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The Viability of Professional Wet Cleaning as a Pollution Prevention Alternative to Perchloroethylene Dry Cleaning

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ABSTRACT

Fu

The vast majority of dry cleaners worldwide use the toxic chemical perchloroethylene (PCE), which is associated with a number of adverse health and environmental impacts. Professional wet cleaning was developed as a nontoxic alternative to PCE dry cleaning but has not been widely adopted as substitute technology. In the greater Los Angeles, CA, region, a demonstration project was set up to showcase this technology and evaluate its commercial viability by converting seven cleaners from PCE dry cleaning to professional wet cleaning. The demonstration site cleaners who switched to professional wet cleaning were able to maintain their level of service and customer base while lowering operating costs. The cleaners were able to transition to professional wet cleaning without a great degree of difficulty and expressed a high level of satisfaction with professional wet cleaning. Crucial to this success was the existence of the demonstration project, which helped to develop a supporting infrastructure for professional wet cleaning that had otherwise been lacking in the garment care industry.

INTRODUCTION

Perchloroethylene (PCE) has been the dominant cleaning agent in the garment care industry since the 1950s and is currently used by 85% of the >30,000 dry cleaners operating throughout the United States. Just as dry cleaners became ubiquitous in cities and small towns, evidence began to emerge in the 1970s of the adverse health and environmental impacts associated with PCE use in dry cleaning.[1,2] Effects of chronic exposure to PCE include dizziness, impaired judgment and perception, damage to the liver and kidneys, and respiratory disease.[3] Other risks include neurotoxicity and reproductive and developmental toxicity, as well as various forms of cancer, such as bladder, stomach, esophageal, intestinal, and pancreatic.[4] PCE has been classified as a probable human carcinogen by the International Agency for Research on Cancer and as a potential human carcinogen by the National Institute of Occupational Safety and Health.[5]

In the 1980s, U.S. Environmental Protection Agency (EPA), as well as state and regional agencies, began to establish standards to regulate PCE as a water, land, and air contaminant.[6] Regulations require that solid waste and discharge water contaminated with PCE be disposed of as hazardous waste, and soil and groundwater contaminated with PCE is subject to Superfund designation and clean-up requirements. The 1990 Clean Air Act Amendments classified 189 chemicals (including PCE) as hazardous air pollutants and developed administrative procedures to establish National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for each classified chemical.[7]

PCE dry cleaning was the first NESHAP promulgated by EPA after the 1990 legislation took effect. Issued in 1993, the rule focused on the use of pollution control ("add-on" or "end-of-pipe") equipment and operator monitoring requirements to assure compliance with emission reduction goals.[8] Initially, implementation of these pollution control regulations appeared to create a degree of certainty within the garment care industry that PCE use would not be subject to further regulatory constraints that would undermine its status as the solvent of choice among cleaners. However, recent revelations concerning a lack of regulatory compliance, as well as questions regarding population exposure to PCE and contamination from dry cleaning (even when facilities are in compliance), have created a crisis both within the regulatory community, as well as within the garment care industry. Enforcement evaluation audits in the late 1990s revealed that few cleaners were in compliance with federal, state, or regional rules.[9] The State Coalition for the Remediation of Drycleaning estimates that 75% of PCE dry clean sites nationwide are contaminated.[10]

IMPLICATIONS

The viability of professional wet cleaning, a nontoxic and zero-emission technology, gives public agencies and policy-makers concerned with the regulation of the dry cleaning industry the opportunity to integrate the principal of pollution prevention into their rule making and eliminate a number of environmental and health hazards associated with traditional dry cleaning. In 2006, the California Air Resources Board voted to phase out perchloroethylene dry cleaning, in part, because of the availability of viable alternatives, including professional wet cleaning.

