WALK-THROUGH SURVEY REPORT:

PERCHLOROETHYLENE EXPOSURES AND ERGONOMIC HAZARDS IN COMMERCIAL DRY CLEANERS

at

Teasdale Fenton Cleaners
Cincinnati, Ohio

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SIC CODE:	7216
SURVEY DATE:	September 1, 1992
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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] Based on environmental research finding perchloroethylene to be a toxic air pollutant, in December of 1991, the Environmental Protection Agency began regulating perchloroethylene as a hazardous air pollutant under Section 112 of the Clean Air Act.[5] 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 20 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 Teasdale Fenton 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 and ergonomic hazards.

PLANT AND PROCESS DESCRIPTION

PLANT DESCRIPTION

Teasdale Fenton Cleaners is one of the oldest and largest dry cleaners in the United States. It was founded in 1830 and was the third dry cleaner opened in the United States. Dry cleaning has been performed at the main facility, the subject of this walk-through in Cincinnati since approximately 1968. The main facility is a large three story building. The top floor is used for dry cleaning and the first and second floors are used for conventional laundry, offices, and storage. Currently this operation has approximately thirty dry cleaning satellite shops in the Cincinnati area where the items that need to be cleaned are transported between the satellite shops and the main plant. Satellite shops increase the customer base without the added expense of hiring a full staff and purchasing new equipment. From an occupational exposure standpoint, employees at satellite shops are not exposed to the quantities of hazardous chemicals as employees at the main facility. In fact, they are generally only exposed to residual levels of perchloroethylene in the clothing.

Teasdale Fenton consumes approximately 600 gallons of PERC per month and cleans about 3,000 pounds of apparel daily. Much of the workload depends on the season of the year; Spring and Fall tend to be busiest. The work force at the main facility varies between 35 and 40 employees. There are over 200 employees located in all the shops across the city. The typical employee works from 6:00 a.m. to 2:30 p.m., five days a week. The main facility is open for business Monday through Friday, 7:00 a.m. to 7:00 p.m. and Saturday 8:00 a.m. to 6:00 p.m.

DRY CLEANING TECHNOLOGY

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]

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 exposure 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 Environmental Protection Agency (EPA).

PROCESS DESCRIPTION

Process equipment used at this shop, include 2 Detrex® model 22-90H dry-to-dry machines and 4 Hoyt® Solvo-miser dryers. There is also one Cleanline® dry-to-dry machine used exclusively for draperies. The Detrex® dry-to-dry machines are only utilized by this facility in the wash cycle. The apparel is transferred to the dryers, following the wash cycle, in order to increase productivity. The washers hold 70 pounds of clothing.

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

The garments are loaded into the washers and washed in a PERC and detergent solution for approximately 9 minutes. 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. The garments are manually transferred to dryers located several feet away. This process takes several minutes. Once in the dryer, it takes approximately 30 minutes to dry the clothing followed by 2 minutes for cool down and 3 minutes to deodorize.

After the dry cycle, garments are manually taken from the dryer and loaded into a waiting basket. The basket holds the garments temporarily until they can be hung on a rack in preparation for pressing. After each garment is pressed, they are sorted, wrapped in plastic, hung back on the rack and returned to the shop of origin at the end of the day.

Air exiting the washers and dryers passes through VIC® vapor adsorbers to remove PERC vapors before being vented through the roof of the building. PERC used in the wash cycle is cleaned continuously by passing through a series of filters that are changed every two weeks. In addition to filtering the solvent, distillation throughout the day helps to maintain its purity. Ventilation within the shop consists of 2 overhead exhaust fans and approximately 10 portable, comfort fans used to draw fresh air into the building through the windows. PERC is delivered by truck to this facility on a weekly basis. It is pumped through a long hose to the third floor holding tank connected to the machines. This process requires the hose to be routed through occupied areas on lower floors. Figure 1 shows a diagram of the facility. Figure 2 is a solvent flow chart.

