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FABRIC PRINTING INDUSTRY

BACKGROUND INFORMATION FOR PROPOSED STANDARDS

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

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1. SUMMARY

Section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary source of air pollution that "causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health and welfare." The fabric printing industry was listed as number 44 of the prioritized major stationary source categories.[1] Background information for the development of a new source performance standard (NSPS) limiting volatile organic compound (VOC) emissions from fabric printing was obtained by literature searches and extensive contacts with industry and trade association sources. A technical and economic analysis of regulatory alternatives for fabric printing and of their impacts was performed. On the basis of the adverse economic impact projected for the alternatives evaluated for this standard, the decision was made to postpone indefinitely development of the fabric printing NSPS.

1.1 Regulatory Alternatives

Four regulatory alternatives were considered. Table 1-1 summarizes the regulatory alternatives. The first was that no regulatory action would be taken. Since there are no RACT recommendations for the states to follow, it was assumed that this regulatory alternative represents uncontrolled emissions.

The second regulatory alternative would reduce emissions from affected facilities by 40 percent. It could be achieved through the use of print pastes containing a weighted average of 24 percent organic solvent (by weight) in printing applications presently utilizing high-organic solvent content print pastes. This alternative would probably affect only that portion of the industry that prints high fashion apparel fabric with high-organic solvent content print pastes (50 to 60 percent by weight).

The third regulatory alternative would reduce emissions from affected facilities by 60 percent. It could be achieved through the use of print pastes containing a weighted average of 12 percent organic solvent (by weight) in printing applications presently utilizing medium- or high-organic solvent

TABLE 1-1. SUMMARY OF FABRIC PRINTING REGULATORY ALTERNATIVES

Regulatory alternative	Model plants affected	Emission reduction (%)	Implementation method
I	None	0	No NSPS
II	Rotary screen Roller	40	Limiting print paste average organic solvent content to 24 percent
III	Rotary screen Roller Unit flat screen (terry towels)	60	Limiting print paste average organic solvent content to 12 percent
IV	Rotary screen Roller Unit flat screen (terry towels)	85	Requiring incineration to reduce drying process emissions by 95 percent

content print pastes. This alternative would affect terry towel printers that print terry towels with medium-organic solvent content print pastes (~ 23 percent by weight), as well as the printers of apparel fabrics for high fashion markets which require the use of high-organic solvent content print pastes to achieve product quality.

The fourth regulatory alternative would reduce emissions from affected facilities by 85 percent. It could be achieved through the use of an add-on control device with a removal efficiency of 95 percent to control drying process emissions from any affected facility utilizing print pastes containing organic solvents. Thermal incineration is technically feasible for all segments of the industry. Therefore, control costs for the fourth regulatory alternative are based on thermal incineration. This regulatory alternative would affect all printers that use organic solvent print pastes.

1.2 Environmental Impact

Under Regulatory Alternative I, there would be no environmental impact, either beneficial or adverse. Under Regulatory Alternative II, VOC emissions would be reduced by 4,500 megagrams (Mg) per year in 1986; under Regulatory Alternative III, they would be reduced by 6,800 Mg; and under Regulatory Alternative IV, they would be reduced by 8,900 Mg. No adverse impacts on water, solid waste or noise would be expected from any of the regulatory alternatives. A matrix summarizing the environmental, energy, and economic impacts is presented in Table 1-2.

1.3 Energy Impact

Under Regulatory Alternative I, no energy impact would occur. Under Regulatory Alternative II, annual energy consumption by the fabric printing industry would be reduced by almost 4 percent in 1986; and under Regulatory Alternative III, it would be reduced by almost 6 percent. Under Regulatory Alternative IV it would be increased by almost 23 percent, since auxiliary fuel would be required for thermal incineration of the dryer exhaust.

1.4 Economic Impact

The decision to terminate development of the NSPS was based on the results of the economic impact analysis which indicate that Regulatory Alternatives II, III, and IV would have an adverse impact on the U.S. fabric printing industry. The rapidly increasing cost of organic solvents has reduced the use of high-organic solvent content print pastes and led to the use of low-organic solvent content and aqueous print pastes as substitutes. The increased cost of organic solvents has also stimulated additional research

TABLE 1-2. ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC IMPACTS FOR FABRIC PRINTING REGULATORY ALTERNATIVES

Administrative action	Air impact	Water impact	Solid waste impact	Energy Impact	Noise Impact	Economic impact
Regulatory Alternative I	0	0	0	0	0	0
Regulatory Alternative II	+2[a]	0	0	+1[a]	0	-4
Regulatory Alternative III	+3[a]	0	0	+2[a]	0	-4
Regulatory Alternative IV	+4[a]	0	0	-4[a]	0	-4

[a]Long-term impact.

