)  OVERVIEW
     1)  DECONTAMINATION: Remove contaminated clothing and
         jewelry and place them in plastic bags. Wash exposed
         areas with soap and water for 10 to 15 minutes with
         gentle sponging to avoid skin breakdown. A physician
         may need to examine the area if irritation or pain
         persists (Burgess et al, 1999).
     2)  Treat dermal irritation or burns with standard topical
         therapy. Patients developing dermal hypersensitivity
         reactions may require treatment with systemic or
         topical corticosteroids or antihistamines.
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Range of Toxicity:

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A)  Exposure to tetrachloroethylene, between 200 and 1500
       ppm, can cause irritant and CNS depressant effects.
       Chronic exposure of 60 to 450 ppm has caused CNS effects
       in workers. Ingestion of as much as 500 mg/kg has been
       survived.
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[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 169, edition expires Aug, 2016. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2016; CCIS Volume 169, edition expires Aug, 2016.] **PEER REVIEWED**

Antidote and Emergency Treatment:

Immediate first aid: Ensure that adequate decontamination has been carried out. If patient is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask, as trained.

Perform CPR as necessary. Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obtain medical attention. /Carbon tetrachloride and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 225] **PEER REVIEWED**

Basic treatment: Establish a patent airway (oropharyngeal or nasopharyngeal airway, if needed). Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with 0.9% saline (NS) during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Cover skin burns with sterile dressings after decontamination ... . /Carbon tetrachloride and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 225-6] **PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in severe respiratory distress. Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial. Consider drug therapy for pulmonary edema ... . Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start IV administration of D5W /SRP: "To keep open", minimal flow rate/. Use 0.9% saline (NS) or lactated Ringer's (LR) if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume. Watch for signs of fluid overload ... . Treat seizures with diazepam or lorazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Carbon tetrachloride and related compounds/

[Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 226] **PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

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: (1) Although **tetrachloroethylene** is known to induce peroxisome proliferation in mouse liver, a poor quantitative correlation was seen between peroxisome proliferation and tumor formation in the liver after administration of **tetrachloroethylene** by inhalation. The spectrum of mutations in proto-oncogenes in liver tumors from mice treated with **tetrachloroethylene** is different from that in liver tumors from mice treated with trichloroethylene. (2) The cmpd induced leukemia in rats. (3) Several epidemiological studies showed elevated risks for esophageal cancer, non-Hodgkin's lymphoma and cervical cancer.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. 63 204 (1995)] **PEER REVIEWED**

A3: Confirmed animal carcinogen with unknown relevance to humans.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical

Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 55] **PEER REVIEWED**

Tetrachloroethylene: reasonably anticipated to be a human carcinogen.

[DHHS/National Toxicology Program; Eleventh Report on Carcinogens: Tetrachloroethylene (127-18-4) (January 2005). Available from, as of July 31, 2009: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s169tetr.pdf **PEER REVIEWED**

Non-Human Toxicity Excerpts:

/LABORATORY ANIMALS: Acute Exposure/ Unconsciousness was observed in rats within few min at concentrations of 6000 ppm or more & after several hours at 3000 ppm, but unconsciousness was not observed at 2000 ppm. At these high-level single exposures, the predominant response was ... depression of nervous system. There were slight changes in liver, characterized by slight increase in wt, slight increase in total lipid, and slight cloudy swelling.

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982., p. 3562] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ ... **Tetrachloroethylene** was prepared for intravenous injection in solutions of Tween 80, which had no demonstrable cardiotoxicity. In rabbits under urethane and in cats and dogs under pentobarbital, **tetrachloroethylene** increased the vulnerability of the ventricles to epinephrine-induced extra-systoles, bigeminal rhythms, and tachycardia. The mean threshold doses of **tetrachloroethylene** were 10 mg/kg in rabbits, 24 mg/kg in cats, and 13 mg/kg in dogs. In rabbits this threshold dose for cardiac arrhythmias correspond to blood levels between 2.2 and 3.6 ug/mL. Animals demonstrating a reflex bradycardia to vasopressor doses of epinephrine were relatively resistant to the arrhythmogenic action of **tetrachloroethylene**. Ventricular arrhythmias occurred in less than 30% of the animals after **tetrachloroethylene** alone. In cats higher doses of **tetrachloroethylene** (40 mg/kg) produced acute pulmonary edema. **Tetrachloroethylene** (30-40 mg/kg) decreased left intraventricular dP/dt (max) in dogs, without significantly increasing left intraventricular end-diastolic pressure, although there was a transient decrease in arterial blood pressure that accompanied the early phase of myocardial depression.

[Kobayashi S et al; J Toxicol Environ Health 10: 23-30 (1982)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Acute Exposure/ Experimental momentary spraying of rabbits eyes with **tetrachloroethylene** from a pressurized fire extinguisher from a distance of 1 foot caused immediate pain & blepharospasm. The corneal epithelium became granular & optically irregular, & patches of epithelium were lost, but the eyes recovered completely within 2 days.

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 888] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Rats died within a few minutes of inhaling a vapor concentration of 30,000 ppm **tetrachloroethylene** and in about 30 min at 19,000 ppm. Death was narcotic /CNS depressant/ in nature. A series of essentially straight lines was obtained when log concentration was plotted against log time for exposures to **tetrachloroethylene** that were just sufficient to cause lethality in rats, just small enough to be survived by all rats, and just small enough to cause no organic injury. A concentration of 2000 ppm was tolerated for up to 14 hr, and 3000 ppm was tolerated for 4 hr with no deaths. Unconsciousness was produced in rats within a few minutes at concentrations of 6000 ppm or greater and after several hours at 3000 ppm, but unconsciousness was not observed at 2000 ppm.

[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991., p. 697] **PEER REVIEWED**

FPL-049-026

/LABORATORY ANIMALS: Acute Exposure/ Increased open-field behavior was observed in rats 1 hr after cessation of exposure to **tetrachloroethylene** 6 hr/day for 4 days at 200 ppm, but none was observed 17 hours after exposure.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Exposure of rats at higher concentrations (> 1000 ppm for four 7 hr/ day exposures) results in CNS depression, including ataxia, somnolence, and anesthesia. Effects were diminished with repeated exposures, suggesting the development of tolerance.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ New Zealand rabbits /were exposed/ once ... /by/ dermal application. Severe erythema and edema with necrosis of the skin was noted.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ In a study on guinea-pigs, 1 mL (1.62 g) of undiluted **tetrachloroethylene** applied to the skin caused severe karyolisis, edema, spongiosis, and pseudoeosinophilic infiltration.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Liver toxicity (tissue changes and dysfunction) has been reported in rats and mice exposed by acute inhalation. Marginal increases in serum enzyme levels (aspartate aminotransferase (AST), alanine aminotransferase (ALT), glucose-6 phosphatase, and ornithine carbamyl transferase) were seen when rats were exposed to **tetrachloroethene** at 3400 mg/cu m for 1 hr. Marked increases were seen at 6900 mg/ cu m. Cloudy swelling and diffusely distributed fat globules were found in the rat liver following exposure at a near-lethal concentration. In mice, a 4-hr exposure at 2800 mg/cu m and above produced dose-dependent increases in fatty infiltration and extractable fat. No effects were seen at 1400 mg/cu m. Decreased liver ATP and marked, persistent increases in liver lipids and triglycerides resulted in mice exposed for 3 hr at 5500 mg/cu m or for 4 hr at 7400 mg/cu m. Following acute exposure at lethal concentrations, the mouse liver showed cloudy swelling, anisokaryosis, and Kupffer cell infiltration.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ Slight and irregular scattered necrotic and degenerative lesions were observed in the kidneys of mice exposed at 20 500 mg/cu m for 6 hr.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ /Oral/ doses ranging from about 100 to 1200 mg/kg body weight were given to dogs, cats, foxes, cows, horses, and sheep. Reported effects (in one or more species) included ataxia, drowsiness, CNS depression, depression of heart rate, inflammation of the small intestines, fatty infiltration and haemosiderosis of the spleen, cell swelling, infiltration, cloudy swelling, and necrosis in the liver, and fatty infiltration, cloudy swelling, hyaline casts, atrophy, and vacuolization in the kidneys.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ 24-hr application of undiluted **tetrachloroethene** to the skin of rabbits at 1.3, 2.5, 5, 10, or 20 g/kg body weight resulted in the deaths of 0/4, 1/4, 1/4, 1/4, and 2/4, respectively. Convulsions were noted at 20 g/kg body weight. The results suggest a low acute dermal toxicity.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ In a study designed to examine the effects of **tetrachloroethylene** on the respiratory mucosa, epithelial degeneration was observed in mice exposed to **tetrachloroethylene** at 300 ppm for 6 hours/day for 5 days. The degeneration was more severe in the olfactory mucosa compared to other sites in the respiratory mucosa. Dilation of Bowman's glands and atrophy of olfactory nerves were also observed.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 33 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/LABORATORY ANIMALS: Acute Exposure/ ... The nephrotoxic potential of S-(1,2,2-trichlorovinyl)-L-cysteine sulfoxide (TCVCS) in rats and TCVCS formation in rat liver and kidney microsomes were investigated. At 5 mM S-(1,2,2-trichlorovinyl)-L-cysteine (TCVC), rat liver microsomes formed TCVCS at a rate nearly 5 times higher than the rate measured with rat kidney microsomes, whereas at 1 mM TCVC only the liver activity was detectable. TCVCS formation in liver and kidney microsomes was dependent upon the presence of NADPH and was inhibited by the addition of methimazole or 1-benzylimidazole, but not superoxide dismutase, catalase, KCN, or deferoxamine, consistent with the involvement of both flavin containing monooxygenases (FMOs) and P450s. Rats given TCVCS at 230 umol/kg ip exhibited acute tubular necrosis at 2 and 24 hr after treatment, and they had elevated blood urea nitrogen levels at 24 hr, whereas TCVC was a much less potent nephrotoxicant than TCVCS. Furthermore, pretreatment with aminooxyacetic acid enhanced TCVC toxicity. In addition, reduced nonprotein thiol concentrations in the kidney were decreased by nearly 50% 2 hr after TCVCS treatment compared with saline-treated rats, whereas the equimolar dose of TCVC had no effect on kidney nonprotein thiol status. No significant lesions or changes in nonprotein thiol status were observed in liver with either TCVC or TCVCS. ... /S-(1,2,2-trichlorovinyl)-L-cysteine, S-(1,2,2-trichlorovinyl)-L-cysteine sulfoxide/

[Elfarra AA, Krause RJ; J Pharmacol Exp Ther 321 (3): 1095-101 (2007)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ The relationship among dose, metabolism and hepatotoxicity in mice which resulted from subchronic exposure to the chlorinated solvents trichloroethylene and **perchloroethylene** were examined. Male Swiss-Cox mice received either trichloroethylene (0 to 3200 mg/kg/day) or **perchloroethylene** (0 to 2000 mg/kg/day) in corn oil by gavage for 6 weeks. Urinary metabolites from individual mice were quantified to estimate the extent to which each compound was metabolized. Four parameters of hepatotoxicity were assessed: liver weight, triglycerides, glucose-6-phophatase activity, and serum glutamic-pyruvic transaminase (SGPT) activity. Trichloroethylene sigificantly affected liver weight and glucose-6-phosphatase activity; **perchloroethylene** affected all four parameters. The metabolism of trichloroethylene was linearly related to dose through 1600 mg/kg, but then became saturated. The metabolism of **perchloroethylene** was saturable. The dose-effect curves of the affected hepatotoxicity parameters of both compounds were nonlinear and resembled the dose-metabolism graph of the corresponding solvent. Plots of the hepatotoxicity data of each compound against total urinary metabolites were linear in all cases, suggesting that the hepatotoxicity of both **perchloroethylene** and trichloroethylene in mice is directly related to the extent of their metabolism. This pattern is consistent with formation of the toxic intermediate in the primary metabolic pathway of each compound.

[Buben JA, O'Flaherty EJ; Toxicol Appl Pharmacol 78 (1): 105-22 (1985)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ The effects of continuous and intermittent inhalation of **perchloroethylene** (PCE) on plasma butyrylcholinesterase (BuChE) activity, organ weights, liver morphology and motor activity in mice (strain NMRI) were tested. PCE exposure increased plasma BuChE activity in a time- and concentration dependent manner in both sexes. The increase was statistically significant at 37 ppm in animals continuously exposed for 30 days. BuChE increased approximately 1.5 times in females and 2.5 times in males after 120 days exposure to 150 p.p.m. After rehabilitation of animals exposed for 30 days to 150 ppm, BuChE levels returned to normal. Liver weight also increased in a time and concentration dependent manner. Both sexes exhibited significant liver enlargement at 9 ppm. The increase was about 2.3 in females and 1.9 in males after continuous exposure to 150 ppm for 120 days. After rehabilitation (120 days) of animals exposed to 150 ppm for 30 days, a 10% increase still remained. A decrease in body weight gain was seen in both sexes after exposure to concentrations above 75 ppm. Female kidney weight was slightly increased. No clear effect on spleen weight could be detected. When the same time-weighted average concentration was used, intermittent exposure for 30 days had similar effects on liver weight and BuChE activity as continuous exposure, even when exposures lasted for only one hour per day. Liver cell morphology was changed after PCE exposure. The alterations could be observed already at 9 ppm but disappeared after rehabilitation.

[Kjellstrand P et al; Acta Pharmacol Toxicol (Copenh) 54 (5): 414-24 (1984)] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ ... /In a/ 30-day gavage study in Swiss Webster mice given **tetrachloroethylene** at 150, 500, and 1,000 mg/kg/day ... the metabolism of **tetrachloroethylene** and its toxicity were examined. That is one of the few studies that were conducted with oral administration and repeated dosing. The investigators found that hepatic injury peaked at 7 days but then was repaired. ...

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ NMRI mice were orally exposed to **tetrachloroethylene** at 0.05 or 0.1 mg/kg per day for 7 weeks. The mice exhibited a reversible hemolytic anemia and had microscopic evidence of splenic involvement, and **tetrachloroethylene** was found to accumulate in the spleen.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ ... Hybrid mice (C57/BL/6 x DBA/2) /were exposed/ to **tetrachloroethylene** at 270 ppm (11.5 weeks) and 135 ppm (7.5 weeks) 6 hours/day 5 days/week. Reductions in the numbers of lymphocytes/monocytes and neutrophils were observed, but they returned to control values over the next 3 weeks. There were no effects on spleen colony-forming units (CFU-Ss), but evidence of a reduction in red cells was supported by decreases in erythroid colony-forming units and erythroid burst-forming units and evidence of reticulocytosis ...

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Rats receiving 405 mg of **tetrachloroethylene** per kg body weight in arachis oil, for 5 days/week, during 4 weeks, showed an increased relative liver weight and

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increased liver aniline hydroxylase activity. No histopathological abnormalities were found. At 16 mg/kg body weight, no effects on the liver were noted.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Increased alpha-2U-globulin hyaline droplet formation was seen in the kidneys of male F344 rats given 1 g/kg body weight per day for 7 days.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Exposed NMRI mice at 9, 37, 75, or 150 ppm **tetrachloroethylene** continuously for 30 days ... found abnormal gross pathological appearance of the liver, including enlargement and yellowish color at concentrations of 9 ppm or greater; histopathologic changes, including enlargement and vacuolization of liver cells, were particularly pronounced in mice exposed at 150 ppm.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Swiss-Cox mice /were exposed/ 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 G-6-P and hepatocellular necrosis, degeneration and polyploidy.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Tetrachloroethylene (127-18-4). Available from as of September 29, 2010: http://www.epa.gov/iris/subst/index.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Differential sensitivity of mice and rats to hepatic effects of **tetrachloroethylene** is indicated /in a study that/ ... administered the compound by gavage to rats and mice for 11 days at 100, 250, 500, or 1000 mg/kg/day. Centrilobular swelling was observed at all doses in mice, and increased relative liver weights were seen for doses >250 mg/kg/day. In rats, evidence of toxic effects in the liver was only apparent at the highest dose.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ After 8 weeks of exposure to 1356 mg/cu m, for 4 hr/day and 5 days/week, rats showed fatty infiltration in the liver and an increase in extractable fat, but no cirrhosis or necrosis. The kidneys were not affected in this study.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Rabbits exposed repeatedly to 15 000 mg/ cu m for 45 days showed increased serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and glutamate dehydrogenase activity and signs of adrenal injury.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ ... No adverse effects were seen in seven guinea-pigs exposed (7 hr) at 700 mg/cu m on 13 occasions over 17 days. At 1400 mg/cu m for 7 hr/day on 14 occasions over 18 days, guinea-pigs showed depressed growth, increased liver weight, and slight fatty liver tissue degeneration ... Severe CNS depression was observed in rats, rabbits, and guinea-pigs exposed at 17 000 mg/cu m for 7 hr/day on 13-28 occasions over 18-39 days. All three species showed liver tissue changes, and cloudy swelling was additionally observed in the kidneys of guinea-pigs.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ ... No overt toxicity or microscopic effects on a comprehensive range of tissues were seen in F344 rats and B6C3F1 mice (groups of five per sex per species) exposed at 0, 690, 1400, or 2900 mg/cu m for 6 hr/day, 5 days/week, for 2 weeks. At 6000 mg/cu m, the mice showed fatty cytoplasmic hepatocyte vacuolation. At 12 000 mg/cu m, there were deaths in both species, preceded by dyspnea, hypoactivity, anesthesia, and ataxia.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ No changes in kidney morphology, levels of alpha-2U-globulin, or biochemical plasma and urinary markers of kidney toxicity were seen in male and female F344 rats exposed to **tetrachloroethene** at up to 5500 mg/cu m for 6 hr/day for 28 days. Male F344 rats exposed by inhalation at 2800 or 6900 mg/cu m for 28 days (in an investigation into the mechanism responsible for the induction of renal tumors in male rats) showed accumulation of protein droplets (alpha-2U-globulin) in the P2 segment of the kidney proximal tubules at the higher concentration, but not at 2800 mg/cu m.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Liver cytochrome P450 concentrations were increased in rats given **tetrachloroethene** in the diet at a concentration of 25 mg/kg (about 1.3 mg/kg body weight per day) for 14 days.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/When **tetrachloroethene** dissolved in corn oil was administered by gavage to mice at 0, 20, 100, 200, 500, 1000, 1500, or 2000 mg/kg body weight per day, 5 days/week, for 6 weeks, there were no liver effects at 20 mg/kg body weight per day. At 100 mg/kg body weight per day and above, there was a dose-related increase of liver weight and accumulation of liver triglycerides. At 200 mg/kg body weight per day and higher doses, alanine aminotransferase (ALT) was raised, and there was minimal to slight karyorrhexis and polyploidy and moderate degeneration (which increased in severity at higher doses). At 500 mg/kg body weight per day and above, liver glucose-6-phosphatase activity was reduced. The DNA content of the liver was normal at 200 mg/kg body weight per day but decreased by 17% at 1000 mg/kg body weight per day. The study included a detailed comparison of metabolism (determined as urinary excretion of trichloroacetic acid and trichloroethanol) and hepatotoxicity. Good linear relationships were found between urinary excretion of metabolites and ALT, serum glucose-6-phosphate, triglycerides, and liver weight, indicating that liver toxicity is caused by metabolites and not by **tetrachloroethene** itself.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Immunohistochemical staining techniques demonstrated the existence of trichloroacylated protein adducts in the liver of mice (female MRL-lpr/lpr and MRL +/+) given 830 mg/kg body weight, by gavage, every 4th day for 6 weeks. Adducts were localized to the centrilobular zones, where toxicity due to **tetrachloroethene** occurs.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Cyanide-insensitive palmitoyl CoA oxidation (a sensitive measure of peroxisome proliferation) was increased 4.3-fold and 2.3-fold in the liver and kidneys of mice, respectively, by gavage administration of **tetrachloroethene** at 1000 mg/kg body weight per day for 10 days. In rats treated similarly, the increases were smaller (1.4-fold in liver; 1.7-fold in kidney).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Sprague-Dawley rats (20 per sex per group; 3-4 weeks old) were given **tetrachloroethene** in the drinking-water at nominal doses of 14, 400, or 1400 mg/kg body weight per day for 90 days (**tetrachloroethene** was present as emulsion droplets), there were no effects on the kidney at the lowest dose level and no serum biochemistry changes indicative of kidney dysfunction at any dose level.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ B6C3F1 mice and F344 rats (groups of 10 per sex per species) were exposed /by inhalation/ at about 0, 690, 1400, 2800, 5500, or 11 000 mg/cu m for 6 hr/day, 5 days/week, for 13 weeks. No liver toxicity was seen at 690 mg/cu m in the mice (the rat liver was not examined at this exposure level). Rats exposed at 1400 mg/cu m and above showed only minimal to mild hepatic congestion. Mice exposed at 1400 mg/cu m had minimal mitotic changes, while at 2800 mg/cu m and above, there were minimal to mild hepatic leukocytic infiltration, centrilobular necrosis, and bile stasis.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ B6C3F1 mice and F344 rats (groups of 10 per sex per species) were exposed /by inhalation/ at 0 or about 690, 1400, 2800, 5500, or 11 000 mg/cu m for 6 hr/day, 5 days/week, for 13 weeks, the mice showed minimal renal tubular karyomegaly at all concentrations except the lowest (incidences were 0/20, 0/20, 14/20, 20/20, 20/20, and 13/14 at 0, 690, 1400, 2800, 5500, and 11 000 mg/cu m, respectively). No kidney lesions were seen in the rats.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Swiss-Cox mice /were exposed/ 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

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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.

[U.S. EPA; IRIS Database for Tetrachloroethylene (CASRN 127-18-4). Available from, as of November 10, 2010: http://www.epa.gov/iris/search_keyword.htm **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Groups of 20 Sprague-Dawley rats of both sexes were administered doses of 14, 400, or 1400 mg/kg/day /of **tetrachloroethylene**/ 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.

[U.S. EPA; IRIS Database for Tetrachloroethylene (CASRN 127-18-4). Available from, as of November 10, 2010: http://www.epa.gov/iris/search_keyword.htm **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ 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. 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.

[U.S. EPA; IRIS Database for Tetrachloroethylene (CASRN 127-18-4). Available from, as of November 10, 2010: http://www.epa.gov/iris/search_keyword.htm **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Nine mice /were exposed to/ 7000 ppm /**tetrachloroethylene** by/ inhalation 2 hr/day 1 day/week for 3 weeks. /All animals died/. Fatty degeneration of the liver and tissue congestion /were noted/.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 104 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ B6C3F1 mice /were given doses of/ 100, 200, 425, 875, or 1750 ppm of **tetrachloroethylene** by inhalation for 6 hr/day, 5 days/week for 2 weeks. Dyspnea, hypoactivity, anesthesia, ataxia, and slightly reduced body weights at 1750 ppm /were noted/. No deaths /occurred/.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 104 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Male Swiss Webster mice (25-29 g) were given three dose levels of Perc (150, 500, and 1000 mg/kg day) via aqueous gavage for 30 days. Tissue injury was measured during the dosing regimen (0, 1, 7, 14, and 30 days) and over a time course of 24-96 hr after the last dose (30 days). Perc produced significant liver injury (ALT) after single day exposure to all three doses. Liver injury was mild to moderate and regressed following repeated exposure for 30 days. Subchronic Perc exposure induced neither kidney injury nor dysfunction during the entire time course as evidenced by normal renal histology and BUN. TCA was the major metabolite detected in blood, liver, and kidney. Traces of DCA were also detected in blood at initial time points after single day exposure. With single day exposure, metabolism of Perc to TCA was saturated with all three doses. AUC/dose ratio for TCA was significantly decreased with a concomitant increase in AUC/dose of Perc levels in liver and kidney after 30 days as compared to 1 day exposures, indicating inhibition of metabolism upon repeated exposure to Perc. Hepatic CYP2E1 expression and activity were unchanged indicating that CYP2E1 is not the critical enzyme inhibited. Hepatic CYP4A expression, measured as a marker of peroxisome proliferation was increased transiently only on day 7 with the high dose, but was unchanged at later time points. Liver tissue repair peaked at 7 days, with all three doses and was sustained after medium and high dose exposure for 14 days. ...

[Philip BK et al; Toxicology 232 (1-2): 1-14 (2007)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ The effects of repeated **tetrachloroethene** exposure (930 mg/cu, 6 hr/day, 5 days/week, for up to 7.5 weeks, or 1900 mg/cu m for up to 11.5 weeks, followed by an

exposure-free period of 3 weeks) on a number of haematological parameters has been investigated in mice. In the peripheral blood, reductions of the lymphocyte, monocyte, and neutrophil counts were observed, followed by an almost complete regeneration during the exposure-free period. Reticulocytosis during and after exposure pointed to a compensatory reaction of the red blood cell system. No effects on the bone marrow pluripotent stem cells were seen. The number of erythroid-committed cells was suppressed, and slight indications for a disturbance of the granulocyte cell series were found.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Continuous exposure of Mongolian gerbils to **perchloroethylene** (PCE) (120 ppm) for 12 months in an inhalation chamber caused no changes in body or brain weights. The protein content, the concentration of lipid phosphorus or cholesterol were unaltered in the cerebral cortex and hippocampus. However, a small change in the fatty acid pattern of phospholipid was observed. In the phosphatidylethanolamine of cerebral cortex and hippocampus a decrease was found among the long-chain, linolenic acid-derived, fatty acids. The ratio 22:4 (N-6)/22:5 (N-3) was increased, indicating a shift towards the corresponding linoleic acid-derived 22-carbon fatty acids. The observed changes among poly-unsaturated fatty acids are similar to those appearing after peroxidation and either protein or essential fatty acid malnutrition. ...

[Kyrklund T et al; Toxicol Lett 22 (3): 343-9 (1984)] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ **Tetrachloroethylene** induces hepatocellular carcinomas and adenomas in mice. The yield of **tetrachloroethylene**-induced hepatocellular carcinomas is statistically significant in both male and female B6C3F1 mice after either oral or inhalation exposure. Both male and female Crj:DBF1 mice also have an increased incidence of hepatocellular carcinomas after inhalation exposure to **tetrachloroethylene**.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Renal-tubular adenoma and carcinoma were observed in male rats in the NTP bioassay and to a lesser extent in the Japan Industrial Safety Association studies. **Tetrachloroethylene** caused a low rate of induction of renal tumors in rats; although the yield at the high dose was not statistically significant. In the NTP bioassay, induction of renal tumors was dose-dependent. The incidence was 1 of 49 in the control group, 3 of 49 in the 200-ppm group, and 4 of 50 in the 400-ppm group. There are wide confidence limits on the data, and some of the error bars approach zero. There is a very low spontaneous incidence of renal tumors in Fischer 344 rats. Induction of renal tumors in rats by **tetrachloroethylene** is therefore easily observed against a low background. In addition, the controls had only benign tumors, not malignant tumors, whereas the high-dose group had two malignant tumors.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Hepatic degeneration and necrosis were observed in a study of B6C3F1 mice exposed 6 hr/day, 5 days/ week for 103 weeks at 200 or 400 ppm.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ No hepatic effects in rats exposed at 70 ppm **tetrachloroethylene** for 8 hr/day, 5 days/week for 7 months, reduced hepatic glycogen was found in rats exposed at 230 ppm, and liver congestion without necrosis or fatty degeneration was found in rats receiving the treatment at 470 ppm **tetrachloroethylene**.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... Osborne-Mendel rats and B6C3F1 mice were treated by gavage with **tetrachloroethylene** containing stabilizers for 78 weeks, followed by observation periods of 32 weeks for rats and 12 weeks for mice. Increased incidences of hepatocellular carcinomas were observed in low-dose and high-dose groups in both male and female mice, with TWA doses of 300 to 550 mg/kg/day. No increases in tumor incidence were observed in rats receiving either low-dose (avg. approx. 470 mg/kg/day) or high-dose (avg. approx. 940 mg/kg/day) treatment.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Sprague-Dawley rats were exposed to **tetrachloroethylene** by inhalation 6 hr/day, 5 days/week for 12 months at 300 or 600 ppm, with an additional 18 months of observation. No significant increases in tumor incidence were found for males or females.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Rats, rabbits, and monkeys did not exhibit any adverse effects, including neurotoxic and behavioral effects during or after repeated exposure to levels of **tetrachloroethylene** up to 2720 mg/cu m for about 200 days. Guinea-pigs, however, showed increased liver weight and a few liver cells containing fat vacuoles at 680 mg/cu m. At levels of 1360 mg/cu m or more, fatty degeneration without cirrhosis was found. Loss of equilibrium, coordination, and strength were observed in rats at 10 900 mg/cu m, and rabbits at 1700 mg/cu m. Kidney damage appeared after 24 days of exposure to 17 000 mg/cu m. The weight was increased and the tubular epithelium was swollen.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Two groups, each consisting of 30 male and 30 female Ha:ICR Swiss mice, received 18 and 54 mg, respectively, of **tetrachloroethylene** in acetone applied to the shaven dorsal skin, 3 times per week for 440-594 days. In a third group, each mouse received one application of 163 mg of **tetrachloroethylene** followed after 2 weeks by a promotor in acetone, 3 times per week for 428-576 days. There were 3 control groups, one for the promoter, one for acetone, and one for no treatment. **Tetrachloroethylene** did not initiate or induce dermal tumors.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... F344 rats (50 per sex per dose) were exposed to **tetrachloroethene** (99.9% purity) at 0, 1400, or 2800 mg/cu m for 6 hr/day, 5 days/week, for 103 weeks. Survival was reduced in the high-dose males. **Tetrachloroethene**-exposed rats showed high incidences of karyomegaly and cytomegaly in the proximal convoluted tubules of the kidneys ... Treatment also induced thrombosis in the nasal cavity (both sexes; considered secondary to leukemia) and squamous cell metaplasia of the nasal cavity (only in males), adrenal medullar hyperplasia (only in males), adrenal cortical hyperplasia (only in females), and forestomach ulcers (only in males). The males showed renal tubular cell hyperplasia and increased incidences of tubular cell adenoma and adenocarcinoma ... There were significant increases in mononuclear cell leukemia in both sexes...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ B6C3F1 mice (50 per sex per group) were exposed to **tetrachloroethene** (99.9% purity) at 0, 700, or 1400 mg/cu m for 6 hr/day, 5 days/week, for 103 weeks. **Tetrachloroethene** reduced survival, induced liver degeneration (vacuolization, necrosis, inflammation, and regenerative foci) (both sexes), kidney casts, tubular cell karyomegaly (both sexes), nephrosis (in females only), and acute passive lung congestion (both sexes). Both sexes showed a statistically significant increase of hepatocellular carcinoma, as well as metastasis to other organs.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Groups of 50 male and female B6C3F1 mice were given **tetrachloroethene** by gavage, in corn oil, on 5 days/week for 78 weeks ... 536 and 1072 mg/kg body weight per day for the males and 386 and 772 mg/kg body weight per day for the females ... Untreated and vehicle-treated control groups consisted of 20 animals of each sex ... The incidence of hepatocellular carcinoma increased from 0-10% in control groups ... to 40% ... and 65% ... in the low-dose females and males, respectively, and to 40% ... and 56% ... in the high-dose females and males, respectively. In a number of animals, the carcinomas metastasized to the lungs (1/49 of the low-dose females, 3/49 of the low-dose males, and 1/48 of the high-dose females) or to the kidneys (1/18 of the untreated males). Tumors appeared much earlier in the **tetrachloroethene**-treated groups than in the untreated and vehicle-treated control groups.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... Groups of 50 male and 50 female Osborne-Mendel rats. The females received average doses of 474 or 949 mg/kg body weight per day, 5 days/week, for 78 weeks, by corn oil gavage, followed by a 32-week observation period. In the males, the average dose levels were 471 and 941 mg/kg body weight. The untreated and vehicle-treated control groups consisted of 20 animals of each sex. A high mortality was observed in the early part of the study (50% survival periods in males: 88, 72, and 44 weeks for control, low dose, and high dose, respectively; 50% survival period in females: 102, 66, and 74 weeks for control, low dose, and high dose, respectively), possibly due to toxic nephropathy (degenerative changes in proximal convoluted tubules, cloudy swelling, fatty degeneration, epithelial necrosis, and some hyaline cast-filled tubules). No indications of hepatotoxicity were obtained. At autopsy, about 80% of the treated animals (compared with 0% of controls) were affected by nephropathy. There was no evidence of an increase in tumor induction.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ No increase in tumor incidence was observed in a limited study in which groups of 40 male and 40 female Sprague-Dawley rats were given 500 mg/kg body weight per day (by olive oil gavage), 4 or 5 days/week, for 104 weeks. Observation lasted to death (up to 141 weeks). The control groups consisted of 50 female and 50 male rats given the vehicle only. Only male rats (32%) showed kidney damage, reported as cytomegaly or karyomegaly in renal tubular cells.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

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/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... **Tetrachloroethene** was given by gavage in corn oil to 160 B6C3F1 males at 800 mg/kg body weight per day on 5 days/week for up to 76 weeks; mice were then killed. Control groups consisted of 50 untreated and 50 vehicle-dosed mice, and these were killed at various times between 76 and 134 weeks. At week 76, the percentages of mice with at least one liver carcinoma were 8%, 12%, and 32% in untreated, vehicle-treated, and test groups, respectively, and mean numbers of carcinoma were 0.09, 0.12, and 0.29, respectively. Corresponding figures for adenomas were 8%, 13%, and 80% and 0.90, 0.13, and 1.43, respectively. Foci of cellular alteration (presumed to be preneoplastic lesions) were common in the **tetrachloroethene**-treated group but rare in the control mice, and there was also mild to marked histological evidence of cytotoxicity in the treated group that was not apparent in the controls.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... The fractional conversion of **perchloroethylene** to TCA by mice was determined from physiologically based pharmacokinetic (PBPK) modeling of TCA in mouse blood at the conclusion of inhalation exposure of male and female B6C3F1 mice to 10, 50, 100, or 200 ppm perc for 6 hr/day for 5 days. The dose-dependent bioavailability of TCA in B6C3F1 mice exposed to TCA in drinking water was estimated by optimizing the fit of time course blood, plasma, and liver TCA concentrations for TCA doses ranging from 12 to 800 mg/(kg day) to predictions of a previously published TCA PBPK model. Using the PBPK models, the area under the liver TCA concentration vs. time curve (liver TCA AUC) was calculated for TCA and perc bioassays. Benchmark dose analyses were conducted to determine the dose-response relationship between liver TCA AUC and the additional risk of hepatocellular adenomas or carcinomas (combined) in mice ingesting TCA. Using the dose-response relationships derived for the TCA-exposed mice, the contribution of TCA produced by metabolism to the additional risk of liver adenomas and carcinomas in mice exposed to **perchloroethylene** by inhalation was computed. The analysis indicated that the levels of TCA observed in **perchloroethylene**-exposed mice are sufficient to explain the incidence of liver adenomas and carcinomas.

