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EPA Office of Compliance Sector Notebook Project

Profile of the Dry Cleaning Industry

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This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates Inc. (Cambridge, MA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be **purchased** from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included at the end of this document.

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Electronic versions of all Sector Notebooks are available on the EPA Enviroene Bulletin Board and via the Internet on the Enviroene World Wide Web. Downloading procedures are described in Appendix A of this document.

Cover photograph by Steve Delaney, EPA

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LIST OF ACRONYMS

AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA- Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation

NO_X - Nitrogen Oxides
NPDES - National Pollution Discharge Elimination System (CWA)
NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement and Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
SO_X - Sulfur Oxides
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/ outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, states, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this

profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or states may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages state and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested states may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with state and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE DRY CLEANING INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the dry cleaning industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes. Additionally, this section contains a list of the largest companies in terms of sales.

II.A. Introduction, Background, and Scope of the Notebook

This notebook covers the entire dry cleaning industry which includes three distinct types of operations: commercial, industrial and coin-operated. The dry cleaning industry is covered by three Standard Industrial Classification (SIC) codes, the codes the Department of Commerce uses to track the flow of goods and services. The commercial sector is included in SIC 7216 (dry cleaning plants except rug cleaning). Commercial plants typically receive small quantities of clothes from individuals and usually do not clean furs or leathers although they offer non-dry cleaning services, such as refreshing garments. The industrial dry cleaning sector is included in SIC code 7218 (industrial launderers). According to the 1987 Census of Service Industries, there are 1,379 industrial laundry facilities. Of these, the Agency estimates that 325 have dry cleaning capacity (USEPA, 1993a) while the remainder are exclusively wet laundries. Industrial dry cleaners primarily clean uniforms and may also rent uniforms and other industrial clothing such as gloves. Coin-operated dry cleaning is included in SIC 7215 (coin-operated laundries and dry cleaning). The Census of Service Industries indicates that there are 27,180 coin-operated laundries (with and without payroll) in 1987. Of these, the Agency estimated that about 3,000 offer dry cleaning services of some kind (USEPA, 1993a) although some estimate that there are fewer than 100 of such cleaners in operation. Coin-operated dry cleaners may be self-service units located in laundromats or may be run by an attendant but located in a self-service laundromat.

II.B. Characterization of the Dry Cleaning Industry

The dry cleaning industry provides garment cleaning services and in most cases will provide related services such as clothes pressing and finishing. The dry cleaning process is physically very similar to the home laundry process, except that clothes are washed in dry cleaning solvent instead of water. Fabric or garment cleaning consists of three basic functions: cleaning, drying and finishing. Garments are pre-treated for stains, and then machine washed in a solution of a solvent, soaps and detergents. The solvent is extracted by first draining, and then spinning the clothes.

Finally, the garments are dried through a combination of aeration, heat and tumbling, and then they are pressed.

These functions are the core of any fabric cleaning process, although the details vary and steps may be minimized or even omitted. All three functions are readily recognizable in the full-service dry cleaning process. Dry cleaners will also "refresh" a garment, concentrating mainly on finishing.

II.B.1. Industry size and geographic distribution

The number and size of dry cleaning firms varies within the three basic categories of dry cleaning operations. The commercial facilities are by far the most prevalent and include full service, retail operations located in shopping centers and near densely populated areas. The industrial dry cleaners operate the largest facilities which are often part of a business that rents uniforms, towels or other garments. The coin-operated sector of the market is typically associated with a laundromat that may provide either full-service retail dry cleaning similar to the commercial sector, or customer operated dry cleaning equipment. All sectors, however, provide a single basic service, clothes cleaning.

Commercial dry cleaning accounts for the majority of the firms with 30,494 facilities, as well as the majority of dry cleaning volume, 630,520 tons of clothes per year as shown in the exhibit below. The average commercial facility cleans approximately 19.7 tons of clothes per year. Industrial facilities while fewer in number, 325, have a larger average cleaning output of 578 tons of clothes per facility per year. Total dry cleaning volume of the industry sector is 187,991 tons per year. The coin-operated sector accounts for the smallest portion of the industry with 3,044 facilities processing 4,914 tons of clothes per year for an average 1.6 tons per facility.

Exhibit 1: Commercial Dry Cleaners Dominate Industry				
	Commercial	Industrial	Coin- Operated	Total
# of Facilities[a]	30,494	325	3,044[b]	33,863
Volume of Clothes Cleaned[c] (Tons/Year)	630,520	187,991	4,914	825,425
Mean Output per Facility[d] (Tons/year)	19.7	578	1.6	not applicable
Sales[e]	$4.8 billion	$385 million	$29 million	$5.2 billion

[a] USEPA, 1991b
[b] The number of coin-operated dry cleaning facilities estimated in USEPA, 1991b is high compared to a more recent estimate of <100 (Torp, 1994).
[c] Estimated values based on USEPA, 1991a and USEPA, 1991b.
[d] Volume/Number of facilities.
[e] USEPA, 1991b, some values were rounded (1993 dollars). Values indexed from 1989 dollars using the CPI for Apparel and Upkeep.

The size of dry cleaners varies by industrial sector. Most commercial dry cleaners are single facility "mom and pop" operations, although there is considerable variation in the size of these businesses. Classic family-owned-and-operated commercial cleaners typically have two or three full-time employees (including the owner) and perhaps some additional part-time employees. A typical firm might consist of a single small store front operation, with customer pickup and delivery in the front, and cleaning and finishing in the back. The store usually has one or two dry cleaning units (either a separate washer and dryer, or a combined "dry-to-dry" machine), and perhaps a water-based laundry machine for shirts and other washables.

Commercial dry cleaning is not a high profit business, and many dry cleaners are barely able to stay in business. Typical start-up costs in 1993 were $113,000, and over 60 percent of dry cleaners had annual revenues below $113,000; however, there is wide variation in the receipts. Official Census figures indicate one-quarter of the firms had annual revenues which were less than $28,000, and six percent had receipts over $564,000 in 1993 dollars (USEPA, 1991). The exhibit below shows the revenue distribution for commercial dry cleaners. The receipts must cover labor costs (by far the largest cost category), rent, capital depreciation, solvent

and other supplies. Wages are typically low; the industry average operator wage is less than $7.00 per hour. Many dry cleaners have difficulty paying competitive wages and earning any profit.

