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Dry Cleaning

Perchloroethylene ("perc") has long been recognized as an effective dry cleaning solvent and today it is by far the most commonly used solvent in dry cleaning shops. However, as a volatile organic solvent, perc may pose serious health hazards if exposure is not properly controlled. Dry cleaning workers who routinely breathe excessive amounts of the solvent vapor or spill perc on their skin are at risk of developing health problems.

Special precautions are recommended to avoid health risks from perc exposure. The purpose of this guidance is to provide practical and effective ways for dry cleaning operators to reduce worker exposure to perc. The guidance emphasizes reducing perc exposure through a combination of using modern equipment and preventive maintenance, control of leaks in dry cleaning equipment, proper ventilation, and good work practices.

Health Hazards

During dry cleaning, perc primarily enters the body from inhalation of the vapors, potentially resulting in the following health hazards:

Dizziness, drowsiness, and loss of coordination;
Mild loss of memory, visual perception, and reaction time after several years of exposure; or
Redness and blistering of the skin after prolonged dermal contact.

There is some evidence of an association between perc and increased risk of certain cancers in dry cleaning workers exposed for many years. The National Institute for Occupational Safety and Health (NIOSH) has designated perc as a "potential occupational carcinogen." The National Toxicology Program has designated it as "reasonably anticipated to be a human carcinogen." The International Agency for Research on Cancer (IARC) has designated perc as a "probable human carcinogen."

The possibility of these health hazards can be minimized by reducing worker exposures to perc vapor and by avoiding skin contact with perc.

Perc Exposure

Primary Sources of Perc Exposure

Dry cleaning employees may be exposed to perc while performing both routine tasks and machine maintenance. Activities that result in elevated exposure include the following:

Loading dirty clothes into the machine (when perc-contaminated air is displaced and forced out of the machine);
Removing clothes, especially thick items, before the drying cycle is finished;
For transfer machines, transferring solvent-laden clothes into the dryer;
Cleaning lint and button traps;
Raking out the still (distillation unit residue);
Changing the solvent filter;
Maintenance of water separator; and
Handling and storage of hazardous waste.

Machine Fugitive Emissions

Uncontrolled emissions, so-called "fugitive emissions," from dry cleaning machines can also expose workers to high levels of perc. These include:

Perc emissions not captured by vapor recovery and thus released when the loading door is opened or through the vent; and
Perc emissions from leaks in machines, hoses, valves, and ducts.

Secondary Sources of Perc Exposure
Other possible sources of perc exposure not directly associated with the dry cleaning equipment include:

Pressing freshly dry-cleaned clothes;
Using a perc-based spotting agent; and
Using a perc-based waterproofing agent.[1]

Current Regulations and Recommendations

OSHA has set mandatory permissible exposure limits (PELs) for perc, presented in Table 1. This table also lists perc exposure limits *recommended* by other safety and health organizations.

Table 1.	Worker Exposure Limits for Perchloroethylene (Tetrachloroethylene)	
Organization	8-hour time-weighted average (TWA)	Other limits
OSHA (mandatory)	Permissible Exposure Limit (PEL): 100 parts per million (ppm)	Ceiling: 200 ppm (for 5 mins. in any 3-hr. period), with a maximum peak of 300 ppm
ACGIH (voluntary)	Threshold Limit Value (TLV): 25 ppm	Short-term exposure limit (STEL): 100 ppm (as a 15-min. TWA)
NIOSH	Potential Occupational Carcinogen; Minimize workplace exposure concentrations.	

[1] Use of perc-based spotting or waterproofing agents is not current practice in the dry cleaning industry. However, these operations are addressed in this document for those few dry cleaning establishments that may continue to use these products.

Other OSHA standards that may apply when workers are exposed to perc include: Hazard Communication (29 CFR 1910.1200); General requirements for personal protective equipment (29 CFR 1910.132); and Respiratory Protection (29 CFR 1910.134).

In addition to these worker exposure limits, dry cleaning facilities must comply with EPA regulations controlling the release of perc into the environment – air, land, and water. EPA has developed regulations that affect many aspects of dry cleaning operations, including machine operation and maintenance, building design and ventilation, work practices, as well as perc storage and disposal. There are also EPA requirements on air monitoring for perc release, recordkeeping, and perc use reporting. (For further information on EPA regulations, see *Plain English Guide for Perc Cleaners*, EPA, 2003.)