[Sweeney LM et al; Toxicology 260 (1-3): 77-83 (2009)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ /In a 9 month study/ monkeys were given 1000 to 4000 ppm /of **tetrachloroethylene**/ 2 hr/day, 6 days/week. Weakness, diarrhea, anorexia, unconsciousness, and body weight changes /were observed/. Blood: decreased leucocytes; Liver: central zone cytoplasm vacuolation.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 108 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ ... Studies of **tetrachloroethylene** (99.9% pure) were conducted by inhalation exposure of groups of 50 male and 50 female F344/N rats and B6C3F1 mice. The exposure concentrations used were selected on the basis of results from 13-week inhalation studies in which groups of 10 rats and 10 mice were exposed to **tetrachloroethylene** at 100-1600 ppm for 6 hr/day, 5 day/week. There was clear evidence of carcinogenicity of **tetrachloroethylene** for male F344/N rats as shown by an increased incidence of mononuclear cell leukemia and uncommon tubular cell neoplasms. There was some evidence of carcinogenicity of **tetrachloroethylene** for female F344/N rats as shown by increased incidences of mononuclear cell leukemia. There was clear evidence of carcinogenicity for B6C3F1 mice as shown by increased incidences of both hepatocellular adenomas and carcinomas in males and hepatocellular carcinomas in females.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 128 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ The aim of this study was to determine the chronic toxicity of a mixture of chlorinated alkanes and alkenes (CA) consisting of chloroform, 1,1-dichloroethane, 1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, and **tetrachloroethylene**. These chlorinated organic solvents were present in the underground water near an electronic appliances manufactory in Taoyuan, Taiwan. Male and female weanling ICR mice were treated with low-, medium-, and high-dose CA mixtures in drinking water for 16

and 18 months, respectively. A significant number of male mice treated with the high-dose CA mixture developed tail alopecia and deformation, which was not prominent in CA-treated female mice. Medium- and high-dose CA mixtures induced marginal increases of liver and lung weights, blood urea nitrogen, and serum creatinine levels in male mice. In female mice, the high-dose CA mixture increased liver, kidney, and uterus and ovary total weights, without affecting serum biochemistry parameters. CA mixtures had no effects on the total glutathione content or the level of glutathione S-transferase activity in the livers and kidneys of male and female mice. Treatments with CA mixtures produced a trend of increasing frequency of hepatocellular neoplasms in male mice, compared to male and female controls and CA-treated female mice. The high-dose CA mixture induced a significantly higher incidence of mammary adenocarcinoma in female mice. The calculated odds ratios of mammary adenocarcinoma in female mice induced by low-, medium-, and high-dose CA mixtures were 1.14, 1.37, and 3.53 times that of the controls, respectively. The low-dose CA mixture induced a higher incidence of cysts and inflammation in and around the ovaries. /artificial mixture/
[Wang FI et al; J Toxicol Environ Health A 65 (3-4): 279-91 (2002)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ Inhalation exposure of rats 8 hr/day for 27 weeks at 70, 230, or 470 ppm **tetrachloroethylene** resulted in no adverse effects on reproductive performance.
[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ Sprague-Dawley rats were exposed at 100 ppm **tetrachloroethylene** on days 14 through 20 of gestation, at 900 ppm on days 14 through 20, or at 900 ppm on days 7 through 13 of gestation. Evaluation of pups with respect to brain histology, neurochemistry, and behavior found no effects resulting from the 100 ppm exposure. Diminished maternal feed consumption and weight gain were found in rats exposed at 900 ppm, and offspring showed some differences from controls in performance on behavioral tests and in the levels of some neurotransmitters.
[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ Seventeen rats exposed to 2060 mg of **tetrachloroethylene** per cu m air on days 6-15 of pregnancy showed reduced body weight and a slightly increased number of resorptions. No teratogenic effects were found. In the same study, pups of 17 mice, exposed to 2060 mg/cu m on days 6-15 of pregnancy showed a reduced body weight. Out of 17 litters, all showed delayed ossification of skull bones, 10 litters showed an increase in the incidence of subcutaneous edema, and 4, split sternebrae.
[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ In a two-generation reproduction study, rats (24 per sex per group) were exposed by inhalation to 0, 700, 2100, or 7000 mg/cu m for 6 hr/day, 5 days/week, for 11 weeks prior to mating, then daily until the end of mating. Females were then exposed daily until day 20 of pregnancy. When the F1 offspring were 6 days old, exposure was restarted and continued daily until selection of weanlings as second-generation parents. Selected weanlings were then exposed for 5 days/week for at least 11 weeks before mating. Three F2 litters were produced. For the F2A litter, dams and pups were treated as for the F1 litters, except that the 7000 mg/cu m group was not exposed during lactation (to prevent the sedation and parental neglect observed at this level in the first generation). The F2B litters were derived from matings that followed at least 2 weeks of daily exposure (0, 2100, or 7000 mg/cu m only); exposure of the dams then continued on days 1-20 of pregnancy, but with no exposure during lactation. Finally, the F2C litters were derived by mating control and 7000 mg/cu m males with unexposed females. Fertility and reproduction were unaffected at up to 2100 mg/cu m. At 7000 mg/cu m, maternal toxicity (reduced growth prior to mating and during pregnancy and lactation) and offspring toxicity (decreases in litter size, pup weight, and survival during lactation) were seen. No effects were seen in the F2C pups, indicating that changes were not male-mediated.
[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010:

http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ No fetotoxicity or teratogenicity was seen when groups of 20 pregnant rats were exposed to **tetrachloroethene** at 3400 mg/cu m for 7 hr/day 1) on days 0-18 of gestation, 2) for 3 weeks before mating and on days 0-18 of gestation, or 3) for 3 weeks before mating and on days 6-18 of gestation. The only maternal effects noted were slight increases in liver or kidney weights, and these were not seen consistently between groups. In a similar study with rabbits, the only treatment-related effect reported was an increase in placental abnormalities in the group exposed on days 7-21 of pregnancy.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ When groups of 18-19 CFY rats were exposed at 0, 1500, 4500, or 8500 mg/cu m for 8 hr/day throughout (days 0-21) pregnancy, 1500 mg/cu m induced no signs of maternal toxicity or significant effects on the fetuses. At 4500 mg/cu m and above, toxic effects were observed in the mothers (reduced growth and increased relative liver weight) and embryos/fetuses (increased preimplantation loss, reduced fetal weight, and increases in skeletal retardation and supernumerary ribs).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ ... Treatment-related increases in embryo resorptions, malformations (small or no eyes), and postnatal deaths occurred when F344 rats were given **tetrachloroethene** by stomach tube at a maternally toxic dose (ataxia and reduced weight gain) of 900 mg/kg body weight per day on days 6-19 of pregnancy.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ When New Zealand rabbits were exposed to **tetrachloroethene** at 0 (n = 10) or 4500 mg/cu m (n = 16) for 8 hr/day throughout the organogenesis period of pregnancy, toxic effects were observed in the mothers exposed to **tetrachloroethene** (reduced weight gain and increased relative liver weight). Fetotoxic effects reported were an increased postimplantation loss and an increase in the number of litters where all fetuses were reabsorbed. No evidence of teratogenicity was seen.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ The potential for trichloroethylene (TCE) and **perchloroethylene** (PERC) to induce developmental toxicity was investigated in Crl:CD (SD) rats whole-body exposed to target concentrations of 0, 50, 150 or 600 ppm TCE or 0, 75, 250 or 600 ppm PERC for six hours/day, seven days/week on gestation day (GD) 6-20 and 6-19, respectively. Actual chamber concentrations were essentially identical to target with the exception of the low PERC exposure level, which was 65 ppm. The highest exposure levels exceeded the limit concentration (2 mg/L) specified in the applicable test guidelines. Maternal necropsies were performed the day following the last exposure. Dams exposed to 600 ppm TCE exhibited maternal toxicity, as evidenced by decreased body weight gain (22% less than control) during GD 6-9. There were no maternal effects at 50 or 150 ppm TCE and no indications of developmental toxicity (including heart defects or other terata) at any exposure level tested. Therefore, the TCE NOEC for maternal toxicity was 150 ppm, whereas the embryo/fetal NOEC was 600 ppm. Maternal responses to PERC were limited to slight, but statistically significant reductions in body weight gain and feed consumption during the first 3 days of exposure to 600 ppm, resulting in a maternal NOEC of 250 ppm.

Developmental effects at 600 ppm consisted of reduced gravid uterus, placental and fetal body weights, and decreased ossification of thoracic vertebral centra. Developmental effects at 250 ppm were of minimal toxicological significance, being limited to minor decreases in fetal and placental weight. There were no developmental effects at 65 ppm.

[Carney EW et al; Birth Defects Res B Dev Reprod Toxicol 77 (5): 405-12 (2006)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ Reproductive and developmental toxicities resulting from exposure to **tetrachloroethylene** include delayed or impaired conception, sperm quality, death during development, developmental neurotoxicity, and growth retardation. In most cases there was concordance between rodents and humans. The risk assessments indicated that neurotoxicity was the most sensitive endpoint for inhalation, whereas growth retardation was the most sensitive endpoint when exposure was by the oral route. The reference concentration (RfC) of 0.01 ppm was based on neurotoxicity among human subjects. The reference dose (RfD) of 0.0006 mg/kg per day was based on small for gestation age infants. In both cases, studies in rodents supported the credibility of these assessments. For the RfD, similar findings for other trihalomethanes have been reported. The latter part of pregnancy and early life may constitute a susceptible period for alterations leading to behavioral deficits. During this period, the capacity to metabolize **tetrachloroethylene** is reduced and may further contribute to the sensitivity during this phase of development. ...

[Beliles RP; Toxicol Ind Health 18 (2): 91-106 (2002)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Developmental or Reproductive Toxicity/ ... Oocytes were obtained from females following exposure and quality assessed by in vitro fertilization rate. One study evaluated fertilizability following 2 weeks exposure of females to inhaled **tetrachloroethylene** (2hr/day, 5 days/week). The remaining studies evaluated fertilizability immediately following 2 weeks exposure via drinking water to **tetrachloroethylene**, trichloroethylene, the fuel oxidants methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), and a metabolite of the first two ethers 2-methyl-1,2-propanediol (2M2P), and to 4-vinylcyclohexene diepoxide. The percentage of oocytes fertilized was reduced following inhalation exposure to **tetrachloroethylene**, or consumption of trichloroethylene or TAME. Fertilizability was not altered by exposures to the other reproductive toxicants or to the other fuel oxidants. Consistent with the reduced oocyte fertilizability following exposure to trichloroethylene, oocytes from exposed females had a reduced ability to bind sperm plasma membrane proteins. Female reproductive capability assessed by the endpoint, oocyte fertilizability, was reduced by exposure to trichloroethylene and inhaled **tetrachloroethylene**.

[Berger T, Horner CM; Reprod Toxicol 17 (3): 273-81 (2003)] **PEER REVIEWED** PubMed Abstract

/LABORATORY ANIMALS: Neurotoxicity/ The literature describing controlled acute and subchronic inhalation exposures of laboratory animals is summarized ... . The end points affected include neurotransmitter or neurochemical concentrations, long-chain fatty acid concentrations, RNA expression, DNA expression and brain weight, electrophysiologic measures and evoked potentials, and locomotor activity, all of which indicate **tetrachloroethylene**'s neurotoxcity.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ ... Rats were exposed head-only to **tetrachloroethylene** while visual evoked potentials (VEPs) were recorded. Exposures were to concentrations of **tetrachloroethylene** ranging from 1,000-4,000 ppm for 1-2 hours, using concentration and time combinations derived from kinetic analyses. The most sensitive end point was the F2 (frequency-doubling) component of the evoked potential spectrum, a measure thought to reflect the activity of cortical neurons that respond to both stimulus offset and onset.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and

Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ ... Rats were exposed by inhalation to **tetrachloroethylene** at 500, 1,000, and 1,500 ppm for 1 hour, during which a visual signal detection task was performed. Rats were trained to indicate the occurrence or nonoccurrence of a light flash during a trial period that lasted from 0.3 to 24.39 seconds, and individual trial durations were random. Exposure to **tetrachloroethylene** did not change the number of "correct" detections, but significantly increased the number of times that the rats incorrectly indicated a signal (false alarm), increased response time, and decreased the number of trials completed. The false-alarm rate was affected at the lowest concentration (500 ppm) and a NOAEL was not identified. ...

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ Neurotoxic effects were observed in rats exposed to 100 mg of **tetrachloroethylene** per cu m air, for 5 hr/day, for 5 months. There were EEG changes together with an increased electrical impedance of cerebral tissue. The protoplasm of some cortex cells was swollen and there were isolated cells with vacuoles and karyolysis. Acetylcholinesterase activity was reduced. Fatty infiltration of the liver was also noted. At 10 mg/ cu m, only changes in impedance and a slight decrease in acetylcholinesterase activity were found.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ Neurotoxic effects were noted in rats following a single exposure to 2000 mg/cu m. Rats exhibited an intensified motor reaction and there were distinct alterations in the EEG, an increased impedance of the cerebral cortex and decreased biopotentials and EEG voltage. Serum acetylcholinesterase activity was decreased.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ A comprehensive neurotoxicological examination was carried out on 16-week-old F344 rats (12 per sex per group) exposed at 0, 340, 1400, or 5500 mg/cu m for 6 hr/day, 5 days/week, for 13 weeks. Animals were monitored throughout the study for overt signs of neurotoxicity and subjected monthly ... Grip performance was tested monthly. During week 14, an electrophysiological test battery was conducted, incorporating flash evoked potential, auditory brain stem response to clicks and to tone pips, somatosensory evoked potentials, caudal nerve action potentials, and rectal temperature. Waveforms were visually analyzed. Comprehensive neuropathological examination of the brain, optic nerve, spinal cord and nerve roots, dorsal root ganglia, peripheral nerves, and skeletal muscles was carried out on five rats per sex at the highest exposure level. The only treatment-related effect was a subtle change (greater amplitude of the longer latency potential) in the flash evoked potential recorded for the visual cortex at 5500 mg/cu m ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ The neurotoxic potential of **tetrachloroethene** has been tested in young (3-4 weeks old) male Sprague-Dawley rats. **Tetrachloroethene** was given by gavage to groups of nine rats at 0, 5, or 50 mg/kg body weight per day, 5 days/week, for 8 weeks, and behavioral tests were initiated 3 days after the final dose.

Nociception (tail immersion, hot-plate, increasing temperature hot-plate), locomotor activity (open field), and seizure induction (pentylenetetrazol-induced) were examined ... Slightly but significantly (P < 0.001) slower responses were seen in all three nociceptive tests at both doses, but no dose-response was seen. Locomotion and rearing activity were reduced at both doses, the changes being statistically significant at the high dose. Both dose levels increased the seizure thresholds for myoclonic twitch and forelimb clonus.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ Unresponsiveness to external stimuli occurred within a few minutes in Wistar rats exposed to >/ = 6000 ppm **tetrachloroethylene** and after several hours exposure to 3000 ppm, but responsiveness was retained during exposure to 2000 ppm for 14 hr. Frequent loss of response to external stimuli was also observed in Wistar rats during repeated exposure to 2500 ppm **tetrachloroethylene** (18 x 7 hr for 25 days). At 1600 ppm drowsiness and signs of stimulation of the cholinergic system were observed. Rabbits and guinea pigs showed signs of CNS depression (anesthetic effects) at 2500 ppm. There were no effects in these species as well as in the rhesus monkeys following exposures to 400 ppm **tetrachloroethylene**.

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 140 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ ... /A study/ measured brain weight and neuronal and glial markers in rats exposed continuously at 300 or 600 ppm for 4 or 12 weeks. Brain weight was significantly reduced at 600 ppm following both 4 and 12 weeks of exposure. Measurement of neuron-specific enolase, a cytosolic neuronal protein in the frontal cerebral cortex, hippocampus, and brainstem did not show any changes. The cytosolic marker of glial cells, glial S-100, was significantly reduced in all three brain regions following exposure at 600 ppm for 12 weeks, with the greatest reduction observed in the frontal cerebral cortex. Cytoskeletal elements of neuronal cells (neurofilament 68 kD polypeptide) and glial cells (glial fibrillary acid protein) were significantly reduced in the frontal cerebral cortex at 600 ppm. The neuronal marker was reduced at both 4 and 12 weeks, while the glial marker was reduced only at 12 weeks. In the hippocampus and brainstem, only the glial cytoskeleton protein was significantly reduced following 12 weeks of exposure at 600 ppm ... The frontal cerebral cortex is more sensitive to **tetrachloroethylene** than other regions of the brain, that cytoskeletal elements are more sensitive than cytosolic proteins, and that in addition to neural cells, glial cells are vulnerable to the effects of **tetrachloroethylene**.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 50 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

/LABORATORY ANIMALS: Neurotoxicity/ ... A physiologically based pharmacokinetic (PBPK) model was implemented to predict concentrations of PCE in the brains of adult Long-Evans rats following inhalation exposure. The model was evaluated for performance against tissue concentrations from exposed rats (n = 40) and data from the published scientific literature. Visual function was assessed using steady-state pattern-elicited visual-evoked potentials (VEPs) recorded from rats during exposure to air or PCE in two experiments (total n = 84) with concentrations of PCE ranging from 250 to 4000 ppm. VEP waveforms were submitted to a spectral analysis in which the major response component, F2, occurring at twice the visual stimulation rate, was reduced in amplitude by PCE exposure. The F2 amplitudes were transformed to an effect-magnitude scale ranging from 0 (no effect) to 1 (maximum possible effect), and a logistical function was fit to the transformed values as a function of estimated concurrent brain PCE concentrations. The resultant function described a dose-response relationship between brain PCE concentration and changes in visual function with an ED(10) value of approximately 0.684 mg/L and an ED(50) value of approximately 46.5 mg/L. The results confirmed that visual function was disrupted by acute exposure to PCE, and the PBPK model and logistic model together could be used to make quantitative estimates of the magnitude of deficit to be expected for any given inhalation exposure scenario.

[Boyes WK et al; Toxicol Sci 108 (1): 159-72 (2009)] **PEER REVIEWED** PubMed Abstract

/DEVELOPMENTAL NEUROTOXICITY/ ... Pregnant rats /were exposed/ to **tetrachloroethylene** at 900 ppm on gestational days 7-13 or 14-20 or at 100 ppm on days 14-20. No significant **tetrachloroethylene** related effects were reported in the animals exposed at 100 ppm, but effects were noted in those exposed at 900 ppm. The **tetrachloroethylene** exposed dams consumed less feed and gained less weight than air exposed controls. No significant differences in growth were noted in offspring, but the draft integrated risk information system (IRIS) assessment incorrectly states that diminished weight gain in offspring was reported. Offspring showed deficits in neuromuscular and sensorimotor functions and increases in locomotor activity.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/DEVELOPMENTAL NEUROTOXICITY/ Groups of 12 male NMRI mice (from 3-4 litters) were given **tetrachloroethene** at 5 or 320 mg/kg body weight per day on postnatal days 10-16 by gavage, locomotion, rearing, and total activity (measures of spontaneous motor activity) were unaffected on day 17. When the mice were 60 days old, statistically significant (P < 0.01) increases in locomotion and total activity were seen at both dose levels ... Rearing activity was unaffected at the low dose and reduced ... at the high dose. Habituation, as defined by decreased activity over 1 hr, in response to diminished novelty of the test chambers was attenuated in the **tetrachloroethene**-treated groups. ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/BEHAVIORAL STUDIES/ Meta- and reanalyses of the available data for the neurobehavioral effects of acute inhalation exposure to toluene /have been/ reported ... The present study was designed to test the generality of the toluene results in as many other solvents as possible by further meta- and reanalyses. Sufficient data for meta-analyses were found for only four solvents; toluene, trichloroethylene, **perchloroethylene**, and 1,1,1-trichloroethane. The results for these solvents showed that rats were less affected by each of the solvents when they were tested in highly motivating situations, for example, rewarded for rapid or correct responding or escape from electrical shock, compared with less motivating circumstances. The four solvents did not differ significantly in potency on any outcome measure when dose was expressed as molar brain concentration. When tested in tasks with low-motivational contingencies, the dose-effect curves of humans (reaction times) and rats (electrophysiological responses to visual stimuli) were not significantly different. However, on an exploratory follow-up analysis, humans were less sensitive than rats. No human data were found to test whether species differed under strong motivation. Dose-equivalence curves were derived for extrapolating to human effects from rat data.

[Benignus VA et al; Toxicol Sci. 2009 Jun;109(2):296-305 (2009)] **PEER REVIEWED** PubMed Abstract

/BEHAVIORAL STUDIES/ ... The current study sought to assess the effects of inhaled /**perchloroethylene**/ PCE on sustained attention in rats performing a visual signal detection task (SDT). Due to its similarities in physiological effect to toluene and trichloroethylene (TCE), two other commonly used volatile organic compounds (VOCs) known to reduce attention in rats, we hypothesized (1) that acute inhalation of PCE (0, 500, 1000, 1500 ppm) would disrupt performance of the SDT in rats; (2) that impaired accuracy would result from changes in attention to the visual signal; and (3) that these acute effects would diminish upon repetition of exposure. PCE impaired performance of the sustained attention task as evidenced by reduced accuracy [P(correct): 500 to 1500 ppm], elevated response time [RT: 1000 and 1500 ppm] and reduced number of trials completed [1500 ppm]. These effects were concentration-related and either increased (RT and trial completions) or remained constant [P(correct)] across the 60-min test session. The PCE-induced reduction in accuracy was primarily due to an increase in false alarms, a pattern consistent with reduced attention to the signal. A repeat of the exposures resulted in smaller effects on these performance measures. Thus, like toluene and TCE, inhaled PCE acutely impaired sustained attention in rats, and its potency weakened upon repetition of the exposure.

[Oshiro WM et al; Neurotoxicol Teratol 30 (3): 167-74 (2008)] **PEER REVIEWED** PubMed Abstract

/BEHAVIORAL STUDIES/ This study was carried out to compare the neurobehavioral profile of acute and subchronic **tetrachloroethylene** (**perchloroethylene**, PCE) exposure in rats. In the acute study, a single bolus of 50 and 500 mg/kg of PCE in corn oil was administered by gavage. In the subchronic experiments, rats were exposed to PCE at a dosage of 5 and 50 mg/kg in corn oil, 5 days per week for 8 weeks. Nociception, locomotion, and seizure susceptibility was tested using open-field, tail immersion, and hot plate and pentylenetetrazol-induced seizures, respectively. Subchronic PCE exposure exhibited higher antinociceptive effect and lower motor activity in comparison with acute exposure. Pentylenetetrazol-induced convulsion thresholds were elevated following acute PCE exposure. In contrast, subchronic PCE exposure only increased thresholds for myoclonic twitch and face and forelimb clonus without altering the thresholds for running and bouncing clonus and tonic hindlimb extension. ...

[Chen HH et al; Toxicology 170 (3): 201-9 (2002)] **PEER REVIEWED** PubMed Abstract

/GENOTOXICITY/ A considerable number of mutagenicity studies of pure **tetrachloroethylene** that used Salmonella strains, Escherichia coli, and Saccharomyces have been performed with and without exogenous metabolic activation by liver S9 fractions from rats, mice, and hamsters (including animals pretreated with Aroclor or phenobarbital). The results have been essentially negative.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/GENOTOXICITY/ /A/ well-done study /using mouse lymphoma L5178Y cells/ revealed that **tetrachloroethylene** at a variety of concentrations, with and without S9 for metabolic activation (but not with GST and rat kidney fractions), did not enhance the frequency of mutations at the thymidine kinase locus. Likewise, investigations of chromosomal aberrations and sister-chromatid exchanges (SCEs) in Chinese hamster ovary (CHO) cells showed no evidence of **tetrachloroethylene**-induced genetic activity,

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/GENOTOXICITY/ **Tetrachloroethylene** was administered to rats orally (1 g/kg at 0 and 12 hours); at 24 hours, no evidence of unscheduled DNA synthesis in isolated renal cells was observed.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/GENOTOXICITY/ /An/ in vivo study /was conducted/ in which the alkaline Comet assay was performed on the liver and kidney of CD1 mice treated orally with **tetrachloroethylene** at 1,000 or 2,000 mg/kg dissolved in corn oil. A slight increase in DNA damage was reported; the effect was significant for one of two end points (tail intensity, but not tail moment) in the liver. No increases were found in the kidney.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/GENOTOXICITY/ The clastogenicity of **tetrachloroethylene** (tetra) was detected by means of the micronucleus assay using hepatocytes and reticulocytes from ddY male mice, to understand its effects in upon hepatocellular carcinomas in mice. The frequency of micronucleated hepatocytes of mice that received a single injection of tetra after partial hepatectomy increased to levels that were significantly higher than those of controls treated with solvent. However, the micronucleus assay using peripheral blood reticulocytes from ddY male mice, revealed that tetra did not induce to a statistically significant increase in micronucleus frequency. These results suggested that tetra metabolites have a clastogenic effect in vivo upon mouse liver but not upon bone marrow cells.

[Murakami k, Horikawa K; Chemosphere 31 (7): 3733-9 (1995)] **PEER REVIEWED**

/GENOTOXICITY/ In host mediated assay in mice, using Salmonella typhimurium TA1950, TA1951 and TA1952, there was a significant increase in number of revertants with doses equiv to LD50 & half the LD50, but this was not dose related. ... There was no induction of chromosomal aberrations in bone marrow cells of mice that had received either single (half LD50) or 5 daily ip injections (1/6 LD50) of ... /**tetrachloroethylene**/..

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V20 503 (1979)] **PEER REVIEWED**

/GENOTOXICITY/ With Escherichia coli K12, **tetrachloroethylene** was non- mutagenic in vitro, with or without metabolic activation.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/GENOTOXICITY/ In a 2 hr test with Saccharomyces cerevisiae D7, no mutagenic alterations were found in vitro or in vivo, with or without metabolic activation. However, /another study/ did find dose-related mutagenic effects with strain D7 at the same loci and at similar concentrations without additional metabolic activation in 1 hr, but not in 4 hr suspension tests. Strain D4 did not show mutagenic activity in vitro. Both /studies/ ... suggest a possible toxic effect on the cytochrome P450 system. Strain D4 contains much less cytochrome P450 than strain D7.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/GENOTOXICITY/ Gavage administration of **tetrachloroethene** at 1000 mg/kg body weight did not induce unscheduled DNA synthesis (UDS) in the kidneys of rats. Increased replicative DNA synthesis was seen following repeated exposure at 1000 mg/kg body weight for 3 weeks.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/GENOTOXICITY/ Exposure of Drosophila melanogaster to **tetrachloroethene** by inhalation (up to 3400 mg/cu m for 7 hr), feeding, or injection did not induce sex-linked recessive lethal mutations or effects upon the chromosomes.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/GENOTOXICITY/ In bacterial assays (including Ames tests), **tetrachloroethene** of a high purity has not given evidence of mutagenic activity. **Tetrachloroethene** was tested in the liquid and vapor phases. As well as the usual Salmonella strains, the less commonly used Salmonella strains UTH 8413 and UTH 8414 have been tested, as has Escherichia coli K12. The influence of mammalian metabolism was investigated using rat, hamster, or mice liver

homogenates (S9) from animals treated with either Aroclor-1254 or phenobarbital as inducers of hepatic biotransformation enzymes. In some of these studies, commercial or technical grades of **tetrachloroethene** were also tested and found to induce mutations. Because the same studies yielded negative results when highly purified **tetrachloroethene** was tested, it appears that impurities were responsible for the mutagenic responses. One study (a spot test) that produced a positive result (in S. typhimurium TA100) did not report the purity of the test compound. When **tetrachloroethene** was preincubated with purified rat liver glutathione-S-transferases in the presence of glutathione and rat kidney fraction, the resulting product was mutagenic in the Ames test, apparently due to the formation of the genotoxic intermediate, S-(1,2,2-trichlorovinyl)cysteine.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/GENOTOXICITY/ **Tetrachloroethene** did not induce chromosomal aberrations or sister chromatid exchanges in Chinese hamster ovary cells with or without S9.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/GENOTOXICITY/ When tested in a high-quality mouse lymphoma assay (using L5178Y cells), **tetrachloroethene** did not induce mutations, with or without S9.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/GENOTOXICITY/ The Ames test /using/ Salmonella typhimurium TA98, TA100, TA1535, TA1537, and TA1538 with concentrations of 1% (v/v) TA98, TA1538 and TA1537 0.1, 1.0, 2.5, 5.0, 7.5, and 10% (v/v) TA100 and TA1535; with metabolic activation (+/- Aroclor 1254 induced rat S9 liver) /had a/ positive /result/. TA100, TA1535 2.5%: (>97% toxic) 3-6 fold response +/- activation, dose-response not established. **Tetrachloroethylene** had a 99.93% purity (stabilized with 0.012% /hydroquinone monomehthyl ether/ (HQMME).

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 110 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

/GENOTOXICITY/ Induction of DNA damage in the liver and kidney of male CD1 mice was studied by means of the alkaline Comet assay after oral administration of **tetrachloroethylene** at the doses of 1000 and 2000 mg/kg/day. A statistically significant dose-related increase in tail intensity was established in hepatocytes, indicating that **tetrachloroethylene** induced DNA damage in the liver. No effect on DNA damage was observed in the kidney. The results are in agreement with carcinogenicity data in mice, in which **tetrachloroethylene** induced tumors in the liver but not in the kidney, and support that a genotoxic mode of action might be involved in liver carcinogenicity in mice.

[Cederberg H et al; Mutagenesis 25 (2): 133-8 (2010)] **PEER REVIEWED** PubMed Abstract

/GENOTOXICITY/ ... The present study examined the potential for trichloroethylene (TCE) and **perchloroethylene** (PERC) to induce oxidative DNA damage in rats that was detectable as increased urinary excretion of 8-hydroxydeoxyguanosine (8OHdG). Thiobarbaturic acid reactive substances (TBARS) and 8-epiprostaglandin F2alpha (8epiPGF) were also measured as biomarkers of increased oxidative stress. Male Fischer rats were administered a single ip injection of 0, 100, 500, or 1000 mg/kg of PERC or TCE. Control rats received only vehicle (1:4 v/v of Alkamuls/water). A positive control group received 100 mg/kg 2-nitropropane (2NP). Rats were sacrificed 24 hr after dosing. In rats receiving 2NP or TCE but not PERC, TBARS and the 8OHdG/dG ratios were significantly elevated in liver. Lymphocyte 8OHdG/dG was not affected significantly by 2NP, TCE or PERC. In rats receiving 2NP, urinary excretion of 8OHdG and 8epiPGF2 were significantly increased. In rats receiving TCE or PERC, significant increases in 8epiPGF2 or 8OHdG were not evident. Results indicate that a single high dose of TCE, but not PERC, can induce

an increase in oxidative DNA damage in rat liver. However, the usefulness of 8OHdG as a biomarker of TCE-induced oxidative DNA damage is questionable.

[Toraason M et al; Toxicology 138 (1): 43-53 (1999)] **PEER REVIEWED** PubMed Abstract

/ALTERNATIVE and IN VITRO TESTS/ The embryotoxicity of trichloroethylene (TRI), **tetrachloroethylene** (PER), and of four of their oxidative metabolites i.e. trichloroacetic acid, dichloroacetic acid, chloral hydrate, and trichloroacetyl chloride, was studied in vitro, using the rat whole embryo culture system. Embryos from Sprague-Dawley rats were explanted on gestational day 10 (plug day = day 0) and cultured for 46 hr in the presence of the test chemical. All of the tested chemicals produced concentration-dependent decreases in growth and differentiation and increases in the incidence of morphologically abnormal embryos. TRI and PER produced qualitatively similar patterns of abnormalities, while TRI and/or PER metabolites, each elicited clearly distinguishable dysmorphogenic profiles. The presence of hepatic microsomal fractions in the culture medium produced marked decreases in TRI- and PER-induced embryotoxic effects, including mortality, severity of malformations, and delayed growth and differentiation.

