WALK-THROUGH SURVEY REPORT:

PERCHLOROETHYLENE EXPOSURES IN COMMERCIAL DRY CLEANERS

at

Hyde Park "One Hour" Martinizing Cleaners
Cincinnati, Ohio

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Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
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PLANT SURVEYED:	Hyde Park "One Hour" Martinizing Cleaners 3439 Edwards Road Cincinnati, Ohio 45208
SIC CODE:	7216
SURVEY DATE:	August 27, 1992
SURVEY CONDUCTED BY:	Gary S. Earnest Amy Beasley Spencer
EMPLOYER REPRESENTATIVES:	Mike Sears, Manager Bill Shaffer, Owner
EMPLOYEE REPRESENTATIVES:	No union
MANUSCRIPT PREPARED BY:	Deanna L. Elfers

DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC).

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), located in the Centers for Disease Control and Prevention (CDC) under the Department of Health and Human Services (DHHS) (formerly the Department of Health, Education, and Welfare), was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct research and education programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards.

The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness. Since 1976, ECTB has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique. The objective of each of these studies has been to document and evaluate control techniques and to determine their effectiveness in reducing potential health hazards in an industry or at specific processes.

In the late 1970s and early 1980s, a NIOSH sponsored engineering control technology study was conducted in the dry cleaning industry.[1] Since then, significant changes involving equipment, processes, and work practices have occurred within the industry. Many of these changes were initiated by new epidemiologic, toxicologic, and environmental data for the primary solvent, perchloroethylene (PERC). Some studies have shown that in addition to the numerous adverse health effects already known, there is evidence of carcinogenicity.[2,3,4] In December of 1991, the Environmental Protection Agency (EPA) began regulating perchloroethylene as a hazardous air pollutant under Section 112 of the Clean Air Act.[5] This decision was based on environmental research finding perchloroethylene to be a toxic air pollutant. The industry has responded with increased research into alternative solvents, a shift from transfer machines to closed loop dry-to-dry machines, and innovations in vapor recovery equipment and other devices to reduce occupational exposures and environmental emissions.

Many of the exposure problems identified during studies in the late 1970s and early 1980s still exist because transfer equipment is still being used, many of the controls that have been developed are cost prohibitive, and work practices are inadequate. The OSHA Integrated Management Information System (IMIS) database indicates that approximately twenty percent of samples taken at dry cleaning shops exceed 100 ppm.[6] During a nationwide query of the OSHA State Consultation Programs in 1988, the dry cleaning industry was the second most mentioned small businesses needing occupational health hazard control technology research.[7]

For these reasons ECTB has undertaken a study of dry cleaners to determine which engineering control recommendations from the 1980 NIOSH report are still valid. Additionally, during the course of this study, controls for other industry hazards, such as ergonomic hazards or exposure to spotting chemicals, will be evaluated. During the initial phase of the study, literature will be reviewed to determine areas in need of research. Walk-through surveys then will be conducted to gain familiarity with the industry and determine locations for future in-depth studies. Next, in-depth surveys lasting several days will be performed during which quantitative data will be collected. Personal and area samples will be obtained, and real-time monitoring will be conducted. Detailed reports will be written to document all findings. These in-depth reports will be used to prepare technical reports and journal articles that summarize the findings concerning effective controls for occupational health hazards in the dry cleaning industry.

This report describes a walk-through survey conducted at the Hyde Park "One Hour" Martinizing Cleaners, located in Cincinnati, Ohio. The purpose of this survey was to qualitatively evaluate occupational health hazards with a focus on worker exposure to perchloroethylene.

PLANT AND PROCESS DESCRIPTION

PLANT DESCRIPTION

Hyde Park "One Hour" Martinizing Cleaners is a small commercial facility, located in the heart of the Hyde Park shopping district. It is on the first floor of a two story building which holds several interconnected street shops. A parking garage behind the building provides access to the businesses on the second floor. This 37 year old facility does all of its own dry cleaning and has no satellite shops. The dry cleaning, pressing, and alteration areas are separated from the customer service and storage area by a wall, with a small walkway, as shown in Figure 1.

