WALK-THROUGH SURVEY REPORT:

PERCHLOROETHYLENE EXPOSURES IN COMMERCIAL DRY CLEANERS

at

Springdale Cleaners
Cincinnati, Ohio

REPORT WRITTEN BY:
Gary S. Earnest

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
4676 Columbia Parkway, R5
Cincinnati, Ohio 45226

PLANT SURVEYED:	Springdale Cleaners 365 West Kemper Road Cincinnati, Ohio 45246
SIC CODE:	7216
SURVEY DATE:	January 14, 1993
SURVEY CONDUCTED BY:	Gary S. Earnest William A. Heitbrink Marjorie A. Edmonds
EMPLOYER REPRESENTATIVES:	Dora Hibbler, Manager Paul Dehler, Owner
EMPLOYEE REPRESENTATIVES:	No union
MANUSCRIPT PREPARED BY:	Deanna L. Elfers

DISCLAIMER

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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] 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 will then 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 Springdale 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

Springdale Cleaners is a large commercial dry cleaner, located in Cincinnati, Ohio. There are approximately thirteen different Springdale Cleaner shops located throughout the city of which eight are franchises. Each shop does its own cleaning on the premises. There are no satellite shops. The focus of this walk-through survey was the shop located in the Springdale area. It was not a franchise.

Dry cleaning has been done at the Springdale area shop for approximately nine years. The shop is located in a single story building adjacent to a pizza pick-up/delivery store. The floor layout is shown in Figure 1. All of the dry cleaning equipment is on the first floor, except for the boiler and air compressor which are located in the basement.

The shop consumes an average of thirty gallons of PERC each month. On a typical day, twenty-eight, fifty pound loads are cleaned for a total of 1,400 pounds of clothes per day. There are approximately twenty-five employees at this shop. Half of the employees work on a part-time basis. The shop is open for business from 7:00 a.m. to 10:00 p.m., Monday through Saturday and Sunday 9:00 a.m. to 6:00 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]

