THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Perchloroethylene (PCE)

This fact sheet is part of a series of chemical fact sheets developed by TURI to help Massachusetts companies, community organizations and residents understand the chemical's use and health and environmental effects, as well as the availability of safer alternatives. Since Massachusetts companies report usage under the Toxics Use Reduction Act, readers will learn how the chemicals are being used and by which companies.

Able to dissolve most organic materials, perchloroethylene (PCE) is the most widely used dry cleaning solvent in Massachusetts and nationally. Its other major uses are as a metal degreaser, a chemical intermediate and an ingredient in consumer products, such as automotive aerosol parts cleaners and degreasers. PCE is reported to be the chemical most widely found in groundwater contamination at Superfund sites.

Testing at TURI's laboratory over the years has revealed a number of suitable replacement cleaners and solvents for many of the uses of PCE throughout various industry sectors. This information can be found on the laboratory's website, ***www.cleanersolutions.org*** or by contacting the lab directly at 978-934-3133.

PCE FACTS	
Other Names	Tetrachloroethylene, Tetrachloroethene, Ethylene tetrachloride, Carbon dichloride
Chemical Formula	C2 Cl4
CAS Number	127-18-4
Vapor Pressure	18.47 mm Hg at 25 °C
Water Solubility	0.15 g in 100m g of water (low solubility)
Description	Clear, colorless, non flammable liquid, ether-like odor

Health and Environmental Impacts

Human Health Effects

Human exposure to PCE can occur from occupational practices, environmental contamination or use of consumer products that contain PCE. PCE levels in the environment tend to be higher in urban and industrial areas. The most prevalent route of exposure to PCE is by inhalation and it is readily absorbed into blood through the lungs.

Another potential exposure route of concern is oral, via drinking water or contaminated food. General dermal exposure is not considered a major route of exposure but direct skin exposure to PCE in the liquid form can result in irritation and blistering. The primary organs targeted by PCE are the central nervous system (CNS) and the liver.

Some studies suggest that long term frequent over-exposure to organic solvents such as PCE may cause lasting and possibly permanent CNS effects. Fatigue, lack of muscle coordination, loss of concentration as well as short term memory loss, and personality changes exhibited as nervousness, anxiety or irritability are some of the potential permanent long-term effects of chronic and frequent exposure. In addition, PCE inhaled by pregnant women can cross the placenta causing exposure of the developing fetus. PCE has also been found in breast milk of mothers exposed to the chemical.

Acute Exposure

Concentrations of 200 ppm or more have been associated with dizziness, confusion, headache, nausea, and irritation of the eyes and mucous tissue. Exposure to extremely high levels of PCE (>1,500 ppm) may lead to unconsciousness and, in extreme cases, death from respiratory depression. Nausea and vomiting may follow from inhalation of large amounts of PCE. The immediately dangerous to life or health air concentration value (IDLH) used by the National Institute for Occupational Safety and Health (NIOSH) as respirator selection criteria for PCE has been set at 150 ppm.

Symptoms of exposure to skin can include redness, itching, and pain. Prolonged exposure can result in the removal of natural protective oils from skin resulting in irritation, dryness, cracking and dermatitis. Likewise, extended dermal contact can result in second- and third-degree chemical burns. Contact of PCE vapors above 75 ppm with the eyes will result in irritation, redness, and pain.

Chronic Exposure

Long term exposure to PCE may cause liver, kidney or CNS damage. Furthermore, the exposure can aggravate pre-existing conditions. For example, persons with pre-existing skin disorders, eye problems or impaired liver or kidney function may be more susceptible to the effects of the substance. PCE can affect your brain and CNS as a whole; in a similar way as the consumption of alcohol does. Therefore the consumption of alcoholic beverages within a short time period of exposure to PCE enhances the toxic effects from PCE and alcohol. The two would have an additive effect on the CNS.

Overexposure may result in cumulative liver and CNS damage or narcosis. Overall, PCE can affect the liver, kidneys, eyes, skin, respiratory system, and CNS.

