CHAPTER 1
INTRODUCTION

This chapter introduces the Design for the Environment (DfE) Cleaner Technologies Substitutes Assessment (CTSA) for Professional Fabricare Processes. Section 1.1 describes the background for the CTSA and its relationship to the broader Garment and Textile Care Program. Section 1.2 discusses the CTSA's approach, including scope of coverage, focus on certain technologies, and why particular information may be relevant. A brief description of the intended use of this document concludes this chapter.

CHAPTER CONTENTS

1.1 PROJECT BACKGROUND

The use of chemical solvents for cleaning clothes began in France in the mid-19th century. In 1925, a petroleum solvent (Stoddard) was developed and used for this purpose, and in the 1960's perchloroethylene (PCE) became the solvent of choice for commercial clothes cleaning because it was considered less flammable than petroleum. PCE is now used by a majority of clothes cleaners and has since been shown to have a variety of health and safety issues associated with it. As a result, it has been subject to increased regulation, taxation, and liability costs. While drycleaners have significantly reduced the use of PCE over the last decade (Rissoto, 1997), it is still released to the environment. For example, PCE has been found in 38% of 9,232 surface water sampling sites throughout the United States. It has also been documented in air, soil, and sediments (ATSDR, 1995). PCE has been found in at least 771 National Priorities List (NPL) sites. The NPL consists of 1,416 hazardous waste sites identified by USEPA as the most serious in the nation (ATSDR, 1995) and they are targeted for long-term federal clean-up. It is unknown how many NPL sites have been evaluated for this compound. As USEPA looks at more sites, the number of sites known to have PCE contamination may increase (ATSDR, 1995).

In May 1992, the Office of Pollution Prevention and Toxics of the U.S. Environmental Protection Agency (USEPA) convened the International Roundtable on Pollution Prevention and Control in the Drycleaning Industry. Researchers, industry representatives, and government officials met to exchange information on the drycleaning industry. Issues discussed included exposure reduction, regulation, and information dissemination. Numerous other topics, such as potential health and environmental considerations related to exposure from drycleaning solvents, were also discussed.

USEPA created the DfE Program the following year and selected drycleaning as the subject of a pilot project. USEPA made this selection in consideration of concerns identified at the Roundtable and based on discussions with the Neighborhood Cleaners Association-International, Greenpeace, the New York State Department of Health, the Fabricare Legislative and Regulatory Education organization, and EcoClean. Dow Chemical, the Center for Emissions Control (currently the Halogenated Solvents Industries Alliance), American Clothing and Textiles Workers Union (now the Union of Needletrades, Industrial, and Textile Employees), the Center for Neighborhood Technologies (CNT), the International Fabricare Institute (IFI), the Federation of Korean Drycleaners Associations (FKDA), and the Toxic Use Reduction Institute at the University of Massachusetts also became active stakeholders. Alliance members

What is Design for the Environment?

"Design for the Environment" means building in pollution prevention aspects when industry is developing a product or process. The Design for the Environment (DfE) Program harnesses USEPA's expertise and leadership to facilitate information exchange and research on risk reduction and pollution prevention efforts. DfE works with businesses on a voluntary basis, and its wide-ranging projects include:

- Encouraging businesses to incorporate environmental concerns into decision-making processes in their general business practices.
- Working with specific industries to evaluate the risks, performance, and costs of alternative chemicals, processes, and technologies.
- Helping individual businesses undertake environmental design efforts through the application of specific tools and methods.

DfE partners often include:

Industry # Professional Institutions # Academia # Labor
Environmental Groups # Public Interest Groups # Other Government Agencies

were committed to exploring ways to prevent pollution, choose safer substitutes, and reduce exposure to traditional drycleaning chemicals.

The fabricare industry is characterized by small companies that rarely have the time or resources to gather information on alternatives to their current processes. As a result, few companies have access to sufficient information to choose safer or lower risk chemicals, work practices, or technologies. DfE prepared the CTSA to help fill this information gap. Specifically, the *CTSA for Professional Fabricare Processes* is a compilation of information on the relative risks, costs, and performance of clothes cleaning operations. USEPA anticipates that this information will be used to develop information products for cleaners so that they may be better equipped to examine trade-offs and incorporate environmental concerns into their day-to-day and long-term business decisions.