A Pollution Prevention Approach

As regulation of PCE dry cleaning intensified in the 1990s, so did interest in the development of alternatives to PCE,

including reformulated petroleum solvents, silicone-based solvents, liquid carbon dioxide, and professional wet cleaning. Yet, it is clear that whereas some of the alternatives (professional wet cleaning and CO_2) represent important pollution prevention options, other alternatives (petroleum and silicone) pose their own set of environmental and occupational problems. Petroleum dry clean emissions are classified as volatile organic compounds,[11] and the silicone dry cleaning solvent (decamethylpentacyclosiloxane) has been identified as a potential carcinogen.[12] In addition, both solvents are combustible.

Since the mid-1990s, professional wet cleaning has emerged as the most commercially viable nontoxic/nonvolatile organic compound alternative to PCE dry cleaning. Wet cleaning, a process of handwashing delicate garments, has long been practiced by cleaners. Professional wet cleaning industrialized this practice by using computer-controlled washers and dryers, specially formulated detergents, and specialized finishing equipment to create a cost-effective alternative to dry cleaning. The essential technological innovation of professional wet cleaning was to mechanically simulate handwashing by using a computer to control the rotation of the drum to minimize agitation while providing sufficient movement for effective cleaning of delicate garments. Wet clean washers are also equipped with a computer-programmed detergent injection system, which allows the cleaner to specify the precise amount and type of wet clean detergents and sizing agents used for each load. Soft water is mixed with these detergents and agents before coming into contact with any garments. Biodegradable cleaning agents have been formulated for wet cleaning by detergent manufacturers to maximize cleaning power while minimizing color change and shrinkage. Wet clean dryers are equipped with moisture sensors to ensure that garments retain the appropriate amount of moisture after the dry cycle is complete. Specialized tensioning pressing machines are used to enhance the restoration of constructed garments, such as suit jackets, suit pants, and tailored items.

Although professional wet cleaning systems are now widely used to supplement dry clean operations, significant barriers have limited the diffusion of this substitute technology. In a random sample survey of dry cleaners in the greater Los Angeles region, cleaners were asked to list their two biggest concerns about professional wet cleaning. The four biggest concerns about professional wet cleaning were as follows: the process would lead to shrinkage, damage, or harm to garments (72%); the process would take longer than dry cleaning (27%); customers would not like it or they would lose business if they switched (11%); and the process was more expensive than dry cleaning (9%). Yet, this opinion was based on limited information about the technology; whereas 9 in 10 respondents stated that they were "very familiar" with PCE dry cleaning, only 1 in 5 cleaners interviewed stated that they were "very familiar" with professional wet cleaning.[13,14]

These negative perceptions prompted the South Coast Air Quality District (SCAQMD) to fund the Professional Wet Cleaning Demonstration Project, administered by the Pollution Prevention Center (PPC) at Occidental College. The demonstration project provided financial and technical assistance for seven PCE dry cleaners to switch to professional wet cleaning and serve as demonstration sites to showcase the technology. This paper presents an evaluation of the degree of success with which the cleaners participating in the demonstration project were able to switch from PCE dry cleaning to professional wet cleaning, with the purpose of assessing the viability of professional wet cleaning as a substitute technology to PCE dry cleaning.

EXPERIMENTAL WORK

The Professional Wet Cleaning Demonstration Project provided the opportunity to conduct before and after evaluations of the seven cleaners switching from PCE dry cleaning and professional wet cleaning under real-world operating conditions. The study evaluated each cleaner's operations as a PCE dry cleaner and used those results as a benchmark for comparison in the evaluation of each cleaner's operations as a professional wet cleaner. A case study analysis of each cleaner was used to assess the success with which he or she was able to switch to professional wet cleaning. A summary analysis of the individual case studies evaluated the general viability of professional wet cleaning as an alternative to PCE dry cleaning. Because the switch from PCE dry cleaning to professional wet cleaning required the cleaners to learn a new cleaning process, data for this evaluation were collected 6 months to 2 yr after the cleaners converted.