Cancer Risk

Several agencies have investigated PCE's association with cancer. The US National Toxicology Program classifies PCE as "Reasonably anticipated to be human carcinogen". IARC lists PCE as Group 2A, "Probably carcinogenic to humans." EPA is currently reassessing PCE's carcinogenicity classification and ACGIH designates it as an

A3, confirmed animal carcinogen.

A recent Massachusetts-based research project on Cape Cod looked at PCE exposure through contaminated drinking water and found an association between PCE exposure and cancer rates.

Reproductive/Developmental Effects

There are conflicting data on the status of PCE as a reproductive or developmental toxin in either humans or animals. Some studies have reported adverse reproductive effects of PCE, including spontaneous abortions, menstrual disorders, altered sperm structure and reduced fertility. These studies were limited and are not generally considered to be conclusive.

Studies also show conflicting evidence of birth defects in animals, with some finding increased incidences in liver tumors and leukemia while others find no teratogenic effects. What is widely agreed upon is that PCE is able to transport across the placenta to the fetuses of pregnant women who have been highly exposed. In addition, PCE has been found in the breast milk of nursing mothers.

Worker Health

The OSHA PELs for PCE are 100 ppm for an 8 hour day and a maximum exposure level of 200 ppm for 5 minutes in any 3-hour period. California's OSHA program has set the PCE permissible exposure level at 25 ppm. ACGIH has established a threshold limit value of 25 ppm, and a short term exposure limit of 100 ppm.

Recent studies in California and Massachusetts have highlighted concerns over the exposure of workers (especially in automotive repair facilities) using aerosol PCE products for cleaning and repair work.

Environmental Hazards

PCE most often enters the environment via fugitive emissions from dry cleaning and metal degreasing industries and by spills or accidental releases to air, soil and water. When released to soil, PCE will evaporate fairly rapidly into the atmosphere due to its high vapor pressure and low rate of adsorption in soil. PCE can leach rapidly through sandy soil and therefore may reach groundwater. PCE is reported to be the chemical most widely found in groundwater contamination at Superfund Sites.

When PCE is released in water, the primary loss is by evaporation. Chemical and biological degradation are expected to be very slow. PCE is not expected to accumulate in aquatic organisms or to adsorb onto sediment; however it is toxic to aquatic organisms.

When released to the atmosphere, PCE is expected to remain in the vapor phase. Photo-oxidation of PCE will form chlorine atoms. PCE can degrade in the atmosphere in two ways, through reaction with photochemical produced hydroxyl radicals or by reacting with the chlorine produced by its own photo-oxidation.

(For section references, see endnote #1)

Use Nationally and in Massachusetts

Uses of PCE nationally typically fall into one of the following categories:

- The major use of PCE is as the basic raw material in the manufacture of hydrofluorocarbon (HFC 134a), a popular alternative to chlorofluorocarbon (CFC) refrigerants. It also is used in the synthesis of several hydrochlorofluorocarbons (HCFC 123 and 124 and HFC 125). In 2004 over 66% of the 355 million pounds of PCE use in the US was for this application.
- Dry cleaning represents 12% of the total PCE usage nationally (43 million pounds, down from 86 million pounds in 1998). The decrease in usage can be attributed to the improved efficiency of dry cleaning machines in the industry as well as the emergence of alternative cleaning processes and chemicals. PCE currently comprises 70% of all commercial dry cleaning solvents.
- In 2004, aerosol products (for cleaning tires, brakes, engines, carburetors and wire, and as an anti-seizing agent) made up 12% of the total use of PCE.
- The use of PCE as an industrial metal cleaning and degreasing agent has declined 16%, from 34.4 million to 28.4 million pounds since 1998. In 2004, 8% of all PCE was used for this purpose.

Table 1 summarizes the historical use of PCE in Massachusetts. The data show the amounts of PCE reported to the Massachusetts Toxics Use Reduction Program for 1990 and 2004. Of the companies that reported their use of PCE in 1990, only one, Shield Packaging, was still using reportable amounts of PCE in 2004. The company is a packager of aerosol products.

Some of the companies who reported using PCE in 1990 found alternative formulations or modified their operations so as to reduce their use of PCE to below the applicable reporting threshold of 10,000 pounds per year.

