

# A Chronology of Historical Developments in Drycleaning

## *State Coalition for Remediation of Drycleaners*

November 2007

**1690** – First reference for the use of an organic solvent (spirits of turpentine) to spot clean fat and oil stains on clothing (Sigworth, 1981).

**1821** - Perchloroethylene (PCE) synthesized by Michael Faraday (Partington, 1964)

**1840s** – The firm of Jolly-Belin opens a commercial drycleaning operation in Paris using spirits of turpentine as a drycleaning solvent (IFI).

**1869** – Pullars of Perth Scotland introduces the first power machinery for drycleaning (Johnson, 1971).

**1879** – At least one drycleaning plant was operating in the U.S. (Sigworth, 1981).

**Late 19<sup>th</sup> Century** – Turpentine spirits, camphor oil, benzene, naphtha, kerosene and white gasoline used as drycleaning solvents. Clothing was washed and rinsed in tubs of solvent and then hung in a warm room to dry.

**1898** – Carbon tetrachloride imported from Germany by Ernest C. Klipstein. Carbon tetrachloride was sold as a drycleaning and spot-removing agent under the trade name of Carbona (Doherty, 2000).

### **Early 1900s**

- Raw white gasoline is the primary drycleaning solvent used in the United States.
- Due to fire and explosion hazards associated with gasoline, drycleaning plants are considered such a poor risk that most insurance companies would not issue a policy for a drycleaning facility (Michelsen, 1957).
- First use of distillation to purify spent solvent (Lohman, 2002).

**1903** - Steam presses introduced to drycleaning operations (Martin, 1958).

**1905** - Clarifying systems (settling tanks) used to purify dirty solvent (Lohman, 2002).

**1915** – The average U.S. drycleaning operation uses 12,000 gallons of gasoline a year (Michelsen, 1957).

### **1920s**

- Bag filters first utilized to purify spent solvent, replacing clarifiers (Lohman, 2002).

- First use of powder filtration systems (Lohman, 2002).
- First dryers (tumblers) utilized in drycleaning plants. They replace drying cabinets or steam cabinets (Lohman, 2002).

**1924** – Lloyd E. Jackson of the Mellon Institute of Industrial Research, working with W.J. Stoddard, an Atlanta drycleaner and president of the National Institute of Drycleaning, develops specifications for a higher flash point petroleum drycleaning solvent which became known as Stoddard solvent (Martin, 1958).

**March 1, 1928** – U.S. Department of Commerce requires a minimum flash point of 100° F for petroleum drycleaning solvents. Drycleaners begin using Stoddard solvent (Martin, 1958).

**1930** – Trichloroethylene (TCE) is introduced as a drycleaning solvent in U.S. Problems with dye bleeding and equipment corrosion limit the use of TCE (Martin, 1958).

**1934** – Perchloroethylene is introduced as a drycleaning solvent in U.S. (Martin, 1958).

**1940** – Chlorinated solvent use by the U.S. drycleaning industry was estimated to be 45 million pounds of carbon tetrachloride, 12 million pounds of perchloroethylene and 5 million pounds of trichloroethylene (Michelsen, 1957).

#### **1940s**

- Combination washer/extractor drycleaning machines marketed (Lohman, 2002).
- Perc reclaimers (solvent recovery tumblers or dryers) introduced (Lohman, 2002).
- Flat screen filters introduced (Lohman, 2002).

**World War II** – Shortages of chlorinated solvents result in most drycleaning being conducted with petroleum drycleaning solvents in the U.S. (Michelsen, 1957).

**1948** – Perchloroethylene replaces carbon tetrachloride as the leading chlorinated solvent used in drycleaning (Chemical Week, 1957).

#### **1950**

- The National Institute of Cleaning and Dyeing worked with the U.S. Bureau of Standards to develop standards for a higher flash point petroleum drycleaning solvent known as 140-F solvent (Michelsen, 1957).
- A study by the National Institute of Cleaning and Dyeing determines that chlorinated solvent use by the U.S. drycleaning industry was 67,500,000 pounds of PCE and 15,000,000 pounds of carbon tetrachloride (Michelsen, 1957).

**1950s** – The use of carbon tetrachloride as a drycleaning solvent is discontinued due to toxicity and corrosion problems with equipment. (Kirk-Othmer, 1965).

