The Massachusetts Toxics Use Reduction Institute

Training Curriculum for Alternative Clothes Cleaning

TOXICS USE REDUCTION INSTITUTE

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Module 1 Introduction

Objective: *To introduce students to course objectives and background.*

This training course teaches garment care professionals and staff about a new way to clean garments. This new technique is called wet cleaning. The Toxics Use Reduction Institute at the University of Massachusetts Lowell has developed this course to explain how wet cleaning works and how to operate a wet cleaning facility. The course also explains how to convert from a dry cleaning facility to a wet cleaning facility.

1.1 Course Objectives

This course gives participants the information and experience they need to:

- *Understand how wet cleaning works*
- *Understand how to set up and run a wet cleaning facility*
- *Understand how wet cleaning and dry cleaning affect the environment, the health of workers, and public health in general*
- *Gain first-hand experience by actually cleaning garments using the wet cleaning method*

The course manual is divided into eleven training modules. Each module explains a topic related to the wet cleaning method. The objectives of each module are listed at the beginning of the module.

Certain words in this manual are printed in ***bold and italic*** type. These are special terms, such as "machine wet cleaning" or "cellulose." Each module contains a section titled "What Does That Mean?" that defines these special terms.

Words printed in bold and italic are defined in a section called "What does that Mean?" in each module

1.2 What is Wet Cleaning?

Wet cleaning is both an old method and a new method for cleaning garments.

Wet cleaning is both an old method and a new method for cleaning garments. Water has been used to clean clothes for centuries. Inventors, scientists and engineers have also been working for centuries to discover new methods to clean clothes quickly and efficiently. By the 1930's, the dry cleaning method became very popular as an affordable and efficient method for cleaning a wide variety of garments.

One concern with dry cleaning, however, is that it uses chemicals that can be hazardous to garment care workers and to the environment. Because of these hazards, scientists and engineers began looking for a cleaning method that does not use hazardous chemicals. They came up with a number of new methods which are addressed in Module 5. One new method is machine wet cleaning, which uses water and detergents to clean clothes.

It is not the use of water that makes wet cleaning a new method for cleaning clothes. New computer-controlled wet cleaning machines, new dryers, new detergents and new spot removers are what make wet cleaning a new method. The new washing machines and dryers have controls that allow them to safely and efficiently clean a wide variety of garments in water. New detergents and spot removers are made of ingredients that are safer for workers and the environment, yet are as safe and effective at removing soils, stains and odors as dry cleaning solvents. Equipment, detergents and skill all contribute to successful wet cleaning

In this course, participants will learn about cleaning garments using the wet cleaning process.

In this course, participants will learn about cleaning garments using the the wet cleaning process. It is hoped that after taking this course, participants will be motivated to add wet cleaning methods to their daily operations.

1.3 Who Should Take This Course?

This course was developed for dry cleaning shop owners, managers, skilled operators or entrepreneurs who want to wet clean all or some of the garments processed in their shop. The course is designed to help garment care professionals make decisions about using wet cleaning in their daily operations. The course explains not only the wet cleaning method itself, but also explains the costs and benefits of wet cleaning.

The course assumes that the participants understand the commercial dry cleaning process. This makes it easier for participants to understand the differences and similarities between wet and dry cleaning. The training that accompanies this manual is centered around creative activities that will allow participants to use their experiences, knowledge and enthusiasm in the learning process.

1.4 Why Do We Need a New Way to Clean?

Environmental regulations are forcing many industries to change their processes.

The professional garment care industry is currently experiencing one of the greatest periods of change since it began. Two forces are driving this change: technology and regulations. The garment care industry is working on new equipment, new detergents and new cleaning methods. Some of this new technology is available now. Some of it is still being developed and tested. Environmental regulations are forcing many industries to change their processes. These regulations have also affected dry cleaners.

Dry cleaning using organic solvents such as camphene, benzene, gasoline and Stoddard solvent began in the mid-1800's. Since then, the garment cleaning industry has continually changed to keep up with consumer demand, new developments, and new regulations. The 1930's and 1940's were profitable years for the industry. It wasn't until the 1950's that the industry hit its first growth challenge: the automatic home washer and dryer. These new machines allowed consumers to clean more of their clothes at home. The 1960's dealt the biggest blow to the industry with the introduction of wash and wear clothing. In the 1970's the popularity of easily cleaned polyester fabrics meant that even fewer clothes were being taken to the cleaners. The coin-operated and discount dry cleaner arrived to challenge neighborhood businesses in the 1980's. In the 1990's, casual office wear has become more acceptable. This has caused the market for dry cleaning services to shrink again. Although casual office wear reduces the market for traditionally dry cleaned garments, it also provides a new marketing opportunity for wet cleaners.

The dry cleaning industry is also being affected by environmental regulations that have been introduced since the 1970's. These regulations are driving the industry to develop cleaning processes that do not use hazardous chemicals. Several new cleaning processes are currently being researched. The goal of this research is to create new processes that do not harm the environment, but are also efficient, effective and profitable.

These new processes include cleaning with liquid carbon dioxide, ultrasonics, ozone, and wet cleaning. At the time this manual was written, wet cleaning was the only practical, environmentally sound and potentially profitable new method. Therefore, the focus of this manual is on wet cleaning.

In this country, 80% of professional cleaners use *perchloroethylene* (or "perc") as their dry cleaning solvent and the remaining 20% use petroleum. Because most cleaners use perchloroethylene, this manual compares wet cleaning with perchloroethylene dry cleaning.

1.5 A Brief History of Wet Cleaning

In May 1992, an International Roundtable on Pollution Prevention and Control in the Dry Cleaning Industry was assembled by the United States Environmental Protection Agency (EPA) and its Design for the Environment Program (DfE). The roundtable was created to consider the health and environmental concerns associated with perchloroethylene dry cleaning. The roundtable participants included professionals from the dry cleaning industry and allied trades, researchers, environmentalists and government officials. These participants formed a partnership that evaluated many methods for reducing the risks to garment care workers and the environment that are associated with the use of perchloroethylene.

EPA's Design for Environment (DfE) staff conducted a test study of multiprocess wet cleaning.

In November and December of 1992, the EPA's Design for Environment (DfE) staff conducted a test study of *multiprocess wet cleaning* at the New York School of Dry Cleaning in New York City. In multiprocess wet cleaning, garments are inspected and pre-treated if necessary. The garments are then spot cleaned, steam cleaned or hand washed.

In this test, the cost and effectiveness of wet cleaning was compared to perchloroethylene dry cleaning. The results of the test are described in the EPA's report "Multiprocess Wet Cleaning— Cost and Performance Comparison of Conventional Dry Cleaning and an

Alternative Process," EPA 744-R-93-004, September 1993. The results stated that under certain situations, multiprocess wet cleaning can be technically feasible and economically competitive with perchloroethylene dry cleaning.

One possible problem this study identified was that multiprocess wet cleaning may require more manual labor than dry cleaning. Additionally, the long term effects on garments were not evaluated. For this reason, dry cleaners may not want to use the multiprocess wet cleaning method. Since the test was done, however, new wet cleaning machines have become readily available. The wet cleaning machines reduce the amount of cleaning that needs to be done by hand. This makes *machine wet cleaning* more efficient than multiprocess wet cleaning, and more attractive to dry cleaners.

...under certain situations, multiprocess wet cleaning can be technically feasible and economically competitive with perchloroethylene dry cleaning.

A second problem related to wet cleaning has been Federal labeling requirements. Current United States Federal Trade Commission (FTC) care labeling rules discourage dry cleaners from wet cleaning garments labeled "dry clean only." The FTC published two requests for public comment on their labeling rules, one in June, 1994, and another in December, 1995. The FTC wanted to know if it should change these rules in order to (among other things) help the EPA's goal of *pollution prevention* in the dry cleaning industry. These rules are currently under review.

The DfE roundtable was also given the job of developing pollution prevention awareness and practices in the dry cleaning industry. One of the products of this group is the Cleaner Technology Substitutes Assessment (CTSA). This study is designed to evaluate garment cleaning methods that could be used instead of perchloroethylene dry cleaning. The study looks at these alternative cleaning methods from environmental, health, and economic points of view. Another role of the study is to communicate information about alternative cleaning methods.

In order to gather information for the study, a demonstration project has been established with partial funding from the EPA. The goals of the demonstration are to examine some of the issues and concerns surrounding garment wet cleaning. This project has resulted in a partnership between a private entrepreneur and the Center for Neighborhood Technology (CNT) in Chicago. CNT is a Chicago-based non-profit organization dedicated to environmentally sound, local economic development. The demonstration involves a garment care shop, “The Greener Cleaner,” which opened to the public in May 1995. “The Greener Cleaner” uses machine wet cleaning.

A garment wet cleaning business depends on customer acceptance in order to be successful. CNT evaluated “The Greener Cleaner” by using customer survey cards and by having volunteers evaluate how well garments were cleaned. Complete results of the CNT study can be obtained by contacting CNT directly. (CNT’s address is listed in Appendix B.)

Many commercial cleaners use wet cleaning as a critical supplement to their cleaning process.

Wet cleaning technologies have proven to be viable in Europe. In the past few years, these wet cleaning technologies have begun to spread in the United States. Many commercial cleaners use wet cleaning as a critical supplement to their cleaning process, and there are a growing number of wet clean-only facilities across the U.S. The USEPA’s Design for Environment program has a brochure on wet cleaning (doc. # EPA 744-K-96-004) which list wet cleaners nationwide. See Appendix B for EPA’s information hotline and website for the most current information

What Does That Mean?

multiprocess wet cleaning — a wet cleaning process in which garments are inspected and pre-treated if necessary. The garments are then spot cleaned, steam cleaned or hand washed.

machine wet cleaning — a process for cleaning textiles in water by professionals using special equipment and detergents. Machines carefully control mechanical action, temperature and humidity. It is normally followed by restorative finishing procedures.

organic solvent — a solvent that contains carbon in addition to other substances.

perchloroethylene — an organic solvent frequently used in dry cleaning and as a spot cleaner. Other names for perchloroethylene are: tetrachloroethylene, PCE, and perc.

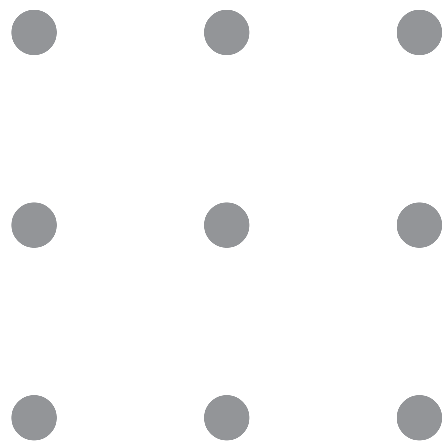
pollution prevention — solving pollution problems by preventing the pollution from occurring in the first place. This is frequently done by eliminating or reducing the amount of materials, hazardous or otherwise, that are used in a process, so that less pollution is created. Elimination is the preferred method of pollution prevention.

solvent — a liquid that is able to dissolve other materials. Water is the most common solvent. Most solvents are only able to dissolve certain types of materials.

Activity 1   Developing Problem Solving Skills

Objective: *This activity is designed to introduce new problem solving skills.*

Task: *Without lifting your pen or pencil from the paper, connect all nine dots with four straight lines. Do not retrace lines or fold the paper.*



Module II Health, Safety and Environmental Regulations

Objectives: *By the end of the module participants will be able to:*

- *Understand the worker, environmental, and public health and safety issues involved in the wet cleaning and dry cleaning processes*
- *List the Federal and state agencies that create regulations governing the garment care industry*
- *List and describe the major regulations that apply to wet and dry cleaning*

Regulations are one of the primary forces that are changing the commercial cleaning industry.

Regulations are one of the primary forces that are changing the commercial cleaning industry. These regulations have been created because Federal and state governments are concerned about the potential hazards involved in garment cleaning processes. This module describes these hazards, the agencies that regulate the garment cleaning industry, and the regulations that are currently in effect.

2.1 What are the Hazards?

Perc can be a hazard to workers and to the environment if it is not used and disposed of properly.

Most of the regulations that are currently in effect are designed to limit the amount of perchloroethylene that comes in contact with workers and the environment. Perchloroethylene, also known as *perc*, can be a hazard to workers and to the environment if it is not used and disposed of properly.

2.1.1 Acute & Chronic Exposure

There are two types of exposure to perc: acute and chronic. Acute exposure to perc occurs when people are exposed to perc for a short amount of time (under 24 hrs). Acute exposure to perc may cause drowsiness, nausea, and irritation of the eyes, skin and respiratory tract.

Chronic exposure may occur when people are exposed to perc repeatedly over a long period of time. Garment care workers have the biggest risk of chronic exposure, because they can be repeatedly exposed to perc at work. The public can also be at risk, however, when perc from a dry cleaning plant gets into the local air and water. Chronic exposure to perc can cause central nervous system damage, and to a lesser degree, lung, liver and kidney damage. The central nervous system effects include irritability, headaches, fatigue and *vertigo*.

There is ongoing debate about whether or not perc is a *carcinogen*, or cancer-causing substance. Different agencies have taken different positions on this question. The U.S. Environmental Protection Agency (EPA) considers perc a suspected carcinogen. The National Institute for Occupational Health and Safety (NIOSH) recommends that perc be handled as a human carcinogen. The International Agency for Research on Cancer (IARC) classified perc as a probable carcinogen in 1995.

2.1.2 Exposure to Workers and Others

Workers are at an especially high risk of occupational exposure in shops where "transfer machines" are used.

Workers are at an especially high risk of occupational exposure in shops where "transfer machines" are used. Transfer machines are dry cleaning machines where the washing and drying take place in two physically separate machines. After the wash cycle is finished, workers have to manually transfer clothes saturated with perc from washers to dryers. During this transfer, workers may be exposed on the surface of the skin, such as arms and hands, when their skin comes in contact with the wet clothes. This is called *dermal exposure*. Even more important, workers may be exposed to perc when they breathe in the fumes while transferring the clothes. This is called *inhalation exposure*.

Currently, there are about 10,000 transfer machines in use. Carbon adsorbers and refrigerated condensers are used to control *emissions* and are currently installed in about half of the transfer machines in operation. Newer machines do not require workers to physically transfer clothes from the washer to the dryer. These newer "closed loop dry-to-dry" machines also have many safety features that help prevent perc from coming in contact with workers or the environment. Dry-to-dry machines allow a dry cleaner to process a load of garments without coming in contact with perc-saturated clothes. Transfer machines can no longer be sold in the U.S., so all the dry cleaning equipment currently available includes these new controls.

People who work in dry cleaning shops have the highest risk of exposure to perc. People living near or above these shops who spend a great deal of time at home, such as the elderly or pregnant women, also can be exposed to perc for extended periods of time.

People living near or above these shops also can be exposed to perc for extended periods of time.

2.1.3 Environmental Effects

The use of perc, regardless of the type of equipment used, may result in some emissions to the air, water or soil.

Perc evaporates quickly when released to soil or surface water (rivers, lakes, oceans, etc). When exposed to sunlight, it breaks down rapidly. When perc gets into water, it does not significantly affect organisms that live in the water. In general, it is not absorbed by aquatic organisms and does not tend to build up in their bodies. A small percentage of the perc in water, however, will be absorbed by microorganisms and enter the food chain.

Currently, there are over 30,000 dry cleaners in the United States, 80% of whom use perc. The total amount of perchloroethylene used for dry cleaning in this country in 1994 was estimated at over 11 million gallons (approximately 147 million pounds). After it has been used, perc may end up as:

- emissions into air
- emissions into water and soil
- hazardous waste

Perc is one of the ten most common contaminants found in groundwater. A Federal survey reported that perc, from all commercial and industrial sources, is present in about 26% of U.S. groundwater supplies. The California Air Resources Board estimates that 30% of the total perc used—3.3 million gallons—ends up as hazardous waste. It is estimated that recyclers can recover up to 80% of the waste generated—2.64 million gallons. Although these recovery figures are impressive, the fact remains that hundreds of thousands of gallons of waste are generated each year which could potentially contaminate the environment.

2.1.4 Environment, Health and Safety in Wet Cleaning

Wet cleaning does not produce hazardous waste or air emissions.

Because perc is not used in the wet cleaning process, wet cleaners do not need to worry about perc related environmental health and safety problems. Wet cleaning uses water as the solvent. The detergents, stain removal agents and finishes used in wet cleaning are generally non-toxic. Companies that produce wet cleaning detergents, stain removers and finishes are sensitive to environmental and t*oxicological* concerns and are producing products that are phosphate free and *biodegradable*.

Data collected by the Center for Neighborhood Technology at the Greener Cleaner show that wet cleaning does not produce hazardous waste or air emissions. Workers, customers and people who live and work near a dry cleaner might benefit from the introduction of wet cleaning and the resulting decrease in the use of perchloroethylene.

One environmental health and safety concern that does apply to wet cleaning is the use of toxic solvents during stain removal.

One environmental health and safety concern that does apply to wet cleaning is the use of toxic solvents during stain removal. A new shop with a 100% wet cleaning operation would probably not use toxic stain removal agents, but a shop that has used perc and converted totally or partially to wet cleaning may still use these chemicals at the stain removal board. Non-toxic stain removal agents are currently available from several different sources and should be used on garments that will be wet cleaned. If the plant operator or owner continues to use toxic stain removal agents, the waste generated by the process should be treated as hazardous waste.

2.2 Who Makes the Rules?

The federal Occupational Safety and Health Administration (OSHA) and state labor departments are in charge of ensuring the safety and health of workers inside the plant. The federal Environmental Protection Agency and the state departments of environmental protection are in charge of regulating pollutants emitted or transferred from the plant. This is because the legislature and regulatory agencies have always considered worker health and safety issues to be separate from environmental protection issues. Some state agencies are starting to combine environmental protection with worker health and safety. This has resulted in state programs to reduce the use of toxic chemicals in processes. However, the regulations that are currently in effect are still mainly divided into environmental regulations and health and safety regulations.

This section presents the minimum compliance requirements of a dry cleaner based on the Federal regulations. Individual states can make regulations of their own that are even stricter than the Federal regulations. When states make their own regulations, the garment cleaning industry only needs to report to and follow the rules of that state. For example, New York and California are two states that have decided to make their own regulations. Anyone who intends to own or operate a professional garment care facility should research state and local regulations to determine which regulations apply in his or her state.

Since 1970, the U.S. Congress has passed several laws designed to protect and improve environmental and public health. The laws set standards for limits of chemical releases to air, water and soil. These laws originally targeted industries that use large quantities of toxic substances. As these industries have come into compliance, the focus has turned toward industries that use small quantities of toxic substances.

2.3 What Rules are Currently in Effect?

The federal regulations outlined below apply to dry cleaning operations. Perc is listed as a hazardous substance under the Occupational Safety and Health Act (OSHA), the Resource Conservation and Recovery Act (RCRA) the Clean Water Act (CWA), the Clean Air Act (CAA), and the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA). A dry cleaner that uses perc must comply with these regulations.

Complying with these regulations can affect a dry cleaner's profit margins. The costs associated with compliance include:

- liability insurance
- permitting fees
- hazardous waste disposal fees
- equipment upgrades
- contaminated site clean up
- time spent learning and complying with regulations

Shifting to a mix of wet cleaning and dry cleaning can provide relief from regulatory requirements imposed on dry cleaners.

Shifting to a mix of wet cleaning and dry cleaning can provide partial relief from some of the regulatory requirements imposed on dry cleaners.

For example, some of the Clean Air Act regulations are based on how much of a toxic chemical is used by a facility. Small garment cleaning businesses with a dry-to-dry machine installed before 1991 are required to upgrade their equipment under the CAA if they purchase more than 140 gallons of perc each year. By switching some cleaning to wet cleaning, a business may be able to reduce its purchases below the 140 gallon limit. Once below 140 gallons, the business would be exempt from the upgrade requirement.

