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STUDY TO SUPPORT NEW SOURCE PERFORMANCE STANDARDS FOR THE DRY CLEANING INDUSTRY - FINAL REPORT

U.S. ENVIRONMENTAL PROTECTION AGENCY
Emission Standards and Engineering Division
Office of Land Use Planning and Standards
Research Triangle Park, North Carolina 27711

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by

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DECLARATION

The format of this report is based generally on the Standard Support-Environmental Impact Statement outline, draft No. 6, dated April 1975. Although some chapters appear to be missing, they were not, in fact, the contractual obligation of TRW Inc. This document completes all the deliverable requirements of the Contract Task Specification.

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3.0 THE DRY CLEANING INDUSTRY

3.1 INDUSTRY DESCRIPTION

The dry cleaning industry is a service industry, involved in the cleaning of apparel or renting of apparel. Basically, the industry is composed of three categories, segregated by the type of services they offer. These are : (1) coin-operated facilities, (2) commercial dry cleaning plants; and (3) industrial dry cleaners.

Coin-operated dry cleaning facilities are usually part of a "laundromat" facility (although there are separate installations), and operate on either an independent or franchise basis. They provide a "self-service" type of dry cleaning for the individual consumer. Commercial dry cleaning plants are the most familiar type of facilities, offering the normal services of cleaning soiled apparel or other fine goods. They include: the small neighborhood dry cleaning shops operating on an independent basis ("Mom and Pop" dry cleaners); the franchise dry cleaning shops (e.g. "One Hour Martinizing") and the specialty cleaners, handling leather and other fine goods. The industrial cleaners are the larger dry cleaning plants predominantly supplying rental services of uniforms or other items to business, industrial, or institutional consumers. The industry's establishments are principally located in urban areas and numbered 46,992 in 1972.* The composition of the industry was approximately 37 percent coin-operated, 60 percent commercial and 2 percent industrial.[1] It should be noted, however, that industrial dry cleaning establishments are generally quite large and account for a much higher fraction of the total U.S. dry cleaning capacity than their numbers would indicate. No data were found which define just how much capacity the industrial sector does have, however.

During the period between 1967 and 1972, the total number of establishments in the industry decreased approximately 3 percent. This trend does not pervade equally throughout the industry. It is mainly attributable to a decrease in the number of establishments in the commercial plant category which decreased approximately 8 percent while the coin-operated and industrial plant categories increased approximately 5 and 11 percent, respectively. The decrease in the number of commercial dry cleaning plants in the past few years has occurred as the result of the following factors:

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* 1972 is the latest year for which actual data is available.

- The use of new equipment which has increased productivity and consequently reduced the need for new plants to supply demand;
- The increasing use of washable synthetic fabrics which has reduced the demand for drycleaning services; and
- The increasing use of coin-operated facilities by consumers.

This trend is reflective of the changing structure of the industry and is significant since the commercial plant category represents the major proportion of the total industry. A more detailed discussion of the industry structure, employment, receipts and projected growth is contained in Chapter 7.

3.2 DRY CLEANING PROCESSES AND EMISSIONS

3.2.1 The Basic Process

Dry cleaning is the cleaning of fabrics in an essentially non-aqueous solvent. The principal steps in the process are identical to those of ordinary laundering in water; 1) one or more washes (baths) in solvent; 2) extraction of excess solvent by spinning; 3) drying by tumbling in an airstream. The solvents used are categorized into two broad groups: 1) petroleum solvents; which are mixtures of hydrocarbons similar--but not identical--to kerosene; and 2) synthetic solvents, which are halogenated hydrocarbons. Differences between the dry cleaning procedures for these two groups of solvents are due primarily to three factors:

- Synthetic solvents are much more expensive than petroleum solvents.
- Petroleum solvents are highly flammable, while synthetic solvents are nonflammable.
- The densities of synthetic solvents are about twice that of petroleum solvents.

The distinctions between the various solvents as well as the processes, are discussed in detail later in this section. By way of illustration, Figure 3-1 is a schematic of a synthetic solvent-based plant. A petroleum solvent-based plant would differ from this chiefly in that there would be no recovery or reclaiming of solvent from the dryer.

3.2.1.1 Washing (Figure 3-2)

Fabrics to be cleaned are placed in the wheel of the cleaning machine, and the machine is filled to a certain level with solvent. The wheel is then rotated to tumble the clothes and force solvent through the fabric. Although some machines use a batch wash operation where the clothes are tumbled in

FIGURE 3-1. PERCHLOROETHYLENE DRY CLEANING PLANT FLOW DIAGRAM.

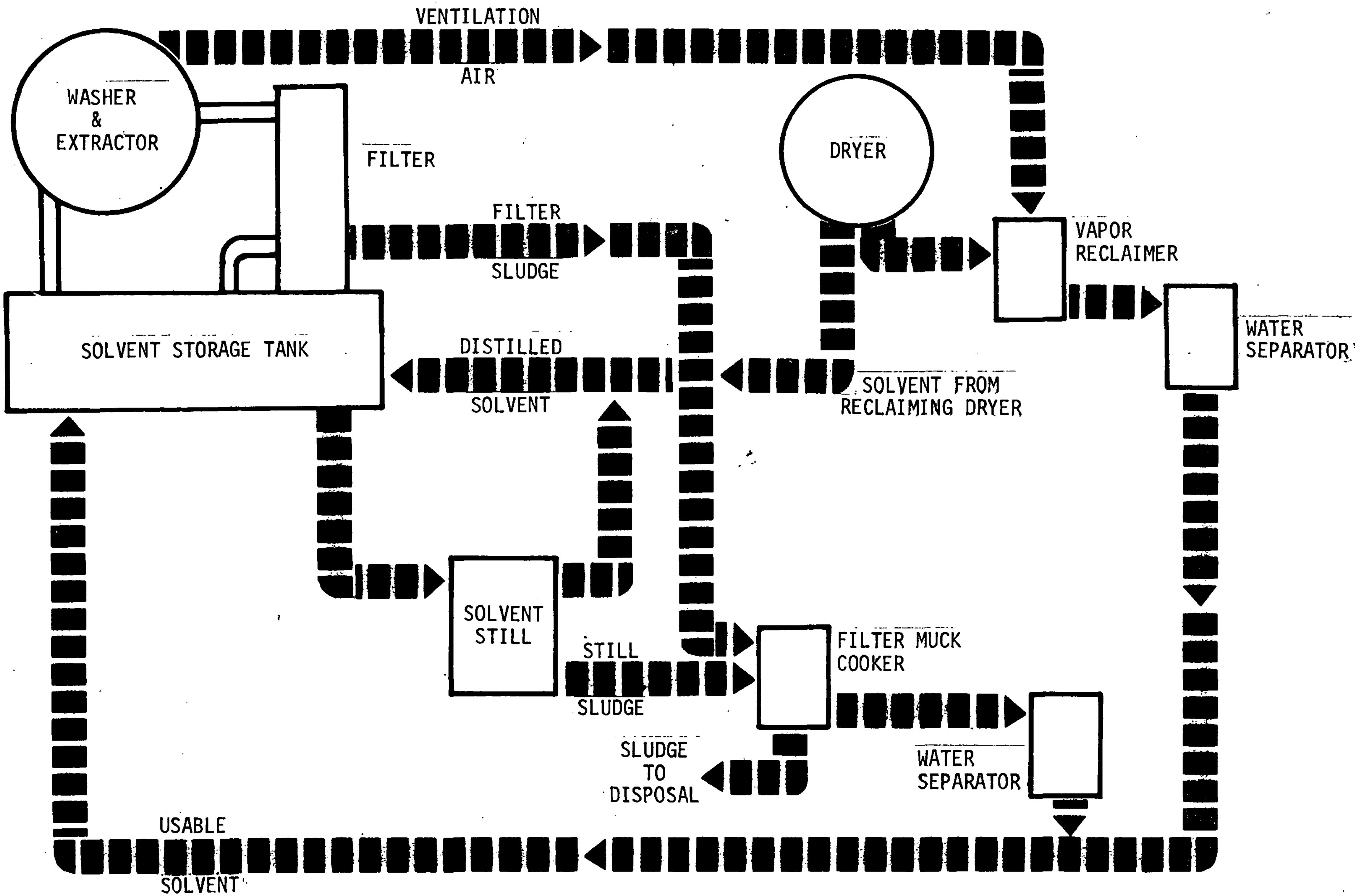
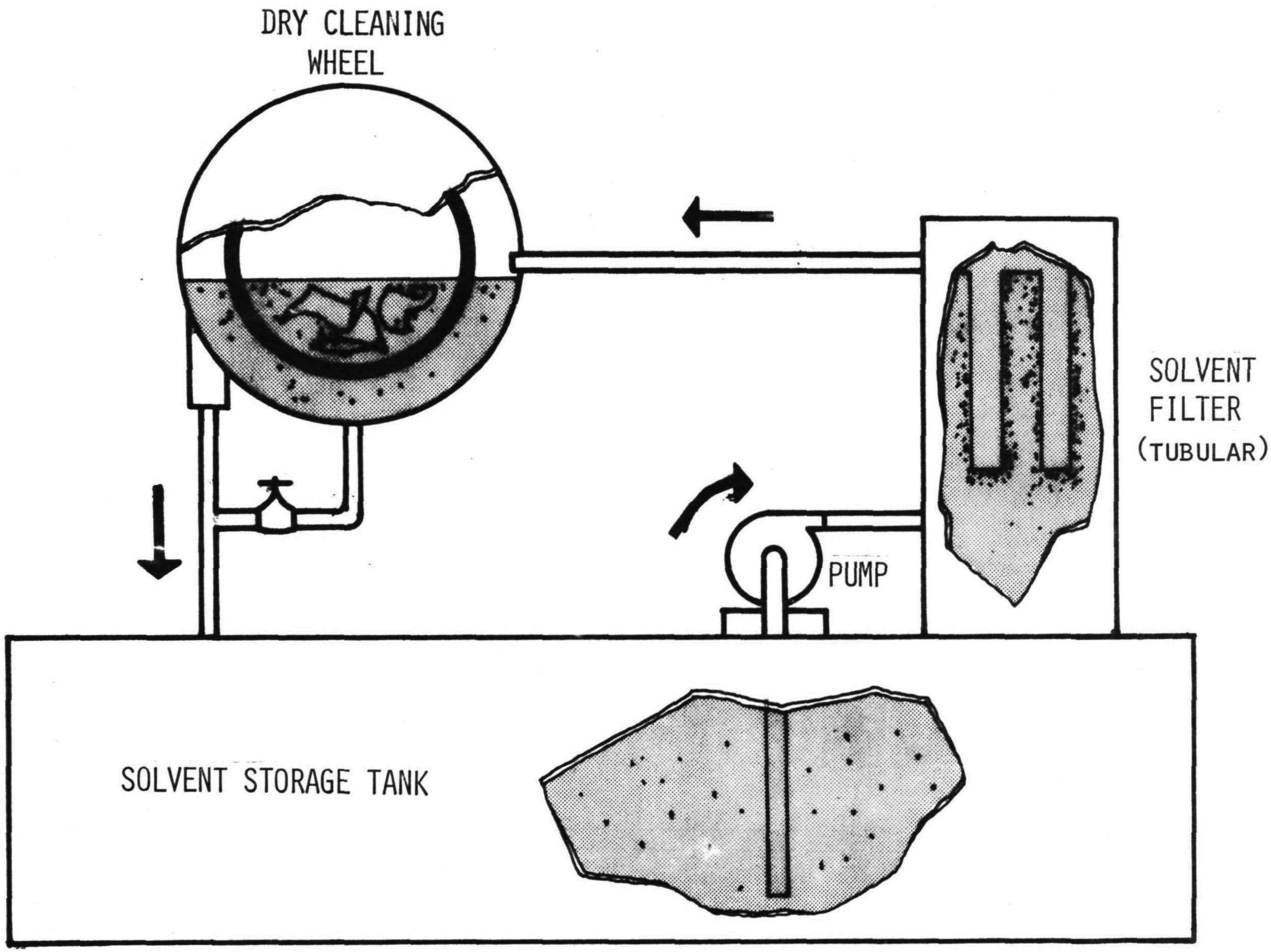


FIGURE 3-2. A TYPICAL DRY CLEANING MACHINE.



the same solvent throughout the cycle, most new equipment provides for continuous flow of fresh solvent through the wheel during the wash. There can be as many as three "baths" or stages in the wash cycle in industrial plants, but the usual commercial operation makes use of one or two.

3.2.1.2 Extraction

Removal of excess solvent from the fabric by spinning is usually accomplished in the same equipment used for washing. Older petroleum plants sometimes have a separate high speed centrifuge called an extractor. A major advantage of dry cleaning solvents over water is that the former are much more readily removed by centrifugal force than is water. Hence, the quantity of solvent to be removed in the drying step is much less than for a water-based laundry, after equivalent extraction.

3.2.1.3 Drying

After extraction, the cleaned fabrics are dried by tumbling in a heated air stream. In petroleum plants, the air flow to the dryer must be sufficient to prevent the formation of an explosive mixture in the exhaust gases, which are vented to the atmosphere. Because of the much higher costs and nonflammability of synthetic solvents, some degree of solvent recovery is always practiced during the drying phase in synthetic plants. An additional advantage of dry cleaning solvents over water cleaning is that the former have lower heats of evaporation than water, so less energy is required for drying.

3.2.1.4 Transfer and Dry-to-Dry Operations

There are only two basic types of dry cleaning machines:

- Transfer machines where washing and drying are performed in different machines. After washing, the fabrics must be <u>transferred</u> to the dryer.
- Dry-to-dry machines in which washing and drying are achieved in a single unit. In the past, these were termed "hot" machines, because they were hot at the end of the complete cycle. However, the advent of room temperature drying renders the latter name inaccurate.

All petroleum solvent machines are of the transfer type, but many synthetic solvent plants can make use of either kind.

3.2.1.5 Solvent Treatment

Because economic operation of a dry cleaning plant necessitates at least partial recovery and reuse of used solvent, some solvent conditioning steps are required to prevent solvent degradation and to otherwise enhance the cleaning operation. The steps generally include filtration, distillation, and "charging".

Some of the soils removed from fabrics are not soluble and must be strained from the solvent by filtration. The filters sometimes contain activated carbon for removal of loose dye from the solvent. For drycleaning, filters are classified into three operational types:

- Single Charge - tube or disc types;
- Multicharge - powder or paper types;
- Regenerative - braided wire, helical spring, or nylon knit tube types.

These classifications are based on the manner in which each filter is operated, and not its physical characteristics, for reasons discussed in the following material.

In single charge filters, the filter medium is used only once to filter one batch of solvent, after which it is discarded. Some of the older coin-operated dry cleaning machines used single charge filters of the tube type. A new filter precoat was applied to the tubular substrate after each load of cleaning.

Several batches of solvent are filtered on the same filter medium when a multicharge filter is used. The total liquid volume which can be filtered before the filter medium must be renewed is dependent chiefly on the soil content of the solvent and the size of the filter. Paper cartridge filters, a type of multicharge filter, first appeared in coin-op machines, but they are becoming of increasing importance in commercial plants. The principal advantage of cartridge filters, compared to other multicharge types, is that they do not have to be changed very frequently, so labor costs are reduced.

The regenerative filter does not fit into either of the above categories. It may be viewed as a multicharge filter since one batch of filter powder is used to filter the solvent from several loads of cleaning. However, it is a single charge type in that the filter powder precoat is destroyed by reverse flow and then reformed after each load, a procedure called bumping. A detailed discussion of all three types of filters is found in reference 2.

The solids or "muck" removed from the filters contains solvent which is recovered by distillation in perchloroethylene plants, except where cartridge filters are used. Cartridge filters are normally just drained and then discarded. In petroleum plants, muck is drained of excess solvent - sometimes a vacuum press is used - air dried, and then discarded.

In addition to the insoluble residue removed by filtration, a build up of soluble non-volatile residue (NVR) occurs in the solvent. NVR is composed primarily or oils, fats, and greases cleaned from fabrics. It is eliminated by distilling the solvent. In some "perc" plants, a single unit serves for both distillation and muck cooking.

In order to remove water-soluble materials from fabrics during dry cleaning, a small amount of detergent and water must be added to the solvent, a step known as "charging". Because these materials are removed during distillation, they must be replaced occasionally.

3.2.2 Petroleum Solvent Plants

Most of the petroleum solvent plants are quite large, and tend to be located away from residential areas or shopping centers because of their high emissions and the potential fire hazard. Although there are numerically more synthetic solvent plants than petroleum plants, the larger size of the latter gives them about fifty percent of the total U.S. dry cleaning capacity.* On the basis of discussions with industry and trade association personnel and numerous operators, it appears that most industrial dry cleaning is done with petroleum solvents.

3.2.2.1 Solvent Characteristics

The principal solvents used are Stoddard or 140-F, both of which are kerosene-like mixtures of hydrocarbons. Important characteristics are as follows:

- Non-agressive (gentle to clothes);
- Highly flammable;
- Inexpensive (57-60¢ per gallon, at this time);

* This figure is only approximate and is based on the estimates given by several industry representatives.

- Lighter than water; and
- Photochemically reactive, although the degree varies.[3]

Table 3-1 is a compilation of physical properties for both petroleum solvents and the two major synthetic solvents.

3.2.2.2 Equipment Characteristics

The equipment and methods used in dry cleaning with petroleum solvents are determined principally by the flammability of the solvents, but the traditionally low cost of the solvents is also a factor. Because of the fire hazard, solvent recovery methods which concentrate the vapors and produce an explosive mixture--condensation is an example--are avoided. In addition, the low solvent cost makes recovery less attractive than for the more expensive synthetic solvents.

Although there are a number of commercial petroleum dry cleaners in operation, most existing plants and virtually all new plants using petroleum solvents are large industrial plants.[8] Because these solvents are less harsh than synthetic solvents and most of the equipment is made to rugged industrial standards, petroleum plants have lifetimes of twenty to thirty years or more.[9] This serves to explain the relatively older age distribution observed for these plants in a survey.[10]

Cleaning in petroleum solvents consists of the same steps outlined in the preceding discussion of the general dry cleaning process. The procedure for a large industrial plant would typically be as follows:

- <u>Wash Phase</u> - Clothes are washed in two or three baths of solvent, the initial one--termed the "break"--uses solvent from a previous wash. The second bath--termed the "wash"--uses solvent charged with detergent and water and the third bath, when used, is a rinse cycle. There are other variations of the wash phase, and one of them, "dual-phase", will be discussed below.
- <u>Extraction</u> - Although a few older plants have separate extractors, all new petroleum plants utilize combination washer-extractors. Most of these units have wheel diameters of 28 to 48 inches and spin at 480 to 800 RPM, generating extraction forces of 150 to 250 G's.[11] Because there is no solvent recovery during the drying step in these plants, low solvent usage is highly dependent on proper extraction.

TABLE 3-1 CHARACTERISTICS OF DRY CLEANING SOLVENTS[4-7]

Property	140-F	140-F R-66[a]	Stoddard	Stoddard R-66[a]	Perchloroethylene	" Freon"113
Flash Point (TCC), °F	138.2	143	100	108	non-flammable & non-combustible	non-flammable & non-combustible
Initial Boiling Point, °F	357.8	366	305	316	250	117.6
Dry End Point, °F	396	400	350	356	254	not known
Specific Gravity, @ 60 °F	0.789	0.8063	0.779	0.788	1.623	1.574
Density, lb/gal	6.57	6.604	6.49	6.56	13.55	13.16
Aromatic Content, Vol. %	12.1	7.0	11.6	5.9	0	0
Corrosiveness	None	None	None	None	Slight on metal	none
Heat of Vaporization, Btu/lb	∼500[b]	∼500[b]	∼500[b]	∼500[b]	90	63
Toxicity (TLV) ppm	200	200	200	200	100	1000
Odor	Mild	Mild	Sweet	Sweet	Like ether	Like CCL_4
Color	Water White	Water white	Water White	Water White	Water White	Water White
Vapor Density (Air=1.00)[c]	1.0	1.0	1.0	1.0	1.1	2.5

[a] This refers to the "old" Los Angeles Rule 66 solvent regulation, which allowed up to 8% aromatic content.

[b] This value can be expected to vary depending as it does on the exact composition of the solvent.

[c] This is the density of a saturated mixture of the solvent in air, not the pure solvent vapor.