This shop consumes an average of four gallons of PERC each month and cleans approximately 650 pounds of apparel daily. The amount of clothing varies with the season, spring and fall tend to be busiest.

The work force consists of approximately six employees, half of which actually operate the dry cleaning machine. The typical employee works from 7:30 a.m. to 3:00 p.m., five days a week. The shop is open for business Monday through Saturday, 7:30 a.m. to 6:15 p.m.

DRY CLEANING TECHNOLOGY

The following two types of machines are generally used in dry cleaning: transfer or dry-to-dry. Transfer machines are older, less expensive, and require manual transfer of solvent laden clothing between the washer and dryer. This is where the highest worker exposure occurs. Transfer machines process twice as much clothing as comparably sized dry-to-dry machines because the process time is half that of a dry-to-dry machine. Some owners of dry-to-dry machines reduce the cycle time to increase productivity. Unfortunately, this practice increases exposure due to residuals left in the clothing.[8]

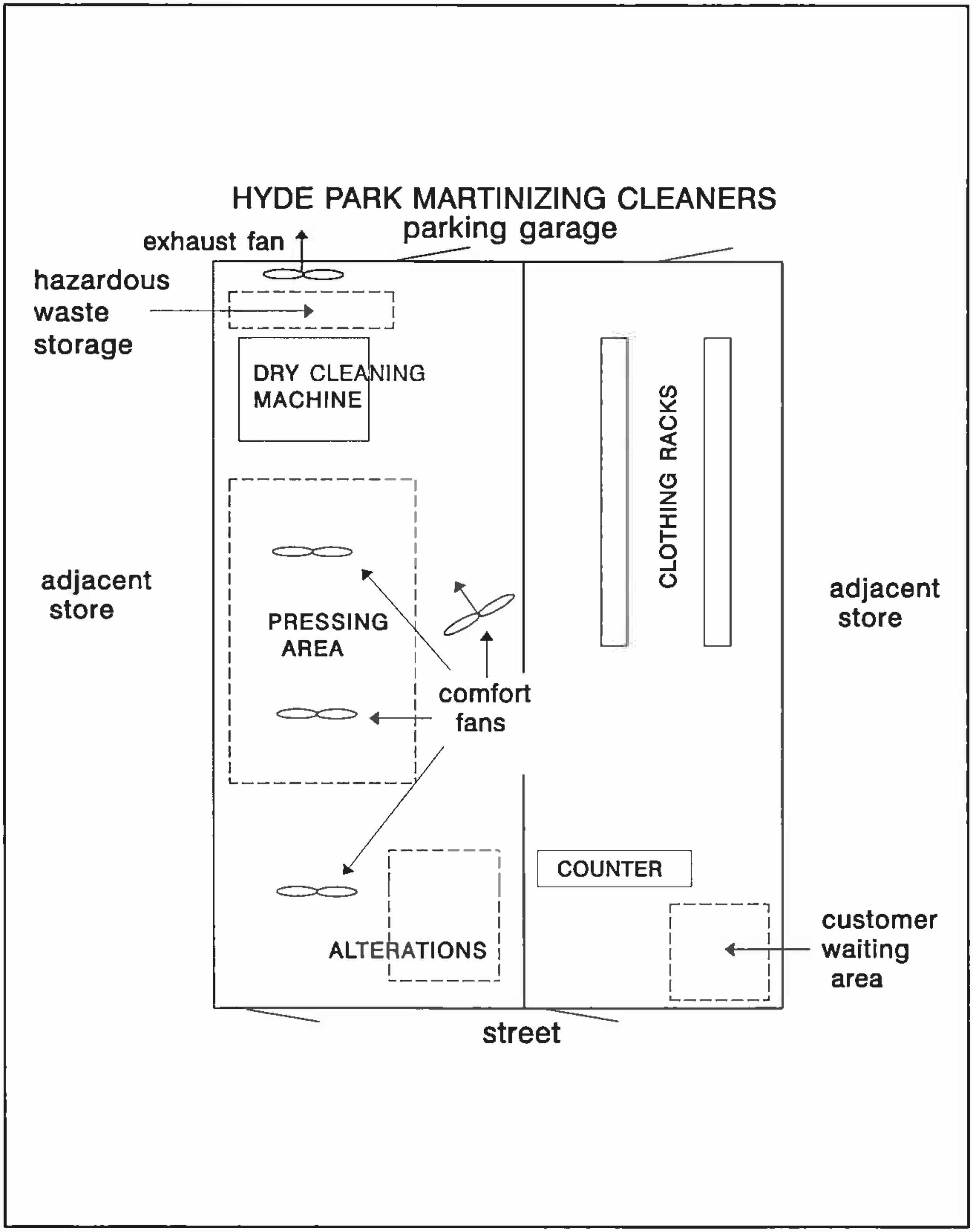

Figure 1. Diagram of the Facility.

Because of the high exposures during transfer, transfer machines are no longer manufactured in the United States. Seventy percent of machines today are dry-to-dry machines using a one step process that eliminates clothing transfer.[9] Clothes enter and exit the machine dry. PERC exposure from dry-to-dry machines is considerably less than transfer machines. No federal or state regulations specifically require the use of dry-to-dry machines, but eliminating the transfer process is a significant step in reducing the level of occupational exposures to PERC. Most shops are moving or have moved to replace transfer machines with dry-to-dry machines because of the trend toward stricter regulations from both state and federal OSHA and the EPA.

PROCESS DESCRIPTION