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: 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: petroleum naphtha, hydrogen peroxide, trichloroethane, amyl acetate, oxalic acid, acetic acid, dilute hydrofluoric acid, 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.

Ergonomic hazards in the dry cleaning industry have been given little attention in the past. The term ergonomic hazard relative to work-related musculoskeletal disorders refers to conditions that pose a risk of injury or illness to the musculoskeletal system of the worker. Ergonomic hazards can include repeated and sustained exertions, temperature extremes, vibration, and awkward postures resulting from poorly designed workstations, equipment, and work methods. Other factors which play a role are excessive work rates and duration, external pacing of work, shiftwork, imbalanced work to rest ratios, and restriction of worker body movement. Work related musculoskeletal disorders can result in damage to tendons, tendon sheaths, muscles, nerves, and ligaments of the area affected.[14-15]

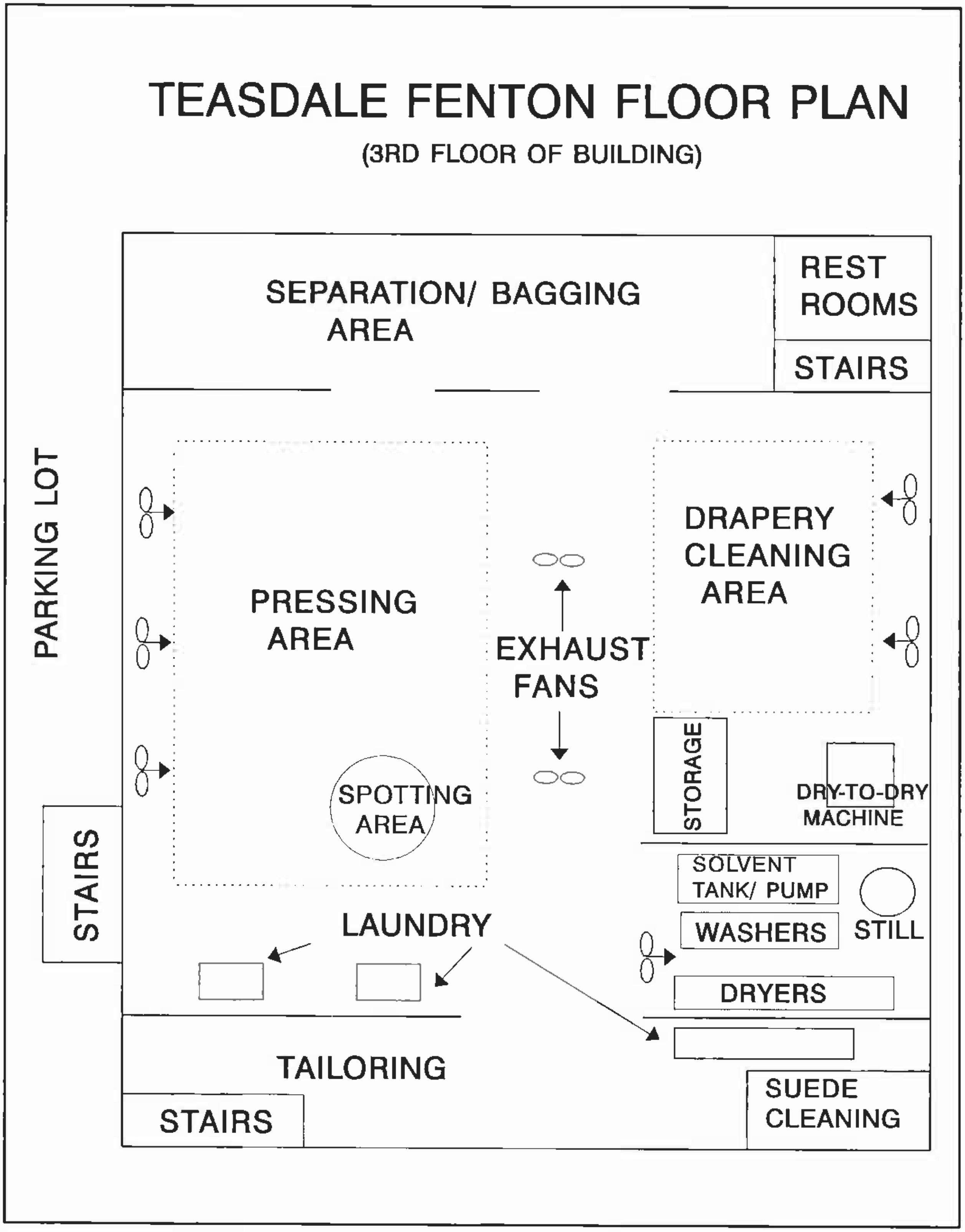

Figure 1. Diagram of the Facility.