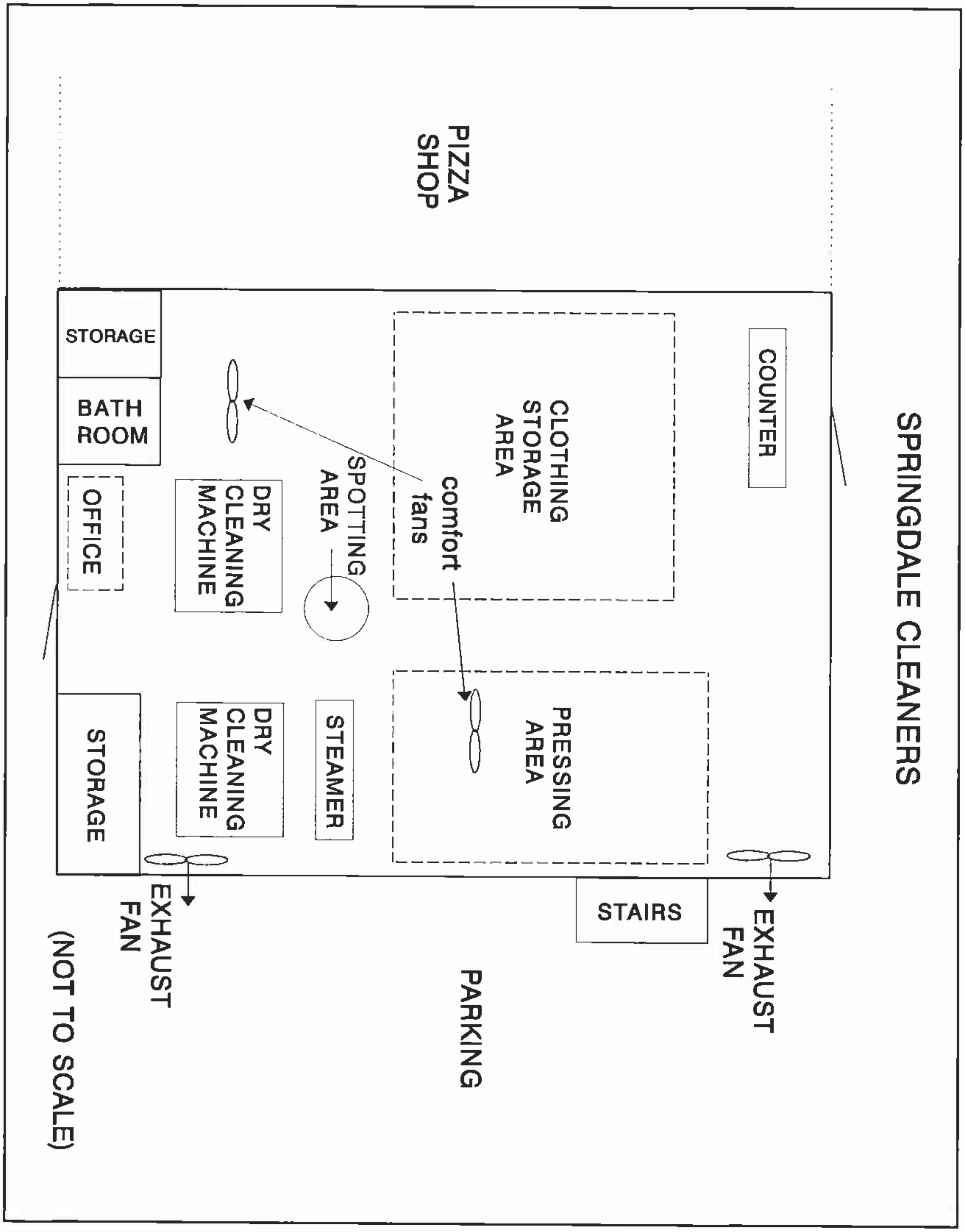

Figure 1. (Springdale Cleaners: Floor plan)

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 EPA.

PROCESS DESCRIPTION

Garments arriving at the shop are examined and tagged. 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 one of two Italian-made Rinzatchi®, enclosed, dry-to-dry, fifty-pound dry cleaning machines. These particular machines were distributed by the American Dry Cleaning Corporation. The machines were approximately six months old. Garments are washed in a PERC solution for approximately nine minutes, extraction takes about five minutes, and then twenty to twenty-five minutes are used for drying. 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 to capture PERC vapors before being exhausted to the room. After the drying cycle is complete, clothes are manually removed from the machine, and are loaded into a basket. They are then run through a steam tunnel to remove some of the wrinkles before going to the pressing station. After each garment is pressed, it is sorted, wrapped in plastic, hung back on the rack, and stored until pick up. A diagram of this process is shown in Figure 2.

A local contractor delivers approximately thirty gallons of PERC each month. 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 dual filtration system that uses both spin disc and cartridge filtration. Distillation is also used to help maintain solvent purity. Filtration removes most of the insoluble soils, and

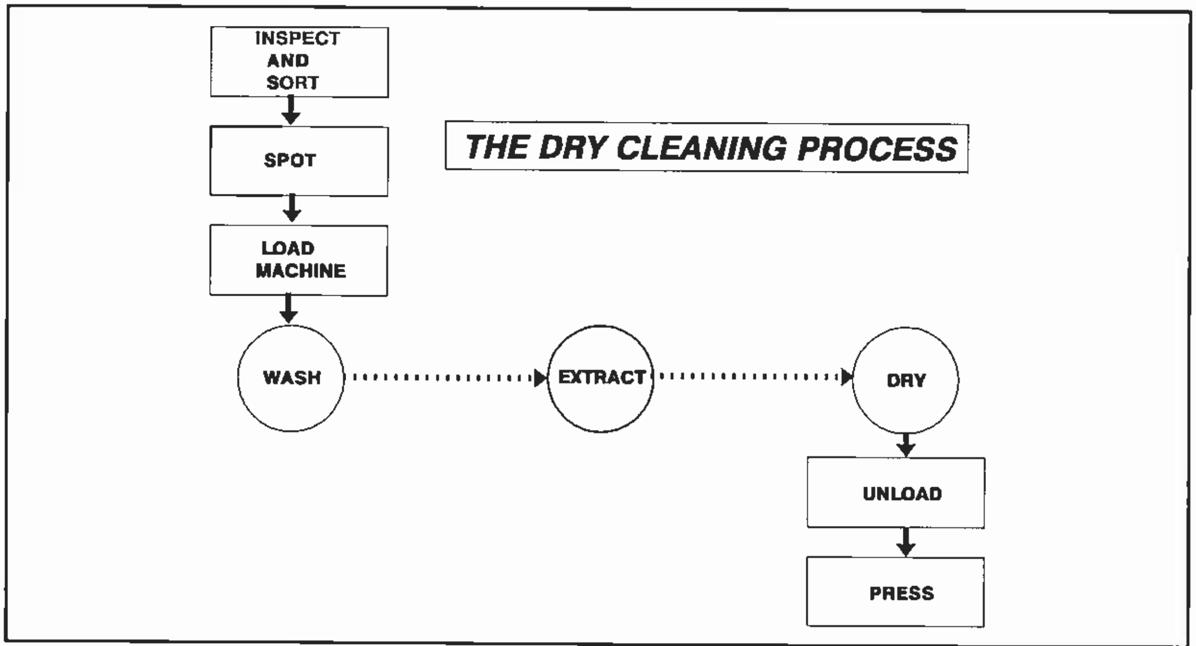

Figure 2. (Process flow diagram)

distillation removes most of the soluble soils. Figure 3 is a flow chart of the solvent pathway through the system.