Prior to being loaded into the washers, garments are inspected and sorted according to weight, color, and finish. Garments with visible stains are pretreated with various chemicals depending on the type of stain, prior to being washed. Some of the more commonly used spotting chemicals include the following: trichloroethane, perchloroethylene, amyl acetate, petroleum naphtha, oxalic acid, acetic acid, dilute hydrofluoric acid, hydrogen peroxide, and aqueous ammonia. Each of these chemicals are used in limited quantities.

The garments are loaded into a modern Multimatic® Shop Star 500 dry-to-dry machine. This particular machine is approximately two years old, with a capacity of sixty-five pounds. The garments are washed in a PERC solution for approximately four minutes and then dried for twenty-five minutes, the final five minutes are used for aeration. After washing, PERC is drained from the machine's tank and excess PERC is extracted by centrifugal spinning. Later, the PERC is returned for the next wash cycle.

During drying, air exiting the dryer passes through a refrigerated condenser to recover PERC vapors. A door interlocking switch is connected to a fan which automatically activates when the door is opened, creating an in-draft. This air is passed through a carbon adsorber which is designed to capture PERC vapors before being exhausted to the room. Clothes are manually removed from the machine and are loaded into a basket. The basket holds the garments temporarily until they can be hung on a rack for pressing. After each garment is pressed, it is sorted, wrapped in plastic, hung back on the rack, and stored until pickup.

A local contractor delivers approximately thirty gallons of PERC every seven months. The solvent is pumped directly into the machine's holding tank which eliminates employee handling. PERC used in the wash cycle is cleaned continuously by passing through a series of sixteen filters that are changed every eight months. In addition to filtration, distillation helps to maintain solvent purity. Figure 2 is a flow chart of the solvent pathway through the system.