What is a *Cleaner Technologies Substitutes Assessment*?

This technical document, referred to as a *Cleaner Technologies Substitutes Assessment* (CTSA), is intended to develop and compile the information needed to systematically compare the trade-offs associated with traditional and alternative products, processes, and technologies. Specifically, these trade-offs include the cost, performance, and environmental concerns (such as risk and environmental releases) associated with a product or technology. This CTSA addresses fabricare alternatives and serves as the repository for technical information developed by the DfE Garment and Textile Care Project on clothes cleaning technologies. It is only one of the products developed for use as part of the Project, including those that may be suitable for a wider audience such as pamphlets and cost accounting worksheets, and those that may pertain to other segments of the textile and garment care industries.

The CTSA is a small part of DfE's Garment and Textile Care Program. The Program's mission is to assist in providing professional garment and textile cleaners with a wide range of environmentally friendly options that they can offer to their customers, while maintaining or increasing economic viability. The core of the Program stems from the fact that drycleaning is at the terminal end of an elaborate chain of industries in the garment and textile industry sectors. Thus, so-called "upstream" industries, such as fabric and garment manufacturing, directly affect the options available to garment and textile care providers. Whether a garment or textile product can be cleaned by a particular method or alternative technology depends largely on decisions made by the upstream industries regarding garment, fabric, and textile design and construction.

As a result, the Garment and Textile Care Program is taking a "systems" or industrial ecology approach to pollution prevention and is soliciting participation from a wider group of stakeholders than is involved in the CTSA. Recent efforts of the Program have focused on expanding the core stakeholder group to include representatives from the upstream industries and beginning development of a long-term plan for change and increased incorporation of pollution prevention practices along the entire value chain. The objective is to promote not only cleaner production in the manufacture of garments and textiles, but also production of garments and textiles that will facilitate the use of clean technologies by the professional fabricare provider.

1.2 CTSA APPROACH

An outcome of the International Roundtable on Drycleaning was the recognition of the need to prevent pollution and reduce exposures to perchloroethylene (PCE) in the drycleaning industry. USEPA has already published materials that examine pollution prevention in the drycleaning industry, including "The Product Side of Pollution Prevention: Evaluating the Potential for Safe Substitutes." This report evaluates the "...possibility of dramatic reductions in toxic chemical releases by focusing on safe substitutes..." (USEPA, 1994) and contains sections specific to PCE.

"The Product Side of Pollution Prevention" identifies existing substitutes for PCE in drycleaning and examines their efficiency and impact on reducing the generation of hazardous waste and the release of toxic chemicals. The report describes priority toxic chemicals generally, as those chemicals that are part of USEPA's 33/50 Program. The report concludes that safe substitute approaches for reducing PCE releases from drycleaning include reducing the use of garments requiring drycleaning, reducing the use of water-sensitive fabrics, altering the drycleaning process to eliminate or reduce organic solvent use, and substituting a safe solvent for PCE (USEPA, 1994).

The CTSA builds on this approach and introduces additional information on PCE and substitute processes that is useful in business decision making. Many of the approaches identified in "The Product Side of Pollution Prevention" such as the reduction in numbers of garments requiring drycleaning and the use of water-sensitive fabrics in garment manufacture, are not within the CTSA's scope. However, the CTSA takes a broad view of the substitutes for PCE, within the context of factors controllable by the drycleaner. Rather than focusing only on reducing hazardous waste generation and release of toxic chemicals, which is the approach of "The Product Side of Pollution Prevention," the CTSA incorporates additional considerations of risk, cost, regulatory environment, and performance.

For instance with "The Produce Side of Pollution Prevention" looks at reducing toxic releases, the CTSA incorporates information on the risks of chemical releases. Therefore, possible substitutes may differ between documents.