Overall, Massachusetts has experienced a 73% reduction in the use of PCE since 1990.

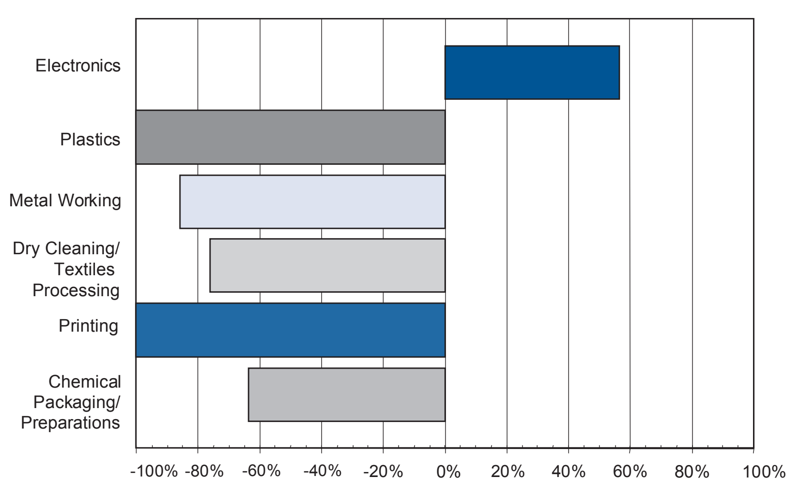
Figure 1 illustrates the percent changes in use of PCE in Massachusetts by industry sector. The printing and plastics sectors both completely reduced their usage of PCE below the reporting threshold.

The electronics sector increased its use of PCE by 57%. A portion of this increase was associated with Aerovox which has been increasing production in the Commonwealth since 2000. As of spring 2005, however, this sector will show a 100% decrease in PCE usage as Aerovox, working with the TURI Laboratory and the Massachusetts Office of Technical Assistance, was able to eliminate its use of PCE and TCE in its vapor degreasing operations. The

Table 1. Massachusetts PCE Consumption by Industry Sector (1990 – 2004)

Industry Sector	*Product/Process*	*Facility Name*	*Location*	*Use (pounds)*	
				1990	*2004*
Chemical Packaging/ Preparations	Chemical Packaging	Callahan Company	Walpole	0	93,107
		Astro Chemical	Springfield	0	20,616
	Industrial Organic Chemicals	AW Chesterton	Groveland	19,480	0
		Safety Kleen	North Andover	454,574	0
	Aerosol Preparations	Shield Packaging	Dudley	75,822	99,499
	Adhesives and Sealants	American Finish & Chemical Co.	Chelsea	32,000	0
Printing	Platemaking Services	Dow Industries	Wilmington	17,000	0
		Mead/Westvaco Corporation	Springfield	21,300	0
		Flexographic Printing Plate Co	Worcester	19,800	0
	Printing	Rexam Medical Packaging Inc	Ashland	17,841	0
		Avery Dennison Corporation	Framingham	56,160	0
Dry Cleaning/ Textiles	Industrial Dry Cleaning	Adams Laundry	Adams	0	15,662
	Cotton Dyeing	Swan Finishing Company, Inc	Fall River	65,760	0
Metal Working	Fabricated Metal	Presmet Corporation	Worcester	24,093	0
		Chemi Graphic Inc	Ludlow	36,000	0
		Springfield Wire	Springfield	17,860	0
	Electroplating	Fountain Plating Company	West Springfield	0	14,663
	Aluminum Extrusion	Extrusion Technology Inc	Randolph	25,967	0
Electronics	Semiconductors	Isotronics Inc	New Bedford	12,900	0
	Electronic Capacitors	Aerovox	New Bedford	0	20,222
Plastics	PTFE Tubing	Dana Corporation Everflex	Ludlow	94,836	0
Total PCE Use				**991,393**	**263,769**

Figure 1. Percent Change in PCE Use (1990 to 2004) by Industry Sector



company was able to identify viable drop-in alternative vapor degreasers, allowing Aerovox to completely eliminate their use of TCE and PCE

While the dry cleaning/textiles processing sector shows an overall reduction of 76%, this is due to the difference in operational changes in the two reporting companies. Swan Finishing Company reduced its use of PCE below reporting thresholds within one year of reporting, though it continued to manufacture flame retardant and other finished textiles until 2003. On the other hand, Adams Laundry, an industrial dry cleaning facility, first exceeded the reporting threshold for PCE in 1991, and has maintained steady or increased production since that time.