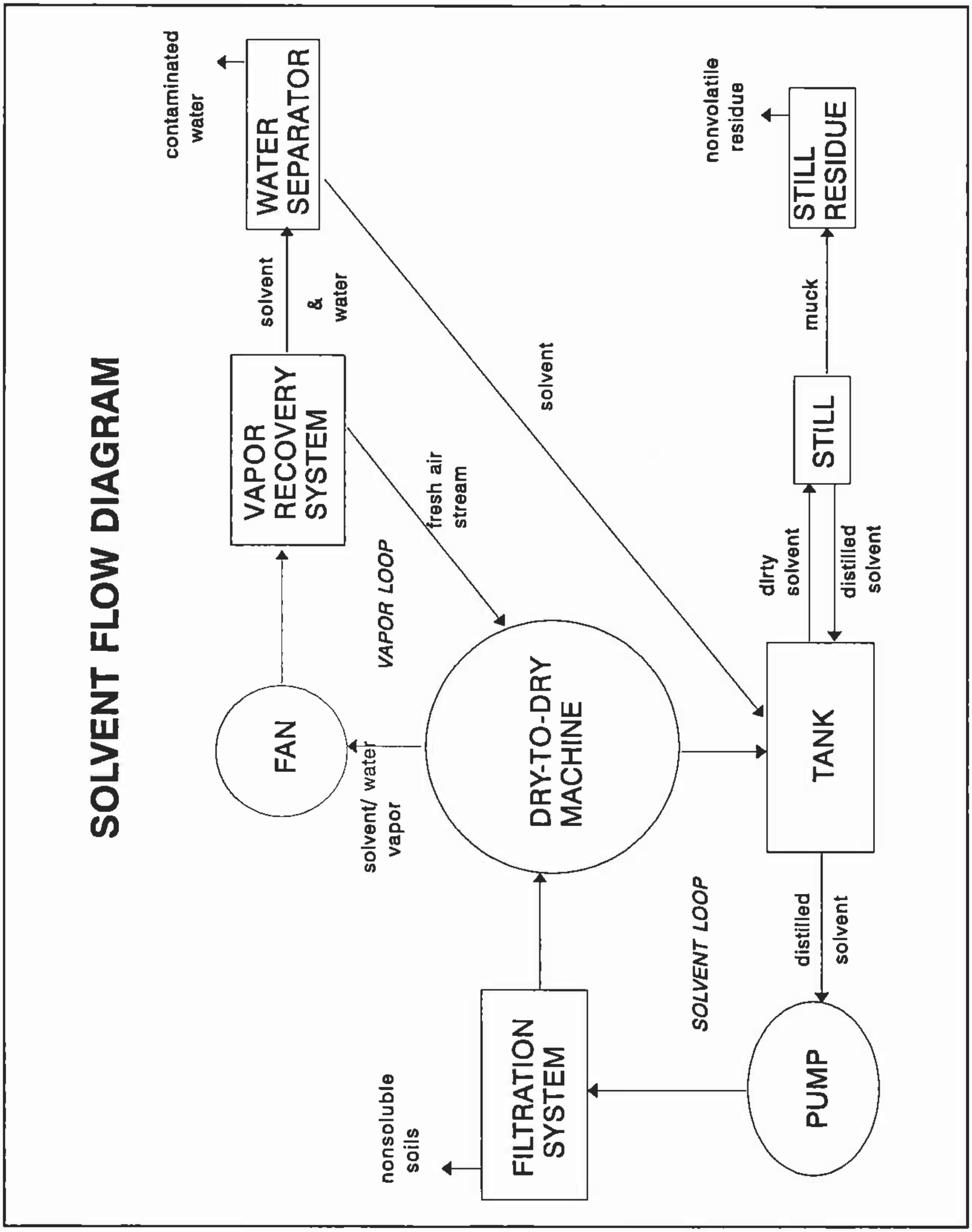

Figure 2. Solvent Flow Chart.

Ventilation consists of a large, radial fan located in the wall behind the dry cleaning machine. The air is exhausted outside the building to the covered parking garage. Several comfort fans are located throughout the pressing area which circulate air. During summer months, the door near the alterations area remains open.