[Saillenfait AM et al; Arch Toxicol 70 (2): 71-82 (1995)] **PEER REVIEWED** PubMed Abstract

/IMMUNOTOXICITY/ Non-purified rat peritoneal mast cells (NPMC) and rat basophilic leukemia (RBL-2H3) cells were sensitized with anti-dinitrophenol (DNP) monoclonal IgE antibody and then stimulated with DNP-conjugated bovine serum albumin (DNP-BSA) and several chlorinated organic solvents. Trichloroethylene (TCE) and **tetrachloroethylene** (PCE) enhanced histamine release from antigen-stimulated NPMC and RBL-2H3 in a dose-dependent manner. In addition, TCE and PCE increased IL-4 and TNF-alpha production from antigen-stimulated RBL-2H3. In an in vivo study, we investigated the effect of TCE and PCE on passive cutaneous anaphylaxis (PCA) reaction. TCE and PCE enhanced PCA reaction markedly.

[Seo M et al; Toxicology 243 (1-2): 75-83 (2008)] **PEER REVIEWED** PubMed Abstract

/OTHER TOXICITY INFORMATION/ The mode of action of **tetrachloroethylene**-induced hepatic tumors is not clear. Many toxic metabolites are formed from **tetrachloroethylene**. Hence, it is likely that key events from several pathways operate in **tetrachloroethylene**-induced hepatocarcinogenesis. It is likely that trichloroacetic acid (TCA), dichloroacetic acid (DCA), and chloral hydrate (if it is formed) - which are carcinogens in rodents - contribute to **tetrachloroethylene**-induced hepatocarcinogenesis. It is also likely that mutagenic metabolites of **tetrachloroethylene** formed via the cytochrome P450 and GSH pathways (**tetrachloroethylene**-epoxide, TCA, DCA, and S-(1,2,2-trichlorovinyl) glutathione (TCVG)) contribute to hepatocarcinogenesis. And it is possible that activation of PPARalpha and consequent peroxisomal proliferation; genotoxic events induced by **tetrachloroethylene** metabolites, including chromosomal aberrations; and other nongenotoxic events - such as promotion of growth of previously initiated foci, changes in epigenetic status, and oxidative stress - may all contribute to the overall MOA through several simultaneous mechanisms. The hypothesis that the mutagenic metabolites of **tetrachloroethylene** (**tetrachloroethylene**-epoxide, TCA, DCA, chloral hydrate [if it is formed], and TCVG) initiate carcinogenesis and that **tetrachloroethylene**-induced promotion of initiated foci, cytotoxicity, and epigenetic events promote carcinogenesis cannot be ruled out.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

/OTHER TOXICITY INFORMATION/ **Perchloroethylene** (perc) is metabolized primarily to trichloroacetic acid (TCA), which is also a mouse hepatocarcinogen. The fractional conversion of **perchloroethylene** to TCA by mice was determined from physiologically based pharmacokinetic (PBPK) modeling of TCA in mouse blood at the conclusion of inhalation exposure of male and female B6C3F1 mice to 10, 50, 100, or 200 ppm perc for 6 hr/day for 5 days. The dose-dependent bioavailability of TCA in B6C3F1 mice exposed to TCA in drinking water was estimated by optimizing the fit of time course blood, plasma, and liver TCA concentrations for TCA doses ranging from 12 to 800 mg/(kg day) to predictions of a previously published TCA PBPK model. Using the PBPK models, the area under the liver TCA

concentration vs. time curve (liver TCA AUC) was calculated for TCA and perc bioassays. Benchmark dose analyses were conducted to determine the dose-response relationship between liver TCA AUC and the additional risk of hepatocellular adenomas or carcinomas (combined) in mice ingesting TCA. Using the dose-response relationships derived for the TCA-exposed mice, the contribution of TCA produced by metabolism to the additional risk of liver adenomas and carcinomas in mice exposed to **perchloroethylene** by inhalation was computed. The analysis indicated that the levels of TCA observed in **perchloroethylene**-exposed mice are sufficient to explain the incidence of liver adenomas and carcinomas.

[Sweeney LM et al; Toxicology 260 (1-3): 77-83 (2009)] **PEER REVIEWED** PubMed Abstract

Ecotoxicity Excerpts:

/BIRDS and MAMMALS/ Effects of inhalation of volatilized trichloroethylene (TCE) or **perchloroethylene** (PCE) were assessed based on the health and population size of wild, burrowing mammals at Edwards Air Force Base (CA, USA). Organic soil-vapor concentrations were measured at three sites with aquifer contamination of TCE or PCE of 5.5 to 77 mg/L and at two uncontaminated reference sites. Population estimates of kangaroo rats (Dipodomys merriami and D. panamintinus) as well as hematology, blood chemistry, and histopathology of kangaroo rats and deer mice (Peromyscus maniculatus) were compared between contaminated and uncontaminated populations. Maximum soil-gas concentrations associated with groundwater contamination were less than 1.5 uL/L of TCE and 0.07 uL/L of PCE. Population estimates of kangaroo rats were similar at contaminated and reference sites. Hematology, blood chemistry, and histopathology of kangaroo rats and deer mice indicated no evidence of health effects caused by exposure. Trichloroethylene or PCE in groundwater and in related soil gas did not appear to reduce the size of small mammal populations or impair the health of individuals.

[Spring SE et al; Environ Toxicol Chem 23 (9): 2162-9 (2004)] **PEER REVIEWED** PubMed Abstract

/AQUATIC SPECIES/ A study was designed to determine the effects of **tetrachloroethylene** on the phyto- and zooplankton community at initial concentrations of 1.2 and 0.44 mg/L in separated compartments of an experimental pond. Measurements in the surrounding water were made simultaneously to detect possible effects of compartmentalization. Residues as low as 0.1 mg/L could be analyzed 5 days (low dose) and 38 days (high dose) post-application. In all applied biotopes, a lethal effect on the Daphnia population was detected. The phytoplankton community showed an increase of relative abundance and a decrease in species diversity. Studies of the frequency distribution of 6 selected phytoplankton species (Spirogyra species, Microcystis flos-aquae, Stichococcus bacillaris, Nitzschia acicularis, Chilomonas parameium, Actinophrys species) demonstrated the total elimination of at least 4 species from the treated compartments. In spite of different dosing, only weak differences were found in toxic effects between the low and high dosed compartments. No significant chemically induced effect was observed on the physicochemical properties of the treated water.

[Lay JP et al; Arch Environ Contam Toxicol 13 (2): 135-42 (1984)] **PEER REVIEWED**

/AQUATIC SPECIES/ In a 60-day study, 3 groups of black mollies (Poecilia sphenops), each comprising 3 females and 3 males, were exposed, respectively, to 0, 0.001, and 0.005 mL **tetrachloroethylene** per liter water. Weights declined by 30 - 40% in the exposed groups and increased in the control group. Survival was 100%, 17%, and 0% at 0, 0.001, and 0.005 mL/ Liter, respectively. The livers of exposed fish showed fatty degeneration.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

/AQUATIC SPECIES/ A recent study ... demonstrated that **tetrachloroethylene** (TCE) is acutely toxic to Japanese medaka (Oryzias latipes) larvae with a 96 hr LC50 of 18 (17-19) mg/mL. In the present study /it was hypothesized/ that TCE exposure induces a developmental effect in Japanese medaka. Growth and age specific sensitivity of Japanese medaka larvae were studied with four age groups (7, 14, 21 and 28 days old) to determine **tetrachloroethylene** effects on these parameters. The medaka larvae were exposed for 96 hours in a single

concentration (10 mg/mL) of TCE. The toxic endpoints evaluated were larvae weight, length, water content and protein concentration. The study revealed that exposure of medaka larvae to this sub-acute concentration of TCE significantly reduced length and weight in the treated group. The difference in growth between control and treated groups was more obvious in age versus length, than in age versus weight. The dry weight-fresh weight ratio (dw/fw) was shown to be higher in the control group. Water content in TCE-treated medaka was higher than in the control group, and younger fry had more water content than older ones. A higher protein concentration was also observed in TCE-treated medaka compared to the control group.

[Spencer HB et al; J Environ Biol 27 (1): 1-5 (2006)] **PEER REVIEWED** PubMed Abstract

/AQUATIC SPECIES/ **Tetrachloroethylene** (PCE), a dry cleaning and degreasing solvent, can enter groundwater through accidental leaks or spills, and concentrations as high as 75 mg/L have been reported in Canadian aquifers. Amphibians in wetlands receiving contaminated groundwater may be exposed to PCE and its degradation products, but little information is available on the impacts of these compounds on indigenous amphibian species. Acute (96-hr static renewal) exposures to PCE and its major degradation products, trichloroethylene (TCE) and cis- and trans-dichloroethylene, were conducted on embryos of four North American amphibian species: wood frogs (Rana sylvatica), green frogs (R. clamitans), American toads (Bufo americanus), and spotted salamanders (Ambystoma maculatum). Subsequently, chronic exposures to PCE and TCE were conducted with the larvae of American toads. Both PCE and TCE were teratogenic to amphibian embryos; median effective concentrations (EC50s) for developmental deformities produced by PCE and TCE exposure for wood frogs and green frogs were 12 and 40 mg/L, respectively. Embryonic survivorship, however, was not compromised at these concentrations. American toads were less sensitive; the EC50 for developmental abnormalities was not attained at the highest test concentrations, 45 and 85 mg/L PCE and TCE, respectively.

[McDaniel TV et al; Arch Environ Contam Toxicol 47 (1): 101-9 (2004)] **PEER REVIEWED** PubMed Abstract

/AQUATIC SPECIES/ ... The acute toxicity of **Tetrachloroethylene** (C(2)Cl(4)) ... its sub-chronic effects on the embryonic development of Japanese medaka (Oryzias latipes) /were investigated/. One-day-old eggs/embryos of this fish species were exposed, under static renewal conditions, to serial concentrations (0, 20, 40, 60, and 80 mg/L) of C(2)Cl(4) for 96 hr (acute) and 10 days (sub-chronic) time periods. The toxic endpoints evaluated included: egg/embryo viability, hatchability, and morphological/developmental abnormalities. The acute toxicity test resulted in a 96 hr-LC(50) of 27.0 (19.5-32.9) mg/L for egg viability. Exposure of eggs to sub-chronic concentrations (0, 1.5, 3, 6, 12, and 25 mg/L) of C(2)Cl(4) significantly reduced hatchability and larval survival, in a concentration dependent manner. At the highest tested concentration (25 mg/L) of the sub-lethal exposure, larval survival was greatly reduced to within three days post-hatch. The lowest tested concentration (1.5 mg/L) produced a significant number of developmental effects to the Japanese medaka, including abnormal development of the circulatory system, yolk-sac edema, pericardial edema, scoliosis, hemorrhaging, blood pooling, and defects in heart morphology. The severity of these abnormalities was concentration-dependent. It can be concluded from these results that **tetrachloroethylene** is teratogenic to the Japanese medaka.

[Spencer HB et al; Arch Environ Contam Toxicol 42 (4): 463-9 (2002)] **PEER REVIEWED** PubMed Abstract

/OTHER TERRESTRIAL SPECIES/ Acute toxicity of **tetrachloroethene** to earthworms (Eisenia foetida) ... has been reported. The earthworms were 2 months old and weighed 246-585 mg. They were exposed to **tetrachloroethene** in glass jars containing an artificial soil (10% peat, 20% kaolin clay, and 70% industrial sand) with a pH of 6 and absolute water content of 34%. The exposure period was 14 days at 20 deg C. Mortality and changes in biomass, behavior, and morphology were recorded, and the LC50 was determined by probit analysis. The highest test concentration causing no mortalities or changes in weight and behavior was 577 mg/kg, the lowest test concentration causing 100% mortality was >1000 mg/kg, and the LC50 was determined as 945 mg/kg. At 1000 mg/kg, worms refused to crawl into the substrate. As reported concentrations were nominal and no precautions were taken to prevent evaporation of **tetrachloroethene**, these results may underestimate actual toxicity.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/OTHER TERRESTRIAL SPECIES/ **Tetrachloroethene** toxicity has been studied in the carabid beetle (Poecilus cupreus). Beetles were exposed for 14 days in sand (99.7% silicon dioxide) moistened to 70% of its holding capacity with water containing **tetrachloroethene** (1.25 mg/L, equivalent to 5 mg/kg sand). Mortality and behavioral changes were observed. There was then a 6-day rest period, followed by exposure to **tetrachloroethene** for a further 11 days, with **tetrachloroethene** applications (3 mg/kg) occurring every 2 days. In the acute tests, no mortality or behavioral changes were observed, although there was an 18% reduction in feeding rate. In the chronic study, no mortality or behavioral changes were observed, although a 14% reduction in feeding rate was observed.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/OTHER TERRESTRIAL SPECIES/ An acute toxicity test ... /was/ carried out in the soil-dwelling springtail (Folsomia candida). The test was modified by using a standard soil (LUFA Speyer) instead of an artificial soil. In the acute test, the springtails were exposed for 24 hr to **tetrachloroethene** concentrations of 0.1, 1.0, 10, 100, or 1000 mg/kg dry weight, and the 24-hr EC50 was calculated as 113 mg/kg. The organic matter content of the test soil was reported as 0.7%, so the 24-hr EC50 was 549 mg/kg when converted to standard organic matter content (3.4%) ...

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/PLANTS/ ... In a field experiment ... a 10-year-old Serbian spruce (Picea omorica) was continually exposed to trichloroethylene and **tetrachloroethylene** for 7 months. The effects observed included chlorosis, necrosis and premature loss, particularly on the sun-exposed faces of the needles. Along several of the sun-exposed twigs, a total loss of chlorophyll was observed. The damage intensified after periods of clear, sunny days. The same toxic effects were observed on the sun-exposed leaves of a hornbeam shrub (Carpinus betulus) located about 2 m downwind from the spruce tree. Concentrations of trichloroethylene among the branches of the spruce ranged from 2.7 to 10.8 mg/cu m (mean = 4.6 mg/cu m) during the study. Concentrations of **tetrachloroethylene** ranged from 3.4 to 13.7 mg/cu m (mean = 11.8 mg/cu m). /It was also/ demonstrated that exposure to similar concentrations of trichloroethylene or **tetrachloroethylene**, in combination with visible/ultraviolet radiation, in the laboratory caused a similar degree of depression in photosynthetic pigments in Norway spruce needles (Picea abies).

[Canadian EPA Priority Substances List Assessment Report for Trichloroethylene p.21 (1993). Available from, as of September 10, 2010: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/index-eng.php **PEER REVIEWED**

/PLANTS/ In a study of effects on the early developmental stage of oats (Avena sativa), germinated plants were exposed for 16 days to **tetrachloroethene** at 1, 10, 100, or 1000 mg/kg dry weight in a standard soil. The 16-day NOEC (growth) was 100 mg/kg, the 16-day NOEC (sublethal effects) was 1 mg/kg, and the 16-day EC50 (growth) was 580 mg/kg. The organic matter content of the test soil was reported as 2.29%. This gives a 16-day NOEC (growth) of 148 mg/kg, a 16-day NOEC (sublethal effects) of 1.48 mg/kg, and a 16-day EC50 (growth) of 861 mg/kg when converted to a standard organic matter content.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/PLANTS/ Cuttings of a hybrid poplar (Populus deltoides /and/ nigra DN34) were exposed to **tetrachloroethene** in hydroponic solutions in closed vessels, to reduce volatilization and maintain concentrations. Solutions were replaced every 2 days, and the concentrations were confirmed by analysis. The mass of the cuttings was determined after 2 weeks of exposure. The use of water by the plants was also monitored at 2-day intervals as a measure of the transpiration rate. The results were presented as the concentration that resulted in no increase in the mass of the plants over the 2-week period (45 mg/L) and as the concentration producing a 50% reduction in the transpiration rate

over the same period (38 mg/L).

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/FIELD STUDIES/ In field studies, **tetrachloroethene** was added to a natural pond at nominal concentrations of 25 and 250 mg/L. The initial concentrations, were measured at 0.44 mg/L and 1.2 mg/L, respectively, and were below the detection limit (0.1 mg/L) after 7 weeks ... The numbers of Daphnia declined to zero within 1 day at the higher concentration and within 3.5 days at the lower concentration.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

National Toxicology Program Studies:

The bioassay of USP grade **tetrachloroethylene** for possible carcinogenicity was conducted using Osborne-Mendel rats and B6C3F1 mice. **Tetrachloroethylene** in corn oil was admin by gavage at either of two dosages to groups of 50 male and 50 female animals of each species, 5 days/wk, over a period of 78 wk followed by an observation period of 32 wk for rats and 12 wk for mice. Initial dosage levels for the chronic bioassay were selected on the basis of a preliminary subchronic toxicity test. Subsequent dosage adjustments were made during the course of the chronic bioassay. The high and low time weighted avg dosages of **tetrachloroethylene** in the chronic study were 941 and 471 mg/kg/day for the male rats, 949 and 474 mg/kg/day for the female rats, 1072 and 536 mg/kg/day for the male mice, and 772 and 386 mg/kg/day for the female mice. For each species, 20 animals of each sex were placed on test as vehicle controls. These animals were gavaged with corn oil at the same time that dosed animals were gavaged with **tetrachloroethylene** mixtures. Twenty animals of each sex were placed on test as untreated controls for each species. These animals received no gavage treatments. No significant incr incidence of neoplastic lesions was observed in treated rats. ... In both male and female mice, admin of **tetrachloroethylene** was associated with a significantly incr incidence of hepatocellular carcinoma. Hepatocellular carcinomas were observed in 2/17 (12%) untreated control males, 2/20 (10%) untreated control females, 0/20 vehicle control females, 19/48 (40%) low dose females, and 19/48 (40%) high dose females. Hepatocellular carcinomas metastasized to the kidney in one untreated control male and to the lung in three low dose males, one low dose female, and one high dose female. ... The results of the bioassay of **tetrachloroethylene** in Osborne-Mendel rats do not allow an evaluation of the carcinogenicity of this cmpd due to the high rate of early death among the treated animals. However, under the condition of this study, **tetrachloroethylene** was a liver carcinogen in B6C3F1 mice of both sexes. Levels of Evidence of Carcinogenicity: Male Rats: Inadequate study; Female Rats: Inadequate study; Male Mice: Positive; Female Mice: Positive.

[DHEW/NCI; Bioassay of Tetrachloroethylene for Possible Carcinogenicity (1977) Technical Rpt Series No. 13 DHEW Pub No. (NIH) 77-813] **PEER REVIEWED**

Toxicology and carcinogenesis studies of **tetrachloroethylene** (99.9%) pure were conducted by inhalation exposure of groups of 50 male and 50 female F344/N rats and B6C3F1 mice 6 hr/day 5 days/wk for 103 wk. The exposure concn used (0, 200 or 400 ppm for rats and 0, 100 or 200 ppm for mice) were selected on the basis of results from a 13 wk inhalation study. ... During the 2 yr studies, exposure to **tetrachloroethylene** did not consistently affect body wt gains in either rats or mice. ... Both concns of **tetrachloroethylene** were associated with incr incidences of mononuclear cell leukemia in male rats (28/50; 37/50; 37/50). In female rats, **tetrachloroethylene** incr the incidence of leukemia (18/50; 30/50; 29/50) and decr the time to occurrence of the disease. **Tetrachloroethylene** produced renal tubular cell karyomegaly in male and female rats, renal tubular cell hyperplasia in male rats, and renal tubular cell adenomas and adenocarcinomas (combined) in male rats (1/49; 3/49; 4/50). The incidence of renal tubular cell tumors was statistically significant; these uncommon tumors have been consistently found at low incidences in male rats in other 2 yr studies of chlorinated ethanes and ethylenes. One low dose male rat had a kidney lipoma, and another had a nephroblastoma. Four high dose male and two high dose female rats had gliomas of the brain, whereas

one control male and one control female had this tumor. In male and female mice, **tetrachloroethylene** caused dose related incr in the incidences of hepatocellular neoplasms. In males, **tetrachloroethylene** at 200 ppm incr the incidence of hepatocellular adenomas (11/49; 8/49; 18/50) and at both concn incr the incidence of hepatocellular carcinomas (7/49; 25/49; 26/50). In female mice, **tetrachloroethylene** at both concn incr the incidences of hepatocellular carcinoma (1/48; 13/50; 36/50). **Tetrachloroethylene** also produced renal cell karomegaly in both sexes of mice, and one low dose male mouse had a tubular cell adenocarcinoma. In these inhalation studies, there was no neoplastic changes in the respiratory tracts of either species, but there was an incr in the incidence of squamous metaplasia in the nasal cavities in dosed male rats (0/50; 5/50; 5/50). ... Under the conditions of these 2 yr inhalation bioassays, there was clear evidence of the carcinogenicity of **tetrachloroethylene** for male F344/N rats as shown by incr incidence of mononuclear cell leukemia and uncommon renal tubular cell neoplasms. There was some evidence of carcinogenicity of **tetrachloroethylene** for female F344/N rats as shown by incr incidences of mononuclear cell leukemia. There was clear evidence of carcinogenicity for B6C3F1 mice as shown by incr incidences of both hepatocellular adenomas and carcinomas in males and of hepatocellular carcinomas in females.

[DHHS/NTP; Toxicology & Carcinogenesis Studies of Tetrachloroethylene in F344/N Rats and B6C3F1 Mice (Inhalation Studies) Technical Report Series No. 311 (1986) NIH Publication No. 86-2567] **PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 2400-13000 mg/kg bw

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LD50 Rat oral 2629 mg/kg

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2857] **PEER REVIEWED**

LD50 Rat oral 320 mg/kg bw

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 83 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

LD50 Rat ip 4678 mg/kg

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2857] **PEER REVIEWED**

LD50 Rat (male) gavage 3835 mg/kg

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

LD50 Rat (female) gavage 3005 mg/kg

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

LC50 Rat inhalation 4100 ppm/6 hr

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at:

http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LC50 Rat inhalation 5000 ppm/8 hr

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LC50 Mouse inhalation 5200 ppm/4 hr

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LC50 Mouse inhalation 2978 ppm/6 hr

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LC50 Rat inhalation 4000 ppm/ 4hr

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

LC50 Rat Inhalation 2445 ppm/ 4 hr

[National Industrial Chemicals Notification and Assessment Scheme; Tetrachloroethylene (127-18-4) Assessment Report No. 15 p. 46 (June 2001). Available from as of September 29, 2010: http://www.nicnas.gov.au/Publications/CAR/PEC.asp **PEER REVIEWED**

LC50 Rat inhalation 34,300 mg/cu m/8 hr

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2857] **PEER REVIEWED**

LD50 Mouse oral 6000-8571 mg/kg bw

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V63 191 (1995)] **PEER REVIEWED**

LD50 Mouse oral 8800 to 10,800 mg/kg

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

LD50 Mouse sc 65 g/kg (65,000 mg/kg)

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2858] **PEER REVIEWED**

LD50 Mouse sc 1109 mg/kg bw

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 92 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

LC50 Mouse Inhalation 2445- 5200 ppm/ 4 hr

[National Industrial Chemicals Notification and Assessment Scheme; Tetrachloroethylene (127-18-4) Assessment Report No. 15 p. 46 (June 2001). Available from as of September 29, 2010: http://www.nicnas.gov.au/Publications/CAR/PEC.asp **PEER REVIEWED**

LC50 Mouse inhalation 40,000 mg/cu m/ 2 hr

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

LC50 Mouse inhalation 20,200 mg/cu m/ 6 hr

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

LD50 Dog ip 2100 mg/kg

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2858] **PEER REVIEWED**

Ecotoxicity Values:

LC50; Species: Limanda limanda (dab); Conditions: flow-through bioassay; Concentration: 5 mg/L for 96 hr

[Pearson CR, McConnell G; WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

LC50; Species: Tanytarsus dissimilis (midge); Conditions: static bioassay; Concentration: 30,840 ug/L for 48 hr

[USEPA; Task 11, Contract No 68-01-3887 (1980) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.B-1 (1980) EPA 440/5-80-073] **PEER REVIEWED**

LC50; Species: Jordanella floridae (American flagfish); Concentration: 8.4 mg/L for 96 hr /Conditions of bioassay not specified in source examined/

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

LC50; Species: Daphnia magna (water flea); Conditions: static bioassay, 22 deg C; Concentration: 18 mg/L for 48 hr

[Le Blanc GA; WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

EC50; Species: Daphnia magna (Water flea, age <24 hr first instar); Conditions: freshwater, static, 20 deg C, pH 7.0-7.5, hardness 44.7 mg/L CaCO3 (43.5-47.5 mg/L CaCO3); alkalinity 41.5 mg/L CaCO3 (37.0-45.5 mg/L CaCO3),

dissolved oxygen 4.1-8.4 mg/L; Concentration: 7500 ug/L for 48 hr (95% confidence limit: 6100-9000 ug/L); Effect: intoxicaiton, immobilization /95-99% pure/

[Richter JE et al; Arch Environ Contam Toxicol 12 (6): 679-84 (1983) as cited in the ECOTOX database. Available from, as of October 20, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

EC50; Species: Daphnia magna (Water flea, age <24 hr first instar); Conditions: freshwater, static, 20 deg C, pH 7.1-7.7, hardness 44.7 mg/L CaCO3 (43.5-47.5 mg/L CaCO3); alkalinity 41.5 mg/L CaCO3 (37.0-45.5 mg/L CaCO3), dissolved oxygen 7.9-9.9 mg/L; Concentration: 8500 ug/L for 48 hr (95% confidence limit: 7000-11000 ug/L); Effect: intoxicaiton, immobilization /95-99% pure/

[Richter JE et al; Arch Environ Contam Toxicol 12 (6): 679-84 (1983) as cited in the ECOTOX database. Available from, as of October 20, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Daphnia magna (Water flea, age <24 hr first instar); Conditions: freshwater, static, 20 deg C, pH 7.1-7.7, hardness 44.7 mg/L CaCO3 (43.5-47.5 mg/L CaCO3); alkalinity 41.5 mg/L CaCO3 (37.0-45.5 mg/L CaCO3), dissolved oxygen 7.9-9.9 mg/L; Concentration: 18000 ug/L for 48 hr (95% confidence limit: 16000-22000 ug/L) /95-99% pure/

[Richter JE et al; Arch Environ Contam Toxicol 12 (6): 679-84 (1983) as cited in the ECOTOX database. Available from, as of October 20, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Daphnia magna (Water flea, age <24 hr first instar); Conditions: freshwater, static, 20 deg C, pH 7.0-7.5, hardness 44.7 mg/L CaCO3 (43.5-47.5 mg/L CaCO3); alkalinity 41.5 mg/L CaCO3 (37.0-45.5 mg/L CaCO3), dissolved oxygen 4.1-8.4 mg/L; Concentration: 9100 ug/L for 48 hr (95% confidence limit: 7700-11000 ug/L) /95-99% pure/

[Richter JE et al; Arch Environ Contam Toxicol 12 (6): 679-84 (1983) as cited in the ECOTOX database. Available from, as of October 20, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Cyprinodon variegatus (sheepshead minnow); Conditions: static bioassay; Concentration: 29-52 mg/L for 96 hr

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p.63 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

LC50; Species: Lepomis macrochirus (bluegill sunfish); Concentration: 46 mg/L for 24 hr at 21-23 deg C (95% confidence limit 11-15 mg/L) /Conditions of bioassay not specified in source examined/

[Buccafusco RJ et al; Bull Environ Contam Toxicol 26: 446 (1981)] **PEER REVIEWED**

LC50; Species: Lepomis macrochirus (bluegill sunfish); Conditions: static bioassay, 21-23 deg C; Concentration: 13 mg/L for 96 hr (95% confidence limit 11-15 mg/L)

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 63 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

LC50; Species: Leuciscus idus (ide); Concentration: 130 mg/L for 96 hr /Conditions of bioassay not specified in source examined/

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (rainbow trout); Conditions: static bioassay, 12 deg C, Concentration: 5 mg/L for

96 hr

[Shubat PJ et al; WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout); Conditions: freshwater, flow through, 11.6 deg C, pH 7.13, hardness 44 mg/L CaCO3, alkalinity 46.9 mg/L CaCO3, dissolved oxygen 81.6%; Concentration: 5000 ug/L for 24 hr /99% purity/

[Shubat PJ et al; Bull Environ Contam Toxicol 28 (1): 7-10 (1982) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout); Conditions: freshwater, flow through, 12.2 deg C, pH 7.23, hardness 46 mg/L CaCO3, alkalinity 46.5 mg/L CaCO3, dissolved oxygen 80.7%; Concentration: >6000 to <7000 ug/L for 24 hr /99% purity/

[Shubat PJ et al; Bull Environ Contam Toxicol 28 (1): 7-10 (1982) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout); Conditions: freshwater, flow through, 11.6 deg C, pH 7.13, hardness 44 mg/L CaCO3, alkalinity 46.9 mg/L CaCO3, dissolved oxygen 81.6%; Concentration: 4990 ug/L for 96 hr (95% confidence interval: 4730-5270 ug/L) /99% purity/

[Shubat PJ et al; Bull Environ Contam Toxicol 28 (1): 7-10 (1982) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Oncorhynchus mykiss (Rainbow trout); Conditions: freshwater, flow through, 12.2 deg C, pH 7.23, hardness 46 mg/L CaCO3, alkalinity 46.5 mg/L CaCO3, dissolved oxygen 80.7%; Concentration: 5840 ug/L for 96 hr (95% confidence interval: 5050-6760 ug/L) /99% purity/

[Shubat PJ et al; Bull Environ Contam Toxicol 28 (1): 7-10 (1982) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Oryzias latipes (Japanese medaka, 1-day-old egg viability); Concentration: 27mg/L for 96 hr (95% CI 19.5-32.9 mg/L) /Conditions of bioassay not specified in source examined/

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

LC50; Species: Oryzias latipes (Japanese Medaka); Conditions: static bioassay, 20 deg C; Concentration: 1.6 mg/L for 48 hr

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 63 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

EC50; Species: Pimephales promelas (Fathead minnow, weight 1.04 g, length 49.0 mm); Conditions: freshwater, flow through, 12 deg C, pH 7.8-8.0, dissolved oxygen > or =5.0 mg/L; Concentration: 14400 ug/L for 24, 48, 72, 96 hr; Effect: intoxicaiton, immobilization

[Alexander HC et al; Bull Environ Contam Toxicol 20 (3): 344-52 (1978) as cited in the ECOTOX database. Available from, as of October 20, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (fathead minnow); Conditions: flow-through bioassay, 12 deg C; Concentration: 18.4 mg/L for 96 hr

[European Commission, ESIS; IUCLID Dataset, Tetrachloroethylene (127-18-4) p. 61 (2000 CD-ROM edition). Available from, as of September 23, 2010: http://esis.jrc.ec.europa.eu/ **PEER REVIEWED**

LC50; Species: Pimephales promelas (fathead minnow); Conditions: static; Concentration: 21.4 mg/L for 96 hr
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 1080] **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, age 30-35 days); Conditions: freshwater, flow through, 25 deg C, pH 6.7-7.6, hardness 45.1 (45.0-45.5) mg/L CaCO3, alkalinity 41.8 (35.6-43.4) mg/L CaCO3, dissolved oxygen 8.0 (7.6-9.2) mg/L; Concentration: 17900 ug/L for 24 hr (95% confidence interval: 17300-18400 ug/L)
[Walbridge CT et al; Arch Environ Contam Toxicol 12 (6): 661-6 (1983) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, age 30-35 days); Conditions: freshwater, flow through, 25 deg C, pH 6.7-7.6, hardness 45.1 (45.0-45.5) mg/L CaCO3, alkalinity 41.8 (35.6-43.4) mg/L CaCO3, dissolved oxygen 8.0 (7.6-9.2) mg/L; Concentration: 15900 ug/L for 48 hr (95% confidence interval: 15000-16800 ug/L)
[Walbridge CT et al; Arch Environ Contam Toxicol 12 (6): 661-6 (1983) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, age 30-35 days); Conditions: freshwater, flow through, 25 deg C, pH 6.7-7.6, hardness 45.1 (45.0-45.5) mg/L CaCO3, alkalinity 41.8 (35.6-43.4) mg/L CaCO3, dissolved oxygen 8.0 (7.6-9.2) mg/L; Concentration: 14900 ug/L for 72 hr (95% confidence interval: 13900-15800 ug/L)
[Walbridge CT et al; Arch Environ Contam Toxicol 12 (6): 661-6 (1983) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, age 30-35 days); Conditions: freshwater, flow through, 25 deg C, pH 6.7-7.6, hardness 45.1 (45.0-45.5) mg/L CaCO3, alkalinity 41.8 (35.6-43.4) mg/L CaCO3, dissolved oxygen 8.0 (7.6-9.2) mg/L; Concentration: 13400 ug/L for 96 hr (95% confidence interval: 12400-14400 ug/L)
[Walbridge CT et al; Arch Environ Contam Toxicol 12 (6): 661-6 (1983) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, weight 1.04 g, length 49.0 mm); Conditions: freshwater, flow through, 12 deg C, pH 7.8-8.0, dissolved oxygen > or =5.0 mg/L; Concentration: 18400 ug/L for 96 hr (95% confidence interval: 14800-21300 ug/L)
[Alexander HC et al; Bull Environ Contam Toxicol 20 (3): 344-52 (1978) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, weight 1.04 g, length 49.0 mm); Conditions: freshwater, static, 12 deg C, pH 7.8-8.0, dissolved oxygen > or =5.0 mg/L; Concentration: 21400 ug/L for 96 hr (95% confidence interval: 16500-26400 ug/L) /formulation/
[Alexander HC et al; Bull Environ Contam Toxicol 20 (3): 344-52 (1978) as cited in the ECOTOX database. Available from, as of October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Pimephales promelas (Fathead minnow, age 28-34 days juvenile, weight 0.12 g); Conditions: freshwater, flow through, 25 deg C, pH 7.6, hardness 44.6 mg/L CaCO3, alkalinity 44.0 mg/L CaCO3, dissolved oxygen > or =80 mg/L; Concentration: 23800 ug/L for 96 hr (95% confidence interval: 20900-26400 ug/L) /formulation/
[Broderius S, Kahl M; Aquat Toxicol 6: 302-22 (1985) as cited in the ECOTOX database. Available from, as of