1.2.1 Coverage of Fabricare Alternatives

Several technology alternatives are available for commercial fabricare. The CTSA generally categorizes these as dry and wetcleaning alternatives. These categories are distinguished by the primary solvent used. Drycleaning refers to those technologies using non-aqueous solvents, although it is recognized that water may be a part of these processes. The CTSA covers PCE and hydrocarbon (HC) drycleaning alternatives. The other process covered uses water as a solvent and is referred to as machine wetcleaning in the CTSA. The extent to which each technology is covered in the CTSA is a function of the amount of data available.

The CTSA includes evaluations on a subset of chemicals used in fabricare processes, for instance, solvents and detergents (in the case of wetcleaning). Spotting chemicals and chemicals in other formulations, such as fabric finishes and water softeners, are not covered in the CTSA. Also, the report does not take an industrial ecology approach and evaluate lifecycle issues surrounding the chemicals and does not fully consider issues related to garment labeling. These important issues may be evaluated outside of this document and will likely be mentioned as considerations in the information products developed from the CTSA for use by cleaners. Finally, the CTSA compiles much of the known information on the cleaning technologies but does not generally develop new conclusions based upon that information. For instance, the CTSA adopts USEPA's current classification of the carcinogenicity of PCE, although USEPA is due to reassess this finding in the near future. Thus, most of what is found in this document will be familiar to the studied reader.

The information in the CTSA shows a range of alternative processes for reducing exposures to drycleaning solvents, (primarily PCE). These range from minor equipment modifications or changes (e.g., adding an emission control) to complete adoption of a new cleaning technology. For the PCE and HC drycleaning technologies, the CTSA evaluates a set of alternative equipment modifications (e.g., changing from a transfer to a dry-to-dry machine). This information is intended to provide a comparison of alternatives that move toward a greater reduction in drycleaning solvent use, recognizing that a complete technology change-over may not be an economically viable alternative for many of the businesses in the short-run.

The evaluation of machine wetcleaning risks focuses mainly on the detergents used in this process. Within the process, detergents are small percentage of the total volume of the solvent (i.e. water) and additive mix, accounting for approximately 1% (Industry Representatives, 1998). Numerous detergent formulations are currently available (Mains, 1996; Starr, 1998), complicating the review of this technology. Therefore, in preparing the CTSA, USEPA contacted wetcleaning product formulators to obtain information (chemical constituents and their weight percentages) on detergent formulations used. As expected, much of this information was deemed proprietary by the manufacturers. Based upon the information received, USEPA constructed an example formulation composed of chemicals (and their weight percentages) that may reasonably represent the chemicals (and percentages in formulation) found in actual formulations. It is not known how representative the selected chemicals and their concentrations are of those found in the myriad detergents available. Therefore, information reported for specific detergent

components is intended only to illustrate the range of effects that could be associated with detergents in general. To account for the variety of constituents that could be found in a detergent product, the CTSA attempts, where possible, to identify the functions of chemicals found in detergents (e.g., surfactants) and to generally identify considerations related to chemicals that can be used in those functions.

The CTSA contains a general section in Chapter 2 describing the market status of each technology. The evolution of some of the technologies is briefly covered. Although some of the material covered in the CTSA addresses older equipment (e.g., transfer machines), the information will provide perspective and be useful to those cleaners who may currently be using this equipment or may be more familiar with it.

Process descriptions of the various technologies are also provided. These descriptions are useful as background information and are general in nature. The reader should understand that specific machine configurations within a given facility may differ.

To present information that is useful for comparison, the CTSA establishes a baseline against which alternatives can be compared. Since the CTSA stakeholders are committed to pollution prevention and solvent exposure reduction and because PCE is the dominant solvent used in the clothes cleaning industry, the PCE technologies are used as the baseline.

1.2.2 Description of Health and Environmental Risks

The CTSA organizes information on the health and environmental risks of clothes cleaning processes so that they can be compared. Characterizing these risks involves gathering a variety of information. This process, known as risk assessment, generally requires the following components of an analysis: hazard assessment, dose-response assessment, exposure assessment, and risk characterization.