POTENTIAL HAZARDS

Exposure to PERC is the primary health hazard for workers in dry cleaning facilities today. PERC can enter the human body through both respiratory and dermal exposure. Symptoms associated with respiratory exposure include the following: depression of the central nervous system; damage to the liver and kidneys; impaired memory; confusion; dizziness; headache; drowsiness; and eye, nose, and throat irritation.[9] Repeated dermal exposure may result in dry, scaly, and fissured dermatitis.[10] Over the past 15 years, researchers have established a link between PERC exposure and cancer in animals. This link was discovered through studies conducted by the National Cancer Institute (1977), the National Institute for Occupational Safety and Health (1978), and the National Toxicology Program (1986). Other studies have shown an elevated risk of liver cancer in males who work in dry cleaning establishments.[11]

Spotting involves the selective application of a wide variety of chemicals and steam to remove specific stains. Some of these chemicals that are used on a fairly regular basis include the following: trichloroethane, perchloroethylene, amyl acetate, petroleum naphtha, oxalic acid, acetic acid, dilute hydrofluoric acid, hydrogen peroxide, and aqueous ammonia. Individuals who perform the spotting process could be exposed to toxic chemicals through skin or eye contact or inhalation of vapors. Previous studies have indicated that inhalation exposures are minimized due to the limited quantities of chemicals and the intermittent nature and short duration of the task.[12] During personal sampling, an International Fabricare Institute study found PERC exposure levels many times lower than OSHA standards and some chemicals being used, below detection limits.[13] The primary hazard posed by chemicals used in the spotting process is skin damage resulting from chronic or acute exposure or injury to the eyes.

EVALUATION CRITERIA

The current OSHA permissible exposure limit (PEL) for perchloroethylene is 100 ppm, time-weighted average (TWA) exposure.[14] OSHA had lowered the PEL to 25 ppm in 1989 under the Air Contaminants Standard.[15] In July 1992, the 11th Circuit Court of Appeals vacated this standard. OSHA is currently enforcing the 100 ppm standard; however, some states operating their own OSHA approved job safety and health programs will continue to enforce the lower limits of 25 ppm. OSHA continues to encourage employers to follow the 25 ppm limit.[16] NIOSH considers perchloroethylene to be a potential occupational carcinogen and recommends that exposure be reduced to the lowest feasible limit.[17]

CONTROLS

PRINCIPLES OF CONTROL

Occupational exposures can be controlled by the application of a number of well-known principles including engineering measures, work practices, and personal protection. Engineering measures are the preferred and most effective means of control. These include material substitution, process and equipment modification, isolation and automation, and local and general ventilation. Control measures also may include good work practices and personal hygiene, housekeeping, administrative controls, and use of personal protective equipment such as respirators, gloves, goggles, and aprons. Table 1 summarizes the spectrum of control measures.

TABLE 1[18]

METHODS OF CONTROL

SOURCE	PATHWAY	RECEIVER
Material substitution	Housekeeping	Training and education
Process change	General exhaust ventilation (Roof fans)	Worker rotation
Process enclosure	Dilution ventilation (Supplied air)	Worker enclosure
Process isolation	Increase worker/ source distance	Personal monitoring
Wet methods	Continuous area monitoring	Personal protective equipment
Local ventilation	Maintenance programs	Maintenance programs
Maintenance programs		

Each of these approaches must be considered when developing a comprehensive, effective control strategy; however, their optimum application varies from case to case. Built-in design modifications are the preferred method of control because they generally are not dependent on human behavior. Additionally, monitoring and maintenance of controls, and education and commitment of both workers and management are important ingredients of a successful control system.

ENGINEERING CONTROLS FOR DRY CLEANING

At dry cleaning facilities, substitution and local exhaust ventilation appear to be the most effective and realistic control approaches for reducing perchloroethylene exposure. Substitution of the process, equipment and material has been looked at extensively in dry cleaning. Process and equipment substitution has been very successful while material substitution has been unsuccessful.