The volume of garments cleaned at each cleaner remained relatively steady from the time the cleaner switched to the time data were collected. Because seasonal variability did not appear to be an issue, we were able to conduct financial and resource use comparisons based on monthly averages.

Significance tests of the impacts of switching from PCE dry cleaning to professional wet cleaning were performed using a paired *t* test and pertain to the sample of cleaners as a whole, not to each individual cleaner.[15] A series of specific criteria were used to evaluate the operations of each cleaner before and after switching from PCE dry cleaning to professional wet cleaning.

Transition

To understand the difficulty of converting to professional wet cleaning, a series of questions were posed to identify the following: concerns the cleaner had about converting, the degree of difficulty in actually converting, the biggest difficulties experienced in converting, the degree of difficulty in learning a new cleaning process, and the importance of technical training. Data was collected through structured interviews with each cleaner.

Performance

Three performance criteria were used to evaluate whether each cleaner was able to maintain his or her quality of cleaning and level of service after switching to professional wet cleaning:

First, a profile of problem garments measured the extent to which cleaners had trouble processing garments before and after switching to professional wet cleaning by quantifying the frequency of sent-out garments (garments processed off-site), redos (garments brought back

by customers for additional work), and customer claims (cash or store credit paid for ruined garments).

Second, ratings of the quality of cleaning service and customer satisfaction assessed each cleaner's perception of the relative quality of cleaning before and after switching to professional wet cleaning and each owner's perception of the relative level of customer satisfaction before and after the switch.

Third, a customer response evaluation characterized the attitudes of customers toward professional wet cleaning and assessed the extent to which the cleaners were able retain their customer base after switching. Data was collected through structured interviews with each cleaner.

Financial

A financial assessment evaluated the relative profitability of each cleaner before and after switching to professional wet cleaning. Only costs that were impacted by the change in cleaning technology, identified as "process-dependent costs," were measured (e.g., rent and advertising were not accounted for), because all of the other costs were held constant at each facility. These costs were calculated for each cleaner in terms of dollars per month. Three of the seven cleaners were excluded from the financial evaluation, because they had removed their dry clean machines ≥1 yr before converting to professional wet cleaning, and it was not possible to reliably collect the full range of necessary data.

The variable process-dependent costs identified were as follows: machine maintenance, filters, solvent, detergent, hazardous waste disposal, electricity, natural gas, and water. The cost estimates drew from financial records provided by each facility, monthly billing records provided by the cleaners and by the utilities, information from industry sources and regulatory agencies, and structured interviews with each cleaner.

The fixed process-dependent costs were regulatory and permit fees and the cost of equipment. The annualized cost of equipment was determined by eqs 1 and 2.

$$CRF = \frac{R}{1 - (1 + R)^{-T}} \quad (1)$$

AQ: A

$$ACRC = [(PP - SV) \cdot CRF] - (SV \cdot R) \quad (2)$$

where CRF is the capital recovery factor; r is the interest rate (4%); T is the useful life of the equipment in years; $ACRC$ is the annual capital recovery charge; PP is the purchase price of the equipment; and SV is the salvage value of the equipment.

Resource Use

An assessment of electricity, natural gas, and water use was undertaken to compare the resource demands of dry cleaning and professional wet cleaning at the four facilities operating dry cleaning machines immediately before switching. Data were based on monthly billing records obtained from the cleaners or their utility providers.

Owner Satisfaction

An assessment of owner satisfaction evaluated whether each cleaner felt it was a good business decision to switch to professional wet cleaning, his or her overall level of satisfaction with professional wet cleaning, and whether any acute health effects related to either cleaning process were experienced. Data was collected through structured interviews with each cleaner.