Ventilation consisted of two large, propeller fans located in the wall. One was near the front of the building, and the other was in the rear behind the dry cleaning machine. The air was exhausted outside the building. Several comfort fans were located throughout the pressing area to circulate air.

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, perchloro-

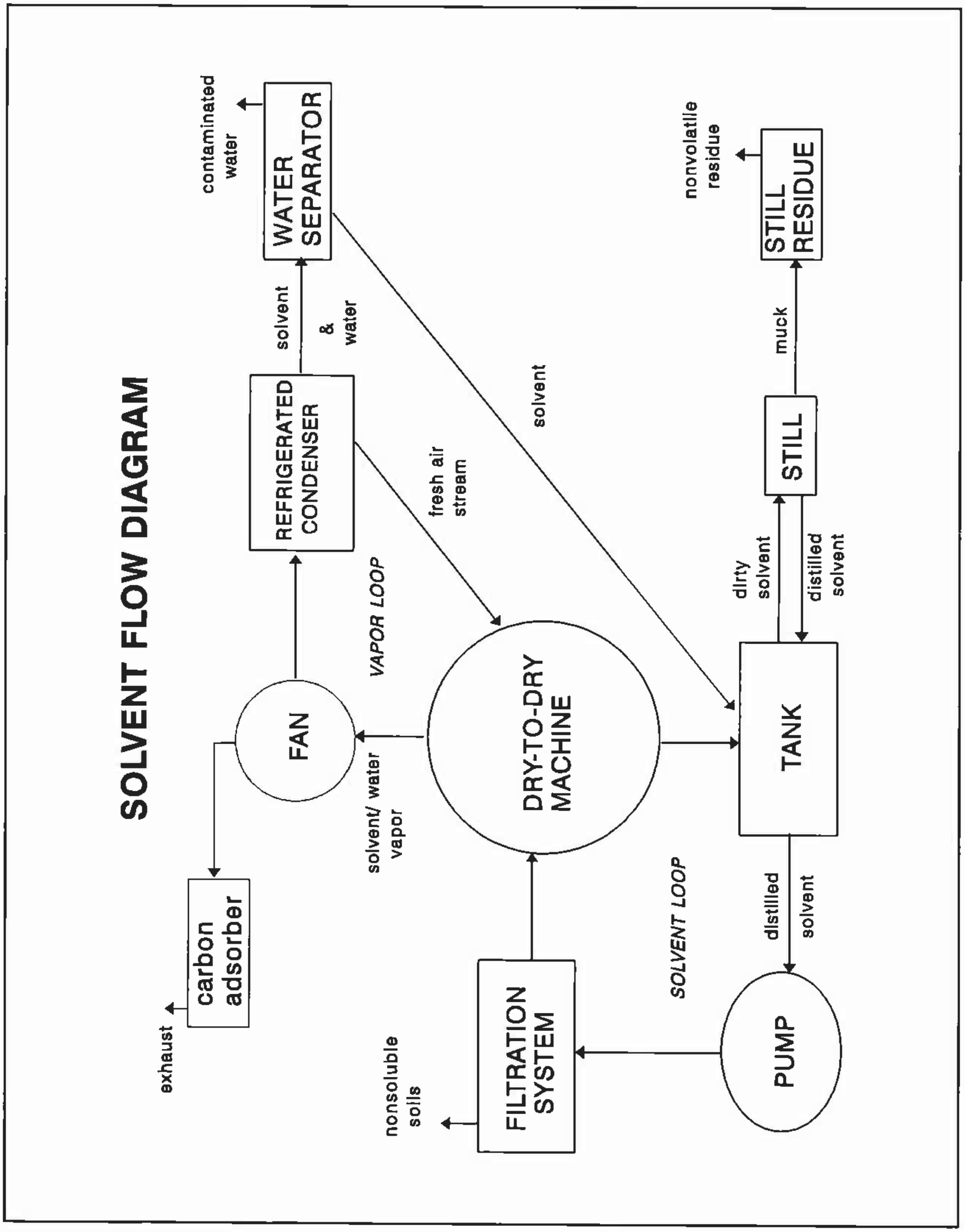

Figure 3. (Solvent flow diagram)

ethylene, 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.[1] 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.[12] 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.[13] OSHA had lowered the PEL to 25 ppm in 1989 under the Air Contaminants Standard.[14] 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.[15] NIOSH considers perchloroethylene to be a potential occupational carcinogen and recommends that exposure be reduced to the lowest feasible limit.[16]

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.