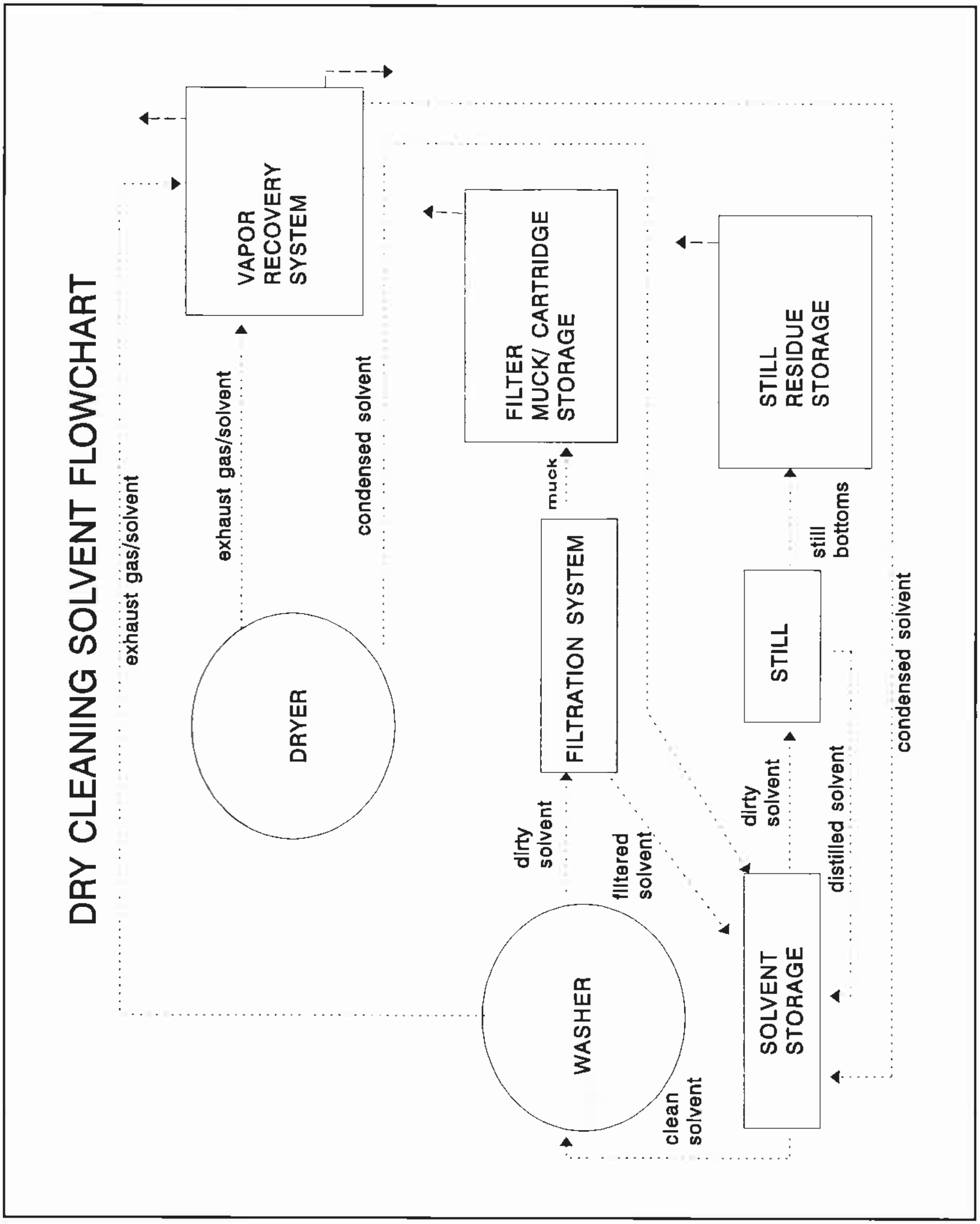

Figure 2. Solvent Flow Chart.

EVALUATION CRITERIA

The current OSHA permissible exposure limit (PEL) for perchloroethylene is 100 ppm, time-weighted average (TWA) exposure.[16] OSHA had lowered the PEL to 25 ppm in 1989 under the Air Contaminants Standard.[17] 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.[18] NIOSH considers perchloroethylene to be a potential occupational carcinogen and recommends that exposure be reduced to the lowest feasible limit.[19]

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.

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

TABLE 1[20]

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		

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.[21,22] 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.[23]

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.[24]

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 TEASDALE FENTON

Teasdale Fenton Cleaners is using limited forms of equipment substitution technology. The dry-to-dry machines pass exhaust air through VIC® carbon absorbers to recover PERC vapors. The vapor absorbers are attached to both the washers and dryers. An internal fan is activated by a switch on the loading doors which causes solvent laden air to be pushed through an activated carbon bed. The carbon bed captures and recovers solvent in the air.

The dry-to-dry equipment at this shop is not used according to design. In order to clean more clothing in less time, the dry-to-dry machines are used in the wash cycle, and the contents are manually transferred to dryers. The integral exhaust fan connected to the carbon adsorber is the only local ventilation present at this shop. General ventilation consists of the two large exhaust fans in the roof and the numerous comfort fans that are used to draw air into the shop through the many windows. The dry cleaning area is partially enclosed by solid walls on two sides. However, solvents are still able to diffuse throughout much of the third floor.

OBSERVATIONS