RESULTS AND DISCUSSION

Transition Evaluation

The cleaners experienced varying degrees of difficulty in transitioning to professional wet cleaning. When asked how difficult it was to learn how to do professional wet cleaning, six of the seven cleaners responded that it was "not at all difficult" or "not too difficult." However, four cleaners found the overall switch to professional wet cleaning to be "somewhat" or "very difficult." The transitional difficulties cited most frequently by the cleaners were related to problems with the programming of the wet clean washers (five cleaners) and the improper installation of equipment (four cleaners). Other difficulties included a lack of sufficient training and technical support (two cleaners) and getting over the fear of harming garments (two cleaners).

Cleaners' concerns about switching before the installation were focused on performance issues, such as shrinkage and dye loss, but these concerns never materialized into major difficulties. Rather, the difficulties actually encountered had more to do with a lack of qualified installers and technical support.

Performance Evaluation

Frequency of Problem Garments. Five of the seven cleaners were able to professionally wet clean >99% of garments brought in by customers. The overall success rate of processing garments before and after cleaners switched was not significantly different ($P > 0.2$). The frequency of problem garments was lower after switching to professional wet cleaning in three cases and higher in four cases (Table 1). T1

The send out rate was higher in three cases after switching to professional wet cleaning and lower in three, but the overall difference was not significant ($P > 0.2$). At Sunny Brite and Del Mar cleaners, the owners stated that they sent out more garments as professional wet cleaners primarily because of difficulties removing oil-based stains.

Four of the seven cleaners lowered redo rates by between 0.12% and 0.40%, whereas three cleaners experienced increased redo rates of between 0.01% and 1.00%. Overall, the switch to professional wet cleaning did not significantly effect redo rates ($P > 0.2$). Where the redo rate was lower in professional wet cleaning, the cleaners reported that fewer garments were returned for stain removal. In the cases where the redo rate was higher in professional wet cleaning, problems with the quality of pressing were reported.

With the exception of Black Tie Cleaners, the switch to professional wet cleaning did not have a major impact on the frequency of customer claims. Two cleaners' claims rates increased, three decreased, and two were unaffected. Three of the cleaners had not paid any claims since

Table 1. Problem garment profile.

	Send-Out Rate		Redo Rate		Claims Rate		Overall	
Cleaner Name	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**
San Clemente	0.03%	0.01%	0.17%	0.03%	0.010%	0.004%	99.8%	99.9%
Del Mar	0.10%	0.63%	0.19%	0.07%	0.007%	0.005%	99.7%	99.3%
Anawood	0.19%	0.07%	0.26%	0.04%	0%	0%	99.6%	99.9%
1 Day	0.05%	0.05%	0.03%	0.11%	0.008%	0.012%	99.9%	99.8%
Eli's Airport	0.61%	0.17%	0.43%	0.03%	0.008%	0%	98.9%	99.8%
Sunny Brite	0.12%	2.46%	0.01%	0.02%	0%	0%	99.9%	97.5%
Black Tie	0.16%	1.22%	0.32%	1.32%	0.001%	0.150%	99.7%	97.3%
Mean	0.18%	0.66%	0.20%	0.23%	0.00%	0.02%	99.64%	99.07%
Standard deviation	0.956		0.455		0.062		1.392	
Level of significance	$P > 0.20$		$P > 0.20$		$P > 0.20$		$P > 0.20$	

switching to professional wet cleaning. Overall, the impact of the switch on claims rates was insignificant ($P > 0.2$)

Cleaners' Ratings of Performance. Switching to professional wet cleaning did not have an impact on the quality of cleaning and perceived customer satisfaction for most of the cleaners. Five of the seven cleaners rated the overall quality of their cleaning services as professional wet cleaners to be equivalent to when they operated as PCE dry cleaners, and six of the seven cleaners rated their customers' satisfaction to be equivalent or higher after switching to professional wet cleaning. Black Tie Cleaners was the only cleaner to rate either his quality of cleaning or his customers' satisfaction as lower in professional wet cleaning.