2.3.1 Occupational Safety and Health Act

The Occupational Safety and Health Act of 1970 was passed to protect the health of the worker in the workplace environment. The Act is administered by the Occupational Safety and Health Administration (OSHA). The Act sets limits on the amount of toxic materials that workers can be exposed to in their workplaces.

The Occupational Safety and Health Act of 1970 was passed to protect the health of the worker in the workplace environment.

2.3.1.1 Permissable Exposure Limits (PELs)

Both long-term and short-term exposure limits have been established. These limits are called the *Permissible Exposure Limits (PELs)*. The long-term limits refer to a worker's allowable average exposure during a normal 8-hour workshift of a 40-hour work week. The average exposure limit takes into account how long a worker is exposed to different levels of the chemical. This average is call the *Time Weighted Average (TWA)*. The overall average exposure for any 8-hour workday of a 40-hour work week cannot be greater than the PEL.

The current long-term PEL for perc is 100 parts per million (ppm). In 1989, because of concerns about whether the 100 ppm limit is low enough to protect workers, OSHA reduced the limit to 25 ppm. Dry cleaners had until December 31, 1991 to meet the new standard. In fact, many dry cleaners have installed control equipment to control emissions so that they meet the 25 ppm PEL. However, soon after the 25 ppm standard was issued, a suit was filed by industry groups to challenge the new limits and a court decision threw out the 25 ppm limit. As a result, currently OSHA can only enforce a PEL of

100 ppm but still recommends that dry cleaners limit indoor air emissions of perc to 25 ppm. Several state occupational agencies continue to enforce the 25 ppm limit. In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) and the perc manufacturers also recommend 25 ppm as an 8-hour TWA. Currently, negotiations are under way to reduce the PEL again, with some public interest groups recommending levels as low as 5 ppm.

In addition to the long-term PEL, two short-term exposure limits have been established by OSHA. These are designed to protect workers from high exposures that might occur occasionally throughout the work day. In dry cleaning, this might occur when opening the machine to remove the clothes, when cleaning the still or filter housings, when cleaning out the button trap, or at any other time when perc vapors are in close contact with the worker.

The OSHA short-term PELs for perc are 200 ppm averaged over 15 minutes, and 300 ppm averaged over 5 minutes. The 5 minute maximum (peak) exposure can only occur once in any 3 hour period. ACGIH recommends a short-term exposure limit of 100 ppm, averaged over 15 minutes.

2.3.2 Resource Conservation and Recovery Act

Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976 regulates what is done with hazardous waste that is generated at facilities. The regulations only apply to facilities that generate more than 100 kilograms (220 pounds) per month of hazardous wastes. Facilities that generate less than this amount are considered small quantity generators and are exempt from this regulation.

Solid wastes and waste water from wet cleaning processes are not considered hazardous under RCRA.

Waste that contains perc is one of the hazardous wastes regulated under RCRA. In the case of a dry cleaner, this waste could consist of still bottoms, cartridge filters and filter muck. This waste must be disposed of at a licensed hazardous waste facility (40 CFR §260- 270).

Some water used in the dry cleaning process becomes contaminated with perc. This occurs when water is used by emission control devices and perc filtration devices, and when water is used to maintain these devices. Waste water generated by dry cleaners, even though only slightly contaminated, is considered hazardous waste under RCRA. The hazardous waste code for this type of waste is F002.

Separator water is also considered hazardous waste because it may contain as much as 150 ppm of perchloroethylene.

Solid wastes and waste water from wet cleaning processes are not considered hazardous under RCRA. Some stain removal agents may also generate hazardous waste.

2.3.3 The Clean Air Act (1977) and Clean Air Act Amendments (1990)

The Clean Air Act Amendments added perc to the list of hazardous air pollutants.

The Clean Air Act of 1977 (CAA) and the Clean Air Act Amendments of 1990 (CAAA) also affect dry cleaners. The CAAA added perc to the list of regulated hazardous air pollutants. In September 1993 the CAAA put out the National Emission Standards for Hazardous Air Pollutants (NESHAP), which regulates emissions of perc by dry cleaners. These standards limit the amount of emissions of regulated hazardous air pollutants including perc.

The CAAA requires that dry cleaners keep track of their use of perc and its disposal. It requires dry cleaners to change their operating procedures and modify their existing equipment to meet new air emissions standards. It also requires that all newly purchased dry cleaning machinery be equipped with control technology. These standards also prohibit the sale of transfer machines. Federal law requires that the industry be in compliance with the perc NESHAP by September 23, 1996.

New Source Performance Standards (NSPS) were put into effect in 1984 for petroleum based dry cleaners. The NSPS's are enforced only in Clean Air Act non-attainment areas—those areas that do not meet national standards for ambient air quality. The NSPS's set limits on solvent loss in drying, set standards on the use of filters, and require leaks to be repaired in a timely fashion.

Wet cleaning processes are not regulated under the Clean Air Act.

Wet cleaning processes do not emit hazardous air pollutants that are regulated under the Clean Air Act.

2.3.4 Comprehensive Emergency Response, Compensation and Liability Act (1980) and Superfund Amendments and Reauthorization Act (1986)

The Comprehensive Emergency Response, Compensation, and Liability Act of 1980 (CERCLA), commonly referred to as Superfund, allows the EPA to respond to potential or actual releases of hazardous substances that threaten public health, welfare or the environment. Superfund also authorizes the EPA to require parties responsible for environmental contamination to clean up or pay back the Superfund for costs incurred by EPA to clean it up.

The CERCLA hazardous substance release reporting regulations (40 CFR Part 302) require the person in charge of a facility to report certain releases of hazardous substances. If the amount released is greater than the limit specified in the regulation (40 CFR § 302.4), then the person in charge must contact the National Response Center (NRC). This may trigger a response by the EPA or a number of state or Federal emergency response agencies.

The materials used in wet cleaning are not a source of liability under the CERCLA.

When a site is found to be contaminated, present or past landowners or dry cleaners can be held liable for any contamination found. The contamination may have resulted from a variety of situations, such as:

- contaminated waste water leaking through sewer pipes
- perc leaks during operation of a dry cleaning machine
- dumping of wastes

The materials used in wet cleaning are not a source of liability under the CERCLA.

2.3.5 Sewer or Septic Discharge

Water discharge from a dry cleaning or wet cleaning facility is subject to restrictions depending on the size of the facility and whether the discharge is to a publicly owned treatment facility or to a septic system. Specifically, the following restrictions apply:

- contact water (separator and vacuum water) must be disposed of properly as hazardous waste or may be evaporated under an EPA policy decision
- boiler blowdown water is regulated on a state by state basis
- vacuum water from the finishing equipment must be disposed of as hazardous waste
- waste from the stain removal board must be treated as hazardous waste

The waste water generated by a wet cleaning operation is discharged either to a municipal sewer—Publicly-Owned Treatment Works or POTW—or to a private septic system. Cleaners should always check with their local POTW, state agency or municipality before discharging into either a sewer or septic system since they may require that waste water must be non-toxic in order to avoid polluting the environment. This will ensure that it is legal to discharge their waste water and that no permits are required. For average size wet cleaning facilities, a discharge permit, a pretreatment system, or monitoring of discharge may not be required by the Publicly-Owned Treatment Works.

Cleaners should always check with their local POTW, state agency or municipality before discharging into either a sewer or septic system.

Discharge to septic systems is regulated by the local municipalities and the state. Waste from a professional cleaner is considered industrial waste, and, in many states, discharge into a septic system is prohibited.

The local regulating authorities, appropriate state agencies and the POTW should be notified during the planning stages of any wet cleaning or dry cleaning facility to determine any applicable regulations or permitting requirements.

2.4 What are the Potential Liabilities?

When new regulations are passed that restrict dry cleaning facilities, the public becomes more aware of the public health and environmental risks of perc. The professional fabricare industry, primarily composed of very small "mom and pop" operations, has been hard hit by these new regulations.

A cleaner who makes a partial or total switch to wet cleaning is subject to limited regulations, and in some cases, no regulations at all.

Landlords are wary of renting to dry cleaners because of the potential liability associated with perc. The cost of compliance and the potential for retroactive liability has affected the profit margin of many operations, forcing some owners to go out of business. Some families that in the past might have passed the family dry cleaning business down to the next generation must now be mindful that current retroactive liability laws may transfer past liability to the new owner.

These regulations have had far-reaching effects on the dry cleaning industry. Not only do dry cleaners need to comply with new Federal regulations by implementing expensive pollution control technology, they need to consider that their home state could pass even stricter regulations in the future. A cleaner who makes a partial or total switch to machine wet cleaning (or water based cleaning) is subject to limited regulations, and in some cases, no regulations at all.

What Does That Mean?

acute exposure — contact with a substance that occurs over a short period of time

biodegradable — able to be broken down into non—harmful substances by natural processes in the environment, such as sunlight, rain and wind

CAA — Clean Air Act of 1977

CAAA — Clean Air Act Amendments of 1990

carcinogen — a substance that causes cancer

CERCLA — Comprehensive Emergency Response, Compensation, and Liability Act

chronic exposure — contact with a substance that occurs over a long period of time

CWA — Clean Water Act

dermal exposure — exposure to a substance when the substance comes in contact with the skin

emission — the release of a substance into the air, water or ground

exposure — coming in contact with a substance. The contact can be on the skin, through breathing into the lungs, or by eating or drinking.

inhalation exposure — exposure to a substance that occurs when something in the air is breathed into the lungs

NESHAP — National Emission Standards for Hazardous Air Pollutants

NSPS — New Source Performance Standards

OSHA — Occupational Safety and Health Administration; the part of the Federal government that administers the Occupational Safety and Health Act of 1970

PEL — Permissible Exposure Limit; the maximum amount of a substance that a worker is allowed to come in contact with based on a daily or weekly average *perc* — a short name for perchloroethylene

RCRA — Resource Conservation and Recovery Act of 1976

toxicology — the science that studies the effects, antidotes and detection of poisons or adverse effects of chemicals on living organisms.

SARA — Superfund Amendments and Reauthorization Act

Superfund — another name for CERCLA

TWA — Time Weighted Average; the method used to calculate a worker's average exposure to a substance

vertigo — dizziness

Health, Safety and Environmental Regulations

Unknown MSDS's

Objective: *This activity is designed to introduce participants to the content and meaning of Material Safety Data Sheets (MSDS's).*

Tasks: *The pages following these instructions contain MSDS for four products. In each of your groups, try to identify what product is described by each MSDS.*

Module III

From Fiber to Garment

Objectives: *By the end of the module participants should be able to…*

- *Understand the relationship between fibers, yarns, fabrics and garments*
- *List and describe the effect of cleaning on fibers*
- *List and describe the effect of cleaning on fabrics*
- *Test a garment to find out what type of fiber it is made of*

3.1 Fibers, Yarns, and Fabrics

A customer walks into a cleaning shop and puts a garment on the counter. To the customer, the garment is only a shirt, or a pair of pants, or a dress. When a cleaner looks at that same garment, he or she sees much more than that. The cleaner sees that the garment is made from a particular type of fabric, and the fabric is made from a particular type of fiber.

This module describes the characteristics of fibers and fabrics.

To successfully wet clean the garment, the cleaner must understand how the fabric and fiber will react to the cleaning process. Fabrics and fibers react differently in water than they do in perchloroethylene or other dry cleaning solvents. Even an experienced fabricare professional must pay careful attention to fabric and fiber when wet cleaning.

This module describes the characteristics of fibers and fabrics. This module also explains the effect of the cleaning process on fibers and fabrics.

3.1.1 What Is a Fiber?

A fiber is a fine hair-like structure that is either natural or man-made. Natural fibers come primarily from plants and animals. Plant fibers come from the seeds of plants like cotton, or from stems like linen, ramie, hemp, or jute. Animal fibers come from the hair of certain animals. For example, the hair of sheep is used to make wool and the hair of goats is used to make cashmere and mohair. Silk fibers are spun by silkworms.

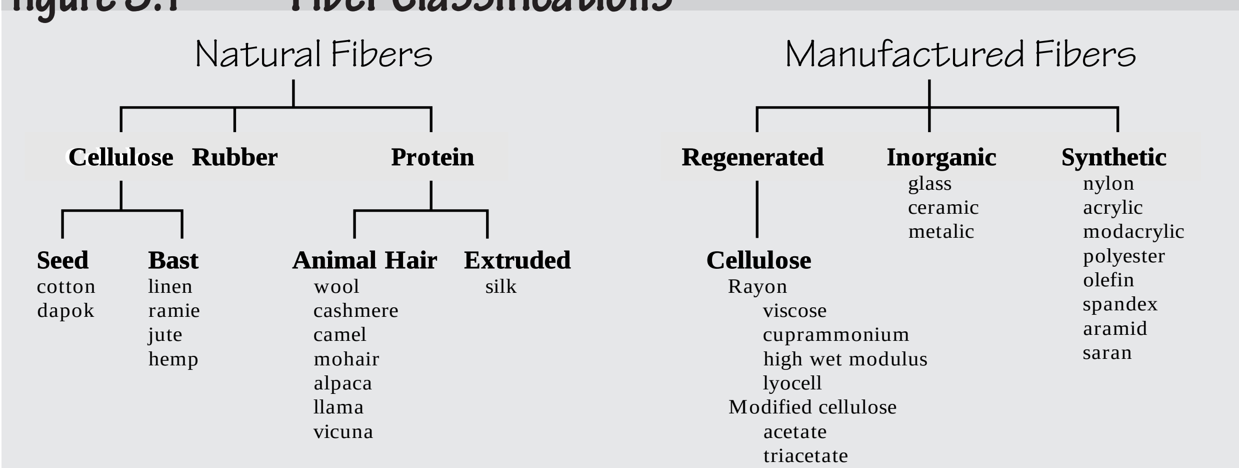
A fiber is a fine hair-like structure that is either natural or man-made.

Manufactured fibers, also called man-made fibers, were developed to provide properties that natural fibers do not have. Manufactured fibers are divided into two main categories: synthetic fibers and regenerated fibers. Synthetic fibers are created from polymers that come from chemicals like petroleum. Nylon, polyester and acrylic are all synthetic fibers. Regenerated fibers are created from polymers that come from natural materials. Rayon and acetate are both regenerated from ***cellulose***, a material that occurs naturally in plants. Figure 3-1 shows the major classifications of fibers.

Manufactured fibers are made using a process that is very similar to the process a spider uses to make strands for its web. Long chains of molecules called ***polymers*** are made into a liquid. This liquid is forced through tiny holes. As the liquid comes out of the holes, it hardens into fiber strands called ***filaments***, or strands of "endless" length.

Both natural and manufactured fibers can be made directly into fabric, such as felts and nonwoven textiles. However, fibers are usually twisted or grouped together into long strands called yarns. The yarns are then used to make a wide variety of knit and woven fabrics, as well as lace.

figure 3.1 Fiber Classifications



The length of the fiber helps to determine the properties of the yarn and of the fabric that is made from that yarn. Almost all natural fibers range in length from less than one inch up to 36 inches. These are called ***staple fibers***. The exception to this rule is silk. The silk worm spins filaments of silk that can be up to 1,600 yards long. Like silk, all manufactured fibers are also spun as filaments. Unlike silk, there is no limit to the length of manufactured fibers. However, these fibers can be cut into short or "staple" lengths if necessary.

3.1.2 Yarns

Yarns are used to make a wide variety of knit fabrics, woven fabrics and lace. The type of fiber used to make a yarn and the way the yarn is made determine the properties of the yarn and of the final fabric. These properties include strength, ***abrasion resistance, elasticity, luster, hand*** and overall surface characteristics.

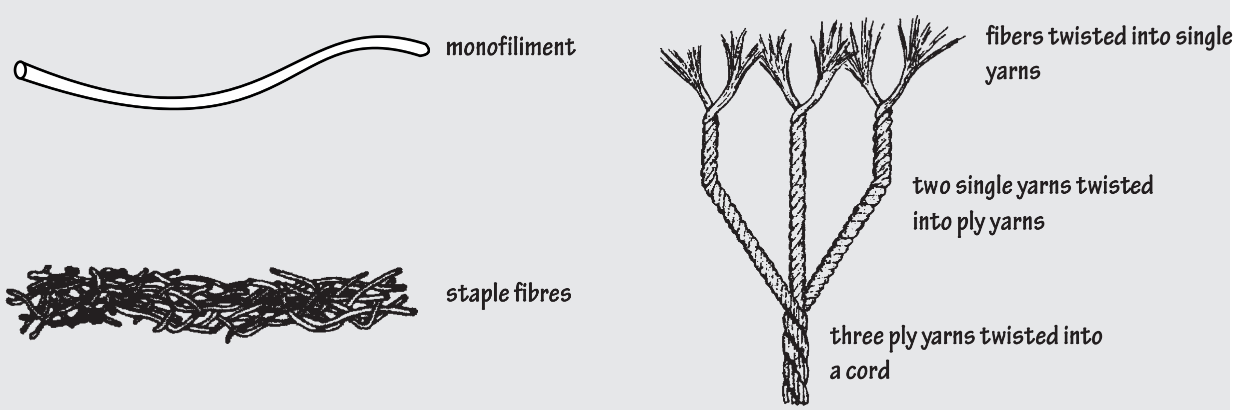
In many cases, fibers are twisted to make yarn. Increasing the twists or turns in a yarn will increase strength, crease resistance and abrasion resistance. Yarns that are more loosely twisted make softer fabrics.

Yarns are used to make a wide variety of knit fabrics, woven fabrics and lace.

Some yarns are made from a single type of fiber, while other yarns are made from more than one type of fiber. Multiple ply yarns are stronger than single yarns. Fancy yarns, like boucle or chenille, can be made to create decorative effects, and may take special care in cleaning. Figure 3-2 shows several different types of fibers and yarns.

Filament fibers are typically sleek and smooth. The surface of fabric made from filament fibers is therefore also sleek and smooth.

figure 3.2 Fiber and Yarns



Natural staple fibers tend to be rougher. The surface of fabric made from staple fibers will also be rougher, due to the exposed fiber ends. For example, nylon and silk fibers have round, smooth surfaces, and therefore nylon and silk fabric may feel smooth and slippery. Wool fibers have a round scaly surface, making wool fabrics feel bulky and slightly rough.

3.1.3 Fabric Types

The basic fabric types can be classified as woven, knitted, lace and nonwoven.

The basic fabric types can be classified as woven, knitted, lace and nonwoven. Woven fabrics consist of two sets of parallel yarns that are interlaced to form a fabric. The lengthwise yarns are called "warp." Warp yarns are held under tension throughout the weaving process. The crosswise yarns are called "weft" or "filling." Some examples of woven fabrics are plain, twill and satin weaves, as well as certain pile fabrics like velvet, velveteen and corduroy. Figure 3-3 shows some examples of woven fabrics.

The weaving process tends to create fabrics that are strong and do not lose their shape. The heavier the fabric and the tighter the weave, the more durable the fabric will be. This assumes, of course, that the yarn and fiber are also strong and stable. Fabrics that are tightly woven with delicate yarns, for example, can still be very fragile.