The scent of PERC was present throughout much of the third floor of the building. This was probably due to a large number of factors including inefficient solvent recovery, PERC escape during the transfer operation, and liquid and vapor leaks. Local ventilation for the machines did not appear to be adequate. VIC® vapor absorbers have reduced some of the PERC vapors in the air at this facility. The transfer operation has resulted in high worker exposures from handling solvent laden garments.

Solvent leakage from processing components behind the machine was a problem at Teasdale Fenton. This is very common with older equipment. Many machine gaskets were old, cracked and leaking. Leaks were clearly visible around the washer door gasket, and behind the machine on the many hose and pipe connections. Puddles of solvent and water were visible on the floor behind the washer. Gaskets are routinely replaced in this shop on an annual basis, but that is not often enough based upon the number of visible leaks. As systems age, leaks can compound resulting in excessive exposures. A halogen leak detector was available at the shop, but it was either not being used or was ineffective.

PERSONAL PROTECTIVE EQUIPMENT

Survivair® and AO Safety® half face piece respirators with organic vapor cartridges were used by the operators at Teasdale Fenton during the transfer operation. There was no respirator training or fit testing provided to the wearer. The respirators were not properly worn or properly stored when not in use. Use of respirators are generally less desirable than engineering measures because their effectiveness is dependent on behavior and training where error is typically more likely to occur.

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. Tubes provide a relative reading. Error is typically between ten and twenty-five percent.[25] Area samples ranged from 2 to 75 ppm. Peak exposures over 300 ppm were measured with Draeger® detector tubes during the transfer operation. Sampling results are listed in Table 2.

Table 2. Detector Tube Measurements.