TABLE 1[17]

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		

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.[1,18] 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.[19]

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.[20]

General ventilation adds fresh air or removes general plant air to dilute 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 SPRINGDALE CLEANERS

Modern equipment substitution technology is being used at this facility. The machines currently used are dry-to-dry machines with features designed to comply with OSHA and EPA regulations. Some of the features of the machines are listed below:

- spin disc and cartridge filtration systems;
- system that reduces exhausting to the atmosphere; and
- refrigerated condenser and carbon adsorber connected to a fan activated by a door interlocking switch.

OBSERVATIONS

No solvent leaks were detected in this shop during the visit. This can probably be attributed to the fact that the equipment was only about six months old. There were no open containers with solvent or solvent contaminated items observed. A halogen leak detector was available and was used on a periodic basis.

General maintenance and housekeeping appeared to be adequate in this shop; however, improvements could be made. Many small shops like this have a lack of adequate space. The need for large amounts of equipment and clothing in the shop can compound the problem. Although the dry cleaning machines were new, other items such as the presses and equipment at the spotting station appeared to be in need of preventative maintenance.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment was not used regularly, with the exception of the maintenance personnel who generally wear gloves and occasionally wear a respirator or goggles when working on the machine. When examining the spotting station, two pairs of North chemical goggles were seen along with a pair of latex gloves. The owner stated that they were seldom used. There was no personal protective equipment training provided and no respirator fit testing. The owner requires all new employees to sign a standard HAZCOM form, which explains the hazards present, when they begin work.

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 10 and 25 percent.[21] Area samples measured in the single digits, with the exception of a peak exposure of approximately 40 ppm measured with Draeger® detector tubes when unloading machine 2. Sampling results are shown in Table 2.

Table 2. Detector Tube Measurements.

Area	Behind Machine 2	In front Machine 1	In front of machine 2 door closed	In front of machine 2 door open	Pressing Area
Conc. (ppm)	4	2	3	40	4

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 6,000 feet per minute. Airflow measurements taken when the machine doors were opened averaged between 30 and 40 feet per minute. These velocities were not adequate and may be responsible for peak exposure levels during the loading and unloading process.

General ventilation in this facility could be improved. There are two large propeller fans located near the ceiling on the side of the building. The fan located behind the dry cleaning machine appeared to be effective at exhausting air behind the machine; however, any contaminated air from the front of the machine was not captured. Rather, it probably diffused throughout the building. Average face velocity of the fans was between 6 and 10 feet per second. Smoke tubes indicated that the air behind the dry cleaning machine was exhausted from the shop; however, air in other parts of the building moved in no established pattern. General ventilation principles require that fans should be arranged to move contaminated vapors away from the employees.

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. There was one instance where detector tube measurements indicated PERC levels exceeding 25 ppm; however, this was not a time weighted average. This elevated measurement was probably the result of inadequate local ventilation around the door which was allowing vapors to escape from the machine.

Process isolation was not used in this shop, and would be difficult to do because of limited floor space. If solvent emissions became a significant problem, process isolation could help to reduce the number of employees exposed. Some facilities have used a wall or barrier within the shop to separate the dry cleaning machine area from other areas of the shop. The majority of PERC emissions originate from the machine. Isolating employees by either time or space will reduce exposure levels to the employee.

Because the machines were new, there were no visible leaks; however, if leaks develop, they 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.[12] 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.[22]

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.[23]

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)[24]. 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.[25]

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.[26]

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.[27] A 1987 study showed that unsupported nitrile was impervious to perchloroethylene after a two hour challenge period.[28] 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 capable of maintaining exposure levels below 25 ppm TWA. Control methods discussed in previous sections of the report could aid in reducing exposure levels. Based upon the information gathered during this walk-through, Springdale Cleaners appears to be a shop where an in-depth study would be of value. Areas which would be useful to examine in greater detail at this shop include the following: efficiency of the vapor recovery system, real-time analysis of manual tasks, residual emissions, and fault tree analysis of the operation. 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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