As a first step in risk assessment, the CTSA provides a review of the human health, environmental, and other (e.g., flammability) hazards (effects) of various fabricare technologies. This step provides a basic description of the potential effects of exposure to the chemicals and processes. Effects can relate to health and well-being, such as the ability of a chemical to cause cancer, respiratory illness, or injury such as repetitive stress injury. They can also be environmental in nature, such as the ability of a chemical to cause harm to aquatic organisms. Additionally, the CTSA describes effects related to flammability resulting from chemical use. In its description of the hazards of individual chemicals, the CTSA generally maintains the findings of USEPA, when available, and thus, does not present additional analysis of hazard data. It does, however, provide a reasonable summary of relevant literature on hazards. Hazard descriptions are summarized in Chapter 3, and a more detailed summary is found in Appendix C.

In addition to the hazards associated with the various cleaning technologies, it is also important to identify who is exposed to the chemicals used in the various processes and thus, who may experience the effects related to the chemical or process. This is the next stage in risk assessment. There are a number of ways in which people and the environment can be subjected to the effects of the processes or individual chemicals used therein. The CTSA limits its coverage of these exposures to those most relevant for the specific technologies and presents these in Chapter 4.

In evaluating exposures, the CTSA primarily uses the results of existing studies as a basis of exposure estimates. These studies include monitoring data, where available, on chemical concentrations in

air and water. These concentration data are then incorporated into models typically used by USEPA with standard assumptions, in order to present ranges of estimates for chemical exposures. The CTSA also describes reported exposure estimates from studies that use modeling.

In some cases, reported concentration data or modeled estimates of exposures are not available. In these cases, it is necessary to develop estimates of chemical releases from various processes to serve as a basis for estimating exposures. The CTSA presents release estimates for multiple media, air, water, and solid waste, depending on the chemical and exposure pathways and populations of concern. Release estimates are primarily developed for the analysis of exposures from wetcleaning operations and are based upon the example detergent formulation developed by USEPA.

The CTSA also presents solvent release estimates from 11 PCE and HC machine configurations. These estimates are intended to illustrate the relative differences in releases due to alternative machine configurations and control technologies. They are not used in risk assessments; however, they are presented in Chapter 10 to provide some information on how PCE and HC solvent reductions can be made.

The health and environmental risks associated with the cleaning technologies and the chemicals used within them are characterized in Chapter 5. Information on the hazards of the chemicals or associated with the technologies is combined with exposure and dose-response information to provide assessments of potential risks. The risk characterization is conducted at a "screening level" and developed using standard approaches. Estimated risks are not meant to predict actual risks to a particular individual; rather, they are meant to give a sense of the significance of the risk. Particular attention is paid to characterizing the uncertainty of the information. Similar to other information collected for this document, the extent of information presented on risk of the individual technologies is a function of the amount of information available on the technologies. Absence of information on a technology does not mean that risks are not associated with it.

The CTSA presents both cancer and non-cancer health risks for humans. It also evaluates environmental effects to aquatic species. Risks to terrestrial species are not considered. Quantitative measures are presented, in some cases, to provide a sense of the magnitude of potential risks. However, since the assessments for the individual technologies vary in the amount and type of hazard and exposure information, type of health concern, and uncertainties, the information is not directly comparable across technologies. Therefore, the comparison of risks is limited to a qualitative presentation in Chapter 10.

1.2.3 Performance Data

In addition to providing information on risks, in Chapter 6 the CTSA aims to provide information on the performance characteristics of alternative clothes cleaning processes. Several performance demonstrations and laboratory studies have been conducted to assess wetcleaning technologies in both the U.S. and Canada. While independent of the CTSA, these demonstrations and studies have provided useful information comparing wetcleaning to more traditional drycleaning technologies. Several studies have been summarized and incorporated into the CTSA. These studies contain information on consumer perceptions of the cleaning process (as it pertains to garments they have had cleaned) as well as information on the costs to run the performance demonstration sites. The CTSA, however, does not derive conclusions about the suitability for individual drycleaners of the alternatives that have undergone the performance testing.

