

A high-speed photograph of water splashing, with several large, spherical droplets suspended in the air above the main splash. The water is clear and blue-tinted, and the background is a soft, out-of-focus light blue.

Professional Wet Cleaning Implementation Guide

New York State Pollution Prevention Institute
Rochester Institute of Technology
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Disclaimer

Any opinions, findings, and conclusions or recommendations expressed are those of the author's and do not necessarily reflect the views of the New York State Department of Environmental Conservation (NYSDEC).



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I. Introduction

This Implementation Guide is meant to serve as a professional wet cleaning resource for dry cleaners and other garment care professionals. The New York State Pollution Prevention Institute (NYSP2I) developed this Guide to explain how wet cleaning works, the benefits of professional wet cleaning (PWC), and provide considerations and questions for cleaners to help with the adoption of PWC.

A future version of this Guide will include examples of New York State cleaners that have successfully implemented wet cleaning in their shop, including details of their wet cleaning equipment selection process, installation schedule and setbacks, economic and resource analyses of their perc operations compared to wet cleaning operations, and other operational details.

Who should read this Guide?

This Guide was constructed for dry cleaning shop owners, managers, skilled operators or entrepreneurs who are interested in wet cleaning all or a portion of the garments processed in their dry cleaning shop. It also includes information to help garment care professionals make decisions about how to implement wet cleaning. While some aspects of the Guide are universal for all dry cleaners regardless of location, information specific to New York State dry cleaners is also included where appropriate.

Individuals interested in PWC should thoroughly understand the costs and benefits of wet cleaning before taking action. This Guide is meant to provide a basic understanding of wet cleaning and considerations to encourage conversation between cleaners and vendors. It is assumed that readers comprehend the dry cleaning process.

Questions and More Information

For questions related to information in this Guide, the wet cleaning process, referrals to existing wet cleaners, or for additional wet cleaning information, contact the New York State Pollution Prevention Institute, 585-475-2512 or nysp2i@rit.edu, or visit the New York State Professional Wet Cleaning website at <http://www.rit.edu/affiliate/nysp2i/garment-cleaning>.

2. History of Dry Cleaning in New York State

Perc has been the solvent of choice of the garment cleaning industry for many years. It requires minimal control over the cleaning process and can be used to clean all types of garments. Perc is classified by the International Agency for Research on Cancer as "Group 2A: Probably carcinogenic to humans" and is also a suspected developmental, gastrointestinal, kidney, reproductive, respiratory, and skin or sense organ toxicant¹. Perc is a central nervous system depressant that can enter the body through respiratory or dermal exposure². Perc also presents a hazard to the environment as it is persistent in water and soil and very persistent in sediment and air³. Once perc is released into the environment, it does not easily or quickly break down into less toxic constituents.

The health and environmental impacts of perc use are of particular concern in New York State, since New York has the second highest number of garment cleaning facilities in the country⁴, many of which are located on the bottom floor of high rise apartment buildings or as part of a strip mall. As such, the health effects are experienced not only by dry cleaning workers, but also by inhabitants of apartments located above dry cleaners as well as businesses located adjacent to them^{5,6}. The New York State Department of Health (NYSDOH) outlines the potential health effects which may result from both long and short term exposure to perc in the air⁷. According to the NYSDOH, apartment residents living near dry cleaning shops are exposed to low levels of perc which may lead to reduced scores on tests of visual perception, reaction time, and attention. Furthermore, long term exposure to higher levels, such as those experienced by dry cleaning workers, can affect the liver, brain, and kidneys.

In July 2006, new federal regulations for perc dry cleaners were put into place⁸. These regulations prohibit new perc dry cleaning machines from operating in residential buildings after July 13, 2006 and require perc dry cleaning machines that were installed in residential buildings before December 21, 2005 to eliminate the use of perc by December 21, 2020. Those cleaners who installed perc dry cleaning machines in residential buildings from December 21, 2005 through July 13, 2006 were required to eliminate the use of perc by July 13, 2009. The US Environmental Protection Agency⁹ and NYSDEC¹⁰ regulations are becoming more stringent with time, working to reduce the amount of perc released to the environment as a result of dry cleaning operations.

It is now unlawful to install perc dry cleaning machines in residential buildings. When your machine wears-out, you must either switch to non-perc equipment, or move to a non-residential building. Both options will require a new, modified or amended permit or registration.

According to the NYSP21 New York State dry cleaner database¹¹ as of November 2012, there are 2,226 dry cleaners in New York State. Of these, 1,760 use perc and 397 use an alternative to perc (e.g. hydrocarbon, GreenEarth®, wet cleaning). The California Air Resources Board estimates a dry cleaner establishment consumes an average of 80 gallons of perc per year¹² and the average perc machine loses about 4 fluid ounces (0.42lbs) of perc to the atmosphere every day¹³. The operation of 1,760 perc based dry cleaners equates to the use of 140,800 gallons of perc each year, and 740 pounds of perc per day (122 metric tons perc per year) emitted to the atmosphere in New York State alone.

3. Professional Garment Cleaning Technologies

In response to landlord concerns about potential human health and environmental effects of perc, many cleaners have switched to other cleaning solvents. Alternative solvents clean garments in a manner similar to perc. Garments are submerged in the solvent, and in some cases detergents and sizers, spun to remove any residual solvent, dried, and pressed to finish them. Many of the alternatives have proved economically and technically viable, although many have their own environmental health, safety, and/or quality concerns^{14,15}.

Based on NYSPI's research, when considering the environmental, human health, and economic aspects as well as cleaning ability, PWC is the garment cleaning technology of choice for cleaners and regulators. PWC uses water, rather than a chemical, as the cleaning solvent. Sophisticated computer-controlled washers, dryers, and finishing equipment are used with water based, biodegradable detergents and sizers (see section 4. *Overview of a Wet Cleaning Operation* on page 9 of this Guide for more information on wet cleaning systems). When compared to perc and other alternative solvents, PWC not only has minimal negative environmental or human health effects, it also has the lowest installed system cost, the smallest electricity usage per load, and the lowest operating cost over the first five years of ownership (see Table I on the following page). Perc cleaners in California, Massachusetts, and New York that switched completely to wet cleaning are able to successfully clean the same types of garments they previously dry cleaned^{16,17,18,19}.

Table I on the following pages summarizes the costs, energy, and environmental & human health attributes of many professional garment cleaning technologies.