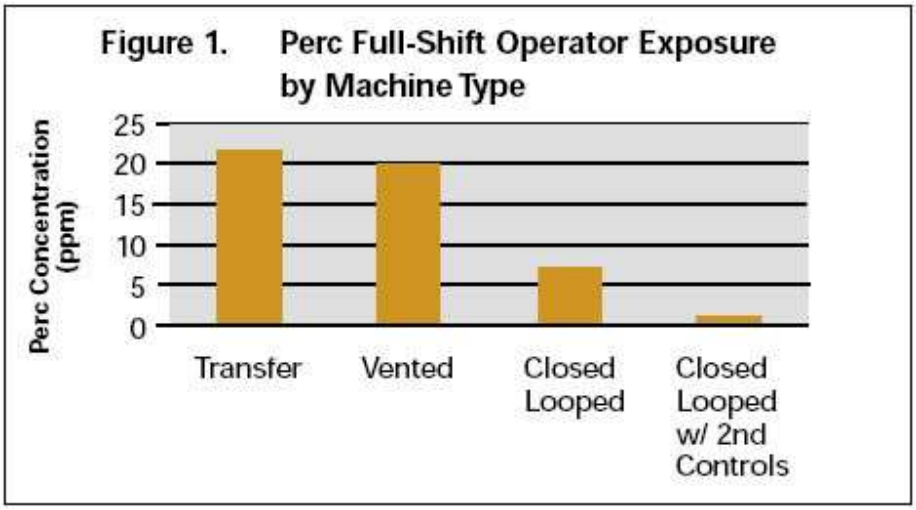
Machine Design and Maintenance

Dry cleaning technology has evolved substantially over the decades. The newer machine designs (dry-to-dry, closed looped) greatly reduce the amount of perc vapor released into the air inside the shop as well as outdoors, resulting in cost savings since more perc is recovered for reuse, as well as safer working conditions and a cleaner environment.

The oldest type of dry cleaning machines – *transfer* machines – can expose workers to high amounts of perc, particularly during transfer of solvent-laden clothing from washer to dryer. Newer equipment (*dry-to-dry* machines) reduces worker exposure by eliminating this transfer step (clothes enter and exit the machine dry).

The first dry-to-dry equipment, dry-to-dry *vented*, exhausts residual solvent vapors either directly outside or first through a perc vapor recovery system. The present designs, dry-to-dry *closed loop* machines, recirculate perc rather than release it outdoors. The latest technology incorporates a secondary vapor recovery system on the dry-to-dry *closed loop machines* that most effectively minimizes perc usage, environmental releases, and worker exposure to perc. Figure 1, below, illustrates the perc exposure levels of machine operators associated

with the various dry cleaning machines.



Source: NIOSH.

Replacing equipment that wears out with modern equipment can reduce exposures. Also, routine machine maintenance combined with detection and timely repair of identified leaks can be extremely effective in controlling airborne levels of perc vapor. (See the Case Studies starting on page 14.) The EPA estimates that as much as 25 percent of solvent emissions can be attributed to leaks. In addition to creating unsafe airborne levels of perc, leaks are waste-ful and costly. Routine machine maintenance needs to be performed to ensure optimal operation of all components. Appropriate personal protective equipment (PPE) needs to be worn during maintenance activities to ensure protection from perc hazards. (See page 10 for more information on PPE.)

Recommended machine maintenance activities include the following:

Clean lint and button traps regularly to prevent clogging of condensers and fans.
Rake out still daily. (Consider installing a pump that allows residue to be pumped directly to a safety can.)
Change all filters as necessary.
Desorb carbon adsorber before saturation point.
Adjust refrigerated condensers to ensure proper temperature of drying air.
Maintain and repair exhaust fans.

A recommended schedule of maintenance activities is provided in Appendix A at pages 16 -17.

NEVER PERFORM MAINTENANCE WHILE
DRY CLEANING EQUIPMENT IS OPERATING.

To control perc leaks from dry cleaning equipment:

Perform daily checks for leaks in door gaskets, valves, hoses, pumps, tubing, and piping connections.
Look for liquid pools and droplets on or around equipment. Unusual solvent odor may indicate a vapor leak (do not rely only on the sense of smell for detecting leaks).
Replace gaskets before they become hard, cracked, or worn.
Use a direct-reading air-monitoring device (see page 13) to detect vapor leaks in piping, exhaust ductwork, and associated components.
Use perc-resistant seals and fittings recommended by the manufacturer of the machine.
Repair leaks immediately.