**1955** – The U.S. drycleaning industry used an estimated 145,000,000 gallons of Stoddard solvent, 4,000,000 gallons of 140-F solvent and 8,500,000 gallons of PCE (Michelsen, 1957).

#### **Late 1950s**

- Petroleum solvents still the predominant solvents used in drycleaning in the U.S.
- Rigid and flexible tube (tubular) screen filters introduced (Lohman, 2002).

**1959** – It is estimated that the average neighborhood PCE drycleaning operation uses 50 to 100 gallons of PCE per month and that a one 55-gallon drum of PCE cleans about 500 pounds of clothing (Doherty, 2000).

**1960** – Whirlpool Corporation introduces the first coin-operated drycleaning machine (Kirk-Othmer, 1965).

**Early 1960s** - Cartridge filters are introduced (Caplan, 2003).

**1962** – PCE becomes the drycleaning solvent of choice in the U.S., and the drycleaning industry accounts for approximately 90% of PCE consumption (Chemical Engineering News, 1963).

**1964** - E.I. du Pont de Nemours & Co. introduces a fluorinated-chlorinated hydrocarbon drycleaning solvent (1,1,2-trichloro-1,2,2-trifluoroethane, or Freon 113) under the trade name Valclene<sup>®</sup> (Johnson, 1971).

**1966** – Drycleaning machines for fluorocarbon solvents developed by Böhler & Weber in Germany (Böwe, 2002).

**1968** – Böhler & Weber develops first dry-to-dry machines in Germany (Böwe, 2002).

#### **1970s**

- Petroleum reclaimers (recovery tumblers) are developed (Lohman, 2002).
- Third generation drycleaning machines (closed loop dry-to-dry machines) are developed (Miller, 1998).

**December 16, 1974** – The Safe Drinking Water Act signed into law. The act requires the states to regulate all direct injections of wastes to the subsurface (Pankow & Cherry, 1996).

**1975** - The average PCE drycleaning machine can clean approximately 8,000 pounds of clothing with one 55-gallon drum of PCE (Kirschner, 1994).

## **1980s**

- Spin disc filters are introduced (Caplan, 2003).
- 1,1,1-Trichloroethane (methyl chloroform or TCA) marketed as a drycleaning solvent (Dowclene LS<sup>®</sup>). There was limited use of this solvent in drycleaning because of corrosion problems.

**1980** – PCE use peaks in the U.S. (Dougherty, 2000).

**November 1980** – Resource Conservation Recovery Act (RCRA) promulgated. This legislation regulates the generation, transportation, treatment and disposal of hazardous wastes in the U.S.

**December 26, 1985** – E.P.A. published a Notice of Intent to list PCE as a potentially toxic air pollutant to be regulated under Section 112 of the Clean Air Act (Office of Air Quality, 1991).

**1986** – According to the U.S. Department of Commerce, there are approximately 21,787 drycleaning plants in the United States. Of these there are 4,300 coin-operated drycleaning facilities (19.7%), 1,182 are industrial laundry and drycleaning facilities (5.4%) and 16,305 are commercial drycleaning facilities (74.8%). Of these facilities, 18,899 (86.7%) use PCE, 489 facilities (2.2% use Valclene), 50 (0.2%) use TCA and 2,349 (10.8%) use petroleum solvent (U.S.D.C., 1986).

**September 1986** – Notification deadline for small quantity generators of hazardous waste under the Hazardous and Solid Waste Amendments (HSWA) to RCRA. Most PCE drycleaners in U.S. began shipping wastes offsite as hazardous wastes.

**September 1987** – Twenty-seven countries sign the Montreal Protocol on Substances that Deplete the Ozone Layer, committing every signatory state to reduce its use of chlorinated fluorocarbons by 50% of their level of use in 1986 by 1999. The drycleaning solvents that would be affected are 1,1,2 trichloro-1,2,2-trifluoroethane (Valclene) and 1,1,1-trichloroethane (Rowland, 1993).

**1988** – A survey of drycleaning equipment and plant operations in the U.S. conducted by the International Fabricare Institute finds that approximately 70.7% of the 909 respondents discharged separator water to either the sanitary sewer or to a septic system (IFI, 1989).

**April 1989** – The City of Lodi, California detects PCE in groundwater samples collected from two of its Municipal wells at concentrations exceeding the California Maximum Contaminant Level for drinking water. This discovery lead to extensive investigations that identified over 50 potential contaminant sources, including a number of dry cleaning facilities (Groundwater Resources Association, 2004).