Typical Professional Garment Cleaning Solutions

Perchloroethylene (perc): traditional dry cleaning solvent; also used in other industry sectors including degreasing operations, paints and coatings, and industrial and consumer products

Professional wet cleaning: water and sophisticated equipment is used to clean garments normally dry cleaned

Acetal (Solvon K4): combustible solvent, can be used in hydrocarbon machines with minimal changes

Glycol ether (Rynex®, Solvair®): biodegradable volatile organic solvent with low volatility and a high flash point

Hydrocarbon (DF-2000™, Ecosolv®): volatile organic compounds (VOC) which contribute to the formation of ozone which is linked to ill-health effects including respiratory irritation, asthma, and premature death; flammable

Liquid carbon dioxide: non-flammable, non-toxic, naturally-occurring gas that becomes a liquid solvent when pressurized; no expected health risk to the general public from these processes; CO₂ is obtained from large combustion sources, so there is no net increase in greenhouse gas emissions due to this process

Mineral spirits or Stoddard solvent: highly flammable organic solvent typically used in painting

n-Propyl Bromide (DrySolv®): volatile organic compounds (VOC), colorless liquid, drop in replacement for perc, known neurotoxicant and reproductive toxicant*

Siloxane D5 (GreenEarth®): silicone based solvent; combustible; adverse human health hazard identified

*California Air Resources Board fact sheet, Dry Cleaning Alternatives

Table I. Summary of operational costs and environmental & human health attributes of garment cleaning solvents* (continued on the following page)

Garment Cleaning Solvent (chemical abstract service number)	Average Installed System Cost ¹	Avg. Cost for first 5 years of Dry Cleaning Facility ²	Cost per pound Cleaned ³	Avg. Natural Gas Usage per 100 pounds cleaned (therms) ⁴	Avg. Electricity Usage per 100 pounds cleaned (kWh) ⁴	
Perchloroethylene (127-18-4)	\$52,000	\$27,376	\$0.63-\$1.94 avg \$1.02	12	26.6	
Professional Wet Cleaning (7732-18-5)	\$47,000	\$20,926	\$0.57-\$1.32 avg \$1.10	9	9.3	
Acetal (Solvon K4) (2568-90-3) ^a	\$50,000- \$100,000 ⁷	unavailable	unavailable	less than hydrocarbon & perc	similar to hydrocarbon	
Glycol Ether (Rynex®) (13279-31-2)	\$56,000 ⁷	\$26,220	\$1.14	unavailable	unavailable	
Hydrocarbon	\$59,000	DF-2000 Fluid (64742-48-9)	\$27,911	\$0.73-\$1.02 avg \$0.88	13.1	35.5
		Sasol LPA 142 (64742-47-8)	unavailable			
		Pure Dry (#not available)	\$28,535			
		Eco Solv (68551-17-7)	\$27,872			
		Shell Sol 140 HT (111-84-2)	\$27,755			
		Stoddard Solvent (8052-41-3)	\$28,308			
Liquid Carbon Dioxide (124-38-9)	\$140,000	\$58,881	\$1.40	7.3-14.2	30.9	
n-Propyl Bromide (DrySolv®) (106-94-5)	\$40,000- \$60,000 for a new system, lower cost to retrofit existing perc system	unavailable	unavailable	unavailable	unavailable	
Siloxane D5 (GreenEarth®) (69430-24-6)	\$61,000	\$32,718	\$1.08-\$2.33 avg \$1.71	13.4	54.2	

Table 1. Summary of operational costs and environmental & human health attributes of garment cleaning solvents* (continued from the previous page)

Garment Cleaning Solvent (chemical abstract service number)	Environmental Impacts ⁵	Potential Human Health Impacts ⁶	
Perchloroethylene (127-18-4)	persistent in water, soil, air; very persistent in sediment; unknown aquatic toxicity	affects central nervous system; irritates eyes, skin, respiratory tract	
Professional Wet Cleaning (7732-18-5)	not persistent or toxic to the aquatic environment	no known impacts	
Acetal (Solvon K4) (2568-90-3) ^a	persistent in sediment, toxic to the aquatic environment	no known impacts	
Glycol Ether (Rynex®) (13279-31-2)	may be toxic to the aquatic environment	causes serious eye damage	
Hydrocarbon	DF-2000 Fluid (64742-48-9)	affects central nervous system; irritates eyes, skin, respiratory tract	
	Sasol LPA 142 (64742-47-8)		very persistent in soil and sediment; highly flammable
	Pure Dry (#not available)		not persistent or toxic to the aquatic environment
	Eco Solv (68551-17-7)		highly flammable, environmental impact not available
	Shell Sol 140 HT (111-84-2)		persistent in sediment; bioaccumulative; very toxic to the aquatic environment; highly flammable
	Stoddard Solvent (8052-41-3)		persistent in sediment; very toxic to the aquatic environment; highly flammable
Liquid Carbon Dioxide (124-38-9)	not persistent or toxic to the aquatic environment	highly flammable, environmental impact not available	
n-Propyl Bromide (DrySolv®) (106-94-5)	not persistent or toxic to the aquatic environment	persistent in air; irritates skin, eyes; frostbite	
Siloxane D5 (GreenEarth®) (69430-24-6)	persistent in sediment, very persistent in air, toxic to the aquatic environment	irritates eyes, skin, respiratory tract; affects central nervous, reproductive, & respiratory systems, kidney, & liver	
Siloxane D5 (GreenEarth®) (69430-24-6)	persistent in soil and air, very persistent in sediment, toxic to the aquatic environment	mild eye irritation	

¹ Alternatives to Perchloroethylene Use in Dry cleaning, City of Los Angeles Environmental Business and Neighborhood Services Division; values normalized to 1 year

² California Dry Cleaning Industry Technical Assessment Report, State of California Air Resources Board, February 2006.

³ Assessment of Alternatives to Perchloroethylene for the Dry Cleaning Industry, Massachusetts Toxics Use Reduction Institute, Methods and Policy Report No 27, June 2012.

⁴ Sinsheimer, Peter, Comparison of Electricity and Natural Gas Usage of Five Garment Cleaning Technologies, February 2009.

⁵ PBT profiler, <http://www.pbtprofiler.net/>, accessed 2/2/10.

⁶ Manufacturer's material safety data sheet

^a More than 99% of Solvon K4 is made up of 1-(butoxymethoxy)butane. Data in the table is representative of this compound.