Customer Response. Demonstration site cleaners reported losing few customers because of switching to professional wet cleaning, as indicated by customer retention rates that ranged between 98% and 100%. With regard to customer awareness of the change, five of the seven cleaners made an effort to educate customers about their switch to professional wet cleaning, and four reported that most of their customers (80–100%) were aware of the switch. Although six of the seven reported very few (<1%) or zero negative customer responses, one of the cleaners who did not make an effort to educate customers about professional wet cleaning reported that a number of customers (13%) responded negatively to the switch. The cleaner attributed most of this negative response to customers becoming suspicious that he was not being straightforward with them about what cleaning methods he was using.

Financial Evaluation

Total Process Dependent Costs. Monthly process-dependent costs were significantly lower after switching from PCE dry cleaning to professional wet cleaning ($P < 0.02$). Each cleaner lowered costs by between $272 and $656 per month (Table 2). T2

Equipment Costs. Although the purchase prices of the PCE dry cleaning equipment and professional wet cleaning

Table 2. Process dependent costs per month.

	San Clemente		1 Day		Eli's Airport		Black Tie	
Monthly Expenses	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**
Equipment	$ 430	$208	$ 299	$ 208	$ 270	$208	$ 299	$280
Machine maintenance	$ 147	$ 24	$ 239	$ 24	$ 83	$ 24	$ 132	$ 24
Filters	$ 60	$ 0	$ 25	$ 0	$ 11	$ 0	$ 23	$ 0
Solvent	$ 50	$ 0	$ 100	$ 0	$ 90	$ 0	$ 56	$ 0
Detergent	$ 53	$121	$ 16	$ 246	$ 21	$ 82	$ 39	$167
Hazardous waste	$ 100	$ 0	$ 54	$ 0	$ 40	$ 0	$ 54	$ 0
Regulatory fees	$ 108	$ 0	$ 108	$ 0	$ 81	$ 0	$ 108	$ 0
Water[a]	$ 44	$ 34	$ 20	$ 30	n.a.	n.a.	n.a.	n.a.
Electricity	$ 89	$ 50	$ 143	$ 115	$ 187	$132	$ 93	$ 75
Gas	$ 278	$266	$ 466	$ 510	$ 221	$144	$ 267	$255
Total	$1359	$703	$1470	$1133	$1004	$590	$1073	$801
Reduction	$(656)		$(337)		$(414)		$(272)	
Average difference	419.75							
Standard deviation	167.85							
Level of significance	$P < 0.02$							

Notes: n.a. = not applicable. [a]Eli's Airport Cleaners and Black Tie Cleaners were not billed for water consumption.

Table 3. Average monthly resource use.

	Electricity (kWh)		Natural Gas (Therms)		Water (HCF)	
Cleaner Name	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**	**Dry Cleaning**	**Wet Cleaning**
San Clemente	1100	616	384	365	23.4	17.9
1 Day	2310	1868	672	739	21.5	29.5
Eli's Airport	1514	1196	296	185	n.a.	n.a.
Black Tie	1502	1218	367	349	n.a.	n.a.
Average	1607	1225	430	410	22.45	23.7
Standard deviation	96.10		72.70		5.51	
Level of significance	$P < 0.005$		$P > 0.5$		$P > 0.5$	

Notes: n.a. = not applicable.

equipment did not differ substantially ($35,973 to $44,357 for PCE equipment compared with $35,530 to $47,930 for professional wet cleaning equipment), monthly equipment costs were lower in each case for professional wet cleaning because of the longer life expectancy of the professional wet cleaning equipment. Based on industry estimates, the useful life of a PCE dry clean machine is 10–15 yr[15] compared with 20 yr for professional wet cleaning equipment.[16] San Clemente and 1 Day Cleaners used their PCE dry clean machines for 10 and 13 yr, respectively. Eli's Airport and Black Tie Cleaners removed their PCE machines after 7 yr of operation, but because their machines were still operable when removed, a life span of 15 yr was assumed based on the high end of industry estimates. The cleaners saved between $19 and $222 per month on equipment costs after switching to professional wet cleaning.