October 26, 2010: http://cfpub.epa.gov/ecotox/quick_query.htm **PEER REVIEWED**

LC50; Species: Poecilia reticulata (guppy); Concentration: 18 ppm for 7 days /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 1080] **PEER REVIEWED**

Ongoing Test Status:

The following link will take the user to the National Toxicology Program (NTP) Test Agent Search Results page, which tabulates all of the "Standard Toxicology & Carcinogenesis Studies", "Developmental Studies", and "Genetic Toxicity Studies" performed with this chemical. Clicking on the "Testing Status" link will take the user to the status (i.e., in review, in progress, in preparation, on test, completed, etc.) and results of all the studies that the NTP has done on this chemical.
[Available from: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=127-18-4

TSCA Test Submissions:

The ability of **tetrachloroethylene** to induce morphological transformation in the BALB/3T3 mouse cell line (Cell Transformation assay) was evaluated. Based on preliminary toxicity test determinations (exposure time=3 days), **tetrachloroethylene** was tested at 0, 2, 10, 50 and 250 ug/ml, with cell survival ranging from 100% to 51% relative to untreated controls. None of the tested concentrations produced significantly greater transformation frequencies relative to untreated controls.
[Arthur D. Little, Inc.; Cell Transformation Assays of 11 Chlorinated Hydrocarbon Analogs. (1983), EPA Document No. 40-8324457, Fiche No. OTS0509392] **UNREVIEWED**

The mutagenicity of **tetrachloroethylene** was evaluated in Salmonella tester strains TA98, TA100, TA1535 and TA1537 (Ames Test), both in the presence and absence of added metabolic activation by Aroclor-induced rat liver S9 fraction. **Tetrachloroethylene** did not cause a positive response in any of the tester strains with or without added metabolic activation. **Tetrachloroethylene** was evaluated using a protocol in which the test article was usually tested over a minimum of 6 dose levels, the highest nontoxic dose level being 10 mg/plate unless solubility, mutagenicity or toxicity dictated a lower upper limit.
[SRI International; Investigations of the Species Sensitivity and Mechanism of Carcinogenicity of Halogenated Hydrocarbons. (1984), EPA Document No. 40-8424225, Fiche No. OTS0509408] **UNREVIEWED**

The ability of **tetrachloroethylene** to induce DNA repair in the hepatocyte primary culture (HPC) system was evaluated using hepatocytes from male B6C3F1 mice and Osborne-Mendel rats. In both the mouse and rat HPC/DNA repair assays, **tetrachloroethylene** was cytotoxic from 0.01% to 0.1% and was not genotoxic from 0.001% to 0.00001%.
[Naylor Dana Institute; DNA Repair Tests of 11 Chlorinated Hydrocarbon Analogs, Final Report. (1983), EPA Document No. 40-8324292, Fiche No. OTS0509403] **UNREVIEWED**

Metabolism/ Pharmacokinetics:

Metabolism/ Metabolites:

Despite the low overall metabolism of **tetrachloroethylene** compared with other chlorinated solvents, its metabolism has been studied extensively in both human volunteers and laboratory animals, using both in vivo and in vitro techniques. The studies showed that many metabolites are produced, including some known to be cytotoxic, mutagenic or both. **Tetrachloroethylene** metabolism can be viewed as having three pathways. The first is cytochrome P-450-mediated (CYP-mediated) oxidation. The second and third share a starting point: direct conjugation with glutathione to S-(1,2,2-trichlorovinyl)glutathione (TCVG) and then further processing to S-(1,2,2-trichlorovinyl)-L-cysteine (TCVC). For the second pathway, beta-lyase catalyzes the formation of reactive products from TCVC. The third pathway is independent of beta-lyase: TCVC is processed further by acetylation and sulfoxidation reactions. Genotoxic and cytotoxic metabolites are formed by each of these pathways. The predominant metabolic pathway is the CYP path, followed by the beta-lyase pathway and then the beta-lyase independent pathway. The TCVC derivatives are toxicologically important but quantitatively minor metabolites.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

Trichloroethylene (TRI) and **tetrachloroethylene** (TETRA) are solvents that have been widely used in a variety of industries, and both are widespread environmental contaminants. ... Seven human volunteers were exposed by inhalation to 1 ppm of TRI or TETRA for 6 hr, with biological samples collected for analysis during exposure and up to 6 days postexposure. Concentrations of TRI, TETRA, free trichloroethanol (TCOH), total TCOH (free TCOH plus glucuronidated TCOH), and trichloroacetic acid (TCA) were determined in blood and urine; TRI and TETRA concentrations were measured in alveolar breath. Toxicokinetic time courses and empirical analyses of classical toxicokinetic parameters were compared with those reported in previous human volunteer studies, most of which involved exposures that were at least 10 fold higher. Qualitatively, TRI and TETRA toxicokinetics were consistent with previous human studies. Quantitatively, alveolar retention and clearance by exhalation were similar to those found previously but blood and urine data suggest a number of possible toxicokinetic differences. For TRI, data from the current study support lower apparent blood-air partition coefficients, greater apparent metabolic clearance, less TCA production, and greater glucuronidation of TCOH as compared to previous studies. For TETRA, the current data suggest TCA formation that is similar or slightly lower than that of previous studies. Variability and uncertainty in empirical estimates of total TETRA metabolism are substantial, with confidence intervals among different studies substantially overlapping. ...

[Chiu WA et al; Toxicol Sci 95 (1): 23-36 (2007)] **PEER REVIEWED** PubMed Abstract

The two major products of **tetrachloroethylene** metabolism by the CYP pathway are trichloroacetyl chloride and oxalyl chloride.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

The beta-lyase pathway: **Tetrachloroethylene** is conjugated with glutathione to S-(1,2,2-trichlorovinyl) glutathione and is later processed by gamma-glutamyl transpeptidase and aminopeptidase to S-(1,2,2-trichlorovinyl)-L-cysteine (TCVC).

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW

FPL-049-059

Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

The beta-lyase-independent pathway: S-(1,2,2-trichlorovinyl)-L-cysteine (TCVC) undergoes acetylation to its mercapturate N-acetyl-TCVC and then sulfoxidation to N-acetyl-S-(1,2,2-trichlorovinyl)-L-cysteine (N-Ac-TCVCS), which is mediated by CYP3A or flavin-containing monooxygenase (FMO). In addition, TCVC undergoes sulfoxidation to TCVC-sulfoxide (TCVCS); this is also mediated by CYP3A or FMO.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

There are important differences between species in the metabolism and toxicity of **tetrachloroethylene**. Much work has focused on differences between humans and rats, particularly on differences that would influence the human risk of renal cancer that has been observed in rat bioassays. Comparison studies between rats and humans indicate that humans metabolize **tetrachloroethylene** less than rats.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

The CYP pathway is the predominant route of **tetrachloroethylene** metabolism in rats and humans. Plasma albumin adducted with the trichloro derivative, indicating metabolism by the CYP pathway, was found in rats and humans exposed to **tetrachloroethylene** at 40 ppm for 6 hours. ... Trichloroacetic acid (TCA) excretion by rats was about 23 fold that of humans; or humans excreted about 4.4% of the amount excreted by rats.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

Metabolism by the beta-lyase pathway results in formation of dichloro protein adducts and dichloroacetic acid (DCA). ... Protein adducts resulting from the beta-lyase-independent pathway have not been reported. N-Acetyl-S-(1,2,2-trichlorovinyl)-L-cysteine, the mercapturate, is excreted in urine.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

Metabolites: trichloroacetic acid; trichloroethanol; inorg chloride; trans-1,2-dichloroethylene in expired air. /From table/

[Sunshine, I. (ed.). CRC Handbook of Analytical Toxicology. Cleveland: The Chemical Rubber Co., 1969., p. 381] **PEER REVIEWED**

Metabolism ... is relatively slow with only few percent of dose being excreted as metabolites, major one being trichloroacetic acid...

[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan

Publishing Co., 1980., p. 476] **PEER REVIEWED**

In **tetrachloroethylene** exposure, urinary metabolite levels of trichloroethanol, total trichloro compounds, and trichloroacetic acid increased until the atmospheric concentration of the solvent reached 50 to 100 ppm; little increase in these metabolites occurred at higher solvent concentration.

[IKEDA M ET AL; BRIT J IND MED 29 (3): 328-33 (1972)] **PEER REVIEWED**

The relationship among dose, metabolism and hepatotoxicity in mice which resulted from subchronic exposure to the chlorinated solvents trichloroethylene and **perchloroethylene** were examined. Male Swiss-Cox mice received either trichloroethylene (0 to 3200 mg/kg/day) or **perchloroethylene** (0 to 2000 mg/kg/day) in corn oil by gavage for 6 weeks. Urinary metabolites from individual mice were quantified to estimate the extent to which each compound was metabolized. Four parameters of hepatotoxicity were assessed: liver weight, triglycerides, glucose-6-phophatase activity, and serum glutamic-pyruvic transaminase (SGPT) activity. Trichloroethylene sigificantly affected liver weight and glucose-6-phosphatase activity; **perchloroethylene** affected all four parameters. The metabolism of trichloroethylene was linearly related to dose through 1600 mg/kg, but then became saturated. The metabolism of **perchloroethylene** was saturable. The dose-effect curves of the affected hepatotoxicity parameters of both compounds were nonlinear and resembled the dose-metabolism graph of the corresponding solvent. Plots of the hepatotoxicity data of each compound against total urinary metabolites were linear in all cases, suggesting that the hepatotoxicity of both **perchloroethylene** and trichloroethylene in mice is directly related to the extent of their metabolism. This pattern is consistent with formation of the toxic intermediate in the primary metabolic pathway of each compound.

[Buben JA, O'Flaherty EJ; Toxicol Appl Pharmacol 78 (1): 105-22 (1985)] **PEER REVIEWED** PubMed Abstract

Trichloro compounds in the urine of workers exposed to 70-2710 mg/cu m for a few hours or repeatedly over several days were identified as metabolites of **tetrachloroethylene** ... Trichloroethanol was also found.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

The excretion of N-acetyl-S-(1,2,2-trichlorovinyl)-L-cysteine in humans (although lower when compared with rats) indicates that glutathione-dependent bioactivation reactions are operative in humans and may be involved in the slight nephrotoxicity observed after occupational **tetrachloroethene** exposure

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

As in humans, the major metabolite in laboratory animals is trichloroacetic acid. Several other minor metabolites have been found, including oxalic acid, dichloroacetic acid, ethylene glycol, trichloroacetyl amide, trichloroacetylaminoethanol, thioethers, and carbon dioxide.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Two biotransformation pathways operate. The main pathway is oxidative and occurs in the liver, the first step being epoxidation by cytochrome P450 to tetrachloro-oxirane, resulting in trichloroacetic acid as the major metabolite. Biotransformation via this pathway occurs mainly in the liver, which is the main target organ for **tetrachloroethene**'s toxicity and carcinogenicity. At higher exposures, a second pathway operates in the liver, the first step being the conjugation of **tetrachloroethene** with glutathione. This reaction is catalyzed by glutathione transferase and leads eventually to S-(1,2,2-trichlorovinyl)-L-cysteine, which can be cleaved in the kidneys by beta-lyase into cytotoxic and genotoxic metabolites. Although quantitatively a minor pathway it is important, as it offers a possible explanation for

the kidney tumors in male rats. Glutathione-S-transferase-mediated formation of S-(1,2,2-trichlorovinyl)glutathione is the initial step in a sequence of reactions finally resulting in the formation of reactive intermediates in the rodent kidney. The enzymatic rates of formation of S-(1,2,2-trichlorovinyl)glutathione in liver and kidney subcellular fractions from rats, mice, and both sexes of humans have been compared. In microsomal fractions from the liver and kidney of all three species, enzymatic formation of S-(1,2,2-trichlorovinyl)glutathione from **tetrachloroethene** could not be observed. Additionally, the ability of subcellular fractions in the human liver to catalyze the formation of S-(1,2,2-trichlorovinyl)glutathione from **tetrachloroethene** is at least 2 orders of magnitude lower than that of rat liver. Sex-specific differences in the extent of hepatic conjugation of **tetrachloroethene** with glutathione, which may be relevant for nephrotoxicity, occur in rats

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Regardless of the route of exposure, only l-3% of the absorbed **tetrachloroethylene** is metabolized to trichloroacetic acid (TCA) by humans, and the metabolism of **tetrachloroethylene** is saturable ...

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 88 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

The elimination and metabolism of (14)C-**tetrachloroethylene** (Tetra) was studied in female rats and mice after the oral administration of 800 mg/kg (14)C-Tetra. Elimination of unchanged Tetra was the main pathway of elimination in both species and amounted to 91.2% of the dose in rats and 85.1% in mice. (14)C-Carbon dioxide (CO2) was found to be a trace metabolite of (14)C-Tetra. Only a small part of the applied dose was transformed to urinary (rats = 2.3%, mice = 7.1%) and fecal (rats = 2.0%, mice = 0.5%) metabolites. The urinary metabolites were separated and quantified by high performance liquid chromatography (HPLC) and identified by gas chromatography/mass spectrometry (GC/MS). The following metabolites could be identified: oxalic acid (8.0% of urinary radioactivity in rats, 2.9% in mice), dichloroacetic acid (5.1%, 4.4%), trichloroacetic acid (54.0%, 57.8%), N-trichloroacetyl-aminoethanol (5.4%, 5.7%), trichloroethanol, free and conjugated (8.7%, 8.0%), S-1,2,2-trichlorovinyl-N-acetylcysteine (N-acetyl TCVC) (1.6%, 0.5%), and another conjugate of trichloroacetic acid (1.8%, 1.3%). The structures of the identified metabolites indicate two different pathways operative in Tetra biotransformation: cytochrome P-450-mediated epoxidation forming reactive metabolites in the liver and conjugation of Tetra with glutathione (GSH) catalyzed by glutathione transferase(s). The formation of reactive intermediates by renal processing of the glutathione conjugates may provide a molecular mechanism for the nephrotoxicity and nephrocarcinogenicity of Tetra in male rats.

[Dekant W et al; J Biochem Toxicol 1 (2): 57-72 (1986)] **PEER REVIEWED** PubMed Abstract

Enhanced excretion of thioethers in occupationally exposed women might have arisen from conjugation between glutathione and an epoxide formed from **tetrachloroethene**.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

/A study/ measured metabolites of **tetrachloroethene** in exhaled air, venous blood, and urine in six male Caucasians and six male Orientals. Observations were compared with predictions, and the models were modified based on ethnic differences in physiological parameters. Differences as high as 20% were often found in the physiological parameters, including differences in average body weight, tissue volumes, and blood flows. Asians exhibited significantly lower peak trichloroacetic acid concentrations and AUC values in urine but higher **tetrachloroethene** concentrations in expired breath and blood than Caucasians (considered consistent with a slower rate of metabolism in Asians), and there were distributional differences between the two ethnic groups. The magnitude of the ethnic differences observed in this study was relatively small, and factors such as differences in body size and other physiological parameters, including differences in various enzyme systems in biotransformation, may all be contributing factors.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number

68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Absorption, Distribution & Excretion:

Tetrachloroethylene is a volatile, lipophilic small molecule that is rapidly and extensively absorbed after inhalation and oral exposure. It can also be rapidly absorbed through the skin, but dermal absorption appears to be a less important route of exposure. In humans, inhalation exposure to **tetrachloroethylene** typically results, within a few hours of exposure, in a pseudoequilibrium between inspired air and blood although there can be substantial interindividual differences in absorption behavior. After oral dosing in animals, peak blood **tetrachloroethylene** concentrations are typically reached within 15-30 min, and systemic bioavailability is typically greater than 80%; once absorbed, **tetrachloroethylene** is rapidly distributed throughout the body, and well-perfused tissues reach a pseudoequilibrium with blood within a few minutes.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

Because of its lipophilicity, the highest concentrations of **tetrachloroethylene** are found in adipose tissue. In humans, the fat-to-blood concentration ratio has been estimated to be as high as 90:1. Relatively high concentrations are also observed in the liver and brain. On the basis of animal studies and sparse human data, the brain concentration of **tetrachloroethylene** is 4-8 times the blood concentration.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

The disposition of an absorbed dose of **tetrachloroethylene** occurs primarily through pulmonary excretion; metabolism is less important than for other chlorinated solvents, such as trichloroethylene. Mass-balance studies in rats with 14C-labeled **tetrachloroethylene** indicated that 70% or more of an oral or inhaled dose can be recovered in expired air as the parent compound. The next most important excreted fraction occurs in urine and feces, which may collectively account for up to 23% of an administered dose. A small portion of the dose (less than 3%) may be converted to CO2 and exhaled. Most of the radioactivity recovered in urine can be attributed to formation of trichloroacetic acid, a nonvolatile metabolite of **tetrachloroethylene** that is excreted primarily in urine. That general pattern of disposition of **tetrachloroethylene** appears to be consistent after both oral and inhalation dosing.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

... Readily absorbed through the lung and to a much smaller degree through skin or mucous membranes or following ingestion.

[Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 257] **PEER REVIEWED**

(36)Cl-**tetrachloroethylene** fed to rats is excreted largely unchanged in expired air (98% of dose in 2 days), and is metabolized, to only slight extent, into trichloroacetic acid (2%) which is excreted in urine.

[Parke, D. V. The Biochemistry of Foreign Compounds. Oxford: Pergamon Press, 1968., p. 213] **PEER REVIEWED**

Personal monitoring of exposure to **tetrachloroethylene** ... and analyses of urine for total trichloro-compounds were carried out in two groups of workers ... one group (20 males and 19 females) in dry-cleaning workshops and the other (16 males and 6 females) engaged in the removal of glue from silk cloth. Comparison of the urinary trichloro-compounds levels with **tetrachloroethylene** in the environment revealed that, while the metabolite levels increased essentially linear to **tetrachloroethylene** concn up to 100 ppm, leveling off was apparent in the metabolite excretion when the exposure to **tetrachloroethylene** was more intense (eg more than 100 ppm), indicating that the capacity of humans to metabolize **tetrachloroethylene** is rather limited. A tentative calculation ... indicated that, at the end of an 8 hr shift with exposure to **tetrachloroethylene** at 50 ppm (TWA), 38% of the **tetrachloroethylene** absorbed through the lung would be exhaled unchanged and less than 2% would be metabolized to be excreted into the urine, while the rest would remain in the body to be eliminated later.

[Ohtsuki T et al; Int Arch Occup Environ Health 51: 381-90 (1983)] **PEER REVIEWED** PubMed Abstract

Tetrachloroethylene was still detectable in the breath of rats 16 hr after a single exposure to levels of 339-3390 mg/cu m for 1-40 hr.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Male Sprague-Dawley rats exposed to (14)C-**tetrachloroethylene** by either gavage (1.0 mg/kg) or inhalation (10 ppm, 10.4 mg/kg) excreted 70% of the dose unchanged in expired air. Approximately 3% was excreted as carbon dioxide, and approximately 23% was excreted in the urine and feces as nonvolatile metabolites.

[NTP; Toxicology and Carcinogenesis Studies of Tetrachloroethylene p.19 Report #311 (1986) NIH Pub# 86-2567] **PEER REVIEWED**

Once in the bloodstream, **tetrachloroethylene** tends to distribute to body fat. In human tissue at autopsy, ratios of fat to liver concentrations are greater than 6:1

[McConnell G et al; Endeavor 34: 13-8 (1975) as cited in USEPA; Health Advisories for 25 Organics: Tetrachloroethylene p.307 (1987) PB 87-235578] **PEER REVIEWED**

An autopsy after a fatal **tetrachloroethylene** exposure revealed an 8 times greater concentration in brain compared with blood ...

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

Tetrachloroethylene reached near steady-state levels in blood of human volunteers within two hours of continuous exposure.

[Stewart RD et al; Arch Environ Health 2: 516 (1961) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-3 (1980) EPA 440/5-80-073] **PEER REVIEWED**

Absorption of **tetrachloroethylene** (PCE) through the skin by immersing the thumbs of volunteers in PCE for 40 minutes and measuring the PCE in the exhaled air. High concentrations of PCE in exhaled breath (160 to 260 ug/cu m) were measurable five hours after exposure.

[Stewart RD and Dodd HC; Am Ind Hug Assoc Jour 25: 439 (1964) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-4 (1980) EPA 440/5-80-073] **PEER REVIEWED**

FPL-049-064

Nine unrelated groups (659 males) working in plastic boat, chemical, plastic button, paint, and shoe factories were studied. Urine samples were collected at the beginning of the workshift and at the end of the first half of the shift. A close relationship (correlation coefficient always above 0.85) between the average environmental solvent concentration (mg/cu m) measured in the breathing zone and the urinary concentration of unchanged solvent (ug/L) was observed. The authors recommended a biological equivalent exposure limit of 101 ug/L. biological exposure data for urine collected over 4 hr during random sampling for at least 1 yr could be used to evaluate long-term exposure and probability of non-compliance for individual or groups of workers.

[Ghittori S et al; Am Ind Hyg Assoc J 48 (9): 786-90 (1987)] **PEER REVIEWED** PubMed Abstract

In vitro dermal absorption was measured for 3 volatile organic compounds in dilute aqueous soln through freshly prepared & previously frozen human skin. The permeability coefficients at 26 deg C for chloroform (0.14 cm/hr) & trichloroethylene (0.12 cm/hr) were similar but much larger than that for **tetrachloroethylene** (0.018 cm/hr). Storage of the skin at -20 deg C did not significantly affect the penetration of these chemicals. The dermal absorption of chloroform through freshly prepared human skin was not changed significantly by pretreatment of the skin with commonly used consumer products (moisturizer, baby oil, insect repellent, sunscreen); however, the permeability coefficient was found to increase from 0.071 cm/hr at 11 deg C to 0.19 cm/hr at 50 deg C. These data suggest that exposure estimates for chloroform & other contaminants in water should consider the appropriate exposure scenario to properly assess the dermal dose.

[Nakai JS et al; J Toxicol Environ Health 58 (3): 157-170 (1999)] **PEER REVIEWED**

During hyperventilation therapy, the relative contribution to the fast elimination process increased from 70% for physiological minute volume to 99.9%. A minor fraction of the ingested dose was excreted with the urine (integral of 1% during the first 3 days). In contrast to previous results, trace amounts of unchanged **tetrachloroethylene** were detected in the urine besides trichloroacetic acid and trichloroethanol.

[Koppel C et al; J Toxicol Clin Toxicol 23 (2-3): 103-15 (1985)] **PEER REVIEWED** PubMed Abstract

Tetrachloroethylene tends to distribute primarily to adipose tissue, and a fat-to-blood ratio of about 90:1 was observed.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

The rate of total urinary **tetrachloroethylene** metabolites excreted by workers occupationally exposed to **tetrachloroethylene** appeared to plateau when air concentrations approached 100 ppm.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

80 to 100% of the total uptake of tetracholorethylene in volunteers exposed by inhalation at 72 or 144 ppm for 4 hours was excreted unchanged via the lungs.

[American Conference of Governmental Industrial Hygienists. Documentation of the TLV's and BEI's with Other World Wide Occupational Exposure Values. CD-ROM Cincinnati, OH 45240-4148 2010.] **PEER REVIEWED**

Tetrachloroethylene /has been reportedly found/ in breast milk.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Dermal absorption was rapid in both mice and guinea-pigs, peak concentrations of **tetrachloroethylene** in the blood

of guinea-pigs being reached 30 minutes after application. The level of **tetrachloroethylene** in the blood of rats reached a maximum 1 hr after oral ingestion, or immediately after 6 hr inhalation.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Seventy-two hours after either oral administration (once by gavage, or for 12 hr in the drinking-water) or 6-hr inhalation of labeled **tetrachloroethylene** by rats and mice, less than 5% of the radioactivity was retained by the body. Most radioactivity was found in body fat, kidneys, and liver of rats. Some radioactivity was also found in the lung, heart, and adrenals.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

In short-term exposures of laying hens, via the feed, **tetrachloroethylene** was mainly deposited in fat and fat-containing tissues. The concentration of **tetrachloroethylene** in eggs and tissues increased proportionally with the concentration in the feed up to 575 mg/kg of feed.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

Exposure of volunteers to 678 mg/cu m for 7.5 hr per day, 5 days/week, resulted in a slightly higher alveolar excretion after each daily exposure.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

Excretion of **tetrachloroethylene** in cows' milk was found after oral ingestion of 100 mg/day with the feed. One percent of the intake was recovered in the milk.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

Tetrachloroethylene /was reportedly/ recovered in hen eggs at a rate of 0.6%, when the hens were repeatedly exposed via the feed.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

After controlled exposures to **tetrachloroethylene** concentrations of 488-1356 mg/cu m for 1-8 hr, less than 2% of the uptake was found as trichloroacetic acid in the urine. /It has been/calculated that 80-100% of the uptake was excreted unchanged via the lungs. The trichloroacetic acid concentration in the urine reached a plateau with repeated exposures above 340 mg/cu m.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

... The systemic toxicity and the presence of **tetrachloroethene** and its metabolites in the blood and urine of humans who accidentally ingested **tetrachloroethene** suggest that it is readily absorbed through the human gastrointestinal tract.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

A 10-min inhalation exposure of pregnant mice to 14C-radiolabelled **tetrachloroethene** /resulted in/ a high uptake of radioactivity in the maternal body fat, brain, nasal mucosa, blood, and well perfused organs such as liver, kidney, and lung. Both volatile (unchanged compound) and non-volatile (metabolite) radioactivity reached embryonic and fetal tissue, particularly the liver and blood. Volatile radioactivity in the fetus was always lower than in the corresponding maternal tissues and was not detected by 4 hr following exposure. Non-volatile radioactivity peaked at 4 hr. Following exposure on day 11 of pregnancy, radioactivity was high in the neuroepithelium of the developing fetal brain. If dams were exposed on day 17 of pregnancy, levels in the fetal brain were lower than in other organs. **Tetrachloroethene** concentrations in the amniotic fluid were 6-14% of those in maternal blood. Concentrations of radiolabelled metabolite (trichloroacetic acid) peaked in the maternal plasma, amniotic fluid, and fetus at 4 hr.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Tetrachloroethylene can cross the placenta and distribute to the fetus and amniotic fluid. Unmetabolized **tetrachloroethylene** was found in the fetoplacental unit following inhalation exposure of pregnant 657BL/6N mice to radioactive **tetrachloroethylene** for 10 minutes or 1 hour.

[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 97-98 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

Trichloroethylene (TRI) and **tetrachloroethylene** (TETRA) are solvents that have been widely used in a variety of industries, and both are widespread environmental contaminants. In order to provide a better basis for understanding their toxicokinetics at environmental exposures, seven human volunteers were exposed by inhalation to 1 ppm of TRI or TETRA for 6 hr, with biological samples collected for analysis during exposure and up to 6 days postexposure. Concentrations of TRI, TETRA, free trichloroethanol (TCOH), total TCOH (free TCOH plus glucuronidated TCOH), and trichloroacetic acid (TCA) were determined in blood and urine; TRI and TETRA concentrations were measured in alveolar breath. Toxicokinetic time courses and empirical analyses of classical toxicokinetic parameters were compared with those reported in previous human volunteer studies, most of which involved exposures that were at least 10 fold higher. Qualitatively, TRI and TETRA toxicokinetics were consistent with previous human studies. Quantitatively, alveolar retention and clearance by exhalation were similar to those found previously but blood and urine data suggest a number of possible toxicokinetic differences. For TRI, data from the current study support lower apparent blood-air partition coefficients, greater apparent metabolic clearance, less TCA production, and greater glucuronidation of TCOH as compared to previous studies. For TETRA, the current data suggest TCA formation that is similar or slightly lower than that of previous studies. Variability and uncertainty in empirical estimates of total TETRA metabolism are substantial, with confidence intervals among different studies substantially overlapping. Relative contributions to observed differences from concentration-dependent toxicokinetics and interindividual and interoccasion variability remain to be determined.

[Chiu WA et al; Toxicol Sci 95 (1): 23-36 (2007)] **PEER REVIEWED** PubMed Abstract

NMRI mice were orally exposed to **tetrachloroethylene** at 0.05 or 0.1 mg/kg per day ... **tetrachloroethylene** was found to accumulate in the spleen.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

Biological Half-Life:

The elimination of **tetrachloroethylene** in expired air ranged from 50 to 150 ppm (339 to 1,017 mg/cu m) for up to 8 hr. Biological half-life for fat stores was 71.5 hr.

[Gruberan E, Fernandez J; Brit J Ind Med 31: 159 (1974)] **PEER REVIEWED**

The biological half-life of **tetrachloroethylene** metabolites (as measured as total trichloro-compounds) is 144 hours.

[Ikeda M and Imamura T; Int Arch Arbeitsmed 31: 209 (1973) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-4 (1980) EPA 440/5-80-073] **PEER REVIEWED**

The excretion via blood and lungs occurred at 3 different rate constants with half-lives of 12-16 hr, 30-40 hr, and about 55 hr, respectively, 20, 50, and 100 hr after exposure. Trichloroacetic acid was excreted from blood with a half-life of 75-80 hr ... The half-life of this metabolite in urine /is/ about 6 days.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Elimination is slow (biological half-life of 65 hours for exhaled **perchloroethylene**) because of continuing release of **perchloroethylene** from fat stores.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

Half-lives for respiratory elimination range from 1 to 72 hr.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Mechanism of Action:

... While the mechanism by which **tetrachlorethylene** acts /to cause neurotoxicity/ is unknown, the evidence is good that it acts on ligand-gated ion channels like other organic solvents.

[Committee to Review EPA's Toxicological Assessment of Tetrachloroethylene, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of Tetrachloroethylene. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001. Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html **PEER REVIEWED**

The mutagenicity of **tetrachloroethene** (tetra) and its S conjugate, S-(1,2,2-trichlorovinyl)glutathione (TCVG) was investigated using a modified Ames preincubation assay. TCVG was a potent mutagen in presence of rat kidney particulate fractions containing high concentrations of gamma-glutamyl transpeptidase (GGT) and dipeptidases. Purified tetra was not mutagenic without exogenous metabolic activation or under conditions favoring oxidative metabolism. Preincubation of tetra with purified rat liver glutathione (GSH) S-transferases in presence of GSH and rat kidney fractions resulted in a time-dependent formation of TCVG as determined by (HPLC) analysis and in an unequivocal mutagenic response in the Ames test. Experiments with tetra in the isolated perfused rat liver demonstrated TCVG formation and its excretion with the bile; bile collected after the addition of tetra to the isolated perfused liver was unequivocally mutagenic in bacteria in the presence of kidney particulate fractions. The mutagenicity was reduced in all cases by the GGT inhibitor serine borate or the beta-lyase inhibitor aminooxyacetic acid. These results support the suggestion that cleavage of the GSH S conjugate formed from tetra by the enzymes of the mercapturic acid pathway and by beta-lyase may be involved in the nephrocarcinogenic effects of this haloalkene in rats.

[Vamvakas S et al; J Biochem Toxicol 4 (1): 21-7 (1989)] **PEER REVIEWED** PubMed Abstract

... /**Tetrachloroethylene** has been/ shown ... to release lysosomal enzymes from granular fractions prepared from nematodes, since gut of nematodes seems to be specialized for lysosomal intracellular digestion of nutrients, interference with this process may well explain action of **tetrachloroethylene** ... It has been assumed that affected worms are paralyzed sufficiently to release their attachment to intestinal wall ...

[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975., p. 1031] **PEER REVIEWED**

The mechanisms underlying the acute neurophysiological and behavioral effects of volatile organic compounds (VOCs) remain to be elucidated. However, the function of neuronal ion channels is perturbed by VOCs. The present study examined effects of toluene (TOL), trichloroethylene (TCE), and **perchloroethylene** (PERC) on whole-cell calcium current (ICa) in nerve growth factor-differentiated pheochromocytoma (PC12) cells. All three VOCs affected ICa in a reversible, concentration-dependent manner. At +10-mV test potentials, VOCs inhibited ICa, whereas at test potentials of -20 and -10 mV, they potentiated it. The order of potency for inhibition (IC50) was PERC (270 uM) > TOL (720 uM) > TCE (1525 uM). VOCs also changed ICa inactivation kinetics from a single- to double-exponential function. Voltage-ramp experiments suggested that VOCs shifted ICa activation in a hyperpolarizing direction; this was confirmed by calculating the half-maximal voltage of activation (V1/2, act) in the absence and presence of VOCs using the Boltzman equation. V(1/2, act) was shifted from approximately -2 mV in control to -11, -12, and -16 mV by TOL, TCE, and PERC, respectively. Similarly, VOCs shifted the half-maximal voltage of steady-state inactivation (V1/2, inact) from approximately -16 mV in control to -32, -35, and -20 mV in the presence of TOL, TCE, and PERC, respectively. Inhibition of ICa by TOL was confirmed in primary cultures of cortical neurons, where 827 uM TOL inhibited current by 61%.