Knitted fabrics consist of one or more continuous yarns that are looped through themselves to form interconnected chains. Weft knits are the most common type of knits. Weft knits use one continuous yarn to form the fabric through a series of loops, and are easy to snag and run. Warp knits use a series of continuous yarns to form the

figure 3.3 Woven Fabrics

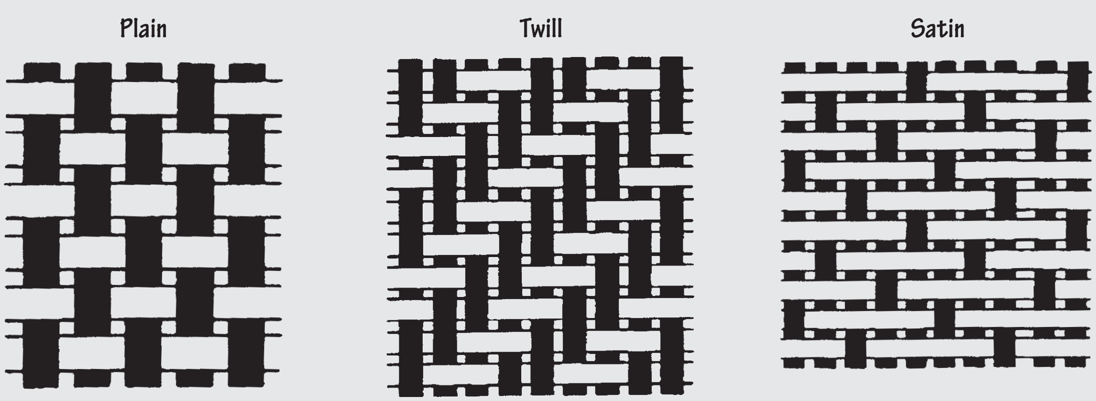
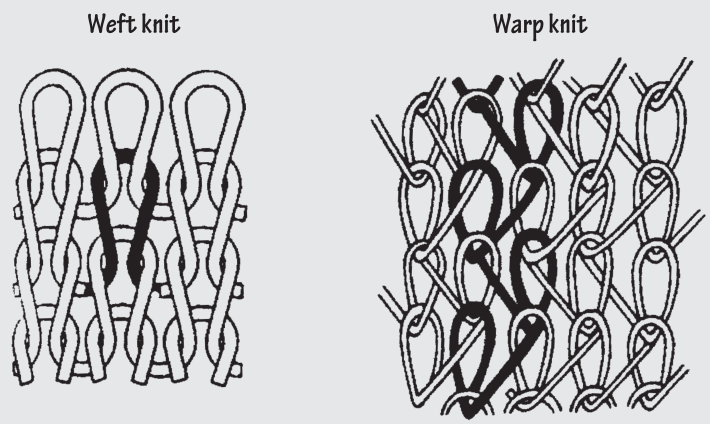


figure 3.4 Knits



fabric, giving the fabric more stability and less tendency to run. Figure 3-4 shows examples of warp and weft knits.

Knit fabrics tend to be more comfortable than woven fabrics because they stretch. This is an advantage for the person who wears the fabric. It can cause problems for the cleaner, however, because this tendency to stretch can cause the fabric to lose its shape when it is handled. Knitted fabrics also tend to shrink. Fortunately, knitted fabrics can be 'blocked' or stretched to recover their original shape and size.

Knitted fabrics consist of one or more continuous yarns that are looped through themselves to form interconnected chains.

Because some fabrics are constructed of loosely twisted yarns, pilling is often a problem. When a knitted fabric is rubbed repeatedly, small balls of fiber called "pills" build up on the surface of the fabric. This is called "pilling." Cleaners need to be careful not to cause pilling when they rub the surface of a knit fabric to remove soil or stains.

Lace is made of yarns that are knotted, twisted, or looped to provide a fragile, sheer pattern. When cleaning garments with lace, great care must be taken not to break the delicate yarns.

Nonwovens are fabrics made by bonding together a web of fibers through physical or chemical means. Felt is an example of a nonwoven fabric. Felt is made primarily from wool fibers. The felting process uses moisture, heat, mechanical action and chemical action to take advantage of the natural tendency of wool fibers to stick together. The result is a dense, bulky fabric. Imitation suede is another example of a nonwoven fabric.

Nonwoven fabrics tend to be weaker and more easily damaged by rubbing than woven or knit fabrics of the same weight. This is because nonwoven fabrics are made directly from fibers, and therefore do not benefit from the strength of yarns. Nonwoven fabrics are often used for interfacing. Nonwovens can be bonded to a fabric to make it more stable. This can cause problems for the cleaner. One problem is that the cleaning process can dissolve the adhesive and cause the two fabrics to separate, or "delaminate." Another problem is that one fabric may shrink more than the other, which can cause puckering.

Each type of fiber reacts differently to the wet cleaning process.

3.2 The Effect of Cleaning on Fibers

Each type of fiber reacts differently to the wet cleaning process. How a fiber reacts depends on a number of factors, including strength, elasticity, dimensional stability, absorbency and the effect of chemicals and heat. These factors have a clear influence on the way a garment should be handled in the wet cleaning process.

3.2.1 Fiber Strength

Fiber strength is a measure of the amount of force needed to cause a fiber to break. It is also called *tenacity*, and it is measured in grams/denier. Fiber strength can change when the fiber is exposed to water. Cotton and linen are the only fibers that get stronger when exposed to water. Rayons and acetates are examples of fibers that get significantly weaker in water. Polyesters and olefins, which are among the strongest of the common fibers, do not get weaker or stronger. The strength of these fibers is not affected by water at all. Figure 3-5 shows the wet and dry strength of different fibers.

The effect of water on fiber strength is very important for the wet cleaner in the stain removal and cleaning stages of garment care.

The effect of water on fiber strength is very important for the wet cleaner in the stain removal and cleaning stages of garment care. Because the strength of fibers can change when the fibers are wet, care must be taken when applying any force to wet fibers. For example, rayons and acetates, since they get significantly weaker in water, could be damaged by scrubbing or harsh agitation. Figure 3-6 shows the resistance of different fibers to abrasion.

Figure 3.5 Fiber Strength

	Dry (grams/denier)	*Wet* (grams/denier)
Acetate	1.2 – 1.5	0.8 – 1.2
Acrylic	2.0 – 3.5	1.8 – 3.3
Cotton	3.0 – 5.0	3.3 – 6.4
Linen	stronger than cotton	
Modacrylic	2.0 – 3.5	2.0 – 3.5
Nylon	3.0 – 6.0*	2.6 – 5.4
Olefin	4.8 – 7.0	4.8 – 7.0
Polyester	4.0 – 5.0*	4.0 – 5.0
Rayon	0.73 – 2.6*	0.70 – 1.8
Silk	2.4 – 5.1	1.8 – 4.2
Wool	1.0 – 1.7	0.8 – 1.6

* high tenacity nylon as high as 9.5 g/den
high tenacity polyester as high as 8.0 g/den
high wet modulus rayon – 4.5 g/den

3.2.2 Elasticity and Dimensional Stability

Elasticity is the ability of a fiber to go back to its original length after being stretched. Fibers that have good elasticity are those that return to their original length when stretched. Cotton, linen and rayon have poor elasticity, while wool, nylon, polyester and olefins are very elastic fibers. Fabric structure, which will be discussed in the next section, also has an influence on elasticity.

Elasticity is the ability of a fiber to go back to its original length after being stretched.

The *dimensional stability* of a fiber is its ability to maintain its original shape. Fibers with good dimensional stability do not shrink

Figure 3.6 Abrasion Resistance

Acetate	fair to low
Acrylic	good to sufficient
Cotton	good*
Linen	good, but damaged by repeated flexing
Nylon	good to excellent
Polyester	good to excellent
Rayon	poortofair
Silk	poor
Wool	good*

* wool and cotton are rated higher or lower than each other in different situations

or stretch during cleaning. Fibers with poor dimensional stability may shrink or stretch during cleaning.

Wool and rayon fibers have poor dimensional stability. They tend to shrink if not treated with care when exposed to water. When a rayon garment shrinks, it can often be stretched back to its original shape in the finishing process. However, when a wool garment shrinks, it can be difficult to return it to its original shape. Proper care when cleaning garments can prevent shrinkage. For example, wool fabric should never be cleaned using moisture with heat, or moisture with vigorous agitation, because these combinations can cause felting and thus permanent shrinkage.

Even some fibers with good dimensional stability can lose their shape during the cleaning process. Synthetic fibers tend to have good dimensional stability, but exposure to high temperatures can permanently change their shape. Figure 3-7 shows the elasticity and dimensional stability of common fibers.

3.2.3 Absorbency and The Effect of Water On Fibers

A fiber's ability to take up moisture is referred to as absorbency.

A fiber's ability to take up moisture is referred to as absorbency. In technical terms, absorbency is called *moisture regain*. Moisture regain is a measure of the weight of the moisture a fiber absorbs compared to the weight of the fiber itself. It is measured at a standard temperature and humidity, usually 70° F and 65% humidity. If 100 grams of a fiber absorbs 5 grams of moisture, then the fiber has a moisture regain of 5%. Cotton, for example, has a high moisture regain of 7%. One hundred grams of cotton will absorb 7 grams of moisture. Polyester, on the other hand, has a low moisture regain of only 0.2%. One hundred grams of polyester will only absorb 0.2 grams of water. Figure 3-8 shows the standard moisture regain for common fibers.

Fibers with a high moisture regain are also called *hydrophilic* or "water-loving" fibers. These fibers possess the ability to absorb water with ease. All natural fibers, as well as rayon and acetates, are examples of hydrophilic fibers. These fibers tend to swell when exposed to water.

The fact that these fibers tend to absorb water is both an advantage and a disadvantage to the cleaner. The primary advantage is that stain

Figure 3.7 Elasticity and Dimensional Stability

	Elasticity	*Dimensional Stability*
Acetate	poor	fair
Acrylic	good	poor
Cotton	poor	good
Linen	poor	good
Modacrylic	fair	good if not exposed to high temperatures
Nylon	excellent	good if not exposed to high temperatures
Olefin	excellent	good if not exposed to high temperatures
Polyester	excellent	good if not exposed to high temperatures
Rayon	poor	poor
Silk	good	good
Wool	excellent	poor

removal is easier, because water and detergent are easily absorbed into and flushed out of the fiber. The primary disadvantage is that swollen, saturated fibers can also cause increased shrinkage, wrinkling and loss of shape of the garment.

Synthetic fibers keep their original shape when processed in water

Fibers with a low moisture regain do not absorb water or absorb only small amounts of water. These fibers are referred to as *hydrophobic* or "water-fearing." Synthetic and inorganic fibers such as polyester and nylon are hydrophobic. These fibers tend to wrinkle less when processed in water. In fact, synthetic fibers keep their original shape when processed in water, just as natural fibers tend to keep their shape when processed in dry cleaning solvents.

Figure 3.7 Absorbency

	*Moisture Regain (%)**
Acetate	6.0 – 6.5
Acrylic	1.0 – 2.5
Cotton	7.0 – 11.0
Linen	8.0 – 12.0
Modacrylic	0.4 – 4.0
Nylon	4.0 – 4.5
Olefin	0.01 – 0.1
Polyester	0.2 – 0.8
Rayon	11.0 – 15.0
Silk	11.0
Wool	13.0 – 18.0

* as a percentage of the dry weight at 70˚F and 65% relative humidity

The majority of garments today consist of blends of natural and manufactured fibers. Because synthetic fibers do not tend to be affected by water, these garments can be easier to clean than garments made entirely of natural fibers.

Some natural fibers are treated with special processes to make them easier and safer to clean. Two of these processes are mercerizing and Sanforizing™. Mercerizing is a process in which cotton fibers, yarns or fabrics are held under tension in a cold alkali bath. This strengthens the cotton fibers, makes them shinier, and allows them to absorb dye better.

The Sanforizing™ process is a pre-shrinking process. This means that the fabric manufacturer shrinks the fabric on purpose. Once the fabric is shrunk, it is sent to a clothing manufacturer to be made into garments. The result is that the garments will not shrink more than two percent when washed and dried in home machines.

A number of different chemicals are useful for getting out soils and stains, and for identifying fabric types.

3.2.4 Effect of Chemicals

A number of different chemicals are useful for getting out soils and stains, and for identifying fabric types. However, these same chemicals can also damage certain fibers. It is important for the garment care professional to understand the effect of certain chemicals on fibers. These chemicals include bleaches, alkalies, acids, and organic solvents.

Bleaches — Bleaches are used to remove color or stains from fabrics. There are two types of bleaches commonly used in fabric care: ***oxidizing bleaches*** and ***reducing bleaches***. Oxidizing bleaches include hydrogen peroxide (H_2O_2), sodium perborate, and sodium hypochlorite (NaClO), also known as chlorine bleach. Reducing bleaches include sodium bisulfite, sodium hydrosulfite and titanium stripper. Of all the bleaches used in garment cleaning, chlorine is the most harmful to fibers. Most other bleaches could be used safely.

Acrylics and polyesters are resistant to damage from all types of bleaches. Cotton, linen, and rayon fibers are not harmed by reducing bleaches, but can only withstand weak chlorine bleaches for short periods of time. Wool and silk—and animal fibers in general— will deteriorate and dissolve in chlorine bleaches, but are more resistant to other bleaches. Some synthetic fibers, such as nylon and modacrylic, may also be harmed by chlorine bleaches. Figure 3-9 shows the resistance of different fibers to bleaches.

Acids and Alkalies — *Acids* and *alkalies* are used in laboratories for fiber identification and in cleaning to remove difficult stains like rust or blood. As might be expected, acids and alkalies each have different effects on fibers. Synthetic fibers are generally resistant to alkalies and acids, with some exceptions. Acrylic and polyester are sensitive to strong alkalies at high temperatures. Acetate, nylon 66 and polyester will decompose in strong acids.

Organic solvents, like perchloroethylene, petroleum and acetone, are used to remove a variety of oil-based stains from fabrics.

The natural fibers are affected differently by acids than alkalies. Plant fibers that contain cellulose are sensitive to acids, but are typically not damaged by alkalies. In fact, exposing cotton to alkalies strengthens the cotton fibers. This is the basis of a process called mercerization, which was discussed in the previous section. The protein, or animal fibers, are generally unaffected by acids, but are damaged by even weak alkalies. Figures 3-10 and 3-11 show the effect of acids and alkalies on different fibers.

Organic Solvents — Organic solvents, like perchloroethylene, petroleum and acetone, are used to remove a variety of oil-based stains from fabrics. Natural fibers, both animal fibers and cellulose fibers, either resist organic solvents or are unaffected by them. This fact has allowed these fibers to be cleaned in dry cleaning solvents like perc and petroleum with little or no damage to the fibers. Synthetic fibers, however, may be damaged by organic solvents. For example, acetate and modacrylic dissolve in acetone, which is used to

Figure 3.9 Effect of Bleaches

Acetate	resistant to oxidizing bleaches
Acrylic	highly resistant
Cotton	resistant, but chlorine bleaches will destroy if uncontrolled
Linen	similar to cotton
Modacrylic	some fibers may be harmed by chlorine bleach
Nylon	may be harmed by chlorine bleach
Polyester	highly resistant
Rayon	similar to cotton
Silk	deteriorates in chlorine bleach
Wool	will yellow and dissolve in chlorine bleach

remove nail polish and paint stains. The olefin fibers (polypropylene, polyethylene) will dissolve in solvents like perc in temperatures above 160° F. Since temperatures in a perc dry cleaning machine do not get this high, it is possible to dry clean these fibers. Figure 3-12 shows the effects of organic solvents on different types of fibers.

There is one major difference between the effects of organic solvents and the effects of water on fibers. The application of some organic solvents to some synthetic fibers, may cause the fibers to melt or dissolve. If this happens, there is no way to reverse this effect.

Figure 3.10 Effect of Acids

Acetate	soluble in acetic acid (33% or stronger); decomposed by strong acids
Acrylic	resistant to most acids
Cotton	similar to rayon
Linen	similar to rayon
Modacrylic	resistant to most acids
Nylon 66	decomposed by strong mineral acids, resistant to weak acids
Olefin	very resistant
Polyester	resistant to most mineral acids; disintegrated by 96% sulfuric
Rayon	disintegrates in cold concentrated acids
Silk	similar to wool, but more sensitive
Wool	generally unaffected by acid

Figure 3.11 Effect of Alkalies

Acetate	little effect from weak alkalies
Acrylic	resists weak alkalies
Cotton	swells when treated with caustic soda, but is not damaged
Linen	very resistant
Modacrylic	resistant to alkalies
Nylon 66	little or no effect
Olefin	very resistant
Polyester	resistant to cold alkalies
Rayon	no effect by weak alkalies; swells and loses strength in concentrated alkalies
Silk	similar to wool, but damage is slower
Wool	attacked by weak alkalies; destroyed by strong alkalies

Figure 3.12 Effect of Organic Solvents

Acetate	soluble in acetone
Acrylic	May swell in some solvents
Cotton	resistant
Linen	unaffected
Modacrylic	soluble in warm acetone, otherwise unaffected
Nylon 66	generally unaffected
Olefin	soluble in chlorinated hydrocarbons above 160˚F
Polyester	generally unaffected
Rayon	unaffected
Silk	unaffected
Wool	unaffected

When water is applied to natural fibers, the fibers may shrink or lose their shape. Some of these effects can be reversed, and both of these effects can be avoided.

3.2.5 Effect of Heat

The effect of heat on fibers is an important factor in both the cleaning and finishing of garments. A cleaner should ask himself or herself a number of questions before applying heat to a fiber:

- Does this fiber melt or decompose, and if so, at what temperature?
- Does this fiber shrink when it is heated?
- Does this fiber stretch when heated under tension?
- Can this fiber be heat-set, or become fixed in a certain state after heating?
- If I heat this fiber for a long time, will it damage the fiber and make the fabric useless?

The effect of heat on fibers is an important factor in both the cleaning and finishing of garments.

Natural fibers do not melt or soften when they are heated. This allows them to be exposed to high temperatures. In fact, fabrics made from natural fibers may actually need these high temperatures to remove wrinkles in the finishing process. Dry heat has very little effect on natural fibers. However, these fabrics may shrink or stretch if exposed to hot water or to moist heat, and must be closely monitored to achieve the desired result. Wools and rayons require particular care in moist heat.

Synthetic fibers have softening or sticking points ranging from 260°F (olefins) to 490°F (acrylic). The lower this softening point, the more care must be taken when using heat in the care of a garment. Too much heat can cause a fabric to stick to pressing equipment or to become permanently heat-set in an undesirable state.

3.3 The Effect of Cleaning on Fabrics

Wet cleaning can negatively affect fabrics in three main ways:

- fabrics can shrink or stretch
- colors can bleed
- textile finishes may be removed

Understanding these effects can make a cleaner more successful.

3.3.1 Shrinkage

During cleaning, water or solvent can cause the fabric to "relax." This can result in shrinkage.

The most common form of shrinkage is called "relaxation shrinkage." During the manufacturing process, fibers and fabrics are constantly stretched in the warp, or length, direction. After manufacturing, the fabric wants to "relax" and return to its natural length. During cleaning, water or solvent can cause the fabric to "relax." This can result in shrinkage.

Relaxation shrinkage usually occurs the first time the garment is cleaned. Woven fabrics generally shrink more lengthwise. This is the direction of the warp yarns when the fabric was woven. Knitted fabrics tend to shrink in both directions.

There are three other main types of shrinkage: natural shrinkage, progressive shrinkage, and differential shrinkage. "Natural shrinkage" depends on the properties of fibers. For example, wool and rayon tend to shrink, while polyesters do not.

Shrinkage in wool is often called "felting." Felting can occur when heat, moisture, and mechanical action are applied to wool fabric. This causes the wool fibers to interlock and results in shrinkage. A "felted" fabric feels thicker and more compact than the original fabric.

"Progressive shrinkage" occurs when a fabric shrinks more each time it is cleaned. This is an important point to note, because even if a garment has been cleaned before, it may continue to shrink.

Differential shrinkage may occur when a garment is constructed of two or more fabric types. Each fabric may shrink differently, causing puckering of the seams or baggy linings.

3.3.2 Colorfastness

Colorfastness is the tendency of a fabric to hold or lose its color. A fabric that is "colorfast" will not lose its color and "bleed" on other garments during cleaning.

Colorfastness is the tendency of a fabric to hold or lose its color.

Color can be added to a polymer, a fiber, a yarn, a fabric, or a garment. Color is added using dyes or pigments. Different dyes are used for different fibers, providing varying levels of colorfastness. The more completely the dye penetrates the fiber, the better the colorfastness of the fabric will be. Manufactured fibers tend to be the most colorfast. Because the fiber is dyed as a polymer, the color is deeply imbedded in the fiber structure. When dyeing is done at a later stage in the manufacturing process, colorfastness may suffer. Some fabrics are printed using pigments, not dyes. These pigments sit on the surface of the fiber and may be sensitive to rubbing or abrasion.