• Drying - All petroleum plants are transfer operations, so the clothes must be carried from the washer--or the separate extractor--to the dryer after extraction. The dryers used are normally about one-hundred pound capacity units, the number of which depends on the size of the dry cleaning operation.* The drying air is heated by steam coils, passed through the tumbling clothes, and vented to the atmosphere. After the clothing is dry, most tumblers have a cool-down cycle to prevent wrinkling. Typical exhaust conditions for a 110 pound dryer are as follows:[12]

Unit--Cissell Model 44/42
Exhaust Temperature--100°F initial
200°F peak
150°F average
Exhaust Air Flow --2200scfm**

At the present time, a large industrial dry cleaner would probably have a 500-lb. capacity washer/extractor and three to six 100-lb. capacity tumblers.

As noted earlier, "dual phase" petroleum machines are now in use in the industrial dry cleaning business. The wash cycle includes an initial bath in petroleum solvent followed by extraction, a bath in water, and a final extraction. In spite of the water wash, solvent retention by the clothes is roughly the same as with a single phase system.[13] However, the presence of water in the clothes does increase the drying time.

Dual phase machines have become a major factor in industrial dry cleaning recently due to the following sequence of events:

1. Polyester clothes, which replaced cotton in the uniform rental business, are dry cleaned because of their short lifetimes in the harsh detergents needed for water washing.

2. Dry cleaning of polyester in petroleum solvent alleviated the excessive fabric degradation, but an odor problem developed in the clothes after cleaning.

3. The dual phase process eliminates the odor problem, which was caused by water soluble soils in the clothes.

4. The increasingly restrictive regulations against sewering of strong detergents added further impetus to the move toward dual phase machines.

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* There are dryers with as much as 450-500 pound capacities, but they are used less frequently.

**This does not include the solvent vapor volume, which varies during the cycle. Because of the explosion hazard of the solvent, this concentration cannot exceed about 0.25% by volume.

This process has some advantages over conventional water-based laundering:

- As noted above, water pollution problems are greatly lessened.
- Load cycle times are reduced because of the shorter drying cycle.
- The energy requirement for drying is much less than for water washing.

3.2.2.3 Emission Characteristics

Because there is no solvent recovery during the drying cycle and the filter muck is not cooked, petroleum plants have much higher solvent losses than synthetic plants. Typical losses for the various elements in a petroleum solvent operation are given in Table 3-2, as reported by the International Fabricare Institute (IFI).[14]

TABLE 3-2

Solvent Losses in Petroleum Plants
(Pounds of Solvent per Ton of Clothing)

Source	Average Loss
Evaporation at Dryer	
• Washer with Separate Extractor	238
• Washer-Extractor/Front Loading	277
• Washer-Extractor/Side Loading	343
Retention in Filter Muck (Drained)	
• Screen or Rigid Tube Filter	191
• Regenerative Filter	102
Retention in Paper Cartridges	16
Retention in Still Residue	20
Miscellaneous Evaporation Losses	13

At the present time, no petroleum plant control systems are known to be operating in the U.S., but one company has tested a prototype solvent recovery device.[15, 16]

3.2.3 Perchloroethylene Plants

In contrast to petroleum plants which are predominantly large industrial operations, perchloroethylene machines find their major use in commercial drycleaning plants. The typical neighborhood dry cleaner uses a perchloroethylene-based process.

3.2.3.1 Solvent Characteristics

Although other chlorinated hydrocarbon solvents have been used for dry cleaning in the U.S., perchloroethylene is the only chlorinated solvent seeing significant use at this time.* An estimated 400 million pounds of "perc" is used annually for dry cleaning purposes.[17] The detailed physical data are in Table 3-5, but the solvent may be generally characterized as follows:

- Usually considered essentially non-reactive photochemically;[3]
- Non-flammable;
- Very high vapor density;
- High cost ($2.50-3.50/gal);
- Moderate toxicity;
- Aggressive solvent properties.

In spite of the higher cost per gallon of perc, solvent costs for perc plants are quite competitive with those for Stoddard plants, because the former are always used with solvent recovery equipment. Stricter fire codes, increases in petroleum solvent costs, and environmental considerations have resulted in the use of perc-based equipment for most new plants. (See subsection 7.1.3)

3.2.3.2 Equipment Characteristics

Petroleum dry cleaning machines are all transfer units, whereas perc machines may be either transfer or dry-to-dry types. However, the great majority of perc machines are transfer units for the following reasons:

- Because washing and drying are performed in different pieces of equipment in transfer machines, these operations can occur simultaneously on different cleaning batches, in contrast to the dry-to-dry machine where a given load must be washed then dried in the same unit. As a result, transfer machines can handle about twice as many loads per day as can dry-to-dry machines using the same solvent.
- As the dry-to-dry machine is hot at the end of a drying cycle, the incoming solvent for the next wash cycle picks up sensible heat from the hot metal and the solvent temperature can become quite high, unless a cooler is added to the system. High solvent temperatures - the desirable range is 85-100°F - cause two problems: (1) hot solvent attacks the machine seals and gaskets, adding to maintenance costs; and (2) the higher vapor pressure of the hot solvent can lead to greater solvent losses.[18] It should be noted that at least one manufacturer now has a single pass system which operates at room temperature.

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* This is probably because it is less toxic and/or less reactive than most other chlorinated hydrocarbons.

- A dry-to-dry machine costs significantly more than a transfer machine including both washer-extractor and reclaiming type dryer.

In spite of these disadvantages, dry-to-dry machines are of increasing interest to the industry as a result of the following advantages:

- Because there is no transfer of solvent-laden clothing between the washing and drying cycles, there is little chance for perc vapors to escape into the work area. Therefore, it is relatively easy to meet the Occupational Safety and Health Administration standards for maximum perc concentrations in the work area.

- The machines are basically "push button" operations and require little attention by the operator during the cleaning cycle. (This does not imply that they do not require a conscientious maintenance program, however.)

- When properly maintained, dry-to-dry machines use less solvent per unit of cleaning than equivalent transfer units.

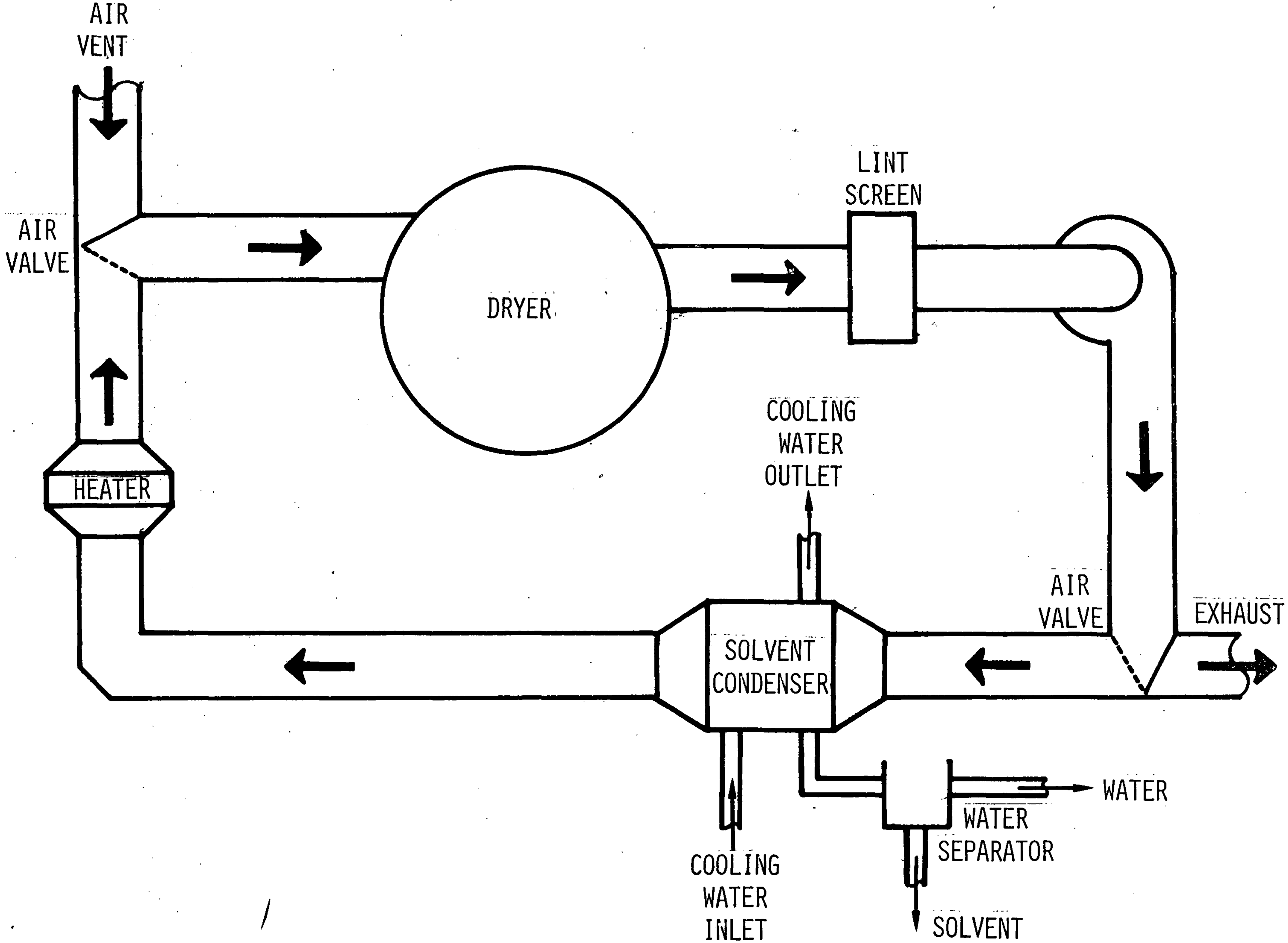
Regardless of the machine type, transfer or dry-to-dry, perc plants have the same three process steps as petroleum plants:

- <u>Washing</u> - A few industrial perc plants make use of a two bath wash cycle as described for petroleum dry cleaning, where an initial wash bath, in highly charged solvent, is followed by a rinse in fresh solvent. However, most commercial perc plants - most perc plants are commercial operations - use a single bath system.

- <u>Extraction</u> - All perc extractors now manufactured are combined washer-extractors, but a few very old plants still have separate extractor units. Good extraction is not so important to solvent conservation in perc plants as it is in petroleum plants, because all perc dryers utilize a solvent recovery system. Extraction forces in modern washer-extractors are usually in the range of 55-95 G's, and extraction times are seldom more than about 5-7 minutes.[11]

- <u>Drying</u> - Perchloroethylene-based dry cleaning plants always use reclaiming dryers. In a reclaiming dryer (Figure 3-3), the evaporated solvent is removed from the exhaust gas by condensation on a cooling coil. Water is removed from this recovered solvent, and it is returned to the storage tank. The exhaust gas is returned to the dryer until the solvent concentration becomes so low that the cooling coils can no longer condense the solvent vapors. Fresh air is then used to complete the drying, and aerate the clothes. This air is vented to the atmosphere. Recovery of solvent from this air requires a control device of some type. In addition to their greater ease of extraction, mentioned previously, synthetic solvents have much lower latent heats of evaporation than water or petroleum solvents, so the heat required for drying is much less

FIGURE 3-3. A TYPICAL RECLAIMING DRYER.



on a per-pound basis. For example, perchloroethylene has a latent heat of 90.2 Btu/lb., compared with about 970 Btu/lb for water and 500 Btu/lb for petroleum solvents. There is no exhaust from a reclaiming dryer during the drying cycle per se, but during the aeration cycle, typical exhaust conditions are as follows:

Dryer Size - 50-lb capacity
Exhaust Temperature - 140°F initial
- 70°F final
- 100°F average
Exhaust Flow - 275 scfm

A typical commercial perc plant has a 30-60 lb. capacity washer-extractor with a reclaiming tumbler of equivalent size, and about half the plants have carbon adsorption-type perc collectors to reduce solvent consumption.[10] These collectors are discussed in detail in Section 4.0, Emission Control Technology.

3.2.3.3 Emission Characteristics

Unlike the situation in petroleum plants, where no emission controls are used, perc plants frequently have vapor adsorbers to reduce solvent usage. Typical solvent losses for both controlled and uncontrolled perchloroethylene drycleaning plants are shown in Table 3-3, as reported by IFI.[14] These are for well-operated plants.

The usual plant has a regenerative filter with a muck cooker, and this results in a consumption rate of about 162.6-lb of solvent per ton of clothing. For an adsorber-equipped plant, the corresponding solvent usage is about 97.6-lb per ton of clothing, which is equivalent to a 40% loss reduction. It should be emphasized that these usage levels are for well-operated plants, and the average losses - including controlled and uncontrolled plants - is estimated to be about 196.8-lb of solvent per ton of clothes cleaned.[10]

TABLE 3-3

Solvent Losses in Perchloroethylene Plants[14]
(Pounds of Solvent per Ton of Clothing)

Source	Plants Without Vapor Adsorber	Plants With Vapor Adsorber
Evaporation @ Washer	10.8	0
Evaporation @ Dryer	59.6	0
Vapor Adsorber Exhaust (Properly Operated)	-	5.4
Retention in Filter Muck		
• Rigid tube filter-no cooker	281.8	281.8
• Rigid tube filter-muck cooker	32.5	32.5
• Regenerative filter-muck cooker	19.0	19.0
Retention in Paper Cartridges		
• Drained	35.2	35.2
• Dried in cabinet vented to adsorber	-	24.4
Retention in Still Residue	32.5	32.5
Miscellaneous Losses	40.7	40.7

3.2.4 Fluorocarbon Plants

All fluorocarbon plants utilize the same solvent, 1,1,2-trichlorotrifluoroethane ("Freon" 113), manufactured by DuPont.* The solvent is sold as a charged dry cleaning agent called "Valclene". At the present time, fluorocarbon dry cleaning machines are used only in commercial and coin-op installations.

3.2.4.1 Solvent Characteristics

The detailed physical description of solvent 113 appears in Table 3-5, but its predominant features may be summarized as follows:

- Extremely unreactive;[3]
- Non-flammable;
- Low toxicity;
- High cost ($8-10.gal);
- Very high vapor density;
- Liquid density greater than water;
- Non-agressive.

The low agressiveness of this solvent makes it very suitable for fine cleaning, and many operators purchase "Valclene" machines for this reason. In addition, the new fire codes and environmental regulations are making its use more advantageous.

3.2.4.2 Equipment Characteristics

Because of the very high cost of "Valclene" solvent, excellent solvent recovery must be obtained to make the machines competitive with perc or petroleum machines. Consequently, all "Valclene" machines are of the dry-to-dry variety, and all have built-in control devices. In the early fluorocarbon machines, the solvent recovery unit was a carbon adsorption column which exhausted to the atmosphere, but new machines use refrigeration coils in a closed loop system similar to the drying stage in a perc reclaiming dryer. Expansion and contraction of the air stream are accounted for by an elastomeric "lung".

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* Both "Freon" and "Valclene" are trademarks of E.I. DuPont de Nemours and Company.

The basic process for fluorocarbon dry cleaning is identical to that for perchloroethylene with minor exceptions:

- The machines are sold as complete packages including the washer/extractor/dryer system, the solvent distillation system and the filtration equipment.
- Currently manufactured fluorocarbon machines are fully closed to the atmosphere during operation.
- Drying is at a low temperature with air entering the cleaning wheel at about 120°F.
- Because of the rapid evaporation rate of fluorocarbon 113, the drying time is very short and the total cycle time for a load of clothes is considerably less than for the same load in a perc dry-to-dry machine of similar size.

Figure 3-4 shows the air flow during the drying cycle.

The rapid, low temperature drying characteristic of solvent 113, together with its gentle solvent properties, make it particularly useful for cleaning such delicate items as leather. In addition, 113 has the lowest toxicity of any of the common dry cleaning solvents, which makes it a good choice for applications involving non-professional operators, such as coin-operated cleaners. As a consequence of these principal areas of use, most fluorocarbon machines are of relatively small capacity. The most common sizes appear to be 12-lb and 25-lb.

3.2.4.3 Emission Characteristics

Because fluorocarbon dry cleaning is a recent development compared to the other basic systems, not a great deal is known about typical solvent losses at this time. There are several possible solvent loss points in a "Valclene" machine:

- Losses from the cleaning wheel when the door is opened between loads.
- Solvent retained by the solvent filter media.
- Solvent retained by clothes.
- Leakage losses due to faulty gaskets and/or seals.

The latter two sources should be negligible in a well-maintained, properly-operated machine. In <u>some</u> machines, solvent retention by filter cartridges can

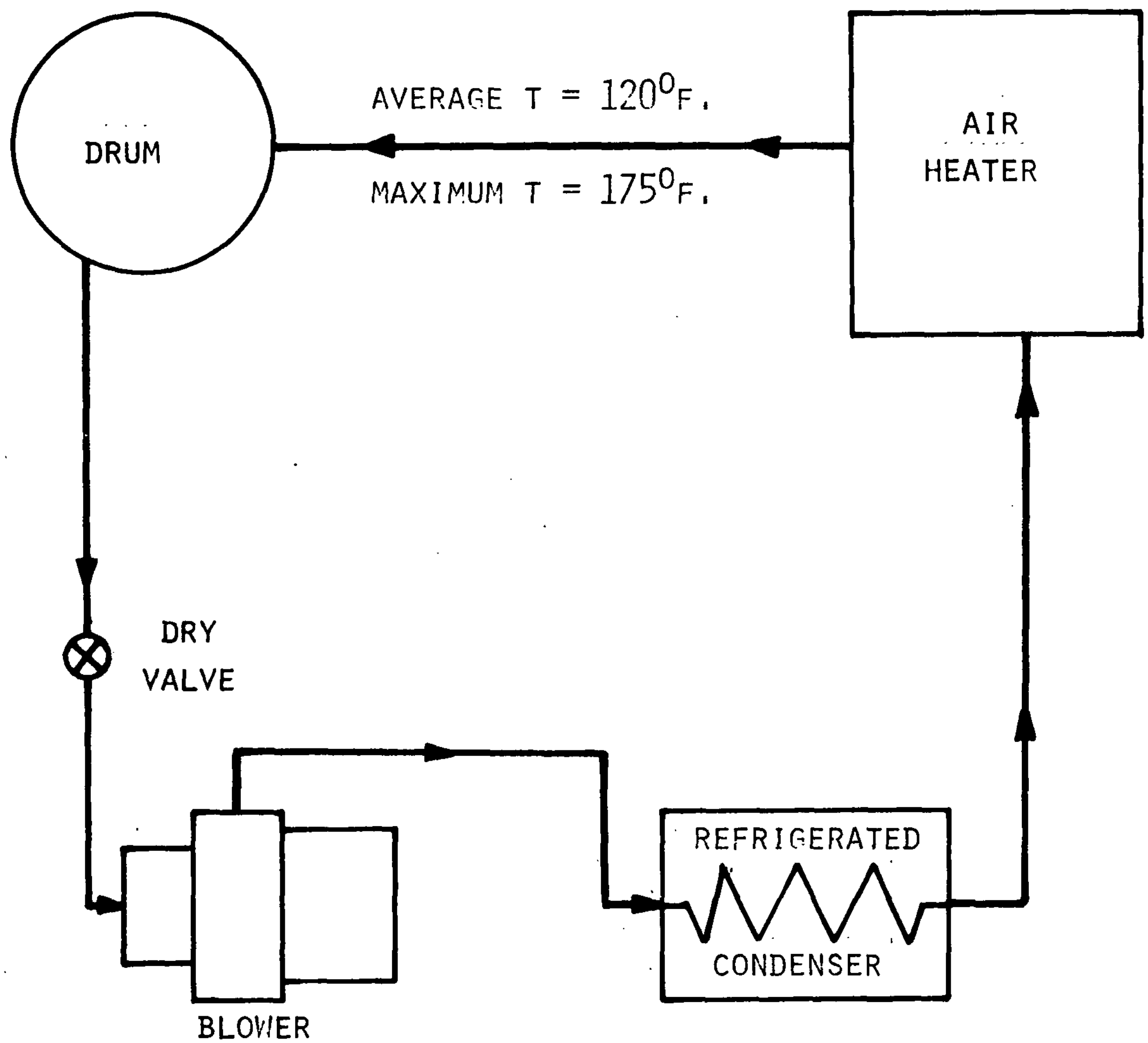

FIGURE 3-4. A TYPICAL FLUOROCARBON DRYING CIRCUIT.

be minimized by placing them in the wheel and running the unit through a drying cycle - the wheel is not rotated during this operation - to evaporate and collect any retained solvent.