Ventilation

Adequate ventilation is essential for controlling perc levels within the dry cleaning shop. *General ventilation*, provided by equipment such as overhead fans, is useful for reducing heat and humidity, and diluting perc levels. Such ventilation can be designed to move the perc vapors away from workers and customers while continuously supplying clean, fresh air to the dry cleaning area.

Local exhaust ventilation (LEV) captures perc vapor at the source of the release, removing the vapor before it enters the air inside the shop. Well-designed LEV may be provided where perc exposure is highest, for example, at the loading door. Newer dry cleaning equipment has built-in LEV designed to prevent escape of vapors during machine loading and unloading. For machines without built-in LEV, an external ventilation hood outside the machine door can be installed to control vapors when the door is open. (A study describing this method of control is summarized in Case Study #5 at page 16.)

Detailed information regarding desirable configurations for general ventilation and LEV as well as recommendations on exhaust fan placement and capacity can be found in pamphlets by the International Fabricare Institute (IFI) (1989)[2] and NIOSH (1998)[3].

PPE, Work Practices and Training

Personal protective equipment **(PPE)** – including aprons, gloves, goggles, and respirators approved for use with organic chemicals – is used to help workers avoid perc exposure. Workers must wear respirators **equipped with filters or cartridges specifically designed for organic vapors** when elevated perc exposures are anticipated (29 CFR 1919.134). Tasks where elevated exposure may occur include machine maintenance, filter changes, waterproofing operations, and loading/unloading machines (depending on the equipment in use). Workers using transfer machines may also need to wear chemical-resistant aprons. Spotters can wear goggles, chemical-resistant aprons, and gloves. Spill cleanup workers always need to wear respirators and gloves.

[2] IFI. 1989. Reducing Vapor Exposure: OSHA compliance. International Fabricare Institute. Vol. 13, No. 5.
[3] NIOSH. 1998. Control of Exposure to Perchloroethylene in Commercial Drycleaning. NIOSH Hazard Controls. DHHS (NIOSH) Publication No. 97-154. http://www.cdc.gov/niosh/hc16.html

Work Practices – Good work practices can greatly minimize worker exposure to perc vapors. For example, peak exposure levels can be reduced by several hundred parts per million simply by proper positioning of the worker's head and body during transfer operations. Other important work practices to reduce perc exposures are listed below.

Work Practice Tips for Dry Cleaning Operators

Do not load the machine past its capacity.
Do not open the machine door when the cycle is running.
Keep the machine door CLOSED as much as possible.
Do not "shortcut" the drying cycle by removing garments from the machine before the cycle is finished.
Keep your head and face turned away from the machine door and clothes when removing solvent-laden clothes from the washer.
Do not transfer perc to machines by hand or with open buckets. Use a closed piping system that connects directly to the machine drum.
WAIT until the machine and solvent are cold before performing maintenance.
Use spotting agents sparingly.
Use perc-free spotting agents.
Clean up perc spills immediately. (The shop should have in place a plan for safely responding to perc spills.)
Store containers of perc and perc wastes in tightly sealed containers.
Position your hand away from the door when opening a transfer machine.

Training – Dry cleaning employees need training on how to protect themselves from the hazards of perc (OSHA Hazard Communication standard, 29 CFR 1910.1200). Employees should be trained in proper work practices for all of their expected tasks – operating and maintaining machines, spotting, waterproofing, housekeeping, and perc transfer and storage.

Workers must be trained on the health hazards and symptoms associated with perc exposure. Workers should become familiar with Material Safety Data Sheets (MSDS) and container labels for perc (OSHA Hazard Communication standard, 29 CFR 1910.1200). The International Chemical Safety Card for perc can be found in Appendix B on pages 18-20 of this publication to help with this training.

In addition, workers should be familiar with the location and proper use of eyewash stations as well as procedures for responding to first aid emergencies, such as eye splashes and skin contamination. OSHA requires employers to train their employees about hazards and methods to prevent exposure to chemicals used

in the workplace (OSHA Hazard Communication standard, 29 CFR 1910.1200). Workers must also be trained on the proper use of respirators (Respiratory Protection standard, 29 CFR 1910.134).