**June 1989** - Amendments to the Clean Water Act identify 83 compounds found in drinking water which may have an adverse effect on people's health. PCE and its degradation products are among these compounds. Drinking water Maximum Contaminant Levels are set for these compounds (Arbuckle, 1991).

**1990** – Drycleaning/textile processing account for approximately 50% of PCE use in the U.S. (HSIA, 1998).

**December 9, 1990** – Clean Air Act Amendments: EPA proposes national emission standards to limit PCE emissions from drycleaning plants (EPA, 2006).

**March 1992** – A study by the Central Valley Region, California Regional Water Quality Control Board, identifies sanitary sewer lines as “the main discharge point for dry cleaners” of wastewater containing “dissolved PCE ... pure cleaning solvent and solids containing PCE” (Izzo, 1992).

### **1993**

- First commercial use of a closed-loop/direct-couple solvent delivery system (Dawson, 2007).
- It is estimated that a typical PCE drycleaning machine can clean 16,000 pounds of clothing using one 55-gallon drum of PCE (Kirshner, 1994).

**September 22, 1993** – EPA promulgated technology-based emission standards to control emissions of PCE from drycleaning facilities. No PCE transfer machines can be installed after this date (EPA, 2006).

### **1994**

- Exxon Chemical begins marketing DF-2000™ a high flashpoint synthetic paraffin (petroleum) drycleaning solvent (Dawson, 2007).
- Connecticut and Florida create the first drycleaning solvent cleanup programs in the United States.

**December 1994** – Dade County, Florida files a law suit against defendants and owners and operators of several dry cleaning facilities in the Suniland area. Drycleaning solvent contaminants were detected in groundwater samples collected from 556 private water wells located hydraulically downgradient of drycleaning facilities in 4 shopping centers. The Dade County Water and Sewer Authority installed public water mains in the area at a cost of over \$5 million (Service, 1994).

**1995** – Kansas, Minnesota, Oregon, South Carolina, create drycleaning solvent cleanup programs.

### **1996**

- Drycleaning is still the highest volume use of PCE in U.S. (Leder, 1999).

- First home drycleaning kits marketed.

**January 1, 1996** – Beginning of phase out of the production of 1,1,1-trichloroethane (methyl chloroform) and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) in the U.S. (ICF, 2004)

**September 21, 1996** - National Emission Standard Hazardous Air Pollutants (NESHAP) Requirements issued. Requirements include drycleaning machinery maintenance, record keeping and monitoring.

### **1997**

- Illinois, North Carolina, Tennessee and Wisconsin create drycleaning solvent cleanup programs.
- The primary use of PCE in the U.S. is no longer as drycleaning solvent but as a chemical intermediary (HSIA, 1998).
- Pilgrim Enterprises sues drycleaning equipment manufacturers and suppliers for \$12 million for cleanup costs associated with 17 contaminated drycleaning sites in Houston and San Antonio (National Clothesline, 2003).

**1998** – Drycleaning/textile processing accounts for 36% of PCE usage in the U.S. (HSIA, 1999).

### **1999**

- Rynex<sup>™</sup> (dipropylene glycol tertiary-butyl ether) first marketed as a drycleaning solvent (Hayday, 2007).
- GreenEarth<sup>®</sup> (Decamethylcyclcopentasiloxane) a silicon-based solvent is first marketed as a drycleaning solvent (Maxwell, 2007).

**February 5, 1999** – The first commercial liquid carbon dioxide (CO<sub>2</sub>) drycleaning plant opens in Wilmington, North Carolina (Wentz, 2001).

**April 13, 1999** - The State Coalition for Remediation of Drycleaners is formed in Washington D.C. This organization is composed of representatives from the states with drycleaning solvent cleanup programs and is sponsored by the U.S. E.P.A.'s Technology Innovation Office.

### **2000**

- Alabama and Missouri create drycleaning solvent cleanup programs.
- PureDry<sup>™</sup>, a mixture of isoparaffinic hydrocarbons, hydrofluoroethers and perfluoroisobutylethers was first marketed as a drycleaning solvent (Eastern Research, 2005).

- The City of Lodi, California filed a suit in Federal Court against 15 Lodi businesses, including a number of drycleaning businesses, for PCE contamination of some of its water supply wells (Groundwater Resources, 2004).