Although no definitive data are presently available on solvent losses from fluorocarbon machines, DuPont has a certification standard for professional machines corresponding to 60 pounds of solvent losses per ton of clothes cleaned.[6] Performance tests carried out in the Vic Manufacturing Co. laboratories gave a solvent consumption rate of about 37 pounds of solvent per ton of clothes cleaned.[15]

3.3 REFERENCES FOR CHAPTER 3.0

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4.0 EMISSION CONTROL TECHNOLOGY

This chapter and Chapter 7.0-Economic Impact are both analyses of available emission control technology for the dry cleaning industry. However, this chapter is a technological assessment of demonstrated control systems, while Chapter 7.0 is an assessment of the costs and economic effects of alternative controls based on demonstrated control technology. Together these two analyses satisfy the requirement of Section 111 of the Clean Air Act that new source performance standards be based on "the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated".

4.1 TYPES OF CONTROL MEASURES

For the most part, solvent emission controls for dry cleaning plants have developed out of economic necessity. In order for the more costly synthetic solvents - chlorinated hydrocarbons and fluorocarbons - to compete with inexpensive petroleum solvents, a substantial degree of solvent recovery is necessary during the drying operation. This is the reason for the use of recovery dryers on all synthetic solvent machines. The move towards the use of synthetic solvents was also abetted by increasingly restrictive fire codes and emission regulations for petroleum solvents.

Because of differences in the dry cleaning processes and the physicochemical characteristics for the various solvent classes, all control measures are not appropriate for every type of plant. Table 4-1 shows possible control measures for the three basic types of cleaning plants, and the following material discusses both current industrial practice and possible improvements in emission controls.

TABLE 4-1 POTENTIAL AND APPLIED CONTROL MEASURES FOR DRY CLEANING PLANTS

Control Measure	Plant Type		
	Petroleum	"Perc"	"Valclene"
Carbon Adsorption	X	X[a]	X[a]
Housekeeping[b]	X[a]	X[a]	X[a]
Incineration	X		
Process Changes	X[c]	X[c]	
Refrigeration Condensation	X	X	X[a]

[a] Commonly used technique.

[b] Includes record keeping for solvent consumption.

[c] For example, eliminate transfer machines at new plants.

4.1.1 Perchloroethylene Plants

As noted in Chapter 3, the high cost of perc necessitates a certain degree of solvent recovery. Although the water-cooled condenser system used for recovery dryers is actually an integral part of the dryer, it serves the same function as an emission control device. Additionally, in many plants, the offgases from the final stages of the drying operation - normally vented to the atmosphere - are sent to a vapor adsorption unit where perc vapors are retained on activated carbon.* The solvent is later desorbed with live steam, condensed, separated from the condensed water, and returned to the storage tank as distilled solvent. There is usually a floor pick-up located near the cleaning machine to collect vapors from transfer operations or leakage losses. The operational performance of carbon adsorbers in perc plants is discussed in detail in Section 4.2, while reference 1 provides supporting information.

Incineration of chlorinated hydrocarbons can produce hydrochloric acid (HCl), chlorine (Cl), and phosgene ($COCl_2$).[3] These compounds can be removed by water scrubbing, but several factors make incineration a questionable practice:

- Fuel prices are very high at this time, and indications are that they will remain so in the future.
- Considering the toxicity of the combustion gases, a failure in the scrubber could have severe consequences.
- The scrubber could constitute a potential water pollution hazard.

Refrigeration does not appear to be in use for control of perc emissions, except for the water-cooled condensers used on recovery tumblers. This is due in large part to the great success enjoyed by carbon adsorption equipment, and the fact that refrigeration cannot achieve the same recovery efficiency as carbon adsorbtion on a vented system.

In addition to the hardware type controls, good emission control can be obtained by maintaining all equipment in good condition and good operating practices. The International Fabricare Institute (IFI) has suggested the list in Table 4-2 as possible causes of excess solvent consumption. A set of operating procedures based on a list such as this constitutes a useful control measure if it is coupled with a mandatory record keeping program.

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* A membership survey by the International Fabricare Institute indicated that about 52 percent of the responding perc plants have vapor adsorbers.[2]

TABLE 4-2
CAUSES OF EXCESSIVE LOSS OF PERCHLOROETHYLENE[3]

1.	Loose bungs on storage drums.
2.	Loose pipe fittings.
3.	Bad gaskets.
4.	Clogged lint filter.
5.	Lint build-up on condenser.
6.	Lint on fan blades.
7.	Lint between basket and shell of dryer.
8.	Water separator malfunction.
9.	Machine overloading.
10.	Leakage in air inlet and outlet vents.
11.	Faulty adsorber operation.

4.1.2 Petroleum Solvent Plants

In the past, there has been little emphasis on reducing solvent consumption in petroleum plants because of the low cost of these solvents. However, recent increases in solvent cost should make solvent recovery much more attractive. Although five control measures - carbon adsorption, housekeeping, incineration, process changes, and refrigeration/condensation - are shown in Table 4-1 as having potential for petroleum plants, only one of these, housekeeping, is currently in use in the United States. Table 4-2 is also applicable to petroleum plants.

4.1.2.1 Carbon Adsorption

A prototype carbon adsorption unit has been developed and tested by Vic Manufacturing Company, one of the major U.S. manufacturers of dry cleaning equipment and carbon adsorption units.[5] From a technological standpoint, the petroleum solvent test unit was a success. However, the equipment cost is very high relative to perc adsorbers, for the following reasons:[6, 7]

- High Exhaust Volumes - because petroleum solvents are flammable, a great deal of dilution air must be used during drying to keep the solvent concentration in the exhaust below the explosive range. Hence, the adsorber must be larger to accomodate the greater flow rate.

- Non-Reclaiming Dryers - whereas, in perc plants, most of the solvent from drying is removed by condensation prior to venting, this is not done in petroleum plants because condensing of the solvent can result in formation of an explosive mixture. Consequently, the carbon bed for a petroleum dryer must be sufficiently large to hold all of the solvent remaining in the clothes after extraction.

- Low Solvent Cost - because petroleum solvents are very cheap compared to synthetics the value of the recovered solvent is less, which makes annualized operating costs relatively higher than for synthetic solvents.

- High Exhaust Temperatures - petroleum dryers have considerably higher exhaust temperatures than perc dryers.* Because the efficiency of carbon adsorbers is reduced by elevated temperatures, and the fire hazard is increased, an intercooler is required between the dryer and the adsorber.

In spite of its high cost, carbon adsorption is considered a viable means of control for petroleum plants. The economic and cost implications are assessed in Section 7.4.

4.1.2.2 Incineration

From a strictly technological standpoint, incineration is a feasible control measure. However, the high exhaust volumes from petroleum dryers and the current cost of fuel severely handicap its use at this time, whether a separate incinerator is used or the boiler of the cleaning plant is used for combustion:[8]

- Separate Incinerator - the high volume of air would require a large quantity of fuel for proper burn-out of the solvent vapors.

- Boiler Incineration - the exhaust volume from a typical petroleum dryer is too great to be handled by the relatively small boilers in industrial laundries.

4.1.2.3 Process Changes

Discussions with trade associations, petroleum plant operators, and equipment manufacturers disclosed no original recommendations for emission-reducing process changes, which could be implemented in a reasonable period of time. A representative of one manufacturer indicated that it might be possible to reduce solvent emissions from petroleum plants by as much as 80 to 90%, but doing so would require considerable research and development of new equipment in such areas as: (1) filter muck cooking; (2) improved distillation; (3) improved liquid and vapor seals; and (4) reclaiming type dryers for petroleum solvents.[9] Study of the solvent loss data in Table 3-2 leads to some other viable alternatives:

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* Both the boiling point and the latent heat of evaporation of petroleum solvents are higher than for perc, so higher drying temperatures are needed.

- Because all of the petroleum solvent remaining in the clothes after extraction is evaporated at the dryer, differences in extraction efficiency of washer/extractors have direct effects on the quantities of emissions. However, emission control by washer/extractor type is limited because the highest emission losses result from the most popular washer/extractor, the side loading model.*

- There is a considerable difference in solvent retention by the various types of filtration systems in use. The replacement of a regenerative filter by a paper cartridge filter can yield emission reductions of 18 to 23 percent, depending on the type of washer/extractor in use. Nevertheless, in industrial plants, the major users of petroleum machines, the extremely high soil loadings would require that the cartridges be changed too frequently for good operation.[11] Therefore, cartridge filters do not appear to be a promising control measure for high soil cleaning applications.

4.1.2.4 Refrigeration/Condensation

As was briefly noted in the discussion of carbon adsorption, this technique is not considered practicable because of the danger of forming an explosive mixture as the exhaust gases are cooled.[7] In addition, the cooling requirements would be very large in view of the high temperature of petroleum dryer exhausts.

4.1.2.5 Conclusion

As a result of the severe constraints on the use of other techniques, the best approach for controlling petroleum solvent dry cleaning plants is considered to be the combination of two control measures:

- Housekeeping - rules for equipment maintenance and operating procedures should be established that correspond to best current practice in the industry. Equipment manufacturers' recommendations provide a good basis for these rules.

- Carbon Adsorption - in spite of its cost, the vapor adsorber appears to be the only device suitable for control purposes.

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* Side loading, dual phase washer/extractors have distinct advantages over the other types, as discussed in Section 3.2. Washex Machinery Corp., which controls an estimated 90 percent of the petroleum machinery market, indicated that 90 percent of their current petroleum machine sales were dual phase models.[10]

4.1.3 Fluorocarbon Plants

At this time, the only fluorocarbon being used for dry cleaning purposes is Freon 113, sold by DuPont as a charged solvent named Valclene.* Because fluorocarbons are by far the most expensive of the ordinary dry cleaning solvents, fluorocarbon machines must show low solvent consumption to be cost competitive with perc or petroleum machines. Consequently, all fluorocarbon machines are of the dry-to-dry type and all have built in control devices, either a refrigeration/condensation system or a dual canister carbon adsorber. All new machines are equipped with refrigeration units, but carbon adsorbers were formerly used. According to one major manufacturer, the reasons for the change were as follows:[12]

- Because fluorocarbon machines are necessarily automatic in coin-op service, the adsorber control system proved to be overly complex.
- If a fluorocarbon machine is used in the presence of a perc plant - frequently the case - there is a chance that perc vapors will be adsorbed by the carbon bed and contaminate the fluorocarbon solvent.
- The adsorber-equipped units required too much floor space, and had high steam consumption, because they required 100 percent distillation.

Regardless of the type of control device, fluorocarbon machines generally show very low solvent consumption rates compared to plants using other solvents. However, poor maintenance and/or operating practices can negate the advantages of dry-to-dry machinery and built-in control systems. Therefore, housekeeping measures with record keeping are considered necessary to ensure that low emissions performance of new machinery is maintained.

4.2 CONTROL SYSTEM PERFORMANCE

The dry cleaning plant operator expresses solvent consumption by means of a term called "mileage", which is the number of pounds of fabric cleaned per 52 gallon drum of solvent consumed. Therefore, mileage is directly proportional

* Both Freon and Valclene are registered trademarks of the DuPont Company.

to the reciprocal of the emission rate, usually expressed as pounds of solvent per ton of fabric cleaned. Mileage depends on many variables, including: the type(s) of fabric; machine and solvent type; ductwork design; the use of control equipment; and operating and maintenance procedures. Consequently, mileage figures show broad variations between different dry cleaning plants. The remainder of this section discusses the mileage performance of emission controls in perchloroethylene, petroleum, and fluorocarbon plants after a brief description of carbon adsorption, the most prevalent type of control device found in dry cleaning plants.

4.2.1 Carbon Adsorbers

Adsorption is the process by which gas molecules are concentrated and retained at a solid surface. Although there are two types of adsorption, physical adsorption and chemisorption, only the former is considered in the present context.* Most solid surfaces will adsorb gases, but the extent depends on the gas/surface combination, as well as temperature, pressure, and the surface area of the solid. The fact that the degree of adsorption decreases with increasing temperature provides the basis for the use of adsorption as a means of emission control for dry cleaning plants. Solvent vapors can be collected from exhaust gases at a low temperature ($\sim 100^{\circ}F$) and then removed (desorbed) later in a concentrated form by application of heat.

For dry cleaning plants, activated carbon is used as the adsorbent for the following reasons:

- The material has higher internal surface area than any other material known, and so it has good capacity for solvent.[1]
- The adsorption/desorption cycle occurs over a temperature range which is easily attainable.
- The efficiency of removal of solvent from exhaust gases can be greater than 99 percent with reasonable bed depths.[13]
- The carbon bed has long life, fifteen years or more, and it can be reprocessed, if it becomes contaminated.[13]

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* Chemisorption involves much higher bonding forces and considerably higher temperatures are needed to remove adsorbed molecules from the surface than is true for physical adsorption.

- Utility costs for regeneration of adsorbed solvent are low.[13] (See Sections 7.3 through 7.5 for more detail on operating costs.)

The activated carbon is placed in metal shells called canisters, and solvent vapors are collected by passage of gases from the following sources through the carbon bed:

- Cleaning Machine - when the machine door is opened, air is drawn through the opening by a blower to prevent accumulation of solvent in the work area.
- Reclaimer - when the dryer switches to the aeration cycle, exhaust air is drawn by the blower through the bed.
- Pickup Vents - floor and other vents are used to reduce solvent levels in the working area.

When the carbon is saturated, the solvent is regenerated by injecting live steam into the canister. The steam and solvent vapors are collected from the off-gases by condensation on a water cooling coil, and the solvent is recovered by means of a water separator.

Carbon adsorption units are available in sizes to fit all commercially-available dry cleaning machines. The size of the adsorber - commonly called a "sniffer" by dry cleaners - needed is based on the solvent consumption of the dry cleaning plant. For larger plants, a double unit with two canisters is recommended, so that one unit can be in the adsorb mode while the other is being regenerated. In smaller plants, the carbon bed can be steamed out at the end of the work day. Table 4-3 gives operating parameters for some commonly used vapor adsorbers.

TABLE 4-3

SPECIFICATIONS OF CARBON ADSORBERS USED IN PERCHLOROETHYLENE DRY CLEANING PLANTS[14]

Plant Solvent Consumption	Adsorber Solvent Capacity[a]	Exhaust Air Capacity	Boiler Requirements
< 1 drum/mo.	1 3/4 gal.	600 CFM	3½ H.P.
1-2 drum/mo.	4 gal.	600 CFM	3½ H.P.
> 2 drum/mo.	8 gal.	1200 CFM	3½ H.P.
-[b]	4½ gal.	1400 CFM	3½ H.P.

[a] Solvent retention before steam-out is needed.

[b] This unit is for coin-op facilities where exhaust flow rates are high relative to solvent consumption if several machines aerate simultaneously.

It should be noted that simply installing a carbon adsorber in a plant is no panacea for poor solvent consumption. Data from several sources indicate that poor operating procedures and inadequate maintenance can negate the potential effectiveness of carbon adsorbers, as the material which follows will illustrate.

4.2.2 Perchloroethylene Plants

The mileage obtained in a perc plant appears to be more strongly affected by the competence of the operator than by any other factor. The following examples serve to illustrate this situation:

- Mileage data collected by Dow Chemical - a major perc manufacturer - in a customer survey indicate that the average perc plant without an adsorber achieves a mileage of 6,940 pounds per drum, and an adsorber increases this figure to about 8,370 pounds per drum. However, in both adsorber-equipped plants and non-adsorber-equipped plants, the range of mileages reported was enormous, and plants in each category showed both operators with mileages less than 2,000 pounds per drum and others with mileages greater than 15,000 pounds per drum.[15]

- The International Fabricare Institute (IFI) gives most of the credit for either poor mileage performance or exceptional mileage performance to the plant operator. One plant (without an adsorber) visited had a mileage of 2,900 pounds per drum. The plant showed obvious mechanical problems which even superficial maintenance should have corrected. In marked contrast, IFI personnel have obtained mileages of 11,000 pounds per drum in transfer machines, without adsorbers.[16]

- In plant visits and tests made in the course of this study, a wide range of mileages were reported. The following are illustrative: 8,000 pound/drum for an adsorber-equipped, dry-to-dry machine;[17] 9,700 pound/drum for an adsorber-equipped transfer machine;[18] 7,500 pound/drum for an adsorber-equipped, transfer machine;[19] 13,136 pound/drum for an adsorber-equipped, transfer machine;[20] and greater than 20,000 pound/drum for an adsorber-equipped, transfer machine.[21]

Two important points can be made on the basis of these examples:

- Without proper maintenance and operation, even well-equipped perc plants can exhibit high solvent losses.

- It is somewhat meaningless to speak of average mileage for perc plants, because of the wide range of performance observed.

Table 4-4 summarizes solvent mileage and emission estimates believed to be somewhat representative of perc plants with different levels of operator proficiency and equipment. The data for petroleum and fluorocarbon plants will be discussed in the remainder of this section.

TABLE 4-4

EMISSION RATES AND SOLVENT CONSUMPTION OF DRY CLEANING PLANTS

Solvent Type	Control Technique	Emission Rate[a]	Mileage[b]	Reference
Perchloroethylene	Uncontrolled - Poor	486	2,900	16
	Uncontrolled - Typical	203	6,940	15
	Uncontrolled - Good	128	11,000	16
	Carbon Adsorber - Typical	168	8,369	15
	Carbon Adsorber - Good	94	15,000	16
	Carbon Adsorber - Best	70	20,000+	21
Petroleum	Uncontrolled - Average	468	1,456	16
	Uncontrolled - Good	310	2,200	16,22
	Carbon adsorber - Good	173	3,935	6,16
Fluorocarbon	Refrigeration - Typical	60	22,800	26
	Refrigeration - Good	37	37,000	5

[a] Units are pounds of solvent per ton of fabrics cleaned.

[b] Units are pounds of clothes cleaned per 52-gallon drum of solvent.

4.2.3 Petroleum Plants

Because no emission controls are used on petroleum plants, and all the solvent remaining in the clothes after extraction is lost during drying, the primary factor governing solvent consumption for any given plant is extraction efficiency. Other than preventing liquid solvent leaks and ensuring good extraction, there is little an operator can do to bolster his mileage. In view of this, a narrower range of solvent mileage would be expected for these plants than was observed for perc plants. Available information seems to support this:

- IFI believes that current average mileage in petroleum plants is about 1,456 pounds/drum. With good extraction, 1,600-1,700 pounds/drum is considered attainable with regenerative filters and 2,200-2,300 pounds/drum with a cartridge filter.[16]
- Visits to three plants during the course of this study found mileages of 1,450-2,200 pound/drum,[22] 1,299-1,732 pound/drum,[23] and 1,039 pound/drum.[24]

There are no known controlled petroleum plants in the U.S., so estimates of emissions from a hypothetical controlled plant must be based on several assumptions:

- Uncontrolled mileage of 1,456 pounds/drum.[16]
- Seventy percent of emissions losses occur at the dryer.[16]
- A properly operated carbon adsorber will recover 90 percent of the dryer losses.[6]

Making use of these assumptions, it should be possible to improve the mileage of the average plant to about 3,935 pounds/drum. The mileages and emission rates of this controlled plant and some typical uncontrolled plants are shown in Table 4-4.

4.2.4 Fluorocarbon Plants

Fluorocarbon machines are all dry-to-dry units with built-in controls so that low solvent consumption is expected of properly operated plants. Because fluorocarbon dry cleaning is relatively new, there is little information available regarding typical solvent consumption. However, the solvent mileage information below was obtained:

- In tests at the IFI Research Center, average solvent mileage of 39,293 pounds/drum was obtained while cleaning over 8,900 pounds of clothes. These tests were under laboratory conditions with highly-qualified personnel so the results should not be considered typical.[25]

- DuPont, who manufactures "Valclene" fluorocarbon solvent, has a certification standard for new machines, which corresponds to about 22,800 pounds/drum.[26]

- In testing their machines in the laboratory, Vic Manufacturing Co. personnel attained average solvent mileage values of about 37,000 pounds/drum. This shows very good agreement with the IFI work, but again it should not be considered typical.[5]

- Tests performed by DuPont and EPA personnel on coin-operated fluorocarbon units in a plant yielded the following results: 15,519 pounds per drum for a 12-lb. machine; and 19,219 pounds per drum for a 25-lb. machine.[27] Although these values are lower than the preceding ones, they are likely to be more representative of performance in the field.