The most significant change involving process/equipment substitution was the introduction of dry-to-dry machines. This change eliminated exposures from the transfer operation. Anytime a process can be made more continuous, the less hazardous it is likely to be. Closed loop systems have reduced exposures from venting contaminated air. In addition, solvent recovery equipment such as carbon absorbers and refrigerated condensers have reduced vented PERC emissions. Substitution of the material, PERC, has been tried for some time with little or no success. Many substitute solvents have been tried, but each has its own set of problems.

Isolation of both equipment and material from the worker is being used in some dry cleaners today. Isolation is the term to describe placing a physical or time barrier between the hazard and the workers that may be injured. Many facilities no longer store large quantities of solvent on the premises. Instead, they have a supplier deliver it as needed. It is difficult to isolate dry cleaning machines in small shops. Larger shops have more space which provides greater flexibility for isolating high exposure processes. Operators spend much of the day at the machine. Consequently, the operator will have greater exposure to PERC than other workers. In order to be effective, process isolation must be used in conjunction with good local and general ventilation.

Local ventilation is considered the "classic method" of control and attempts to capture contaminant before escaping into the environment. National Fire Protection Association codes for the dry cleaning industry recommend dry cleaning machines with an integral exhaust system having a door face velocity of 100 fpm. This has become a widely accepted practice in the industry.[19,20] This face velocity will help to prevent solvent vapors from escaping into the shop by providing a draft of clean air to pass over the items being removed from the machine. The integral exhaust system is activated by a door interlocking switch. An alternative to this is placing a ventilation shroud outside the machine door with an airflow capacity in cfm not less than 100 times the door opening area in square feet.[21]

Local exhaust ventilation is effective because it captures solvent vapors where they are most concentrated, at the source. This prevents vapors from reaching the worker's breathing zone, as well as, reducing diffusion throughout the plant. Local exhaust ventilation can be improved with a number of measures. Hood modifications such as placing a flange on a slotted hood to reduce turbulence is helpful. Isolating the capture area from strong air drafts is another effective measure.[22]

General ventilation adds fresh air or removes general plant air to keep contaminant concentrations below a specified level. Replacement air enters naturally through windows and doors or through large fans in the ceiling or walls. Fans should pull fresh air through the cleaning area and draw vapors away from the workers prior to exhaust. This reduces movement of contaminated air into other areas of the shop. Emergency ventilation systems are needed to handle spills and leaks.

ENGINEERING CONTROLS AT HYDE PARK "ONE HOUR" MARTINIZING CLEANERS

The machine currently being used in this shop is a closed loop, dry-to-dry machine with advanced engineering features designed to comply with OSHA and EPA regulations. The machine is approximately two years old and manufactured by the Multimatic® Corporation. Some of the prominent features of the machine are listed below:

- dual cartridge filtration system which holds 16 cartridge filters;
- enclosed system that eliminates venting or exhausting to the atmosphere;
- refrigerated condenser and carbon adsorber connected to a fan activated by a door interlocking switch; and
- all stainless steel parts (including the entire solvent line piping).

A limited form of process isolation is used in this shop. As shown in Figure 1 the dry cleaning, pressing, and alteration areas are separated from the rest of the shop by a wall which runs through the middle of the building.

OBSERVATIONS

General maintenance and housekeeping appeared to be very good in this facility. The shop was neat and orderly, and regular maintenance was performed. A contractor performed routine maintenance on the machine approximately every three months. During this maintenance, any seals or gaskets needing replaced were replaced. The Multimatic® machine was procured in order to replace an aging machine that had developed excessive leaks. No leaks were detected on the new machine.

The wall running through the center of the shop appeared to contain any vapors originating from the machine. This should reduce exposures to employees in other areas of the shop. This barrier would be more effective if only the dry cleaning machine and its components were isolated. This is where the majority of exposures originate.