[Shafer TJ et al; J Pharmacol Exp Ther 315 (3): 1109-18 (2005)] **PEER REVIEWED** PubMed Abstract

Interactions:

... In a field experiment ... a 10-year-old Serbian spruce (Picea omorica) was continually exposed to trichloroethylene and **tetrachloroethylene** for 7 months. The effects observed included chlorosis, necrosis and premature loss, particularly on the sun-exposed faces of the needles. Along several of the sun-exposed twigs, a total loss of chlorophyll was observed. The damage intensified after periods of clear, sunny days. The same toxic effects were observed on the sun-exposed leaves of a hornbeam shrub (Carpinus betulus) located about 2 m downwind from the spruce tree. Concentrations of trichloroethylene among the branches of the spruce ranged from 2.7 to 10.8 mg/cu m (mean = 4.6 mg/cu m) during the study. Concentrations of **tetrachloroethylene** ranged from 3.4 to 13.7 mg/cu m (mean = 11.8 mg/cu m). /It was also/ demonstrated that exposure to similar concentrations of trichloroethylene or **tetrachloroethylene**, in combination with visible/ultraviolet radiation, in the laboratory caused a similar degree of depression in photosynthetic pigments in Norway spruce needles (Picea abies).

[Canadian EPA Priority Substances List Assessment Report for Trichloroethylene p.21 (1993). Available from, as of September 10, 2010: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/index-eng.php **PEER REVIEWED**

/When formerly used/ ... alcohol must be avoided before and for 24 hours after use of **tetrachloroethylene**. ... No laxative should be given, since this increases the toxic effects and decreases the effectiveness of the drug.

[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986., p. 1612] **PEER REVIEWED**

Intubation of rats with mixtures of benzene and **tetrachloroethylene** yielded a combined toxicity which was only slightly less than additive. Mixtures of toluene with **tetrachloroethylene** resulted in LD50 values of less than than

predicted for simple additivity, indicating synergistic effects.

[USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-17 (1980) EPA 440/5-80-073] **PEER REVIEWED**

There is evidence of hepatotoxic effects caused by **Perchloroethylene** (PCE), presumably due to reactive metabolic intermediates; lipid peroxidation is under study as a potential mechanism of toxicity. /This study sought/ to verify if PCE levels comparable to those reached in the blood of exposed subjects can cause cell damage and lipid peroxidation. The association of PCE with lipid peroxidation inducing drugs (cyclosporine A, valproic acid and amiodarone) was also tested on rat isolated hepatocytes. AST and LDH release, MTT test and lipid peroxidation assay showed that PCE determines dose-dependent effects on rat isolated hepatocytes. The toxic potential resulting from /the/ data would be valproic acid < cyclosporine A < amiodarone. While valproic acid and cyclosporine caused a mild toxicity, the effects of amiodarone were more severe; in particular, the association of PCE with amiodarone showed a clear additive effect. The role of lipid peroxidation in the liver toxicity exerted by the tested compounds was confirmed by /the/ data, and resulted relevant after treatment of cells with amiodarone and PCE. Extrapolating these results to human, /it is suggested/ that a subject professionally exposed to PCE, who chronically assumes a lipid peroxidation inducing drug like amiodarone, may be potentially exposed to a higher risk of liver toxicity.

[Costa C et al; Toxicol In Vitro 18 (1): 37-44 (2004)] **PEER REVIEWED** PubMed Abstract

Pharmacology:

Therapeutic Uses:

MEDICATION (VET): After the advent of phenothiazine ... little use has been made of the chlorinated hydrocarbons ... /as a ruminant anthelmintic/. **Tetrachloroethylene** has continued to be used in small animals over the years but has been largely replaced by drugs that are less toxic & easier to admin. /Former use/

[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 839] **PEER REVIEWED**

.../It/ is useful only against hookworm infestations in man. Treatment with this agent is more effective against Necator americanus than against Ancylostoma duodenale ... /Former use/

[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975., p. 1032] **PEER REVIEWED**

Drug Warnings:

VET: At one time it was used fairly extensively against gi parasites of ruminants. Its disadvantage in ruminants is necessity of stimulating closure of esophageal groove so that medication is delivered directly to abomasum rather than passing into rumen which ... reduces effectiveness of drug. ... No food or water should be allowed for 12-18 hr before & for 4 hr after dosing. ... /It/ is contraindicated in tapeworm-infected animals since irritation of these worms may result in their balling up & occluding digestive passage. It is ... contraindicated in animals with distemper ... & should not be admin to nursing animals or those weighing less than 2 lb (approx 1 kg). /Former/

[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 839] **PEER REVIEWED**

VET: Restrict dietary fat within 2 days before and after use to avoid enhanced absorption of this fat sol liver toxicant.

Contraindicated in febrile diseases or in debilitated animals. Strong mucosal irritant. Breaking capsules in mouth has produced ataxia, convulsions, and anesthesia. /Former/

[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974., p. 587] **PEER REVIEWED**

Interactions:

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[Canadian EPA Priority Substances List Assessment Report for Trichloroethylene p.21 (1993). Available from, as of September 10, 2010: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/index-eng.php **PEER REVIEWED**

/When formerly used/ ... alcohol must be avoided before and for 24 hours after use of **tetrachloroethylene**. ... No laxative should be given, since this increases the toxic effects and decreases the effectiveness of the drug.

[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986., p. 1612] **PEER REVIEWED**

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[USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-17 (1980) EPA 440/5-80-073] **PEER REVIEWED**

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[Costa C et al; Toxicol In Vitro 18 (1): 37-44 (2004)] **PEER REVIEWED** PubMed Abstract

Environmental Fate & Exposure:

FPL-049-071

Environmental Fate/Exposure Summary:

Tetrachloroethylene's production and use as a dry cleaning agent, chemical intermediate, industrial solvent, in desulfurization of coal, and transformer insulating fluid may result in its release to the environment through various waste streams. Its former use as a pesticide resulted in its direct release to the environment. If released to air, a vapor pressure of 18.5 mm Hg at 25 deg C indicates **tetrachloroethylene** will exist solely as a vapor in the atmosphere. Vapor-phase **tetrachloroethylene** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 96 days. Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum. If released to soil, **tetrachloroethylene** is expected to have moderate mobility based upon Koc values in the range of 200-237; **tetrachloroethylene** has often been detected in groundwater. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 0.0177 atm-cu m/mole. **Tetrachloroethylene** may volatilize from dry soil surfaces based upon its vapor pressure. Volatilization half-lives in the range of 1.2-5.4 and 1.9-5.2 hrs were measured from a sandy loam soil surface and an organic topsoil, respectively. Using soil microcosms (60% municipal solid, 40% bulk, industrial, and sewage treatment sludge), **tetrachloroethylene**, present at 5 ug/L, exhibited no degradation when incubated at 20 deg C, indicating that biodegradation is not a fast environmental fate process in soil. There is evidence that slow biodegradation of **tetrachloroethylene** occurs under anaerobic conditions when the microorganisms have been acclimated, yielding trichloroethylene as a product. If released into water, **tetrachloroethylene** is not expected to adsorb to suspended solids and sediment in water based upon the Koc data. The biodegradation half-lives of **tetrachloroethylene** in aerobic and anaerobic waters were reported as 180 and 98 days, respectively, suggesting that biodegradation is not a fast environmental fate process in water. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 4 hours and 5 days, respectively. Measured BCF values of 26-115 in fish indicate that bioconcentration in aquatic organisms is low to high. Hydrolysis is not expected to be an important environmental fate process based on a hydrolysis half-life of 9 months. **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic material are present. Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used. The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking water. (SRC)

PEER REVIEWED

Probable Routes of Human Exposure:

Currently at risk of exposure are more than 500,000 workers, primarily in the dry cleaning and textile industries, which use more than 2/3 of the domestically produced **tetrachloroethylene**.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

According to the 2006 TSCA Inventory Update Report, the number of persons reasonably likely to be exposed in the industrial manufacturing, processing, and use for **tetrachloroethylene** is 1000 or greater; the data may be greatly underestimated(1).

[(1) US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Nov 10, 2010: http://cfpub.epa.gov/iursearch/index.cfm **PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 688,110 workers (177,342 of these were female)

were potentially exposed to **tetrachloroethylene** in the US(1). Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used. **Tetrachloroethylene** was detected, not quantified in blood samples from New York City firefighters who had responded to the World Trade Center fire and collapse(2). Mean levels inside and outside a tollbooth at the Baltimore Harbor Tunnel during the summer of 2001 were reported as 1.95 and 0.39 ug/cu m, respectively; the median indoor/outdoor ratio a the tollbooth is 8.3, compared to 1.3, 1.1, and 1.8 for homes in New York City, Los Angeles, and Baltimore, respectively(3). Concentration ranges in three photocopy centers 0.2-0.32, 0.1-0.2, and not detected to 0.2 ppb; detection limit not specified(4). The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking water(SRC).

[(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available from, as of Nov 19, 2010: http://www.cdc.gov/noes/ (2) Edelman P et al; Environ Health Perspect 111: 1906-1911 (2003) (3) Sapkota A et al; Environ Sci Technol 39:2 936-2943 (2005) (4) Stefaniak AB et al; Environ Res 83: 162-73 (2000)] **UNREVIEWED**

Body Burden:

Tetrachloroethylene was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2). **Tetrachloroethylene** was detected in expired breath and blood from 9 individuals living in Love Canal, NY at 600-4,500 ng/cu m and 0.35-260 ng/mL, respectively(3). The mean concentration of **tetrachloroethylene** in alveolar air in 136 residents living near 12 dry-cleaning stores were: living equal to or <5 floors above the stores 5 mg/cu m, adjacent houses 1 mg/cu m, one house away 0.2 mg/cu m, across street <.1 mg/cu m, whereas the mean concentration in 18 workers from these stores was 73 mg/cu m(4).

[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)] **PEER REVIEWED**

Breath samples (ug/cu m, weighted statistics), Elizabeth and Bayonne, NJ, 1981, 295-339 samples, 93% pos, 280 max, 13.0 avg, 6.8 median(1). Alveolar air in children and teachers in school situated near factory were 24 ug/cu m avg for children and 11 and 47 ug/cu m for the teachers(2). The mean concentration of **tetrachloroethylene** in the classroom was 13 ug/cu m(2). Alveolar air of residents of a nursing home situated near a former chemical waste dump averaged 7.8 ug/cu m first floor and 1.8 ug/cu m on the second floor, where ambient concentrations averaged 8.2 and 1.6 ug/cu m, respectively(2). Breathing zone samples collected in three photocopy centers were reported as 0.5, 0.2, and 0.1 ppb; the compound was not identified as a building background contaminant(3). A positive correlation has been identified between the incidence of asthma symptoms in children and presence of **tetrachloroethylene** in air of the Huntington Park region, Los Angeles, CA studied in 1999/2000(4). The mean personal air concentration was 7.98 and 9.18 ug/cu m in winter and summer, respectively, for 47 high school students from northern Manhattan and the South Bronx, Queens, and Brooklyn, New York City, NY, tested in 1999(5).

[(1) Wallace L et al; J Occup Med 28: 603-7 (1986) (2) Monster AC, Smolders JFJ; Int Arch Environ Health 53: 331-6 (1984) (3) Stefaniak AB et al; Environ Res 83: 162-73 (2000) (4) Delfino RJ et al; Environ Health Perspect 111: 647-656 (2003) (5) Kinney PL et al; Environ Health Perspect 110: 539-546 (2002)] **PEER REVIEWED**

Whole blood, USA survey of 250 (121 males, 129 females), 0.7-23 ppb, 2.4 ppb avg(1). The geometric mean concentration in 43 blood samples from children living in a socioeconomically disadvantaged area of Minneapolis was 0.04 ng/L, in a study conducted from January through April 2002(2). USA FY82 National Human Adipose Tissue Survey specimens, 46 composites, 61% pos (>3 ppb, wet tissue concentration), 94 ppb max(3). **Tetrachloroethylene** was detected in human body fat (8 subjects) 0.4-29.2 ppb and various human organs less than 6 ng/g(4).

[(1) Antoine SR et al; Bull Environ Contam Toxicol 36: 364-71 (1986) (2) Sexton K et al; Environ Health Perspect 114: 453-459 (2005) (3) Stanley JS; Broad Scan Analysis of the FY82 National Human Adipose Tissue Survey

Specimens Vol. I Executive Summary p. 5 USEPA-560/5-86-035 (1986) (4) McConnell G et al; Endeavour 34: 13-8 (1975)] **PEER REVIEWED**

... **Tetrachloroethylene** ... in the blood and brain (4.4 mg/l00 mL and 36 mg/l00 g, respectively). /fatal/
[U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Number 18: Tetrachloroethylene p. 13 (September 1997). Available from as of September 27, 2010: http://www.atsdr.cdc.gov/toxprofiles/index.asp **PEER REVIEWED**

Average Daily Intake:

The AVDI of **tetrachloroethylene** measured in 8 urban areas of Japan was reported as 21 ug (inhalation) and 0.84 ug (ingestion)(1).
[(1) Yoshida K; Chemosphere 27: 621-30 (1993)] **PEER REVIEWED**

Artificial Pollution Sources:

Water pollution by **tetrachloroethylene** leaching from vinyl liners in asbestos-cement water pipelines for water distribution.
[Yuskus LR; J Am Water Works Assoc 76 (2): 76-81 (1984)] **PEER REVIEWED**

Tetrachloroethylene concentrations in homes with freshly dry-cleaned clothing stored in the closets may be 2 to 30 times higher than average background levels. In addition, workers in the dry-cleaning industry are a source of exposure to their families. In one study, indoor air concentrations in apartments where dry cleaning workers lived were more than 10-fold higher than in other apartments.
[DHHS/National Toxicology Program; Eleventh Report on Carcinogens: Tetrachloroethylene (127-18-4) (January 2005). Available from, as of September 27, 2010: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s169tetr.pdf **PEER REVIEWED**

A new form of substance abuse in adolescents is the inhalation of fumes from typewriter correction fluids (Liquid Paper, Wite-Out, Snopake, etc), which are composed of various chlorinated solvents, /including **tetrachloroethylene**/, to induce euphoria. Medical complications of such abuse and medical management of acute toxic episodes are discussed herein, along with suggestions for controlling this substance abuse.
[Greer JE; South Med J 77 (3): 297-8 (1984)] **PEER REVIEWED** PubMed Abstract

During chlorination water treatment, it can be formed in small quantities.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977., p. 769] **PEER REVIEWED**

Tetrachloroethylene's production and use as a dry cleaning agent, chemical intermediate, industrial solvent, in desulfurization of coal, and transformer insulating fluid(1) may result in its release to the environment through various waste streams(SRC). Its former use as a pesticide(2) resulted in its direct release to the environment(SRC).
[(1) Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000 (2) United States Environmental Protection Agency/

Prevention, Pesticides and Toxic Substances; Status of Pesticides in Registration, Reregistration, and Special Review. (1998) EPA 738-R-98-002. (1998). Available from, as of Nov 10, 2010: http://www.epa.gov/oppsrrd1/Rainbow/98rainbo.pdf **UNREVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values in the range of 200-237(2-4) indicate that **tetrachloroethylene** is expected to have moderate mobility in soil(SRC). Volatilization of **tetrachloroethylene** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 0.0177 atm-cu m/mole(5). **Tetrachloroethylene** may volatilize from dry soil surfaces based on a vapor pressure of 18.5 mm Hg at 25 deg C(6). Volatilization half-lives in the range of 1.2-5.4 hrs were measured for **tetrachloroethylene** from a sandy loam soil surface and volatilization half-lives of 1.9-5.2 hrs were measured from an organic topsoil(7). Using soil microcosms (60% municipal solid, 40% bulk, industrial, and sewage treatment sludge), **tetrachloroethylene**, present at 5 ug/L, exhibited no degradation when incubated at 20 deg C(8) indicating that biodegradation is not a fast environmental fate process in soil(SRC). There is evidence that slow biodegradation of **tetrachloroethylene** occurs under anaerobic conditions when the microorganisms have been acclimated, yielding trichloroethylene as a product(9,10).

[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Choiu CT et al; Science 206: 831-2 (1979) (3) Wilson JT et al; Environ Qual 10: 501-506 (1981) (4) Friesel P et al; Fresenius Z Anal Chem 319: 160-64(1984) (5) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (6) Riddick JA et al; Organic Solvents. 4th ed., New York, NY: Wiley Interscience (1986) (7) Zytner RG et al; pp. 101-8 in 43rd Purdue Indust Waste Conf (1989) (8) Scheutz C et al; J Environ Qual 33: 61-71 (2004) (9) Bouwer EJ, McCarty PL; Appl Environ Micribiol 45: 1286-94 (1983) (10) Wilson JT et al; Devel Indust Microbiol 24: 225-33 (1983)] **PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), Koc values in the range of 200-237(2-4) indicate that **tetrachloroethylene** is not expected to adsorb to suspended solids and sediment in water(SRC). Volatilization from water surfaces is expected(5) based upon a Henry's Law constant of 0.0177 atm-cu m/mole(6). Using this Henry's Law constant and an estimation method(5), volatilization half-lives for a model river and model lake are 4 hours and 5 days, respectively(SRC). Hydrolysis is not expected to be an important environmental fate process for **tetrachloroethylene** based on a hydrolysis half-life of 9 months in purified, de-ionized water(7). **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic acids are present(8). This process is only expected to be important in sunlit surface waters containing humic material. According to a classification scheme(9), BCF values in the range of 26-115 measured in fish(10-13) indicate that bioconcentration in aquatic organisms is low to high(SRC). The biodegradation half-lives of **tetrachloroethylene** in aerobic and anaerobic waters were reported as 180 and 98 days, respectively(14), suggesting that biodegradation is not a fast environmental fate process in water(SRC).

[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Choiu CT et al; Science 206:831-2 (1979) (3) Wilson JT et al; Environ Qual 10: 501-506 (1981) (4) Friesel P et al; Fresenius Z Anal Chem 319: 160-64(1984) (5) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (6) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (7) Dilling WL et al; Environ Sci Technol 9: 833-88 (1975) (8) Mill T; Chemosphere 38: 1379-90 (1999) (9) Franke C et al; Chemosphere 29: 1501-14 (1994) (10) Neely WB et al; Environ Sci Technol 8: 1113-15 (1974) (11) Barrows ME et al; Dyn Exposure Hazzard Assess Toxic Chem Ann Arbor, MI: Ann Arbor Sci p. 379-92 (1980) (12) NITE; Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Tokyo, Japan: Natl Inst Tech Eval. Available from, as of Nov 10, 2010: http://www.safe.nite.go.jp/english/db.html (13) Rathbun RE; Crit Rev Environ Sci 30: 129-295 (2000) (14) Capel PD, Larson SJ; Chemosphere 30: 1097-1106 (1995)] **PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **tetrachloroethylene**, which has a vapor pressure of 18.5 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase **tetrachloroethylene** is degraded in the atmosphere by

reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 96 days(SRC), calculated from its rate constant of 1.67X10-13 cu cm/molecule-sec at 25 deg C(3). **Tetrachloroethylene** may also be degraded in the atmosphere by reaction with ozone, but the rate of this reaction is too slow to be environmentally important(4). Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum(5).

[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Riddick JA et al; Organic Solvents. 4th ed., New York, NY: Wiley Interscience p. 522 (1986) (3) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (4) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (5) Crutzen PJ et al; J Geophys Res 83: 345-63 (1978)] **PEER REVIEWED**

Environmental Biodegradation:

AEROBIC: **Tetrachloroethylene**, present at 30 mg/L, reached 11% of its theoretical BOD in 4 weeks using an activated sludge inoculum at 100 mg/L in the Japanese MITI test(1). The biodegradation half-life of **tetrachloroethylene** in aerobic waters was reported as 180 days(2). **Tetrachloroethylene** was degraded to trichloroethene, 1,2-dichloroethene and ultimately vinyl chloride during a 6 day incubation period using a groundwater and sediment microcosm obtained from a contaminated site in Toronto, Canada(3). Using soil microcosms, **tetrachloroethylene**, present at 5 ug/L, exhibited no degradation when incubated at 20 deg C using soil from the Skellingsted Landfill, Holbaek, Denmark (60% municipal solid, 40% bulk, industrial, and sewage treatment sludge)(4).

[(1) NITE; Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Tokyo, Japan: Natl Inst Tech Eval. Available from, as of Nov 10, 2010: http://www.safe.nite.go.jp/english/db.html (2) Capel PD, Larson SJ; Chemosphere 30: 1097-1106 (1995) (3) Hunkeler D et al; Environ Sci Technol 33: 2733-38 (1999) (4) Scheutz C et al; J Environ Qual 33: 61-71 (2004)] **PEER REVIEWED**

AEROBIC: No degradation occurred in 21 days in 3 biodegradability tests with acclimated or unacclimated inocula or in a river die-away test(1). Microbial degradation did not contribute to the removal of **tetrachloroethylene** in a mesocosm experiment which simulated Narraganset Bay, RI(2). Under aerobic conditions there was no degradation in 25 weeks in a batch experiment with a sewage inoculum(3) or when low concentrations of **tetrachloroethylene** (16 ug/L) were circulated through an acclimated aerobic biofilm column over a period of 1 year(4). While only 3.75% of the **tetrachloroethylene** treated by conventional, extended and 2-stage activated-sludge pilot plants appeared in the effluent, most of the **tetrachloroethylene** was discharged to the air from the extended aeration(5).

[(1) Mudder TI; Amer Chem Soc Div Env Chem Conf p. 52-3 (1982) (2) Wakeham SG; Environ Sci Technol 17: 611-7 (1983) (3) Bouwer EJ et al; Environ Sci Technol 15: 596-9 (1981) (4) Bouwer EJ, McCarty PL; Environ Sci Technol 16: 836-43 (1982) (5) Watanabe H; Gesuido Kyokaiski 20: 29-37 (1983)] **PEER REVIEWED**

ANAEROBIC: A large reduction of **tetrachloroethylene** which had been recirculated through a soil column for 14 days was attributed to adsorption and volatilization(1). In a microcosm containing muck from an aquifer recharge basin, 72.8% loss was observed in 21 days against 12-17% in controls, and the metabolites trichloroethylene, cis- and trans-1,2-dichloroethylene, dichloromethane, and chloroethene were identified(2). However, when subsurface samples were aseptically removed from above and below the water table and incubated in the laboratory, no degradation occurred in 16 weeks(3). In one field groundwater recharge project, degradation was observed in the 50 day recharge period(4).

[(1) Bouwer EJ et al; Water Res 15: 151-59 (1981) (2) Parsons F et al; J Amer Wat Works Assoc 76: 56-9 (1984) (3) Wilson JT et al; Ground Water 21: 134-42 (1983) (4) Bouwer EJ et al; Environ Sci Technol 15: 596-99 (1981)] **PEER REVIEWED**

ANAEROBIC: There is evidence that slow biodegradation of **tetrachloroethylene** occurs under anaerobic conditions when the microorganisms have been acclimated, yielding trichloroethylene as a product(1,2). An experiment in a continuous-flow laboratory methanogenic column using well acclimated mixed culture and a 2-day detention time had

an average **tetrachloroethylene** removal rate of 76%(3). In a continuous-flow mixed-film methanogenic column with a liquid detention time of 4 days, mineralization of 24% of the **tetrachloroethylene** present occurred; trichloroethylene was the major intermediate formed (72%), but traces of dichloroethylene isomers and vinyl chloride were also found(4). In other column studies under a different set of methanogenic conditions, nearly quantitative conversion of **tetrachloroethylene** to vinyl chloride was found in 10 days(4). Removal of 86% **tetrachloroethylene** occurred in a methanogenic biofilm column (8 weeks of activation followed by 9-12 weeks of acclimation(5).

[(1) Bouwer EJ, McCarty PL; Appl Environ Micribiol 45: 1286-94 (1983) (2) Wilson JT et al; Devel Indust Microbiol 24: 225-33 (1983) (3) Bouwer EJ, McCarty PL; Ground Water 22: 433-40 (1984) (4) Vogel TM, McCarty PL; Appl Environ Microbiol 49: 1080-3 (1985) (5) Bouwer EJ, Wright JP; Am Chem Soc Div Environ Chem. 191st Natl Meet 26: 42-5 (1986)] **PEER REVIEWED**

ANAEROBIC: The biodegradation half-life of **tetrachloroethylene** in anaerobic waters was reported as 98 days(1). The first-order anaerobic biodegradation rate constant of **tetrachloroethylene** was reported in the range of 0.00042 to 0.0071 day-1(2), corresponding to half-lives of 98 to 1,650 days(SRC). Natural attenuation analysis of **tetrachloroethylene** biodegradation in an anaerobic chlorinated ethene contaminated aquifer in the Bitterfeld/Wolfen area identified potential dechlorinating microorganims including Dehalococcoides, Desulfuromonas, Desulfitobacterium and Deholabacter(3). Using an enrichment culture developed from aquifer solids exposed to alkylbenzenes and chlorinated ethenes at the US Coast Guard Air Station in Traverse City, MI and employing toluene as the sole carbon source, **tetrachloroethylene** dechlorination slowed during days 46-89 following depletion of toluene. Respiking toluene at day 94 resulted in immediate restoration rate of **tetrachloroethylene** dechlorination(4). Under reducing conditions, tetrachloroethylne degrades via hydrogenolysis to trichloroethylene, ultimately resulting in vinyl chloride via cis-1,2-dichloroethylene(5).

[(1) Capel PD, Larson SJ; Chemosphere 30: 1097-1106 (1995) (2) Rathbun RE; US Geol Surv Prof Pap 1589: 1-151 (1998) (3) Nijenhuis I et al; Chemosphere 67: 300-11 (2007) (4) Shen H, Sewell GW; Environ Sci Technol 39: 9286-9294 (2005) (5) Washington JW, Cameron BA; Environ Toxicol Chem 20: 1909-15 (2001)] **PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **tetrachloroethylene** with photochemically-produced hydroxyl radicals is 1.67X10-13 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 96 days at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(1). **Tetrachloroethylene** may also be degraded in the atmosphere by reaction with ozone, but the rate of this reaction is too slow to be environmentally important(2). Hydrolysis is not expected to be an important environmental fate process for **tetrachloroethylene** based on a hydrolysis half-life of 9 months in purified, de-ionized water(3). Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum(4). **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic material are present(5). When **tetrachloroethylene** in aqueous solution was irradiated with light greater than 290 nm in wavelength, 75% degradation was observed over the course of one year, while 59-65% degradation was observed for dark controls(3).

[(1) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (2) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (3) Dilling WL et al; Environ Sci Technol 9: 833-88 (1975) (4) Crutzen PJ et al; J Geophys Res 83: 345-63 (1978) (5) Mill T; Chemosphere 38: 1379-90 (1999)] **PEER REVIEWED**

Photodegradation in the stratosphere is rapid(1). When **tetrachloroethylene** adsorbed to silica gel is irradiated through a pyrex filter, 50-90% is lost in 6 days(2).

[(1) Mueller JPH Korte F; Chemosphere 3: 195-8 (1977) (2) Gaeb S et al; Nature 270: 331-3 (1977)] **PEER REVIEWED**

Environmental Bioconcentration:

The BCF value of **tetrachloroethylene** in fathead minnows was 39(1) and the BCF value for bluegill sunfish was 49(2). BCF values of 26-77 were observed for carp exposed to 0.1 mg/L of **tetrachloroethylene** and values of 28-76 were observed for carp exposed to 0.01 mg/L over an 8 week incubation period(3). A log BCF 1.69 was reported for bluegill (Lepomis macrochirus) and a range of 1.59-2.06 for rainbow trout (Salmo gairdneri)(4), corresponding to BCFs of 49 and 36-115, respectively(SRC). According to a classification scheme(5), BCF values of zero to 30 are low and from 100 to 1,000 are high.

[(1) Neely WB et al; Environ Sci Technol 8: 1113-15 (1974) (2) Barrows ME et al; Dyn Exposure Hazzard Assess Toxic Chem Ann Arbor, MI: Ann Arbor Sci pp. 379-92 (1980) (3) NITE; Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Tokyo, Japan: Natl Inst Tech Eval. Available from, as of Nov 10, 2010: http://www.safe.nite.go.jp/english/db.html (4) Rathbun RE; Crit Rev Environ Sci 30: 129-295 (2000) (5) Franke C et al; Chemosphere 29: 1501-14 (1994)] **PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc value of **tetrachloroethylene** in a silt loam was measured as 210(1) and the Koc in a Lincoln fine sandy soil was 200(2). An average Koc of 237 was calculated for **tetrachloroethylene** in 6 soils (acid peat, acid humic, calcareous humic, iron-oxide rich subsurface soil, clay subsurface soil, and sandy subsurface soil)(3). According to a classification scheme(4) these Koc data suggest that **tetrachloroethylene** is expected to have moderate mobility in soil(SRC). Using an Oberlausitz lignite (11.1% moisture content, 53.5% carbon, 0.6% nitrogen) and a Pahokee peat soil (10.2% moisture content, 46.1% carbon, 3.3% nitrogen) log Freundlich constants of 2.76 and 2.13 were measured(5).

[(1) Choiu CT et al; Science 206: 831-2 (1979) (2) Wilson JT et al; Environ Qual 10: 501-506 (1981) (3) Friesel P et al; Fresenius Z Anal Chem 319: 160-64 (1984) (4) Swann RL et al; Res Rev 85: 17-28 (1983) (5) Endo S et al; Environ Sci Technol 42: 5897-5903 (2008)] **PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **tetrachloroethylene** is 0.0177 atm-cu m/mole(1). This Henry's Law constant indicates that **tetrachloroethylene** is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 4 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 5 days(SRC). The volatilization half-life of **tetrachloroethylene** was reported as 3.2 minutes in laboratory experiments using distilled water(3). **Tetrachloroethylene**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). **Tetrachloroethylene** is expected to volatilize from dry soil surfaces based on a vapor pressure of 18.5 mm Hg at 25 deg C(4). Volatilization half-lives in the range of 1.2-5.4 hrs were measured for **tetrachloroethylene** from a sandy loam soil surface and volatilization half-lives of 1.9-5.2 hrs were measured from an organic topsoil(5).

[(1) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Chiou CT et al; Environ Int 3: 231-4 (1980) (4) Riddick JA et al; Organic Solvents. 4th ed., New York, NY: Wiley Interscience (1986) (5) Zytner RG et al; pp. 101-8 in 43rd Purdue Indust Waste Conf (1989)] **PEER REVIEWED**

Environmental Water Concentrations:

GROUNDWATER: Samples for analysis of volatile organic compounds were collected from 315 wells in the Potomac-Raritan-Magothy aquifer system in southwestern New Jersey and a small adjacent area in Pennsylvania (USA) during 1980-1982. Volatile organic compounds were detected in all 3 aquifer units of the Potomac-Raritan-Magothy aquifer system. Most of the contamination appeared to be confined to the outcrop area. Low levels of contamination were found away from the outcrop area in the upper and middle aquifer. Trichloroethylene, **tetrachloroethylene** and benzene were the most frequently detected compounds. Differences in the distributions of light chlorinated hydrocarbons, /(including **tetrachloroethylene**)/, trichloroethylene, and aromatic hydrocarbons, ie, benzene, were noted and were probably due to differences in the uses of the compounds and the distribution patterns of potential contamination sources. The distribution patterns of volatile organic compounds differed greatly among the 3 aquifer units. The upper aquifer, which cropped out mostly in less-developed areas, had the lowest percentage of wells with volatile organic compounds detected (10% of wells sampled). The concentrations in most wells in the upper aquifer which had detectable levels were <10 ug/L. In the middle aquifer, which cropped out beneath much of the urban and industrial area adjacent to the Delaware River, detectable levels of volatile organic compounds were found in 22% of wells sampled, and several wells contained concentrations >100 ug/L. The lower aquifer, which was confined beneath much of the outcrop area of the aquifer system, had the highest percentage of wells (28%) with detectable levels. This was probably due to vertical leakage of contamination from the middle aquifer and the high percentage of wells tapping the lower aquifer in the most heavily developed areas of the outcrop.

[Fusillo TV et al; Ground Water 23 (3): 354-60 (1985)] **PEER REVIEWED**

GROUNDWATER: The median concentration of **tetrachloroethylene** in groundwater from 27 US cities was 0.6 ppb(1). The max concentration of **tetrachloroethylene** in groundwater wells from San Fernando Valley, CA was 130 ppb(2). Groundwater from Britain contained less than 2 ppb of **tetrachloroethylene** in 8 out of 10 samples analyzed(3). Groundwater underlying 2 rapid infiltration sites in the US contained **tetrachloroethylene** at concentrations of 0.07 and 0.63 ppb(4). Shallow groundwater wells in Japan contained **tetrachloroethylene** at concentrations of 0.2-23,000 ppb and deep wells contained 0.2-150 ppb(5). **Tetrachloroethylene** was identified, not quantified in 27% of groundwater samples obtained from shallow wells in southern New Jersey(6). A 1992-1999 survey of large aquifers across the United States serving 1255 domestic drinking water and 242 public supply wells reported **tetrachloroethylene** exceeding the 5 ug/L maximum contaminant limit in 3 of 1,228 analyses(7).