New York State Dry Cleaning Operating Regulations

Cleaners that use liquid carbon dioxide and PWC exclusively in New York State are exempt from New York State Department of Environmental Conservation (DEC) air permitting requirements.

Perc dry cleaners in New York are required to comply with a series of requirements for equipment design, facility design, facility operation, owner/manager training and certification, and performance standards. Dry cleaning equipment must be certified by the DEC. Cleaners that use alternative solvents approved by the DEC must be registered through the DEC. Hydrocarbon cleaners in New York State are required to comply with Chapter 12 of the Fire Code of New York State. Dry cleaning plants operating with Class II, Class IIIA, and Class IIIB solvents (those with flash points at or above 100°F) are required to install an automatic sprinkler system²⁰. Most hydrocarbon solvents used for dry cleaning are Class IIIA, having a flashpoint between 140°F and 200°F (i.e. Exxon DF2000 has a flash point of 147°F). Hydrocarbon cleaners in New York City are required to comply with the same requirements²¹.

See Appendix A for NYS Requirements for Perc Dry Cleaners, Appendix B for Federal Rules for Dry Cleaners, and Appendix C for NYS Approved Alternative Solvents for Dry Cleaning.

New York City Dry Cleaning Operator Regulations

Cleaners located in New York City are required to comply with the NYC Department of Environmental Protection (DEP) Regulations and Permitting Requirements for dry cleaners. These air and sewer use regulations can be accessed online at <http://www.nyc.gov/html/dep/html/businesses/dryclean.shtml>.

In February 2013, the NYC DEP announced that as of February 11, 2014, dry cleaners will be required to post the primary chemicals used in dry cleaning so customers can access information about the chemicals and their impact.

New Dry Cleaning Rule for NYC Cleaners

A new rule will take effect February 11, 2014 that requires an additional notice for perc cleaners to inform the public how to access Material Safety Data Sheets (MSDS) from the NYC DEP's website. These MSDS provide more detailed information about the chemicals used in dry cleaning. The rule will require that the notice include the dry cleaner's DEP permit number & inform the public that it can call 311 to report chemical odors or leaks. Additionally, the rule requires dry cleaners that use chemicals other than perc to post a notice that would identify the primary non-perc chemical used in the cleaning process. Recently, dry cleaners have been promoting the use of non-perc solvents as environmentally green solvents, but customers typically are not informed about what chemical the dry cleaner uses. The notice would also contain the information about the MSDS, the dry cleaner's DEP permit number, and a phone number for reporting chemical odors or leaks.

For more information, visit http://www.nyc.gov/html/dep/html/air/dry_cleaner_msds.shtml

US Federal Trade Commission Care Label Rule

The Federal Trade Commission's (FTC) Care Labeling Rule requires manufacturers and importers to attach care instructions to garments. In September 2012, the FTC requested public input on proposed changes to the Care Label Rule that would²²:

- Allow manufacturers and importers, if they so choose, to include professional instructions for wet cleaning – an environmentally friendly alternative to dry cleaning – on labels if the garment can be professionally wet cleaned;
- Permit manufacturers to use updated ASTM (American Society for Testing and Materials) or ISO (International Organization for Standardization) symbols on labels in lieu of written terms providing care instructions;
- Clarify what constitutes a reasonable basis for care instructions; and
- Update and expand the definition of "dry clean" to reflect current practices and account for the advent of new solvents.

In total, 87 comments were received from professional garment cleaners, organizations representing professional garment cleaners, researchers, and alternative solvent companies. Comments expressed overwhelming support for the addition of wet cleaning language on the Care Label. To date, additional action has not been taken by the FTC.

To read the proposed amendments to the Rule see section "IV. Proposed Amendments" on page 58344, visit <http://www.ftc.gov/os/2012/09/12091120911carelabelingfrm.pdf>.

To read the public comments on the proposed amendments to the Rule, visit <http://www.ftc.gov/os/comments/carelabelingnprm/index.shtml>

The FTC's guide *Clothes Captioning: Complying with the Care Labeling Rule* is available at <http://business.ftc.gov/documents/bus59-clothes-captioning-complying-care-labeling-rule>.

Financial Costs

PWC has the lowest average installed system cost, maintenance cost, and solvent use, than any other solvent. While PWC detergent may be more expensive than perc or other alternatives, the total cost of operations is lower as PWC does not require solvents that must be purchased with other alternatives.

The following costs associated with perc and many other cleaning solvents are eliminated with PWC:

- Cost to purchase filters, the time to change them, and hazardous waste disposal costs
- Cost to purchase perc, waste perc storage, hazardous waste disposal costs and associated labor
- Regulatory compliance, including labor to track perc waste, time for staff to attend annual DEC operator training, and cost of the annual DEC operating permit

Cleaning Performance

Perc is well known for removing oil based stains better than other cleaning solvents and not always getting out water based stains. Wet cleaning has proven to be effective at removing both water and oil based stains, although pre-spotting and/or post-spotting may be required to remove certain oil-based stains. *For more information on wet cleaning spotters, see Spotters & Stain Removal on page 9 in this Guide.*

Many cleaners are concerned that wool garments, specifically wool suit jackets, cannot be successfully wet cleaned. This is not the case. Wet cleaners throughout the country routinely clean structured wool garments, such as suit jackets, blazers, pants, and skirts, many of them lined, without shrinkage or distortion. Table 2 below summarizes the performance of many cleaning solvents.

Cleaners interested in the performance and cleaning ability of PWC are encouraged to talk with and visit existing wet cleaners to see a wet cleaning operation in action. Many wet cleaners are willing to share tips they have learned along the way with other cleaners, and your equipment distributor may be able to put you in contact with them.

Contact the NYSP2I (585-475-2512 or nysp2i@rit.edu) if you are interested in visiting or talking with a cleaner that has successfully implemented PWC at their shop.