Fabric can lose its color for a number of reasons, including:

- exposure to water or chemicals such as acids, alkalides, bleaches or perc.
- exposure to light, especially sunlight
- exposure to atmospheric gases
- exposure to heat
- perspiration
- abrasion or rubbing

Garments must be tested for colorfastness before they are cleaned. This is especially important for dark fabrics and for garments that are made of both dark and light fabrics. Experienced garment care professionals, no matter what the cleaning method, will learn which types and colors of fabrics are the problems or "bleeders."

3.3.3 Textile Finishes

Finishes are applied to fibers, yarns and fabrics for a variety of reasons. They can be used to modify the appearance of the fabric to provide a shine or soft feel to the fabric surface. Finishes can also be applied to fabric to reduce its shrinkage, help prevent it from wrinkling, or improve its resistance to water or soil.

Finishes can be applied to fabric by mechanical or chemical means. The finish can be:

- permanent, which means it lasts as long as the fabric lasts
- durable, which means it lasts for a relatively long time
- temporary, which means it lasts for a relatively short time

One of the finishes that is used on fabric is called "sizing." Sizing is a chemical treatment that adds body and luster to fabrics. In this process the microscopic spaces between the individual fibers are filled with starch or resin. This reduces the amount of water the fabric will absorbed, which means the fabric will not swell as much when it is cleaned with water.

The starch and gelatin sizings used on cottons and rayons are usually temporary and may be removed by water.When the sizing is removed, fabrics can shrink, lose their shape, or lose their surface finish. Some more durable resin sizings last somewhat longer on the fabric surface, and are not affected as much by water.

3.4 Garment Construction

Garments are made of many different parts. All these parts must be considered when cleaning the garment. The first part to consider is the fiber and fabric that the garment is made of. A garment can be made from a single-fiber fabric, a multi-fiber fabric (or blend), or more than one type of fabric.

Garments are made of many different parts. All these parts must be considered when cleaning the garment.

- A garment that is made from only one type of fiber should be cleaned according to the properties of that fiber. For example, a wool sweater should not be cleaned in hot water with vigorous agitation. A rayon blouse should be treated very delicately and may need some reshaping or stretching during the finishing process.
- A garment made from a fabric blend—such as wool/polyester or polyester/rayon—should be cleaned with the properties of the more delicate or sensitive fiber in mind. For example, a wool/polyester blend should be treated as if it were wool, and a polyester/rayon blend should be treated as if it were rayon.

- Garments that are made of several types of fabrics can present two major problems. If the fabrics are very different colors—such a navy blue and white—the darker color must be tested for colorfastness before the garment is cleaned. If the fabrics are made of different fibers, shrinkage may occur at different rates in the different fabrics. The garment should be cleaned with the properties of the more delicate or sensitive fiber in mind, to best prevent either fabric from shrinking.

Finishes are applied to fibers, yarns and fabrics for a variety of reasons.

In addition to the fiber and fabric, other parts of the garment also need to be considered:

- Care must be taken on certain garments that seams, collars, and lapels do not pucker. These parts of the garment are often made of different materials that shrink at different rates. For example, when the fabric shrinks at a different rate than the thread or fused interfacing, puckering can occur. Often, this puckering can be fixed during finishing, but it is better to avoid the problem than to fix it.
- Delicate garments may be prone to seam ravelling and edge fray, especially if the seams are not secured with proper tailoring. Seams should be inspected before the garment is cleaned in order to determine if this will be a problem.
- Plastic buttons and non-fabric trims are typically a problem for dry cleaners because plastic and non-fabric trims can melt or stick when they come in contact with perc. This is not a problem with the wet cleaning process because water will not damage these types of materials.

3.5 How to Identify Fibers

Garment care professionals should know how to identify the fiber content of a garment. Knowing the types and percentages of fibers in a garment will help the cleaner determine the best care and treatment.

Federal law requires that certain information be provided with each garment, including fiber content and care labelling. These labels are usually attached permanently to the garment. This is not required by law in all circumstances, however, and consumers will often remove labels for reasons of comfort.

If a garment has no identifying label, the cleaner should take the time to identify the garment's fiber content.

Garment care professionals should know how to identify the fiber content of a garment.

The burn test is a simple method of fiber identification. This test can be done on almost any garment where there is an unexposed area from which a small sample can be clipped. Never try to do the burn test on a piece of fabric that is still attached to the garment.

Different fibers have distinct odors and appearances when they are burned. Exact identification can be difficult, but the cleaner will almost always be able to narrow the identification down to one of three categories: cellulose, protein, or synthetic. Based on this information, the cleaner can determine the best method for cleaning the garment. Figure 3-13 shows the burning characteristics, odor of residue, and appearance for several cellulose, protein and synthetic fibers.

Figure 3.13 Fiber Identification by Burning

Fiber	Burning Characteristics	Odor of Residue	Appearance
Cellulose Fibers			
acetate	yellow flame, melts	acetic acid or vinegar	hard bead — cannot crush
cotton	yellow flame, continues to burn when flame removed	burning wood or paper	grey fluffy ash
linen	yellow flame, continues to burn when flame removed	burning wood or paper	grey fluffy ash
rayon	yellow flame, continues to burn when flame removed	burning wood or paper	grey fluffy ash
Protein Fibers			
silk	burns in short jumps, does not burn when flame removed	burning hair	crushable black bead
wool	burns in short jumps, does not burn when flame removed	burning hair	crushable black bead
Synthetic Fibers			
acrylic	ignites and burns	acrid	hard black bead — cannot crush
modacrylic	melts, does not burn when flame is removed	acrid	hard bead — cannot crush
nylon	melts, does not burn when flame is removed	burning wax	amber bead — cannot crush
olefin	melts, burns with sooty smoke, continues to burn when flame removed	chemical odor	hard bead — cannot crush
polyester	shrinks from flame and melts; may self-extinguish	strong pungent or sweet odor	hard bead — cannot crush
spandex	melts	musty	soft, sticky, gummy

1 Adapted from table by Jane Rising, IFI, and Tortora, Phyllis, *Understanding Textiles*, Fourth EdItion, MacMillan, NY, 1992.

What Does That Mean?

abrasion — the wearing away of material by rubbing against another surface

abrasion resistance — the ability of a fiber or fabric to withstand surface wear and rubbing

acid — a substance with a pH less than 7

akali — a substance with a pH greater than 7

cellulose — a basic raw material from the cell walls of plants, used in manufacturing rayon, acetate, and triacetate fibers

dimensional stability — the ability of a fiber or yarn to withstand shrinking or stretching

elasticity — the ability of a fiber or fabric to recover its size and shape after stretching

filament — an indefinitely long fiber, measured in yards or meters

hand — the qualities of a fabric that are felt when the fabric is touched, such as softness, firmness, elasticity, and resilience

hydrophilic — having an affinity for water; "water loving"

hydrophobic — having no affinity for water; "water fearing"

laminate — to compress or bond thin layers together

luster — to have a shiny or reflective surface

moisture regain — the amount of moisture a textile absorbs as a percent of the textile's dry weight

oxidizing bleach — a bleach that whitens by adding oxygen to the substance

pH — a measure of the acidity or alkalinity of a material

polymer — a chain-like structure of many molecules used to make man-made fibers

reducing bleach — a bleach that whitens either by removing oxygen from a substance or by adding hydrogen to it

staple fiber — a fiber of relatively short length, measured in inches or centimeters

tenacity — the strength of a fiber

Module 3 Activity 3

Fiber and Fabric — Burn Test

Objective: *This activity is designed to give participants practical experience in performing the burn test, which is a simple method of identifying fibers. The following items are considered:*

- *melting and/or burning characteristics*
- *odor of the fumes; and*
- *appearance, shape, feel, and color of the residue or remains after burning.*

Tasks: *You will be given a piece of aluminum foil about a foot square. All work should be done over this foil. You will also be given small swatches of fabric. Separate the fabric into individual yarns. Hold one end of the yarn with a pair of tweezers that were also supplied.*

First, hold the free end of the yarn close to the flame of a match. Do the fibers melt, shrivel up or harden? (Melt test). Next, put the yarn into the flame to see the burning characteristics of the fiber (burn test). Any reaction to the flame should be noted such as; shrinking back from the flame, dripping, color of smoke and whether the fabric is self-extinguishing once the flame is removed.

Sample	Melt Test	Burn Test
1.		
2.		
3.		
4.		

Module 3 Activity 4

Fiber and Fabric — Fiber Identification by Tensile Strength

Objective: *This activity is designed to give participants an understanding of how fibers react when exposed to water. Participants will be classifying fibers based on their reaction to being saturated with water.*

Task: *The instructor will give you two strands of two types of fibers to identify. Working in groups of two, first hold the fiber at each end and pull ends apart to determine how much pressure needs to be applied to snap the strand. Record on a scale of 1–5 the pressure required for the strand to break. Next, repeat this process after adding a drop of water to the center of the strand. Finally, switch and allow the other partner to perform both tests.*

Complete the following chart for the fibers that you are given.

Fiber type	*Reaction to water* Stronger or weaker?	*Fiber type* Cotton or Rayon?
Type 1		
Type 2		

Module IV

Soils, Odors, Stains and Separation

Objectives: *By the end of the module participants should be able to…*

- *Identify the sources of soils, odors and stains*
- *Understand how mechanical processes and chemical agents separate soils, odors and stains from garments*
- *List the appropriate cleaning techniques for removing soils, odors and stains*

Customers bring garments to commercial cleaners for many reasons. Several of the most common problems are:

- the garment is soiled with dirt
- the garment has a spot or stain
- the garment has an objectionable odor
- the garment is wrinkled or creased
- the garment has lost its color or brightness
- the garment has lost its desired shape or finish
- the garment has been worn once and needs to be “cleaned” before it can be worn again

If the cleaner uses the wrong cleaning process, there is a risk of damaging the garment.

Each of these conditions presents the commercial cleaner with a specific problem. If the cleaner uses the wrong cleaning process, there is a risk of damaging the garment. If the cleaner relies on the general cleaning process, there is a risk that the garment will be cleaned but the specific problem will remain. The cleaner must use the specific cleaning process that will solve the problem without damaging the garment. This will guarantee that the customer will be satisfied when the garment is returned.

4.1 Soils, Odors and Stains

Soils, odors and stains are some of the most challenging problems that cleaners must solve.

Soils, odors and stains are some of the most challenging problems that cleaners must solve. It is important to get as much information as possible from the customer about the source of the soil, odor or stain. If the source is known, it is much easier to choose the correct process to remove the problem.

4.1.1 Soils

Garments can become soiled from many different sources. These include:

- inorganic dust, dirt and particulates from the air
- *inorganic* dirt from rubbing the garment on dirty surfaces
- *organic* oils from soot and pollen
- food and drink
- blood and urine
- greases, tars, adhesives or other thick, sticky substances
- aged skin cells that have flaked off the body

With the exception of the organic oils and greases, most of these soils do not penetrate deeply into the fibers of the fabric. However, many of these soils may be tightly attached to the garment. Soils can be hard to remove when:

- they have been ground into the fabric structure by a strong force
- they are attached to the fabric by *electrostatic bonding* with the fibers
- the ragged surfaces of the soil particles cling to the surface of the fabric

Soil can be removed by:

- dry mechanical agitation such as beating or scrubbing
- dry mechanical spinning
- flushing with a water, *surfactant* or solvent solution

The fabricare professional can also combine these methods if a single method does not remove the soil.

4.1.2 Odors

There are several sources of objectionable odors. These include:

- decomposing perspiration and body oils ground into the garment
- organic contaminants from foods, solvents, greases or oils
- bacteria or mites attracted to organic contaminants on the garment
- particles of smoke and soot from cigarettes or fires
- synthetic *volatile organic compounds*—such as fuels, paints, and solvents—that have been transferred to the garment

Odors typically suggest that some organic process is taking place on the garment. Either a volatile compound is evaporating, or a food particle or body cell is decomposing, or bacteria are *metabolizing*. The odor itself is not on the garment, but the source of the odor is.

Odors typically suggest that some organic process is taking place on the garment.

The techniques that can remove odor are:

- removing the source of the odor by agitation, steaming or washing with a water, surfactant or solvent solution
- "airing out" the garment over time in an oxygen rich atmosphere to allow the source of the odor to completely decompose
- disinfecting the garment with a bleach or peroxide
- heating the garment to promote rapid oxidation
- masking the odor with a more dominant odor or perfume (this method does not remove the odor; it only covers up the odor temporarily)

The cleaner can also combine these methods if a single method does not remove the source of the odor.

4.1.3 Stains

Stains tend to color a fiber in much the same way that a commercial dye does. Sources of stains include:

- ink
- dye
- solvents
- food and drink
- perspiration
- blood

Some stains are drawn up through the fibers by capillary action, the same way juice or coffee is soaked up by a paper towel. These

Stains tend to color a fiber in much the same way that a commercial dye does.

stains stick to the surface of the garment and yarns, but do not penetrate the fibers. Other stains soak into the fibers themselves. Depending on the type of fiber, stains that penetrate into the chemical structure of a fiber may "set" over time. These stains can be very difficult to remove.

The more a stain contrasts with the color of the garment, the more of a problem it is. A red ink stain on a white shirt must be completely removed, but a red ink stain on a red, floral garment may only need to be hidden. The stain can be hidden by reducing its color so that it blends into the background.

Stains can be removed or hidden by:

- flushing with a water, surfactant or solvent solution
- bleaching or dyeing

The cleaner can also combine these methods if a single method does not treat the stain successfully.

4.2 Separating Soils, Odors and Stains from Fabrics

Separating soil, odor sources and stains from fabric is a two-step process: "get it off" and "keep it off." From the point of view of wet cleaning, this process consist of:

- wetting a fabric and the soil, odor source or stain in order to separate the problem from the fabric
- holding the soil, odor source or stain away from the fabric to prevent it from soiling the fabric again during the cleaning process

Different separation techniques are effective at separating different soils, odor sources and stains. Some of these techniques are mechanical processes; others involve the use of chemical agents.

4.2.1 Processes

Mechanical agitation removes dirt from a garment by either direct force or by breaking and pulverizing dirt particles. Breaking and pulverizing results in smaller particles, which are able to leave the fabric structure more easily. These smaller particles are able to leave the fabric more easily than larger particles. Mechanical agitation does not work for all soils, however. For example, mechanical agitation alone may remove sand from a garment but may not be as effective at removing ground-in dirt. Other techniques are also required for removing stains.

Mechanical agitation removes dirt from a garment by either direct force or by breaking and pulverizing dirt particles.

Water is a powerful solvent that can help separate certain soils and stains from fabrics. Some soils dissolve in water that is used to clean a garment. The mechanical force of water flushing can also remove some soils, even though the soils themselves do not dissolve in water.

Adding certain chemicals to water can help water clean more effectively. These chemical additives decrease the surface tension of the water. This allows the water to penetrate the fabric more rapidly and thoroughly. These chemical additives are called "surfactants" because of their effects on surface tension.

Steaming and heating a garment also assist in separating soils and stains from a fabric. Heat can melt or soften particles. Steam can cause particles to expand or lose their electrostatic charges.

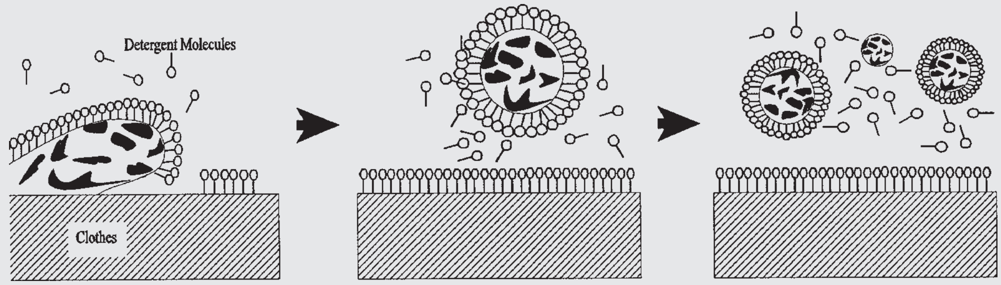
Finally, drying can assist in soil separation as particles curl, break or change shape during the evaporation process. A dehydrated particle or cell is less likely to decompose rapidly or to attract bacteria and, therefore, less likely to generate odors.

4.2.2 Chemical Agents

Detergents. Detergents are a particular kind of surfactant. Detergents penetrate into tight spaces such as those between fibers and soils. Surfactants ease the process of separation by surrounding the soil particle and easing it away from the fabric and into the water. Once a surfactant has surrounded a soil particle and released it from a fabric, the problem is to keep the soil particle from attaching itself to the fabric again. Electrostatic charges help solve this problem.

Most surfactants and most fabrics carry negative electrostatic charges in water. These charges repel each other. Every time a soil particle surrounded by surfactant comes close to the fabric, the negative charges repel each other. This keeps the soil particles from reattaching themselves to the fabric. The soil particles stay suspended in water until they are flushed away in a rinse. Figure 4-1 illustrates this process.

Figure 4-1 How Surfacants Work



Detergent molecules surround the dirt, and weaken its attachment to the clothes

This chemical action separates the dirt from the clothes.

The separated dirt does not attach to the clothes again because it is surrounded by detergent molecules.

Detergents penetrate into tight spaces such as those between fibers and soils.

Surfactants (detergents) are made up of two different parts. One portion has an attraction to water which allows the detergent to be soluble in water. The other repels water but is attracted to fatty and oily compounds. When surfactants are dissolved in water that contains fabric with fat or oil spots, the surfactants are attracted to the fat or oil. Because surfactants are also attracted to water, they tend to pull the fat or oil away from the fabric and into the water. This helps remove these spots from fabrics.

Soaps. Soaps are a surfactant that is made when fatty acids are combined with alkali. Many soaps include extra alkali. This increases the effectiveness of the soap. Because most dirt is slightly acidic, the alkali in soaps tends to neutralize the dirt. This releases the chemical bonds that exist between the dirt and the fabric.

Synthetic Solvents. There are many synthetic surfactants and solvents on the market. Many of these solvents are made from petroleum. The most common synthetic solvent used for garment cleaning is perchloroethylene. Stoddard solvent, which is distilled from petroleum, is also commonly used in dry cleaning.

Bleaches and Oxidizers. Bleaching does not clean garments; it merely disinfects them. Whitening, odor removal and some organic stain removal is often accomplished by disinfection. Disinfection kills bacteria and mites that may accumulate on organic soils.

Disinfection is accomplished by oxidation. Chlorinated bleaches oxidize and dissolve organisms that can then be flushed away in rinses. The speed of oxidation can be increased by exposing fabrics to certain forms of oxygen such as ozone or peroxide.

Digestors. The separation of some organic materials such as food or blood from a fabric can be accomplished by biological means. Enzymes are biologically active organisms that eat and digest organic soils such as food and blood. This loosens the soils and breaks them down into other materials that can be rinsed away.

Finishing Agents. Finishing agents are used for a number of purposes. For example, they restore body, resilience and smoothness to garments after processing. They also make fabric more soil resistant. This is accomplished by forming a film around the surface of the fiber. The film makes it more difficult for soil to become attached to the fiber. If soil does become attached to the fiber, the film also makes it easier to remove that soil.

What Does That Mean?

capillary action — the movement of a liquid in-between fibers

electrostatic bonding — bonds formed by the transfer of electrons from one atom to another

inorganic — not derived from living organisms

metabolize — to transform a nutrient from a useful substance to a waste

organic — derived from living organisms

oxidation — the combination of a substance with oxygen

surfactant — a substance that helps remove material from a surface by reducing the surface tension between the material and the surface to which it is attached

volatile organic compound (VOC) — an organic compound that evaporates easily; technically, a hydrocarbon (except methane and ethane) with a vapor pressure greater than or equal to 0.1mm Hg

Module V Garment Cleaning Methods

Objective: *By the end of the module participants should be able to…*

- *List and describe the steps required to clean garments using dry cleaning*
- *List and describe the steps required to clean garments using wet cleaning*
- *Identify three additional alternative methods for cleaning garments*

This module describes dry cleaning and the alternatives processes that are currently available or under development. This module also compares conventional dry cleaning with the wet cleaning process.