Maintenance Costs. According to industry estimates, maintenance and repair costs associated with operating PCE dry clean machines are substantially higher than for professional wet cleaning equipment.[15] This is attributable, in part, to the fact that PCE dry clean machines have become increasingly complex to comply with stringent environmental regulations and need to be carefully maintained to stay in compliance.

PCE and Hazardous Waste. There are a number of costs associated with the use of PCE solvent and the hazardous waste and air emissions it produces, including: solvent, filters, hazardous waste disposal, hazardous waste and materials licenses, and regulatory fees. After switching to professional wet cleaning, each cleaner saved between $222 and $318 per month by eliminating these costs.

Utilities. After switching to professional wet cleaning, three of the four cleaners reduced monthly utility bills by between $30 and $132. One cleaner's monthly utility bills increased by $26. All four of the cleaners reduced monthly electricity consumption, and three of the four cleaners reduced natural gas consumption. Water consumption increased at one cleaner and decreased at another. The two other cleaners' facilities were neither metered nor billed for water consumption, and any change in consumption levels had no financial impact.

Detergent. Monthly detergent costs increased after switching to professional wet cleaning at each cleaner by between $61 and $230. PCE dry cleaners typically use only a small amount of detergent per load, whereas detergents play a much larger role in the professional wet cleaning process.

Labor. None of the cleaners reported an increase in labor costs after switching from PCE dry cleaning to professional wet cleaning, although several cleaners reported changes in labor time. San Clemente and Del Mar Cleaners reported that their pressers worked fewer hours after the switch to professional wet cleaning and attributed this reduction to the efficiency of the tensioning finishing equipment. The owner and operator of Black Tie Cleaners reported that after switching to professional wet cleaning it took him 45 min longer per day to wash and dry garments and that it took his presser 45 min longer per day to finish garments. The presser was reportedly reluctant to use the tensioning finishing equipment. The increased processing time did not result in an increase in the number of hours the presser worked at the facility, although he was busier during working hours.

Resource Use Evaluation

Electricity Consumption. Electricity consumption was significantly lower after switching to professional wet cleaning ($P < 0.005$). At each cleaner evaluated, electricity use was reduced by between 19% and 44% (Table 3). These reductions were attributed to the removal of the PCE dry clean machines and water-cooling towers, which demanded more power to operate than the professional wet clean systems that replaced them. For example, the PCE dry clean machine at Eli's Airport was rated at 7.8 kW of power, whereas the professional wet clean washer and dryer were rated at a total of 3 kW. The drying process is particularly energy intensive for PCE dry cleaning, because regulations require that solvent vapors be recaptured and reused. This is accomplished by condensing the PCE vapors back into liquid with the assistance of a refrigerated condenser and cooling tower.

Natural Gas Consumption. Natural gas consumption was not significantly different after switching to professional wet cleaning ($P > 0.5$). Three of the four cleaners experienced a reduction in natural gas use (Table 3). At San

Clemente and Black Tie, the reductions were relatively modest (5%), but Eli's Airport Cleaners experienced a 38% reduction. 1 Day Cleaners experienced an increase in natural gas use of 67 therms per month, or 10%. The variation is likely because of differences in how each cleaner processed garments in professional wet cleaning. Eli's Airport wet cleaned garments in the afternoon, tumbled the garments with no heat for 5 min, and air-dried over night. The other three cleaners (San Clemente, 1 Day, and Black Tie), often processed their garments for same-day service, requiring heat from the dryer to remove the remaining moisture, a practice that uses more natural gas than air drying. 1 Day Cleaners dried each jacket on the tensioning press for several minutes, which placed a particularly high demand on the natural gas boiler; the standard program for the tensioning presses, used by the other case study cleaners, is <30 sec.