[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Chemical Engineering 90: 35 (1983) (3) Fielding M et al; Environ Technol Lett 2: 545-50 (1981) (4) Hutchins SR et al; Environ Toxicol Chem 2: 195-216 (1983) (5) Magara Y, Furuichi T; pp. 231-43 in New Concepts and Development in Toxicol. Chambers PL et al, eds. Elsevier Sci Publ (1986) (6) Baehr L et al; Water Resour Res 35: 127-36 (1999) (7) Squillace PJ et al; Environ Sci Technol 36: 1923-1930 (2002)] **PEER REVIEWED**

DRINKING WATER: The National Health Department (Italy) had promoted and supported a preliminary survey on the presence of some chlorinated organic compounds in the drinking water. The drinking water of some cities of northern Italy was analyzed for the presence of trichloroethylene, **tetrachloroethylene**, methylchloroform, carbon tetrachloride, trihalomethanes, polychlorinated biphenyls, and the most common chlorinated pesticides. From March, 1981 to June, 1982, 8 controls were done for 11 sampling points. All water underwent different treatments with carbon. In the raw water, trichloroethylene (47/48) and **tetrachloroethylene** (34/48) showed the highest frequency of positivity. One well had the highest concentrations of these compounds (trichloroethylene 81-158 ug/L; **tetrachloroethylene** 15-32 ug/L). In the finished waters, carbon trichloride the most abundant trihalomethane formed during chlorination, was detected in 80% of the 39 samples, against 31% in the 48 raw water samples. No polychlorinated biphenyls and chlorinated pesticides were found at the chosen detection limit (0.05 ug/L).

[Ziglio G et al; Ig Mod 82 (3): 419-35 (1984)] **PEER REVIEWED**

DRINKING WATER: In a survey of 180 US cities with finished surface water, the median concentration of **tetrachloroethylene** in drinking water was reported as 0.3 ppb with a max concentration of 21 ppb(1). In survey of 36 US cities with finished groundwater, the median concentration of **tetrachloroethylene** was 3 ppb(1). **Tetrachloroethylene** was detected at a max concentration of 1.5 ppm in contaminated drinking wells in the US(2,3). Drinking water in Niagra Falls, NY had **tetrachloroethylene** concentrations of 0.35-2.9 ppb(4). A survey of drinking water for individual states in the US reported that 220 of 1,569 samples contained **tetrachloroethylene** at

concentrations of trace to 3,000 ppb(5). **Tetrachloroethylene** was detected in 264 drinking water wells in California at a maximum concentration of 166 ug/L(6). The compound was detected at a maximum concentration of 36 ug/L (2.8% detection frequency) following analysis of 952 drinking-water sources from the US, Native American lands, and Puerto Rico from May 3, 1999 to Oct 23, 2000; solvents were detected 115 times with 60 of the 954 sources (6.3%) testing positive. **Tetrachloroethylene** had the highest percent detection frequency at 4.2 and 1.7% in groundwater and river sources, respectively(7). **Tetrachloroethylene** was detected in 130 of 1,179 domestic wells in the United States, sampled from 1985-2002, with a detection frequency of 11.0%. In an analysis of 2,371 wells, five had levels of **tetrachloroethylene** greater than the US EPA maximum contaminant level of 5 ug/L(8). Water samples from a US drinking water treatment facility in a heavily urbanized drainage basin were collected during November-December 2001. **Tetrachloroethylene** had a 58% frequency of detection and the highest concentration in sample of finished water was 0.1 ug/L; reporting level 0.5 ug/L(9).

[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (3) Giger W, Molnar-Kubica E; Bull Environ Contam Toxicol 19: 475-80 (1978) (4) Barkley J et al; Biomed Mass Spectrum 7: 139-47 (1980) (5) Cotruvo JA et al; pp. 511-30 in Organic Carcinogens in Drinking Water. Ram NM et al, eds., New York, NY: Wiley (1986) (6) Lam RHF et al; pp. 15-44 in Water Contamination and Health. Wang RGM, ed., New York, NY: Marcel Dekker, Inc (1994) (7) Grady SJ; A National Survey of Methyl tert-Butyl Ether and Other Volatile Organic Compounds in Drinking-Water Sources: Results of the random survey. National Water-Quality Assessment Program. National synthesis on volatile organic compounds. Denver, CO: U.S. Geological Survey 1-85 (2003) (8) Rowe BL et al; Environ Health Perspect 115: 1539-1546 (2007) (9) Stackelberg PE et al; Sci Total Environ 329: 99-113 (2004)] **PEER REVIEWED**

DRINKING WATER: The average concentration of **tetrachloroethylene** from 30 Canadian potable water facilities was reported as 1 ppb(1). A survey of drinking water sources in the Netherlands showed that 64 sources had **tetrachloroethylene** concentrations greater than 10 ppb, 12 sources had concentrations greater than 100 ppb, 4 sources had concentrations greater than 1 ppm and 2 sources had concentrations greater than 100 ppm(2). Drinking water obtained from the Rhine River, Netherlands had a max concentration of 50 parts per trillion **tetrachloroethylene**(3). The compound was reported in 4 major European treated surface waters and 2 treated groundwaters at mean concentrations of 0.17 and 0.02 ug/L, respectively, with maximum concentrations of 0.68 and 0.3 ug/L reported, respectively(4).

[(1) Otson R et al; J Assoc Off Anal Chem 65: 1370-4 (1982) (2) Trouwborst T; Sci Total Environ 21: 41-6 (1981) (3) Piet GJ, Morra CF; pp. 31-42 in Artificial Groundwater recharge; Huismon L, Olsthorn TN, eds, Pitman Pub (1983) (4) Palacios M et al; Water Res 34: 1002-16 (2000)] **PEER REVIEWED**

SURFACE WATER: The median concentration of **tetrachloroethylene** in surface water from 154 US cities was 2 ppb(1). **Tetrachloroethylene** was identified, not quantified, in 2,346 out of 4,972 samples of water from the Ohio River(2). The avg concentration of **tetrachloroethylene** in Lake Ontario water was reported as 0.009 ppb(3). The concentration of **tetrachloroethylene** in the Rhine River, Netherlands was reported as 0.12-0.62 ppb from 1976-1982(4). The concentration of **tetrachloroethylene** in Lake Zurich, Switzerland was reported as 0.025-0.14 ppb(5,6). The STORET Database of US surface water reported that **tetrachloroethylene** was identified in 3,543 out of 9,323 surface water samples(7). **Tetrachloroethylene** was detected in the Elbe River near Hamburg Germany at concentrations of 16-163 ng/L from 1992-1993(8). The compound exhibited a 20% frequency of detection according to a USGS survey of US streams(9).

[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Water. USEPA-560/6-77-015 and USEPA-560/6-77-015A (1977) (3) Kaiser KLE et al; J Great Lakes Res 9: 212-23 (1983) (4) Malle KG; Z Wasser Abwasser Forsch 17: 75-81 (1984) (5) Grob K, Grob G; J Chrom 90: 303-13 (1974) (6) Schwarzenbach RP et al; Environ Sci Technol 13: 1367-73 (1979) (7) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (8) Gotz R et al; Chemosphere 36: 2085-2101 (1998) (9) Snyder SA et al; Environ Eng Sci 20: 449-469 (2003)] **PEER REVIEWED**

SEAWATER: **Tetrachloroethylene** has been detected in seawater at concentrations of 0.1 to 0.8 parts per trillion(1,2). **Tetrachloroethylene** was detected in the Gulf of Mexico at concentrations of 0 ng/kg in open ocean; a trace (<1 ng/kg)in unpolluted to 40 ng/kg in polluted coastal waters(3). Surface water from the Eastern Pacific Ocean

contained **tetrachloroethylene** at concentrations of 0.1-2.8 parts per trillion(4).

[(1) Murray AJ, Riley JP; Nature 242: 37-8 (1973) (2) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (3) Sauer TC Jr; Org Geochem 3: 91-101 (1981) (4) Singh HB et al; J Geophys Res 88: 3675-83 (1983)] **PEER REVIEWED**

RAIN/SNOW/FOG: Tetrachloroetheylene was detected in rain from an industrial city in England at 150 parts per trillion(1). West Los Angeles (3/26/82) **tetrachloroethylene** was detected in rain at a concentration of 21 parts per trillion(2). **Tetrachloroethylene** was detected in rain from La Jolla, California at 5.7 parts per trillion(3) and central and southern California at 1.4 and 2.3 parts per trillion, respectively(3). The compound was detected at concentration ranges of 21-73 and 2.8-15 ng/kg, in Antarctic superficial snow sampled during Italian ITASE expeditions 1998/1999 from Terra Bay to Dome Concordia and in 2001/2002 through Adelie, George V, Oates, and Northern Voctoria Lands, respectively(4). A log sorption coefficient on snow surfaces of -4.41 (cu m/sq m) has been calculated(5).

[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Kawamura K, Kaplan IR; Environ Sci Technol 17: 497-501 (1983) (3) Su C, Goldberg ED; Mar Poll Transfer 1976: 353-74 (1976) (4) Zoccolillo L et al; Chemosphere 67: 1897-1903 (2007) (5) Roth CM et al; Environ Sci Technol 38: 4078-4084 (2004)] **PEER REVIEWED**

Effluent Concentrations:

Tetrachloroethylene was detected in industrial effluent at concentrations of 1-20 ppb and in the effluent of municipal treatment plants at concentrations of 1-10 ppb(1). **Tetrachloroethylene** was released from the Baltimore Municipal Treatment Plant at concentrations of 8-129 ppb(2). Maximum concentrations of **tetrachloroethylene** were reported in wastewater from the following industries: auto and laundry facilities, 93 ppm; aluminum forming facilities, 4 ppm; metal finishing plants; 110 ppm; organic chemical/plastic manufacturing plants, 5.1 ppm (mean value); paint and ink plants, 4.9 ppm(3). **Tetrachloroethylene** was detected in landfill gas from 7 waste sites in the United Kingdom at concentrations of 0.1-255 ng/cu m(4). **Tetrachloroethylene** was detected in the effluent of a municipal waste incinerator in Germany at 0.16 ug/cu m(5). **Tetrachloroethylene** was identified, not quantified, in water samples at 279 hazardous waste sites in the US(6). Water samples from a US drinking water treatment facility in a heavily urbanized drainage basin were collected during November-December 2001. **Tetrachloroethylene** had a 58% frequency of detection and the highest concentration in sample of finished water was 0.1 ug/L; reporting level 0.5 ug/L(7).

[(1) STORET Data Base (2) Helz GR, Hsu RY; Limnol Oceanogr 23: 858-69 (1978) (3) US EPA; Treatability Manual. p.I.12.26-1 to I.12.26-5 USEPA-600/2-82-001A (1981) (4) Allen MR Environ Sci Technol 31: 1054-61 (1997) (5) Jay K, Stieglitz L; Chemosphere 30: 1249-60 (1995) (6) Johnson BL; Chemosphere 31: 2415-28 (1995) (7) Stackelberg PE et al; Sci Total Environ 329: 99-113 (2004)] **PEER REVIEWED**

Sediment/Soil Concentrations:

SOIL: **Tetrachloroethylene** was detected in soil samples from rural areas of the Netherlands at concentrations of 0.2-1.0 ug/kg(1). **Tetrachloroethylene** was identified, not quantified, in soil samples from a photocopier refurbishing plant in NY(2). **Tetrachloroethylene** was detected in soil from an industrial waste disposal site in Denmark at a concentration of 19 mg/kg(3).

[(1) Hoekstra EJ et al; Chemosphere 38: 2875-83 (1999) (2) Pavlostathis SG, Zhuang P; Chemosphere 27: 586-96 (1993) (3) Broholm K et al; Environ Technol 12: 279-89 (1991)] **PEER REVIEWED**

SEDIMENT: **Tetrachloroethylene** was detected in sediment from 172 stations in Liverpool Bay, England at an avg concentration of 4.8 parts per trillion(1). **Tetrachloroethylene** was detected in 25 of 359 sediment samples from the

US at a median concentration of less than 0.050 ppb(2). **Tetrachloroethylene** was detected in sediment from Ijmeer, Netherlands at concentrations of 0.02 and 0.07 mg/kg(3).

[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (3) Heida H; Contam Soil Int Conf 909-912 (1986)] **PEER REVIEWED**

Atmospheric Concentrations:

URBAN/SUBURBAN: The concentration of **tetrachloroethylene** at various US cities ranged from less than 0.2 to 9.75 ppb(1). **Tetrachloroethylene** mean concentrations from seven U.S. cities (1980-1981) ranged from 0.290-0.590 ppb with a max concentration of 7.60 ppb(2). Median **tetrachloroethylene** concentrations outside homes in urban centers were (ug/cu m): 1.40, New York City, NY; 1.40, Los Angeles, CA; 0.28, Baltimore, MD(3). Daily analysis of 6 Southern California urban areas showed a marked decrease on Sundays in 5 of the cities studied from 1989 through 2001(4). Mean **tetrachloroethylene** concentration was 0.51 ppb (0.05 ppb min; 1.40 ppb max)in air from the Huntington Park region, Los Angeles, CA sampled from 4 November 1999 through 23 January 2000(5). The mean home outdoor concentration was 2.42 and 9.46 ug/cu m in winter and summer, respectively, for 36 homes located in northern Manhattan and the South Bronx, Queens, and Brooklyn, New York City, NY, sampled in 1999(6). Analysis of 3,650 data samples collected from 1991-1998 in the state of Minnesota showed a **tetrachloroethylene** mean concentration of 0.44 ug/cu m (maximum 25.08 ug/cu m), with the highest concentrations being near the center of the Minneapolis-St. Paul metropolitan area(7). **Tetrachloroethylene** mean concentration was 1.40 and 0.04 ug/cu m in Nagoya, Japan sampled in February 1998 and in Uppsala, Sweden, tested from February through May 1998, respectively; detection limit = 0.21 ug/cu m(8). The 50 year trend for outdoor concentrations in the US is showing a decrease as indicated by median US concentrations of 2.9 and 0.8 ug/cu m in 1981-1984 and 1999-2001, respectively(9). Outdoor sampling of 75 residential houses in Ottawa, Ontario, Canada tested during the winter of 2002/2003 exhibited a concentration range of 0.015-2.44 ug/cu m(10).

[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Andelman JB; Environ Health Persp 62: 313-8 (1985) (3) Sapkota A et al; Environ Sci Technol 39: 2936-2943 (2005) (4) Austin J; J Air Waste Manage Assoc 53: 889-896 (2003) (5) Delfino RJ et al; Environ Health Perspect 111: 647-656 (2003) (6) Kinney PL et al; Environ Health Perspect 110: 539-546 (2002) (7) Pratt GC et al; Environ Health Perspect 108: 815-25 (2000) (8) Sakai K et al; Environ Res 94: 75-85 (2004) (9) Weschler CJ; Atmos Environ 43: 153-169 (2009) (10) Zhu J ET et al; Environ Sci Technol 39: 3964-3971 (2005)] **PEER REVIEWED**

INDOOR: The median concentration of **tetrachloroethylene** inside 9 homes near Old Love Canal, Niagara, NY was reported as 71 parts per trillion(1). **Tetrachloroethylene** was detected in a classroom near a dry cleaning facility in the Netherlands at 1.9 ppb,(2) and a nursing home situated near a former chemical waste dump at 1.2 and 0.2 ppb on first and second floors, respectively(3). Median **tetrachloroethylene** concentrations in homes in urban centers were (ug/cu m): 2.75, New York City, NY; 1.60, Los Angeles, CA; 0.50, Baltimore, MD(4). The mean home indoor concentration was 7.53 and 6.45 ug/cu m in winter and summer, respectively, for 36 homes located in northern Manhattan and the South Bronx, Queens, and Brooklyn, New York City, NY, sampled in 1999(5). Monitoring of air in 104 wooden detached houses in Niigata Prefecture Japan indicated **tetrachloroethylene** concentrations ranging from 2-5 ug/cu m(6). **Tetrachloroethylene** mean concentration was 3.72 and 0.10 ug/cu m in 37 urban dwellings in Nagoya, Japan sampled in February 1998 and in 27 urban dwellings in Uppsala, Sweden, tested from February through May 1998, respectively; detection limit = 0.21 ug/cu m(7). The compound was detected in all 100 samples from suburban and rural homes in New Jersey with concentrations of <1.5, <3.4, <3.4, 4.39, and 9.53 in the 25th, 50th, 75th, 90th and 95th percentile results, respectively; a maximum of 540 ug/cu m was reported. Sampling was conducted between December 2003 and April 2006(8). The 50 year trend for indoor concentrations in the US is showing a decrease as indicated by median US concentrations of 6.1 and 0.8 ug/cu m in 1981-1984 and 1999-2001, respectively(9). Indoor sampling of 75 residential houses in Ottawa, Ontario, Canada tested during the winter of 2002/2003 exhibited a concentration range of 0.015-9.23 ug/cu m(10).

[(1) Barkley J et al; Biomed Mass Spectron 7: 139-47 (1980) (2) Monster AC, Smolders JFJ; Int Arch Occup Environ Health 53: 331-6 (1984) (3) Herbert P et al; Chem Ind 24: 861-9 (1986) (4) Sapkota A et al; Environ Sci Technol 39: 2936-2943 (2005) (5) Kinney PL et al; Environ Health Perspect 110: 539-546 (2002) (6) Sakaguchi J, Akabayashi S;

Indoor Air 13: 42-49 (2003) (7) Sakai K et al; Environ Res 94: 75-85 (2004) (8) Weisel CP et al; Environ Sci Technol 42: 8231-8238 (2008) (9) Weschler CJ; Atmos Environ 43: 153-169 (2009) (10) Zhu J; et al; Environ Sci Technol 39: 3964-3971 (2005)] **PEER REVIEWED**

RURAL/REMOTE: **Tetrachloroethylene** was detected in air samples from White Face Mountain, NY at concentrations of less than 0.02 to 0.19 ppb from September 16-19 1974(1). **Tetrachloroethylene** was detected in Barrows, Alaska at concentrations of 56-128 parts per trillion(2). The average concentration of **tetrachloroethylene** in the northern hemisphere was reported as 40 parts per trillion(3). The annual mean concentration in North America has been estimated at 0.022 ug/cu m, with a seasonal range of 70 to 134% during 2003(4).

[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Khalil MAK, Rasmussen RA; Environ Sci Technol 17: 157-64 (1983) (3) Singh HB et al; Atmospheric Distributions, Sources and Sinks of Selected Halocarbons, Hydrocarbons, SF6 and N20. USEPA-600/3-79-107 p. 88, 117-8 (1979) (4) McCarthy MC et al; J Air Waste Manage Assoc 56: 3-11 (2005)] **PEER REVIEWED**

SOURCE DOMINATED: Typical concentrations of **tetrachloroethylene** in source dominated and industrial areas have been reported in the range of 0.3-1.5 ppb, with max concentrations of 10 ppb(1-5). **Tetrachloroethylene** was detected in Old Love Canal, Niagara, NY at a median concentration of 109 parts per trillion(6). **Tetrachloroethylene** was detected around a playground near a dry cleaning facility in the Netherlands at 0.15 ppb(7). **Tetrachloroethylene** was detected in industrialized regions of Tsubame, Japan (0.019-0.23 ppb), Tokamachi, Japan (0.20-2.8 ppb) and Kubiki, Japan (0.024-0.63 ppb)(8). The compound was detected at an concentration of 12 ppb volume in air samples from a commercial retail site in Dallas, TX which had housed a dry cleaning business in the past. The ambient outside concentration was 0.11 ppb volume; 2,600,000 parts per billion volume was reported for subslab soil gas(9). **Tetrachloroethylene** was detected, not quantified in air samples from the Thane Belapur Industrial Area in Mumbai, India, measured during summer, monsoon, and winter of 2004; the area is the site of industries encompassing petrochemical, chemical, pharmaceutical, engineering, plastic, and dye production(10).

[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Pellizzari ED; Quantation of Chlorinated Hydrocarbons in Previously Collected Air Samples. USEPA-450/3-78-112 (1978) (3) Singh HB et al; Environ Sci Technol 16: 872-80 (1982) (4) Su C, Goldberg ED; Mar Pollut Transfer pp. 353-74 (1976) (5) Leoy PJ et al; Atmos Environ 17: 2321-30 (1983) (6) Barkley J et al; Biomed Mass Spectron 7: 139-47 (1980) (7) Monster AC, Smolders JFJ; Int Arch Occup Environ Health 53: 331-6 (1984) (8) Kawata K et al; Bull Environ Contam Toxicol 57: 1-7 (1996) (9) Eklund BM, Simon MA; J Air Waste Manage Assoc 57: 753-760 (2007) (10) Srivastava A, Som D; Chemosphere 69: 458-468 (2007)] **PEER REVIEWED**

Food Survey Values:

Tetrachloroethylene concentrations in foods ranged from non-detectable amounts (<0.01 ug/kg) in orange juice to 13 ug/kg in English butter.

[McConnell G et al; Endeavour 34: 13 as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-1 (1980) EPA 440/5-80-073] **PEER REVIEWED**

Tetrachloroethylene was detected in Chinese style sauce (2 ppb), quince jelly (2.2 ppb), crab apple jelly (2.5 ppb), grape jelly (1.6 ppb) and chocolate sauce (3.6 ppb)(1). **Tetrachloroethylene** was detected in various food from England at concentrations of 0.01-0.13 ppb(2). **Tetrachloroethylene** was detected in 2 of 10 wheat samples at 1.8 and 2.1 ppb and 2 corn samples at 0.45 and 0.54 ppb(3). **Tetrachloroethylene** was detected in butter and margarine at concentrations of 0.7-18 ug/kg and peanut butter at concentrations of 0.6-9.7 ug/kg(4).

[(1) Entz RC, Hollifield HC; J Agric Food Chem 30: 84-88 (1982) (2) McConnell G et al; Endeavour 34: 13-18 (1975) (3) Heikes DL, Hopper ML; J Assoc Anal Chem 69: 990-98 (1986) (4) Page BD, Lacroix GM; J AOAC Int 78: 1416-28 (1995)] **PEER REVIEWED**

Tetrachloroethylene occurrence following analysis of 70 foods over a 5 year period from 1996-2000 as part of the US Total Diet Program(1).

Commodity	Number positive	Minimum (ppb)	Maxiumum (ppb)
mixed nuts	4	9	54
ground beef	2	3	6
cream cheese	1	5	5
frankfurters - beef	3	2	60
chocolate cake with icing	5	3	32
eggs - scrambled	1	3	3
peanut butter	1	7	7
raw advocado	3	5	12
blueberry muffin	3	3	27
strawberries - raw	1	5	5
sweet roll/danish	3	8	12
potato chips	1	7	7
quarter pound hamburger - cooked	1	38	38
margarine	6	3	42
butter	8	11	102
chocolate chip cookies	4	2	18
sour cream	1	7	7
apple pie - frozen	5	3	52
graham crackers	2	2	5
french fries - fast food	1	8	8
cheeseburger - quarter pound	1	40	40
cheese pizza	1	16	16
bologna	7	2	27
cheese and pepperoni pizza	1	19	19
olive/safflower oil	1	7	7
sugar cookies	3	5	35
cake donuts with icing	2	12	15

[(1) Fleming-Jones ME, Smith RE; J Agric Food Chem 51: 8120-8127 (2003)] **PEER REVIEWED**

Plant Concentrations:

Tetrachloroethylene was detected in marine algae at concentrations of 13-23 ppb(1).

[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-22 (1975)] **PEER REVIEWED**

Fish/Seafood Concentrations:

Tetrachloroethylene was detected at concentrations of 0.3-43 ppb in marine fish, 0.5-176 ppb in marine invertebrates in England(1), 250 ppb in American eel (Delaware River), 1,050 ppb in American eel (Newark Bay), 77 ppb in carp (Delaware River), 108 ppb in striped bass (Raritan River), 88 ppb in spot fish (Houston Ship Channel)(2). **Tetrachloroethylene** was detected in fish from the Rhine River and Lake Constance Germany at concentrations of 25-100 ppb(3). **Tetrachloroethylene** was detected in clams from the Ariho River, Japan at 0.6 ug/kg(4).

[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976) (3) Binnemann PH et al; A Lebensm - Unters Forsch 176: 253-61 (1983) (4) Gotoh M et al; Bull Environ Contam Toxicol 60: 74-80 (1998)] **PEER REVIEWED**

Animal Concentrations:

Tetrachloroethylene was detected at concentrations of 0.6-19 ppb in grey seal blubber (NE Coast of England) and at concentrations of 1.4-39 ppb in marine and freshwater birds (coast of England)(1).

[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975)] **PEER REVIEWED**

Milk Concentrations:

Six wk old breast-fed infant had obstructive jaundice & hepatomegaly. **Tetrachloroethylene** was detected in milk & blood. After discontinuance of breast-feeding rapid clinical & biochem improvement were noted.

[BAGNELL PC, ELLENBERGER HA; CAN MED ASSOC J 117 (9): 1047-8 (1977)] **PEER REVIEWED** PubMed Abstract Full text: PMC1880184

ENVIRONMENTAL: **Tetrachloroethylene** was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2).

[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983)] **PEER REVIEWED**

Tetrachloroethylene /has been reportedly found/ in breast milk.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Excretion of **tetrachloroethylene** in cows' milk was found after oral ingestion of 100 mg/day with the feed. One percent of the intake was recovered in the milk.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html] **PEER REVIEWED**

Other Environmental Concentrations:

Tetrachloroethylene average sorption parameters (kd 1/hr) ranged from 0.32-0.47 and in carpets with underlying pad, 0.17-0.25(1).

[(1) Won D et al; Environ Sci Technol 34: 4193-8 (2000)] **PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

As the federal pesticide law FIFRA directs, EPA is conducting a comprehensive review of older pesticides to consider their health and environmental effects and make decisions about their continued use. Under this pesticide reregistration program, EPA examines newer health and safety data for pesticide active ingredients initially registered before November 1, 1984, and determines whether the use of the pesticide does not pose unreasonable risk in accordance to newer saftey standards, such as those described in the Food Quality Protection Act of 1996. Pesticides for which EPA had not issued Registration Standards prior to the effective date of FIFRA '88 were divided into three lists based upon their potential for human exposure and other factors, with List B containing pesticides of greater concern than those on List C, and with List C containing pesticides of greater concern than those on List D. **Tetrachloroethylene** is found on List C. Case No: 3109; Case Status: No products containing the pesticide are actively registered. Therefore, we are characterizing the case as "cancelled." Under FIFRA, pesticide producers may voluntarily cancel their registered products. EPA also may cancel pesticide registrations if registrants fail to pay required fees or make/meet certain reregistration commitments, or if EPA reaches findings of unreasonable adverse effects.; Active ingredient (AI): **tetrachloroethylene**; AI Status: The active ingredient is no longer contained in any registered products ... "cancelled.".

[United States Environmental Protection Agency/ Prevention, Pesticides and Toxic Substances; Status of Pesticides in Registration, Reregistration, and Special Review. (1998) EPA 738-R-98-002, p. 269] **PEER REVIEWED**

Acceptable Daily Intakes:

Suggested No-Adverse-Response Level (SNARL): In light of the lack of definitive information regarding the quantity of **tetrachloroethylene** that must be ingested to depress psychophysiological function, it seems appropriate that calculations for a SNARL be based upon quantities of the chemical that are required to produce tissue injury. ... the 0.3 ml/kg (0.49 g/kg) dose appears to be a reasonable "minimum toxic dose" from which to calculate a 24-hr SNARL for contamination of drinking water, assuming that the sole source of **tetrachloroethylene** during this period will be from 2 l/day of drinking water consumed by a 70 kg human. A safety factor of 100 is applied: 490 mg/kg times 70 kg/100 times 2 l= 172 mg/l. The above considerations ignore the possibility that **tetrachloroethylene** may be carcinogenic. ... a 7-day standard for drinking water contamination, which was obtained by dividing the 24-hr standard by 7 (172 mg/l/7 days= 24.5 mg/l), should protect against adverse effects by the chemical.

[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980., p. 140] **PEER REVIEWED**

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. **Tetrachloroethylene** is included on this list. Effective date 6/1/87; Sunset date: 6/1/97.

[40 CFR 716.120 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.4 kg. The toll free number of the NRC is (800) 424-8802. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV.D.3.b).

[40 CFR 302.4 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

RCRA Requirements:

D039; A solid waste containing **tetrachloroethylene** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.

[40 CFR 261.24 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

U210; As stipulated in 40 CFR 261.33, when **tetrachloroethylene**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).

[40 CFR 261.33 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

F002; When **tetrachloroethylene** is a spent halogenated solvent, it is classified as a hazardous waste from a nonspecific source (F002), as stated in 40 CFR 261.31, and must be managed according to state and/or federal hazardous waste regulations.

[40 CFR 261.31 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of

continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. **Tetrachloroethylene** is produced, as an intermediate or a final product, by process units covered under this subpart.

[40 CFR 60.489 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Tetrachloroethylene** is included on this list.

[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990] **PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations.

[40 CFR 401.15 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Federal Drinking Water Standards:

Maximum contaminant levels (MCL) for organic contaminants apply to community and non-transient, non-community water systems: **Tetrachloroethylene**, MCL 0.005 mg/L.

[40 CFR 141.61(a) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

EPA 5 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

State Drinking Water Standards:

(DE) DELAWARE 1 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **UNREVIEWED**

(FL) FLORIDA 3 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

(NJ) NEW JERSEY 1 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 0.67 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

(CT) CONNECTICUT 5 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

(ME) MAINE 7 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

(MN) MINNESOTA 5 ug/L

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present] **PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C2-Cl4

PEER REVIEWED

Molecular Weight:

165.833

[Lide, D.R. CRC Handbook of Chemistry and Physics 88TH Edition 2007-2008. CRC Press, Taylor & Francis, Boca Raton, FL 2007, p. 3-470] **PEER REVIEWED**

Color/Form:

Colorless liquid

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human

Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Odor:

Ether-like odor

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 958] **PEER REVIEWED**

Mildly sweet, chloroform-like odor

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.] **PEER REVIEWED**

Chlorinated solvent odor

[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)] **PEER REVIEWED**

Boiling Point:

121.3 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 88TH Edition 2007-2008. CRC Press, Taylor & Francis, Boca Raton, FL 2007, p. 3-470] **PEER REVIEWED**

Melting Point:

-22.3 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 88TH Edition 2007-2008. CRC Press, Taylor & Francis, Boca Raton, FL 2007, p. 3-470] **PEER REVIEWED**

Corrosivity:

Corrosion of aluminum, iron, and zinc, which is negligible unless water is present, can be inhibited by the addition of stabilizers

[Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000] **PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 347.1 deg C; critical pressure: 9.74 MPa (to convert MPa to atm, divide by 0.101)

[Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000] **PEER REVIEWED**

Density/Specific Gravity:

1.6230 g/cu cm at 20 deg C

[Lide, D.R. CRC Handbook of Chemistry and Physics 88TH Edition 2007-2008. CRC Press, Taylor & Francis, Boca Raton, FL 2007, p. 3-470] **PEER REVIEWED**

Heat of Combustion:

679.9 kJ/mol (constant pressure with formation of aq hydrochloric acid; 831.8 kJ/mol (constant volume at 18.7 deg C) (to convert J to cal, divide by 4.184)

[Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000] **PEER REVIEWED**

Heat of Vaporization:

90.2 BTU/lb = 50.1 cal/g = 2.10X10+5 J/kg

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.] **PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow = 3.40

[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995., p. 3] **PEER REVIEWED**

Solubilities:

Miscible with alcohol, ether, chloroform, benzene

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1581] **PEER REVIEWED**

Miscible with solvent hexane; dissolves in most of the fixed and volatile oils

[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980., p. 1184] **PEER REVIEWED**

In water, 206 mg/L at 25 deg C

[Horvath AL; Halogenated hydrocarbons: solubility-miscibility with water. New York, NY: Marcel Dekker, Inc pp. 889 (1982)] **PEER REVIEWED**

Spectral Properties:

SADTLER REF NUMBER: 237 (IR, PRISM); 79 (IR, GRATING)

[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979., p. C-298] **PEER REVIEWED**

Index of Refraction: 1.5053 at 20 deg C/D

[Lide, D.R. CRC Handbook of Chemistry and Physics 88TH Edition 2007-2008. CRC Press, Taylor & Francis, Boca Raton, FL 2007, p. 3-470] **PEER REVIEWED**

Raman: 283 (Sadtler Research Laboratories spectral collection)

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V3: 2771] **PEER REVIEWED**

IR: 4786 (Coblentz Society Spectral Collection)

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V3: 2771] **PEER REVIEWED**

MASS: 107150 (NIST/EPA/MSDC Mass Spectral Database, 1990 version); 242 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)

[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V3: 2771] **PEER REVIEWED**

Surface Tension:

31.74 dynes/cm at 20 deg C in contact with vapor

[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. F-37] **PEER REVIEWED**

Vapor Density:

5.7 (Air = 1)

[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965., p. 213] **PEER REVIEWED**

Vapor Pressure:

18.5 mm Hg at 25 deg C

[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985., p. 522] **PEER REVIEWED**

Relative Evaporation Rate:

Evaporation rate slower than that for trichloroethylene, about 3-1.