The construction and location of this shop restricted natural ventilation. There were not any windows in this facility. The side walls were shared with other businesses. The rear wall had two doors which opened into a parking garage. The front was primarily glass with two doors. Air entered and exited the shop through doors at the front and rear of the shop.

PERSONAL PROTECTIVE EQUIPMENT

MSA®, half-face piece respirators with organic vapor cartridges were worn by employees at Hyde Park Cleaners while performing periodic machine maintenance. There was no respirator training or fit testing provided to the wearer. The respirators were stored in plastic bags when they were not being used. Wearing of the respirators was not observed.

RESULTS

INDUSTRIAL HYGIENE SAMPLING

Draeger® perchloroethylene 2a detector tubes were used to determine approximate levels of PERC in different areas of the shop and identify emission sources and operations with potential for exposure. These tubes had a measuring range between 2 and 300 ppm. Detector tubes consist of a glass tube containing an inert carrier impregnated with a reagent. The ends of the tube are broken and the tube connected to a hand-operated bellows pump. Workplace air is pulled through the tube and the contaminant reacts with the reagent. The concentration is determined by the length of color change.

These measurements were used to identify areas or operations causing potential exposure. These tubes were used to provide a relative reading. Error is typically between 10 and 25 percent.[23] Sampling results are listed in Table 2.

Bulk samples were taken from both the still and refrigerated condenser run off. Ninety percent by weight of the still run off was PERC. No PERC was detected in the condenser run off.

Table 2. Detector Tube Measurements.

Area	Customer Area	Pressing Area	In front of machine	Behind machine
Conc. (ppm)	None detected	None detected	3	15

Note: These are single, instantaneous measurements used to identify areas or operations causing potential exposure; they may not reflect actual exposures measured by long-term sampling techniques.

VENTILATION MEASUREMENTS

Local and general ventilation measurements were taken with a Kurz® model 1440 velometer with a measuring range from 0 to 6000 feet per minute. Local ventilation for the dry cleaning machine appeared to be excellent. The integral exhaust fan connected to an interlocking switch on the machine door appeared to be doing an exceptional job of drawing PERC vapors away from the operator's breathing zone while loading and emptying the machine. This was demonstrated by the use of smoke tubes. No air velocity measurements were taken at the machine door.

The large radial fan located in the wall behind the dry cleaning machine had a face velocity of approximately 400 ft/min. Smoke tubes demonstrated that this fan did a good job of removing vapors that originated from behind the machine; however, it was ineffective removing those in front of the machine.

CONCLUSIONS AND RECOMMENDATIONS

This small dry cleaning facility appeared to have adequate controls to maintain exposure levels below 25 ppm, which is the level that OSHA encourages dry cleaners to follow. NIOSH recommends controlling PERC to the lowest feasible limit. The primary factor contributing to PERC in the atmosphere was allowing the still run off to remain uncovered during the workday. This allowed PERC to evaporate into the atmosphere. Fortunately, the large radial fan behind the machine exhausted the vapors outside of the building.

Smoke tubes indicated that the fan behind the dry cleaning machine was able to remove air behind the machine; however, contaminated air from the front of the machine was not captured. Much of it diffused throughout the building. Air in other parts of the building moved in no established pattern. General ventilation principles require that fans be arranged to move contaminated vapors away from the employees.

One apparent problem was allowing still run off to remain open to the atmosphere until the end of the workday. This should not be done because it allows PERC to evaporate into the atmosphere. Instead it should be immediately moved to an air tight container. This was not a problem with the refrigerated condenser run off because analysis detected no PERC.

There were few leakage problems in this facility because the equipment was only a few years old. As systems age, leaks can compound resulting in excessive exposures. A leak detector or monitoring device was not available. However, it would be important to have a detector available as the machine gets older and more likely to leak.