Table 2. Cleaning performance of dry cleaning solvents

Cleaning Solvent	Cleaning Performance
Perchloroethylene	good for oil based stains, most water-based stains, silks, wools, rayons, not good for delicates ¹ ; best of all solvents on oil based stains, good for water based stains, good for rayon, acetate, silk, and wool; some trims are a problem ²
Professional Wet Cleaning	aggressive, good for both oil and water based stains, can handle delicate garments ¹ ; very good on water based stains, problem with special construction garments if tensioners are not used ²
GreenEarth®	less aggressive than perc for oil-based stains, good for water based stains, delicates ¹ ; not as effective as perc for all stains, good on water soluble stains ²
Carbon Dioxide	good for all stains and most fabrics, very effective in removing oils, greases, sweats ¹ ; good for all soils and all fabrics except for acetate; less graying, reduced dye transfer
Hydrocarbon	less aggressive than perc for oil based stains, can handle delicate garments ¹ ; almost equal to perc, good for oil based stains, easier to press, better finish ²
Rynex®(glycol ether)	aggressive, cleans water soluble and oil based stains ¹

¹ California Dry Cleaning Industry Technical Assessment Report, Feb 2006

² Alternatives to Perchloroethylene Use in Drycleaning, City of Los Angeles

4. Overview of a Wet Cleaning Operation

This section presents an overview of a typical wet cleaning system, including equipment and detergents. It is a guideline and is not meant to be exhaustive. It is recommended that cleaners contact an equipment vendor or wet cleaning manufacturer for questions related to equipment.

Sorting

Garment sorting procedures are typically provided by detergent and equipment manufacturers to ensure the proper wash and dry cycles are used for each garment type. Generally, garments may be sorted by fabric type, light and dark colors, and weight.

Spotters & Stain Removal

Wet cleaning is typically better than perc at removing water-based stains²³ and oil-based stains may require pre-spotting for effective removal. Biodegradable pre-spotting agents have been specially formulated for wet cleaning systems as wastewater is generally discharged to municipal sewer systems.

Table 3. General guidelines for pretreating wet cleaned garments²⁴

Garment type	Time from pretreatment to washing
Most garments	15 minutes
Protein & blood stains	12 hours
Silk	immediately; no need to wait

Wet Cleaning Washer & Detergents

The distinctive characteristic of the PWC washer is its frequency-controlled motor. The motor is controlled by an internal computer with wash program software to achieve the optimal formulation of water level, cycle time, degree of agitation, temperature, and cleaning agents for each garment load. The idea is to minimize agitation while supplying enough movement for effective cleaning capabilities by controlling the accelerating and decelerating rotation of the cleaning drum for an ultra-gentle wash. The drum itself is mounted horizontally to allow use of low water quantities and easier water extraction. The computer control system also operates an external detergent injection system to provide a precise amount and combination of cleaning agents for every load.

An essential step in the PWC process is to select the appropriate wash mode and combination of detergents. PWC equipment manufacturers work with wet cleaners to ensure the wash modes are set up correctly and are appropriate for the types of garments cleaned. PWC detergents are non-toxic, pH-neutral, biodegradable, and approved for discharge into sanitary sewers²⁵. Within these



Figure 1. Typical wet cleaning dryer, washer, and detergent injection system (left to right)

detergents are additives which optimize cleaning ability while minimizing color change and shrinkage. The automated detergent injection system uses a computer program to ensure the optimal combination of detergent and sizers are used and are injected into the cleaning cycle at the appropriate time.

The major functions of detergents are to protect the fiber against damage, remove dirt, and prevent re-deposition of suspended dirt. In general, detergents work best in roughly 80°F water because warm water increases surface activity of chemicals and therefore decreases interfacial tension of detergents between fabric, soil and solvents. Lowered interfacial tensions will allow better soil removal. Wet cleaning detergents usually have strong anti-deposition characteristics and are slightly acidic to decrease color loss. Sizing agents add body and improve creases, which makes finishing easier. Combinations of cleaning agents may be found in the same product, such as conditioner and sizing agent.

Wet Cleaning Dryer

PWC dryers utilize a computer controlled moisture sensor to detect moisture in garments and ensure loads are sufficiently dry without over drying. Cycle times are minimized by high-speed moisture extraction using heat sourced either directly from natural gas or indirectly in the form of steam heat from a boiler²⁶. Electricity is used by the internal computer for mechanical motions, sensor systems and the control panel.

Wet cleaned garments are typically dried down to a specific moisture level. Leaving a small amount of moisture in the garment, usually less than 10%, allows wrinkles to more easily be removed from the garment when it is finished and prevents shrinking or distortion in the garment. Wet cleaned garments may have more wrinkles than perc cleaned garments out of the dryer. While this is a difference between the technologies, the finishing step removes these wrinkles.

Finishing

Wet cleaned garments may be finished using traditional pressing equipment or tensioning equipment specialized for wet cleaning. While presses can be used exclusively to finish wet cleaned garments, form finishers and pant toppers are typically used as they significantly reduce the amount of time it takes to finish garments.



Figure 2. Typical pant topper (left) and form finisher (right)

5. Selecting PWC equipment and detergents

Considerations

There are a number of operational aspects to consider as well as the type of cleaning performed at a cleaner to ensure a PWC system will meet a cleaner's needs. This list is not meant to be exhaustive and cleaners should work with an equipment vendor or manufacturer to identify equipment that will meet their cleaning and operational needs.

1. **Cost.** Cost of washers, dryers, tensioning equipment, and detergents can vary considerably as can performance. A cleaner may find that by spending a bit more for equipment or detergents, less time may be spent on redos or fewer claims may result. Higher end equipment and/or detergent are generally more effective at protecting garments from the adverse impacts of using water – like shrinkage, color loss, etc. – that may result from professional cleaning.
2. **Types of garments cleaned at the shop.** The types and ranges of garment and fabric types cleaned may affect the model washer, dryer, and tensioning equipment recommended. Consider if garments cleaned are mostly blue collar, couture, wedding gowns, expensive suits, wools, specialty garments (i.e. costumes) or a mix.
3. **Same day service.** Some wet cleaning shops choose to air dry select, very delicate, wet cleaned garments while others use dryers for all garments. Same day service may require a different dryer model than cleaners who have the space and wish to air dry garments.
4. **PWC replacing an existing cleaning system or used in addition to the current system.** This will help determine what capacity washer and dryer are needed.
5. **Tensioning equipment.** Tensioning equipment is recommended for cleaners that plan to clean a significant portion of their garments with PWC, become 100% wet cleaners, or who plan to wet clean a lot of wool and/or structured garments.
6. **Available floor space.** The footprint of systems can vary significantly.



Figure 3. PWC system at a NYS cleaner, from left: washer & dryer, detergent injection system, pant topper, form finisher.

Wet Cleaning Equipment Vendors

The Massachusetts Toxics Use Reduction Institute developed the *New England Wet Cleaning Equipment Manufacturers Information Report*²⁷ as a resource for wet cleaning washer, dryer, tensioning equipment, detergent dispensing systems, and cleaning agent information. Tables 4 and 5 are compiled from TURI's report.