5.1 Current and Alternative Garment Cleaning Methods

Most of the commercial garment cleaning in the United States is currently done using the dry cleaning process. In the future, however, new cleaning processes may also be widely used. Some of these new processes are:

- carbon dioxide
- ozone
- ultrasonic cleaning
- wet cleaning

Only wet cleaning is currently ready to be used as an alternative to dry cleaning.

All of these processes have been or are currently being studied as methods for commercial garment cleaning. Only wet cleaning is currently ready to be used as an alternative to dry cleaning on a large commercial scale. The other processes require further testing and development.

5.1.1 Dry Cleaning

Conventional dry cleaning treats garments in either perchloroethylene or petroleum. Perchloroethylene is the solvent used in 80% of dry cleaning plants. Petroleum is used in the remaining 20%.

The machinery used with these solvents has been modified over time resulting in four "generations" of machines. All four generations are still in use at this time. The first generation has separate washers and dryers, and operators transfer garments from the washer to the dryer. For this reason, these are called "transfer machines."

Conventional dry cleaning treats garments in either perchloroethylene or petroleum.

The second generation combined the washer and dryer into one unit. The third generation added controls to help reduce perchloroethylene vapor emissions. The fourth generation included additional controls that recycle the air in the machine in order to further reduce vapor emissions. As a result of these improvements, workers are exposed to less perchloroethylene vapor and the machines themselves use less perchloroethylene.

Dry cleaning has proven itself to be an efficient, affordable, cost-effective process for cleaning a wide variety of fibers and fabrics without causing damage to garments. The primary drawback to dry cleaning is that perchloroethylene and petroleum solvents are hazardous substances. Because of the hazards, the use of these solvents is becoming increasingly regulated.

In order to comply with present and future regulations, the garment care industry has two options. First, the manufacturers can develop another generation of dry cleaning equipment with more effective controls. These machines would use less perchloroethylene and petroleum solvents, and release less of these solvents into the workplace and the environment. Second, the industry can invest in alternative cleaning processes that do not depend on hazardous solvents. In both cases, dry cleaning facilities will need to replace older equipment with new equipment.

5.1.2 Carbon Dioxide: Supercritical and Liquid

Research is being conducted using carbon dioxide (CO_2) in both the *supercritical* and liquid state as a method of cleaning clothes. Carbon dioxide possesses several qualities that make it a desirable alternative for clothes cleaning:

- it is not *toxic* to humans
- it is easily recycled
- it is an inexpensive solvent
- it does not cause damage to *ozone* in the atmosphere
- it does not cause metal to corrode
- it is non-flammable
- it does not pollute ground water or soil
- it is readily available

Carbon dioxide possesses several qualities that make it a desirable alternative for clothes cleaning

Liquid carbon dioxide has become the primary focus of much of the research because it is safer to use and handle than supercritical carbon dioxide.

Carbon dioxide is a molecule formed naturally when two oxygen atoms join one carbon atom ($C+O+O=CO_2$). Under normal circumstances, carbon dioxide is an *inert gas*. Carbon dioxide is familiar to everyone. When we breath in, our bodies absorb oxygen from the air. When we breath out, much of what we exhale is carbon dioxide gas. Carbon dioxide gas is typically found in very low concentrations in the atmosphere.

Under conditions of high temperature and pressure, CO_2 reaches a state called the supercritical phase. Grease and oils dissolve when they come in contact with CO_2 that is in the supercritical phase. This makes supercritical CO_2 an effective cleaner. Supercritical CO_2 has other advantages as well. When the pressure is reduced, grease and oil that are dissolved in the supercritical CO_2 separate from the CO_2. The grease and oil can then be disposed of, and the CO_2 can be reused.

Supercritical CO_2 has been used by the manufacturing industry to clean metal parts for some time. It has been tested in limited situations to determine if it can be used to clean garments. Further testing is required to determine if supercritical CO_2 is effective, affordable, and safe to use as a garment cleaner.

Liquid CO_2 exists at lower temperature and pressure than supercritical CO_2. Liquid carbon dioxide was originally developed by the aerospace industry for cleaning optical and electrical parts. It has been modified to dry clean garments.

Liquid CO_2 has no surface tension, which helps it separate dirt and grease from fabric. It can also be combined with surfactants to make it more effective. Like supercritical CO_2, liquid CO_2 can be recycled during the cleaning process. It has been reported that liquid CO_2 can clean leather, furs and fine garments without causing damage or degradation.

Ozone (O_3) has the ability to disinfect, deodorize and bleach fabrics.

5.1.3 Ozone Cleaning System

The Ozonated Water Continuous Cleaning System is a new process that is still being studied but is available commercially on a limited basis. The theory behind the process is that ozone (O_3), working as an oxidizing agent, has the ability to disinfect, deodorize and bleach fabrics. Ozone can be added to water, in much the same way that carbon dioxide is used in carbonated soft drinks. Ozonated water can be combined with detergents to produce a garment that is cleaned, disinfected and deodorized.

The garment remains on a hanger throughout the wash, rinse, extraction and drying cycles. The ability to let the garment remain on the hanger during the cleaning process reduces the amount of labor used for finishing. The tendency of the garment to crease and wrinkle is decreased because each garment is processed individually.

The company conducting the research suggests that with this process there is a reduced amount of labor required. The researchers report no shrinkage, change of shape, or wrinkling and claim that ornamental buttons do not need to be removed. They also state that it is cost effective to process clothes using this process.

Ultrasonic cleaning is currently being investigated as a possible alternative to conventional dry cleaning.

5.1.4 Ultrasonic Cleaning

Recent research cooperatively funded by the U.S. Department of Energy and Kansas City Plant and Garment Care, Inc. determined that agitation for a continuous-flow, water-based clothes washing process could be provided by ultrasound. When clothes cleaned with ultrasound were examined, the clothes were clean enough to encourage researchers to continue developing this process.

Ultrasonic cleaning works by the pressure of ultrasonic waves directed at the fabric through a solution of water and soaps. Ultrasonic waves are sound waves at a frequency that is higher than the human ear can hear. Ultrasound works because molecules of soil are more dense than molecules of fiber. The energy from the ultrasound excites the molecules of soil and causes them to separate from the fabric.

Ultrasonic cleaning is currently being investigated as a possible alternative to conventional dry cleaning. The method has been shown to be effective, but more testing is required to determine the effect of ultrasound on various fabrics.

5.1.5 Wet Cleaning

Cleaning garments with water is an age-old technology which is currently attracting attention from consumers and cleaners interested in using an environmentally friendly method. Unlike traditional laundering methods, wet cleaning combines the gentle mechanical action of hand washing with the convenience of machine laundry. The success of wet cleaning is dependent upon more than just the machine itself. Wet cleaning machine operators need to be knowledgeable in the area of fiber science because wet cleaning requires a certain amount of observation and skill. Success is also dependant upon the combination of quality detergents, proper training and commitment to the process.

Cleaning garments is currently attracting attention from consumers and cleaners interested in using an environmentally friendly method.

Wet cleaning uses a wet cleaning machine, detergents, additives, stain removal agents and a specialized dryer. Conventional additives to the wet cleaning process are not considered environmentally hazardous.

The cleaning process consists of essentially the same steps as conventional dry cleaning. Basically the process can be broken down into sorting, stain removal, wet cleaning, drying and finishing. A more detailed description of the process is provided in the Module 6, entitled *Overview of Wet Cleaning*.

5.2 A Comparison of Dry Cleaning and Wet Cleaning

Dry cleaning and wet cleaning are currently the two most efficient, affordable and cost-effective processes for cleaning garments. Figure 5-1 illustrates the dry cleaning process. Figure 5-2 illustrates the wet cleaning process. In general, these two cleaning processes are similar.

Dry cleaning and wet cleaning are the two most efficient, affordable and cost-effective processes for cleaning garments.

The basic steps in each process are preparation, washing, drying, and finishing and assembly. The differences are in the details of each step.

5.2.1 Preparation

In both processes, the cleaner inspects, sorts and removes stains from the garments before washing. Inspection is basically the same for dry and wet cleaning. In both cases, the cleaner inspects the garments to determine what problems may occur in the cleaning process and to determine the best way to clean the garments.

If two dry cleaners were given the same garments and asked to sort them, they probably would not sort them the same way. If two wet cleaners were given the same test, they probably would not sort the garments the same way, either. Even so, the dry cleaners would be using one set of general rules for sorting, and the wet cleaners would be using another set of rules. The general rules for sorting are different because the cleaning processes are different. Module 6, *Overview of Wet Cleaning*, describes the general rules for sorting for wet cleaning in more detail.

Dry cleaners would be using one set of general rules for sorting, and the wet cleaners would be using another set of rules.

The differences between cleaning with solvents and cleaning with water also result in differences in the stain removal process:

- Because the wet cleaning machine removes some water-based stains, these stains do not have to be removed before washing.
- Pretreated garments need to be dry before they can be put in a dry cleaning machine. Pretreated garments do not need to be dry before going into a wet cleaning machine. In fact, it is better in some cases to make sure that pretreated garments do not dry out, because this can cause rings to form on the fabric. This means that the wet cleaner can remove stains and immediately put garments in the wet cleaning machine.
- Several manufacturers have developed stain removers specifically for wet cleaning. Many of these products are less toxic than stain removing agents that are used for dry cleaning.

5.2.2 Washing and Drying

The washing and drying processes are the heart of the differences between dry cleaning and wet cleaning. These differences include:

- Dry cleaning machines and wet cleaning machines have different controls.
- With the exception of older transfer machines, most dry cleaning machines both wash and dry. Wet cleaning machines only wash garments. Separate dryers are used for drying garments. Many of these dryers have been developed specifically for wet cleaning.

Figure 5.1 Garment Dry Cleaning Process Flow Diagram

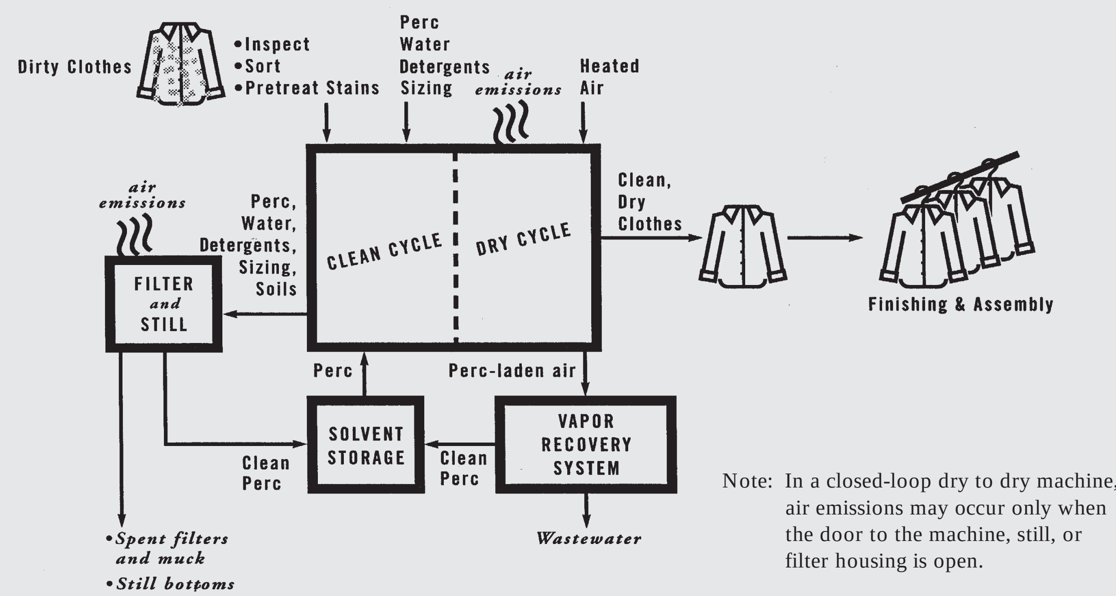
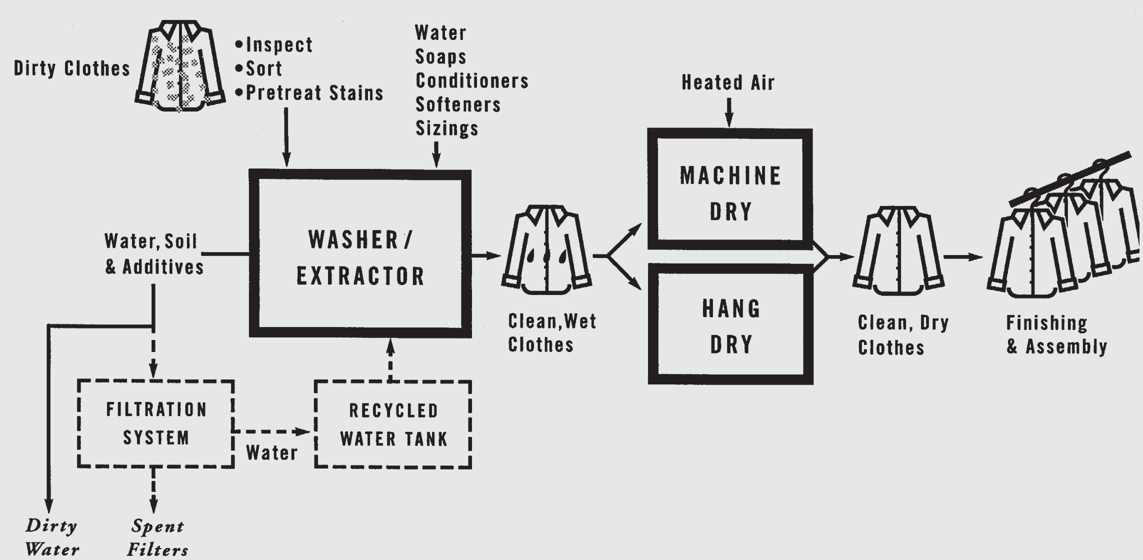


Figure 5.2 Garment Wet Cleaning Process Flow Diagram



The washing and drying processes are the heart of the differences between dry cleaning and wet cleaning

- Some wet cleaners choose to partially or completely air dry certain garments. This can require more space in which to hang the garments. It can also increase turnaround time.
- Somewhat more care is initially required to monitor the wet cleaning process in order to ensure that garments are cleaned successfully. The cleaner must have a good knowledge of fibers, fabrics, and the effects of the wet cleaning process.
- Dry cleaning machines use organic solvents like perchloroethylene or petroleum as the primary cleaning agent. Water, detergent and sizing are added to increase the efficiency of the dry cleaning process. Wet cleaning machines use water and detergent as the primary cleaning agent. Soap, sizing, conditioner and softener are added to the wet cleaning process.
- The waste products produced by dry cleaning machines include air and water that are hazardous. Special filters and control devices are required to minimize the amount of toxic waste that comes in contact with workers and the environment. These hazardous wastes also expose dry cleaners to liability if the waste is not disposed of properly. Wet cleaning machines do not produce hazardous waste, though some stain removal agents may be hazardous.

5.2.3 Finishing and Assembly

Garments that have been wet cleaned will require more work in the finishing step. This happens most often when the cleaner is learning the wet cleaning process. Less time will be required to finish these garments as the cleaner and the finisher gain more experience with the wet cleaning process. The purchase of state-of-the-art finishing equipment can help shorten finishing time.

What Does That Mean?

inert gas — a gas that does not react with other substances under normal conditions

ozone — three oxygen atoms bonded together; a layer of ozone surrounds the earth high up in the upper atmosphere and blocks out harmful rays of the sun

supercritical CO_2 — Carbon dioxide in a certain range of temperature and pressure that has properties of both a gas and a liquid. Supercritical CO_2 penetrates fibers and fabrics like a gas but removes soils like a liquid.

toxic — harmful to life

Module 5 Activity 5

Garment Cleaning Methods

Process factors identification

Objective: *This activity is designed to give participants the opportunity to identify the factors which are critical to wet cleaning.*

Task: *In your groups, develop a list of factors (elements) that you believe are critical to the clothes cleaning process. These factors should apply to both wet and dry cleaning.*

1. *(eg. time)* ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Module VI Overview of Wet Cleaning

Objectives: *By the end of the module participants should be able to….*

- *Understand how and why the wet cleaning process works.*

There are a number of factors that are critical to using the wet cleaning process successfully:

- well trained and skilled personnel
- processing garments according to manufacturers' instructions
- quality detergents
- appropriate finishing techniques

Most of these are also factors that apply to dry cleaning. In fact, the wet cleaning process is similar in many ways to dry cleaning. Several of the skills used in professional dry cleaning are transferrable to wet cleaning, including:

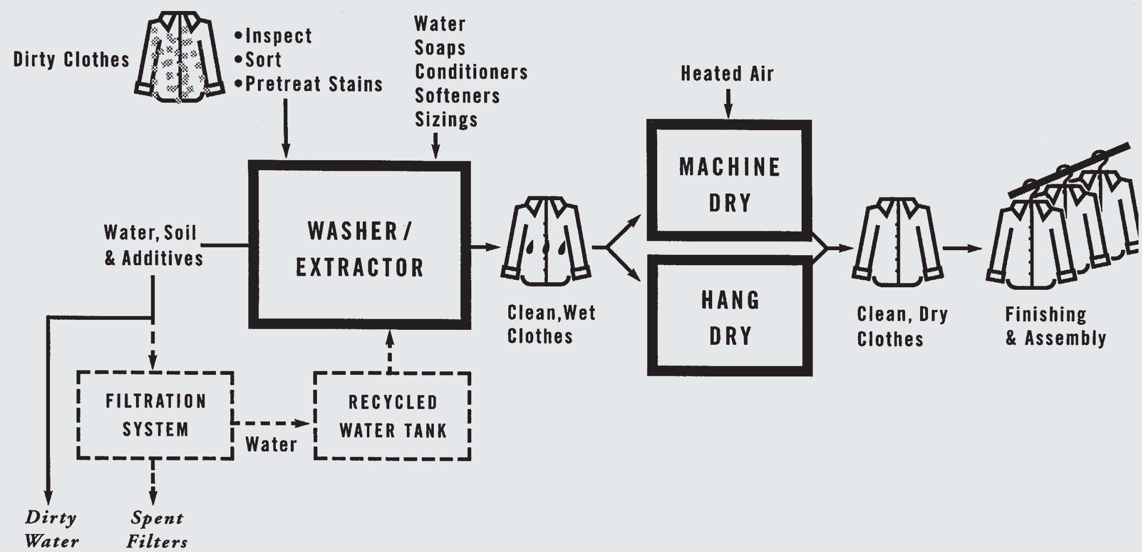
- testing for colorfastness
- sorting of garments
- stain removal techniques
- pressing
- finishing

Because so many skills are transferrable, the skilled professional dry cleaner is at a distinct advantage over someone who has no previous cleaning experience.

The skilled professional dry cleaner is at a distinct advantage over someone who has no previous cleaning experience.

Figure 6-1 illustrates the basic wet cleaning process flow. Each manufacturer of wet cleaning equipment, however, recommends slight variations on this process for their machines, including different practices for sorting, choice of chemicals, machine program cycles, drying times and humidity levels at the end of the drying cycle.

Figure 6.1 Garment Wet Cleaning Process Flow Diagram



6.1 Front Counter

The front counter needs to be staffed with alert and well- trained personnel.

The cleaning shop needs to be staffed with alert and well-trained personnel. The counter person needs to examine each garment for defects such as sun damage, tears, missing adornments, seams and hems in need of repair or stains. If possible, the following things should also be determined:

- the origin of the stain
- the customer's occupation
- whether the customer has tried removing the stain
- what chemical stain removers may have been used
- how long the garment has been stained
- whether the garment has been put through a dryer.