[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965., p. 213] **PEER REVIEWED**

Viscosity:

Liquid (cP): 0.932 at 15 deg C; 0.839 at 25 deg C; 0.657 at 50 deg C; 0.534 at 75 deg C. Vapor: 9900 cP at 60 deg C

[Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000] **PEER REVIEWED**

Other Chemical/Physical Properties:

Liquid-water interfacial tension: 44.4 dynes/cm = 0.0444 N/m at 25 deg C

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.] **PEER REVIEWED**

Conversion factors: 1 mg/L equals 147.4 ppm and 1 ppm equals 6.78 mg/cu m at 25 deg C, 760 mm Hg

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 4208] **PEER REVIEWED**

Partition coefficients at 37 deg C for **tetrachloroethylene** into blood = 13.1; into oil = 1,920

[Sato A, Nakajima T; Scand J Work Environ Health 13: 81-93 (1987)] **PEER REVIEWED** PubMed Abstract

Saturation concentration in air: 126 g/cu m at 20 deg C, 210 g/cu m at 30 deg C

[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. V2: 1949] **PEER REVIEWED**

Decomposes slowly in water to yield trichloroacetic and hydrochloric acids; oxidized by strong oxidizing agents

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at:

http://monographs.iarc.fr/ENG/Classification/index.php p. V20: 492 (1979)] **PEER REVIEWED**

Henry's Law constant = 0.0177 atm-cu m/mole at 25 deg C
[Gossett JM; Environ Sci Technol 21: 202-6 (1987)] **PEER REVIEWED**

Hydroxyl radical reaction rate constant = 1.67X10-13 cu cm/molecule-sec at 25 deg C
[Atkinson R; J Phys Chem Ref Data Monograph No. 2 (1994)] **PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

The major hazards encountered in the use and handling of **tetrachloroethylene** stem from its toxicologic properties. Exposure to this colorless liquid may occur from its use as a solvent and as an intermediate in chemical syntheses. In addition to eye and skin inflammation from contacting liquid **tetrachloroethylene**, inhalation of its vapor can cause central nervous system depression, liver necrosis, and effects on the lung, heart, and kidney. The ACGIH recommends a workplace limit (TLV) of 50 ppm as an 8 hr time-weighted average (TWA) with a note to prevent skin contact. **Tetrachloroethylene**'s sweet chloroform-like odor may warn of its presence at a sub-TLV level of 4.68 ppm; however,the distinctive odor of **tetrachloroethylene** does not necessarily provide adequate warning. Because **tetrachloroethylene** quickly desensitizes olfactory responses, persons can suffer exposure to vapor concentrations in excess of TLV limits without smelling it. To assure against exposure, it is recommended that self-contained breathing apparatus and full protective clothing be worn, especially in fire or spill situations. Although considered nonflammable, containers of **tetrachloroethylene** may explode in the heat of a fire and its vapor will decompose in contact with open flames or red-heated materials to yield the poisonous gas, phosgene. For small fires involving **tetrachloroethylene**, extinguish with dry chemical or CO2, and for large fires, use water spray, fog, or foam. Cool containers with water. If the fire involves a tank car or truck, isolate the area for 1/2 mile in all directions. **Tetrachloroethylene** should be stored in a cool, dry, well-ventilated location, away from strong oxidizers, potential fire hazards, caustic soda, potash, and chemically active metals such as barium, lithium, and beryllium. For small spills of **tetrachloroethylene**, ventilate the area then take up with vermiculite, dry sand, or earth. Large spills should be diked for later disposal. Prior to implementing land disposal of waste residues (including waste sludge), consult environmental regulatory agencies for guidance.
PEER REVIEWED

DOT Emergency Guidelines:

/GUIDE 160: HALOGENATED SOLVENTS/ Fire or Explosion: Some of these materials may burn, but none ignite readily. Most vapors are heavier than air. Air/vapor mixtures may explode when ignited. Container may explode in heat of fire.
[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Health: Toxic by ingestion. Vapors may cause dizziness or suffocation. Exposure in an enclosed area may be very harmful. Contact may irritate or burn skin and eyes. Fire may produce irritating and/or toxic gases. Runoff from fire control or dilution water may cause pollution.
[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER

REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Public Safety: CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). Keep out of low areas. Ventilate closed spaces before entering.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Protective Clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing that is specifically recommended by the manufacturer. Structural firefighters' protective clothing will only provide limited protection.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Evacuation: Large Spill: Consider initial downwind evacuation for at least 100 meters (330 feet). Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Fire: Small Fire: Dry chemical, CO2 or water spray. Large Fire: Dry chemical, CO2, alcohol-resistant foam or water spray. Move containers from fire area if you can do it without risk. Dike fire-control water for later disposal; do not scatter the material. Fire involving Tanks or Car/Trailer Loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ Spill or Leak: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you can do it without risk. Small Liquid Spill: Take up with sand, earth or other non-combustible absorbent material. Large Spill: Dike far ahead of liquid spill for later disposal. Prevent entry into waterways, sewers, basements or confined areas.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

/GUIDE 160: HALOGENATED SOLVENTS/ First Aid: Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Wash skin with soap and water. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

[U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012] **PEER REVIEWED**

FPL-049-095

Odor Threshold:

The distinctive odor of **tetrachloroethylene** does not necessarily provide adequate warning. Because **tetrachloroethylene** quickly desensitizes olfactory responses, persons can suffer exposure to vapor concentrations in excess of TLV limits without smelling it.

[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984., p. 5(79) 761] **PEER REVIEWED**

Recognition in air: 4.68 ppm (chemically pure)

[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978., p. 155] **PEER REVIEWED**

The odor threshold for **tetrachloroethylene** has been established as 32 mg/ cu m.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Perchloroethylene has a not unpleasant etheral or aromatic odor. ... 50 ppm, odor threshold (very faint) to unacclimated; no physiological effects (8 hr). 100 ppm, odor (faint) definitely apparent to unacclimated; very faint to not perceptible during exposure; no physiological effects (8 hr). 200 ppm, odor (definite) moderate to faint upon exposure; faint to moderate eye irritation; minimal light-headedness; (eye irritation threshold 100-200 ppm). 400 ppm, odor (strong) unpleasant; definite eye irritation, slight nasal irritation; definite incoordination (2 hr). 600 ppm, odor (strong) very unpleasant but tolerable; definite eye & nasal irritation; dizziness, loss of inhibitions (10 min). 1000 ppm, odor (very strong) intense, irritating; markedly irritating to eyes & resp tract; considerable dizziness (2 min). 1500 ppm, odor (almost intolerable) "gagging"; irritation almost intolerable to eyes & nose; complete incoordination within minutes to unconsciousness within 30 min.

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 4240] **PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Eye exposure can lead to conjunctivitis; Skin exposure can lead to inflamation; Inhalation can lead to respiratory tract irritation.

[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982., p. 507] **PEER REVIEWED**

Tetrachloroethylene vapor is a mucous membrane & upper resp irritant at levels above 75 to 100 ppm.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988., p. 986] **PEER REVIEWED**

Neat **tetrachloroethene** is irritating to human skin.

[International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: Tetrachloroethene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html **PEER REVIEWED**

Fire Potential:

Tetrachloroethylene itself does not burn.

[Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 5th Edition Volume 1: A-H,Volume 2: I-Z. William Andrew, Norwich, NY 2008, p. 2390] **PEER REVIEWED**

NFPA Hazard Classification:

Health: 2. 2 = Materials that, under emergency conditions, can cause temporary incapacitation or residual injury.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Flammability: 0. 0 = Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone, and sand.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Instability: 0. 0 = Materials that in themselves are normally stable, even under fire conditions.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Flash Point:

No flash point in conventional closed tester.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141-2] **PEER REVIEWED**

Fire Fighting Procedures:

Approach from upwind to avoid hazardous vapors and toxic decomposition products. Use water spray to keep fire-exposed containers cool. Use flooding quantities of water as fog or spray. Extinguish fire using agent suitable for surrounding fire.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Wear full protective clothing and positive pressure self-contained breathing apparatus. Polyvinyl alcohol, Teflon, or Viton barrier recommended.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Toxic Combustion Products:

Combustion by-products may include hydrogen chloride and phosgene.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Explosive Limits & Potential:

Mixtures with lithium shavings ... are impact-sensitive and will explode, sometimes violently.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1315] **PEER REVIEWED**

The presence of 0.5% of trichloroethylene as impurity in **tetrachloroethylene** during unheated drying over solid sodium hydroxide caused the generation of dichloroacetylene. After subsequent fractional distillation, the volatile fore-run exploded.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 211] **PEER REVIEWED**

Mixtures of /dinitrogen/ tetraoxide with ... **tetrachloroethylene** are explosive when subjected to shock of 25 g TNT equivalent or less.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1352] **PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

... Reacts violently with concentrated nitric acid to give carbon dioxide as a primary product.

[Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 5th Edition Volume 1: A-H,Volume 2: I-Z. William Andrew, Norwich, NY 2008, p. 2388] **PEER REVIEWED**

Reacts violently under the proper conditions with /barium/, /beryllium/, /lithium/, /nitrogen tetroxide/, metals, /sodium hydroxide/.

[Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2858] **PEER REVIEWED**

Granular barium in contact with ... **tetrachloroethylene** ... is susceptible to detonation.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 78] **PEER REVIEWED**

Reacts with metals to form explosive mixtures; Sodium hydroxide, possible explosion.

[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982., p. 696] **PEER REVIEWED**

Several cases of violent reaction between aluminum and ... **tetrachloroethylene** in vapor degreasers have been noted.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 26] **PEER REVIEWED**

Strong oxidizers; chemically-active metals such as lithium, beryllium, and barium; caustic soda; sodium hydroxide; potash.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Hazardous Decomposition:

On contact with hot surfaces or flames this substance decomposes forming toxic and corrosive fumes (hydrogen chloride, phosgene, chlorine).

[International Program on Chemical Safety/Commission of the European Communities; International Chemical Safety Card on Tetrachloroethylene (April 2000). Available from as of September 29, 2010: http://www.inchem.org/pages/icsc.html **PEER REVIEWED**

When in contact with activated charcoal decomposes to form hexachloroethane and hexachlorobenzene at 700 deg C.

[Gonikberg MG et al; Bul Acad Sci USSR Dir Chem Sci p.739 (1956)] **PEER REVIEWED**

Slowly decomposes on contact with moisture producing trichloroacetic acid and hydrochloric acid. Decomposes in UV light and in temperatures above 150 deg C forming hydrochloric acid and phosgene.

[Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 5th Edition Volume 1: A-H,Volume 2: I-Z. William Andrew, Norwich, NY 2008, p. 2388] **PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH has recommended that **tetrachloroethylene** be treated as a potential occupational carcinogen.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Protective Equipment & Clothing:

FOR HIGH VAPOR CONCN USE APPROVED CANISTER OR AIR-SUPPLIED MASK; CHEMICAL GOGGLES OR

FACE SHIELD; PLASTIC GLOVES.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8] **PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possbility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Respirator Recommendations: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

Assigned Protection Factor (APF)	Respirator Recommendation
APF = 10,000	Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

APF = 10,000	Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Respirator Recommendations: Escape conditions:

Assigned Protection Factor (APF)	Respirator Recommendation
APF = 50	Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister/Any appropriate escape-type, self-contained breathing apparatus.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Preventive Measures:

SRP: The scientific literature for the use of contact lenses by industrial workers is inconsistent. The benefits or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place. **PEER REVIEWED**

If material not involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 862] **PEER REVIEWED**

Personnel protection: Keep upwind ... Wash away any material which may have contacted the body with copious amounts of water or soap and water. Do not handle broken packages unless wearing appropriate personal protective equipment.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 862] **PEER REVIEWED**

Environmental considerations - land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner./ Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash or cement powder.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface

Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 862] **PEER REVIEWED**

Environmental considerations - water spill: If dissolved, in region of 10 ppm or greater concentration, apply activated carbon at ten times the spilled amount. Remove trapped material with suction hoses.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 862] **PEER REVIEWED**

Environmental considerations - air spill: Apply water spray or mist to knock down vapors. Vapor knockdown water is corrosive or toxic and should be diked for containment.

[Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 862] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be

used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 9] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 9] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 10] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres for chem such as nitrosamines. Methods ... should ... where possible, be simple & sensitive. ... /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 10] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 10] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 11] **PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed or replaced.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. The completeness of the cleaning procedures should be considered before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at the end of shift, but should remain at employee's place of work for cleaning.

PEER REVIEWED

SRP: Wastewater from contaminant suppression, cleaning of protective clothing/equipment, or contaminated sites should be contained and evaluated for subject chemical or decomposition product concentrations. Concentrations shall be lower than applicable environmental discharge or disposal criteria. Alternatively, pretreatment and/or discharge to a permitted wastewater treatment facility is acceptable only after review by the governing authority and assurance that "pass through" violations will not occur. Due consideration shall be given to remediation worker exposure (inhalation, dermal and ingestion) as well as fate during treatment, transfer and disposal. If it is not practicable to manage the chemical in this fashion, it must be evaluated in accordance with EPA 40 CFR Part 261, specifically Subpart B, in order to determine the appropriate local, state and federal requirements for disposal.

PEER REVIEWED

Stability/Shelf Life:

Rapidly deteriorates in warm climates

[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975., p. 1031] **PEER REVIEWED**

Tetrachloroethylene is stable up to 500 deg C in the absence of catalysts, moisture, and oxygen.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

The material is extremely stable and resists hydrolysis.

[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984., p. 2518] **PEER REVIEWED**

Pure compound is slowly decomp by various metals in presence of moisture.

[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980., p. 1177] **PEER REVIEWED**

The physical stability of emulsions of **tetrachloroethylene** can be enhanced by diluting the **tetrachloroethylene** with arachis oil before emulsification. This practice may be harmful because the oil increases the absorption, & thus the toxicity, of the drug.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./

[49 CFR 171.2; U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of February 15, 2006: http://www.gpoaccess.gov/ecfr/ **PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.

[International Air Transport Association. Dangerous Goods Regulations. 47th Edition. Montreal, Quebec Canada. 2006., p. 259] **PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.

[International Maritime Organization. International Maritime Dangerous Goods Code. London, UK. 2004., p. 92] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13] **PEER REVIEWED**

Do not transport with food and feedstuffs.

[International Program on Chemical Safety/Commission of the European Communities; International Chemical Safety Card on Tetrachloroethylene (April 2000). Available from as of September 29, 2010: http://www.inchem.org/pages/icsc.html **PEER REVIEWED**

Storage Conditions:

Store in cool, dry, well-ventilated location. Separate from active metals. Isolate from open flames and combustibles.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-142] **PEER REVIEWED**

It is stored in mild steel tanks equipped with breathing vents & chemical driers. It can be transferred through seamless black iron pipes, with gasketing materials of compressed asbestos, asbestos reinforced with metal, or asbestos impregnated with Teflon or Viton, employing centrifugal or positive displacement pumps of cast iron or steel construction. Small quantities ... may be stored safely in green or amber glass containers.

[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984., p. 5(79) 759] **PEER REVIEWED**

TEMPERATURE: AMBIENT. VENTING: PRESSURE-VACUUM.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13] **PEER REVIEWED**

Cleanup Methods:

Ventilation. Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place.

[International Program on Chemical Safety/Commission of the European Communities; International Chemical Safety Card on Tetrachloroethylene (April 2000). Available from as of September 29, 2010: http://www.inchem.org/pages/icsc.html **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 15] **PEER REVIEWED**

Approach release from upwind. Stop or control the leak, if this can be done without undue risk. Control runoff and isolate discharged material for proper disposal.

[National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-141] **PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number U210, F002, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.

[40 CFR 240-280, 300-306, 702-799 (7/1/2008)] **PEER REVIEWED**

Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. Alternatively, PCE may be recovered from waste gases and reused.

[Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 5th Edition Volume 1: A-H,Volume 2: I-Z. William Andrew, Norwich, NY 2008, p. 2390-1] **PEER REVIEWED**

... Tower aeration is the most cost-effective technique for removing volatile organic chlorine chemicals from drinking water. /Volatile organic chlorine chemicals/

[Clark RM et al; J Environ Eng 110 (6): 1146-62 (1984)] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 14] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Total destruction ... by incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose.The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 15] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 15] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as sat soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 16] **PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating, or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols, & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 17] **PEER REVIEWED**

Chemical Treatability of **Tetrachloroethylene**; Concentration Process: Activated carbon; Chemical Classification: Halocarbon; Scale of Study: Laboratory scale; Type of Wastewater Used: Well water; Results of Study: Performance for treatment of water containing several halogens. Virgin: 5100 bed volume to 33 ppb compound leakage; 13.3 days;

gal treated/cu ft sorbent, 38,250. Regenerated: 4000 bed volume to 33 ppb compound leakage; 10.4 days; gal treated/cu ft sorbent, 30.0; (column studies 14 mm diameter glass tubes, height 4 in (15 cu cm absorbent) Flow-2 gpm/cu ft (16 bed volume per hr) regenerated at 37 lb steam/cu ft @ 5 psig).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-159 (1982)] **PEER REVIEWED**

Chemical Treatability of **Tetrachloroethylene**; Concentration Process: Resin Adsorption; Chemical Classification: Halocarbon; Scale of Study: Laboratory Scale; Type of Wastewater Used: Well Water; Comments: Column studies: 14 mm diameter glass tubes, height 4 in (15 cu cm adsorbent) Flow-2 gallons per min/cu ft (16 bed volume per hr) regenerated at 37 lb steam/cu ft at 5 psig.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-192 (1982)] **PEER REVIEWED**

A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-15 (1981) EPA 68-03-3025] **PEER REVIEWED**

Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. Alternatively, it may be recovered from waste gases and reused. Recommendable method: Incineration.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985., p. 180] **PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 100 ppm.
[29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 200 ppm.
[29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift. Concentration: 300 ppm. Maximum Duration: 5 minutes in any 3 hours.
[29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of October 28, 2010: http://www.gpoaccess.gov/ecfr **PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 25 ppm (170 mg/cu m) is still enforced in some states.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997., p. 372] **PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA): 25 ppm; 15 min Short Term Exposure Limit (STEL): 100 ppm

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 55] **PEER REVIEWED**

A3: Confirmed animal carcinogen with unknown relevance to humans.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 55] **PEER REVIEWED**

Biological Exposure Index (BEI): Determinant: **Tetrachloroethylene** in end-exhaled air; Sampling Time: Prior to shift; BEI: 3 ppm.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 106] **PEER REVIEWED**

Biological Exposure Index (BEI): Determinant: **Tetrachloroethylene** in blood; Sampling Time: Prior to shift; BEI: 0.5 mg/L.

[American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2010, p. 106] **PEER REVIEWED**

NIOSH Recommendations:

NIOSH recommends that **tetrachloroethylene** be regulated as a potential occupational carcinogen.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concn.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Minimize workplace exposure concentration.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH has recommended that **tetrachloroethylene** be treated as a potential occupational carcinogen.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards & Other Databases CD-ROM. Department of Health & Human Services, Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2005-151 (2005)] **PEER REVIEWED**

Other Standards Regulations and Guidelines:

Emergency Response Planning Guidlines (ERPGs) for **perchloroethylene**:

ERPG	Maximum Airborne Concentration
The ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.	100 ppm (Odor should be detectable near ERPG-1)
The ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.	200 ppm
The ERPG-3: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.	1000 ppm

[American Industrial Hygiene Association. 2010 Emergency Response Planning Guidelines (ERPG) Workplace Environmental Exposure Level (WEEL). American Industrial Hygiene Association Guideline Foundation. Fairfax, VA 2010., p. 25] **PEER REVIEWED**

Maximum allowable concentrations range from 10 mg/cu m (1.5 ppm, ceiling value) in the USSR, 140 mg/cu m (20 ppm, TWA) in Sweden, and 250 mg/cu m (37 ppm) in Czechoslovakia to 340 mg/cu m (50 ppm) in the Federal Republic of Germany, Japan. Short-term exposure limits range from 340 mg/cu m (50 ppm) in Sweden to 1250 mg/cu m (183 ppm) in Czechoslovakia and 1340 mg/cu m (200 ppm) in the USA. The acceptable limit in Brazil is 525 mg/cu m (78 ppm) for 48 hr per week.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Maximum allowable concentrations are 1.0 mg/cu m average per day or 4.0 mg/cu m average per 0.5 hr in Czechoslovakia and 0.06 mg/cu m average per day in the USSR.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

Manufacturing/Use Information:

View products that contain this chemical: Tetrachloroethylene

Uses:

For **Tetrachloroethylene** (USEPA/OPP Pesticide Code: 078501) there are 0 labels match. /SRP: Not registered for current use in the U.S., but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./

[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://npirspublic.ceris.purdue.edu/ppis/ **PEER REVIEWED**

The active ingredient is no longer contained in any registered /pesticide/ products ... "cancelled.".

[United States Environmental Protection Agency/ Prevention, Pesticides and Toxic Substances; Status of Pesticides in Registration, Reregistration, and Special Review. (1998) EPA 738-R-98-002, p. 269] **PEER REVIEWED**

Approximately 50% of demand is in the dry cleaning business where about 80% of all dry cleaners use it as their primary cleaning agent. Use as a feedstock for chlorofluorocarbon production - 30% of current demand. Metal cleaning and miscellaneous (such as transformer insulating fluid, chemical maskant formulations, process solvent for desulfurizing coal) applications - 12 and 8%, respectively

[Hickman JC; Kirk-Othmer Encyclopedia of Chemical Technology. (2001). New York, NY: John Wiley & Sons; Tetrachloroethylene. Online Posting Date: 4 Dec 2000] **PEER REVIEWED**

Used in the textile industry for dry-cleaning & for processing & finishing; used in both cold cleaning & vapor degreasing of metals; it is used as a chem intermediate in the synthesis of fluorocarbon 113, 114, 115, & 116; it is used as a heat-exchange fluid

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V20: 494 (197)] **PEER REVIEWED**

Scouring, sizing, and desizing agent in textile manufacture

[SRI] **PEER REVIEWED**

COMPONENT OF AEROSOL LAUNDRY-TREATMENT PRODUCTS

[SRI] **PEER REVIEWED**

SOLVENT, EG, FOR SILICONES

[SRI] **PEER REVIEWED**

Insulating fluid and cooling gas in electric transformers

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1581] **PEER REVIEWED**

In typewriter correction fluids (eg, Liquid Paper, Wite-Out, Snopake, etc)

[Greer JE; South Med J 77 (3): 297-8 (1984)] **PEER REVIEWED** PubMed Abstract

Formerly used, but no longer approved, in mixtures with grain protectants and certain liquid grain fumigants

[Farm Chemicals Handbook 87. Willoughby, Ohio: Meister Publishing Co., 1987., p. C-248] **PEER REVIEWED**

... Used in the coal industry ... To determine the specific gravity of the various fractions of a sample provided by the /coal/ mine ...

[National Industrial Chemicals Notification and Assessment Scheme; Tetrachloroethylene (127-18-4) Assessment Report No. 15 p. 16 (June 2001). Available from, as of September 29, 2010: http://www.nicnas.gov.au/Publications/CAR/PEC.asp **PEER REVIEWED**

Tetrachloroethylene is used to clean dirt, grease and minor scratches from the print and the negative films prior to printing.

[National Industrial Chemicals Notification and Assessment Scheme; Tetrachloroethylene (127-18-4) Assessment Report No. 15 p. 17 (June 2001). Available from, as of September 29, 2010: http://www.nicnas.gov.au/Publications/CAR/PEC.asp **PEER REVIEWED**

/**Tetrachloroethylene** is used in/ catalytic reforming in petrol production ... /used as a/ maskant, analytical reagent, electric motor and electrical equipment cleaner, cleaning of flexograph printing plates /and as a/ carpet stain remover. /Also used in/ aerosol car care products.

[National Industrial Chemicals Notification and Assessment Scheme; Tetrachloroethylene (127-18-4) Assessment Report No. 15 p. 18-22 (June 2001). Available from, as of September 29, 2010: http://www.nicnas.gov.au/Publications/CAR/PEC.asp **PEER REVIEWED**

MEDICATION: Anthelmintic (Nematodes, Trematodes). (See also: Therapeutic Uses)

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 1581] **PEER REVIEWED**

MEDICATION (VET): After the advent of phenothiazine ... little use has been made of the chlorinated hydrocarbons ... /as a ruminant anthelmintic/. **Tetrachloroethylene** has continued to be used in small animals over the years but has been largely replaced by drugs that are less toxic & easier to admin. (See also: Therapeutic Uses)

[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 839] **PEER REVIEWED**

Manufacturers:

The Dow Chemical Co., 2030 Dow Center, Midland, MI 48642, (989) 636-1000; Production site: Plaquemine, LA 70764

[SRI Consulting, 2010 Directory of Chemical Producers. Menlo Park, CA. 2010, p. 754] **PEER REVIEWED**

Occidental Chemical Corp., Occidental Tower, 5005 LBJ Freeway, Dallas, TX 75244-6119, (972) 404-3800; Chloro-Vinyls Group; Production site: Geismar, LA 70734

[SRI Consulting, 2010 Directory of Chemical Producers. Menlo Park, CA. 2010, p. 754] **PEER REVIEWED**

PPG Industries, Inc, One PPG Place, Pittsburgh, PA 15272, (412) 434-3131; Chemicals Group; Production site: Lake Charles, LA 70601

[SRI Consulting, 2010 Directory of Chemical Producers. Menlo Park, CA. 2010, p. 754] **PEER REVIEWED**

Tetrachloroethylene - Producers 2009

Company	Address	City, State, Country
Compania Industrial Progreso S.A.	Camino General Belgrano 2158	B1869BPD Avellaneda (BA), Argentina
Dalgar S.A.	Ruta de la TradiciAln 7168, Barrio 9 de Abril	B1839FSR Esteban EcheverrA-a (BA), Argentina
Quimibras Industrias Quimicas S.A.	Rua General Correa e Castro 445/465, Jardim America	21240-030 Rio de Janeiro (RJ), Brazil
Dow Brasil S.A.	Rua Alexandre Dumas, 1671 Chacara Santo Antonio	04717-903 Sao Paulo (SP), Brazil
Guangzhou Chemical Reagent Factory	882 Gongye Dadao South Avenue, Haizhu District	Guangzhou 510288, China
Nantong Eagle Paint Co., Ltd. (Formerly Jiangsu Xiongying Industry)	12, South Mafeng Road Rudong County	Jiangsu Province 226401, China
Alashan Dakang Fine Chemical Co., Ltd (Jilantai Salt Industry Group)		Wusutu Town Alashan, Inner Mongolia 750336, China
Changshu Yudong Chemical Co., Ltd.	88 Yingbin Road	Wangshi Haiyu Town Changshu, Jiangsu 215519, China
Shanghai Chlor-Alkali Chemical Co., Ltd.	4747 Longwu Road	Minhang District Shanghai 200241, China
Zhejiang Sunrise Fine Chemicals Co., Ltd.	22/F, East Sea Sunshine Building, 455 Zhongshan East Road	Ningbo City, Zhejiang Province 315040, China
Shanghai Chemical Reagent Co., Ltd., (Shanghai Huayi Group)	Mansion of Hualun, 560 Xu Jia Hui Road	Shanghai 200062, China
Shantou Xilong Chemical Co., Ltd.	2 XiLong Middle Street, ChaoShan Road	Shantou, Guangdong Province 515064, China
Juhua Group Corporation	849 Jiangcheng Road	Hangzhou, Zhejiang Province, 310009 China
Dow Chemical (Guangzhou) Co., Ltd.	Jinhua Er Street, Jinxiu Road	GETDD Guangzhou City, Guangdong Province 510730, China
Dow Quimica de Colombia S.A.	Tranversal 18, 96-41 Piso 7	Bogota, Colombia
Spolchemie - Spolek pro chemickou a hutni vyrobu	a.s. Revolucni	86 40032 Usti nad Labem, Czech Republic
Ste Charbonneaux-Brabant S.A.		BP 341 51062 Reims Cedex, France

Solvay, S.A.	25 rue de Clichy	75442 Paris Cedex 09, France
Solvents Documentation Syntheses, S.A. (SDS)	Z.I. de Valdonne	13124 Peypin, France
Dow Deutschland GmbH & Co.	OHG Postfach 1120	21677 Stade, Germany
Solvay Chemicals GmbH	Xantener Strasse 237	47495 Rheinberg, Germany
Vickers Laboratories Ltd.	Richardshaw Road	Pudsey, West Yorkshire LS28 6QW, Great Britain
Chemplast Sanmar Ltd.	9 Cathedral Road	Chennai 600.086, India
Bio-Lab Ltd.	P.O. Box 34038	Jerusalem 91340, Israel
Solvay Chimica Italia S.p.A.	Via Piave, 6	57013 Rosignano Solvay (LI), Italy
Tokyo Junyaku Kogyo Co. Ltd.	Murayama Bldg., 1-7-6 Kaji-cho, Chiyoda-ku	Tokyo 101-0044, Japan
Toagosei Co., Ltd.	1-14-1 Nishi-shimbashi Minato-ku	Tokyo 105-8419, Japan
Kanto Denka Kogyo Co., Ltd.	Tokio Marine Nichido Building, Shinkan, 1-2-1 Marunouchi Chiyoda-ku	Tokyo 100-0005, Japan
Egon Meyer, S.A.	De C.V. Avenida Henry Ford 38, Fracc. Industrial	San Javier 54030 Tlalnepantla, Mex., Mexico
Pemex Petroquimica	Av. Marina Nacional Numero 329, Torre Ejecutiva Piso 27, Colonia Huasteca, Delegacion Miguel Hidalgo	11311 Mexico, D.F., Mexico
Dow Benelux B.V.	Postbus 48	4530 AA Terneuzen, Netherlands
Chimmed LLC	Kashyrskoye shosse 9, Building 3	115230 Moscow, Russia
Ekos-1 CJSC	P.O. Box 42	107076 Moscow, Russia
Kaustik JSC	32, Tekhnicheskaya Street	453110, Sterlitamak, Bashkortostan Republic, Russia
Ercros Industrial S.A.	Basic Chemicals Division Avda. Diagonal	595 08014 Barcelona, Spain
Acideka, S.A.	Capuchinos de Basurto, 6, 4-andar planta	48013 Bilbao (Vizcaya), Spain
Panreac Quimica, S.A.U.	C/Garraf, 2, Poligono Pla de la Bruguera	08211 Castellar del Valles (Barcelona), Spain
Sheng Li Chemical Co., Ltd.	215-3 Tienfu Road	Sanshia Chen Taipei Hsien 237, Taiwan
Dowpharma	2030 Dow Center	Midland, MI 48674, U.S.A.
Advanced Synthesis, S.A.	P.O. Box 437920	San Ysidro, CA 92173, U.S.A.
Basic Chemicals Company, LLC (A Subsidiary of Occidental Chemical)	5005 LBJ Freeway	Dallas, TX 75244-6119, U.S.A.
Hydrite Chemical Co.	300 N. Patrick Boulevard	Brookfield, WI 53045, U.S.A.

PPG Chlor-Alkali & Derivatives	440 College Park Drive	Monroeville, PA 15146, U.S.A.
The Dow Chemical Company	P.O. Box 1206	Midland, MI 48642, U.S.A.

[Directory of World Chemical Producers, Chemical Information Services. 2009 Directory of World Chemical Producers, Chemical Information Services, 9101 LBJ Frwy., Suite 310, Dallas, TX 75243, (214) 349-6200. Date downloaded: September 2009. Available from, as of Oct, 2011: http://www.chemicalinfo.com/dwcp **UNREVIEWED**

Tetrachloroethylene - Company and Site Information (2006)

Company	Site	City, State, Zip	Manufacture	Import
Basic Chemicals Company, LLC	Basic Chemicals Co - Geismar	Geismar LA 70734	Yes	No
Basic Chemicals Company, LLC	Basic Chemicals Co - Wichita Plant	Wichita KS 67215	Yes	No
Georgia Gulf Corporation	Georgia Gulf Lake Charles, LLC	Westlake LA 70669	Yes	No
ICC Chemical Corporation	ICC Chemical Corporation	New York NY 10022	No	Yes
Ineos Chlor Americas, Inc	Ineos Chlor Americas, Inc	Wilmington DE 19810	No	Yes
K.G. International, Inc.	K.G. International, Inc.	Miami FL 33166	No	Yes
Oxy Vinyls, LP	Oxy Vinyls - LaPorte	La Porte TX 77571	Yes	No
PPG Industries, Inc.	PPG Industries - Lake Charles	Lake Charles LA 70602	Yes	No
Petrochem Americas LLC	Petrochem Americas LLC	Plano TX 75093	No	Yes
TR International, Incorporated	TR International Inc - Seattle	Seattle WA 98101	No	Yes
The Dow Chemical Company	Dow Chemical - Freeport, TX	Freeport TX 77541	Yes	No
The Dow Chemical Company	Dow Chemical - Headquarters	Midland MI 48674	No	Yes
The Dow Chemical Company	Dow Chemical - Plaquemine	Plaquemine LA 70764	Yes	No
Vulcan Materials Company	Vulcan Materials Co - Geismar Plant	Geismar LA 70734	Yes	No

[US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Nov 10, 2010: http://cfpub.epa.gov/iursearch/index.cfm **PEER REVIEWED**

Methods of Manufacturing:

Manufactured by catalytic oxidn of 1,1,2,2-tetrachloroethane: Ellsworth, vancamp, US patent 2,951,103 (1960 to Columbia-Southern Chem); Feathers, Rogerson, US patent 3,040,109 (1962 to Pittsburgh Plate Glass) ... by catalytic chlorination of acetylene: Thermet, Parvi, US patent 2,938,931 (1960 to Societe d'electrochimie, d'electrometallurgie et des acieries electriques d'Ugine).