Exhibit 2: Very Small and Very Large Establishments Dominate Commercial Dry Cleaning (1993 dollars)

Annual Receipts ($/year) per Establishments	Number of Establishments	Percent	Total Annual Receipts ($1,000/year)	Percent
0-28,000	8,026	26%	160,474	53%
28,000-56,000	5,024	17%	229,611	5%
56,000-85,000	3,096	10%	233,950	5%
85,000-113,000-	3,096	10%	327,530	7%
>113,000	11,251	37%	3,857,651	80%
Total	30,494	100%	4,809,217	100%

Source: USEPA, 1993a

Coin-operated dry cleaners are gradually being phased out of the dry cleaning market. New coin-operated equipment is reported to be no longer available on the market (SRRP, 1990). The coin-operated segment of the dry cleaning industry resides in laundromats. There are two basic types of operations, including: commercial dry cleaners operating a laundromat and self-service dry cleaning operations. Commercial dry cleaners operating at a laundromat are classified as coin-operated because the dominant business at the location is the coin-operated laundromat. The dry cleaning side of the business can be fully staffed and provide the full services of a commercial dry cleaner. Alternatively, it can provide more limited service, with an operator receiving, cleaning, and returning batches of clothes to the customer, but not providing pressing, spotting or other services. The second type of coin-operated dry cleaning facility is the self-serve dry cleaning machine. These are truly coin-operated, with the customer operating the dry cleaning equipment. The exhibit below shows the total dry cleaning output and the average output per establishment as categorized by the coin-operated sector income. Comparing the total coin-operated dry cleaning sales from the first exhibit to total coin-operated sales below, shows that dry cleaning makes up only about 10 percent of the receipts in this sector, a much smaller fraction than for commercial or industrial laundries (USEPA, 1993a).

Exhibit 3: Medium-Sized Establishments Dominate Coin-operated Dry Cleaning and Laundries
(1993 dollars)[a]

Annual Receipts ($/year) per Establishment	Number of Establishments[b]	Percent	Total Annual Receipts ($1,000/yr)	Percent
0-28,000	523	17%	10,425	4%
28,000-56,000	1,451	48%	66,180	23%
56,000-85,000	475	16%	35,888	12%
85,000-113,000	169	5%	17,664	6%
>113,000	426	14%	158,468	55%
Total	3,044	100%	288,627	100%

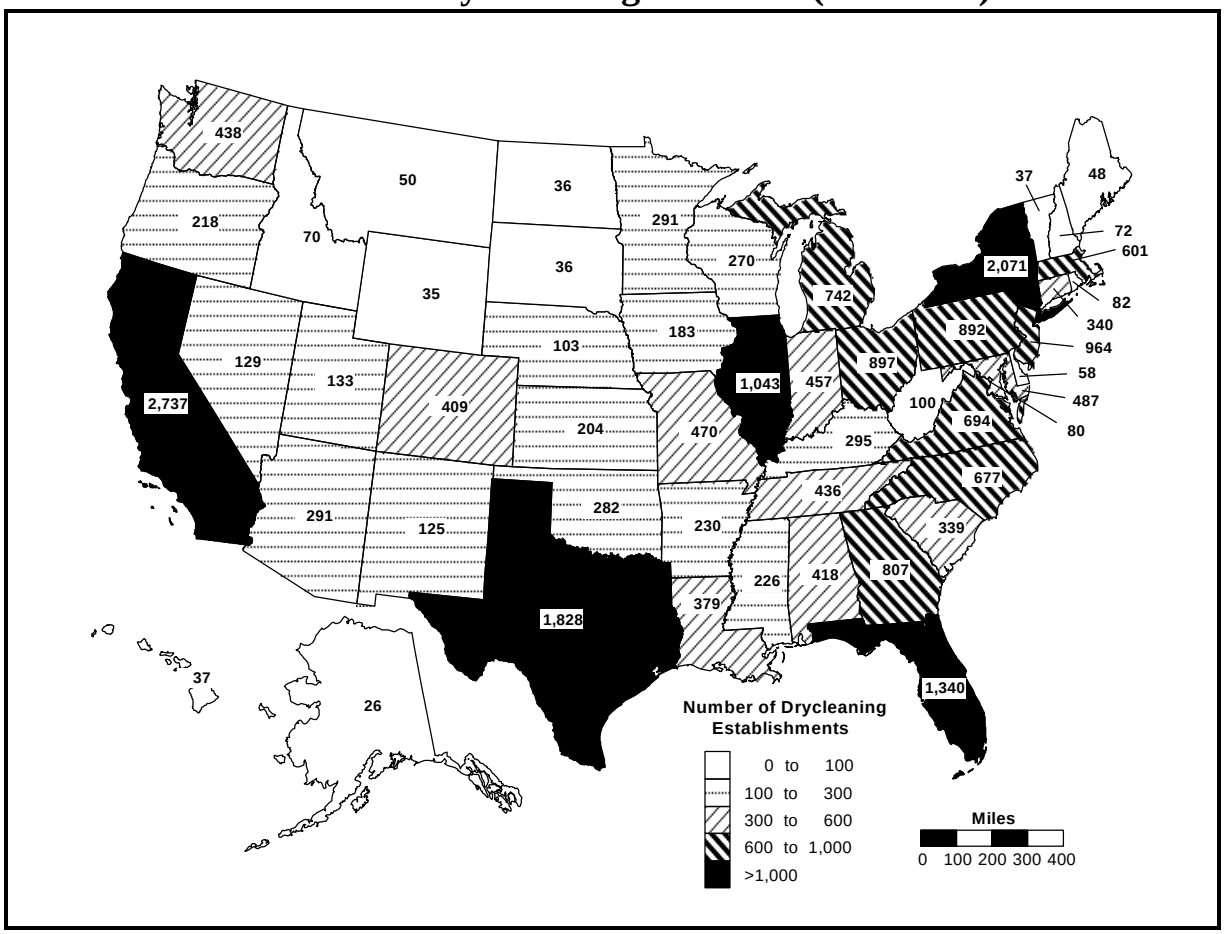
[a] Based on payroll converted to 1993 dollars using the CPI for Apparel and Upkeep.
[b] The distribution of establishments is based on the distribution of all coin-operated laundries with payroll (including those without dry cleaning capacity) reported in the 1987 Census of Service Industries.
Source: U.S. Environmental Protection Agency. 1993a. Economic Analysis of Regulatory Controls in the Dry Cleaning Industry. Final. EPA 450/3-91-021b. September.