Perc Air Monitoring

A variety of devices and instruments are available to measure perc levels in the air. Reasons for performing air monitoring include:

To determine the perc exposure levels of individual employees;
To identify sources of leaks in equipment; and
To measure perc levels before and after modifications to equipment or procedures.

The type of air monitoring method used depends on the purpose of the sampling, the technical abilities of the person who conducts the testing, and the cost of the equipment. To determine the perc exposures of individual workers, a sample can be obtained by clipping a monitoring device to the worker's collar either with a battery-powered pump or a simple monitoring badge.

The samples are then sent to a qualified laboratory to analyze the perc concentration. The results can be compared with the OSHA PEL and other recommended exposure limits for perc (listed in Table 1, on page 6).

For detecting equipment leaks and other emissions, portable, direct-reading devices provide either a visual/audible indication of a leak or an instantaneous measurement of the perc vapor concentration at the source of the emission. These instruments vary in terms of cost, accuracy, and ease of use.

Two relatively inexpensive, easy to use leak-detection devices are:

Small, hand-held refrigerant leak detectors that indicate a perc leak by a visual and audible signal; and
Colorimetric detector tubes (used with small, hand-operated pumps) that change color depending on the perc vapor concentration.

More sophisticated types of direct reading devices include infrared analyzers and photoionization detectors that provide accurate measurements of perc concentration, but are more expensive and require technical expertise to operate.

Case Studies

Dry cleaning shop owners have numerous options available for reducing the perc exposures of their employees. The case studies below describe the effectiveness of measures such as installing relatively low-cost machine retrofits, installing LEV, and performing routine machine maintenance and leak detection.

Case Study #1: Emission Control Retrofit – Carbon Adsorber

Installing a new carbon adsorber on a dry cleaning machine reduced the perc exposures of operators by 92 percent, according to a NIOSH study. The 60-pound, closed-loop carbon adsorber was installed to remove residual perc not collected by the existing refrigerated condenser on the closed-loop, dry-to-dry machine. The retrofit cost less than $5,000.

Before the retrofit, the average perc exposure of operators during the one-minute machine loading and unloading process was 353 ppm. After the carbon adsorber was installed, the average exposure was 29 ppm, a reduction of approximately 92 percent.

Case Study #2: Emission Control Retrofit – Refrigerated Condenser

A NIOSH study found that perc exposures of dry cleaning machine operators were reduced by 60 percent after a refrigerated condenser was installed on a dry cleaning machine.

A 5-ton cooling capacity refrigerated condenser was installed on a vented, dry-to-dry machine in place of its original water-cooled condenser and single-pass carbon adsorber. The retrofit cost less than $5,000. Before the installation of the refrigerated condenser, the average perc exposure of machine operators during the one-minute machine loading and unloading phase was 1,139 ppm. After the retrofit, the average exposure was 456 ppm, a reduction of about 60 percent. NIOSH cautioned that only dry cleaning machines in good repair with few leaks should be considered for retrofitting. Although this technology significantly reduced perc exposure in this

case, it does not eliminate it and additional controls would be needed to achieve further reductions.

Case Study #3: Gasket Leak – Detection and Repair

Repairing a leaking gasket on a dry cleaning machine resulted in a full-shift perc exposure reduction of 22 ppm, according to a NIOSH study of retrofit emission controls (described further in Case Study #2). The gasket at the rear of the machine being retrofitted with a new refrigerated condenser sprung a leak during the installation. Before the retrofit, TWA perc concentrations averaged 47 ppm. Measurements taken after the leak was fixed resulted in an average perc exposure of 25 ppm.

Case Study #4: Distillation Unit Leak – Detection and Repair

During the LEV evaluation (described in Case Study #5), NIOSH noted that the full-shift perc exposures of machine operators were up to four times higher on the day when the distillation unit was operating (about 20 ppm vs. 5 ppm when the unit was turned off). These elevated readings led to the identification and repair of a leak in the distillation system. If perc monitoring had not been conducted, the leak might not have been detected. This study underscores the importance of routine perc air monitoring to identify and repair equipment leaks.

Case Study #5: Local Exhaust Ventilation

A NIOSH study showed that installation of a simple, inexpensive LEV system was effective in reducing average full-shift TWA perc exposures of machine operators by 37 percent.