Proper maintenance can be instrumental to reducing leakage. Leaks are more easily seen if proper maintenance and housekeeping is performed. Lint build-up is a real problem in many dry cleaners. If lint accumulates on the floor and around equipment, leaks are much harder to locate. Gaskets prone to deterioration must be inspected and replaced on a regular basis. Several devices can aid in leak detection. These include the following: the halide torch, photo-ionization detector, and pocket dosimeters. Passive exposure monitoring devices cannot be used to aid in leak detection, but should be used periodically to alert management when an exposure problem may exist.[24]

Use of personal protective equipment (PPE) at this shop was not in accordance with Federal Regulation 29 CFR 1910.134 because there was no established program. In addition to the measures mentioned earlier, occupational exposure could be further reduced through the proper use of PPE. PPE does nothing to reduce or eliminate the source of the hazard and must be used properly to be effective.

Because NIOSH has classified PERC as a potential occupational carcinogen, the following two types of respirators are recommended: a self-contained breathing apparatus (SCBA) with full facepiece operated in pressure demand or positive pressure mode, or a supplied-air respirator (SAR) operated in pressure demand or positive pressure mode with auxiliary SCBA. The auxiliary

SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.[25]

Though not recommended by NIOSH because PERC is a potential occupational carcinogen, the currently used respirators (half-mask facepiece with organic vapor cartridges), may be used for short-term exposures to low levels of perchloroethylene. At a minimum, the cartridges must be changed prior to breakthrough (approximately 130 minutes based on room concentrations)[26]. Regular cartridge changes are important because the odor threshold of PERC is 27 ppm. This low odor threshold will prevent the worker from smelling PERC until significant breakthrough and exposure has occurred.[27]

Where employees must wear respirators, an appropriate respiratory protection program in accordance with 29 CFR 1910.134 must be instituted. This Federal regulation contains provisions for:

- a written standard operating procedure
- respirator selection based upon hazards
- instruction and training of the user concerning the proper use and limitations of respirators
- regular cleaning, disinfection, and proper storage
- medical review of the health and condition of the respirator user
- use of certified respirators which have been designed according to standards established by competent authorities.[28]

Gloves, aprons, and goggles should be used to reduce exposure to hazardous chemicals such as perchloroethylene. Gloves and aprons provide limited dermal protection and should be made of solvent resistant materials such as Viton® fluoroelastomer, polyvinyl alcohol or unsupported nitrile. When deciding on a specific glove to use, factors such as permeation, durability, dexterity, and cost should be considered. Viton® and polyvinyl alcohol to have a perchloroethylene breakthrough time in excess of eight hours.[29] A 1987 study showed that unsupported nitrile was impervious to perchloroethylene after a two hour challenge period.[30] Some of the drawbacks associated with these materials are that Viton® is expensive, polyvinyl alcohol significantly reduces dexterity, and unsupported nitrile has a higher permeation rate. Whenever swelling or softening of the gloves or seepage of perchloroethylene into the glove is observed, the gloves should be replaced.

Chemical splash goggles should be worn to prevent eye injury when workers are using hazardous chemicals. Accidental contamination of the eye could result in minor irritation or complete loss of vision. Use of chemical splash goggles is particularly important in the spotting area at this shop where a wide variety of toxic chemicals were being used to remove stains. Additionally, an unobstructed eye wash station should be located in the vicinity of the spotting area to provide prompt eye irrigation in the event it is needed. If chemical contamination of the eye does occur, prompt irrigation for at least fifteen minutes can play a deciding role in limiting the extent of damage.

Generally speaking, controls at this facility appeared to be very good. Control methods discussed in previous sections of the report could aid in reducing exposure levels. Areas at this facility which would be of interest during an in-depth survey include the following:

- detailed evaluation of engineering controls;
- relationship of work practices and maintenance procedures to occupational exposure to PERC;
- analysis of a Multimatic®, dry-to-dry, no vent machine design and components;
- build-up and decay rates for solvent residuals in clothing; and
- analysis of hazards and possible controls at the spotting station.

A decision concerning a possible in-depth survey at this facility will be made following the completion of all walk-through surveys and finalization of the study protocol.

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