1.2.4 Analysis of the Costs of the Alternative Clothes Cleaning Technologies

A cost analysis was developed for the alternative technologies by using data supplied by industry and publicly available information. Cost information from the performance demonstrations was not incorporated into the cost analysis. The cost information in the performance studies was not developed for machine configurations similar to the model plant configurations in the CTSA and could not, therefore, be applied in the cost analysis. The cost analysis considers a subset of the costs of running a professional clothes cleaning business: the private costs to the business. The CTSA includes estimates of some of these costs, including capital equipment, solvent, energy, hazardous waste disposal, filters, and maintenance costs. The CTSA uses this information to assess the relative costs of alternatives for a cleaning technology.

The concept of social costs is introduced in Chapter 10. These costs could include the costs to human and environmental health resulting from various technology choices. These costs are not quantified in the same manner as the private or business costs in this document, but are presented qualitatively.

1.2.5 Selected Federal Regulations

Professional clothes cleaners are affected by the requirements of many federal air, water, waste management, and occupational health and safety regulations. State, local, and other requriements may also pertain to clothes cleaning operations, however, are not covered in detail in the CTSA. Compliance with regulatory requirements can affect the choice of technology by limiting available alternatives or by increasing costs through compliance or liability. Chapter 6 summarizes many of the requirements faced by cleaners, and encourages them to investigate additional federal, state, and other requirements that may affect their operation. However, due to the variation in requirements across localities and operations, specific cost estimates are not included.

1.2.6 Environmental Improvements

Individual drycleaning shops have unique circumstances that impinge upon their ability to make certain process and technology changes. Therefore, in Chapter 9 the CTSA provides a listing of management practices and improvements that can be used at drycleaning shops to prevent pollution, reduce chemical consumption (and possibly exposure), and minimize waste. These opportunities can contribute to a facility's ability to reduce drycleaning solvent use.

1.2.7 Evaluation of Trade-Off Issues

For alternative technologies, the CTSA considers private costs (costs to the cleaner), such as operating and regulatory costs. It also considers *external* costs, including environmental damage and the risk of illness to the general public or workers. These are described qualitatively in the CTSA in Chapter 10. In addition, other factors such as performance and state-of-the-art technology are included as factors necessary in comparing alternatives. This material is presented in several frameworks that demonstrate how useful comparisons can be made, including cost-benefit and cost-effectiveness analyses.

1.2.8 Emerging Technologies

Chapter 11 of the CTSA provides some information on emerging technologies, liquid carbon dioxide (CO_2), and ultrasonic processes, in addition to Rynex and Biotex solvents. Information is generally limited due to the pre-commercial status of most, and they have therefore not been compared to existing technologies.

1.2.9 Additional Information

Several appendices are added to the CTSA to provide detailed information on various aspects. Appendix A details chemical and physical properties of chemicals evaluated in the CTSA. Appendices providing more technical coverage of hazard and dose-response (Appendices B, C, and D) are included. Release and exposure methodology and data are found in Appendix E. Finally, a description of the peer review process that the CTSA underwent is included in Appendix F.

1.3 HOW TO USE THIS DOCUMENT

1.3.1 Clothes Cleaners

While a CTSA contains the technical information developed about a use cluster (in this case, professional fabricare processes), it is not intended to guide the small business in making decisions. This document should be used by technically informed decision makers. USEPA will develop user-friendly information products based on the technical information in the CTSA and disseminate them to interested parties. After reviewing these more targeted information products, clothes cleaners may choose to return to the CTSA to obtain technical details on a specific alternative that is of interest to their operation.

The methods used to evaluate the technologies in this project may also be of interest to clothes cleaners. These individuals may use the methodologies described in this document to conduct their own evaluations of alternative projects or processes specific to their operation.

1.3.2 Other Readers

For technical assistance programs, the CTSA can provide background information on fabricare, the applicable technologies, and the DfE Garment and Textile Care Project. The comparative information on the cost, risk, and performance of alternative clothes cleaning technologies can be useful when working with cleaners to move toward reducing risks or pollution. Comparative risk information in the CTSA can be disseminated to workers and the general public so that they can better understand the risks associated with the various cleaning technologies.

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