Before the LEV installation, the average full-shift perc exposure was 4.7 ppm. The 12-year-old dry cleaning machine was a dry-todry, closed-loop design with a 50-pound capacity. The LEV system, including fabrication, installation, and electric wiring, was installed for $2,560. The LEV was positioned directly above the dry cleaning machine door and exhausted air from in front of the door only when the door was opened. The average perc exposure was reduced by about 37 percent, to 3.0 ppm, after the LEV installation.

Appendix A

Recommended Maintenance Schedule for Dry Cleaning Machines

Daily Maintenance Tasks

Clean button trap strainer and lint bag.
Dispose of contaminated water from the water separator.
Desorb the carbon adsorber.
Rake out the still of the distillation unit (or weekly as needed).

Weekly Maintenance Tasks*

Check door seatings and gaskets of machine cylinder for liquid and vapor leaks.
Check the button trap for lid leaks.
Launder the lint bag.
Check seals and gaskets of the refrigerated condenser's diverter valve, distillation unit, filters, filter housings, and muck cooker for liquid and vapor leaks.
Rake out the still of the distillation unit (or daily as needed).
Clean the separator tank of the water separator and perform leak checks.
Measure the exhaust temperature of the refrigerated condenser.
Measure perc in the exhaust system.
Perform leak checks on hose and pipe connections, fittings, couplings, and valves.

Monthly Maintenance Tasks

Check the exhaust damper (vented machines) for liquid and vapor leaks.
Check for lint buildup on the heating and condensing coils and refrigerated condenser coils.
Check for leaks in the ductwork of the lint trap and carbon adsorber.
Check for lint buildup on the temperature probe of the lint trap.

Clean the vent of the water separator.

Semi-Annual Maintenance Tasks

Clean the muck cooker's steam and condensation coils.

Annual Maintenance Tasks

Clean the heating/condensing and refrigerated condenser coils.

Other

Clean and change filters according to the manufacturer's schedule.

*Note: The EPA requires weekly leak detection and repair for large dry cleaners and bimonthly leak detection and repair for small dry cleaners. The type of machine (dryto-dry or transfer) and the amount of perc purchased each year determines whether a dry cleaner is large or small. Refer to the *Plain English Guide for Perc Cleaners* for details (http://www.epa.gov/opptintr/dfe/pubs/garment/perc/).

International Chemical Safety Card for Tetrachloroethylene

The following International Chemical Safety Card (ICSC) for tetrachloroethylene was published in 2000. The ICSCs project is an undertaking of the International Programme on Chemical Safety (IPCS). The project is being developed in cooperation between the IPCS and the Commission of the European Communities. The IPCS is a joint activity of three cooperating international organizations: the United Nations Environment Programme (UNEP), the International Labour Office (ILO) and the World Health Organization (WHO). The main objective of the IPCS is to carry out and disseminate evaluations of the hazards posed by chemicals to human health and the environment.

ICSC cards summarize essential health and safety information on chemicals for their use at the shop floor level by workers and employers. Cards are available for over 1,300 chemicals, and they are provided in several languages, including English, Korean, Spanish, Russian, French, German, Japanese and Chinese.

To access the most recent ICSC card for perc, to locate the perc card in another language, or to find the card for another chemical, access the NIOSH Internet site at: http://www.cdc.gov/niosh/ipcsneng/neng0076.html.

International Chemical Safety Cards

TETRACHLOROETHYLENE **ICSC: 0076**

1,1,2,2-Tetrachloroethylene
Perchloroethylene
Tetrachloroethene
C_2Cl_4 / $Cl_2C=CCl_2$
Molecular mass: 165.8
ICSC # 0076
CAS # 127-18-4
RTECS # KX3850000
UN # 1897
EC # 602-028-00-4
April 13, 2000 Peer reviewed

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Not combustible. Gives off irritating or toxic fumes (or gases) in a fire.		In case of fire in the surroundings: use appropriate extinguishing media.
EXPLOSION			