In a professional cleaning plant, the front counter person is very likely the only person who meets the customer. A counter person who is well-trained, reasonably paid, and actively appreciated benefits the plant in three ways. First, he or she tends to treat customers in a courteous and friendly manner. Second, he or she will be more skilled at identifying soils and stains. Third, he or she will be less likely to look for another job, which will save the cost of training a replacement.

6.2 Garment Measuring

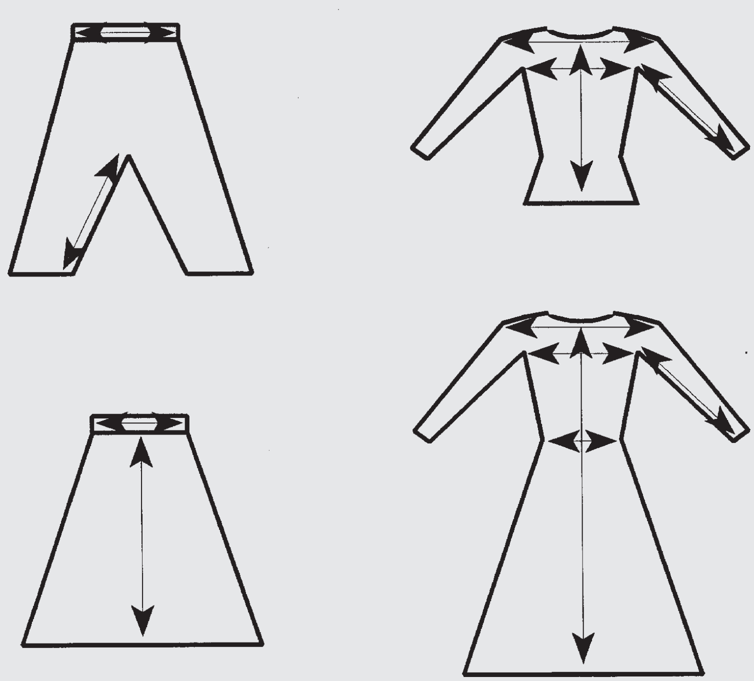
In cases where the wet cleaner is inexperienced or is trying to increase the percentage of garments that are wet cleaned, it is a good idea to measure garments. This will allow the cleaner to ensure that the garment did not change shape or size as a result of wet cleaning. The cleaner should measure garments before any cleaning steps have been performed and again after the garment has been cleaned. Once the cleaner is comfortable with the wet cleaning process and the types of garments that can be safely cleaned, there will be less need to measure.

It is a good idea to measure garments.... to ensure that the garment did not change shape or size as a result of wet cleaning.

To make comparison easier, and to avoid any confusion, the cleaner should use a standard procedure to measure garments. To make sure garments are measured the same way each time, follow these guidelines:

- Use inside seams on legs and sleeves
- Measure the right side of the garment
- Close the waist and double the measurement

Figure 6.2 Recommended Sites for Garment Measuring



- Do not include the waistbands on pants or cuffs on shirts in measurements
- Note any additional measurements that are taken

Figure 6-2 shows the recommended sites for measuring garments.

6.3 Sorting

Sorting garments for wet cleaning differs from sorting garments for dry cleaning.

Sorting garments for wet cleaning differs from sorting garments for dry cleaning. Each wet cleaning machine and dryer manufacturer recommends their own individual sorting procedure, but they all make the same general recommendation: similar garment types should be processed together.

Wet cleaning machine programs have been developed specifically for certain fabric and garment types. Examples of these programs include:Outergarments. This program is designed for garments that can withstand the greatest amount of mechanical action, heat and exposure to water. Items processed in this cycle include non-wool coats, dockers, non-wool sport jackets and cotton bedspreads.

Delicates. Garments processed in this cycle can only withstand a limited amount of mechanical action, exposure to water and drying time. Some examples of this type of garment include rayons, silks, acetates and fine beaded washables.

Wools. This fabric by its nature can only withstand a minimum amount of mechanical action, heat and exposure to water. Wool and wool-blend garments processed in this cycle include coats, suits and sweaters.

Heavier weight garments of the same fabric type may require additional drying time. Manufacturers sometimes recommend additional sorting for these garments, either before wet cleaning or as they are transferred to the dryer.

Wet cleaning machines produce the best results if the wheel is filled to the recommended capacity. Recommendations range from 50% to 60% capacity, depending on the manufacturer. In order to reach the recommended capacity, the cleaner might choose to mix some of the sorted loads.

If the cleaner mixes sorted loads to make a full load, or if a garment has the fiber content tag removed, he or she should always use the least aggressive cycle for wet cleaning and drying. For example, if the cleaner is unable to identify the fiber content of a sport coat, it should be processed on the wool cycle to ensure that it is not damaged by the process.

6.4 Testing for Colorfastness

Some garments "bleed" when they are cleaned in water. To help solve this problem, certain detergents contain agents that reduce the amount of dye a garment will lose in the wet cleaning machine. These agents can be added to the wash cycle. These agents do not guarantee that a garment will not bleed, however. Garments made of fabrics that have dramatically different colors—such as navy blue and white—should always be tested for colorfastness.

A wet cleaner with limited experience should test as many as 1 in 4 garments.

A wet cleaner with limited experience should test as many as 1 in 4 garments. This number will drop as the cleaner becomes more knowledgeable and comfortable with the process. It is difficult to say how many garments an experienced wet cleaner will test because the comfort level will vary among cleaners. Experience has shown that somewhere in the vicinity of 1 in 10 to 1 in 15 garments will be routinely tested for colorfastness.

The cleaner should test for colorfastness with a *1:4 solution* of wet clean detergent to water. A clean white cloth should be moistened with solution and rubbed on the suspect area with light pressure. If color is transferred to the cloth, then it is likely that the garment will bleed during the wet cleaning process. Color loss can be minimized by using vinegar or one of a number of commercially available products.

6.5 Stain Removal

Stain removal is a critical part of the professional garment cleaning process. Many garments are brought in to be processed for this purpose alone. The cleaner's goal is to remove the maximum amount of stains in the minimum amount of time with the least amount of damage possible to the fabric.

Each garment should be examined thoroughly but quickly for any stains before processing. For an experienced cleaner this inspection

The cleaner's goal is to remove the maximum amount of stains in the minimum amount of time with the least amount of damage possible to the fabric.

should only take a few seconds per garment. This is time well spent considering how much time and effort can be lost trying to fix the problem later. The inspection table should be about three feet by three feet and lighting should consist of full spectrum fluorescent lighting mimicking natural light as closely as possible.

This inspection will catch any stains the counter person may have missed. This inspection can also help identify the source of the stain. Odor, location, appearance and feel can also be helpful in identifying the stain. Once the stain is identified, the cleaner can choose the proper stain removal agent.

The wet cleaning machine will remove some water-based stains. Water-based stains typically make up 70% of the stains a cleaner encounters. The fact that these stains do not have to be removed by hand will save the cleaner time. If the cleaner wants to remove water-based stains at the inspection table, he or she can use the same mixture of 1 part detergent to 4 parts water that is used to test for colorfastness. Using a flat brush or spatula, apply the mixture to the stains and tap gently.

Grease-based stains must be removed before the garment is processed in the wet cleaning machine. Grease-based stains make up 30% of the stains a cleaner encounters. If a grease-based stain is not removed before washing, there is a risk that the stain will be set on the garment in the dryer.

Intermediate stain removal is a process where a heavily stained garment or one with a problem stain is inspected for stains before it is put into the dryer. In wet cleaning, because garments need to be handled between the wet cleaning machine and the dryer, the cleaner has an opportunity to inspect garments before they are dried. If stains or soil are still present on the garment, the cleaner can again work on the garment at the stain removal board. This eliminates the possibility that the stain will be set in the garment during the drying process.

6.5.1 Stain Removal Equipment

A professional garment cleaner should invest in a quality stain removal board that is comfortable for the worker. Two types of boards are available: cold boards and hot boards. Both cold and hot boards can be made from several different materials, including synthetic materials, plastic laminate, stainless steel or glass. Both cold and hot boards also have a screened area into which soil and liquid are vacuumed. Cold boards come equipped with pressurized air and vacuum as an option. Hot boards come standard with vacuum, steam and pressurized air.

The following tools are also useful for removing stains:

Steam spray guns. Using a steam spray gun makes stain removal much more efficient. However, steam should be used with care because it can also cause problems:

- heat from the steam can activate certain chemicals and cause damage to the garment
- heat from the steam can set the stain
- pressure from the steam spray gun can distort delicate fabrics

Water spray guns. Water spray guns can be connected to either the plant water supply or to a steam condensate line. Connecting the water spray gun to a steam condensate line will provide a more constant pressure.

Spatula. Spatulas work by massaging the stain removal agent with a back and forth or tamping motion into the stained area without damaging the fabric. They can be made of bone, metal or plastic. Spatulas must not have any burrs or sharp edges that could snag, pull or otherwise damage fibers. The type of motion used with the spatula should be appropriate to the fabric being worked on. For example, a gentle motion should be used on sensitive fabrics.

Brushes. Brushes must be used with caution. They can be useful on a raised stain to break up the soil build-up. If the brush is equipped with a padded head, the head can be used to break up stains or on delicate fabrics such as satins and silks. Many cleaners color code brushes so that the same brush is always used with the same stain removal agent. For example, a cleaner might use black brushes for solvent-based dry cleaning stain removal agents and white brushes for water-based stain removal agents.

Cloths. Supplies of clean, print free, absorbent cloths are also a necessity at the stain removal board. Excess moisture and colored stains can be absorbed using these cloths. Grease stains can be flushed out more easily with an absorbent cloth underneath the fabric to absorb the soil and water.

A professional garment cleaner should invest in a quality stain removal board that is comfortable for the worker.

Drying Equipment. In wet cleaning, garments can go directly from the stain removal board to the wet cleaning machine for processing. This means that the cleaner does not have to wait for garments to dry after stains have been removed.

6.5.2 Stain Removal Agents

Several manufacturers have developed stain removal agents specifically for wet cleaning. Most companies produce four basic stain removal agents:

- a degreaser that can be used on any grease-based stain such as lipstick, cooking oil or motor oil
- a stain remover for tannin-based stains such as coffee and tea
- a protein remover for stains such as blood and egg
- a neutral stain remover which is a gentle product for stains such as ground-in dirt

Stain removal agents that have been developed specifically for wet cleaning also tend to be non-toxic.

6.6 Cleaning with Water

Successful wet cleaning depends in part on matching the features of the wet cleaning machine, the detergent and the properties of the water.

Successful wet cleaning depends in part on matching the features of the wet cleaning machine, the detergent and the properties of the water. The cleaner should select a wet cleaning machine with the unique features that precisely match his or her needs. The cleaner must match the type of detergent to the type of fiber and fabric that is being processed. The cleaner must also be aware of the properties of the water, because hard and soft water have different effects on the wet cleaning process.

6.6.1 Wet Cleaning Machine

The basic technology of the wet cleaning machine is a drum for tumbling and a *frequency controlled motor* which is controlled by a *microprocessor*. This allows the wet cleaner to precisely control the rotation of the wash drum. This precise control produces a cycle that mimics the gentleness of hand washing and provides very smooth acceleration and deceleration.

Cycle programs for wet cleaning machines control drum rotation, timing, temperature, addition of chemicals, water level and extraction. Some machines come with preprogrammed cycle programs. The cleaner can also custom-design the cycle programs based on information from the chemical and detergent manufacturers. Cycles can be created, deleted or altered by the cleaner at any time to improve the performance of the machine.

The basic technology of the wet cleaning machine is a drum for tumbling and a frequency controlled motor which is controlled by a microprocessor.

It is critical to properly match the cycle with the garment being processed. Many fabrics require unique cycles to be programmed because the fiber is so delicate that even mild agitation could cause damage to the garment. Machine *RPMs* and agitation can be programmed to meet the needs of the fabric or garment.

There are a number of different wet cleaning machines on the market. Each machine has a unique set of features. Before purchasing a wet cleaning machine, a cleaner should carefully determine his or her requirements. The cleaner should examine the features of the various wet cleaning machines to determine which one has the features that match those requirements.

Wet cleaning machines also vary greatly in styles and prices. Each cleaner must determine what type of system suits his or her particular business needs. The level of sophistication of the wet cleaning machine and the percentage of cleaning volume that will be processed in water should be considered when selecting equipment. While one cleaner may find a need for a highly programmable wet cleaning system with all the bells and whistles, another may find that a less sophisticated home-style washer can meet his or her needs.

6.6.2 Detergents

Detergents play a critical role in the success of a wet cleaner. Detergents have been formulated to prevent permanent damage from occurring when certain fabrics are cleaned in water. The three major functions of detergents in the cleaning process are:

- protecting the fiber against damage
- removing dirt
- keeping dirt suspended in the wash water so that the dirt does not redeposit on the clothes during the cleaning process

Detergents have been formulated to prevent permanent damage from occurring when certain fabrics are cleaned in water.

Detergents work most efficiently in warm water. Warm water helps to increase the surface activity of the chemicals in the detergent. Most manufacturers recommend a water temperature of about 80°F. However, some detergents are formulated to work just as well in cold water. This gives the cleaner the option of using cold water for items that would be damaged by washing in hot water.

Surface activity takes place on the surface of the fabric, where the fibers, the detergent and the soil meet. When detergent foams on the surface of the fabric, the action of the detergent breaks the connection between the soil and the fabric. The detergent detaches the soil from the fabric, and the soil becomes suspended in the wash water. The detergent also acts as a surfactant to keep the soil suspended in the wash water. This prevents the soil from becoming attached to the fabric again. Instead, the soil is washed away when the wash water is flushed.

The cleaner can also choose detergents that help prevent color loss and protect protein fibers such as wool. Detergents with a slightly acidic *pH* lessen the tendency of dye to bleed. Detergents at an alkaline pH are damaging to protein fibers, slightly acidic detergents work best with wools. Antishrink and antifelt agents and conditioners are sometimes added to the detergent to prevent shrinking, stretching and *felting*.

6.6.3 Know Your Water

Other factors to consider when wet cleaning are the temperature of the water and its hardness or softness.

Other factors to consider when wet cleaning are the temperature of the water and its hardness or softness. The temperature of the wash and rinse water is critical to the success of wet cleaning. Water that is too cold when it enters the wash drum may not properly clean garments. Warm water is necessary to obtain the greatest efficiency of dirt removal. On the other hand, if the water used in the wash or rinse cycle is too warm, it can cause a change in the shape, size or texture of the garment. Water that is extremely soft may require decreasing the amount of detergent and increasing the amount of sizing added per load.

6.7 Drying

The drying of wet cleaned garments requires as much care as wet cleaning itself. If garments are tumbled in the dryer for too long, the mechanical action can damage the fabrics. In order to minimize the mechanical action, drying is typically done at high temperatures for a brief period of time.

The drying of wet cleaned garments requires as much care as wet cleaning itself.

The dryer capacity should be twice the capacity of the wet clean unit. In other words, if your wet cleaning machine capacity is 20 lbs., your dryer capacity should be 40 lbs. This is necessary to allow for adequate mixing. With adequate mixing, heated air circulates throughout the dryer and dries the garments quickly and evenly. This minimizes shrinkage, deformation, and wrinkling.

The dryer should have controls that monitor temperature and humidity levels in either the drum or the exhaust air. Tests have shown that the most shrinkage occurs when the humidity in the drum drops below ten percent. Most manufacturers therefore recommend drying fabrics to between 10 and 14 percent *residual moisture*.

Currently, there are three types of dryers available. The first are home dryers, which are typically time and temperature controlled. These dryers do not monitor humidity levels. The other two types of dryers have been developed specifically for use in the wet clean process. One measures the moisture in the dryer exhaust air and compares it with the moisture in the room air. The other is equipped with humidity sensors in the drum that actually measure the residual moisture in the fabrics. Both types of dryers are designed to achieve the same purpose: to dry the fabrics to a desired moisture level in as short a time as possible with as little mechanical action as possible.

Even though sophisticated dryers are available, some fabricare specialists who wet clean garments allow certain garments to partially or completely air dry. Professional cleaners who air dry garments need to have additional space to hang the garments. Air drying also requires more time, so turnaround time may increase.

6.8 Finishing

The finishing of garments is a critical part of the process for either a wet or dry cleaner. Even if the garment has been cleaned impeccably it will be unacceptable if it has not been finished in a professional manner. Consumers expect that a professionally cleaned garment will look as good or better than it did when it was purchased.

The finishing of garments is a critical part of the process for either a wet or dry cleaner.

Certain garments can become a challenge when processed in a wet cleaning machine. Excess wrinkling, shrinkage or stretching can occur that requires additional attention. A skilled finisher working with quality finishing equipment will find that these garments may require some additional processing time. As finishers become more experienced with the wet cleaning process, they will develop the skills that will allow them to produce a fine product while minimizing finishing time.

Certain techniques can be used to help prevent finishing problems. In order to decrease the amount of wrinkling, garments should be taken out of the dryer immediately after the cycle is completed or the drying time is finished. The dryer should be large enough to allow clothing adequate room to tumble properly. State-of-the-art finishing equipment can also help the cleaner achieve the desired garment finish

What Does That Mean?

1:4 solution — a solution of 1 part detergent and 4 parts of water; for example, 1 cup of detergent and 4 cups of water

felting — tangling, shrinking or matting of fibers, generally caused by exposing them to heat, moisture and mechanical or chemical action

frequency controlled motor — a motor that allows precise control of the tumbling rate, as well as smooth acceleration and deceleration

microprocessor — a small device, often called a "computer chip," that uses a program to control the operation of a machine

pH — a measure of the acidity or alkalinity of a material

residual moisture — the amount of moisture remaining in a fabric after drying

RPM — revolutions per minute; the number of times a drum turns every minute

Module VII Hands-On Wet Cleaning

Objectives: *By the end of the module participants should be able to…*

- *Understand the wet cleaning process based on first-hand experience*
- *Operate a wet cleaning machine and perform routine maintenance*

In this module, participants will learn how to operate and maintain a wet cleaning facility. At the same time, participants will discuss skills that are common to wet and dry cleaning, such as sorting, spotting, pressing and finishing.

In this module, participants will learn how to operate and maintain a wet cleaning facility.

Participants will split up into five groups, with each group observing and participating at different wet cleaning stations. The five stations are sorting, stain removal, wet cleaning, drying and finishing.

7.1 Sorting

Section 6.3 in the previous module covers general information on the sorting process. The following additional steps will be covered at the sorting station:

- Sort loads according to machine manufacturers' and detergent manufacturers' instructions
- Suit pieces should be sorted into same load
- Sort complete full loads and half loads
- Ties should be pinned inside pant leg or put in a mesh bag
- Put all knit sweaters in mesh bag

7.2 Stain Removal

Section 6.4 in the previous module covers general information on testing for colorfastness, and Section 6.5 covers stain removal. The following information and steps will be covered at the stain removal station:

- Start in the morning with dark loads, because dark loads tend to have fewer stains. This means that dark loads can be put in the washer more quickly. While the dark loads are being washed, the cleaner can remove stains from light-colored garments.
- Stain removal agents should be biodegradable and non-toxic. If dry cleaning solvents are used, waste should be collected and disposed of as hazardous waste.
- Excellent lighting will enhance results
- Test for colorfastness

7.3 Wet cleaning

Section 6.6 in the previous module covers general information about the wet cleaning process. The following information and steps will be covered at the wet cleaning station:

- Match machine program to load size and type
- If using for both wet cleaning and laundry, switch machine to wet clean cycle
- Use only EPA-approved soaps and detergents
- If the water is very soft, decrease detergent and increase sizing to protect fabric
- Watch for cracks in the door tubing that can cause leaking
- Take clothes out upon completion of cycle
- If using for both wet cleaning and laundry, rinse between cycles
- Clean drum after waterproofing or fire retardant cycle
- Clean suit pieces in the same load
- Process jackets in the afternoon so the jackets have time to hang overnight
- When cleaning down garments use a quick fill and extract cycle to completely wet the down

7.4 Drying

Section 6.7 in the previous module covers general information about drying. The following information and steps will be covered at the drying station:

- Use a large enough dryer for adequate tumbling
- Use the shortest cycle possible to prevent relaxation damage
- Take clothes out immediately after processing
- Do not dry clothes to less than 10% humidity
- Air dry garments when necessary
- Very fine and loose weave sweaters should be dried flat
- Molded black plastic form hangers work best

7.5 Finishing

Section 6.8 in the previous module covers general information about finishing.The following information and steps will be covered at the finishing station:

- Finish garments only when the amount of moisture in the garment is the same as the amount of moisture in the air of the cleaning facility
- Less finishing time is required if the finisher uses stretching equipment
- Conditioners, including starches, can reduce finishing time on some garments
- To bring back nap, brush suedes with a copper wire brush toward the nap
- Heavy wool coats should be brushed with a carding brush to pick up the pile
- Wipe velvet with a velvet brush to get all the pile going in the same direction

Module VIII Economics of Wet Cleaning

Objective: *By the end of the module participants will be able to:*

- *Identify the costs associated with all cleaning facilities, both wet and dry*
- *Identify the costs that are specific to wet cleaning*
- *Identify the costs that are specific to dry cleaning*
- *Compare the costs of wet and dry cleaning*

Will I make money or lose money by converting?