The solvent emissions of new fluorocarbon dry cleaning machines are very low, based on the preceding examples. Therefore, good housekeeping practice and the maintenance of solvent consumption records appears to be a useful control measure for these machines. Solvent mileage and emissions data for fluorocarbon machines are summarized in Table 4-4.

4.3 ALTERNATIVE CONTROL SYSTEMS

Available emission controls and their performance have been discussed in the preceding sections. The purpose of the present section is to utilize this information in compiling a set of alternative emission controls for new dry cleaning plants. The alternatives will provide the basis for the cost analyses developed in Chapter 7.0. Table 4-5 summarizes the suggested alternatives for several categories of dry cleaning plants, including commercial (retail), coin-operated, and industrial. The type of machine assigned to each plant category was chosen on the basis of the machine types found most frequently in each category.

TABLE 4-5

ALTERNATIVE MILEAGE AND EMISSION CONTROLS FOR DRY CLEANING PLANTS

Plant Category	Machine Type	Control Measure	Standard		Additional Investment Cost?	Additional Operating Cost?
			Emissions[a]	Mileage[b]		
Coin-Operated	Perchloroethylene (Dry-to-dry)	Housekeeping	176	8,000	No	Negligible
		Above+Adsorber	117	12,000	Yes	Yes
	Fluorocarbon (Dry-to-dry)	Housekeeping	68	20,000	No	Negligible
Commercial	Perchloroethylene (Dry-to-dry)	Housekeeping	141	10,000	No	Negligible
		Above+Adsorber	94	15,000	Yes	Yes
	Perchloroethylene (Transfer)	Housekeeping	141	10,000	No	Negligible
		Above+Adsorber	94	15,000	Yes	Yes
Industrial	Perchloroethylene (Modular machine)	Housekeeping	141	10,000	No	Negligible
		Above+Adsorber	70	20,000+	Yes	Yes
	Petroleum (Transfer)	Housekeeping	310	2,200	No	Negligible
		Above+Adsorber	173	3,935	Yes	Yes

[a] Pounds of solvent per ton of fabrics cleaned.

[b] Pounds of clothes cleaned per 52-gallon drum of solvent.

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5.0 DRY CLEANING PLANT MODIFICATIONS

Section 111 of the Clean Air Act requires that the Environmental Protection Agency develop and promulgate standards of performance for both new and modified stationary sources of air pollutants. In the case of the dry cleaning industry, the term "new plant" is sufficiently clear to require no explanation, but "plant modification" requires precise definition, because of the numerous equipment changes possible in an existing plant. For the dry cleaning industry, a modification is considered to involve one of the following kinds of alterations:

- Alterations which cause an increase in the emissions of a solvent, which was in use at the plant prior to the alteration.
- Alterations which change the chemical or physical characteristics of the solvent emissions so that they have a greater potential to cause air pollution problems.

The precise meanings of these kinds of modifications and the equipment and process changes which constitute the modifications are given in the remainder of this chapter.

5.1 GENERAL

5.1.1 Emission-Increasing Modifications

Any alteration to an existing plant which increases the emissions of a solvent which had been in use at the plant prior to the alteration is a modification in the context of Section 111. This includes such changes as: (1) increasing the capacity of a plant using a particular solvent by replacement of existing equipment - either the entire dry cleaning machine, the washer/extractor, or the drying unit - with larger capacity equipment, which uses the same solvent; or (2) increasing the capacity of a plant using a particular solvent by addition of equipment, which uses the same solvent.* Specific examples of these types of modifications for perchloroethylene, petroleum and fluorocarbon dry cleaning plants are discussed in Section 5.2. The remainder of this section concerns modifications, in which a change in the type of solvent used by a plant is made.

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* In this discussion, capacity does not necessarily refer to the per-load capacity of the equipment, but it is based on the average hourly sustained production rate of the equipment involved.

5.1.2 Modifications Involving Solvent Substitution*

The major reason for controlling emissions of organic compounds into the atmosphere is to reduce the effects of photochemical oxidants. There are marked differences in the rates at which organic compounds undergo the atmospheric reactions leading to smog formation. As a result of these differences in reactivity, two forms of control have been exerted for organic solvents used in dry cleaning:

- Emission limitation, where the absolute quantity of solvent lost to the atmosphere is controlled.
- Solvent substitution, wherein a less photochemically reactive solvent is substituted for a more reactive one.

For dry cleaning solvents, the general order of reactivities, from least reactive to most reactive is : fluorocarbon < perchloroethylene < petroleum. Accordingly, some control agencies have accepted emission controls based on substitution of either of the synthetic solvents for petroleum solvent or of replacement of one petroleum solvent by another less-reactive solvent.**

Recent evidence has given reason to doubt the validity of the reactivity approach to smog control.[2] These findings indicate that practically all organic compounds can undergo photolytic reactions, which potentially lead to photochemical smog.*** Consequently, the current policy of the Environmental Protection Agency is as follows: "... the reactivity concept is useful as an interim measure for controlling the formation of photochemical oxidants. The ultimate goal of the SIP [State Implementation Plan], however, must be to reduce emissions of all non-methane organic compounds in a region to the degree necessary to meet the NAAQS for oxidant".[3]

Because controls for new sources should take a long range viewpoint, this policy is adhered to in the following ways:

- Solvent type will not be a factor in determining which alterations are to be classified as Section 111 modifications.

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* Except where otherwise noted, the following material is based on reference No. 1.

** This approach is based on the Los Angeles "Rule 66" approach, so the less reactive petroleum solvents are frequently called Rule 66 solvents.

*** The fluorocarbon solvents are among the very few organic compounds which do not participate in photochemical smog formation.

- Any alteration which decreases the emission rate of a plant will not be termed a modification.

The latter exception is made because emission rates (pounds of solvent per ton of cleaning) are much less for the synthetic solvents than for petroleum solvents. Hence, substitution of synthetic dry cleaning machinery for petroleum machinery results in greatly reduced air pollution potential, unless an enormous capacity increase is involved. Because of this, the dry cleaner who wishes to up-grade his operation, in this way, should not be penalized.

5.2 SPECIFIC TYPES OF MODIFICATIONS

The general policy presented in Section 5.1 was applied to each of the three basic types of dry cleaning processes. The results of this application follow for each process.

5.2.1 Perchloroethylene Plants

The types of plant alterations considered to be modifications according to Section 111 of the Clean Air Act are as follows:

- Any capacity expansion of an existing facility including: (1) addition of a complete new dry cleaning machine; (2) installation of an additional dryer for use with a dry-to-dry machine, to increase production; or (3) replacement of an existing perc machine with a perc machine of greater capacity.

- Any installation of a petroleum machine at a plant formerly using only perchloroethylene, whether for expansion or replacement purposes, unless the emissions are not increased.

- Addition of a fluorocarbon machine to an existing perc plant. (Replacement of a perc machine with a fluorocarbon machine of equivalent capacity, is specifically excluded from this category.)

5.2.2 Petroleum Plants

The following alterations are considered modifications according to Section 111 of the Clean Air Act:

- Any capacity expansion of an existing facility including: (1) addition of a complete new dry cleaning machine; (2) installation of additional drying capacity to increase production; or (3) replacement of an existing petroleum machine with another petroleum machine of greater capacity.

- Addition of any synthetic solvent machine to an existing petroleum plant. (Substitution of a synthetic solvent machine for a petroleum machine of equivalent capacity is specifically excluded from this definition.)

5.2.3 Fluorocarbon Plants

The plant alterations below are defined to be plant modifications according to Section 111 of the Clean Air Act:

- Any capacity expansion of an existing plant whether by addition of a new fluorocarbon machine or by replacement of an existing fluorocarbon machine with one of greater capacity.
- Any installation of petroleum or perchloroethylene dry cleaning machinery at an existing fluorocarbon plant, whether for expansion or replacement purposes.

5.2.4 Combination Plants

Some plants use more than one type of solvent. If a proposed alteration is a modification based on any solvent used at the plant, it shall be considered a Section 111 modification.

5.2.5 New Coin-Operated Plants

Any installation of coin-operated dry cleaning machinery at a facility formerly having no dry cleaning machinery - for example, a laundromat - shall be considered a new plant.

5.3 EFFECTS OF MODIFICATIONS ON EMISSIONS

Changes to dry cleaning plants which are to be considered modifications should be justified by their propensity to increase solvent emissions. Some changes such as simple capacity increases with no change in solvent type can be assumed to increase the emissions in direct proportion to the capacity increase.* Hence, such changes should always be considered modifications. Installation of additional dry cleaning machinery which uses a different solvent than that used by the existing machinery will obviously increase the emission rate. Here, the amount of increase can be estimated by use of the emission rates in Table 4-4 and the

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* It is realized that this is not strictly true, since new equipment will normally have lower emission rates than old equipment. However, some simplification is necessary, and this adds conservatism to the analysis.

expected usage of the new equipment.

The effect on emissions of the replacement of a dry cleaning machine of one type with an equal capacity of another type can be assumed to be proportional to their uncontrolled emission rates for simplicity. Any time the ratio of the emission rate of the new machine to that of the old machine is greater than one, the change should be termed a modification. Table 5-1 shows many of the possibilities. Other replacements can be analyzed by the use of Table 4-4.

TABLE 5-1

EFFECTS OF DRY CLEANING MACHINE REPLACEMENT ON SOLVENT EMISSION RATES

Type of Replacement[a]	Emission Ratio[b]
Fluorocarbon Machine by Percl Machine	3.4
Fluorocarbon Machine by Petroleum Machine	7.8
Perc Machine by Fluorocarbon Machine	0.30
Perc Machine by Petroleum Machine	2.3
Petroleum Machine by Fluorocarbon Machine	0.13
Petroleum Machine by Perc Machine	0.43

[a] The machines are assumed to be of equivalent capacity (pounds per hour not pounds per load).

[b] These ratios are based on the typical or average emission rates for uncontrolled machines in Table 4-4.

On the basis of discussions with plant operators, a fairly common type of capacity increase is the addition of a separate dryer to a dry-to-dry perchloroethylene machine. In essence, this converts the machine to a transfer type when the demand is sufficiently great. This can almost double the plant capacity and the resulting emissions. Hence, such alterations should always be classed as modifications.

5.4 COMMON ALTERATIONS TO DRY CLEANING PLANTS

According to a major manufacturer of dry cleaning machines, new units are used in the following applications:[4]

- Perc or Petroleum Machines
  - 70% - replacements
  - 10% - new plants
  - 20% - expansions

- Fluorocarbon Machines {40% - new plants; 60% - expansions}

As noted, replacement is by far the most common alteration to plants purchasing perc or petroleum machines. The different usage of fluorocarbon machines is probably caused by the following factors:

- The machines represent relatively new technology and there are not many machines old enough for replacement.
- Fluorocarbon machines are useful for leather cleaning and other specialty uses, for which they would be added to an existing plant.

No data were available to indicate the frequency with which external drying capacity is added to dry-to-dry perc plants. However, it was mentioned several times during the study, and it must be somewhat common.

5.5 REFERENCES FOR CHAPTER 5.0

1. Feldstein, Milton, "A critical review of regulations for the control of hydrocarbon emissions from stationary sources," J. Air Poll. Control Assoc. 24, No. 5, May 1974.
2. "Control of Photochemical Oxidants-Technical Basis and Implications of Recent Findings," Document No. EPA-450/2-75-005, U.S. Environmental Protection Agency, July 1975.
3. "Policy Statement on Use of the Concept of Photochemical Reactivity of Organic Compounds in State Implementation Plans for Oxidant Control," U.S. Environmental Protection Agency, 29 January 1976.
4. Information provided by Vic Manufacturing Company to C.F. Kleeberg, U.S. Environmental Protection Agency, 12 January 1976.

6.0 ENVIRONMENTAL IMPACT

In order to prevent the promulgation of performance standards demonstrating a myopic view of other environmental effects and energy considerations, information pertaining to these important elements should be collected throughout the standard development program. A performance standard for air pollution which causes extreme degradation of water quality, for example, should not be promulgated. Likewise, standards which encourage excessive consumption of scarce fuels should be avoided, where possible. However, where the decision is a choice between endangering human health and using more fuel, the latter route must be chosen.

Totally avoiding conflicts between environmental goals is not possible, in most cases. However, the severity of any conflicts should be assessed before emission standards are promulgated so that there will be confidence that the environmental and/or energy trade-offs required are acceptable ones. The purpose of this Chapter is to discuss the environmental and energy impacts of alternative solvent emission controls for the dry cleaning industry. The alternative emission controls are founded on two control options: (1) Option 1, which requires good operating and maintenance procedures, including solvent consumption and production records, for all new or modified dry cleaning plants; and (2) Option 2, which combines Option 1 with a requirement for a vapor adsorber on all new or modified perchloroethylene and petroleum dry cleaning plants.

6.1 AIR POLLUTION IMPACT

6.1.1 Direct Impact

The effects of the control alternatives on solvent emissions are presented in Table 6-1 in comparison with both uncontrolled plants and with the strictest known local regulation, the Maricopa County, Arizona regulation.[1] The percentage emission reductions expected from each of the control options are shown in Table 6-2. Both of the control options show significant emission reductions in all cases, except the fluorocarbon case. This is a consequence of the very low emission rates found for these machines, even with no additional controls. (See Sections 3.2 and 4.2 for more details concerning fluorocarbon machines.)

TABLE 6-1

EFFECT OF ALTERNATIVE CONTROLS FOR DRY CLEANING PLANTS ON SOLVENT EMISSION RATES[a]

Basis for Control	Coin-Op		Commercial	Industrial	
	Perc	Fluorocarbon	Perchloroethylene	Perc	Petroleum
None	321[c]	72[d]	203[c]	203[c]	468[e]
Maricopa	228[c]	72	168[c]	168[c]	468[e]
Option 1[f]	176	68	141	141	310
Option 2[f]	117	68	94	70	173

[a] Units are pounds of solvent per ton of clothes.

[b] The bases for the controls are: None - uncontrolled; Maricopa - the Maricopa County, Ariz. regulation which requires an adsorber on all perc plants; Option 1 - housekeeping; and Option 2 - housekeeping plus a carbon adsorber.

[c] Obtained from Dow survey.[2]

[d] Based on EPA plant test.[3] (Fluorocarbon plants are not affected by the Maricopa regulations.)

[e] Based on IFI data.[4]

[f] See Chapter 4.0 for the derivation of these emission levels.

TABLE 6-2

PERCENTAGE EMISSION REDUCTIONS EXPECTED FROM SOLVENT EMISSION CONTROLS FOR THE DRY CLEANING INDUSTRY[a]

Basis for Control	Coin-Op		Commercial	Industrial	
	Perc	Fluorocarbon	Perchloroethylene	Perc	Petroleum
Maricopa	29.0	0	17.0	17.0	0
Option 1	45.2	5.6	30.5	30.5	33.8
Option 2	63.6	5.6	53.7	65.5	63.0

[a] The data in this table are based on Table 6-1.

As discussed in Section 5.1, organic solvent emissions are controlled because of their participation in the photochemical reactions leading to oxidant formation. These processes are highly complex, and, at this time, it is not possible to determine the impact of a single source on ambient oxidant levels by means of atmospheric modeling. Because of this, the expected air quality impact of the alternative controls cannot be estimated.

6.1.2 Indirect Impact

The only indirect emissions from either of the alternative controls results from the steam consumed in regenerating the solvent from the carbon adsorber of Option 2. Option 1 generates no additional emissions. The emissions produced by the additional steam generation may be computed for a commercial perc plant by means of the following assumptions:

- Boiler horsepower required - 3½ or about 117,200 Btu/hr.*
- Daily steam-out time - 1-hr.[6]
- Fuel - 1% sulfur distillate oil.
- Operating Cycle - 6 days per week.

To simulate worst case conditions, a 2-hr. steam-out is used:

$$\text{Total Oil Used} = \frac{117{,}200\text{Btu.}}{\text{hr.}} \times \frac{2\text{-hr.}}{\text{day}} \times \frac{1\text{ gal.}}{140{,}000\text{ Btu.}} \times \frac{312\text{days}}{\text{yr.}} = 522\text{ gal.per yr.}$$

Using AP-42,[7] the pollutant annual emissions resulting from this operation are: sulfur oxides-75 pounds; particulates-8 pounds; carbon monoxide-2 pounds; hydrocarbons-1½ pounds; and nitrogen oxides-42 pounds. These emissions are considered totally negligible from an ambient air quality standpoint, because they are spread over an entire year. Even in an industrial perc operation, where ten times as many clothes might be cleaned in a year, the emissions of each pollutant should be less than ½ ton per year. This is still considered negligible.

Detailed operating data for the petroleum plant adsorber are not available, because the unit is not yet in production. However, a rough estimate of fuel and emissions can be made by means of the following assumptions:

- Utility costs are $0.15 per gallon of recovered solvent and all of this is for fuel.[8]
- Oil costs $0.40 per gallon.

* This horsepower is adequate for a plant doing more than 3000 pounds of cleaning per month. See Table 4-3 and reference 5.

- Solvent usage - { uncontrolled - 468 lb./ton; controlled - 173 lb./ton; recovery - 295 lb./ton }

- Annual plant production - 1,500,000 lb./yr.

Then annual fuel oil usage is:

$$\text{Total Fuel Oil} = \frac{\$0.15/\text{gal.}}{\$0.40/\text{gal.}} \times \frac{295\text{lb.}}{\text{ton}} \times \frac{1,500,000\text{lb.}}{\text{yr.}} \times \frac{1\ \text{ton}}{2,000\text{lb.}} \times \frac{1\ \text{gal.}}{6.56\text{lb.}}$$

$$= 12,650\ \text{gal. per year}$$

The emissions resulting from usage of this quantity of 1% sulfur distillate oil are: particulates-0.1 ton; sulfur oxides-0.9 ton; carbon monoxide-0.03 ton; hydrocarbons-0.02 ton; and nitrogen oxides-0.5 ton. These annual emissions are considered negligible in terms of the solvent emission reduction achieved.

6.2 WATER POLLUTION IMPACT

Only Option 2 has any potential for water pollution impacts, whatsoever. During steam-out of the adsorber, the steam and solvent vapors are passed over a water-cooled coil, condensed, and then passed through a separator where the solvent and water are separated. The separator is a gravity-type with no moving parts, so that it should never create a problem, if properly maintained.

6.3 SOLID WASTE DISPOSAL IMPACT

No solid waste is produced by any of the control options.

6.4 ENERGY IMPACT

The energy consumption of the adsorbers used for Option 2 in commercial perc plants and industrial petroleum plants was calculated in Section 6.1, in order to estimate the indirect air quality impacts of the controls. The approximate amount of fuel consumed by the other perc plants can be estimated by assuming that the fuel consumption is proportional to the solvent recovered. The solvent recovered may be estimated by multiplying the difference in emission rates for uncontrolled and controlled plants by the annual production rates from Table 7-8. The energy consumed is compared with the solvent recovered in Table 6-3.* The controls for fluorocarbon plants require no additional energy consumption.

* Oil is used as the basic energy source because of the difficulty of obtaining new natural gas hookups.

TABLE 6-3

SOLVENT RECOVERY VERSUS ENERGY CONSUMPTION
FOR THE OPTION 2 CARBON ADSORBERS
FOR DRY CLEANING PLANTS

Plant Type	Solvent Recovered (gal.)	Fuel Oil Consumed (gal.)
Perchloroethylene		
Coin-Op	602	782
Commercial	402	522
Industrial	4,908	6,373
Petroleum		
Industrial	33,727	12,650

These estimates indicate no adverse energy impacts. In the industrial plant, where the most fuel is required, the solvent recovered is almost three times the volume of the oil burned.

6.5 OTHER ENVIRONMENTAL IMPACTS

Other than the impacts already discussed, no environmental impacts should result from the alternative controls including noise, radiation or heat. Although some additional heat release will occur during the daily adsorber steam-out, this is negligible in comparison to the total heat release by a dry cleaning plant for clothes pressing, solvent distillation, steam cabinets and other operations.

6.6 REFERENCES FOR CHAPTER 6.0

1. Maricopa County Bureau of Air Pollution Control, Rules and Regulations, Maricopa County Health Dept., Phoenix, Arizona, 1 October 1975.