Water Consumption. Water data was available at only two facilities. Water consumption was not significantly different after switching to professional wet cleaning ($P > 0.5$). At 1 Day Cleaners, water use increased by 37% after switching to professional wet cleaning. At San Clemente, however, water use decreased by 24% after the switch. This difference may be because of two factors. First, at 1 Day Cleaners, the cooling tower fan had been broken for >1 yr before the cleaner switching to professional wet cleaning; the cooling tower fan assists in the evaporation of water as a means of cooling the dry clean machine. In addition, at 1 Day Cleaners, most wet clean programs were set at a medium water level, whereas at the other demonstration sites, including San Clemente, a low water level was used.

Owner Satisfaction

All seven of the cleaners considered switching to professional wet cleaning to be a good business decision and said they would make the same decision again. When asked whether they would recommend professional wet cleaning to other cleaners who needed to buy new cleaning equipment, all seven cleaners responded affirmatively. With one exception, each grantee stated that their overall level of satisfaction as a professional wet cleaner was equal to or higher than their overall level of satisfaction as a PCE dry cleaner. A number of factors appear to underlie this high level of satisfaction.

Comparable Quality. Six of the seven cleaners stated that the quality of their cleaning service was at least as good as the quality of their service as a dry cleaner; three stated that the quality was better because they now offer customers a nontoxic and or odor-free service.

Freedom from Regulation. Five of the cleaners mentioned being free from regulations as one of the reasons why they would recommend wet cleaning to other cleaners. Four of the cleaners expressed relief that they no longer had to worry about PCE regulations and or insurance issues.

Table 4. Occurrences of symptoms associated with PCE exposure.

Cleaner Name	Headache	Dizziness	Runny Nose	Fatigue	Nausea
San Clemente	√	√	√	√	
Del Mar	√	√			
Anawood	√				
1 Day	√	√	√	√	
Eli's Airport	√	√			√
Black Tie					

Better Health. Of the six cleaners who personally operated a PCE dry cleaning machine before converting to professional wet cleaning, five reported experiencing one or more symptoms associated with PCE exposure when operating their dry clean machines (Table 4). In addition to the machine operators, the pressing staffs at two of the cleaners also experienced one or more of these symptoms. Since switching to professional wet cleaning, these symptoms have not reoccurred at any of the locations. The two cleaners experiencing the most symptoms had been in the dry cleaning business the longest and were operating the oldest equipment.

CONCLUSIONS

The technical evaluation of cleaners switching from PCE dry cleaning to professional wet cleaning showed professional wet cleaning to be a viable alternative to traditional dry cleaning. Environmentally, professional wet cleaning proved to be an energy efficient, nontoxic, zero-emission technology that eliminates hazardous air emissions, hazardous waste production, and the potential for soil and groundwater contamination. From a performance standpoint, the cleaners who switched to professional wet cleaning were able to maintain their level of service and customer base while lowering operating costs. The cleaners in the study were able to transition to professional wet cleaning without a great degree of difficulty and expressed a high level of satisfaction as professional wet cleaners.

Although the results of this study indicate that professional wet cleaning is a viable substitute for dry cleaning, it is important to consider the conditions under which the cleaners evaluated in this study switched to professional wet cleaning. The Professional Wet Cleaning Demonstration Project was established to help jump start this nontoxic technology in the greater Los Angeles region. It is unlikely that the cleaners evaluated would have been as successful, or switched at all, without the existence of the demonstration project, which created a number of conditions important to the success of their conversion. These conditions include the following: (1) an extensive outreach effort informing dry cleaners about the capabilities of professional wet cleaning; (2) the creation of demonstration sites to serve as venues for workshops that allowed cleaners to observe and evaluate the technology first hand; (3) a grant program that provided financial and technical assistance for cleaners to switch to professional wet cleaning and serve as demonstration sites; and (4) the development of relationships with equipment manufacturers, distributors, trainers, and installers who built a supporting infrastructure for professional wet cleaning in the region.

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