Table 4. Wet cleaning washer & dryer vendors

Company	Overview	Contact
Wascomat	Headquartered in Inwood, NY Distributed through New England distributors	800-645-2205, www.wascomat.com
Miele	Distributed from Princeton, NJ Partner with Veit finishing equipment and Kreussler detergents for full package	800-991-9380 x2435 www.wetcleaning.com
American Dryer	Dryers made in Fall River, MA Check for technical support prior to purchase	508-678-9000, www.amdry.com
Maytag	Contact local distributor to determine availability	800-662-3587, www.maytagcommerciallaundry.com
Ipsos	Distributed by Aldrich Clean Tech.	920-748-3121, www.ipsosusa.com 508-792-1007, www.aldrichcleantech.com
Imesa	Made in Italy, US headquarters in Livingston, NJ Deal through Trevil America	ImesaUSA@aol.com, 954-861-4572 www.imesa.it

Table 5. Wet cleaning tensioning equipment vendors

Company	Overview	Contact
Hi-Steam	Made by European Finishing Equipment Corp	Yuriko Tanabe, 201-460-7397, Yuriko@histeam.com
Veit	Made in Germany, Partners with Miele	info@veit.de , www.veit.de/en
Trevil	Made in Italy	Stuart Ilkowitz, (877) 873-8451, trevilamerica@aol.com
Unipress	Headquartered in Tampa, FL	813-623-3731, www.unipresscorp.com

Potential Funding Sources in New York

New York State government does not currently offer financial incentives specifically for dry cleaners to install any professional cleaning system, including PWC. Dry cleaners may be able to take advantage of low interest loans or energy reduction incentives offered by NYSERDA as shown in Table 6 below.

Cleaners located in other states should contact their state environmental and/or energy regulatory bodies to determine if funding is available to help offset the cost of purchasing and/or installing wet cleaning equipment.

Table 6. Potential funding sources for New York State cleaners

Type	Highlights*	Organization/Program	Contact Information
Low Interest Loans	2-3% reduction in bank interest rates Apply directly through participating banks	Empire State Development (ESD) Linked Deposit Program	http://esd.ny.gov/BusinessPrograms/LinkedDeposit.html (518) 292-5261, Linkeddeposit@empire.state.ny.us
Microloans	Minimum credit score 575 Typical rates: 8.9 – 15.9% Loans from \$5k - \$50k	Accion USA, Jennifer Spaziano,	jspaziano@accionisa.org , 212-387-0377,
Energy Reduction Incentive	High-volume cleaners, must save at least 83,330kwh/year	NYSERDA "Existing Facilities Program",	518-862-1090 http://www.nyserda.org/programs/Existing_Facilities/electric.html

*Note: As of March 2013. Eligibility requirements are governed by the funding organization. Restrictions may apply.

6. Installing PWC Equipment

This section outlines considerations and questions cleaners should ask throughout the installation process. Addressing these considerations upfront may save valuable time and resources during installation and in the weeks that follow.

1. **Removing your existing dry cleaning system.** Consider whether the existing dry cleaning system will continue to be used in combination with PWC or if it will be removed at the same time the PWC system is installed. This decision may be affected by the amount of available floor space and will impact how much time and coordination is required to install the PWC system. See the following section, *Options to remove a perc machine*, for the three options to remove a perc dry cleaning system in New York State.
2. **Time commitment.** Installing a PWC system may take as little as a day or two, or as long as a week, depending on the type of equipment being installed, whether or not your existing system will be removed at the same time, and the amount of work needed to connect the plumbing and other operational requirements for the PWC system. It is important to consider the amount of time required to install the system and to what degree your shop is able to continue operating while the new system is being installed.
3. **Scheduling the installation.** Consider if there is a time of day, day of the week, or month of the year that will work best for you for installation. Consider the schedules of neighboring businesses, neighboring residences, and anything else that may affect your ability to install equipment. For example, a New York City cleaner had to postpone installation for a month due to construction work on the street and scaffolding outside which made it impossible for the delivery truck to drive up to the shop and get the equipment into the building.
4. **Staff training and information.** Staff training is typically provided by the equipment or detergent vendor, and it is recommended that cleaners discuss training needs when selecting new equipment. PWC builds upon traditional dry cleaning skills, as wet cleaned garments are pretreated, sorted, washed, dried, and finished differently than their dry cleaned counterparts. All staff may require some type of training, as front desk staff communicates the PWC process to customers, spotters will treat wet cleaned garments differently, and finishers may be tensioning garments. While staff training time requirements are not necessarily significant, it is important to consider how your staff will receive training and the type of training they will receive. Be sure to ask about included training when purchasing equipment and detergent.
5. **Equipment adjustments.** The first few days or weeks operating a PWC system may require adjustments to the washer and dryer modes, detergent mix, or tensioning equipment. It is important to understand that these adjustments are normal and occur with adoption of any new dry cleaning solvent or system. Typically, the equipment vendor will make adjustments to the PWC system. Once set up and properly adjusted, wet cleaners operate with minimal, if any, regular adjustments to their system.

Options to remove a perc machine in New York

In New York State, there are three options for removing a perc dry cleaning machine, as listed below. More details can be found in Appendix D. NYS law does not specify the options to remove a dry cleaning machine that uses a solvent other than perc.

OPTION 1: The machine is taken out of service in New York State, is sold and subsequently used for perchloroethylene dry cleaning in another state.

OPTION 2: The used machine is to be disposed of as a "Non-Hazardous Waste"

OPTION 3: The machine is disposed of as "Scrap Metal"

7. Summary

Whether choosing to replace a current dry cleaning system with PWC or adding PWC to your current cleaning mix, adopting PWC is an important decision. While this Guide is not exhaustive, it provides a comparison of PWC to other dry cleaning solvents and considerations for cleaners and technical assistance providers to help with the process of adopting PWC.

Cleaners considering the adoption of PWC should work with a reputable vendor or equipment manufacturer to ensure the system selected is appropriate for the cleaners' operations. This Guide is meant to help cleaners understand the benefits of PWC and the main questions to ask when implementing PWC.