2. Data provided by Mr. Robert J. Lundy, Dow Chemical, U.S.A., Midland, Michigan, 8 April 1975.

3. Kleeberg, C.F., "Testing of Fluorocarbon Dry Cleaning," test report, U.S. Environmental Protection Agency, Emission Standards and Engineering Division, memo to J.F. Durham, 20 February 1976.

4. Fisher, William, "The ABC's of Solvent Mileage," Part One, International Fabricare Institute, Special Reporter No. 3-4, July-August 1975.

5. "Mileage Boosters," carbon adsorber data sheet, Form No. 325E 669, Vic Manufacturing Co., Minneapolis, Minn.

6. "Instruction Manual," Vic Air Pollution Control Systems, VMC 5046, Vic Manufacturing Co., Minneapolis, Minn., February 1973.

7. "Compilation of Emission Factors," 2nd ed. Publication No. AP-42, U.S. Environmental Protection Agency, amended December 1975.

8. Mr. J.W. Barber, Research Director, Vic Manufacturing Co., Minneapolis, Minn., letter to Charles F. Kleeberg, dated 6 February 1976.

7.0 ECONOMIC IMPACT

Chapter 4.0 of this document discusses available control technology for solvent emissions from the various sectors of the commercial dry cleaning industry strictly in terms of the expected emission reductions. In addition to this performance-based analysis, Section 111 of the Clean Air Act requires that the cost of achieving the reduction(s) be taken into account in defining demonstrated control technology for new source performance standards. This chapter is intended to satisfy this requirement for the commercial dry cleaning industry. Its contents are arranged as follows:

- 7.1 INDUSTRY ECONOMIC PROFILE - This section describes the general economic conditions in the industry in terms of growth rates, cash receipts, employment and other relevant criteria.
- 7.2 MODEL PLANT SELECTIONS - The estimation of control costs for an industry requires that well-defined plants be available. This section defines the models used in the present study for cost analysis.
- 7.3 ECONOMIC IMPACT ANALYSIS FOR COMMERCIAL PLANTS - This section includes the following material: (1) control cost analysis; (2) other cost considerations; (3) economic analysis; and (4) socio-economic and inflation impact analysis.
- 7.4 ECONOMIC IMPACT ANALYSIS FOR INDUSTRIAL PLANTS - This section is similar to 7.3, but is for the industrial dry cleaning sector.
- 7.5 ECONOMIC IMPACT ANALYSIS FOR COIN-OPERATED PLANTS - This section is similar to 7.3, but is for the coin-operated dry cleaning sector.
- 7.6 REFERENCES FOR CHAPTER 7.0

7.1 INDUSTRY ECONOMIC PROFILE

7.1.1 The Current Status of the Industry

As mentioned briefly in chapter three, the total number of establishments in the drycleaning industry numbered 46,992 in 1972, a total which represents a 3 percent decrease since 1967. This overall negative growth is mainly attributable to a decrease in the number of establishments in the commercial sector, which comprises the major portion of the industry, since the coin-operated and industrial sectors have, in fact, grown during this period.

Table 7-1 contains a summary of salient economic statistics for the drycleaning industry broken down by sector in 1967 and 1972. The data contained in the table and utilized throughout the rest of this section were available from the U.S. Census for Standard Industrial Classifications 7215, 7216 and 7218.[1] These data, which were found to be the best available, are assumed to be representative of the changes taking place in the drycleaning industry.

As listed in the table, the makeup of the industry is 37 percent coin-operated (17,550 establishments), 61 percent commercial (28,422) and 2 percent industrial (1,020). Between 1967 and 1972 the number of establishments increased in the coin-operated sector approximately 5 percent, increased in the industrial sector approximately 11 percent and decreased in the commercial sector approximately 8 percent. The decline of the commercial sector was mainly a function of the following factors:

- The use of new equipment which has increased productivity and consequently reduced the need for new plants to supply demand;
- The increasing use of washable synthetic fabrics which has reduced the demand for drycleaning services;
- The increasing use of coin-operated facilities by consumers; and
- General economic conditions during the period, which tended to affect service industries adversely.

Also indicated in Table 7-1, is the fact that total employment in the industry has declined approximately 12 percent between 1967 and 1972.

TABLE 7-1

UNITED STATES DRY CLEANING INDUSTRY

SUMMARY OF SALIENT ECONOMIC STATISTICS

1967 - 1972

Industry Category	Number of Establishments[a]		Number of Paid Employees[a]		Total Receipts[a] ($1000)	
	1967	1972	1967	1972	1967	1972
Coin-Operated Dry cleaning[b]	15,981	17,550	32,207	46,110	557,364	673,361
Commercial Dry cleaning[c]	30,625	28,422	246,348	186,701	1,938,024	1,759,486
Industrial Dry cleaning[d]	918	1,020	45,183	48,859	561,459	782,228
Industry Total	47,524	46,992	323,738	281,670	3,056,847	3,215,075

[a]Establishments with payroll

[b]Based on SIC 7215 (Coin-Operated Laundries and Dry Cleaning)

[c]Based on SIC 7216 (Dry cleaning Plants, except rug cleaning). Among the industry's three categories, the most representative data for the number of establishments are provided for commercial dry cleaning plants. These data focus only on dry cleaning facilities while the remaining two categories include laundering facilities.

[d]Based on SIC 7218 (Industrial Dry cleaners and Launderers)

Sources: 1967 data -- U.S. Department of Commerce, Bureau of Census, 1967 Census of Business, Selected Services, Laundries, Cleaning Plants, and Related Services.

1972 data -- U.S. Department of Commerce, Bureau of Census, 1972 Census of Business, Selected Services Industries, Area Statistics, by State.

Examining the sector breakdown again indicates a decline in employment in the commercial sector of approximately 24 percent, and an increase in the coin-operated and industrial sectors of approximately 43 and 8 percent, respectively. In 1972, total employment in the dry cleaning industry was 281,670. Approximately 16 percent (46,110) of the toal workers were employed in the coin-operated sector, 66 percent (186,701) in the commercial sector and 17 percent (48,859) in the industrial sector.

Total receipts for the dry cleaning industry show an absolute increase of about 5 percent over the period between 1967 and 1972. The sector breakdown indicates that receipts declined 9 percent in the commercial sector, increased 21 percent in the coin-operated sector and increased 39 percent in the industrial sector. When adjusted for the inflation which occurred during that period, however, total receipts for the industry show a relative decrease of about 16 percent when expressed in terms of constant 1967 dollars.* As would be expected, when adjusted for inflation, the decline in receipts in the commercial sector is magnified even further. Commercial receipts in terms of constant 1967 dollars decreased about 27 percent. Coin-operated receipts decreased approximately 4 percent, an interesting fact, since the coin-operated category grew in establishments and employment during the same period. This may indicate, in general, that although the number of plants and employment may be growing due to population growth, urbanization, and other factors, levels of service may be declining somewhat. It should be noted that it is possible some of the difference may be due to the manner in which the statistics were recorded.

The receipts per dry cleaning plant are very important for properly assessing the economic status of the industry. The data from Table 7-1 were used to calculate the income per plant for both 1967 and 1972, the latter being expressed in 1967 dollars. These data and the relative change in income per plant are given in Table 7-2.

*In order to compare receipts in terms of constant 1967 dollars, 1972 receipts were divided by a price index of 1.205. (U.S. Department of Commerce, Bureau of Economic Analysis and U.S. Department of Agriculture, Economic Research Service, 1972 OBERS Projections-Economic Activity in the U.S., Vol. I, prepared for the U.S. Water Resources Council, April 1974)

TABLE 7-2

TOTAL RECEIPTS PER PLANT (1967 DOLLARS)[1]

Industrial Category	1967	1972	% Change
Coin-operated	$34,880	$31,840	-8.7
Commercial	$63,280	$51,370	-18.8
Industrial	$611,610	$636,420	4.1

This characterization of the industry provides a bleaker picture of its economic health than do the raw data of Table 7-1. On a per-plant basis, the industrial sector showed modest improvement in receipts, the coin-operated sector showed a decline in receipts, and the commercial category suffered a sharp decline in receipts. The negative growth rate of commercial dry cleaning together with this poor income performance are indicative of an economically unsound industry.

7.1.2 Projection of Growth in the Industry

Simple extrapolations of growth rates, which occurred during the 1967-1972 period, were performed to project the number of establishments in the dry cleaning industry by sector in 1975 and 1980. Projections were made on a regional basis and are contained in Tables 7-4, 7-5, and 7-6. Growth trends for each sector and the industry on a national level are illustrated graphically in Figure 7-1 and are summarized below in Table 7-3.

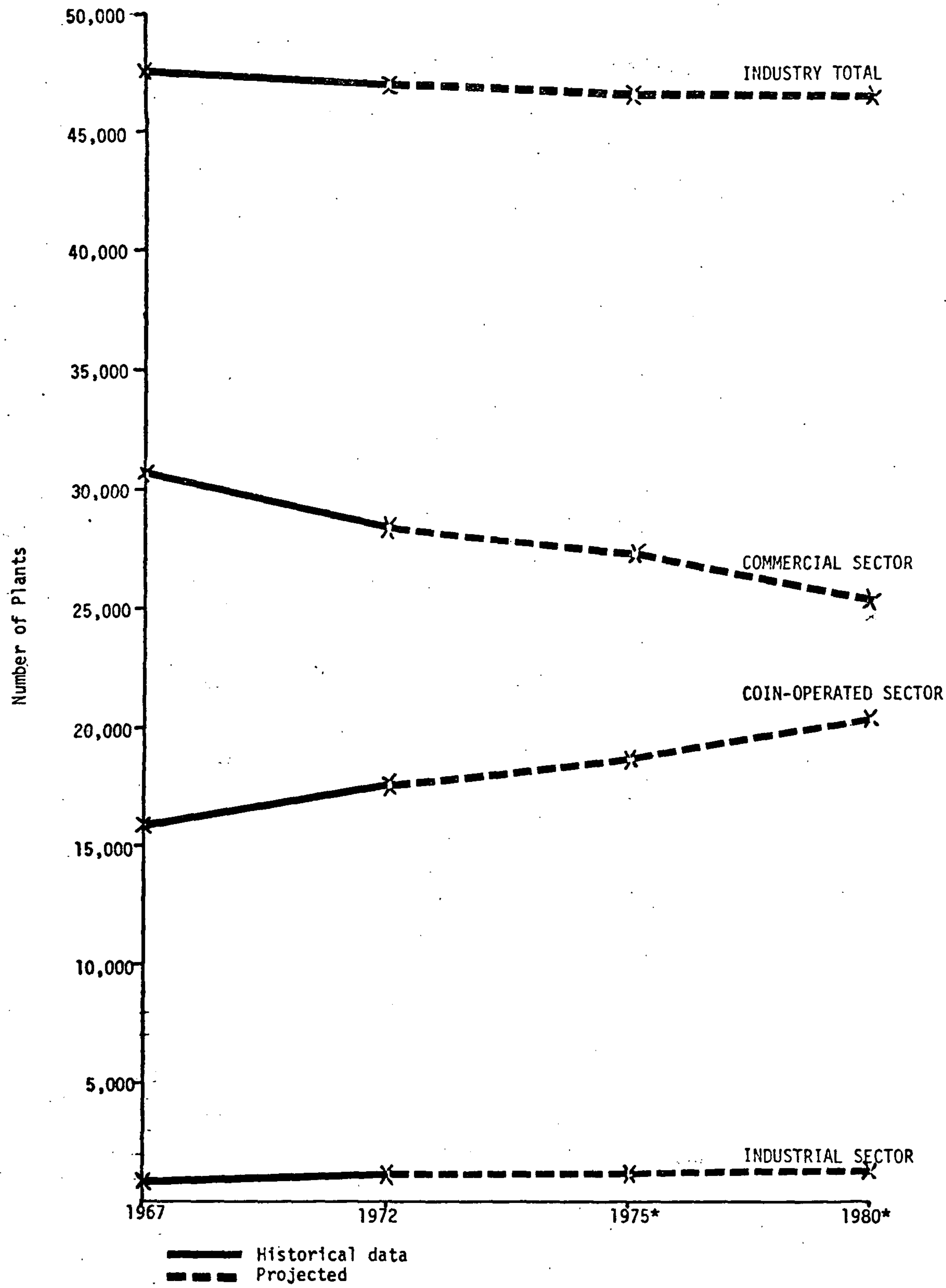
TABLE 7-3

PROJECTED NUMBER OF ESTABLISHMENTS IN THE DRY CLEANING INDUSTRY 1975, 1980

	1967	1972	1975	1980
Coin-operated	15,981	17,550	18,564	20,387
Commercial	30,625	28,422	27,179	25,226
Industrial	918	1,020	1,087	1,207
TOTAL	47,524	46,992	46,830	46,820

These data indicate that, based on continuation of current trends, the industry as a whole will decline slightly. The total number of establishments in the industry is projected to be 46,820 in 1980, which represents a less than one percent decrease from 1972. The number of establishments in the coin-operated sector is projected to increase to 20,387 in 1980, an increase of 16 percent from 1972; the commercial sector is projected to decrease to 25,226 establishments in 1980, a decline of 11 percent; and the industrial sector is projected to increase to 1,207 establishments in 1980, an increase of 18 percent.

FIGURE 7-1
PROJECTED GROWTH IN THE U.S.
DRY CLEANING INDUSTRY BY SECTOR



*Based on extrapolation of growth trends between 1967 and 1972.

Sources: 1967 data -- U.S. Department of Commerce, Bureau of Census, 1967 Census of Business, Selected Services, Laundries, Cleaning Plants, and Related Services.

1972 data -- U.S. Department of Commerce, Bureau of Census, 1972 Census of Business, Selected Services Industries, Area Statistics, by State.

TABLE 7-4

COIN-OPERATED DRY CLEANING PLANTS[a]

REGIONAL PROJECTIONS

Region[b]	1967-1972 Growth Rate (%/Yr)	1967	1972	1975[c]	1980[c]
United States	+1.89	15,981	17,550	18,564	20,387
New England	+1.75	717	782	824	898
Middle Atlantic	-0.04	2,559	2,554	2,551	2,546
East North Central	+2.00	3,606	3,981	4,224	4,664
West North Central	+0.53	1,449	1,488	1,512	1,553
South Atlantic	+4.16	2,445	2,998	3,388	4,154
East South Central	+5.29	1,091	1,412	1,648	2,133
West South Central	+0.75	2,052	2,130	2,178	2,261
Mountain	+4.07	653	797	898	1,096
Pacific	-0.01	1,409	1,408	1,407	1,406

[a] Based on SIC 7215 (Coin-Operated Laundries and Dry Cleaning).

[b] U.S. Census regions.

[c] Projected from 1972 data using the 1967-1972 annual growth rate.

TABLE 7-5
COMMERCIAL DRY CLEANING PLANTS[a]
REGIONAL PROJECTIONS

Region[b]	1967-1972 Growth Rate (%/Yr)	1967	1972	1975[c]	1980[c]
United States	-1.48	30,625	28,422	27,179	25,226
New England	-1.21	1,621	1,525	1,470	1,383
Middle Atlantic	-1.89	6,188	5,625	5,312	4,829
East North Central	-1.07	5,195	4,924	4,768	4,518
West North Central	-2.44	2,347	2,074	1,926	1,702
South Atlantic	-0.27	4,779	4,715	4,677	4,614
East South Central	-1.78	2,163	1,977	1,873	1,712
West South Central	-3.81	3,908	3,218	2,864	2,358
Mountain	-0.77	1,140	1,097	1,071	1,031
Pacific	-0.11	3,285	3,267	3,256	3,238

[a] Based on SIC 7216 (Dry Cleaning Plants, Except Rug Cleaning).

[b] U.S. Census regions.

[c] Projected from 1972 data using the 1967-1972 annual growth rate.

TABLE 7-6
INDUSTRIAL DRY CLEANING PLANTS[a]
REGIONAL PROJECTIONS

Region[b]	1967-1972 Growth Rate (%/Yr)	1967	1972	1975[c]	1980[c]
United States	+2.13	918	1,020	1,087	1,207
New England	-1.42	58	54	52	48
Middle Atlantic	-1.61	167	154	147	135
East North Central	-0.10	197	196	195	194
West North Central	+2.67	64	73	79	90
South Atlantic	+4.04	128	156	176	214
East South Central	+3.66	61	73	81	97
West South Central	+3.85	101	122	137	165
Mountain	+8.90	32	49	63	97
Pacific	+5.39	110	143	167	218

[a] Based on SIC 7218 (Industrial Launderers).

[b] U.S. Census regions.

[c] Projected from 1972 data using the 1967-1972 annual growth rate.

The changing structure of the industry is indicated by the percentage breakdowns contained in Table 7-7. The commercial sector, which constituted approximately 64 percent of the total establishments in the industry in 1967 and 60 percent in 1972, is projected to represent only 54 percent of the total in 1980.

TABLE 7-7

PERCENTAGE BREAKDOWN OF ESTABLISHMENTS

	1967	1972	1975	1980
Coin-operated	33.6	37.3	39.6	43.5
Commercial	64.4	60.5	48.0	53.9
Industrial	1.9	2.2	2.3	2.6

7.1.3 Dry Cleaning Equipment Sales

Another way of assessing the health of the dry cleaning industry is by means of historical and recent sales data for the industry. Sales data were obtained from manufacturers and from the Laundry and Cleaners Allied Trade Association (LACATA), a leading manufacturers trade organization.

7.1.3.1 Synthetic Dry Cleaning Units

This category includes both fluorocarbon machines and perchloroethylene machines. The former are solely used for commercial (retail) or coin-operated dry cleaning, but the latter may be used for industrial cleaning, in addition. In order to better make use of sales data tabulated by machine size, it is necessary to determine which size perc machines are used for these different classes. A member survey by the International Fabricare Institute (IFI) provides some help.[2] The IFI membership is predominantly commercial, and virtually all of the machines reported in the survey are less than 100 pounds/load capacity. Hence, for the present analysis, it is assumed that machines with greater than 100 pounds/load capacity are chiefly industrial units, and machines with less capacity are mostly commercial units.

The best sales data for synthetic machines were obtained from LACATA.[3] Historical sales data for non-coin-operated units are given in Table 7-8.

TABLE 7-8

SALES DATA FOR SYNTHETIC DRY CLEANING MACHINES

Year	POUNDS/LOAD CAPACITY					Total
	0-19	20-40	41-55	56-99	≥100	
1967	-[a]	979	187	112	36	1,314
1968	-[a]	1,047	209	137	56	1,449
1969	-[a]	1,024	167	161	35	1,387
1970	-[a]	712	74	99	54	939
1971	-[a]	613	-[a]	83	102	798
1972	-[a]	415	-[a]	-[a]	67	482
1973	-[a]	313	-[a]	37	50	400
1974	-[a]	226	-[a]	-[a]	58	284

[a] Insufficient participation, not included in total units.

These sales data confirm the earlier comments on the poor economic conditions in the commercial dry cleaning industry. If the earlier assumption that the 100 pound and larger category is predominantly industrial, this sector appears to be relatively stable. No data were found for coin-op machines.

7.1.3.2 Petroleum Dry Cleaning Units

Data for petroleum machines were obtained from Washex Machinery Corporation, the largest U.S. manufacturer of petroleum dry cleaning machinery.* Washex provided the historical sales data listed in Table 7-9.[4] The commercial unit sales data further confirm the weak conditions in that sector. The sales of industrial units indicate relatively sound economic conditions in that sector.

* Washex estimates that they sell about 90 percent of the industrial units and 50 percent of the commercial units in the United States.[4]

TABLE 7-9

SALES DATA FOR PETROLEUM DRY CLEANING MACHINES

Year	Commercial Units[a]	Industrial Units[b]
1967	55	25
1968	36	96
1969	23	112
1970	23	65
1971	18	88
1972	4	65
1973	0	95
1974	2	88
1975[c]	2	53

[a] Average capacity of 100 pounds/load.

[b] Average capacity of 500 pounds/load.

[c] Through September.

7.2 MODEL PLANT SELECTIONS

In making control cost estimates for the dry cleaning industry, it is necessary to designate model plants, since the cost of control varies with such factors as rated plant capacity (lb. per load), plant type (industrial, commercial, or coin-op.), solvent type, and the annual production (lb. per year). Accordingly, the model plants in Table 7-10 were selected after study of technical literature and equipment sales information, and discussions with industrial and trade association representatives. The models are not intended to represent particular plants, but they provide a basis for making cost estimates. The rationale for choosing these plant configurations follows the table.