Industrial dry cleaners tend to be larger than commercial establishments. They service institutional, professional and industrial customers by providing cleaning services for uniforms, restaurant linens, wiping towels, floor mats and work gloves. In many cases industrial dry cleaning firms offer rental as well as cleaning services. According to Census data, 1,379 industrial laundry facilities were operating in 1987 of which 325 were estimated to have dry cleaning operations. While sales for all operations at these facilities totaled $1.1 billion, only about 35 percent ($385 million) of the receipts were related to dry cleaning. The balance of receipts were from water washing or other activities (USEPA, 1993a).

Dry cleaners are spread throughout the United States although their location depends on both the type of operation and the solvent used. Commercial dry cleaners are distributed in a six to one ratio of urban to rural as a result of the greater demand for dry cleaning in urban settings. Their distribution roughly follows the population as shown in the exhibit below. Industrial laundries, however, tend to be located in medium to small cities to take advantage of the lower capital and labor costs. Industrial laundries are also less reliant upon being in their customer's immediate neighborhood. Coin-operated laundries tend to be in rural areas

where commercial dry cleaning is not available. The type of solvent used for dry cleaning also varies by geographic region. Petroleum dry cleaners are concentrated in the Gulf states, particularly Texas and Louisiana, partly due to the availability of petroleum in these locations and partly because local fire regulations prohibit petroleum cleaners in many other regions.

Exhibit 4: Dry Cleaning Facilities (SIC 7216)



Source: 1992 Census of Service Industries, Geographic Area Series

Exhibit 5: Geographic Distribution of Dry Cleaning Facilities Corresponds to Population in U.S.

State	Percent of Facilities[a]	Receipts ($1,000)	Facilities Rank	Population Rank	1990 Pop. (1,000)[b]
California	11.8	629,747	1	1	29,760
New York	8.9	346,412	2	2	17,990
Texas	7.9	448,292	3	3	16,987
Florida	5.8	273,109	4	4	12,938
Illinois	4.5	231,475	5	6	11,431
New Jersey	4.1	186,588	6	9	7,730
Ohio	3.9	208,832	7	7	10,847
Pennsylvania	3.8	196,682	8	5	11,881
Georgia	3.5	161,054	9	11	6,478
Michigan	3.2	161,270	10	8	9,295
Virginia	3.0	165,446	11	12	6,187
North Carolina	2.9	172,653	12	10	6,628
Massachusetts	2.6	136,666	13	13	6,016
Maryland	2.1	107,265	14	19	4,781
Missouri	2.0	98,485	15	15	5,117
Indiana	2.0	102,078	16	14	5,544
Washington	1.9	79,471	17	18	4,867
Tennessee	1.9	110,116	18	17	4,877
Alabama	1.8	93,949	19	22	4,041
Colorado	1.8	77,212	20	26	3,294
Louisiana	1.6	80,484	21	21	4,345
Connecticut	1.5	90,111	22	27	3,287
South Carolina	1.5	78,297	23	25	3,487
Kentucky	1.3	61,293	24	23	3,685
Minnesota	1.3	72,772	25	20	4,375
Arizona	1.2	73,290	26	24	3,665
Oklahoma	1.2	70,665	27	28	3,146
Wisconsin	1.2	63,964	28	16	4,891
Arkansas	1.0	45,053	29	33	2,351
Mississippi	1.0	46,756	30	31	2,573
Oregon	0.9	40,728	31	29	2,842

State	Percent of Facilities[a]	Receipts ($1,000)	Facilities Rank	Population Rank	1990 Pop. (1,000)[b]
Kansas	0.9	41,941	32	32	2,478
Iowa	0.8	36,487	33	30	2,777
Utah	0.6	26,191	34	35	1,723
Nevada	0.5	34,118	35	39	1,202
New Mexico	0.5	22,225	36	37	1,515
Nebraska	0.4	22,339	37	36	1,578
West Virginia	0.4	19,301	38	34	1,793
Rhode Island	0.3	17,081	39	43	1,003
D.C.	0.3	13,898	40	48	607
New Hampshire	0.3	17,519	41	40	1,109
Idaho	0.3	12,558	42	42	1,007
Delaware	0.2	13,530	43	46	666
Montana	0.2	6,576	44	44	799
Maine	0.2	9,623	45	38	1,228
Hawaii	0.2	21,141	46	41	1,108
Vermont	0.2	7,680	47	49	563
South Dakota	0.2	4,481	48	45	696
North Dakota	0.2	8,280	49	47	639
Wyoming	0.1	4,168	50	51	454
Alaska	0.1	17,679	51	52	550
Total	100	5,069,031			248,710

[a] Number of facilities comes from the 1992 Census of Service Industries. Drycleaning plants, except rug cleaning (SIC 7216).
[b] Populations are from 1990 Census, Summary Population and Housing Characteristics, Table I: US Summary.
Total may vary due to rounding.

Ward's Business Directory of U.S. Private and Public Companies, produced by Gale Research Inc., compiles financial data on U.S. companies including those operating within the dry cleaning industry. Ward's ranks U.S. companies, whether they are a parent company, subsidiary or division, by sales volume within the 4-digit SIC codes that they have been assigned as their primary activity. Readers should note that: 1) companies are assigned a 4-digit SIC that most closely resembles their principal industry; and 2) sales figures include total company sales, including subsidiaries and operations not related to dry cleaning.

Additional sources of company specific financial information include Standard & Poor's *Stock Report Services*, Dun & Bradstreet's *Million Dollar Directory*, Moody's Manuals, and annual reports.

Exhibit 6: Top U.S. Companies with Dry Cleaning Operations

Rank[a]	**Company**[b]	**1993 Sales** (millions of dollars)
1	Initial USA, Inc. - Atlanta, GA	170
2	Concord Custom Cleaners - Richmond, KY	25
3	Dryclean USA, Inc. - Miami, FL	25
4	Pride Cleaners, Inc. - Leawood, KS	16
5	Fashion Care, Inc. - Atlanta, GA	10
6	Spic and Span, Inc. - Milwaukee, WI	10
7	Al Phillips the Cleaner, Inc. - Las Vegas, NV	8
8	Admiral, Inc. - Annapolis, MD	7
9	Walker, Inc. - Omaha, NE	3
10	WH Christian and Sons, Inc. - Brooklyn, NY	3

Note: [a] When Ward's Business Directory lists both a parent and subsidiary in the top ten, only the parent company is presented above to avoid double counting. Not all sales can be attributed to the companies dry cleaning operations.
[b] Companies shown listed SIC 7216 as primary activity.

Source: Ward's Business Directory of U.S. Private and Public Companies - 1993.