8. Resources for more Information

State Wet Cleaning Conversion Programs

New York State Professional Wet Cleaning Program

New York State Pollution Prevention Institute

Web: <http://www.rit.edu/affiliate/nysp2i/garment-cleaning>

Contact: Kate Winnebeck, kmhasp@rit.edu, (585) 475-5390

Wet Cleaning Demonstration Site Matching Grants

Massachusetts Toxics Use Reduction Institute

Web: http://www.turi.org/Our_Work/Business/Small_Businesses/Dry_Cleaning

Contact: Joy Onasch, Joy@turi.org, (978) 934-4343

Non-Toxic Dry Cleaning Incentive Program

California Air Resources Board (CARB)

Web: <http://www.arb.ca.gov/toxics/dryclean/ab998.htm>

Contact: Sonia Villalobos, svillalo@arb.ca.gov, (916) 327-5983

Environmental Garment Care Demonstration Program

UCLA Sustainable Technology & Policy Program

Web: www.stpp.ucla.edu/node/12

Federal Dry Cleaning Regulations and Information

US EPA Dry Cleaning Sector: perc laws & regulations, compliance, policies and guidance

<http://www.epa.gov/lawsregs/sectors/drycleaning.html>

US EPA Garment & Textile Care Partnership: information on wet cleaning & carbon dioxide cleaning

<http://www.epa.gov/opptintr/dfe/pubs/projects/garment/>

New York State Dry Cleaning Regulations and Information

Dry Cleaner Regulation Overview, web: <http://www.dec.ny.gov/chemical/8567.html>

Dry Cleaning Machine Disposal, web: <http://www.dec.ny.gov/chemical/8941.html>

Dry cleaning Small Business Environmental Assistance Program (SBEAP), New York State Environmental Facilities Corporation: free, confidential technical assistance to New York's small-business owners to assist them in complying with state and federal air regulations

Web: <http://www.nysefc.org/Default.aspx?tabid=499>

Contact: Harry Ching, sbeap@efc.ny.gov, 518-402-7461

New York City Department of Environmental Protection: regulations and permitting requirements for NYC dry cleaners

Web: <http://www.nyc.gov/html/dep/html/businesses/dryclean.shtml>

Appendix A: NYS Requirements for Perc Dry Cleaners

6 NYCRR Part 232 Perchloroethylene Dry Cleaning Facilities, "Part 232", is the New York State (NYS) air pollution control regulation that applies to all dry cleaning facilities which use perchloroethylene (Perc) solvent. Part 232 went into effect on May 15, 1997 to protect the public and workers from harmful exposure to perchloroethylene vapors. The DEC maintains a Part 232 website (<http://www.dec.ny.gov/chemical/8567.html>) which is your gateway to many informational resources helpful for running a successful dry cleaning facility in full compliance with the regulations. The following is an overview of Part 232's major regulatory requirements:

Shop Registrations or Permits: Most perc dry-cleaning facilities must obtain a NYS Air Facility Registration. Larger facilities must get a NYS Air Facility Permit or Title V Facility Permit. Registration information must be kept up-to-date: Part 232 requires you to re-file and update your DEC records any time you make machine and equipment changes.

Dry-Cleaning Machines - replacement requirements, and NYS Testing and Certification Program: Existing, older, and more polluting dry-cleaning machines must be replaced with modern perc-efficient fourth generation designs. Most of these replacements were phased-in over the eight year period ending in January of 2005. Only brand-new DEC-Certified fourth generation machines can be legally installed at this time. Part 232 establishes dry-cleaning machine equipment design and performance standards, and machine testing and certification requirements. A list of NYS Certified dry-cleaning equipment is available.

Vapor Barriers/Room Enclosures and General Exhaust Ventilation Systems: perc containment and ventilation measures for dry-cleaning shops in Mixed-Use buildings. These requirements keep perc from migrating to adjacent occupancies.

Checklists and Record-Keeping: Shop operation, maintenance, record-keeping and reporting requirements. Records must be kept on-site for five years.

Hazardous Waste Management: Specific Hazardous Waste and Perc-contaminated Wastewater disposal and record-keeping requirements.

Staff Training and Certification: Shop Owners and/or Managers and all machine Operators must attend a 16-hour training course, successfully pass a DEC Certification test and hold current, valid DEC Owner/Manager and/or Operator Certificates. Every shop must have at least one person with an Owner/Manager and Operator Certification.

Yearly Compliance Inspections: Every perc dry-cleaning facility must be inspected at least once each year by an independent DEC-approved Part 232 Registered Compliance Inspector. Facility inspection reports are reviewed by regional DEC engineering/technical staff for compliance and enforcement purposes. A list of DEC Registered Compliance Inspectors is available.

Posting Notice: Perc dry-cleaners must post a DEC informational sign in a place where it can be read by the public. This posting notice informs the public that the shop uses perc, lists where to report odors and other problems, and states where additional information may be found about the potential health effects of perc exposure.

Public Access: Part 232 requires that you must provide public access to your shop's yearly Compliance Inspection reports (form 232-9).

Appendix B: Federal Rules for Dry Cleaners

NYSDEC Dry Cleaner Regulation, <http://www.dec.ny.gov/chemical/8567.html>

Effective July 27, 2006

The EPA has issued revised NESHAP standards that effect New York State dry cleaning facilities which use perc. Below is a summary of the new NESHAP requirements for perc dry cleaning facilities:

1. Perc dry cleaning machines may not be installed in residential buildings after July 13, 2006.
2. Perc dry cleaning machines that were installed in residential buildings between December 21, 2005 and July 13, 2006 must eliminate perc use by July 13, 2009. In the interim, all perc dry cleaning facilities must continue to comply with the requirements of Part 232.
3. Compliance with the July 13, 2009 perc prohibition may be accomplished by either moving to a non-residential building (moving perc machines requires a variance) or by switching to an alternative solvent.
4. Perc dry cleaning machines that were installed in residential buildings before December 21, 2005 (the date of the proposed rule) must eliminate perc use by December 21, 2020.
5. **NEW REPORTING REQUIREMENTS:** Each owner or operator of a dry cleaning facility using perc, or an alternative solvent, must submit information to the USEPA and DEC pertaining to the compliance status of each dry cleaning facility. This information must be recorded on a form (Notice of Compliance Status) that will be posted on this website (<http://www.dec.ny.gov/chemical/8567.html>) and mailed to each permitted dry cleaning facility. The DEC intends to mail out this form in the near future. Additional information on this requirement will be posted on the DEC website.

NOTE: It is now unlawful to install perc dry cleaning machines in residential buildings. When your machine wears-out, you must either switch to non-perc equipment, or move to a non-residential building. Both options will require a new, modified or amended permit or registration certificate.