TABLE 7-10
MODEL DRY CLEANING PLANTS

Plant Type	Solvent	Machine Type	Capacity (lb. per load)	Production Rate (lb./yr.)
Commercial	Perc	Dry-to-dry	40	100,000
Commercial	Perc	Transfer	40	100,000
Industrial	Perc	Transfer	250	1,000,000
Industrial	Petroleum	Transfer (Dual Phase)	500	1,500,000
Coin-Op	Perc	Dry-to-dry	4x25[a]	80,000
Coin-Op	Fluorocarbon	Dry-to-dry	4x12[a]	80,000

[a] The numbers 4x25 and 4x12 mean four 25-lb. capacity and four 12-lb. capacity units, respectively.

7.2.1 Commercial Plants

The reasons for selecting these particular plant configurations are as follows:

- According to industry representatives and a survey of dry cleaners, most commercial plants use perchloroethylene.[2]

- There are two common types of perc machines, dry-to-dry and transfer. Hence, economic impacts should be assessed for each.

- The 30 to 50 pound sizes were most commonly used in the industry, according to the International Fabricare Institute (IFI) survey.[2] In addition, a representative of a major manufacturer indicated that the average machine size was about 40 pounds.[5]

- About two-thirds of the respondents to the IFI survey reported annual cleaning volumes of 52,000 to 156,000 pounds. Here the approximate middle of this range was selected as being representative.

7.2.2 Industrial Plants

The characteristics of these model plants were based on the following factors.

- Either perchloroethylene or petroleum solvent is commonly found in industrial applications.

- All petroleum machines and most industrial perc machines are transfer types.

- According to the major manufacturer of petroleum machinery, the 500-lb. dual phase machines are their biggest sellers at this time.[4]

- A 250 pound perc machine has almost the same short-term production rate as a 500 pound dual phase machine. (Paragraph 7.4.1.1 has a more thorough discussion.)

- The petroleum machine was assumed to process 10 loads per day, 6 days per week, 50 weeks per year.

- The perc machine was assumed to process about 15 loads per day, 6 days per week, 50 weeks per year.*

7.2.3 Coin-Operated Plants

The defining parameters of the coin-operated model plants were based on the factors below:

- Only perc and fluorocarbon machines are used in coin-op service, and all coin-op units are dry-to-dry types.

- The 12 pound fluorocarbon machine is the most common size for these units.[5]

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* According to the manufacturer's brochures, this machine has a capacity of between 200 and 250 pounds per load, depending on the clothing type. Hence, an average capacity of 225 pounds was used.

- A fluorocarbon machine has about the same production capacity as a perc machine twice as large in per load capacity. (See subsection 7.5.1 for more detail.)

- Each machine is assumed to process three partial loads - 20-lb. for the perc units and 10-lb. for the fluorocarbon units - per day, 7 days per week, 50 weeks per year. (The results are rounded to 80,000 pounds per year.)

7.3 ECONOMIC IMPACT ANALYSIS FOR COMMERCIAL PLANTS

The model plants selected for the economic analysis of the commercial dry cleaning industry are both based on perchloroethylene cleaning machines, for reasons discussed in the previous section. Two control measures have been shown to have excellent potential for reducing solvent emissions from either new or modified commercial plants: (1) housekeeping procedures, including the keeping of production and solvent consumption records; and (2) a properly installed and operated carbon adsorber. The first measure is considered essential to the effectiveness of the second, as discussed in Section 4.0.

7.3.1 Control Cost Analysis

7.3.1.1 New Facilities

At the present time, only about 10 percent of perchloroethylene dry cleaning machine sales are for new plants, roughly 70 percent are replacement machines, and the remaining 20 percent are for plant expansions.[5] Table 7-11 shows the required investment for equipment to outfit each of the model plants. The cost of the vapor adsorber needed to implement the recommended control system is also given. The other component of the system, housekeeping, requires no capital outlay.

The size of the building needed for either of the model plants can be estimated using the formula below:[8]

$$\text{Required Square Feet} = \frac{\$1.50}{\text{Base Price}} \times \frac{\text{Average Weekly Volume(\$)}}{1.2}$$

The base price, which is the cost of cleaning a dress or a 2-piece mans suit, is currently about $2.25, although it does vary nationally.[9] Each model plant will generate annual receipts of about $125,000, using a dry cleaning cost of $1.25 per pound and the assumed production volume of 100,000 pounds. Inserting these values in the formula, the required building size is 1335 square feet. With a building cost of $15 per square foot, suggested by industry representatives,[9,10] the cost of the structure is about $20,000. A commercial lot for this size building typically costs about $3,500 with utility connections.[11] The total investment costs for the model plants, as well as the incremental costs of control, are summarized in Table 7-12.

TABLE 7-11

TYPICAL EQUIPMENT COSTS FOR A COMMERCIAL PERCHLOROETHYLENE DRY CLEANING PLANT[7]

Item(s)	Cost
1 - 10 H.P. Boiler (oil or gas fired), return system, blow down tank, and accessories	$3,300
1 - 3 H.P. Air Compressor	1,200
1 - Spotting board with spray tank	700
1 - Garment steam cabinet	1,200
1 - Topper and legger with puff iron, complete pants unit	4,200
1 - All-purpose utility press, 3-puff irons, form finisher, complete all-purpose unit.	3,900
1 - Tailoring machine	600
1 - Automatic garment conveyor	2,600
1 - Monorail assembly	1,800
1 - Garment bagger	75
2 - Counters for office	600
1 - Cash register	1,200
Complete Installation Cost (including equipment below)	7,500
Above Costs	$28,875
Dry-to-dry 40-lb. machine, cartridge filter & still	23,000
Total Installed Cost/Dry-to-dry Plant	$51,875
Above Costs	$28,875
Transfer 40-lb. machine, cartridge filter, still & drier	17,000
Total Installed Cost/Transfer Plant	$45,875
Dual canister vapor adsorber (installed with either of above systems)	3,300

TABLE 7-12

EFFECTS OF EMISSION CONTROLS ON INVESTMENT COSTS IN COMMERCIAL DRY CLEANING PLANTS

Item	Dry-to-Dry Plant	Transfer Plant
Equipment	$51,875	$45,875
Building	20,000	20,000
Land	3,500	3,500
Total Cost (Uncontrolled)	75,375	69,375
Control Device (Adsorber)	3,300	3,300
Total Cost (Controlled)	78,675	72,675
Incremental Control Cost (%)	4.4	4.8

The calculation of direct operating costs and annualized capital charges for the complete 2-part control system is based on the following assumptions.

- Annualized Capital Charge (based on a sinking fund factor)
  - SBA-approved 10% p.a. note (3% above prime rate) for 10 years
  - Equipment amortized over 10 yr. period
  - Equipment cost of $3300
- Direct Operating Costs
  - Total maintenance and operating cost is 5% of original equipment cost without solvent recovery credit.[12]
  - Solvent cost is $2.80 per gallon.
  - Solvent mileages { uncontrolled plant - 6,000 lb./drum; housekeeping procedures - 10,000 lb./drum; housekeeping + adsorber - 15,000 lb./drum }

Table 7-13 summarizes the annualized costs of meeting the 15,000 lb./drum mileage requirement, which corresponds to a perc emission rate of about 94 lb. per ton.

TABLE 7-13

ANNUALIZED COST OF EMISSION CONTROL
FOR MODEL COMMERCIAL DRY CLEANING PLANT

Item	Cost
Capital Charges	
Interest	$ 196
Depreciation	330
Total Capital Charge (C)	$ 526
Direct Operating Costs	
Maintenance and Operating Expenses	$ 165
Solvent Credit	-1456
Net Direct Cost (D)	-$ 1291
Net Annualized Cost (C+D)	-$ 765

Although dry-to-dry plants are commonly believed to exhibit better mileage performance than transfer plants, no reliable data are available to confirm any such differences. Consequently, in the estimation of annualized costs of control, the same solvent mileage assumptions were made for both model plants.

7.3.1.2 Modified Facilities

For cost estimation purposes, the plant modification considered is the addition of a new 40-lb. dry cleaning machine to an existing plant. No additional land area or floor space is assumed to be needed for the control equipment. For the new facilities, installation costs were 16.9% and 19.5% of total equipment costs for the dry-to-dry and transfer plants, respectively. Installation of equipment in an existing plant is more difficult, so a higher installation rate of 25 percent is assumed. The total investment cost of the control equipment is about $4125, of which $825 is for installation and $3300 is actual equipment cost. Table 7-14 summarizes the total installed cost of the modified facilities.

TABLE 7-14

EFFECTS OF EMISSION CONTROLS ON INVESTMENT COSTS FOR A DRY CLEANING PLANT EXPANSION

Item	Dry-to-Dry Plant	Transfer Plant
Cleaning Machine	$23,000	$17,000
Installation Cost	4,500	4,500
Total Cost (Uncontrolled)	$27,600	$21,500
Vapor Adsorber	$ 3,300	$ 3,300
Installation Cost	825	825
Total Cost of Control	$ 4,125	4,125
Total Cost of Controlled Plant Expansion	$31,725	$25,625
Incremental Control Cost (%)	14.9	19.1

In estimating annualized costs of emission controls for new commercial installations, the capital charges were based on the uninstalled price of the control device. This was because the incremental cost of installing an adsorber at a new site was negligible in comparison with total installation costs. However, as noted previously, the greater difficulty of placing equipment in an existing plant requires that these costs be explicitly considered in plant modifications. Direct operating costs of the control device will be identical to those for new facilities, since the equipment and operational parameters are the same. Table 7-15 summarizes the annualized costs of a control system for an addition to an existing plant.

TABLE 7-15

ANNUALIZED COST OF EMISSION CONTROL FOR EXPANSION OF COMMERCIAL DRY CLEANING PLANT

Item	Cost
Capital Charges	
Interest	$ 246
Depreciation	412
Total Capital Charge (C)	$ 658
Direct Operating Costs	
Maintenance & Operating Expenses	$ 165
Solvent Credit	- 1456
Net Direct Cost (D)	-$ 1291
Net Annualized Cost (C+D)	-$ 633

7.3.2 Other Cost Considerations

For the most part, state solvent emission regulations governing dry cleaning plants are based on the Los Angeles "Rule 66" approach or on the control of hydrocarbons, alone.* Under this type of regulation, perchloroethylene is an exempt solvent for which there are no emission limitations. Hence, existing state solvent emission laws are not expected to exacerbate any costs resulting from the recommended control alternative for commercial perc plants.

* At least one local agency - the Maricopa County, Arizona Bureau of Air Pollution Control - requires the use of a vapor adsorber on new perc plants.[14]

Perchloroethylene plants have little potential for causing water pollution problems and are currently under no costly effluent control guidelines. Likewise, relatively small amounts of solid waste result from the dry cleaning process, and disposal costs are minimal. Therefore, no significant cost impacts are expected from either water quality or solid waste regulations.

The principal control costs currently being imposed on perc plants are the Occupational Safety and Health Administration (OSHA) restrictions for solvent vapors in the working environment. At the present time, the allowable time-weighted-average (TWA) perc levels in working areas are as follows:

- 8-hr, TWA - - 100 parts per million (ppm).
- 200 ppm may be exceeded only once every 3-hr. for no more than 5-minutes.
- Never to be exceeded - - 300 ppm.

Although it is possible to meet these standards by ventilation alone, a better approach is directing air collected from machine vents and floor pick-ups to a vapor adsorber. This allows the dry cleaner to meet the OSHA requirements and reduce his solvent costs. In a survey of IFI members, 52 percent of the perc plant operators now have vapor adsorbers in their plants.[2] Consequently, the OSHA regulations are not expected to increase the cost of implementing the proposed control alternative.

7.3.3 Economic Analysis

7.3.3.1 New Facilities

For the past several years, as indicated in Section 7.1, the commercial dry cleaning industry has been experiencing sharp declines in both numbers of plants and in real gross income per plant. Additional evidence of this decline is the estimate by one equipment manufacturer that only 10 percent of their new cleaning machines are being used in new installations.[5] Even more discouraging is the fact that total machine sales in the sizes used for retail cleaning decreased by about 75 percent between 1970 and 1974.[3] Although no data are available to confirm the claims, discussions with industry representatives indicate that the following factors are responsible for the decline:

- The national economic conditions, which tend to affect service industries, specifically, quite severely.

- Increasing usage of synthetic fibers, which do not require dry cleaning.
- A general "weeding out" of older less efficient plants which were built during the "boom periods" of the 1940's and 1950's but which cannot compete economically with newer installations.

In spite of the weak economic conditions in the commercial sector, the additional investment cost of the proposed controls for a new plant is less than 5 percent (Table 7-12) and would not be expected to prevent the construction of a new plant. The incremental cost of control is considered a minor factor in comparison with the other economic factors.

The annualized costs of the controls (Table 7-13) show that the controls result in a net savings for the dry cleaner. Although it is possible that this savings could be passed on to the customer, it is not likely because a customer survey in the northeast indicated that price is a very minor item in selecting a dry cleaner.[15] However, it is also unlikely that prices would be raised as a result of the reduction in costs. The net effect of the controls on price will probably be zero and profits should be increased.

7.3.3.2 Modified Plants

Although, in the case of new plants, the incremental investment cost of control represents a relatively small part of total investment, the same cannot be said of additions to existing plants. As Table 7-14 showed, control equipment adds 14.9 percent and 19.1 percent, respectively, to the total capital requirement for dry-to-dry and transfer plants adding a new 40-lb. cleaning machine. In view of the poor economic status of the commercial dry cleaning sector at this time, this additional cost could prevent operators from adding capacity. In the case of an operator who is only considering adding capacity, the additional cost might well prove decisive in preventing the addition.

With regard to the annualized cost of the controls, the situation is similar to that of new facilities: If an operator can afford the initial cost of control, his annual operating expenses will be reduced. Consequently, no effect on prices is expected, and profits should be boosted.

7.4 ECONOMIC IMPACT ANALYSIS FOR INDUSTRIAL PLANTS

Two model dry cleaning plant configurations were designated for analysis of the industrial sector:

- A plant utilizing a 250-lb. capacity industrial perchloroethylene machine.
- A plant utilizing a 500-lb. dual phase petroleum machine.

A complication arises in defining an entire industrial laundry plant as opposed to that part of the facility doing dry cleaning per se. Virtually all industrial dry cleaning facilities are associated with laundering facilities. Hence, in determining total investment costs for a new plant, the laundry equipment should be considered as well as the dry cleaning machinery.

The control system believed to be most appropriate for use in each of the two industrial model plants and for modifications to existing plants consists of two control measures: (1) housekeeping procedures, including the recording and retaining of production and solvent consumption data; and (2) a properly installed and operated carbon adsorber. It should be noted that carbon adsorbers for petroleum plants are not available commercially at this time, and cost estimates for the device are based on data provided by Vic Manufacturing Co., a major manufacturer of adsorbers for the industry.

7.4.1 Control Cost Analysis

The assistance of industry spokesmen - including equipment manufacturers, trade associations, and operators - was utilized to define typical industrial laundry facilities, which included the previously-described dry cleaning model plants as component parts. Equipment costs, installation costs and operating costs were obtained from these same sources for estimating investment and annualized control costs for new and modified plants.[16, 17]

7.4.1.1 New Facilities

Complete investment cost data for new industrial plants with perc-based and petroleum-based dry cleaning machines are shown in Tables 7-16a and 7-16b, respectively. All of the data are the most current available, as the reference dates indicate. With the exception of the dry cleaning machinery, these plants are identical, to allow more meaningful cost comparisons. The paragraphs below serve to emphasize the differences between the two operations:

TABLE 7-16a

INVESTMENT COSTS OF EMISSION CONTROLS IN AN INDUSTRIAL LAUNDRY: CASE 1 - PERC DRY CLEANING MACHINE

Item(s)	Cost	Reference
2 - 600-lb laundry machines with dryers, complete and installed	$115,000	10
Boilers for steam and hot water, complete and installed	90,000	10
Finishing equipment, compressors, and other ancillary equipment, installed	115,000	10
Building (30,000 sq. ft. @ $10/sq. ft.)	300,000	10
Land (33,333 sq. ft. @ $2.25/sq. ft.)	75,000	11
1 - 250-lb. Industrial cleaning machine, complete and installed, w. still	94,500	16
1 - 250-lb. Reclaiming dryer for the above, installed	35,500	16
1 - 40 H.p. Boiler, complete and installed	8,000	16
Total Cost of Uncontrolled Facility	$833,000	--
Control device (carbon adsorber, installed)	7,000	16
Total Cost of Controlled Facility	$840,000	--
Incremental Control Cost (% based on total plant cost)	0.84	--
Incremental Control Cost (% based only on drycleaning equipment cost)	5.1	--

TABLE 7-16b

INVESTMENT COSTS OF EMISSION CONTROLS IN AN INDUSTRIAL LAUNDRY: CASE 2 - PETROLEUM DRY CLEANING MACHINE

Item(s)	Cost	Reference
2 - 600-lb. laundry machines with dryers, complete and installed	$115,000	10
Boilers for steam and hot water, complete and installed	90,000	10
Finishing equipment, compressors, and other ancillary equipment, installed	115,000	10
Building (30,000 sq. ft. @ $10/sq. ft.)	300,000	10
Land (33,300 sq. ft. @ $2.25/sq. ft.)	75,000	11
1 - 500-lb. Dual phase cleaning machine, complete and installed, with pumps, filter, and vacuum still	80,500	4
Dryers for above, complete and installed	35,000	4
1 - 40 H. p. Boiler, complete and installed	8,000	16
Total Cost of Uncontrolled Facility	$818,500	--
Control device (carbon adsorber, installed	90,000	17
Total Cost of Controlled Facility	$908,500	--
Incremental Control Cost (% based on total plant cost)	11.0	--
Incremental Control Cost (% based only on drycleaning equipment cost)	72.9	--

- Perc Installation - The prices of this machinery are based on a modular dry cleaning system. The very low installation costs - $1,000-4,000 for the entire system - are a consequence of the modular construction and the pre-assembly of many critical elements, such as wiring harnesses.[16] To minimize solvent losses during transfer of clothing from the washer/extracter to the dryer the latter is mounted on tracks so that it mates with the former during transfer. This also reduces labor requirements and reduces the transfer time. Although this perc machine has only half the capacity of the petroleum machine of the other model plant, the production rates are similar because the perc machine processes a load in about half the time required by the petroleum unit.[4, 18]

- Petroleum Installation - This plant uses the dual phase (solvent and water) process discussed in Section 3.0. According to the major manufacturer of petroleum machines, about 80 percent of all new petroleum units use this system.[4] As noted earlier, carbon adsorbers are not available in the U.S. for petroleum machines at this time, and the costs shown in Table 7-16b are rough estimates provided by a manufacturer.[17]

The incremental investment cost of control for the perc plant is less than 1 percent of total plant cost or about 5 percent of the uncontrolled dry cleaning equipment cost, values which are considered quite modest. In marked contrast, the incremental investment cost of control for the petroleum plant is 11 percent, which represents almost 73 percent of the uncontrolled dry cleaning equipment cost. The economic impacts of these costs are discussed later in this section.

Annualized control costs for the two model plants were separated into the usual two components: (1) capital charges (depreciation and interest); and (2) direct operating costs and credits. The assumptions used for both plants are tabulated below:

<u>PERC PLANT</u>

- Annualized Capital Charge (based on a sinking fund factor)
  - SBA-approved 10% p.a. note (3% above prime rate) for 10 years
  - Amortization period of 10 years
  - Equipment cost of $7000
- Direct Operating Costs
  - Annual maintenance cost of ½% of equipment cost [17]
  - Utility charge for solvent recovery of $0.15 per gallon [17]

- Solvent mileages { uncontrolled plant - 10,000 lb./drum; housekeeping procedures - 15,000 lb./drum; housekeeping + adsorber - 20,000 lb./drum }

- Solvent cost of $2.80 per gallon

PETROLEUM PLANT

- Annualized Capital Charge (based on a sinking fund factor)
  - SBA-approved 10% p.a. note (3% above prime rate) for 10 years
  - Amortization period of 10 years
  - Equipment cost of $90,000
- Direct Operating Costs
  - Annual maintenance cost of ½% of equipment cost[17]
  - Utility charge for solvent recovery of $0.15 per gallon[17]
  - Uncontrolled solvent mileage of 1436 lb./drum[19]
  - Losses from tumbler are 70% of total solvent losses [19, 20]
  - Adsorber recovers 90% of tumbler losses
  - Solvent cost of $0.57 per gallon.