A dry cleaner who is considering a complete or partial conversion to wet cleaning will certainly ask the following questions:

- What will it cost to convert to wet cleaning?
- What will it cost to operate a wet cleaning facility once I have converted?
- How do these costs compare with my current costs for dry cleaning?
- Will I make money or lose money by converting?

The information in this module gives a dry cleaner the tools to answer these questions.

8.1 Understanding and Finding Costs

There are many ways to look at the cost of doing business. One way is to divide the various costs into categories. For example, we can separate costs into capital costs, operating costs and intangible costs.

8.1.1 Capital Costs

Capital costs are one-time investments. These are the costs of items that a cleaner buys once and uses repeatedly in his or her daily operation. Capital costs include such items as:

- new equipment and installation
- new buildings.

These items themselves do not get "used up" in the course of doing business. These items generally do not get replaced very often, but they can be depreciated.

8.1.2 Operating Costs

Operating costs are ongoing expenses. Generally, operating costs are for items that get "used up" in the course of doing business, or for items that the cleaner pays for on an "as used" basis. These items include:

- consumable materials, such as detergent, sizing, conditioners and stain removers
- utilities, such as water and electricity
- labor, both direct and indirect, including cleaning, stain removal and finishing
- waste disposal
- regulatory compliance

8.1.3 Intangible Costs

Intangible costs are costs that are difficult to measure in dollars and cents. Unlike capital costs or operating costs, intangible costs represent things that a cleaner cannot see or touch but still affect the cleaner's bottom-line. These costs often include:

- public image
- community goodwill
- product quality
- financial liability related to correctly transporting and disposing of hazardous waste

Some of the costs, such as liability and public image, are not as obvious as others.

Some of the costs listed above—such as financial liability and public image—are not as obvious as others. This can make it difficult to completely identify certain costs, like the cost of using perc. If perc, still bottoms, cartridge filters and filter muck are disposed of illegally, the dry cleaner who generated this waste can be made to pay for cleaning up a hazardous waste site. Negative publicity surrounding the hazardous waste cleanup can cost as much or more in lost business as the cleanup itself.

8.2 Converting from Dry to Wet

8.2.1 Environment Canada's Test Conversion

The intent of the project was to process as many garments as possible using the wet cleaning process.

In August 1995, Canada's federal environmental agency, *Environment Canada*, began a project to test the costs and benefits of converting from dry cleaning to wet cleaning. Environment Canada provided funds to completely replace conventional dry cleaning equipment with wet cleaning equipment at a facility in Hamilton, Ontario. The intent of the project was to clean as many garments as possible using the wet cleaning process. Funding was provided with the agreement that only wet cleaning would be performed at the facility.

It was felt that if the dry cleaning equipment remained in the facility, the cleaners would tend to use equipment they were comfortable with rather than become skilled at wet cleaning. For this reason, all the dry cleaning equipment was replaced. All garments that needed to be dry cleaned were taken to another facility for processing. Care labels were used only as a guide to help decide whether a garment should be wet cleaned or dry cleaned. Care labels were not followed rigidly.

Because the project was not complete at the time this training manual was being written, it is not possible to include detailed results. However, some preliminary information is available.

The information gathered during this project was for the purpose of comparing the performance and cost of dry cleaning versus wet cleaning. Information for the first quarter of facility operation shows that 51% of the total garments taken in were processed in the wet cleaning machine. During the second quarter, the information shows that 75% of the total garments taken in were processed in the wet cleaning machine.

The results of Environment Canada's project to date have shown that the costs of wet cleaning are almost identical to the costs of dry cleaning. More projects need to be done, however, in order to determine if Environment Canada's results are true for wet cleaning costs in general.

8.2.2 The Greener Cleaner Demonstration Shop

The results of Environment Canada's project to date have shown that the costs of wet cleaning are almost identical to the costs of dry cleaning.

The Center for Neighborhood Technology (CNT) is an independent, nonprofit research and technical assistance organization with a tradition of working with industry partners to find practical solutions to environmental problems. Through funding from the USEPA, CNT initiated the Alternative Clothes Cleaning Demonstration Project with the goal of evaluating the performance and commercial viability of wet cleaning. The CNT research project included:

- the design, monitoring and evaluation of all aspects of a commercial shop, *The Greener Cleaner,* using only wet cleaning, and
- data collection at two shops relying on both water and traditional dry cleaning solvents.

CNT partnered with a private investor to design *The Greener Cleaner* as an average commercial dry cleaning operation in size, prices, and fabric, fiber and garment types cleaned. The difference was that all items brought in for cleaning were wet cleaned.

Working with an Advisory Committee, two tests were designed to measured performance issues on separate groups of garments.

- In the first test, CNT measured performance through customer satisfaction and through intensive evaluations of a random sample of garments cleaned at *The Greener Cleaner.* These intensive evaluations were conducted by independent evaluators, who inspected 460 customer garments *before* and *after* cleaning.
- The second test compared the performance of wet cleaning and dry cleaning on 52 sets of identical garments. All the test garments specified dry cleaning in their care instructions and many were selected as likely "problem garments" for wet cleaning. In each set, one garment was wet cleaned, one dry cleaned and the third was stored and used as the "control" to help evaluators judge the changes in the cleaned garments.

The Greener Cleaner also served as a true demonstration shop — several hundred cleaning professionals, consumers and regulators have taken advantage of the opportunity to tour the shop during business hours, watching the wet cleaning process from start to finish and interviewing shop personnel. When *The Greener Cleaner* opened its doors in May, 1995, fewer than 10 cleaners were using wet cleaning equipment systems. A year later there were well over 100 cleaners with wet cleaning systems and a significant percentage of those visited *The Greener Cleaner* prior to making their decision.

For a full copy of the full report, contact CNT (see Appendix B).

8.3 Identifying and Comparing Costs of Dry vs. Wet Cleaning

The following pages contain a set of draft worksheets developed by Tellus Institute of Boston that can be used to identify and compare the costs of wet cleaning versus dry cleaning. The worksheets are divided into two categories: one-time investment costs (also referred to as capital costs) and annual operating costs. These worksheets can be very useful to a cleaner who is considering different options for improving his or her facility.

The one-time investment cost worksheets can be filled out once for each option that the cleaner is considering. For example, these worksheets could be filled out once for upgrading existing dry cleaning equipment and once for replacing dry cleaning equipment with wet cleaning equipment. This will allow the cleaner to compare the one-time costs of each option.

The annual operating cost worksheets can be used to compare the operating cost of an existing dry cleaning operation with the estimated cost of a similar wet cleaning operation. Dry cleaning costs can be taken from a cleaner's existing accounting records. Wet cleaning costs can be estimated based on manufacturer's specifications for wet cleaning machines and on the results of studies such as Environment Canada's test project and the Center for Neighborhood Technology's study of "The Greener Cleaner."An equipment distributor may also be able to help with cost estimates.

Figure 8.1 Cost Comparison Worksheets*

One-Time Investment Costs

Project Title: ____________________

Date: ____________________

Purchased Equipment (Purchase, Tax, Delivery)	**COST New System**
Protective Equipment, e.g. eyewash station	$
Solvent Leak Detector	$
Perchioroethylene Storage & Handling Materials	$
Spill Containment System	$
Solvent Filter System	$
Steam Cabinets for Steam Stripping Cartridge Filters	$
Housing for Draining/Drying Cartridge Filters	$
Water Softening Unit	$
Water Cooling Unit (Chiller)	$
Refrigerated Condenser	$
Thermometer for Condenser Coil Temperature Measurements	$
Water Separator	$
Solvent Filtration/Distillation Unit	$
Muck Cooker	$
Azeotropic Control Devices	$
Rag Filter	$
Wastewater Carbon Adsorber	$
Wastewater Evaporator	$
Other Water Treatment/Recycle System	$
Vapor Carbon Adsorbers	$
Dry Cleaning Machine	$
	$
Wet Cleaning System	$
Domestic Washer and/or Dryer	$
Pressing Equipment	$
	$
	$
	$
	$
SUBTOTAL	**$**

*These worksheets are in draft form. For final copy contact Tellus Institute (see Appendix B).

Figure 8.1 Cost Comparison Worksheets

One-Time Investment Costs

Project Title: ______________________

Date: ______________________

Construction/Installation (Labor, Supervision, Materials)	COST New System
Shop Labor & Supervision	$
Contractor/Vendor Fees	$
Construction Equipment Rental	$
Demolition	$
Old Equipment/Rubbish Hauling & Disposal	$
Plumbing/Piping	$
Electrical Systems	$
Ventilation/Exhaust Systems	$
	$
	$
	$
SUBTOTAL	$

Permitting (City, County, State, Federal) (Labor, Supervision, Materials)	COST New System
Shop Labor & Supervision	$
Contractor/Vendor Fees	$
City, County, or State Business License	$
City or County Health Department Permit	$
Perchloroethylene Use Permit	$
Wastewater Evaporator Permit	$
	$
	$
	$
SUBTOTAL	$

Figure 8.1 Cost Comparison Worksheets

One-Time Investment Costs

Project Title: ______________________

Date: ______________________

Start-up/Training (Labor, Supervision, Materials)	COST New System
Training in Equipment Operation	$
Training in Equipment Maintenance	$
Training in Dry/Wet Cleaning	$
Safety Training	$
Cleaning Test Runs	$
Start-up Supplies	$
	$
	$
	$
SUBTOTAL	**$**

One-Time Investment Cost Summary

Project Title: ______________________

Date: ______________________

Category Subtotals	COST New System
Purchased Equipment (*page 1)*	$
Construction/Installation *(page 2)*	$
Permitting *(page 2)*	$
Start-up/Training *(page 3)*	$
TOTAL	**$**

Salvage Value	COST Old System
Sale of Used Equipment	$
	$
SUBTOTAL	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ____________________

Date: ____________________

Cleaning Supplies (Purchase, Delivery, Storage)	COST	
	Current System	**New System**
Perchloroethylene (including any taxes)	$	$
Detergent for Dry Cleaning Charge	$	$
Solvent Filters	$	$
Solvent Filter Additives	$	$
Detergent/Soap for Wet Cleaning	$	$
Finisher/Sizer	$	$
Starch	$	$
Water Repellent	$	$
Odor Neutralizer	$	$
Fabric Softener	$	$
Spotting Chemicals	$	$
Spotting Brushes/Bone Scrapers	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Clothes Handling Supplies (Purchase, Delivery, Storage)	COST	
	Current System	**New System**
Order Tickets/Receipts	$	$
Garment Tags	$	$
Staples	$	$
Durable Bags/Baskets	$	$
Nets	$	$
Hangers	$	$
Drapery Tubes and Bands	$	$
Safety Pins and Other Clips	$	$
Plastic Garment Bags	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ______________________________

Date: ______________________________

Labor and Supervision (Wage or Salary, Fringe Benefits)	COST	
	Current System	New System
Management	$	$
Cleaning	$	$
Spotting	$	$
Pressing	$	$
Counter	$	$
Training	$	$
Advertising	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Utilities	COST	
	Current System	New System
Water	$	$
(for cleaning, steam generation, cooling)	$	$
	$	$
Electricity	$	$
	$	$
Fuel	$	$
	$	$
Sewer	$	$
	$	$
Refrigerant	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ______________________________

Date: ______________________________

Maintenance & Waste Management (Labor & Materials)	**COST**	
	Current System	**New System**
Monitoring Perchloroethylene Mileage	$	$
Monitoring Pressure Gauges	$	$
Perchloroethylene Vapor and Liquid Leak Repair	$	$
Cleaning Solvent Storage Tank(s)	$	$
Changing Cartridge Solvent Filters	$	$
Changing Polishing Filters	$	$
Precoating Tubular Solvent Filters	$	$
Regeneration of Tubular/ Disc Solvent Filters	$	$
Water Cooling Unit (Chiller) Maintenance	$	$
Condenser Maintenance	$	$
Water Separator Maintenance	$	$
Solvent Still Draining and Cleaning	$	$
Muck Cooker Draining and Cleaning	$	$
Replacing Wastewater Carbon Adsorber Filters	$	$
Wastewater Evaporator Maintenance	$	$
Wastewater Treatment/ Recycle Unit Maintenance	$	$
Replacing Vapor Carbon Adsorbers Filters	$	$
Cleaning Button Trap	$	$
Cleaning Lint Trap	$	$
Other Cleaning Machine Maintenance	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ______________________________

Date: ______________________________

Waste Storage, Hauling & Disposal (Labor, Supervision, Materials)	**COST**	
	Current System	**New System**
Perchloroethylene	$	$
Used Solvent Filters & Prefilters	$	$
Spent Carbon from Vapor/ Wastewater Adsorbers	$	$
Filter Muck	$	$
Muck Cooker Residue	$	$
Solvent Still Sludge	$	$
Water Separator Wastewater	$	$
Water Treatment/Recycle Unit Sludge	$	$
Refrigerant	$	$
Lint & Rags	$	$
Solvent Containers	$	$
Spotting Chemicals/Containers	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Regulatory Compliance (Labor, Supervision, Materials)	**COST**	
	Current System	**New System**
Permitting	$	$
Training	$	$
Monitoring/Testing	$	$
Inspections/Audits	$	$
Labeling	$	$
Manifesting	$	$
Recordkeeping & Reporting	$	$
Spill Containment/Clean-up	$	$
	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ______________________________

Date: ______________________________

Liability and Insurance	**COST**	
	Current System	**New System**
Legal Fees	$	$
Fines/Penalities	$	$
Site Cleanup & Monitoring	$	$
Personal Injury	$	$
Property/Natural Resource Damage	$	$
	$	$
General Business Insurance	$	$
Pollution Liability Insurance	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Advertising Materials	**COST**	
	Current System	**New System**
Signs	$	$
Business Cards	$	$
Flyers	$	$
Postage	$	$
Advertising Fees	$	$
	$	$
	$	$
SUBTOTAL	**$**	**$**

Off-Site Services	**COST**	
	Current System	**New System**
Shirt laundering	$	$
Leathers	$	$
Tailoring	$	$
	$	$
SUBTOTAL	**$**	**$**

Figure 8.2 Cost Comparison Worksheets

Annual Operating Costs

Project Title: ____________________

Date: ____________________

Claims	**COST**	
	Current System	**New System**
Cost for Damaged Clothing	$	$
	$	$
SUBTOTAL	**$**	**$**

Annual Operating Costs Summary

	Category Subtotals	
	Current System	**New System**
Cleaning Supplies *(page 1)*	$	$
Clothes Handling Supplies *(page 1)*	$	$
Labor and Supervision *(page 2)*	$	$
Utilities *(page 2)*	$	$
Maintenance & Waste Management *(page 3)*	$	$
Waste Storage, Hauling & Disposal *(page 4)*	$	$
Regulatory Compliance *(page 4)*	$	$
Liability and Insurance *(page 5)*	$	$
Advertising Materials *(page 5)*	$	$
Off-Site Services *(page 5)*	$	$
Claims *(page 6)*	$	$
TOTAL	**$**	**$**

Enter: Total CURRENT Operating Costs	$
Enter: Total NEW Operating Costs	$
Annual Change in Cost/Savings (Current-New)	$

Module IX
Available Wet Cleaning Equipment

Objectives: *By the end of the module participants should be able to…*

- *List and describe the range of features offered by currently available wet cleaning equipment*

Wet cleaning equipment can be divided into two categories:

- wet cleaning machines, or washers
- dryers that have been specifically developed for the wet cleaning process

Both wet cleaning machines and dryers are available with a wide range of standard and optional features.

9.1 Wet Cleaning Machines

Wet cleaning machines have been designed to process a wide range of garments, including garments that are usually dry cleaned. Manufacturers have focused on mechanical agitation and programmable controls to give the wet cleaner flexible options for safe, efficient cleaning.

Wet cleaning machines have been designed to process a wide range of garments, including garments that are usually dry cleaned.

Some of the new wet cleaning machines use a gentle, rolling action to minimize the risk of damage to fabric. These machines provide wash speeds as low as 5 to 10 rpm and programmable wash action that allows for minimal agitation, such as 1 second on and 60 seconds off. Other wet cleaning machines use air bubbles to provide gentle agitation. Gentle wet cleaning machines also have programmable spin speeds for extracting water from garments. Extraction cycles can be set to match the garment and fabric weight, so that the maximum amount of water is removed for each type of garment.

Additional controls are available for water use, water level, temperature, heating, and automatic chemical injection. These features allow wet cleaners to precisely control the wet cleaning process. These controls also allow the wet cleaner to automatically process garments that would ordinarily be hand washed.

The drum capacity or load size of wet cleaning machines ranges from 10 to 135 pounds. An important fact to keep in mind is that the wet cleaning capacity of the machine is 50-60% of the laundry capacity. This means that if the cleaner plans to routinely process 25 pound loads on a wet cleaning cycle, the machine purchased should have a minimum capacity of 50 pounds.

The amount of water used per wet cleaning cycle should be considered when choosing a wet cleaning machine, particularly in areas where water and sewer costs are high. Studies done in Chicago and Canada show that switching from dry to wet cleaning may increase water use. However, the studies also show that wet cleaning was still economically favorable to dry cleaning.

Machines with automatic detergent feeds should also have either an alarm on the detergent and/or additive tanks, or an automatic shut off. These features ensure that detergents and finishes are added when garments are processed. Processing garments without detergents and finishes can result in wasted labor, detergents and utility costs. The machine should also be equipped with enough detergent dispensers to allow the cleaner to process the full range of garments that he or she wishes. If skins are to be processed, the machine needs to be equipped with 2 dispensers in addition to the dispensers needed for normal garments on the wet clean cycle.

All currently available wet cleaning machines can be used as either a wet clean system or a standard laundry machine.

All currently available wet cleaning machines can be used as either a wet clean system or a standard laundry machine. This allows the cleaner to process shirts and “dry clean only” garments in one machine. Another advantage to purchasing a wet clean system is the ability to process skins. Leathers and furs are generally a high profit item for the professional cleaner and the ability to process them in-house can increase profits.

9.2 Dryers

A number of dryers have been developed specifically for wet cleaning. Most machines have programmable temperature and humidity controls that help the cleaner precisely set the amount of moisture that remains in the garment at the end of the drying process.

Even though the dryers have sophisticated temperature and humidity controls, the cleaner must pay careful attention to the load size and the mix of garments and fabric weights. Because different fabrics dry at different rates, sorting garments by fabric type and weight is even more important for drying than it is for wet cleaning. Cleaners can also program drying cycles specifically for loads that contain a mix of fabrics, but care is needed to ensure that all garments dry properly.

A number of dryers have been developed specifically for wet cleaning.