Appendix C: NYS Approved Alternative Solvents for Dry Cleaning

NYSDEC's Approved Alternative Solvents for Dry Cleaning, <http://www.dec.ny.gov/chemical/72273.html>

The health risks of perchloroethylene (perc) as a dry cleaning solvent has spurred the interest in alternative solvents to replace the use of perc. The Department has responded to many requests to approve such alternative solvents and to make complying with air pollution regulations as easy as possible. Recognizing the facility operator's desire to have the least burdensome requirements and while maintaining a focus on the protection of public health and the environment, the Department has approved several alternatives to using perc solvent. Toward that end, the Department is providing a list of these alternative dry cleaning solvents, the use of which would allow the dry cleaning facility to obtain a simple Air Facility Registration (a.k.a.; AFR, Registration) if certain criteria are met as noted below.

All stand-alone and mixed-use (co-located with residential or other commercial) dry cleaning facilities that use only approved alternative dry cleaning solvents may apply for a Registration if all dry cleaning machines are non-vented, closed-loop and equipped with a refrigerated condenser. These facilities will be issued a Registration unless emissions exceed the Volatile Organic Compound (VOC) RACT threshold (25 or 50 tons per year, depending on location). Facilities with multiple dry cleaning machines that use both perc and approved alternative solvents must meet other additional regulatory requirements (6NYCRR Part 232 and 40 CFR Part 63 Subpart M) to be granted a Registration. Facilities using unapproved alternative dry cleaning solvents will not be issued Registrations. **Water-based cleaning machines (a.k.a., "wet cleaning") and dry cleaning machines that use only liquid carbon dioxide are exempt from air permitting requirements.**

The following alternative dry cleaning solvents have been approved by the Department for use in non-vented, closed-loop dry cleaning machines that are equipped with a refrigerated condenser, conform to local fire codes, and meet the additional specifications required by the alternative solvent manufacturer:

- Green Earth® (SB-32): decamethylcyclopentasiloxane, CAS 541-02-6
- Rynex 3™: dipropylene glycol tert-butyl ether, CAS 132739-31-2
- ExxonMobil DF-2000¹: synthetic hydrocarbon, CAS 64742-48-9
- Sasol (LPA-142)¹: highly refined hydrocarbon, CAS 64742-47-8
- Chevron Philips EcoSolv®: highly refined hydrocarbon, CAS 68551-17-7
- R.R. Streets Solvair™: dipropylene glycol n-butyl ether (DPGnBE), CAS 29911-28-2
- SolvonK4™: dibutoxymethane, CAS 2568-90-3
- Green Earth® GEC-5: decamethylcyclopentasiloxane, CAS 541-02-6

NOTE: None of the above approved alternative solvents is a drop-in replacement for perc. Contact the alternative solvent manufacturer for the required dry cleaning machine specifications.

¹ Facilities with dry cleaning machines using hydrocarbon solvents (e.g., DF-2000, EcoSolv® & SASOL LPA-142) may be subject to the NSPS (40 CFR Part 60, Subpart JJJ) if the manufacturer's rated capacity from all machines combined is equal to or greater than 84 pounds. Petroleum machines installed between 12/14/82 and 9/21/84 are exempt from the NSPS if the annual facility petroleum solvent usage is less than 4,700 gallons per year. The Department believes the test method procedures of Subpart JJJ, Section 60.624 were developed for petroleum transfer machine dryers and are not applicable to non-vented, closed-loop machines that are equipped with a refrigerated condenser. Further, the Department

will use its discretionary authority in enforcing the provisions of Paragraph 201-5.1(a)(3) and allow dry cleaning facilities to obtain a Registration if all machines use only approved alternative hydrocarbon solvents in non-vented, closed-loop machines equipped with refrigerated condensers and the facility emissions do not exceed the Volatile Organic Compound (VOC) RACT thresholds.

² The Solvair™ dry-cleaning system uses both nPGnBE and carbon dioxide (exempt) as dry cleaning solvents and has been approved for Air Facility Registration.

Appendix D: Proper Disposal of Used Perc Dry Cleaning Equipment

NYSDEC's Dry Cleaning Machine Disposal and Other Regulatory Issues,
<http://www.dec.ny.gov/chemical/8941.html>.

As many New York dry-cleaners are already aware, there are many regulations and requirements which Perc dry-cleaners must abide by. In the past, most of the regulatory requirements have been associated with New York State's Part 232. You should however be aware that the disposal of dry cleaning machines comes under the Hazardous Waste Regulation - Part 236. Part 236 requires dry cleaners to carefully consider how they will dispose of their used Perc machines.

Basically there are three different options for dealing with used Perc Dry-cleaning machines which are being taken out of service. Each option has its own requirements.

OPTION 1: The Machine is Taken out of Service in New York State, is Sold and Subsequently Used for Perchloroethylene Dry Cleaning in Another State.

If the Perc dry cleaning machine is to be sold and subsequently used again for perchloroethylene dry cleaning, the machines themselves would never actually become solid waste and would not require any special permitting before being relocated to the new owner. However, all the drainings and spent wash solution from the machine must be managed and disposed as a hazardous waste. **It is essential to note that since June 26, 2003 Part 232 expressly forbids the installation of anything but a brand-new, just out-of-the-box New York State CERTIFIED DEC Fourth Generation dry cleaning machine. Therefore, in this case the used machine MUST be sold to an out-of-state dry-cleaner, as the installation of any used Perc dry-cleaning machine in New York State is forbidden.**

OPTION 2: The Used Machine is to be Disposed of as a "Non-Hazardous Waste"

If the Perc dry cleaning machines are to be disposed of as non-hazardous waste, New York State's Part 376 requires that the machine be cleaned using a cleaning or destruction method such as water washing as described in the regulation [Part 376.4(g)]. The cleaning can be done at the dry cleaners site without needing a Part 373 Hazardous Waste Treatment Permit provided that the cleaning operation and removal of the machine from the dry cleaner's site takes place within 90 days from when the machine was taken out of service. *It is very important that all cleaning and machine removal take place within this 90 day period.* Failure to do so forfeits the cleaner's ability to have onsite cleaning performed and would require the cleaner to be responsible for the added expense of having the cleaning done at a facility with a valid Part 373 hazardous waste treatment facility.