II.B.2. Product characterization

The dry cleaner's product is the service of cleaning clothes conveniently. The products may also include services such as pressing and finishing. The market is divided into two parts, those customers who shop for price and will accept adequate quality and those who are buying quality cleaning with price being less of a concern. The latter are more steady dry cleaning

customers while the former will forego dry cleaning during financial downturns.

II.B.3. Economic trends

In 1992, the total dry cleaning market generated $5.2 billion in revenues, with $4.8 billion generated by the commercial sector and $385 million and $29 million generated by the industrial and coin-operated sectors respectively. Current industry estimates indicate a zero growth rate for the commercial sector through 1996 while both the industrial and coin-operated sectors are anticipated to continue their decline during this period. More clothes are being made of launderable fabrics which reduces the demand for commercial dry cleaning. Self-service coin-operated dry cleaning machines are no longer manufactured and those currently in use are being phased out as they age. The trend toward launderable fabrics will inevitably reduce the need for industrial dry cleaning as well.

Convenience is the driving force in commercial dry cleaning. Location near the consumer and fast turnaround on their clothes as well as the cleanliness of the item are important to dry cleaning success. Consumers care little about what solvent is used to clean their clothes as long as the cleaning service is convenient, fast and effective. While the switch to launderable fabrics reduces the need for dry cleaning, the other services such as laundering, pressing and finishing may still be in demand.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the dry cleaning industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (via air, water, and soil pathways) of these waste products.

III.A. Industrial Processes in the Dry Cleaning Industry

Dry cleaning processes garments in a way that avoids saturating fabrics with water. If thoroughly saturated with water, agitated and heated, certain fabrics (especially wool, silk and rayon) may shrink or the dye may run. Other garments that are constructed from several materials can be damaged if the various layers react differently to the cleaning process. Because dry cleaning solvents do not saturate the fibers of the fabric, the swelling and shrinking from water saturation is avoided, allowing nearly all types of fabrics and garments to be safely dry cleaned.

Four solvents dominate the dry cleaning market: perchloroethylene (PCE), petroleum solvents, chlorofluorocarbons (CFC-113) and trichloroethane (TCA). The manufacture of the latter two will be banned in 1995 under the Clean Air Act Amendments. The exhibit below shows that PCE dominates the commercial sector while petroleum solvent is used in the majority of industrial machines.

One important characteristic of the dry cleaning industry is that the machinery used with these solvents has evolved over time. The development encompasses four "generations" of machines, all of which are still in use. The first generation of equipment has separate washers and dryers, thus the operator must transfer the clothes between the two. The second generation machine design eliminates the stand-alone dryer and

combines both washing and drying into a single machine. The third generation of equipment includes added control technology to reduce the vapor emissions. The fourth generation of machine design modifies the third generation by recycling the air in the machine to further reduce emissions. Each generation is described further below.

Exhibit 7: Number of Dry Cleaning Facilities by Process and Industrial Sector[a]

Process Solvent	Industrial Sector			
	Commercial	Industrial	Coin-operated	Total
PCE	24,947	130	3,044	28,121
Petroleum	4,548[b]	195	0	4,743
CFC-113	949[b]	0	0	949
Trichloroethane	50[c]	0	0	50
Total	30,494	325	3,044	33,863

[a] USEPA, 1991b, unless otherwise indicated.
[b] Estimate based on USEPA, 1991a.
[c] Wolf, 1992.

First Generation Machines

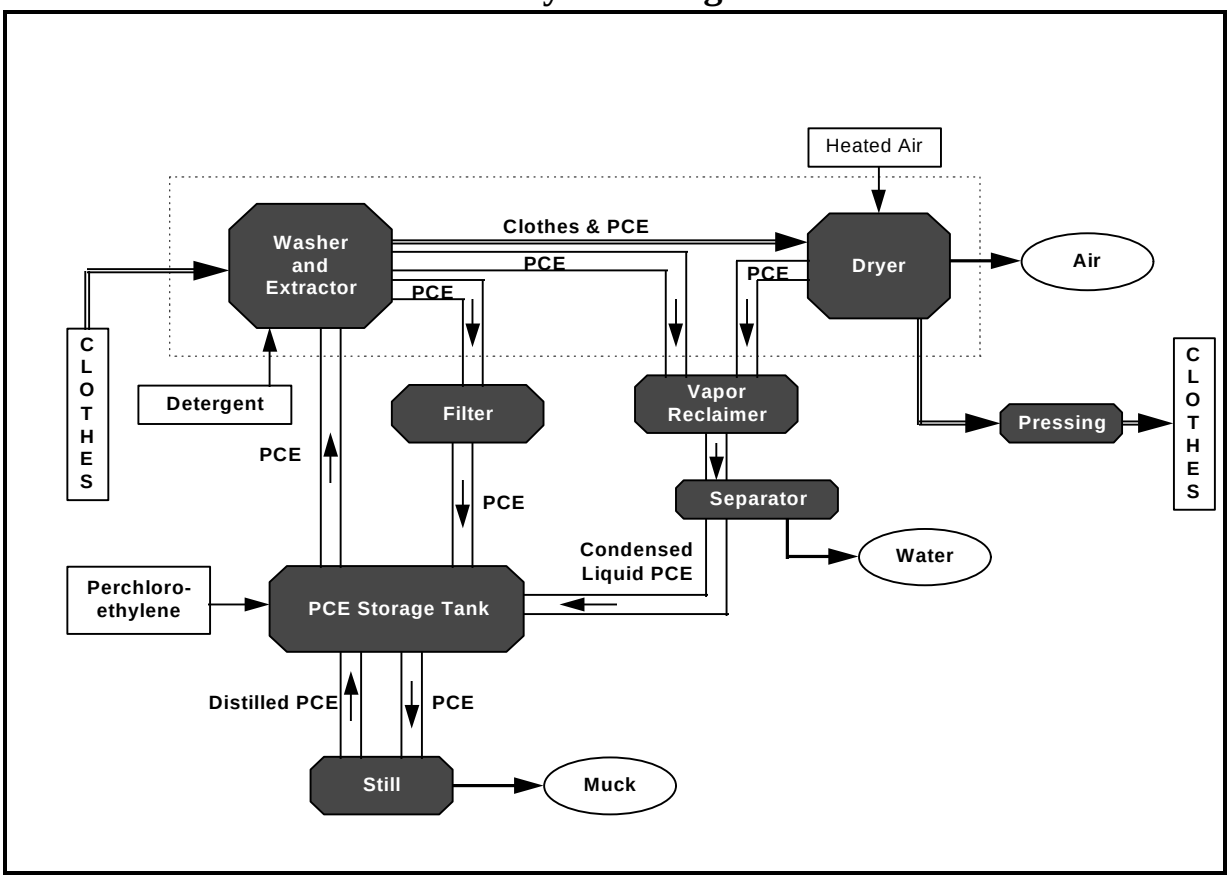
The first generation of dry cleaning machines had separate washers and dryers. These transfer machines (so-called because the wet clothes were transferred from the washer to the dryer) were the predominant type of machine used until the late-1960s, when dry-to-dry machines were developed that reduced solvent loss and improved dry cleaning economics. In a typical transfer process, the clothes are loaded into the washer, where the solvent is combined with a water and detergent charge, and the clothes and solvent are agitated by rotation of the washer's drum. After washing, the drum is rotated at high speeds to extract the residual solvent. The clothes are then manually transferred to a dryer where recirculating warm air causes most of the remaining solvent to vaporize. To reduce wrinkling, the drying cycle is followed by a brief cool-down cycle during which unheated air is circulated through the clothes (USEPA, 1991). A flow diagram for a typical PCE transfer machine is shown below. The advantages of using transfer equipment are: (a) more production since a