Both electric and steam dryers use considerable energy. An electric dryer may need up to a 100 amp service to run properly. Cleaners who are considering installing a new dryer need to find out if they need to install 100 amp service to run it. One dryer manufacturer will be modifying their machine from a three phase to a single phase in the future, but for now the 100 amp service is necessary. If the cleaner is considering a steam dryer, he or she must determine if the current boiler has the capacity to support the dryer. A gas dryer should not be used in a shop that uses perc.

Though garments should be removed from the dryer when they are still slightly moist to prevent shrinkage, it is often necessary to let the garment dry completely before finishing. It is possible to let the garments air dry, or to purchase equipment to speed up this final drying process. Wind whips are available to blow dry garments, especially those with heavy areas like shoulder pads and thick waist bands. Drying cabinets can be used to dry garments that may be damaged by agitation of any sort.

9.3 Wet Cleaning Equipment Features and Specifications

Figure 9-1 summarizes the features that are available on five gentle wet cleaning machines. Figure 9-2 summarizes the features for five dryers. Figures 9-3 and 9-4 compares these new machines to conventional dryers and commercial equipment.

This information was originally published by Environment Canada's Green Clean Project in October, 1995. Wet cleaning technology is developing rapidly and machines available today may have different features than those described in the figures. For a copy of the full report contact Environment Canada (see Appendix B).

FIGURE 9-1 - Summary of Wet Cleaning Machine Features

	Machine #1	Machine #2	Machine #3	Machine #4	Machine #5
Sizes Available					
— Laundry Capacity	" 30, 50 & 70 lbs"	55 lbs	" 30, 50 & 80 lbs"	"18, 35, 50 & 85 lbs"	42 lbs
— Wet Clean Capacity (60%)	"18, 30 & 42 lbs"	33 lbs	"18, 30 & 48 lbs"	"12, 20, 30 & 52 lbs"	25 lbs
Frequency controlled motor ?	Yes	Yes	Yes	Yes	Yes
Soft Mount & Reversing Cylinder ?	Yes	Yes	Yes	Yes	Yes
Programmable Microprocessor ?	Yes	Yes	Yes	Yes	No (dials or cards)
Number of Programs	up to 39	up to 100	up to 99	up to 39	"7 wet clean, 16 laundry"
Wash Speed Range (rpm)	10 to 50 rpm	5 to 40 rpm	24 OR 48 rpm	23 OR 46 rpm	43 rpm
— Programmable wash speed ?	(prog. 1 rpm incr.)	(prog. 1 rpm incr.)	(2 prog. choices)	(2 prog. choices)	(no choice)
Wash Action Range					
— On Time	0.1 to 60 sec	0 to 999 sec	1 to 255 sec	3 OR 27 sec	Pre-set (No Info)
— Off Time	0.1 to 60 sec	1 to 999 sec	1 to 255 sec	27 OR 3 sec	
— Program. ?	fully programmable	fully programmable	fully programmable	7 choices	
Extract Speed Range (rpm)	250 to 1000 rpm	200 to 835 rpm	320 or 950 rpm	305 to 900 rpm	300 to 1100 rpm
— Programmable extract speed ?	(prog. 1 rpm incr.)	(prog. 1 rpm incr.)	must set manually (8 choices)	programmable (4 choices)	must set manually
Average Wash Cycle Time	15-30 minutes	15-30 minutes	20-30 minutes	15-40 minutes	25-40 minutes
Steam Heat Option ?	Yes (Direct to sump)	Yes (Direct to sump)	Yes (Direct to sump)	Yes (Indirect to sump)	Yes (No Info)
— indirect steam heat exchanger ?	No (Option planned)	No (Option planned)	No (Option planned)	Yes (Inlet & Outlet)	(No Info)
Electric Heat Option ?	Yes (dual also)	Yes	Yes (not rec)	Yes	Yes
Temperature Control Fill/Modulation?	No	Yes	Yes	Yes	No
— hot & cold water feed control	"(prog., pre-mixed)"	"(3 auto, pre-mixed)"	"(auto, pre-mixed)"	"(auto, pre-mixed)"	
— fill from bottom or top ?	top fill	bottom fill	bottom fill	bottom fill	No Info
Water Level Programmable ?	Yes (50 settings)	Yes (8 settings)	Yes (35 settings)	Yes (3 settings)	No (dial setting)
Water Recirculation During Cycle ?	Optional	Optional	No	Optional	No
Water Recycle Tank Option ?	Optional	Optional	Optional	Optional	No
Automatic Chemical Injector Signals	up to 6	up to 6	up to 8	up to 8	up to 5
Automatic Chemical Pumps	up to 6	up to 6	up to 8	up to 8	2 standard
Through-the-Door Injection?	Yes	Yes	Yes	Yes	No

Figure 9-2 - Summary of Wet Cleaning Dryer Features

	Machine #1	Machine #2	Machine #3	Machine #4	Machine #5
Drying Cycle Features:					
— Drying Temperature Range (‘F)	100 to 200 ‘F	100 to 200 ‘F	112 OR 158 ‘F	100 to 180 ‘F	No Info
— Programmable temp. (manual) ?	(prog. 1 ‘F incr.)	(prog. 1 ‘F incr.)	(prog. 1 ‘F incr.)	(prog. 5 ‘F incr.)	No (dial or card)
— Number of Custom Temp. settings ?	up to 6	up to 6	2 choices	up to 4	No (dial or card)
— Drying Time Range (manual)	0 to 99 min	0 to 99 min	0 to 99 min	0 to 99 min	0 to 60 min.?
— Humidity Control (% res. moisture)	0-20%	0-10%	0-30%	0-10%	No Info
— Number of Moisture settings ?	up to 6	up to 6	4 choices	up to 3	
Cooling Cycle Features:					None
— Cooling Temperature Range (‘F)	70 to 100 ‘F	70 to 100 ‘F	air	100-180’F	No
— Programmable temp. (manual) ?	(prog. 1 ‘F incr.)	(prog. 1 ‘F incr.)	(no choice)	(shut-off setting)	No
— Cooldown Time Range (minutes)	0 to 99 min	0 to 99 min	0 to 9 min	1 to 60 min	No
Reversing Cylinder Option ? (stainless steel cylinder recommended)	Yes	Yes	Yes	Yes	No
Anti-wrinkle feature ? (continued rotation after cycle)	Yes	Yes	Yes	Yes	No
Approx. Average Cycle Time	15-30 minutes	10-20 minutes	10-20 minutes	10-20 minutes	20-40 minutes
Steam Heat Option ?	No (planned)	Yes	Yes	Yes	Yes
Gas Heat Option ?	No (planned)	Yes	Yes	Yes	No
Electric Heat Option ?	Yes	Yes	No	Yes	Yes
Special Features	* Residual moisture & Temperature Gradient (decrease temp. with moisture content) * Garment/Fabric specific preset programs	* Temperature sensor to allow auto drying & manual flexibility	* Residual moisture sensor on drum ribs senses humidity directly in garments	* Temperature sensor to allow auto drying & manual flexibility	* Residual moisture control

Figure 9-3 - Summary of Wet Clean Machine Features

Feature	Conventional Domestic Top-Loader (Laundry)	Commercial Front-Loader (Laundry)	Commercial Front-Loader (Wet Clean)
Temperature/Heating Control ?	No (hot/cold)	Yes	Yes
Level Control ?	No	Yes	Yes
Frequency controlled motor ?	No	No	Yes
Programmable Microprocessor ?	No	Yes (some)	Yes (most)
Variable Wash Speed & Action ?	No	No	Yes
Variable Extract Speed & Action ?	No	No	Yes
Automatic Chemical Pumps ?	No	Yes (option)	Yes
Through-the-Door Injection ?	No	Yes (some)	Yes (most)

Figure 9-4 - Wet Clean Dryer Features

Feature	Domestic Dryer (Laundry)	Conventional Commercial Dryer (Laundry)	Commercial Dryer (Wet Clean)
Temperature/Heating Control ?	No (hot/cold)	Yes (some)	Yes
Manual Temperature Adjust ?	No	Yes (some)	Yes (some)
Programmable Microprocessor ?	No	Yes (some)	Yes
Programmable Drying Cycles ?	No	Yes (some)	Yes
Programmable Cooling Cycles ?	No	No	Yes (some)
Automatic Drying Cycle for Moisture?	No	No	Yes
Temperature Sensor/Display ?	No	Yes (some)	Yes (some)
Residual Moisture Sensor ?	No	No	Yes (some)
Variable Temperature / Moisture ?	No	No	Yes (some)

Module X Facility Function and Design

Objectives: *By the end of the module participants should be able to…*

- *Understand the level of retraining that will be required to adapt personnel to the wet cleaning process*
- *Design a functional wet cleaning facility*

A properly trained staff and a cleaning facility with a functional layout are two requirements for a successful wet clean business. Shops should be designed with work load, staffing and turn-around time in mind. Converting to wet cleaning means that staff will need to be trained to understand the differences between the wet and dry cleaning processes. When new wet cleaning equipment is installed, the cleaner should take advantage of this opportunity to improve the layout of the facility if possible.

A properly trained staff and a cleaning facility with a functional layout are two requirements for a successful wet clean business.

10.1 Adapting the Staff to Wet Cleaning Procedures

As in dry cleaning, the wet cleaning process places an emphasis on teamwork. Counter personnel need to thoroughly inspect garments for stains. When a counter person finds a stain, he or she needs to ask the customer about the origin of the stain and how long it has been on the garment. This person should also be able to answer most questions about the wet cleaning process as compared to dry cleaning. If necessary, counter personnel can pass these questions on to the owner or cleaner.

The garment then needs to be processed in compliance with the established procedures of the shop. Stain removal personnel who are familiar with dry cleaning need to be retrained to use water-based stain removal agents and to remove only grease-based stains and heavily soiled protein-based stains. Most water-based stains will be removed in the wet cleaning machine.

Sorting skills are transferrable from dry to wet cleaning, though the sorting categories may be different. Sorting personnel need to follow the specific instructions that come with the wet cleaning machine and with the detergents that are being used.

Finishing personnel may require the most amount of retraining because wet cleaning can cause garments to wrinkle or shrink more than in dry cleaning.

Personnel that are accustomed to operating a dry cleaning machine should have no trouble adapting to the wet cleaning machine. The principle of selecting an appropriate wet cleaning program for the load is similar to dry cleaning. Some training may be required to learn how to properly program a particular wet cleaning machine for different types of fabrics.

Personnel responsible for drying garments need to keep in mind that a percentage of moisture needs to remain in wet cleaned garments after drying. Most wet cleaning operations in this country finish the garments after they have been allowed to hang for 12-15 hours. The cleaner may also choose to air dry some garments if there is enough time. The cleaner needs to manage the schedule to allow for these drying times.

Finishing personnel may require the most amount of retraining because wet cleaning may cause garments to wrinkle and/or shrink more than in dry cleaning. Quality finishing equipment, combined with more experience, can cut down on the amount of time for finishing.

10.2 Designing a Functional Floor Plan

The amount of time it takes to completely process garments from front counter to final finishing and assembly partly depends on how well the cleaning facility is designed. Equipment should be laid out in a way that streamlines the flow of garments through the plant and allows the staff to complete tasks with as few steps and movements as possible. When a piece of equipment is replaced, the new piece should not automatically be placed in the same spot. Replacing one or more pieces of equipment is an opportunity to improve the existing layout.

To properly analyze an existing or proposed cleaning plant, the cleaner should create a scale drawing of the facility. This drawing should include the location of all doors, windows, partitions, machinery and conveyors, as well as hookups for water and electricity. The cleaner can use this drawing for two purposes:

- to verify that all the equipment fits in the space available, and that all the equipment can be connected to the necessary water, electrical, steam and ventilation systems
- to trace the path that each garment takes from the time it enters the building until it leaves, to plan for efficient work flow

The most efficient work flow paths are roughly a circle or a "U" shape.

The most efficient work flow paths are roughly a circle or a "U" shape. Work flow paths that backtrack or repeatedly cross over themselves are warning signs that the layout needs to be improved. The best work flow for a particular plant depends on the size and shape of the building, the types of garments that are cleaned, and the specific procedures used by a particular cleaner.

Most wet cleaned garments are taken out of the dryer when they reach a 10–15% humidity level. Therefore, when redesigning an existing plant or building a new one, space must be provided for storing garments while they are air drying. Additional drying equipment, such as wind whips and drying cabinets, can also affect the layout of the facility.

Module XI Labeling Liability

Objectives: *By the end of the module participants should be able to…*

- *Understand the current state of garment care labeling liability associated with wet cleaning*

Under a Federal Trade Commission (FTC) regulation (36 FR 23883, 1971; amended 48 FR 2273, 1983), apparel manufacturers are required to attach care labels stating a single care method for the proper and safe care of a garment. Because only one care method must be on the label, manufacturers may use a "dry clean only" label even though wet cleaning may be a safe option. Since wet cleaning is a "new" and developing care method, appropriate care instructions have not yet been developed. As a result, there is not yet a Federal Trade Commission approved wet clean label. This means that if a fabricare specialist deviates from a label's recommended cleaning method and damage occurs, the customer may try to make the cleaner liable for any damage.

Since wet cleaning is a "new" and developing care method, appropriate care instructions have not yet been developed.

11.1 Proposed Changes in Care Labeling

The United States government is in the process of reviewing the FTC Care Labeling Regulations. In a June 15, 1994 "Request for Comments Concerning Trade Regulation Rule on Care Labeling of Textile Wearing Apparel and Certain Piece Goods," the FTC requested public comment on the modification of the current care labeling regulations in the following three areas:

1. whether to use symbols instead of words;
2. whether to provide information for consumers about whether a garment could be both washed and dry cleaned;
3. clarification of manufacturers' testing requirements

On December 28, 1995, the FTC published a proposed rule and further request for comment. Though the deadline for comments was March 13, 1996, no final rule has been published. Several groups are

One of the care symbols that the U.S. government is considering is a wet clean symbol.

working on care labeling practices for the fabricare industry, both in the United States and in Europe.

One of the care symbols that the U.S. government is considering is a wet clean symbol. Adding a wet clean symbol to the labeling rule would reduce the risk involved with wet cleaning by allowing a cleaner to return garments damaged by wet cleaning to the manufacturer for payment. The labeling rule changes are being proposed partly because professional cleaners would like to wet clean garments currently labeled "dry clean only."

11.2 The Current Situation

Common sense and the current care label rules leave wet cleaners with three choices for cleaning a garment:

- clean the garment according to the care label, if one is attached, even if that means sending the garment out for dry cleaning
- wet clean the garment, after examining the garment and determining that wet cleaning will not damage the fabric
- reject the garment because it is too soiled, not colorfast, or not appropriate for wet cleaning

If a garment is damaged by the wet cleaning process, the fabricare specialist can use the same customer relation techniques that are used by dry cleaners. If, for example, the color of a skirt from a suit has become slightly brighter after wet cleaning, the operator could offer to process the jacket for free so that it would match the skirt. The cleaner can save the cost of paying for the skirt and win back the customer's confidence.

Ultimately, the cleaner is responsible for choosing the best method of cleaning a garment, and the cleaner is also liable for the result.

Ultimately, the cleaner is responsible for choosing the best method of cleaning a garment, and the cleaner is liable for the result whether the garment is wet or dry cleaned. Following the care label can reduce this liability, but cannot remove it completely. Even when the recommendation on the care label is followed, cleaners often accept liability for damage to garments. This allows the fabricare specialist to satisfy the customer and increase the chance of repeat business.

With proper training and skill, wet cleaning more garments should not increase the number of claims for damaged garments. Experience to date has shown that a skilled wet cleaner should not have any more claims than an equally skilled dry cleaner.

Appendix A

Manufacturers

As demand increases, manufacturers are developing and marketing new equipment. For that reason, the information in this appendix may not include all current resources.

Wet Cleaning Machines

Aqua Clean
Neal Milch, Kevin Daley
Aqua Clean Systems, Inc.
461 Doughty Blvd.
Inwood, NY 11696-1384
516-371-4513
Fax 516-371-4204

Aquatex
Chris Dolan
Iowa Techniques Inc.
PO box 1322
Cedar Rapids, Iowa 52406
319-365-9788
Fax 319-364-6502

DAE WOO Air-Power Washer CNA Inc.
1111 Plaza Dr. #750
Schaumburg, IL 60173
708-995-9600
Fax 708-995-9609

Fashion Ace Equipment
Hyok Su Kwon
514 Warren Blvd.
Bromall, Pa. 19008
610-353-6707

Miele Kreussler (not currently in US market)
Bernard Sessman
Miele Professional
22D Worlds Fair Drive
Somerset, NJ 08873
908-560-0899
Fax 908-560-7469

Pellerin Milnor Corporation
Leroy Trevigne
PO Box 400
Kenner, LA 70063-0400
504-467-9591
Fax 504-468-9307

Schulthess

John Tipps
Clean Concepts
Technology Inc.
2154 West NW Highway
Suite 200
Dallas, Texas 75220-4220
1-800-765-0682
Fax 214-409-0388

UniMac

Tom Fleck
3595 Industrial Park Drive
Marianna, FL 32446-9458
904-526-3405
Fax 904-526-1509

Ultrasonic Cleaning

Allied Signal Aerospace

Tom Hand,
D/ME1-7, 2B3S
P.O. Box 419159
Kansas City, MO
64141-6159
816-997-3614
Fax 816-997-7081

Garment Care

David Porter
2018 Swift St.
N. Kansas City, MO 64116
816-221-1066

CO2 Cleaning

Caled Chemical

William Bernard
26 Hanes Drive
Wayne, NJ 07470
201-696-7575
Fax 201-696-4290

Detergent Manufacturers

Caled Chemical

Mike Meilor
26 Hanes Drive
Wayne, NJ 07470
201-696-7575
Fax 201-696-4290

CNA Inc.

1111 Plaza Dr. #750
Schaumburg, IL 60173
708-995-9600
Fax 708-995-9609

Fabritec/Stamford Research

Bob Knippling
200 Industrial Road
Cold Spring, KY 41076
606-781-8200
Fax 606-781-8280

Laidlaw

Michael Achin
6625 Scottsdale Road
Scottsdale, AZ 85250
602-951-0003
Fax - 602-991-1563

R.R. Streets
Manfred Wentz
184 Shuman Blvd.
Naperville, IL 60563-8464
708-416-4244
Fax 708-416-4266

Wet Cleaning Technologies
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Appendix B

Organizations

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Chicago, IL 60647
312-278-4800
Fax 312-278-3840

Federation of Korean Dry Cleaning Associations
54 East Avenue
New Canaan, CT 06840
203-966-8192

Greenpeace U.S.
Jack Weinberg
1436 U St. NW
Washington, D.C. 20009
202-462-1177

International Fabricare Institute
Mary Scalco
12251 Tech Road
Silver Spring, MD 20904
301-622-1900
800-638-2627
Fax 301-236-9320

Neighborhood Cleaners Association
Bill Seitz
252 W. 29th Street
New York, NY 10001
212-967-3002
Fax 212-967-2240

North East Fabricare Association
Peter Blake
343 Salem Street
Wakefield, MA 01880
617-245-6688
800-442-6848
Fax 617-224-0166

Tellus Institute
Deborah Savage
11 Arlington Street
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617-266-5400
Fax 617-266-8303

Toxics Use Reduction Institute
1 University Avenue
Lowell, MA 01854
508-934-3275
Fax 508-934-3050
http://www.turi.org

UCLA-Pollution Prevention Education & Research Center

Jessica Goldheart
3250 Public Policy Building
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Fax 310-825-1575

Government Agencies

Environment Canada

Brad Cumming
Pollution Prevention & Abatement Division
Environment Canada
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U.S. EPA

Design for Environment
401 M Street, SW (7406)
Washington, DC 20460
202-260-1678
Fax 202-260-0981
http://www.epa.gov/docs/dfe/dryclean

Pollution Prevention Information Clearinghouse (PPIC)
202-260-1023
Fax 202-260-0178
e-mail: ppic@epamail.epa.gov

Appendix C

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