Area	Pressing Area	Between Machine	Behind Machine	Between Machine (During Transfer)
Conc. (ppm)	2	55	75	(+)300

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. Air velocity measurements taken at the door of the washers were between 200 and 250 fpm. Air velocity at the door of the dryers was negligible.

General ventilation appeared to be better than the local ventilation. Quantities of supplied air appeared adequate; however, there was not a clearly established airflow pattern within the building. Smoke tubes indicated that air was moving, but in no established pattern. Vapors did not appear to be carried away from the workers. PERC escaped into the breathing zone of workers transferring the clothing and then dissipated throughout the building.

ERGONOMICS

Along with exposure to PERC some employees may be exposed to other potential risk factors related to work and operation. The other potential risk factors are ergonomic hazards which pose a risk of injury to the workers musculoskeletal system. These hazards can result from repetitive and forceful motions, vibration, temperature extremes, and awkward postures.

The dry cleaning and conventional laundry areas were the main areas in this shop where ergonomic factors were observed. The most active areas included the pressing, washing and drying, and tailoring areas. The pressing seemed to be very dynamic and repetitive. Some of the pressing areas required a high level of reaching and precision gripping. The washing area was less repetitive due to the batch nature of the process; however, available space and cart handling appeared to present some problems. Finally, there appeared to be problems in the tailoring section due to nonadjustable workstations. Activities in other areas were not evaluated.

The pressing area contained twelve pressing machines (six for shirts and six for pants). An overhead conveyor for finished items ran by every pressing station on the floor. The pressing machines were of fixed height and equipped with foot pedals and hand levers on top of the pressing lid to control steam. A hand iron was often used to remove wrinkles before the main pressing operation began. The irons were of standard design with a lever to provide steam when needed.

One concern with pressing is the dynamic nature of the task. Although pressers did not perform a lot of heavy lifting, they did perform highly repetitive tasks. Awkward postures and excessive reaching were also observed. Some pressers of smaller stature were required to reach beyond their anthropometric envelope because work stations and equipment were not adjustable. This was true when using the material rack. The rack was approximately six feet off the ground. Shorter employees were required to frequently reach well overhead when hanging pants or shirts. Although the dynamic nature of this task is primarily limited to the upper extremity, the static posture of the lower extremity may also present problems. Aside from scheduled breaks the employees stood on a concrete floor throughout the day. The pressing stations did not appear to have any floor mats.

The operator's task did not seem as repetitive as the presser's tasks. This is because dry cleaning is performed as a batch operation; whereas pressing must be done individually. Operators do perform reaching and manual material handling activities. Individuals that loaded and unloaded the washers and dryers had little room to maneuver. Additionally, the carts used to transport clothing appeared to be difficult to handle.

Tailoring was performed in a separate room near the rear of the building. Individuals in this area generally work three to four hours per day. The sewing stations consisted of four standard sewing machine tables with a box of sewing accessories perpendicular to the employee near the end of each table. Work space lighting seemed to be sufficient with a separate lamp attached to each sewing table to augment general lighting. One of the two employees hunched over his work to compensate for the nonadjustable workstations. The lack of adjustable sewing tables and chairs caused the larger employees to adjust their position. This position along with abduction, adduction, and rotation of the shoulders and upper arms could cause neck and shoulder musculoskeletal irritation and strain. The only other employee tailoring clothes was of smaller stature and seemed to reach farther when manipulating material and operating the sewing machine.

Most of the conventional laundry was cleaned on the second floor. This floor had a washer and dryer, a shirt pressing, and an employee break area. The washers and dryers were along the wall with the clothes categorized by type and material in the center of the room. Employee tasks in this area included sorting clothes and loading and unloading the washers and dryers.