new load is being washed while the previous one is being dried; (b) less complicated construction with less automation and thus greater ease of repair; and (c) reduction of fabric damage since the cylinder remains cool after the prior load is removed. The disadvantages are: (a) the additional labor required to handle the heavy volume; (b) the solvent vapors that escape to the atmosphere during transfer; (c) exposure of the worker to the solvent; and (d) the garments that can fall on the floor during transfer. Currently, about 34 percent of dry cleaning machines in the U.S. are transfer units (Brown, 1993). However, the National Emissions Standards for Hazardous Air Pollutants (NESHAP) for PCE dry cleaning facilities will not allow new transfer machines that use PCE (USEPA, 1993b). Transfer machines cannot be converted to dry-to-dry machines, but they can be retrofitted with vapor control devices and with impermeable enclosures to capture fugitive emissions. Two technologies that can capture the solvent that escapes during clothing transfer are hamper enclosure and room enclosures.

Hamper enclosures consist of a hood or canopy usually made of polyethylene -- impervious plastic that encloses the clothing hamper and the open door of the washer when clothing is removed from the washer of a transfer machine and placed in the dryer. The same canopy is used when transferring the clothes from the hamper to the dryer (Environmental Reporter, 1992).

Room enclosures usually consist of a metal frame covered with clear impervious plastic that encloses both the washer and dryer of a transfer machine. During clothing transfer, a fan is turned on to draw air from outside the room enclosure through louvered door openings in the enclosure and then to a vapor emission control device.

Exhibit 8: Process Flow Diagram for Perchloroethylene Solvent Transfer Dry Cleaning Machines



Source: Adapted from USEPA, 1991b

Second Generation Machines

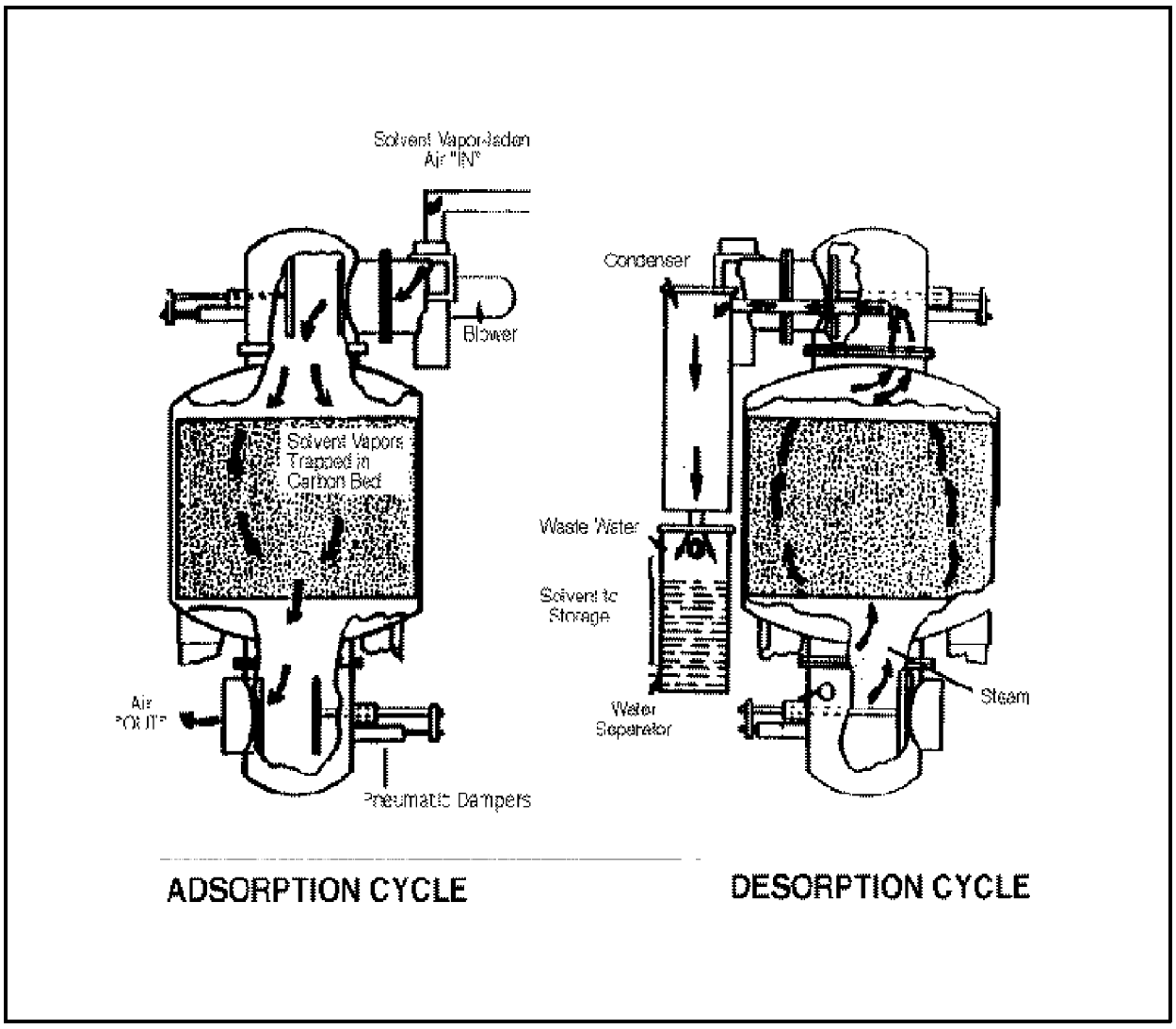
Transfer units were used exclusively until the late 1960s, when a second generation of equipment was introduced to reduce the amount of space the machines occupied and to decrease solvent consumption. Called "dry-to-dry" machines, these units integrate the washing and drying into the same unit. This saves space, requires less labor (because the operator does not have to transfer garments), reduces the amount of solvent vapor that escapes, lowers worker exposure to solvent vapor, and generates a higher solvent mileage (the quantity of solvent needed to clean a quantity of clothes). The disadvantages are lower production and less flexibility, since each machine is committed to a single load during its entire wash-dry cycle. Dry-to-dry machines currently comprise 66 percent of the units used in the U.S. (Brown, 1993). Of these, 32 percent are the vented units