More thorough discussions of the technical bases for the emission and control-related assumptions may be found in Sections 3.0 and 4.0.

The annualized control costs are tabulated in Table 7-17 for both plants. The results may be summarized as follows:

- The control equipment on the perc plant reduces annualized costs by $5,739, a return-on-(original)-investment of 82 percent. This is a function of the modest cost of the control equipment and the high value of the recovered solvent.

- The annualized cost of control for the petroleum equipment is quite modest, only $347 per year. This differs from the preceding case because: (1) the adsorber is much more expensive; and (2) the recovered solvent has relatively little value.

TABLE 7-17

ANNUALIZED COSTS OF EMISSION CONTROL FOR MODEL INDUSTRIAL DRY CLEANING PLANTS

Item	Perc-Based Plant	Petroleum-Based Plant
Capital Charges		
Interest	$ 416	$ 5,344
Depreciation	700	9,000
Total Capital Charge (C)	$1,116	$ 14,344

TABLE 7-17 (contd.)

Item	Perc-Based Plant	Petroleum-Based Plant
Direct Operating Costs		
Maintenance	$ 35	$ 375
Utilities	390	5,133
Solvent Credit	-7,280	-19,505
Net Direct Cost (D)	-$ 6,855	-$ 13,997
Net Annualized Cost (C+D)	-$ 5,739	$ 347

7.4.1.2 Modified Facilities

Most modifications to an existing plant will involve one of the following changes: (1) replacement of a worn-out machine with a newer one of the same type; (2) replacement of a machine using one solvent type by one of another type; or (3) addition of a new machine to increase capacity. Because each of these modifications involves the addition of a new machine, this is the option used for cost estimation purposes. No additional floor space or land area is assumed to be needed, and the dry cleaning equipment added is the same as was used in the new plant estimates. The additional installation costs due to maneuvering and working in an existing plant were based on the following assumptions:

- For the modular perc equipment, installation costs were doubled from $500 per piece of equipment to $1000.
- Installation costs for the petroleum cleaning machine were increased from about 15 percent to 20 percent of base price. The installation cost of the vapor adsorber was increased from 20 percent of base price to 25 percent.

Table 7-18 shows the effects of the control systems on investment costs for expansion of both plant types. In summary, the results are as follows:

- For the perc plant expansion, the controls add a modest 5.1 percent ($7,500) to investment costs.
- The controls add 73.2 percent ($94,000) to investment costs in the petroleum plant expansion. This is a very large, possibly critical, increase in costs, as discussed later in this section.

TABLE 7-18

EFFECTS OF EMISSION CONTROLS ON INVESTMENT COSTS FOR INDUSTRIAL DRY CLEANING PLANT EXPANSIONS

Item	Perc-Based Plant	Petroleum-Based Plant
Cleaning Machine	$ 95,000	$ 84,000
Dryer (s)	36,000	36,000
Boiler	8,500	8,500
Total Cost (Uncontrolled)	$139,500	$128,500
Vapor Adsorber	$ 7,500	$ 94,000
Total Cost of Controlled Plant Expansion	$147,000	$222,500
Incremental Control Cost (%)	5.1	73.2

Estimates of annualized costs of control for the two plant expansions were based on the same assumptions as were the estimates for new plants, with the exception of installed cost of the equipment. The latter costs were adjusted, as discussed previously, to account for higher installation costs in existing plants. The results appear in Table 7-19 and may be summarized as follows:

- The control system for the perchloroethylene-based plant reduces annualized costs sharply. The return on investment is about 75 percent per year.
- Although the petroleum plant control system does not decrease annualized costs, the estimated increase in these costs is small.

TABLE 7-19

ANNUALIZED COSTS OF EMISSION CONTROL FOR INDUSTRIAL DRY CLEANING PLANT EXPANSIONS

Item	Perc-Based Plant	Petroleum-Based Plant
Capital Charges		
Interest	$ 446	$ 5,582
Depreciation	750	9,400
Total Capital Charge (C)	$1,196	$14,982

TABLE 7-19 (contd.)

Item	Perc-Based Plant	Petroleum-Based Plant
Direct Operating Costs		
Maintenance	$ 35	$ 375
Utilities	390	5,133
Solvent Credit	-7,280	-19,505
Net Direct Cost (D)	-$6,855	-$13,997
Net Annualized Cost (C+D)	-$5,659	$ 985

7.4.2 Other Cost Considerations

As noted in the discussion for commercial plants, most state solvent emission regulations for dry cleaning plants are based on the Los Angeles "Rule 66" approach or on control of hydrocarbons, alone. Perc is normally exempt from the regulations, although a few agencies require use of vapor adsorbers on new plants. As a result, existing state air quality regulations are not expected to add to the cost of the proposed control system.

The situation is different with regard to petroleum solvents, since these are frequently subject to regulation by state or local agencies. The regulations commonly allow compliance by either of the following measures:[13]

- Limiting daily emissions, or
- Utilizing a non-photochemically reactive petroleum solvent.

The latter approach is preferred by dry cleaners, and the so-called "Rule 66" solvents are generally available at little or no extra cost. The cost of implementing the proposed control alternative should not be affected by these regulations.

Perchloroethylene plants have little potential for causing water pollution problems and are currently under no costly effluent control guidelines. Likewise, relatively small amounts of solid waste result from the dry cleaning process, and disposal costs are minimal. Therefore, no significant cost impacts are expected from either water quality or solid waste regulations.

In Section 3.0, it was noted that some of the major forces causing a shift towards dual phase dry cleaning machines were increasingly restrictive local regulations against discharge of harsh detergents from industrial laundries into sewers.

Hence, dry cleaning is viewed as a water pollution control measure in this case and local regulations should not exacerbate the cost of meeting the control alternative. No costly solid waste disposal problems occur in petroleum plants, so there should be only minimal cost impacts in this area.

As was true for commercial perc plants, the principal control costs currently being imposed on industrial perc plants are the Occupational Safety and Health Administration (OSHA) restrictions for solvent vapors in the working environment. Although the OSHA requirements can be met be ventilation alone, the reduction of solvent losses to the atmosphere resulting from emission controls should help to reduce the ventilation requirements. Although the OSHA limits are less restrictive for petroleum plants, similar reasoning applies.

7.4.3 Economic Analysis

On the basis of the industry profile in Section 7.1, the industrial laundry sector appears to be a healthy, but not thriving industry. Some of the important points are as follows:

- Nationwide, the industry had a growth rate of 2.13 percent in the years 1967 through 1972, although there were some regions of the country showing negative growth. (Table 7-6)
- Total receipts per plant increased by a modest 4.1 percent (constant 1967 dollars) between 1967 and 1972. (Table 7-2)
- Sales of industrial-sized machines have remained stable and strong. Sales of petroleum machines appear to have peaked in 1969, decreased sharply during the 1970 recession year, and then recovered with moderate growth since that time.[4] Perchloroethylene machines have shown similar, but not identical trends.[3]

In view of the modest growth in the industry as a whole, it appears that most of the new machines are being used as replacements or add-on units. The replacements can be of two types: (1) replacement of dry cleaning equipment by other dry cleaning equipment; or (2) replacement of industrial laundry equipment by dry cleaning machines. The latter type of exchange seems likely to have increased in importance recently as a result of water pollution regulations and the increasing use of synthetic fabrics in uniform rental operations.*

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* For more details, see subsection 3.2.2, Petroleum Solvent Plants.

However, statistics to support this premise were not available from industry sources. The following material discusses the potential economic impacts of the control alternative on the industry in light of its current economic condition.

7.4.3.1 New Facilities

For new plants with perchloroethylene dry cleaning machines, the incremental investment cost of control is less than 1 percent of the uncontrolled plant cost. In addition to this low investment cost, the control system reduces annualized costs by almost $6,000. As a result, the proposed control system is not expected to have any impact on growth in the perc-using sector of the industry. Because the reduction in annualized costs is relatively small in comparison with total investment costs and annual average receipts, no effects on pricing policies are expected. The operating cost savings would most likely be used to marginally increase profits.

In the case of new plants using petroleum dry cleaning equipment, the incremental investment cost of control is 11 percent of the uncontrolled plant cost. This is considered a significant impact in this relatively stagnant industry. The annualized operating cost of control is only $347, a negligible increase. Although the increased investment cost might prevent the construction of a new plant, another possibility seems more likely. Because, for controlled plants, the perc-based industrial laundry has an investment cost about 7.5 percent ($68,500) less than the equivalent petroleum operation, a shift towards perc machinery in new facilities seems possible. If a new petroleum plant is built, the increased annual costs resulting from the control system are so small that no pricing changes would be expected.

A further comment seems appropriate in regard to the possible shift towards perc machinery. Although personalized viewpoints abound in this industry, there is no good reason to believe that there would be any change in the quality of cleaning or increased deterioration of fabrics, as a result of the (possible) change. Numerous examples of successful perchloroethylene-based industrial plants exist at this time.

7.4.3.2 Modified Facilities

For modifications entailing addition of a perc machine, whether for expansion or replacement, the emissions control increases investment costs by

5.1 percent ($7,500), which is considered reasonable. This modest investment cost, when coupled with a $5,659 reduction in annualized costs is expected to have little or no impact on future plant modifications. The effect of the reduction in annual costs is not believed to be large enough to significantly affect prices in the industrial sector.

For the modification of a plant involving the addition of a petroleum machine, the investment picture is much less encouraging than for the preceding case. The incremental investment cost of control is 73.2 percent ($94,000), a highly significant figure. This makes the cost of a controlled petroleum plant modification more than 50 percent greater than the equivalent perchloroethylene plant modification. Hence, most operators would probably choose the latter option when they modify their plants. If the petroleum machine should be chosen, the additional annual costs ($985) should not be sufficient to result in any changes in pricing structure.

From a technical point of view, there are no major difficulties involved in either of these modifications. However, there are two installation advantages for the perc machine:

- The perc machine is modular and less bulky, so it is more easily installed.
- Local fire regulations require underground tanks for petroleum solvent storage, and it might prove difficult to make this installation in some cases.

With these two qualifications, either type of machine should interface well with either an existing perc plant or a petroleum plant.*

* It should be kept in mind that the dual phase petroleum machine requires a hot water supply, but in an industrial laundry, this should be no problem.

7.5 ECONOMIC IMPACT ANALYSIS FOR COIN-OPERATED PLANTS

Only dry-to-dry machines are used in coin-operated plants, so all machines use synthetic solvents, either perchloroethylene or Freon 113.* Like industrial plants, coin-operated dry cleaning machines are commonly associated with laundry facilities, though in the latter case the laundry machinery is also coin-operated. In view of this, coin-operated plants are considered to be adjuncts of laundromats, and incremental control costs are assessed in comparison to dry cleaning equipment costs rather than to total plant costs.

7.5.1 Control Cost Analysis

Because fluorocarbon machines have shorter cycle times, - the solvent is much more volatile than perchloroethylene - they have more productive capacity for a given size machine than perchloroethylene machines. Consequently, comparison of equivalent plants requires that larger capacity be assigned to the perc plant. However, machines are not made in every possible size, and the two plants can only be matched approximately. In the present case, 4-25 lb. perc machines are compared with 4-12 lb. fluorocarbon units, and the former probably have somewhat more long-term production capacity.

Table 7-20 summarizes the investment costs and the incremental effects of emission controls for the two model plants. As noted, the fluorocarbon plant requires no additional equipment for control, since these machines have built-in control devices.

There are no capital charges for the fluorocarbon plant emission controls, and no more than manufacturer's suggested maintenance is needed for retaining the low emission levels of the machines. In view of this, the annualized cost of control for fluorocarbon plants is considered negligible.**

The calculation of direct operating costs and capital charges for control of the perc installation is predicated on the assumptions below:

- Annualized Capital Charge (based on sinking fund factor)
  - SBA-approved 10% p.a. note (3% above prime rate) for 10 years

* Freon is a trademark of E.I. DuPont de Nemour and Company.

** The cost of the required record-keeping should be insignificant.

TABLE 7-20

INVESTMENT COSTS OF EMISSION CONTROLS IN COIN-OPERATED DRY CLEANING PLANTS

Item(s)	Perchloroethylene Plant[21]	Fluorocarbon Plant[22]
4 - Dry-to-dry cleaning machines[a]	$32,000	$31,900
4 - Cartridge filter/still units	6,000	Built-in
1 - Air compressor	500	500
Installation	8,750	1,000[b]
Total Cost of Uncontrolled Plant	$47,250	$33,400
Control device (carbon adsorber, installed)	6,050	-[c]
Total Cost of Controlled Plant	$53,300	$33,400
Incremental Cost of Control (%)	12.8	0.0

[a] As discussed in the text, the perchloroethylene and fluorocarbon machines are not precisely equivalent, but they are matched as well as possible.

[b] Fluorocarbon machines need no installation other than bolting to the floor and connections to the power lines and compressed air source.

[c] Fluorocarbon machines have built-in refrigeration units which serve as control devices during the drying/aeration cycle.

- Equipment amortized over 10 yr. period
- Equipment cost of $6,050.

- **Direct Operating Costs**
  - Total maintenance and operating cost is 5% of installed adsorber cost without solvent recovery credit.[12]
  - Solvent cost is $2.80 per gallon.
  - Solvent mileages { uncontrolled plant-4,400 lb./drum[23]; housekeeping-8,000 lb./drum; housekeeping+adsorber-12,000 lb./drum }

Table 7-21 summarizes the annualized costs for meeting the 12,000 lb./drum mileage requirement, which corresponds to a perc emission rate of about 118 lb. per ton of cleaning. The value of the recovered solvent more than compensates for the capital charges and additional operating costs, and annualized costs are reduced by $410 compared to the uncontrolled case.

7.5.2 Other Cost Considerations

Existing state and local solvent regulations for coin-operated perc plants are the same as those for other plants. That is, the solvent is either considered exempt from the regulations or, in one case,[14] a carbon adsorber is required in new plants. As a result, these regulations will not exacerbate the costs of implementing the recommended emission control alternative. No regulations are known to exist for fluorocarbon plants.

Properly maintained coin-op machines have only slight water pollution potential and no costly effluent controls are known to be in effect. Also, only small amounts of solid waste - chiefly filter cartridges and lint - are produced by the machines. Cost impacts from these two pollutants are minimal.

For the Occupational Safety and Health (OSHA) limitations on solvent levels in the working environment, the same considerations apply to coin-op plants as for commercial plants (subsection 7.3.2). That is, the OSHA standards and the proposed control system are complementary, and neither should exacerbate the costs of the other.

7.5.3 Economic Analysis

The industry profile in Section 7.1 indicated that the coin-operated sector is a somewhat stagnant industry, as illustrated by the following salient points:

TABLE 7-21

ANNUALIZED COSTS OF EMISSION CONTROL FOR
MODEL COIN-OPERATED PERCHLOROETHYLENE PLANT

Item	Cost
Capital Charges	
Interest	$ 359
Depreciation	605
Total Capital Charge (C)	$ 964
Direct Operating Costs	
Maintenance & Operating Costs	$ 303
Solvent Credit	- 1,677
Net Direct Costs (D)	-$1,374
Net Annualized Costs (C+D)	-$ 410

- The number of establishments increased by less than 10 percent between 1967 and 1972, an annual growth rate less than 2 percent.
- Gross receipts per plant decreased by 8.7 percent in the same five year period.
- The number of paid employees increased by more than 43 percent in the period, so a larger number of employees are generating less income.

As a consequence of these general economic conditions in the coin-op sector, most purchasers of coin-op equipment will probably be trying to minimize their investment costs. From this standpoint, the fluorocarbon equipment would probably be chosen, because the model plant costs $19,900 less than the equivalent perc model plant. Even though the controls for the perc plant reduce annualized costs, it would require about twenty years to make up the initial difference in costs, if the equipment should last that long.

No matter which type of equipment is chosen for a new or modified plant, there would most likely be no change in pricing structure as a result of the recommended control alternative. The perc plant controls reduce annualized costs by only a moderate amount, while the fluorocarbon controls should have an even lesser effect.

7.6 REFERENCES FOR CHAPTER 7.0

1. U.S. Department of Commerce, Bureau of Census, 1967 and 1972 Census of Business, Selected Service Industries-Area Statistics.

2. Watt, Andrew, IV and William E. Fisher, "Results of Membership Survey of Drycleaning Operations," International Fabricare Institute (IFI) Special Reporter #3-1, January-February 1975.

3. "Quarterly Machinery Market Report for the Quarter Ended June 30, 1975, "Laundry and Cleaners Allied Trades Association, 22 August 1975.

4. Information provided by Mr. Steven Landon, President, Washex Machinery Corporation, 4 December 1975.

5. Information provided by Mr. J.W. Barber, Research Director, Vic Manufacturing Co., Minneapolis, Minn., 12 January 1976.

6. Information provided by Mr. G.H. Smith, General Sales Manager, American Laundry Machinery, Cincinnati, Ohio, 19 February 1976.

7. Information provided by Mr. A.C. Cullins, Laundry and Dry Cleaning Consultant, Standard Laundry Machinery Co., Inc., Mt. Ranier, Md., 25 February 1976.

8. Anonymous, "Plant Layout," National Institute of Drycleaning (now part of IFI), Management Bulletin M-106, April 1969.

9. Conversation with Mr. Ken Faig, International Fabricare Institute, Joliet, Ill., 20 February 1976.

10. Conversation with Mr. Steven Landon, President, Washex Machinery Corporation, Wichita Falls, Tex., 2 March 1976.

11. Marshall-Swift, "Evaluation & Cost Estimates." (This publication contains property costs for all parts of the U.S., and is updated monthly.)

12. Information provided by Mr. J.W. Barber, Research Director, Vic Manufacturing Co., Minneapolis, Minn., 12 December 1974.

13. Feldstein, Milton, "A critical review of regulations for the control of hydrocarbon emissions from stationary sources," J. Air Poll. Control Assoc. 24:469-78 (1974).

14. Maricopa County Bureau of Air Pollution Control, Rules and Regulations, Maricopa County Health Dept., Phoenix, Arizona, 1 October 1975.

15. "The Drycleaner Prepares for the Future", a statement by the Neighborhood Cleaners Association, New York, N.Y.

16. Conversation with Mr. Fred H. Smith, General Sales Manager, American Laundry Machinery Industries, Cincinnati, Ohio, 12 March 1976.

17. Letter from Mr. J.W. Barber, Research Director, Vic Manufacturing Co., Minneapolis, Minn., to Mr. C.F. Kleeberg, U.S. Environmental Protection Agency, 6 February 1976.

18. Kleeberg, C.F., "Plant Visit to a Large Industrial Dry Cleaner," memo to J.F. Durham, U.S. Environmental Protection Agency, 9 December 1975.

19. Fisher, W.E., "The ABC's of Solvent Mileage," Part One, IFI Special Reporter #3-4, July-August 1975.

20. Landon, Steven, President, Washex Machinery Corp., letter to C.F. Kleeberg, E.P.A., 27 January 1976.

21. Information provided by Mr. Harry Oliver, President, State Equipment Co., Inc., Arlington, Virginia, 16 March 1976.

22. Price List No. 1751T-6, dated 2/10/75, Vic Manufacturing Co., Minneapolis, Minnesota.

23. Customer Solvent Consumption Survey, Dow Chemical U.S.A., Midland, Michigan.

APPENDIX A

EVOLUTION OF PROPOSED STANDARDS

22 November 1974 - Contract Kick-off Meeting

Location: EPA offices, Mutual Building, Durham, N.C.

Attendees: For Dow Chemical U.S.A. - K.O. Graves and K.S. Surprenant; for EPA - Thomas Bibb/ESED, Frank Bünyard/SASD, Stanley Cuffe/ESED, Jim Homolya/CPL-SSMRS; William Johnson/ESED, ED McCarley/ESED, and David Patrick/ESED; and, for TRW - Tony Eggleston, Billy McCoy and, William Piske.

Agenda: General approach to be taken in developing new source performance standards for the vapor degreasing industry (Dow) and the dry cleaning industry (TRW).