The shirt pressing area consisted of four separate workstations. Each station contained four pieces of equipment, with the following functions:

> One machine devoted to pressing sleeves (Cabinet Bag Sleever): sleeves are fitted over two vertical posts and slid into the presser one shirt at a time.
>
> Two machines for pressing collars and cuffs (Collar and Cuff Laundry Press), similar to a regular press: The collar and cuffs are laid across the presser one shirt at a time on each machine.
>
> Also one machine designed for pressing the back and front (Buck Cabinet Bosom, Body, and Yoke Press): The shirt is fitted over a vertical plate and slid into the presser, one shirt on each plate but two plates per presser with an alternating pressing operation.

The machines were located in an area approximately 7 x 6 feet. One corner of each station had a small opening for egress and placement of a rack for pressed shirts. Normally two people work at a station. One operates the collar/cuff and sleeve presser, while the other operates the front/back presser. They alternate at mid-day. During our visit, there was only one person per station.

Unlike the other presses, these machines performed the pressing operation automatically. The automatic nature of the pressing operations allowed the employee to work at a faster pace. Workers went from machine to machine spending no more than ten to fifteen seconds on each machine. The tasks were highly dynamic and repetitive. Reaching and precision gripping were required. These actions combined with a high frequency could present musculoskeletal problems to individuals working in this area. Some of these observations could change if two employees worked at each station.

This initial assessment found some potential problems, but more intensive job analyses and surveillance is needed. Research, analysis, and documentation should be conducted to assess the impact of other variables such as thermal stress from the hot and humid environment. Investigators might examine the entire operation with respect to the psychological effects of incentive pay on physical performance.

CONCLUSIONS AND RECOMMENDATIONS

This large dry cleaning facility did not appear to have adequate controls to maintain PERC 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 major contributing factors to high levels of PERC in the atmosphere appeared to be the many leaks in the system and lack of adequate ventilation and vapor recovery during the transfer operation.

If ventilation and vapor recovery of the dryer were improved, PERC exposure would fall. A local exhaust hood should be installed near the washer door, or an efficient, integral exhaust and vapor recovery system should be used to capture concentrated PERC vapors. The machines in use are older and less efficient than modern systems. Equipment should be used as designed. Dry-to-dry equipment should not be used in the transfer mode; if current amounts of clothing can't be cleaned, then more equipment should be purchased. Modern closed loop systems utilizing a carbon adsorber and refrigerated condenser are more effective than the transfer system in use.

Although air was circulating, fans should be arranged to move contaminated vapors away from the employees. Local ventilation problems should be resolved prior to improving the general ventilation. Local ventilation is much more effective and economical than general ventilation.

Process isolation could be improved. Isolating the machines from the rest of the shop would help contain the solvent leaks and vapors exiting the machine. PERC delivery by an outside firm is an effective way to prevent dry cleaning operators from directly handling solvents.

All leaks should be repaired promptly. Proper maintenance can be instrumental to reducing leakage. Leaks are more easily seen if proper maintenance and housekeeping is performed within the shop. Lint build-up is a real problem in most dry cleaning shops. If lint is allowed to accumulate 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.[26] 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.[27]

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.[28]

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 129 minutes based on room concentrations)[29]. 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.[30]

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 the following:

- 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; and
- use of certified respirators which have been designed according to standards established by competent authorities.[24]

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 have a perchloroethylene breakthrough time in excess of eight hours.[31] A 1987 study showed that unsupported nitrile was impervious to perchloroethylene after a two hour challenge period.[32] 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.

Many of the ergonomic hazards at this facility involved repetitive motions and awkward postures. Most of these problems occurred at the pressing stations. A number of measures could be taken in order to control these hazards. Frequent breaks and worker rotation are often used to control the hazards of repetitive tasks. This appears to be a feasible option at this facility. Redesign of the workstation could be used to eliminate many of the awkward postures and excessive reaching performed.

Based upon the information gathered during this walk-through, Teasdale Fenton Cleaners appears to be a shop where an in-depth study of workplace hazards and control measures would be of value. Specific areas which would be useful to examine in greater detail at this shop include the following: leakage of equipment, efficiency of the vapor recovery system, real-time analysis of manual tasks, residual emissions, fault tree analysis of the operation, and ergonomic hazards. 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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