**December 6, 2002:** The South Coast Air Quality Management District's governing board voted unanimously to require the region's estimated 2,200 dry cleaners to switch from PCE to a non-toxic alternative. The proposed phase-out of PCE would begin on January 1, 2003 and end with total phase-out of PCE by 2020. This is the nation's first proposed ban on PCE (Wides, 2002).

**2003** – Texas creates a drycleaning solvent cleanup program.

**April 2004** – Impress™ (propylene glycol-ether based drycleaning solvent) first marketed (Liotta, 2007).

**January 25, 2006** – California Air Resources Board votes to phase out PCE drycleaning by 2023 (California EPA, 2007).

**June 2006** – A San Francisco Superior Court jury awards the City of Modesto, California over \$178 million dollars in compensatory and punitive damages for PCE contamination of its water wells and other city properties. The defendants were drycleaning chemical manufacturers and drycleaning companies (National Clothesline, 2006).

**July 27, 2006** – Effective date for final rule for National Perchloroethylene Air Emissions Standards for Dry Cleaning Facilities (40 CFR Part 63). This is a revision of standards promulgated on September 22, 1993. New drycleaning machines installed in residential buildings are not allowed to use PCE (EPA 2006).

**October 2006:** DrySolv™ (n-propyl bromide) first marketed as a drycleaning solvent (Roccon, 2007).

**July 27, 2008** – Deadline for phase-out of PCE transfer machines (EPA, 2006).

**December 21, 2020** – All existing PCE drycleaning machines in co-residential facilities are prohibited in the U.S. (EPA, 2006).

## References

Arbuckle, J. Gordon. Mary E. Bosco. David R. Case. Elliot P. Laws. John C. Martin. Marshall L. Miller. Robert D. Moran. Russell V. Randle. Daniel M. Steinway. Richard G. Stoll. Thomas F. P. Sullivan. Timothy A Vanderver Jr. Paul A. J. Wilson. 1991. Environmental Law Handbook. Rockville: Government Institutes, Inc.

Böwe Textile Cleaning USA, Inc. 2002. The History of Drycleaning. [www.boewe-tc.com](http://www.boewe-tc.com).

California Environmental Protection Agency: January 2007. News Release. Sacramento: California Air Resources Board.

Caplan, Stan. January, 2003. Understanding Filtration: Cartridges. Willow Grove: National Clothesline, Vol. 43, No. 4, p. 28.

Caplan, Stan. March 2003. Understanding Spin Disc Filtration. Willow Grove: National Clothesline, Vol. 43, No. 6, p. 56.

Chemical Engineering News. 1962. Coin-op Dry-cleaners Boost Perchloroethylene. Chemical Engineering News. August 40, 21.

Chemical Engineering News. 1963. New Dry-Cleaning System Under Field Test. Chemical Engineering News. November, 41, 28.

Chemical Engineering News. 1967. Wide Scope seen for Dry Cleaning Chemicals. 45, 30.

Chemical Week. 1953. Tri, Per and Carbon Tet. 72, 56.

Dawson, David W. 2007. E-mail from David E. Dawson, R.R. Streets & Co., Inc. to William J. Linn, Florida Department of Environmental Protection.

Dawson, David W. 2007. E-mail from David E. Dawson, R.R. Streets & Co., Inc. to Steve Risotto, Halogenated Solvents Industry Alliance.

Doherty, Richard E. 2000. A History of the Production and use of Carbon Tetrachloride, Tetrachlorethylene, Trichloroethylene and 1,1,1-Trichloroethane in the United States: Part 1 – Historical Background; Carbon Tetrachloride and Tetrachloroethylene. Environmental Forensics, Vol. p. 69-81.

Eastern Research Group. 2005. Control and Alternative Technologies Memorandum. Morrisville: Memorandum, Eastern Research Group to U.S. E.P.A.

Groundwater Resources Association of California. 2004. Summary: City of Lodi Groundwater Case Study. Sacramento: The 10<sup>th</sup> Symposium in GRA's Series on Groundwater Contamination.

Halogenated Solvents Industry Alliance, Inc. (HSIA). 1998. Facts About PERC Dry Cleaning. Washington D.C.: 3.

Halogenated Solvents Industry Alliance, Inc. 1999. Perchloroethylene White Paper. Washington D.C.: 3.

Hayday, William. 2007. E-mail from William Hayday, Rynex Holdings, Ltd. To William J. Linn, Florida Department of Environmental Protection.