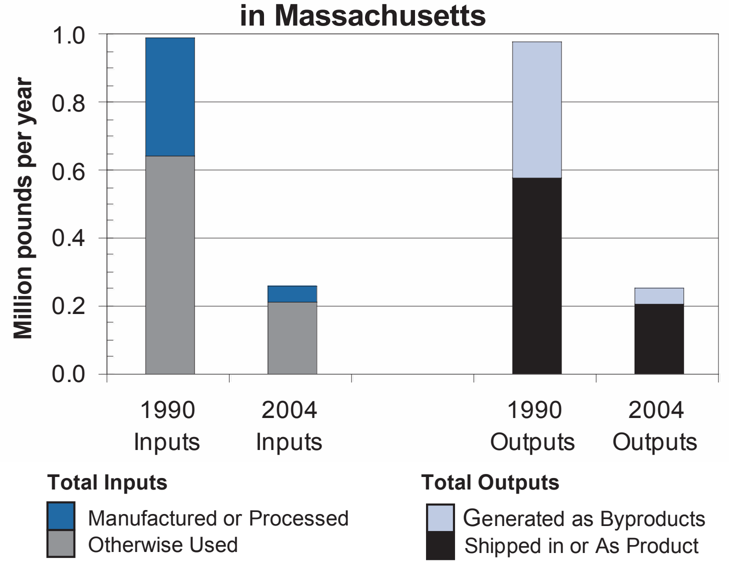
The metal working sector showed an 86% decrease in PCE usage over the 1990 to 2004 time frame. Of the companies in this sector, Fountain Plating is the only one that was still using reportable amounts of PCE in 2004 for its metal parts masking metal parts process. Springfield Wire continues its operations, but was able to modify its processes to reduce its use of PCE below the 10,000 pound per year threshold by 1994. Presmet continued operations in Massachusetts until recently though it was able to eliminate its use of PCE by 1991.

The chemical packaging sector reduced its use of PCE by 63% from 1990 to 2004. Callahan Company and Astro Chemical repackage PCE for bulk sales. Shield Packaging mixes and packages aerosol formulations containing PCE for other companies. Shield reported a 31 percent increase in use of PCE from 1990 to 2004. However this company relies on the requirements of its customers to dictate the formulations it manufactures and therefore is limited in its ability to reduce PCE use other than through education of its customers.

Working with the TURA program, Aerovox was recently able to eliminate over 20,000 pounds of PCE use in the electronics sector.

Figure 2 illustrates the change from 1990 to 2004 in inputs and outputs of PCE in Massachusetts. Inputs include PCE that is manufactured or processed, as well as PCE that is "otherwise used" – ancillary uses that do not become incorporated into the final product. Outputs include PCE that is generated as byproduct (i.e., all non-product material created by a process line prior to release, on-site treatment, or transfer) and the amount of PCE that is shipped in or as product.

Figure 2. Inputs and Outputs of PCE in Massachusetts



Both inputs and outputs of PCE were significantly reduced overall in the Commonwealth from 1990 to 2004. Specifically, from 1990 to 2004 the total input of PCE, including otherwise used, manufactured or processed PCE, was reduced by 85%, while the total output of PCE, the amount generated as byproduct, shipped in or as product, over the same time period was reduced by 89%. (It is likely that there will be a further decrease in PCE use for 2005 due to Aerovox discontinuing use of PCE for cleaning in 2005.)