EXPOSURE		STRICT HYGIENE! PREVENT GENERATION OF MISTS!	
• INHALATION	Dizziness. Drowsiness. Headache. Nausea. Weakness. Unconsciousness.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Artificial respiration may be needed. Refer for medical attention.
• SKIN	Dry skin. Redness.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse and then wash skin with water and soap.
• EYES	Redness. Pain.	Safety goggles, face shield.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
• INGESTION	Abdominal pain. (Further see Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Give plenty of water to drink. Rest.
SPILLAGE DISPOSAL		**STORAGE**	**PACKAGING & LABELLING**
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. Do NOT let this chemical enter the environment. Personal protection: filter respirator for organic gases and vapours.		Separated from metals ,(see Chemical Dangers), food and feedstuffs . Keep in the dark. Ventilation along the floor.	Do not transport with food and feedstuffs. Marine pollutant. Xn symbol N symbol R: 40-51/53 S: (2-)23-36/37-61 UN Hazard Class: 6.1 UN Packing Group: III
SEE IMPORTANT INFORMATION ON BACK			
ICSC: 0076		Prepared in the context of cooperation between the International Programme on Chemical Safety & the Commission of the European Communities (C) IPCS CEC 1994. No modifications to the International version have been made except to add the OSHA PELs, NIOSH RELs and NIOSH IDLH values.	

International Chemical Safety Cards

TETRACHLOROETHYLENE		**ICSC: 0076**
I M P O R T A N T	**PHYSICAL STATE; APPEARANCE:** COLOURLESS LIQUID , WITH CHARACTERISTIC ODOUR. **PHYSICAL DANGERS:** The vapour is heavier than air. **CHEMICAL DANGERS:** On contact with hot surfaces or flames this substance decomposes forming toxic and corrosive fumes (hydrogen chloride, phosgene, chlorine). The substance decomposes slowly on contact with moisture producing trichloroacetic acid and hydrochloric acid. Reacts with metals such as aluminium,	**ROUTES OF EXPOSURE:** The substance can be absorbed into the body by inhalation and by ingestion. **INHALATION RISK:** A harmful contamination of the air will be reached rather slowly on evaporation of this substance at 20°C. **EFFECTS OF SHORT-TERM EXPOSURE:** The substance is irritating to the eyes , the skin and the respiratory tract . If this liquid is swallowed, aspiration into the lungs may result in chemical pneumonitis. The substance may

D A T A	lithium, barium, beryllium. **OCCUPATIONAL EXPOSURE LIMITS:** TLV: 25 ppm as TWA, 100 ppm as STEL; A3 (confirmed animal carcinogen with unknown relevance to humans); BEI issued; (ACGIH 2004). MAK: skin absorption (H); Carcinogen category: 3B; (DFG 2004). OSHA PEL†: TWA 100 ppm C 200 ppm 300 ppm (5-minute maximum peak in any 3-hours) NIOSH REL: Ca Minimize workplace exposure concentrations. See Appendix A NIOSH IDLH: Ca 150 ppm See: 127184	cause effects on the central nervous system. Exposure at high levels may result in unconsciousness. **EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:** Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the liver and kidneys. This substance is probably carcinogenic to humans.
PHYSICAL PROPERTIES	Boiling point: 121°C Melting point: -22°C Relative density (water = 1): 1.6 Solubility in water, g/100 ml at 20°C: 0.015	Vapour pressure, kPa at 20°C: 1.9 Relative vapour density (air = 1): 5.8 Relative density of the vapour/air-mixture at 20°C (air = 1): 1.09 Octanol/water partition coefficient as log Pow: 2.9
ENVIRONMENTAL DATA	The substance is toxic to aquatic organisms. The substance may cause long-term effects in the aquatic environment	
N O T E S		
Depending on the degree of exposure, periodic medical examination is suggested. The odour warning when the exposure limit value is exceeded is insufficient. Do NOT use in the vicinity of a fire or a hot surface, or during welding. An added stabilizer or inhibitor can influence the toxicological properties of this substance, consult an expert. Card has been partly updated in April 2005. See section Occupational Exposure Limits. Transport Emergency Card: TEC (R)-61S1897 NFPA Code: H2; F0; R0;		
ADDITIONAL INFORMATION		
ICSC: 0076	**TETRACHLOROETHYLENE**	
(C) IPCS, CEC, 1994		
IMPORTANT LEGAL NOTICE:	Neither NIOSH, the CEC or the IPCS nor any person acting on behalf of NIOSH, the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use. The only modifications made to produce the U.S. version is inclusion of the OSHA PELs, NIOSH RELs and NIOSH IDLH values.	

The information in this Safety Meeting Topic was provided by OSHA.

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