Comments:

- William Johnson will be the EPA Project Officer.
- First priority will be location and description of candidate emission control systems. (Prototypes can be candidates.)
- A total organic compound approach will be used, not a reactive compound approach.
- Development of test methodology will be an EPA responsibility.
- Principal information sources expected to be trade associations, EPA, and journals.

12 December 1974 - Meeting with Dow Personnel

Location: Dow Chemical U.S.A. offices, Midland, Michigan.

Attendees: For Dow - primarily Jack Copus, Robert Lundy, Don Ritzema, K.O. Groves, Lyman Skory, and K.S. Surprenant; for EPA - William Johnson and David Patrick of ESED; and, for TRW - B.C. McCoy.

Agenda: General discussions of dry cleaning industry, including the processes, solvents, health effects, and test methods.

Comments:

- The meeting provided an extremely valuable introduction to the industry.
- Process descriptions for perchloroethylene dry cleaning were obtained.

- Proper operation and maintenance of dry cleaning equipment was considered the major factor in low solvent losses.

- Most common hardware for solvent emission control is carbon adsorption. The major manufacturer is Vic Manufacturing Co. of Minneapolis, Minn.

13 December 1974 - Meeting with Vic Manufacturing Co. Personnel

Location: Vic offices, Minneapolis, Minnesota.

Attendees: For Dow Chemical - K.O. Groves and K.A. Surprenant; for EPA - William Johnson and David Patrick; for TRW - B.C. McCoy; and, for Vic - J.W. Barber, Charles Gorman, Irving Victor and Oscar Victor.

Agenda: Morning-use of carbon adsorber for reducing solvent losses in vapor degreasing; afternoon-use of carbon adsorbers for reducing solvent losses in dry cleaning.

Comments:

- Meeting served as valuable introduction to carbon adsorber technology.

- In perchloroethylene plants, Vic estimated that solvent losses could be reduced by 50% with carbon adsorbers.

- No adsorbers are commercially available for petroleum plants, but Vic has operated a test unit.

- Refrigeration is being used as an emission control technique in fluorocarbon dry cleaning machines.

- Many useful process descriptions, flow sheets, and other data were provided by Vic.

- K.S. Surprenant (Dow) provided a meeting report to William Johnson (EPA) on 20 December 1974.

8 January 1975 - Meeting with DuPont

Location: DuPont offices, Wilmington, Delaware.

Attendees: For DuPont - (various times during the day) Frank Bower, Joseph Hoops, Don Kjelleren, and Ray McCarthy; for EPA - Jim McCarthy; and, for TRW - B.C. McCoy.

Agenda: Discussions of DuPont "Valclene" dry cleaning solvent and fluorocarbon dry cleaning process.

Comments:

- A good introduction to both the economics and processes of fluorocarbon dry cleaning was obtained.
- Jim McCarthy, the new EPA Project Officer, prepared a trip report dated 20 January 1976.

10 January 1975 - "Strategy Session" for OMB Briefing

Location: EPA offices, Mutual Building, Durham, N.C.

Attendees: For EPA - Frank Bunyard, Bill Johnson, Jim McCarthy, Dave Patrick, and John O'Connor; and for TRW - B.C. McCoy.

Agenda: Discussions of the scope of a presentation to be made by TRW for the Office of Management and Budget.

Comments:

- Presentation should emphasize: the processes; general industry description; approach to be used for cost analysis; and data sources.

17 January 1975 - OMB Briefing

Location: EPA offices, Waterside Mall, Washington, D.C.

Attendees: For Council of Wage & Price Stability - Roger Mallet; for EPA - Frank Bunyard, James McCarthy, David Patrick, and John O'Connor; for OMB - Vaughan Blankenship and Ben Massell; and, for TRW - Kevin Guinaw, B.C. McCoy, and W.E. Piske.

Agenda: To familiarize the OMB representatives with the dry cleaning industry and the approach to be used in developing NSPS.

Comments:

- A brochure, with somewhat simplified process descriptions and the general industry structure, was prepared beforehand by TRW and distributed at the meeting.
- Good rapport was established with OMB, and they seemed satisfied with the briefing.

23 January 1975 - Meeting with Neighborhood Cleaners Association (NCA)

Location: NCA offices, New York, New York.

Attendees: For NCA - Frank Pollatsek and William Seitz; and, for TRW - B.C. McCoy.

Agenda: Discussions of the general characteristics of the NCA and commercial dry cleaners.

Comment:

- The meeting provided a much clearer picture of the commercial dry cleaner.
- NCA provided some useful economic data for their organization.
- A report was prepared by TRW for the visit.

30 January 1975 - Meeting with International Fabricare Institute (IFI)

Location: IFI offices, Silver Spring, Md.

Attendees: For EPA - Frank Bunyard, Jim McCarthy, and Dave Patrick; for IFI - William Fisher and Andrew Watt; and, for TRW - Robert Manson and B.C. McCoy.

Agenda: Discussions of the IFI membership, dry cleaning processes, economic conditions, and environmental impacts of dry cleaning plants.

Comment:

- Good rapport was established with the largest of the dry cleaning trade associations. This proved useful later in the study.
- IFI agreed to assist EPA and TRW in locating well-controlled dry cleaning plants.
- Most of the information provided by IFI was found in three documents later obtained from IFI and other sources: (1) "Results of Membership Survey of Drycleaning Operations"; (2) "The ABC's of Solvent Mileage," Part 1; and (3) "Experimental Study on Solvent Discharge from Drycleaning Establishments to the Environment (Field Study of Selected California Drycleaning Plants)".
- The common means of expressing solvent usage is mileage, the pounds of clothes cleaned per 52 gal. drum of solvent. IFI believed 6,500 is about average, 10,000 is obtaining by good operation without a carbon adsorber, and 14,000-16,000 is obtainable with an adsorber in perc plants.

11 February 1975 - Bi-Monthly Briefing No.1

Location: EPA offices, Mutual Building, Durham, N.C.

Attendees: For Dow Chemical - Bob Lundy and Ken Surprenant; for EPA - Ken Baker, John Bollinger, Bill Grimley, Bill Johnson, Jim McCarthy, and David Patrick; and, for TRW - B.C. McCoy and W.E. Piske.

Agenda: Discussions of progress made on the dry cleaning study, potential problem areas, candidate test sites, future planning and possible standards.

Comment:

- Most discussion involved a possible problem in working through trade associations to obtain potential test sites. Associations seem to be cautious in this area, because of possible harm to their relationship with members.
- B.C. McCoy was requested to obtain a complete set of the IFI library for the dry cleaner, a compilation of IFI reports, for EPA.

14 February 1975 - Interim Report Delivery

An interim report on the study was submitted to EPA by TRW. It was essentially a very early draft of the final report. Possible standards were only briefly discussed.

19 February 1975 - Letter from IFI

Mr. William Fisher, Development Engineer, gave his formal agreement to assist in obtaining candidate test sites.

28 February 1975 - Telephone Call

Mr. Julius Hovaney of the National Automatic Laundry and Cleaning Council provided the names of three coin-op plants whose owners will allow source testing.

4 March 1975 - Letter from DuPont

Don Kjelleren, Sales Manager, "Valclene" Drycleaning Fluids, provided a list of eight dry cleaning plants with fluorocarbon machines. They were taken at random from DuPont files.

24 March 1975 - Telephone Conversation with Jim McCarthy, EPA

There will probably be no tests of fluorocarbon plants, and the NSPS will probably be based on a record keeping and housekeeping requirement.

4 April 1975 - Telephone Conversation with Bill Fisher, IFI

Bill transmitted the names of 11 candidate test sites. See Progress Report No. 4.

8 April 1975 - Bi-Monthly Briefing No.2

Location: EPA offices, Mutual Building, Durham, N.C.

Attendees: For Dow - Robert Lundy and K.S. Surprenant; for EPA - Frank Bunyard, Stanley Cuffe, Bill Johnson, Wayne Kelly, and David Patrick; and, for TRW - B.C. McCoy.

Agenda: Progress made, potential problems, and future plans, for the dry cleaning study.

Comments:

- Robert Lundy provided the results of a Dow customer survey of solvent mileages being obtained by perc plants.
- "Action items" were considered to be: (1) dry cleaning equipment cost data, including control equipment; (2) obtaining final approval for contacting plants from IFI; (3) making arrangements for visit to plant in Hershey, Pa.

17 April 1975 - Visit to Hershey Drycleaners' and Laundry

The subject plant was visited, and recommended for possible testing of both the fluorocarbon machines and the perc machines. See TRW trip report dated 30 April 1975.

30 April 1975 - Visit to State Cleaners, Suitland, Md.

The subject plant was visited, but did not appear to be appropriate for testing. See trip report dated 8 July 1975.

21 May 1975 - Telephone Conversation with Jim Mc Carthy, EPA

Dry cleaning NSPS study is being transferred within ESED to the Non-Criteria Pollutants Section. Charles Kleeberg is the new Project Officer.

28 May 1975 - Plant Visit to Country Squire Cleaners, Springfield, Va.

This plant appeared to be an excellent example of a well-operated plant without a carbon adsorber. It was recommended for a pre-survey and possible test. See trip report dated 8 July 1975.

6 June 1975 - Organizational Meeting

An informal meeting was held between the EPA Project Officer, Charles Kleeberg, the former Project Officer, James McCarthy, and the TRW Project Engineer, B.C. McCoy. The purpose was to facilitate the transfer of the dry cleaning study within ESED. See Charles Kleeberg's report dated 25 June 1975.

16 June 1975 - Bi-Monthly Briefing No. 3

Location: EPA offices, Mutual Bldg., Durham, N.C.

Attendees: For EPA - Frank Bunyard, John Bollinger, Charles Kleeberg, Jim McCarthy, and William Johnson; and, for TRW - B.C. McCoy.

Agenda: Progress made, potential problems, and future plans, for the dry cleaning study.

Comments:

- Possible standards were discussed. The mileage levels being considered were: 12,000-15,000 lb./drum for perc; 20,000-25,000 lb./drum for fluorocarbon; and 8,000-10,000 pounds/drum for petroleum solvents.
- Control measures would be a housekeeping regulation for all plants with the addition of a carbon adsorber for the perc and petroleum plants.

23 July 1975 - Visit to Sterling Laundry, Washington, D.C.

Attendees: For EPA - Francis Alpiser, Region III, Frank Bunyard, Jim Durham, and Charles Kleeberg, all of ESED, Durham; for Sterling - R. Jacobson, Jr., Cliff Hale, and Joe Smisek; and, for TRW - B.C. McCoy.

Purpose: To tour the subject plant and to assess its suitability for testing.

Comments:

- The plant had both perc and petroleum equipment and was useful for comparing the two processes.

- The plant was not recommended for testing. See TRW trip report dated 28 July 1975.

23 July 1975 - Dry Cleaning Project Meeting

Attendees: For EPA - Frank Bunyard, James Durham, and Charles Kleeberg; for TRW - B.C. McCoy.

Agenda: Implementation of dry cleaning emission test program, control options, and program development.

Comments:

- The major reason for the delay in locating candidate test sites was the decision made early in the program to work through trade associations instead of going directly to the plant operators.
- The principal data expected from a source test of a dry cleaning plant will be solvent mileage and possibly a qualitative idea of the major loss points.

25 July 1975 - Visit to Crystal Valet, Arlington, Va.

The owner, Mr. Robert Smith, of this plant has a chain of 3 stores in the area. However, the solvent mileage reported (7,000 lb./drum) was not good enough for recommendation as test sites.

31 July 1975 - Meeting with Detrex Sales Representative

Location: TRW offices, Vienna, Va.

Attendees: Joseph Panepinto, Detrex, and B.C. McCoy, TRW.

Agenda: Discussion of mileage performance of dry-to-dry machines, with a representative of one of the larger manufacturers of these units.

Comments:

- Typical solvent mileages of dry-to-dry units were stated by Mr. Panepinto to be: 8,000-12,000 lb. per drum with no adsorber; and 10,000-20,000 lb. per drum with an adsorber.
- Because of the higher operating temperatures of these units, maintenance is more critical than for transfer machines.

7 August 1975 - Meeting at International Fabricare Institute (IFI)

Attendees: For Amato Solvents, Bob McClain; for EPA, Charles Kleeberg; for IFI, William Fisher; and, for TRW, B.C. McCoy.

Agenda: Controlling solvent losses from perc machines. Testing dry cleaning plants.

Comments:

- 1-2 weeks of testing are needed for an accurate mileage estimate in a perc plant. Most inaccuracies involve clothes weighing.
- Most solvent losses are caused by: (1) poor adsorber operation; (2) poor extraction; or (3) faulty tumbler operation.
- Inspection check lists used by Amato in trouble-shooting dry cleaning plants were provided by Mr. McClain.

28 August 1975 - Visit to Paul's Custom Cleaners

On the basis of this visit, the plant was suggested as a good potential test site. See TRW trip report dated 29 August 1975.

28 August 1975 - Visit to Morningside Cleaners, Silver Spring, Md.

This plant was not recommended as a potential test site. See TRW trip report dated 29 August 1975.

10 September 1975 - Material Balances for Dry Cleaning Plants

On the basis of the 7 August 1975 meeting of EPA, IFI, Amato Solvents, and TRW personnel, a draft of a methodology for determining solvent mileage was prepared by EPA and sent to TRW and IFI for review. See memo, C.F. Kleeberg to J.F. Durham, dated 10 September 1975.

16 September 1975 - Presurvey of Hershey Drycleaners and Laundry Plant

Attendees: For EPA - Francis Alpiser, Region III, Terry Harrison and Charles Kleeberg, of ESED, Durham; for Hershey - Robert Gallagher, John Koch, and Todd Pagliarulo; and, for TRW - A.T. Barnard, John Haslbeck, and B.C. McCoy.

Purpose: To thoroughly assess the suitability of both the fluorocarbon and the perc machines at this site for test work.

Comment: It was decided to test both the fluorocarbon and perc machines.

30 September 1975 - Receipt of IFI Comments on Mileage Determination Methodology

Mr. William Fisher (IFI) made some recommendations to Mr. C.F. Kleeberg (EPA) regarding some small changes in the subject mileage test. See letter dated 30 September 1975.

1 October 1975 - Meeting with Detrex Distributor

Location: State Equipment Co., Arlington, Va.

Attendees: Harry Oliver, of State, and B.C. McCoy of TRW.

Agenda: Current status of dry-to-dry perc machines in the dry cleaning industry. Solvent emission control.

Comments:

- The trend towards transfer units in the past was caused by the desire to increase through-put.
- Carbon adsorbers should increase mileage by about 35-40%.
- Hot machines without adsorbers can attain 10,000-11,000 lb./drum when properly maintained.

10 October 1975 - Visit to Vic Manufacturing

See EPA trip report dated 15 October 1975 by Charles Kleeberg to J.F. Durham. The major topic of discussion was the use of fluorocarbon machine technology for reducing emissions in perc machines.

30 October 1975 - Meeting with DuPont Personnel to Discuss Material Balances for Fluorocarbon Machines

See meeting report by Charles Kleeberg, EPA, to James Durham, EPA.

3-20 November 1975 - Plant test at Hershey Drycleaners and Laundry

Both the fluorocarbon machines and the perc machine were tested during this period. Because of some problems, the former machines were re-tested later. See EPA test report dated 17 March 1975.

13 November 1975 - Visit to Rentex Corporation Petroleum Dry Cleaning Plant, York, Pa.

This plant seemed in excellent operating condition, but showed only average solvent usage, so it did not seem useful for testing. See TRW trip report dated 14 November 1975.

25 November 1975 - Meeting with DuPont in Wilmington, Delaware

This meeting was held primarily to discuss the shortcomings in the test procedures used for the fluorocarbon machines at Hershey on 3-20 November 1975. See EPA meeting report dated 2 December 1975, Charles F. Kleeberg to James F. Durham.

26 November 1975 - Meeting with International Fabricare (IFI)

Charles Kleeberg of EPA met with William Fisher of IFI to obtain solvent test procedures for the samples collected at Hershey on 3-20 November 1975.

3 December 1975 - Visit to Texas Industrial Services Industrial Dry Cleaning Plant, San Antonio, Texas.

Charles Kleeberg (EPA) visited this large perc unit and found it to be an excellent candidate for testing. See EPA trip report dated 9 December 1975.

4 December 1975 - Visit to Washex Machinery Corp., Wichita Falls, Texas

This visit was made by Charles Kleeberg (EPA) to the largest manufacturer of petroleum dry cleaning equipment to obtain information regarding: (1) industry growth rates; (2) control techniques and equipment; and (3) economics. Mr. Steven Landon, the President of Washex, was helpful as he has been on numerous other occasions during the study. See EPA trip report dated 12 December 1975.

5 December 1975 - Visit to Industrial Towel and Uniform, Houston, Texas

This industrial petroleum plant, visited by Charles Kleeberg (EPA) was found to be unsuitable for testing. See trip report dated 12 December 1975.

11 December 1975 - Bi-Monthly Briefing

Location: EPA offices, Mutual Building, Durham, N.C.

Attendees: For EPA - Frank Bunyard, James Durham, William Hamilton, and Chuck Kleeberg; and, for TRW - B.C. McCoy, and W.E. Piske.

Agenda: Principal topics were: (1) model plants for economic analysis; (2) control alternatives; and (3) dry cleaning machine sales.

Comments:

- The machines chosen for the economic analysis were: (1) 500-lb. petroleum unit and 250-lb. perc unit, for industrial plants; (2) 80-lb. transfer and dry-to-dry perc units for commercial plants; and (3) 25-lb. perc and fluorocarbon units for coin-ops.
- Control alternatives were to be housekeeping alone and housekeeping plus an adsorber for perc and petroleum and housekeeping only for fluorocarbon.

20 April 1976 The last part of the draft final report from TRW was submitted to EPA. (This was Appendix B.)

29 April 1976 Final comments on draft report received from EPA.

7 May 1976 Revised final report sent to EPA.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
1. Background and description of proposed action Summary of proposed standards	The proposed standards are summarized in Chapter 1, Section 1.1, pages through .
2. Statutory basis for proposed standards	The statutory basis for the proposed standards is summarized in Chapter 2, Section 2.1, pages through .
3. Relationship to other regulatory agency actions	The various relationships between the proposed standards and other regulatory agency actions are summarized in Chapter 2, Section 2.2, pages through .
4. Industry affected by the proposed standards	A discussion of the industry affected by the standards is presented in Chapter 3, Section 3.1, pages 3-1 through 3-2. Further details covering the "business/economic" nature of the industry are presented in Chapter 7, Section 7.1, pages 7-2 through 7-12.
5. Specific processes affected by the standards	The specific processes and facilities affected by the proposed standards are summarized in Chapter 1, Section 1.1, pages through . A discussion of the rationale for selecting these particular processes or facilities is presented in Chapter 8, Section 8.2, pages through . A detailed technical discussion of the sources and processes affected by the proposed standards is presented in Chapter 3, Section 3.2, pages 3-2 through 3-20.
6. Emission control technology	A discussion of the alternative emission control systems and their effectiveness is presented in Chapter 4, pages 4-1 through 4-13. The costs associated with these systems are presented in Chapter 7, Section 7.3, pages 7-16. through 7-23, for commercial dry cleaning plants; Section 7.4, pages 7-24 through 7-34, for industrial dry cleaning plants; and Section 7.5, pages 7-35 through 7-39, for coin-operated dry cleaning plants.

APPENDIX B

(Continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
7. Environmental and energy impacts of the proposed standards	A discussion of environmental and energy impacts of the standards is presented in Chapter 6, pages 6-1 through 6-5.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-76-029	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Study to Support New Source Performance Standards for the Dry Cleaning Industry		5. REPORT DATE May 1976
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Billy C. McCoy		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Engineering Division, Energy Systems Group of TRW, Inc., 800 Follin Lane, S.E., Vienna, Virginia 22180		10. PROGRAM ELEMENT NO.
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15. SUPPLEMENTARY NOTES

EPA Project Officer: Charles F. Kleeberg

16. ABSTRACT

The dry cleaning industry is described in terms of structure, processes, and emissions, air pollution control techniques used, and typical plant modifications. Hydrocarbon emissions occur from the evaporation of dry cleaning solvents, which include trichlorotrifluoroethane, perchloroethylene, and petroleum distillates. Certain control technique configurations are assumed, and the environmental and economic impacts of those controls are assessed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Control Equipment Hydrocarbons Dry Cleaning Solvents	Air Pollution Control Stationary Sources Hydrocarbon Emission Control	13 B
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