ICF Consulting. 2004. The U.S. Solvent Cleaning Industry and the Transition to Non-Ozone Depleting Substances. Washington D.C.

International Fabricare Institute. March 1989. IFI's Equipment and Plant Operations Survey. Silver Spring: Focus on Drycleaning, Vol. 13, No.1.

International Fabricare Institute (IFI). What is Drycleaning?  
[www.IFI.org/consumer/Whatis-drycleaning.html](http://www.IFI.org/consumer/Whatis-drycleaning.html).

Izzo, Victor J. March 1992. Dry Cleaners – A Major Source of PCE in Ground Water. Sacramento: California Regional Water Quality Control Board, Central Valley Region.

Johnson, Albert E. 1971. Drycleaning. Watford: Merrow.

Kirk-Othmer. 1965. Encyclopedia of Chemical Technology. New York: John Wiley & Sons, Inc. Vol. 7.

Kirschner, E.M. 1994. Environment, Health Concerns Force Shift in Use of Organic Solvents. Chemical Engineering News. June 20, 1994. 72, 13.

Leder, A. 1999. C2 Chlorinated Solvents. Chemical Industries Newsletter.

Liotta, Frank J. 2007. E-mail from Frank J. Liotta, Lyondell Chemical to William J. Linn, Florida Department of Environmental Protection.

Lohman, John H. 2002. A History of Dry Cleaners and Sources of solvent Releases from Dry Cleaning Equipment. Environmental Forensics Vol. 3, p. 35-58.

Martin, Albert R. George P. Fulton. 1958. Drycleaning Technology and Theory. New York. Textile Book Publishers for The National Institute of Drycleaning.

Maxwell, Tim. 2007. E-mail from Tim Maxwell, GreenEarth Cleaning, to William J. Linn, Florida Department of Environmental Protection.

Michelsen, Edna M. 1957. Remembering the Years 1907 – 1957. Silver Spring: National Institute of Drycleaning.

Miller, Susan. 1998. The Use of Perchloroethylene in Dry Cleaning. Fullerton: California State University, Fullerton. Research Project for Master of Science in Environmental Studies.

Morrison, Robert D. 2000. Critical Review of Environmental Forensic Techniques: Part I. Environmental Forensics. Vol.1, p. 157-173.

National Clothesline: October 2003. Texas Court Gets Opinions from IFI. Willow Grove: Vol. 44 No. 1.

National Clothesline. July 2006. Companies Appeal Contamination Lawsuit. National Clothesline: Willow Grove: Vol. 46, No. 10.

Office of Air Quality Planning and Standards. 1991. Dry Cleaning Facilities – Background Information for Proposed Standards, Draft EIS. Research Triangle Park: Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency.

Pankow, James F. John A. Cherry. 1996: Dense Chlorinated Solvents and Other DNAPLs in Groundwater: History, Behavior, and Remediation. Portland: Waterloo Press.

Partington, James R. 1964. A History of Chemistry. London: Macmillan.

Roccon, Ray. 2007. E-mail from Ray Roccon, National Sales Manager, Drycleaning Technologies to William J. Linn, Florida Department of Environmental Protection.

Rowland, I.H. 1993. The fourth Meeting of the Parties to the Montreal Protocol: Report and Reflection. Environment 35 (6): 25.

Service, Gary M. 1994. The Suniland Experience. Miami: Dade County Department of Environmental Resources Management.

Sigworth, V. 1981. Dry Cleaning. Chicago: Encyclopedia Americana. Vol. 3, p. 424.

U.S. Department of Commerce. 1986. County Business Patterns for the United States. Washington D.C.: Bureau of the Census.

U.S. Environmental Protection Agency. July 27, 2006. National Perchloroethylene Air Emission Standards for Dry Cleaning Facilities – Part II: Final Rule. Washington D.C.: U.S. E.P.A. Federal Register, 40 CFR Part 63.

Wentz, Manfred. Keith R. Beck & V. Monfalcone III. 2001. Colorfastness of Fabrics Cleaned in Liquid Carbon Dioxide. Research Triangle Park: American Association of Textile Chemists and Colorists, Vol. 1, No. 5.

Wides, Laura. December 2002. Southern California Air Quality Board Votes to Ban Toxic Dry Cleaning Chemical Because of Health Concerns. Associated Press.