Alternatives

PCE is used as a solvent on a wide array of organic soils and contaminants. It is valued for its solvent capacity for clothing in the dry cleaning industry, for oil, grease and buffing compounds on metal parts and for baked-on carbon, dirt and oil on automotive parts and brakes. The following sections provide a brief overview of the alternatives for these three uses. For more detailed information, see TURI's "Five Chemicals Alternatives Assessment Study" on our web site.

Alternatives for Dry Cleaning

Since the 1960s, the dry cleaning industry has predominantly used PCE as its primary cleaning solvent. There are over 550 dry cleaning facilities in Massachusetts that report their activities as part of DEP's Environmental Results Program. These facilities use over 970 thousand pounds of PCE, resulting in the generation of 600,000 pounds of hazardous waste. With the emergence of viable alternatives, and with pressure from states, communities and building owners to move away from PCE, the amount of PCE used by drycleaners has been decreasing.

Dry cleaning performance is influenced by operating times, amount of clothes cleaned, quality of cleaning, compatibility with a wide range of clothing materials, pre-spotting requirements, and post cleaning handling (e.g., pressing). The overall performance of a dry cleaning process depends on soil chemistry, textile fabric type, transport medium (aqueous or non-aqueous), chemistry of additives such as detergents and surfactants, the use of spotting agents, and other process considerations. Additional properties to consider include evaporation rate and ease of purification through distillation. In addition, the solvent should not cause fabric to unnecessarily fade, shrink, weaken, or bleed color and should be compatible with detergents.

Several dry cleaning alternative chemicals and processes are currently available on the market. The most widely used alternatives are hydrocarbon-based systems from three manufacturers. Capitalizing on the success of these hydrocarbon systems, one manufacturer created a mixture of hydrocarbons (isoparaffins) with a hydrofluoroether and a perfluorocarbon to further enhance its performance (expanded cleaning capabilities) and improve safety (by raising the flash point). Another option uses volatile methyl siloxane as the cleaning solvent. Glycol ether-based alternatives are also used to a lesser extent.

Non-solvent based alternative dry cleaning systems currently on the market include carbon dioxide and wet cleaning. Carbon dioxide, as either a liquid or a supercritical fluid, can be used with specialized equipment to clean garments. Typically, liquid carbon dioxide is maintained under a pressure of 700 pounds per square inch and is combined with detergents specifically designed for this process. Companies are also using wet cleaning processes for more dry clean-only garments. These processes rely on water, detergent, conditioners and/or degreasers to clean the garment. Wet cleaning processes sometimes use specialized equipment designed to minimize temperature and agitation or to create a fine mist to deliver the water-based detergents to the materials to be cleaned.

Alternatives for Vapor Degreasing

Over the years, preferred vapor degreasing solvents have included chlorofluorocarbons (CFCs), trichloroethane (TCA), trichloroethylene (TCE) and PCE. CFCs and TCA were found to cause ozone depletion and were phased out under the Clean Air Act. Currently, the primary solvent used in vapor degreasing operations is TCE. PCE is used less often than TCE, but is still used in significant quantities.

For vapor degreasing, key physical properties include: low vapor pressure, low latent heat, low boiling point, low flash point, low surface tension and high solvency powers. Typically, an alternative solvent's performance must be equal to or greater than the current vapor degreasing solvent in order to be adopted.

PCE is generally used in degreasing operations because of its high boiling point, which allows the solvent to remove soils and waxes that lower-boiling solvents may not. The stability of the chemical makes it particularly useful in airless degreasing systems where low emissions mean less virgin solvent and stabilizers need to be added.

There are many reasons why companies continue to use vapor degreasing rather than liquid phase (e.g., aqueous) cleaning such as:

- Aqueous-based cleaning processes are less efficient at producing clean and dry parts.
- The high surface tension typical of aqueous cleaning formulations inhibits the ability of the cleaner to get into small, blind holes without implementing a significant process change. Solvents in the vapor form are more successful at cleaning these hard to reach areas.
- The capital investment already put into existing equipment used for vapor degreasing can pose a barrier to change.

Switching to aqueous systems does, however, represent a feasible alternative to many solvent-based vapor degreasing operations, though it may involve additional process time and capital investment. Each company's cleaning needs are unique and a cleaning process should be specifically tailored for those needs. Information on the success of the TURI Lab's efforts in helping companies switch to aqueous-based vapor degreasing alternatives can be found at www.cleanersolutions.org.