OPTION 3: The Machine is Disposed of as "Scrap Metal"

If the Perc machine is to be sent for scrap metal reclamation instead of disposal there are two possibilities:

- I. The dry-cleaner can clean the machine as prescribed in option two and then turn the machine over to a scrap metal reclaimer. This means that the machine would not be considered as hazardous waste and that the scrap metal dealer does not have any responsibility for the hazardous waste.

2. The machine can be sent to a scrap metal reclaimer without cleaning however, the dry-cleaner must be aware that the scrap metal reclaimer must possess the proper permit and facilities to handle the hazardous waste. The dry-cleaner must be aware that even though the scrap metal reclaimer takes possession of the machine and is responsible for the cleaning, the ultimate legal responsibility for the proper handling of the hazardous waste (i.e. the Perc contaminated machine) always remains with the cleaner. For this reason it is very important that the dry-cleaner deal with a reputable hazardous waste handler/recycler. Additionally, if the cleaner decides to let the scrap metal reclaimer handle the removal of the uncleaned machine as hazardous waste, the cleaner must file a "C7" Notification for Hazardous Waste Generators". This notification which documents the name, date and waste hauler and waste generator should be sent to the appropriate Department of Environmental Conservation regional office.

Remember that no matter which option you choose, all Perc and Perc-contaminated washing solutions and drainings from the machine must be handled as hazardous waste. In most cases your regular hazardous waste hauler can handle the extra volume. If you have any questions about disposal of your dry cleaning machine you can call the SBEO at 1-800-STATE-NY.

End Notes

¹ Scorecard Chemical Profile, TETRACHLOROETHYLENE, <http://www.scorecard.org/chemical-profiles/>, accessed March 26, 2009

² Center for Disease Control, National Institute for Health & Safety, HC 19: Control of Exposure to Perchloroethylene in Commercial Drycleaning (Ventilation), Dec, 23 1997, <http://www.cdc.gov/niosh/hc19.html>

³ PBT Profiler, <http://www.pbtprofiler.net/>.

⁴ According to the 2007 US Economic Census, NAICS 8123202 "Dry Cleaning Plants", there are 20,465 dry cleaning plants in the US. California has the highest number of plants (2,824) and New York is second, with 1,960 plants.

⁵ Ma et.al., Association between Residential Proximity to PERC Dry Cleaning Establishments and Kidney Cancer in New York City, Journal of Environmental and Public Health, 2009, doi:10.1155/2009/183920.

⁶ Schreiber et. al., Apartment Residents' and Day Care Workers' Exposures to Tetrachloroethylene and Deficits in Visual Contrast Sensitivity, Environmental Health Perspectives, 2002, 110:7.

⁷ NYSDOH, Fact Sheet: Tetrachloroethylene (perc) in Indoor and Outdoor Air, May 2003, http://www.health.state.ny.us/environmental/chemicals/tetrachloroethene/docs/fs_perc.pdf.

⁸ NYS DEC, Dry Cleaner Regulation, <http://www.dec.ny.gov/chemical/8567.html>

⁹ US EPA Rule and Implementation Information for Perchloroethylene Dry Cleaning Facilities, <http://www.epa.gov/ttnatw01/dryperc/dryclpg.html>

¹⁰ 6NYCRR Part 232 Perchloroethylene Dry Cleaning Facilities, <http://www.dec.ny.gov/chemical/8567.html>.

¹¹ The database is compiled primarily using National Emissions Standards for Hazardous Air Pollutants (NESHAP) reporting data. Cleaners using selected alternative solvents, including wet cleaning, are not required to report their usage and therefore may not be included in the database.

¹² State of California Air Resources Board, "California Dry Cleaning Industry Technical Report," February 2006

¹³ Dry Cleaning & Laundry Institute, A DLI Whitepaper: Key Information on Industry Solvents, July 2007

¹⁴ Solvent descriptions adapted from California Air Resources Board, Alternative Solvents Used for Dry Cleaning Operations, Dry Cleaning Notice 2009-2, http://www.arb.ca.gov/toxics/dryclean/notice2009_2.pdf

¹⁵ For more information on the potential health effects of dry cleaning solvents, see California Environmental Protection Agency Air Resources Board, Dry Cleaning Alternative Solvents: Health and Environmental Impacts, Fact Sheet, March 2008, http://www.arb.ca.gov/toxics/dryclean/AlternativeSolvs_E.pdf

¹⁶ Sinsheimer, P. and Latif, A. The Viability of Professional Wet Cleaning as a Pollution Prevention Alternative to Perchloroethylene Dry Cleaning, J. Air & Waste Manage. Assoc., 2007, 57:172-178.

¹⁷ Massachusetts Toxics Use Reduction Institute, Eliminating the Use of Toxic Chemicals in Dry Cleaning: A Cost Analysis of a Wet Cleaning Shop, Best Neighborhood Care Dry Cleaner

¹⁸ Massachusetts Toxics Use Reduction Institute, Eliminating the Use of Toxic Chemicals in Dry Cleaning: A Feasibility and Cost Comparison of Perchloroethylene Dry Cleaning to Professional Wet Cleaning, Ace Cleaners

¹⁹ Massachusetts Toxics Use Reduction Institute, Eliminating the Use of Toxic Chemicals in Dry Cleaning: A Cost Analysis of a Wet Cleaning Shop, Case Study of Silver Hanger Cleaners, Bellingham, Massachusetts

²⁰ 2010 Fire Code of New York State, section 1203.1 Solvent Classification and section 1208 Fire Protection requirements

²¹ New York City Administrative Code, Title 29, New York City Fire Code, Chapter 12

²² FTC Proposes Changes to its Care Labeling Rule for Clothing, 9/11/2012, <http://www.ftc.gov/opa/2012/09/carelabeling.shtm>

²³ US EPA Design for the Environment, Case Study: Wetcleaning Systems for Garment Care,
<http://www.epa.gov/dfe/pubs/garment/wsgc/wetclean.htm>

²⁴ Training Curriculum for Alternative Clothes Cleaning, Massachusetts Toxics Use Reduction Institute, 1997

²⁵ Viable Alternatives to Perchloroethylene in Dry Cleaning, Environmental Business & Neighborhood Services of the Environmental Affairs Department of the City of Los Angeles, December 2004

²⁶ Sinsheimer, Peter. Professional Wet Cleaning Demonstration Project, Pollution Prevention Center Urban and Environmental Policy Institute at Occidental College, 2009

²⁷ The report is available for download at
www.turi.org/content/download/5733/61046/file/New%20England%20Equipment%20Report.pdf