(2nd generation machines) that are designed to send residual vapors to the atmosphere or an external control device (Brown, 1993). The remainder are third or fourth generation machines as described below. Second generation machines can be retrofitted with control devices such as carbon adsorbers (not allowed under current regulations) and refrigerated condensers.

Carbon adsorbers recover solvent by sending contaminated air through a bed of activated carbon that then adsorbs[a] the solvent vapors as shown below. The adsorbed solvent is recovered by passing low-pressure steam (new designs use hot air) through the carbon bed. The mixed steam and solvent vapors are then passed through a water-cooled condenser and are collected in a phase separator.[b] The carbon is dried and reused while the recovered solvent is returned to the dry cleaning system (SRRP, 1990). Carbon adsorbers can be retrofitted to both dry-to-dry and transfer machines. In tests of carbon adsorbers, the removal efficiencies were above 95 percent (USEPA, 1991). However, subsequent data from the California Air Resources Board led the Agency to believe that in actual practice the removal efficiencies are much lower. As a result, the NESHAP does not allow them as an option for primary control except in certain large facilities where carbon adsorbers were installed prior to the promulgation of the regulation, September 22, 1993.

[a] The system will hold molecules on its surface (adsorb) and then release them (desorb) when steam is passed through the bed.

[b] PCE and water are reasonably insoluble in the liquid phase. The cooled PCE/water mixture will enter the phase separator where two layers will form. The PCE will then be drawn off for recycling.



Source: USEPA 1991a

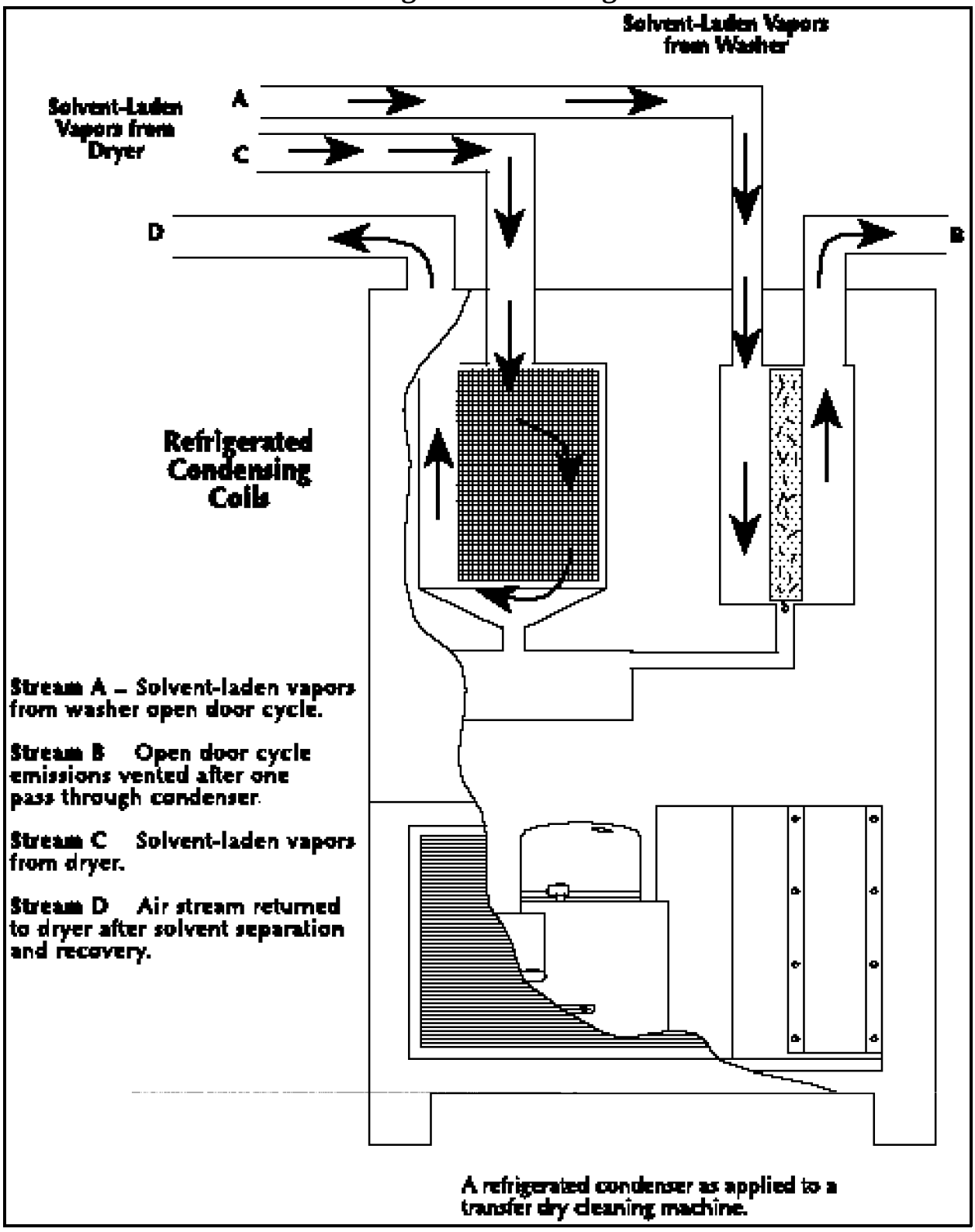
Exhibit 9: Flow Diagram of a Carbon Adsorber

Refrigerated condensers have both an advantage and a disadvantage when compared to carbon adsorbers. They require less maintenance because the refrigerant only needs to be replaced yearly while carbon adsorbers must be desorbed daily.[c] The disadvantage of refrigerated condensers compared to carbon adsorbers is that they cannot be used to control low concentration emission streams (USEPA, 1991a).