For facilities that prefer to investigate vapor-phase solvent degreasing alternatives, there are many alternative solvents that have been researched and tested for performance in TURI's Lab and elsewhere. Effective drop in replacement solvent alternatives include n-propyl bromide (nPB), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), hydrofluoroethers (HFEs) and volatile methyl siloxanes (VMSs). These drop-in solvents have purchase costs that range from 3 to 43 times greater than that of PCE on a per gallon basis. Some savings may be achieved using the drop-in solvents through lower operating temperatures.

Because each of the solvent alternatives has some level of concern regarding health and/or environmental impacts, it is worth considering the following safer alternatives:

- Alternative cleaning processes such as aqueous or semi-aqueous,
- Working within the supply chain to eliminate hard-to-remove contaminants on the parts requiring cleaning, and
- Investigating process changes to prevent contamination and cleaning altogether.

Alternatives for Automotive Aerosols

PCE is found in a wide range of consumer aerosol products. For aerosol products PCE can be used as a solvent in a cleaner or spotting agent and a carrier in a glue, adhesive, lubricant or car detailing product. Some of the consumer aerosol products containing PCE listed on the Household Products Database, found at http://householdproducts.nlm.nih.gov, include; Liquid Wrench Super Lubricant with Teflon (65-80%), Gumout Professional Non Flammable Brake Parts Cleaner (50-90%), Hagerty Silversmiths Spray Polish (30.5%) and Champion Spot It Gone (45-50%).

A major concern for consumer and worker health and safety is the wide variety of automotive aerosol detailing products and cleaners that contain PCE in high concentrations. Engine cleaning aerosol products include those that are used externally and those used for more sensitive internal engine parts (e.g., carburetors and fuel injection systems). The major use in the automotive industry for PCE-based aerosols, however, is for brake cleaning. Alternatives for brake cleaning are available and include aqueous parts washers and aerosol products that do not contain PCE.

Performance considerations for effective aerosol brake cleaners include efficiency, drying, and residue. Aerosol brake cleaners allow quick repairs, only requiring spraying on of cleaner and wiping off of cleaner and soils. As part of the cleaning process, road dirt, grease and oils must be cleaned off and fibers from brake pads must be wetted and removed.

Many solvent mixtures can be aerosolized and used for brake and automotive parts cleaning or degreasing. Main components in some of the cleaners found on the market are heptane, C9-C12 hydrocarbons, toluene and xylene. Aqueous-based aerosolized products and aqueous parts cleaners have also proven to be effective.

The TURI Lab has conducted performance testing in the laboratory as well as field evaluations on alternative aerosol brake cleaners. Evaluation of formulations containing soy and acetone utilizing nitrogen as a propellant in a rechargeable and refillable spray delivery system are under way. Preliminary laboratory results indicate that these alternative brake cleaning aerosols have equivalent performance to PCE based products. Many of these alternative aerosol products are cost comparable to the PCE based products. For on these performance and field tests see the TURI Lab's website, www.cleanersolutions.org.

(For section references, see endnote #2)

Regulatory Context

The US Occupational Safety and Health Administration (OSHA), the US Environmental Protection Agency (EPA) and the US Food and Drug Administration (FDA) regulate PCE.

The OSHA permissible exposure limit (PEL) for PCE is 100 ppm for an 8 hour day (time weighted average) with a maximum exposure level (ceiling) of 200 ppm, except that an exposure of 300 ppm (peak) is allowed for 5 minutes in any 3 hour period.