[O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station,

NJ: Merck and Co., Inc., 2006., p. 1581] **PEER REVIEWED**

Prepared primarily by two processes: (1) The Huels method whereby direct chlorination of ethylene yields 70% **perchloroethylene**, 20% carbon tetrachloride, and 10% other chlorinated products; (2) Hydrocarbons such as methane, ethane, or propane are simultaneously chlorinated and pyrolyzed to yield over 95% **perchloroethylene** plus carbon tetrachloride and hydrochloric acid.

[Fishbein L; Potential Indust Carcin & Mutagens p.148 (1977) USEPA 560/5-77-005] **PEER REVIEWED**

Tetrachloroethylene is produced mainly by oxyhydrochlorination, perchlorination, and/or dehydrochlorination of hydrocarbons or chlorinated hydrocarbons such as 1,2 dichloroethane, propylene, propylene dichloride, 1,1,2-tri-chloroethane, and acetylene.

[WHO; Environmental Health Criteria Document No. 31: Tetrachloroethylene (127-18-4). Available from, as of September 20, 2010: http://www.inchem.org/pages/ehc.html **PEER REVIEWED**

General Manufacturing Information:

Method of purification: distillation

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 958] **PEER REVIEWED**

Formulations/Preparations:

Grade: purified, technical, USP, as **tetrachloroethylene**, spectrophotometric

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 958] **PEER REVIEWED**

Available in the United States ... in veterinary preparations (eg, Nema Worm Capsules (Parke-Davis)). These capsules contain pure **tetrachloroethylene**. Avail sizes are 0.2, 0.5, 1.0, 2.5 & 5 ml.

[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986., p. 1612] **PEER REVIEWED**

Tetrachloroethylene, USP ... Available in soft gelatin capsules containing 0.2, 1.0, or 2.5 ml of drug. It may be difficult to obtain drug in capsule form for human use. /former use/

[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975., p. 1031] **PEER REVIEWED**

Tetrachloroethylene is avail in the USA in the following grades: purified, technical, USP, spectrophotometric, & dry-cleaning. The technical & dry-cleaning grades both meet specifications for technical grade & differ only in the amount of stabilizer added to prevent decomposition. Stabilizers ... incl amines or mixtures of epoxides & esters. Typical analysis of the commercial grade is ... nonvolatile residue, 0.0003%; free chlorine, none; moisture, no cloud at -5 deg C ... USP grade contains not less than 99.0% & no more than 99.5% **tetrachloroethylene**, the remainder consisting of ethanol. ...

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health

Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V20: 492 (1979)] **PEER REVIEWED**

Food Grade

[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988., p. 116] **PEER REVIEWED**

/**Tetrachloroethylene** (BP) may/ ... contain thymol 0.01% wt/wt as a preservative.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 106] **PEER REVIEWED**

Tetrachloroethylene Capsules (USP, BP, 1973)

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Tetrachloroethylene Draught (BNF, 1966): **tetrachloroethylene** 2.5 ml, acacia 2 g, peppermint emulsion 0.3 ml, chloroform water to 50 ml.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Perklone (ICI Mond, UK): a brand of **tetrachloroethylene** for dry-cleaning purposes.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Consumption Patterns:

The consumption pattern in the USA in 1974 is est to have been as follows: Textile and dry cleaning industries, 69%; Metal cleaning, 16%; Chemical intermediate (eg, prepn of trichloroacetic acid in some fluorocarbons), 12%; Miscellaneous uses, 3%.

[Fishbein L; Potential Indust Carcins & Mutagens p.148 (1977) EPA-560/5-77-005] **PEER REVIEWED**

Demand: (1982), 545 million lb; (1983), 679 million lb; (1987), 625 million lb

[Kavaler. Chem Market Reporter 1983] **PEER REVIEWED**

(1974) Dry cleaning & textile processing, 59%; Industrial metal cleaning, 21%; Exports, 11%; Chemical intermed (mostly fluorocarbons), 6%; Other, 3%.

[Kavaler. Chem Market Reporter 1983] **PEER REVIEWED**

SOLVENT IN DRY CLEANING, 46%; DEGREASING SOLVENT, 21%; CHEM INTERMED FOR FLUOROCARBONS, 12%; AGENT IN TEXTILE MFR, 7%; COMPONENT OF AEROSOL PRODUCTS, 2%; OTHER, 12% (1980, EST)

[SRI] **PEER REVIEWED**

CHEMICAL PROFILE: **Perchloroethylene**. Demand: 1988: 495 million lb; 1989: 495 million lb; 1993 /projected/: 495 million lb. (Includes exports, but not imports, which totaled 121 million lb last yr).
[Kavaler AR; Chemical Marketing Reporter 235 (6): 46 (1989)] **PEER REVIEWED**

CHEMICAL PROFILE: **Perchloroethylene**. Dry cleaning and textile processing, 50%; chemical intermediate (mostly fluorocarbon F-113), 28%; industrial metal cleaning, 9%; exports, 10%; other, 3%.
[Kavaler AR; Chemical Marketing Reporter 235 (6): 46 (1989)] **PEER REVIEWED**

Demand: (1996) 280 million pounds; (1997) 290 million pounds; (2001, projected) 335 million pounds
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)] **PEER REVIEWED**

(1998) 312 million pounds; (1999) 318 million pounds; (2003) /projected/ 340 million pounds
[ChemExpo; Chemical Profile Database on Perchloroethylene (127-18-4). 10/30/00.] **PEER REVIEWED**

Chemical precursor, 50 percent; dry cleaning, 21 percent; metal cleaning and vapor degreasing, 18 percent; other, 11 percent.
[ChemExpo; Chemical Profile Database on Perchloroethylene (127-18-4). 10/30/00.] **PEER REVIEWED**

U. S. Production:

(1981) 3.16X10+11 GRAMS
[US INT'L TRADE COMM. SOC SERIES C/P-82-1] **PEER REVIEWED**

(1976) 121x10+6 lb
[Fishbein L; Potential Indust Carcins & Mutagens p.35 (1977) USEPA 560/ 5-77-005] **PEER REVIEWED**

(1978) 3.34X10+11 G
[SRI] **PEER REVIEWED**

(1983) 2.40X10+11 G
[SRI] **PEER REVIEWED**

(1985) 3.08X10+11 g
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.268] **PEER REVIEWED**

(1986) 4.05X10+8 LB
[USITC. SYN ORG CHEM-U.S. PROD/SALES. PRELIMINARY 1988 SERIES C/P-87-5] **PEER REVIEWED**

(1987) 4.70X10+8 LB
[USITC. SYN ORG CHEM-U.S. PROD/SALES. PRELIMINARY 1988 SERIES C/P-87-5] **PEER REVIEWED**

(1982) 550 million lb

[USITC; USITC Publications 1422 (1983) as cited in USEPA; Health Advisories for 25 Organics: Tetrachloroethylene p.306 (1987) PB 87-235578] **PEER REVIEWED**

(1974) 333,100 tons; (1976) 303,400 tons; (1978) 333,400 tons; (1980) 347,100 tons; (1982) 265,300 tons; (1984) 260,000 tons; (1986) 187,800 tons; (1988) 225,800 tons; (1989) 218,300 tons; (1990) 132,300 tons.

[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)] **PEER REVIEWED**

Ethene, tetrachloro- is listed as a High Production Volume (HPV) chemical (65FR81686). Chemicals listed as HPV were produced in or imported into the U.S. in >1 million pounds in 1990 and/or 1994. The HPV list is based on the 1990 Inventory Update Rule. (IUR) (40 CFR part 710 subpart B; 51FR21438).

[EPA/Office of Pollution Prevention and Toxics; High Production Volume (HPV) Challenge Program. Ethene, tetrachloro- (127-18-4). Available from, as of October 28, 2010: http://www.epa.gov/hpv/pubs/general/opptsrch.htm **PEER REVIEWED**

Production volumes for non-confidential chemicals reported under the Inventory Update Rule.

Year	Production Range (pounds)
1986	>500 million - 1 billion
1990	>500 million - 1 billion
1994	>100 million - 500 million
1998	>100 million - 500 million
2002	>100 million - 500 million

[US EPA; Non-confidential Production Volume Information Submitted by Companies for Chemicals Under the 1986-2002 Inventory Update Rule (IUR). Ethene, tetrachloro- (127-18-4). Available from, as of October 28, 2010: http://www.epa.gov/oppt/iur/tools/data/2002-vol.html **PEER REVIEWED**

Production volume for non-confidential chemicals reported under the 2006 Inventory Update Rule. Chemical: Ethene, 1,1,2,2-tetrachloro-. Aggregated National Production Volume: 500 million to < 1 billion pounds.

[US EPA; Non-Confidential 2006 Inventory Update Reporting. National Chemical Information. Ethene, 1,1,2,2-tetrachloro- (127-18-4). Available from, as of October 28, 2010: http://cfpub.epa.gov/iursearch/index.cfm?s=chem&err=t **PEER REVIEWED**

U. S. Imports:

(1977) 5.98X10+10 G

[SRI] **PEER REVIEWED**

(1982) 1.70X10+10 G

[SRI] **PEER REVIEWED**

(1985) 6.36X10+10 g
[BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-584] **PEER REVIEWED**

(1986) 1.83X10+5 LB
[BUREAU OF THE CENSUS. US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1986 P.1-530] **PEER REVIEWED**

61 million pounds in 1996.
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)] **PEER REVIEWED**

U. S. Exports:

(1978) 2.90X10+10 G
[SRI] **PEER REVIEWED**

(1983) 2.47X10+10 G
[SRI] **PEER REVIEWED**

(1985) 9.84X10+9 g
[BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-69] **PEER REVIEWED**

48 million pounds in 1996.
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)] **PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Method: NIOSH 3704, Issue 1; Procedure: gas chromatography (portable)/photoionization detector; Analyte: **perchloroethylene**; Matrix: exhaled breath and air; Detection Limit: 0.01 ppm.
[CDC; NIOSH Manual of Analytical Methods, 4th ed. Perchloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.cdc.gov/niosh/docs/2003-154/ **PEER REVIEWED**

DETERMINATION OF **TETRACHLOROETHYLENE** IN FISH BY GAS CHROMATOGRAPHY; DETECTION LIMITS IN 0.1-1.0 PPB RANGE.
[OFSTAD EB ET AL; THE SCIENCE OF THE TOTAL ENVIRONMENT 20: 205-16 (1981)] **PEER REVIEWED**
PubMed Abstract

The expired breath of subjects, exposed for periods of approx 90 min to atmospheres artificially contaminated with low levels ... **tetrachloroethylene** (approx 50 ppm), was monitored during and after the exposure period using an atm pressure ionization mass spectrometer (API/MS), fitted with a direct breath analysis system. The retention of solvent by the subjects estimated from steady state levels in the expired breath, averaged 87%. The elimination of unchanged solvent via respiration during the post exposure period followed first order kinetics a with mean half-life value of 79 min.

[Benoit FM et al; Int Arch Occup Health 55 (2): 113-20 (1985)] **PEER REVIEWED**

NIOSH Method 3704. **Perchloroethylene** in exhaled breath and air. Portable GC/PID.

[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.] **PEER REVIEWED**

Analytic Laboratory Methods:

Method: NIOSH 1003, Issue 3; Procedure: gas chromatography with flame ionization detection; Analyte: **tetrachloroethylene**; Matrix: air; Detection Limit: 1.0 ug/sample.

[CDC; NIOSH Manual of Analytical Methods, 4th ed. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.cdc.gov/niosh/docs/2003-154/ **PEER REVIEWED**

Method: OSHA 1001; Procedure: gas chromatography using flame ionization detection; Analyte: **tetrachloroethylene**; Matrix: air; Detection Limit: 14 ppb (98 ug/cu m) (charcoal tubes); 104 ppb (705 ug/cu m) (SKC 575-002 samplers).

[U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Tetrachloroethylene (127-18-4). Available from, as of November 1, 2010: http://www.osha.gov/dts/sltc/methods/toc.html **PEER REVIEWED**

Method: USGS-NWQL O-4127-96; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: surface- or ground-water; Detection Limit: 0.027 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: USGS-NWQL O-3115; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: water and water suspended-sediment; Detection Limit: 3 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: USGS-NWQL O-1433-01; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: filtered wastewater and natural-water samples; Detection Limit: 0.03 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: Standard Methods 6200C; Procedure: gas chromatography; Analyte: **tetrachloroethylene**; Matrix: water; Detection Limit: 0.01 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: Standard Methods 6200B; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: water; Detection Limit: 0.04 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OSW 8260B; Procedure: gas chromatography/mass spectrometry (GC/MS); Analyte: **tetrachloroethylene**; Matrix: various; Detection Limit: not provided.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OSW 8021B; Procedure: gas chromatography with photoionization detector; Analyte: **tetrachloroethylene**; Matrix: ground water, aqueous sludges, caustic liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments; Detection Limit: 0.05 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OSW 8021B; Procedure: gas chromatography with electrolytic conductivity detector; Analyte: **tetrachloroethylene**; Matrix: ground water, aqueous sludges, caustic liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments; Detection Limit: 0.04 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OSW 5030C; Procedure: purge-and-trap; Analyte: **tetrachloroethylene**; Matrix: water; Detection Limit: not provided.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OGWDW/TSC 551.1; Procedure: gas chromatography with electron capture detector; Analyte: **tetrachloroethylene**; Matrix: finished drinking water, drinking water during intermediate stages of treatment, and raw source water; Detection Limit: 0.002 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-OGWDW/TSC 524.3; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: finished drinking waters; Detection Limit: 0.036 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-NERL 524.2; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: surface water, ground water, and drinking water in any stage of treatment; Detection Limit: 0.05 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-NERL 502.2; Procedure: gas chromatography with photoionization detector; Analyte: **tetrachloroethylene**; Matrix: finished drinking water, raw source water, or drinking water in any treatment stage; Detection Limit: 0.05 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-NERL 502.2; Procedure: gas chromatography with electrolytic conductivity detector; Analyte: **tetrachloroethylene**; Matrix: finished drinking water, raw source water, or drinking water in any treatment stage; Detection Limit: 0.04 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-EAD 1624; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: water; Detection Limit: 10 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-EAD 624; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: water; Detection Limit: 4.1 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: EPA-EAD 601; Procedure: gas chromatography with electrolytic conductivity or microcoulometric detector; Analyte: **tetrachloroethylene**; Matrix: municipal and industrial discharges; Detection Limit: 0.03 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

Method: ASTM D5790; Procedure: gas chromatography/mass spectrometry; Analyte: **tetrachloroethylene**; Matrix: validated for treated drinking water, wastewater, and ground water; Detection Limit: 0.25 ug/L.

[National Environmental Methods Index; Analytical, Test and Sampling Methods. Tetrachloroethylene (127-18-4). Available from, as of October 29, 2010: http://www.nemi.gov **PEER REVIEWED**

A freeze-out concn method is used to determine trace levels of **tetrachloroethylene** in the presence of other cmpd. Detection limit is 0.2 ppt (1.36X10-6 mg/cu m) for 500 ml aliquots of ambient air samples. Samples are measured by gas chromatography coupled with electron capture configuration. When freeze-out is completed, **tetrachloroethylene** remains behind; While oxygen and nitrogen gasses are passed through as the freeze-out loop is heated. Carrier gas sweeps the contents onto the column.

[Rasmussen RA et al; J Air Poll Cont Assoc 27: 579 (1977)] **PEER REVIEWED**

DETERMINATION OF TRACE AMT OF 136 C1-C13 ORG CMPD (INCL **TETRACHLOROETHYLENE**) IN AIR SAMPLES COLLECTED FROM THE ATMOSPHERE OF STREETS BY GC IS DISCUSSED.

[IOFFE BV ET AL; J CHROMATOGR 142: 787-95 (1977)] **PEER REVIEWED** PubMed Abstract

TETRACHLOROETHYLENE IN DRINKING WATER IS ANALYZED DIRECTLY WITH GAS CHROMATOGRAPHY EQUIPPED WITH ELECTRON CAPTURE DETECTION. THE LIMIT OF DETECTION IS 0.5 UG/L (NICHOLSON AA

ET AL; ANAL CHEM 49: 814-9 (1977)).

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V20 498 (1979)] **PEER REVIEWED**

TETRACHLOROETHYLENE WAS DETERMINED IN WASTE-CONTAMINATED SOIL AND CHEMICAL STILL BOTTOM EXTRACTS BY GAS CHROMATOGRAPHY.

[GURKA DF, BETOWSKI LD; ANAL CHEM 54: 1819 (1982)] **PEER REVIEWED**

DETERMINATION OF **TETRACHLOROETHYLENE** IN FISH BY GAS CHROMATOGRAPHY; DETECTION LIMITS IN 0.1-1.0 PPB RANGE.

[OFSTAD EB ET AL; THE SCIENCE OF THE TOTAL ENVIRONMENT 20: 205-16 (1981)] **PEER REVIEWED**
PubMed Abstract

NIOSH Method 1003. Analyte: **Tetrachloroethylene**; Matrix: air; Procedure: Gas chromatography, flame ionization detector; Desorption: 1 ml CS2, stand 30 min; Range: 0.4 to 12 mg/sample; Precision: 0.052; Est LOD: 0.01 mg/sample; Interferences: none

[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.] **PEER REVIEWED**

EPA Method 8010: Halogenated Volatile Organics. For the analysis of solid waste ... Under the prescribed conditions, **tetrachloroethylene** has a detection limit of 0.03 ug/l, an average recovery range of four measurements of 8.1-29.6 ug/l, and a limit for the standard deviation of 5.4 ug/l.

[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)] **PEER REVIEWED**

EPA Method 8240B: Gas Chromatography/Mass Spectrometry for Volatile Organics Method 8240 can be used to quantify most volatile organic commpounds that have boiling points below 200 deg C and that are insoluble or slightly soluble in water, including the title compound. ... Under the prescribed conditions, **tetrachloroethylene** has an average recovery range for four samples of 17.0-26.6 ug/l with a limit for the standard deviation of 5.0 ug/l and a retention time of 22.2 min.

[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)] **PEER REVIEWED**

AOB Method VA-005-1. Volatile Organic Compounds (VOCs) in Ambient Air by Purge and Trap Gas Chromatography. No detection limit.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

AOB Method VA-006-1. Volatile Organic Compounds (VOCs) in Ambient Air by Direct Portable GC/PID. No detection limit.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

AOB Method VA-008-1. Volatile Organic Compounds (VOCs) in Ambient Air by Portable GC/PID with Direct Sampling via Pump and Sample Loop. No detection limit.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

APHA Method 6210-D. Volatile Organics in Water by Gas Chromatographic/ Mass Spectrometric Purge and Trap Capillary-Column Technique. No detection limit

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

APHA Method 6220-C. Volatile Aromatic Organics in Water by Purge and Trap Gas Chromatography. Detection limit = 0.05 ug/l.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

APHA Method 6230-C. Volatile Aromatic Organics in Water by Purge and Trap Gas Chromatography. Detection limit = 0.03 ug/l.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

AOB Method VS-001-1. Volatile Organic Compounds (VOCs) in Soil by Purge and Trap GC/PID/ELCD. Detection limit = 10 ug/kg.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

AOB Method VS-001-1. Volatile Organic Compounds (VOCs) in Soil and Sediment by Automated Headspace GC/PID/ELCD. Detection limit = 100 ug/kg.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] **PEER REVIEWED**

Sampling Procedures:

Volatile organic compounds pose a challenge to ground-water sampling protocols, since they can be lost as a water sample degasses or lost due to sorption on tubing or pump materials. Laboratory sorption experiments were conducted with 5 common flexible tubing materials to determine the impact of sorptive bias for chloroform, trichloroethylene, trichloroethane and **tetrachloroethylene**. Tubes made of Teflon, polyethylene, polypropylene, polyvinyl chloride and silicone rubber were all found to sorb the test compounds in short exposure periods. Virgin tubing materials introduce substantial amounts of leachable organic matter in similar exposures. Tubing made of Teflon showed the least absorption and leaching problems and should be the tubing material of choice for detailed organic sampling purposes. Absorption into the polymer matrix is the likely mechanism for the errors.

[Barcelona MJ et al; Anal Chem 27 (2): 460-4 (1985)] **PEER REVIEWED**

Analyte: **Tetrachloroethylene**; Matrix: Air; Sampler: Solid sorbent tube (coconut shell charcoal, 100 mg/50 mg); Flow rate: 0.01-0.2 l/min; Vol: min: 0.2 @ 100 ppm, max: 40; Stability: not determined

[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994., p. V2 1003-1] **PEER REVIEWED**

Special References:

Special Reports:

International Programme on Chemical Safety's Concise International Chemical Assessment Documents. Number 68: **Tetrachloroethene** (127-18-4). CICADs are concise documents that provide summaries of the relevant scientific information concerning the potential effects of chemicals upon human health and/or the environment. The primary objective of CICADs is characterization of hazard and dose-response from exposure to a chemical.
[Available from, as of September 20, 2010: http://www.inchem.org/pages/cicads.html

DHHS/ATSDR; Toxicological Profile for **Tetrachloroethylene** (1997). The ATSDR toxicological profile succinctly characterizes the toxicologic and adverse health effects information for a hazardous substance.
[Available from, as of November 10, 2010: http://www.atsdr.cdc.gov/ToxProfiles/tp18.pdf

European Commission, ESIS; IUCLID Dataset, **Tetrachloroethylene** (127-18-4) (2000 CD-ROM edition) contains information on use, toxicology, and environmental effects of this chemical as supplied to the European Union by industry.
[Available from, as of November 10, 2010: http://ecb.jrc.ec.europa.eu/IUCLID-DataSheets/127184.pdf

Committee to Review EPA's Toxicological Assessment of **Tetrachloroethylene**, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies; Review of the Environmental Protection Agency's Draft IRIS Assessment of **Tetrachloroethylene**. 186 pp. (2010). The National Academies Press, 500 Fifth Street, NW Washington, DC 20001
[Available from, as of November 10, 2010: http://www.nap.edu/catalog/12863.html

NIOSH Current Intelligence Bulletin No 20 for **Tetrachloroethylene** (1978)

WHO; Environmental Health Criteria for **Tetrachloroethylene** No 31 (1984). EHC are designed for scientists and administrators responsible for the establishment of safety standards and regulations and provide basic scientific risk evaluations of a wide range of chemicals and groups of chemicals.
[Available from, as of November 10, 2010: http://www.inchem.org/documents/ehc/ehc/ehc31.htm

DHEW/NCI; Bioassay of **Tetrachloroethylene** for Possible Carcinogenicity (1977) Technical Rpt Series No. 13 DHEW Pub No. (NIH) 77-813

DHHS/NTP; Toxicology & Carcinogenesis Studies of **Tetrachloroethylene** in F344/N Rats and B6C3F1 Mice (Inhalation Studies) Technical Report Series No. 311 (1986) NIH Publication No. 86-2567

National Toxicology Program. Eleventh Report on Carcinogens (2005). The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Tetrachloroethylene** (127-18-4) is listed as reasonably anticipated to be a human carcinogen.
[Available from, as of July 31, 2009: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s169tetr.pdf

History and Incidents:

On September 28, 1982, an Illinois Gulf Railroad freight train derailed 43 cars in Livingston, Louisiana. Thirty-six cars were tank cars, of which 27 contained various regulated hazardous or toxic chemical commodities, 2 contained nonregulated hazardous materials, and 5 contained flammable petroleum products. Fires resulted and toxic gases were released into the atmosphere. Residents within a 5 mile radius of the derailment were evacuated for up to two weeks. More than 200,000 gal of toxic chemical products were spilled and absorbed into the ground. Extensive excavation of the contaminated soil and its transportation to a distant dump site were required. Property damage was estimated to be greater than 14 million dollars and long-term closure of the railroad line and adjacent highway resulted. ... Evacuation of the residents was accomplished successfully although no contingency plan had been developed. The effort to contain and remove chemical pollution resulting from the derailment was directed effectively by the Louisiana Department of Natural Resources. The principal problem was **tetrachloroethylene**... .
[Nat Transp Safety Board; Railroad Accident Report: Derailment of Illinois Central Gulf Railroad Freight Train Extra 9629 East and Release of Hazardous Materials at Livingston, LA on September 28, 1982 80 pp. (1983) NTSB/RAR-83105] **PEER REVIEWED**

Synonyms and Identifiers:

Related HSDB Records:

169 [VINYL CHLORIDE] (degradation product)

Synonyms:

AI3-01860
PEER REVIEWED

Ankilostin
PEER REVIEWED

Antisal 1
PEER REVIEWED

Antisol 1
PEER REVIEWED

Carbon bichloride
PEER REVIEWED

Carbon dichloride
PEER REVIEWED

Caswell no 827
PEER REVIEWED

Czterochloroetylen (Polish)
PEER REVIEWED

Didakene
PEER REVIEWED

Dilatin PT
PEER REVIEWED

Dow-Per
PEER REVIEWED

ENT 1,860
PEER REVIEWED

EPA pesticide chemical code 078501
PEER REVIEWED

Ethene, tetrachloro-
PEER REVIEWED

Ethylene tetrachloride
PEER REVIEWED

Ethylene, tetrachloro-
PEER REVIEWED

Fedal-Un
PEER REVIEWED

Freon 1110
PEER REVIEWED

NCI-C04580
PEER REVIEWED

Nema
PEER REVIEWED

PCE
PEER REVIEWED

PER
PEER REVIEWED

Perawin
PEER REVIEWED

PERC
PEER REVIEWED

Perchloorethyleen, Per (Dutch)
PEER REVIEWED

Perchlor
PEER REVIEWED

Perchloraethylen, Per (German)
PEER REVIEWED

Perchlorethylene
PEER REVIEWED

Perchlorethylene, Per (French)
PEER REVIEWED

Perchloroethylene
PEER REVIEWED

Perclene
PEER REVIEWED

Percloroetilene (Italian)
PEER REVIEWED

Percosolve
PEER REVIEWED

Perk
PEER REVIEWED

Perklone
PEER REVIEWED

Persec
PEER REVIEWED

Tetlen
PEER REVIEWED

Tetracap
PEER REVIEWED

Tetra-chlooretheen (Dutch)
PEER REVIEWED

Tetrachloraethen (German)
PEER REVIEWED

Tetrachloroethene
PEER REVIEWED

1,1,2,2-**Tetrachloroethylene**
PEER REVIEWED

Tetracloroetene (Italian)
PEER REVIEWED

Tetracloroetileno (Spanish)
PEER REVIEWED

Tetraguer
PEER REVIEWED

Tetraleno
PEER REVIEWED

Tetralex

PEER REVIEWED

Tetravec

PEER REVIEWED

Tetroguer

PEER REVIEWED

Tetropil

PEER REVIEWED

Formulations/Preparations:

Grade: purified, technical, USP, as **tetrachloroethylene**, spectrophotometric

[Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 958] **PEER REVIEWED**

Available in the United States ... in veterinary preparations (eg, Nema Worm Capsules (Parke-Davis)). These capsules contain pure **tetrachloroethylene**. Avail sizes are 0.2, 0.5, 1.0, 2.5 & 5 ml.

[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986., p. 1612] **PEER REVIEWED**

Tetrachloroethylene, USP ... Available in soft gelatin capsules containing 0.2, 1.0, or 2.5 ml of drug. It may be difficult to obtain drug in capsule form for human use. /former use/

[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975., p. 1031] **PEER REVIEWED**

Tetrachloroethylene is avail in the USA in the following grades: purified, technical, USP, spectrophotometric, & dry-cleaning. The technical & dry-cleaning grades both meet specifications for technical grade & differ only in the amount of stabilizer added to prevent decomposition. Stabilizers ... incl amines or mixtures of epoxides & esters. Typical analysis of the commercial grade is ... nonvolatile residue, 0.0003%; free chlorine, none; moisture, no cloud at -5 deg C ... USP grade contains not less than 99.0% & no more than 99.5% **tetrachloroethylene**, the remainder consisting of ethanol. ...

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: http://monographs.iarc.fr/ENG/Classification/index.php p. V20: 492 (1979)] **PEER REVIEWED**

Food Grade

[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988., p. 116] **PEER REVIEWED**

/**Tetrachloroethylene** (BP) may/ ... contain thymol 0.01% wt/wt as a preservative.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 106] **PEER REVIEWED**

Tetrachloroethylene Capsules (USP, BP, 1973)

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Tetrachloroethylene Draught (BNF, 1966): **tetrachloroethylene** 2.5 ml, acacia 2 g, peppermint emulsion 0.3 ml, chloroform water to 50 ml.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Perklone (ICI Mond, UK): a brand of **tetrachloroethylene** for dry-cleaning purposes.

[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982., p. 107] **PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1897; **Tetrachloroethylene**

IMO 6.1; **Tetrachloroethylene**

Standard Transportation Number:

49 403 55; **Tetrachloroethylene**

EPA Hazardous Waste Number:

D039; A waste containing **tetrachloroethylene** may or may not be characterized as a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations.

U210; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

F002; A hazardous waste from nonspecific sources when a spent halogenated solvent.

Administrative Information:

Hazardous Substances Databank Number:

124

Last Revision Date:

20120503

Last Review Date:

Reviewed by SRP on 1/20/2011

Update History:

Field Update on 2015-04-13, 1 fields added/edited/deleted
Field Update on 2014-12-05, 2 fields added/edited/deleted
Field Update on 2013-04-02, 3 fields added/edited/deleted
Complete Update on 2012-05-03, 95 fields added/edited/deleted
Field Update on 2010-06-02, 4 fields added/edited/deleted
Field Update on 2009-08-12, 2 fields added/edited/deleted
Field Update on 2008-09-02, 2 fields added/edited/deleted
Field Update on 2008-08-23, 1 fields added/edited/deleted
Field Update on 2008-08-22, 1 fields added/edited/deleted
Field Update on 2008-08-21, 1 fields added/edited/deleted
Field Update on 2008-08-15, 25 fields added/edited/deleted
Field Update on 2007-06-07, 1 fields added/edited/deleted
Field Update on 2006-04-18, 2 fields added/edited/deleted
Field Update on 2006-04-17, 2 fields added/edited/deleted
Complete Update on 2005-08-23, 2 fields added/edited/deleted
Field Update on 2005-04-29, 4 fields added/edited/deleted
Complete Update on 2003-08-29, 1 fields added/edited/deleted
Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 10/16/2002, 1 field added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 02/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/23/2001, 85 fields added/edited/deleted.
Complete Update on 02/22/2000, 1 field added/edited/deleted.
Complete Update on 02/11/2000, 1 field added/edited/deleted.
Complete Update on 02/08/2000, 1 field added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 11/18/1999, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/26/1999, 1 field added/edited/deleted.
Complete Update on 07/20/1999, 3 fields added/edited/deleted.
Complete Update on 05/18/1999, 7 fields added/edited/deleted.
Complete Update on 05/04/1999, 1 field added/edited/deleted.
Complete Update on 03/29/1999, 2 fields added/edited/deleted.
Field Update on 03/19/1999, 1 field added/edited/deleted.
Complete Update on 02/24/1999, 1 field added/edited/deleted.
Complete Update on 02/01/1999, 1 field added/edited/deleted.
Complete Update on 01/20/1999, 3 fields added/edited/deleted.
Field Update on 12/18/1998, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 1 field added/edited/deleted.

Complete Update on 09/11/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 02/25/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 05/08/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 2 fields added/edited/deleted.
Complete Update on 03/11/1997, 3 fields added/edited/deleted.
Complete Update on 02/24/1997, 1 field added/edited/deleted.
Complete Update on 01/09/1997, 2 fields added/edited/deleted.
Complete Update on 09/12/1996, 2 fields added/edited/deleted.
Complete Update on 09/11/1996, 2 fields added/edited/deleted.
Complete Update on 06/06/1996, 2 fields added/edited/deleted.
Complete Update on 05/10/1996, 1 field added/edited/deleted.
Complete Update on 04/09/1996, 8 fields added/edited/deleted.
Field Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 09/26/1995, 2 fields added/edited/deleted.
Complete Update on 06/09/1995, 1 field added/edited/deleted.
Complete Update on 02/13/1995, 1 field added/edited/deleted.
Complete Update on 01/23/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 08/02/1994, 1 field added/edited/deleted.
Complete Update on 06/28/1994, 1 field added/edited/deleted.
Complete Update on 05/05/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 01/17/1994, 1 field added/edited/deleted.
Complete Update on 11/05/1993, 1 field added/edited/deleted.
Complete Update on 09/15/1993, 1 field added/edited/deleted.
Complete Update on 08/07/1993, 1 field added/edited/deleted.
Complete Update on 08/04/1993, 1 field added/edited/deleted.
Complete Update on 04/28/1993, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Complete Update on 12/03/1992, 1 field added/edited/deleted.
Complete Update on 04/27/1992, 1 field added/edited/deleted.
Complete Update on 04/01/1992, 1 field added/edited/deleted.
Complete Update on 03/11/1992, 4 fields added/edited/deleted.
Field Update on 01/13/1992, 1 field added/edited/deleted.
Field Update on 09/27/1991, 1 field added/edited/deleted.
Complete Update on 10/23/1990, 8 fields added/edited/deleted.
Field Update on 08/23/1990, 1 field added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 05/04/1990, 1 field added/edited/deleted.
Field Update on 02/02/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 5 fields added/edited/deleted.
Complete Update on 07/28/1989, 108 fields added/edited/deleted.
Complete Update on 09/03/1987
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