[c] The desorption of solvent is accomplished by passing steam (or hot air) through the carbon bed.

Refrigerated condensers remove vapors from the exhaust stream by cooling them to below their dew points. Most new machines have built-in refrigerated condensers, but the condensers can be retrofitted to both transfer and dry-to-dry machines (USEPA, 1991a). Refrigerated condensers achieve about 95 percent control of HAPs when compared to uncontrolled machines (Smith, 1995). The figure below shows a typical refrigerated condenser that can accommodate two HAP (hazardous air pollutant such as PCE)-laden streams. In transfer machines, a stream (Stream A) from the exhaust fan used when the washer door is opened will feed through the condenser and be vented (Stream B) and a stream from the dryer (Stream C) passes through the condenser, and after separation and recovery of the solvent returns the air stream to the dryer (Stream D). Dry-to-dry machines only have the second stream. In transfer machines, the exhaust vapors from the washer are vented (in one pass) through the condenser to the atmosphere, and thus the system can achieve only about 85 percent control of HAPs compared to an uncontrolled machine (USEPA, 1991a).

Exhibit 10: Flow Diagram of a Refrigerated Condenser



Source: USEPA 1991a

Third Generation Machines

The third generation of machines that were designed in the late 1970s and early 1980s are dry-to-dry with built-in refrigerated condensers. These are closed loop machines. A closed-loop machine does not vent air to the atmosphere but recycles it continuously throughout the dry cleaning cycle. The only air exchange with the atmosphere occurs during loading and unloading. Thirty-four percent of the machines currently in use in the U.S. are of this design (Brown, 1993). The advantage is a single unit that will release smaller amounts of vapor. The disadvantage is the greater complexity of machine design which could lead to higher maintenance costs and more frequent breakdowns. The principles of operation are the same as for the second generation machines that use refrigerated condensers.

Fourth Generation Machines

The fourth generation machine is a non-vented, closed loop process with an additional internal vapor recovery device. The control technologies used in these machines are refrigerated condensers and carbon adsorbers. In non-vented, closed loop machines, refrigerated condensers can match carbon adsorber's 95 percent control efficiency (USEPA, 1991a).

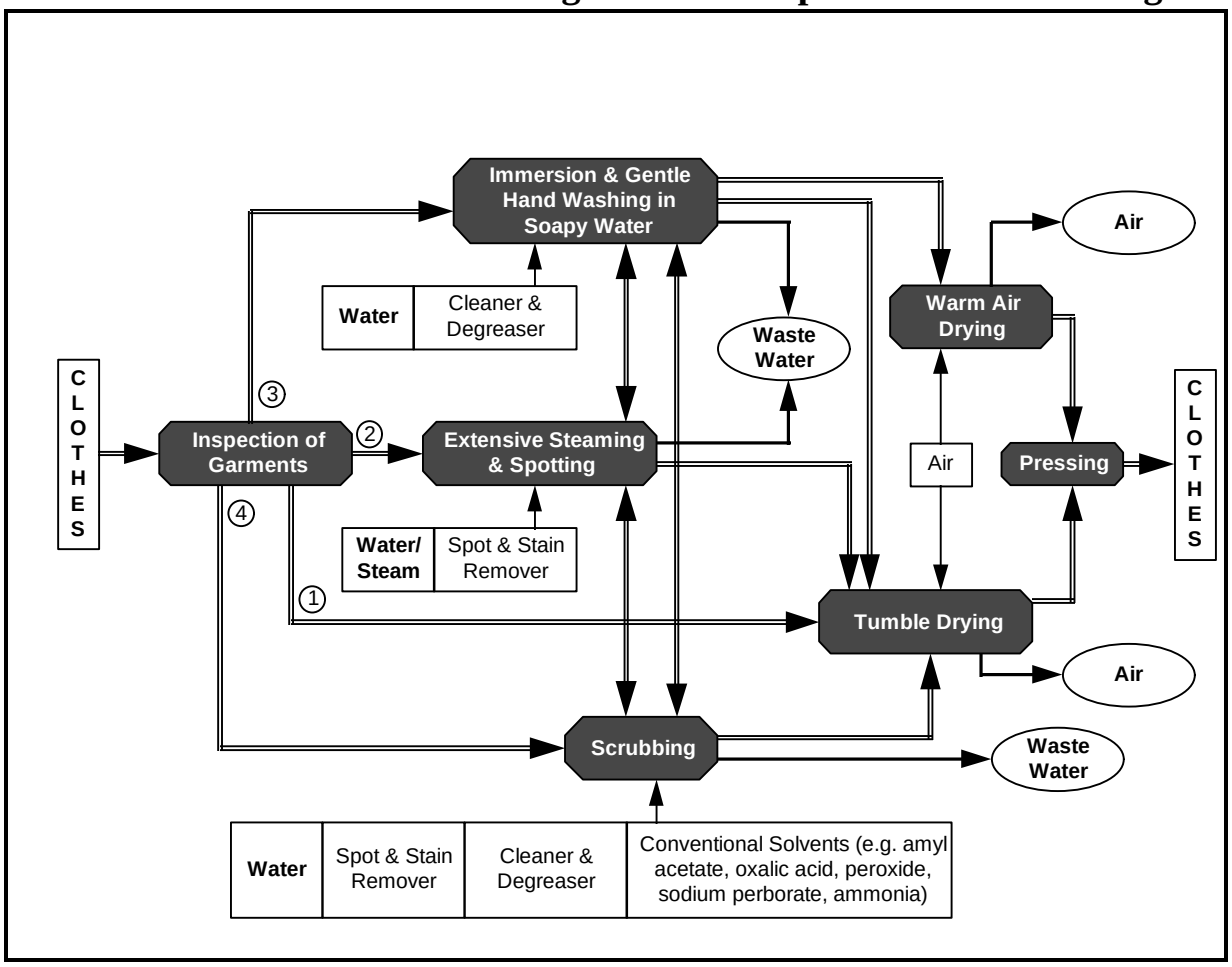
Technological Trends

The recent technological trends have been to increase mileage and to reduce emissions. The increased mileage decreases solvent costs for the facility while the reduced emissions are driven by both environmental and worker protection laws. In September, 1993 the Agency promulgated a National Emission Standard for Hazardous Air Pollutants (NESHAP) for Perchloroethylene Dry Cleaners. These regulations require both existing and new facilities that meet certain size requirements to use designated vapor control technologies and undertake leak detection and equipment repair to prevent fugitive emissions. Occupational Safety and Health Act regulations have imposed limits on worker exposure to perchloroethylene which has led to machine designs that reduce emissions from opening the door after operation. For petroleum solvents the trend has been towards development of solvents with higher flash points to reduce the explosion potential and to solvents with lower volatile organic compound content to reduce VOC emissions.