The US EPA regulates PCE in a number of ways:

- Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAP) for Organic Solvent Degreasing:
  - This NESHAP sets two standards. The MACT-based equipment and work practice compliance standard requires a facility to use a designated type of pollution prevention technology along with proper operating procedures. Existing operations that use a performance-based standard can continue to do so if they can achieve the same level of control as the equipment and work practice compliance standard.
  - Urban Air Toxics Strategy: PCE is identified as one of 33 HAPs that present the greatest threat to public health in urban areas and are therefore regulated.
- Air Toxics Standards for Perchloroethylene Dry Cleaners
  - On July 13, 2006, the EPA strengthened the air toxics requirements for dry cleaners using PCE. The rule includes a phase-out of PCE used at dry cleaners located in residential buildings, along with requirements that will reduce PCE emissions at other dry cleaning facilities.
- Clean Water Act
  - Effluent Guidelines: Listed as a Toxic Pollutant for several industry categories
  - Water Quality Criteria: Based on fish/shellfish and water consumption = 0.69 μg/L; based on fish/shellfish consumption only = 3.3 μg/L
- Comprehensive Environmental Response, Compensation, and Liability Act Reportable Quantity (RQ) = 100 lb
- Emergency Planning and Community Right-To-Know Act Toxics Release Inventory: Listed substance subject to reporting requirements
- Resource Conservation and Recovery Act
  - Listed Hazardous Waste: Waste codes in which listing is based wholly or partly on substance - U210, F001, F002, F024, F025, K019, K020, K073, K116, K150, K151
  - Characteristic Toxic Hazardous Waste: TCLP Threshold = 0.7 mg/L
  - Listed as a Hazardous Constituent of Waste
- Safe Drinking Water Act Maximum Contaminant Level (MCL) = 0.005 mg/L

The US FDA regulates PCE. Its maximum permissible level in bottled water is 0.005 mg.

(For section references, see endnote #3)

Endnotes

1. Habeck, M. 2003, Tetrachloroethylene. Available: www.eco-usa.net/toxics/pce.shtml [2004, May 18, 2004]; Agency for Toxic Substances and Disease Registry (ATSDR) 1997, ToxFAQs: Tetrachloroethylene, CAS # 127-18-4, U.S. Department of Public Health, Public Health Service; California Department of Health Services, Hazard Evaluation System & Information Service (HESIS) 1989, Perchloroethylene. Available: www.dhs.ca.gov/ohb/HESIS/perc.htm; National Institute for Occupational Safety and Health, Documentation for Immediately Dangerous to Life of Health Considerations, NTIS Publication No PB-94-195047, May 1994; National Institute for Occupational Safety and Health (NIOSH) 1996, Tetrachloroethylene (IDLH Documentation). Available: http://www.cdc.gov/niosh/idlh/127184.html [1996, 8/16/96]; National Institute for Occupational Safety and Health (NIOSH) 2000, Tetrachloroethylene; National Toxicology Program 2005, Tetrachloroethylene (Perchloroethylene) CAS No. 127-18-4, United States Department of health and Human Services; Occupational Safety and Health Administration (OSHA) 2005, Safety and Health Topics: Tetrachloroetyhlene [Homepage of U.S. Department of Labor], [Online]. Available: www.osha.gov/dts/chemicalsampling/data/CH_270620.html [2005, 12/13/05]; American Conference of Governmental Industrial Hygienists (ACGIH) 2006, TLVs and BEIs; Aschengrau, A., Rogers, S. & Ozondoff, D. 2003, "Perchloroethylene-contaminated drinking water and the risk of breast cancer: Additional results from Cape Cod, Massachusetts, USA", Environmental Health Perspectives, vol. 111, no. 2, pp. 167-173; United States Environmental Protection Agency (USEPA) 1994, August,1994-last update, Chemical Summary for Perchloroethylene [Homepage of U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics], [Online]. Available: www.epa.gov/chemfacts/s_perhl.txt [2006, 2/27/06].
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3. National Toxicology Program 2005, Tetrachloroethylene (Perchloroethylene) CAS No. 127-18-4, United States Department of Health and Human Services. OSHA, Chemical Sampling Information, http://www.osha.gov/dts/chemicalsampling/data/CH_270620.html, updated Jan, 2006; EPA Fact Sheet - Final Amendments to Air Toxics Standards for Perchloroethylene Dry Cleaners [Dry Cleaning Emission Standards], [Online]. Available: http://www.epa.gov/air/drycleaningrule/percfs20060717.html [June 12th, 2007]