One of the most important current developments in the industry is the commercialization of aqueous alternatives for a portion of the clothes currently dry cleaned. Multi-process wet cleaning is a method of hand cleaning clothes using a controlled application of water. It is called "multi-

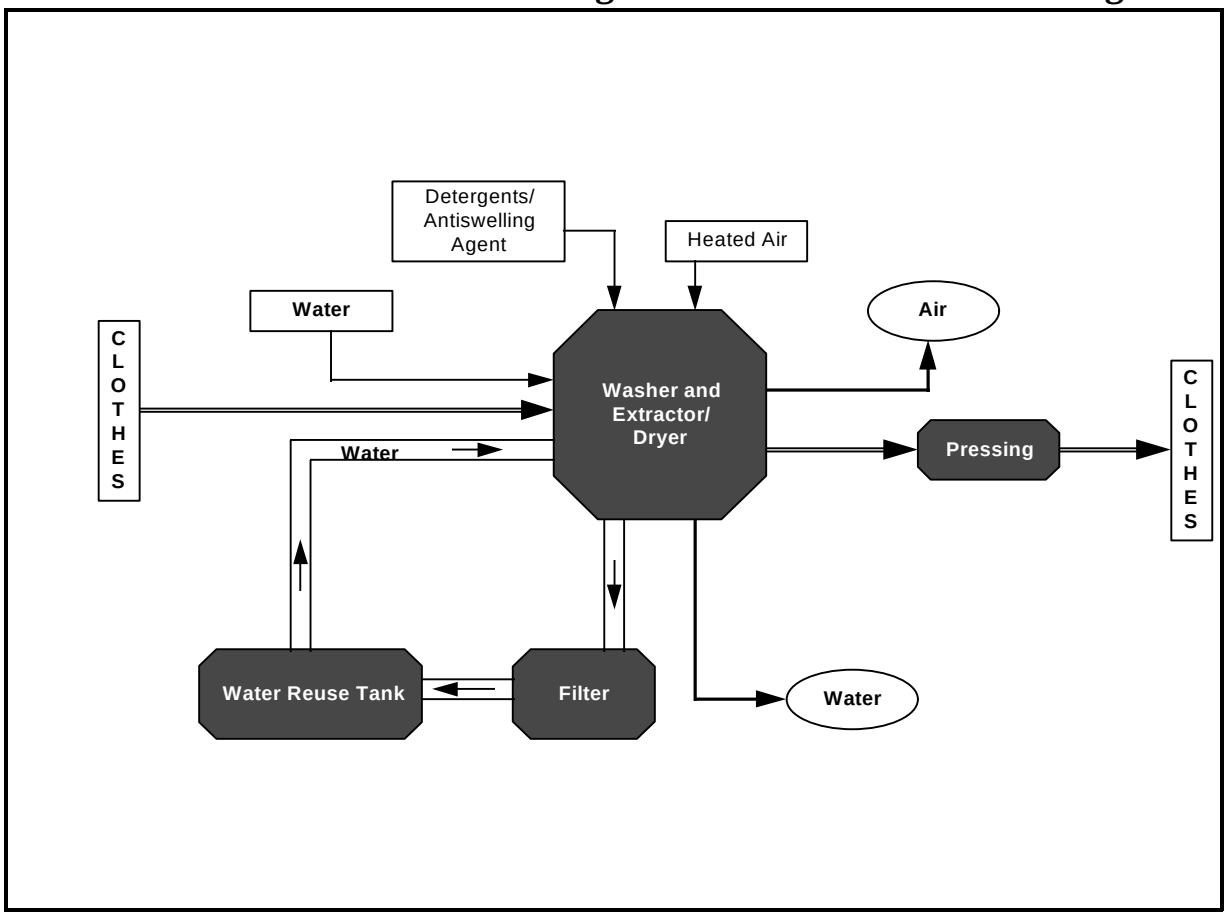
process" because a number of different steps can be included in the process depending upon the fabric type and the soil and stains on the garment. A cleaning technician inspects incoming garments for the degree of soiling and based on that and the fiber type a cleaning process is chosen. The process could be spotting, localized steaming, hand washing or machine washing. A flow diagram of multi-process wet cleaning is shown below. The second aqueous alternative is machine wet cleaning. This process uses a specially designed washing machine that reduces the agitation the clothes are subject to in a traditional laundering process and adds proprietary chemicals (that satisfy the German environmental regulations) to reduce fiber swelling. These machines have been used profitably in Europe (primarily Germany) and are now being introduced into the U.S. market by several manufacturers. The process is diagramed below. The critical test for market acceptance will be the percent of the current U.S. dry cleaning clothes stream that these processes can clean effectively without damaging the garments. Two firms in New York City currently are using a combination of the two aqueous processes and report eighty percent repeat business.

Exhibit 11: Process Flow Diagram of Multiprocess Wet Cleaning



Source: Developed for USEPA Office of Pollution Prevention and Toxics' Design for the Environment Program.

Exhibit 12: Process Flow Diagram of Machine Wet Cleaning



Source: Developed for the USEPA Office of Pollution Prevention and Toxics' Design for the Environment Program.

III.B. Raw Material Inputs and Pollution Outputs

The primary dry cleaning releases are to air (through both fugitive emissions and direct release at the end of the cycle), water (from water that was contained in the clothes and from regenerating carbon adsorbers) and solid waste (such as the muck from stills used to evaporate solvent-contaminated water, the residue remaining after contaminated solvent is filtered, and the carbon from an adsorber). There is an active recycling market for solvent recovered from dry cleaning facilities, although the overall percentage of solvent recovered is not known.

Exhibit 13: Pollution Releases from Dry Cleaning Operations	
Release Medium	Emissions
Air	Solvent spills Fugitive leaks from piping Vapor released with transferring or removing clothes from machines Vapor release from clothes dryers Residual vapor release from clothes after they are removed from the dryer
Water	Water from separator
Hazardous/Solid Waste	Residue from solvent still Filters