KEY:
- \+ Beneficial impact
- \- Adverse impact
- 0 No impact
- 1 Negligible impact
- 2 Small impact
- 3 Moderate impact
- 4 Large impact

and development on aqueous print pastes. However, the state-of-the-art has not advanced to the point that aqueous or low-organic solvent print pastes give identical properties to high solvent print pastes for printing high fashion apparel and possibly some other products. Thus, promulgation of an NSPS limiting print paste organic solvent content under Regulatory Alternatives II and III could affect product quality in some fabrics presently printed with medium- or high-organic solvent print pastes. Printing these fabrics with aqueous or low-organic solvent print pastes would cause the fabric to feel stiff and lose brightness of color according to industry spokesmen. With present technology, firms printing fashion apparel fabrics and firms printing terry towels could lose market shares to imports if required to reduce solvent content to the levels specified in Regulatory Alternatives II and III.

The installation of a thermal incinerator (Regulatory Alternative IV) would not be affordable by any commission printers. Due to the competitive structure of the industry, firms would not be able to pass the high costs of the thermal incinerator on to the consumer. Therefore, installation of a thermal incinerator would cause commission printers' profitability to decline below zero. Due to the anticipated severe economic effects of Regulatory Alternative IV, it is likely that firms, rather than incur the costs of a thermal incinerator, may simply choose not to replace obsolete or worn out equipment.

It is possible that carbon adsorption or catalytic incinerators may be cost effective as add-on devices for Alternative IV, but the economic impacts of using these techniques are not evaluated in this document. Possibly, economic evaluations for these control techniques will be done in the future after more study is done to determine their technical feasibility for the fabric printing industry.

1.5 References

1. U.S. Environmental Protection Agency. Priority List and Addition to the List of Categories of Stationary Sources. Federal Register. 44(163): 49222. August 21, 1979.

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2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control, based on different technologies and degrees of efficiency, are expressed as regulatory alternatives. Each of these alternatives is studied by the U.S. Environmental Protection Agency (EPA) as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and impacts on the environment. This document summarizes the information obtained through these studies so interested persons will be able to see the information considered by EPA in the development of the proposed standards.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 USC 7411) as amended, herein referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution that ". . . causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance.

- EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

  a. 25 percent of the listed categories by August 7, 1980,

  b. 75 percent of the listed categories by August 7, 1981, and

  c. 100 percent of the listed categories by August 7, 1982.

A governor of a State may apply to the Administrator to add a category not on the list or may apply to the Administrator to have a standard of performance revised.

- EPA is required to review the standards of performance every 4 years and, if appropriate, to revise them.
- EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.
- The term "standards of performance" is redefined, and a new term, "technological system of continuous emission reduction," is defined. The new definitions clarify that the control system must be continuous and may include a low- or nonpolluting process or operation.
- The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, considering the cost of achieving such emission reduction, any nonair-quality health and environmental impacts, and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to prevent situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by eliminating the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coalburning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend for New Source Performance Standards to contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term best available control technology (BACT), as defined in the Act, means:

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 or 112 of this Act. (Section 169[3])

Where feasible standards of performance are normally structured in terms of numerical emission limits. However, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in cases where it is not feasible to prescribe or enforce a standard of performance. For example, hydrocarbon emissions from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions--high concentrations for short periods during filling and low concentrations for longer periods during storage--and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, Section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. To grant the waiver, the Administrator must find:

- A substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic, energy, or environmental cost;
- The proposed system has not been adequately demonstrated;
- The technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety;
- The governor of the State where the source is located consents; and
- The waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to ensure that the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest consideration of the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants emitted by stationary sources. Source categories that emit these pollutants are evaluated and ranked by a process involving such factors as:

- Level of emission control (if any) already required by State regulations,
- Estimated levels of control that might be required from standards of performance for the source category,
- Projections of growth and replacement of existing facilities for the source category, and
- Estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category.

Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected on these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all major source categories not yet listed by EPA. These are:

- The quantity of air pollutant emissions that each such category will emit, or will be designed to emit;
- The extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and
- The mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible to develop a standard for a source category with a high priority immediately. This problem might arise when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the development of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must:

- Realistically reflect best demonstrated control practice;
- Adequately consider the cost, the nonair-quality health and environmental impacts, and the energy requirements of such control;
- Be applicable to existing sources that are modified or reconstructed as well as new installations; and
- Meet these conditions for all variations of operating conditions considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: information gathering, analysis of the information, and development of the standard of performance.

During the information-gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss with members of the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) the possibilities of a standard and the form it might take. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are considered as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standards are officially endorsed by the EPA Administrator. After they are approved by the Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed standards, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standards with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, DC.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a "promulgation package," which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of:

- Costs of compliance with the regulation, including the extent to which the cost of compliance varies, depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance;

- Potential inflationary or recessionary effects of the regulation;
- Effects the regulation might have on small business with respect to competition;
- Effects of the regulation on consumer costs; and
- Effects of the regulation on energy use.

Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and in terms of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is necessary because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact from the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decisionmaking process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 USC 793c[1])

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by section 102 (2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section in this document is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111 (d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every 4 years, review and, if appropriate, revise . . ." the standards. Revisions are made to ensure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive, but will apply to stationary sources constructed or modified after proposal of the revised standards.

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3. THE FABRIC PRINTING INDUSTRY PROCESSES AND POLLUTANT EMISSIONS

3.1 GENERAL

For the purpose of New Source Performance Standards (NSPS) development, the U.S. Environmental Protection Agency (EPA) has defined the fabric printing industry to include roller, flat screen, and rotary screen printing. Fabric printing is a subset of textile finishing, which includes fabric preparation (desizing, bleaching, and mercerizing), decorative enhancement (dyeing, printing, plisseing, and felting) and functional enhancement (permanent press, softening, and soil resistance). Transfer printing, carpet printing, and printing of vinyl-coated cloth are specifically excluded from this definition.

The specific intention of this NSPS is to control volatile organic compound (VOC) emissions occurring in the printing, drying, and curing operations of fabric printing. EPA has defined VOC as "any organic compound which participates in atmospheric photochemical reactions or is measured by the applicable reference methods under any subpart."[1]

Approximately 200 fabric printing facilities are found in the United States. Most of these facilities are located in the Atlantic Coast States, although most recent growth has occurred in the Southeast. Many fabric printing facilities perform other textile finishing operations in addition to fabric printing.

A typical fabric printing facility uses only one type of print machine and prints fabrics for only one or two types of markets. However, each type of machine can print a multitude of designs and colors and uses similar operations in the printing process (Figure 3-1). Woven or knit fabric (prepared at the facility or purchased) is fed into a print machine, and print paste is applied to the fabric in a design or in a series of designs. After printing, the fabric enters a drying oven to remove excess solvent, and then may proceed into a curing oven to fix the color in the fabric. In some cases the fabric is then washed and dried to remove excess water, thus completing the fabric printing process.

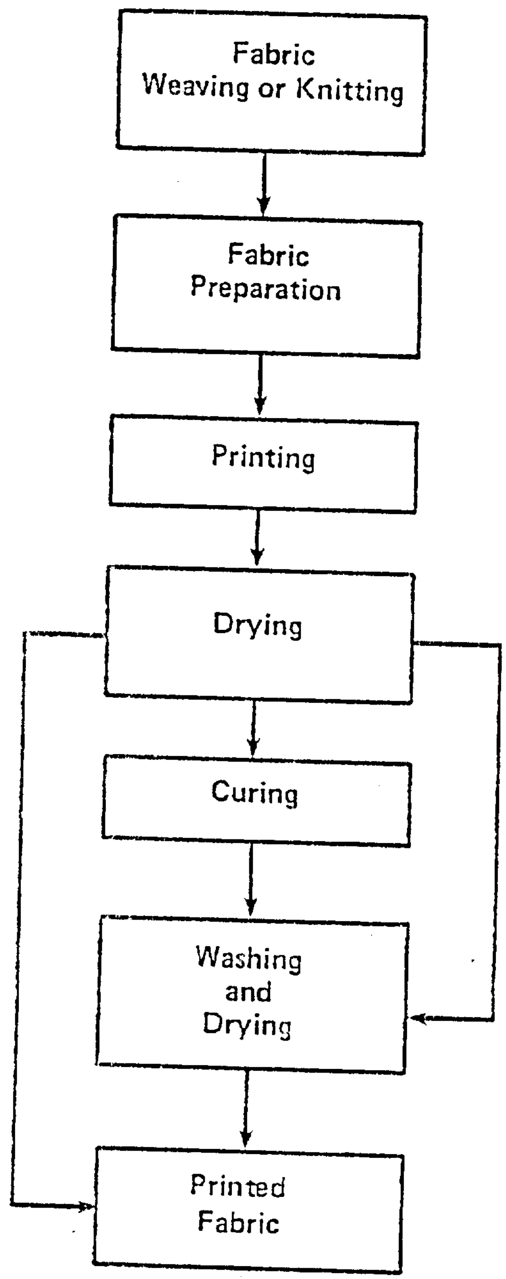

Figure 3-1. Block diagram of fabric printing operations.

3.2 PROCESSES OR FACILITIES AND THEIR EMISSIONS

3.2.1 Fabric

The two categories of fabric processed during fabric printing are woven and knit. Woven fabric can be further divided into broadwoven fabric (over 15 inches wide), narrow fabric, tire cord, and woven terry towels. The NSPS will be concerned with the printing of broadwoven and knit fabrics and terry towels. The yarns used to construct the fabric are spun from fibers that are either manmade or natural. Manmade fibers include cellulose acetate, cellulose triacetate, nylon, polyester, polyolefin, and rayon, while natural fibers include cotton, linen, silk, and wool. The composition of these fibers determines which dyes the fabric will accept and what texture the printed fabric will have. Texture is commonly referred to as "hand." Fabric entering the printing process is usually prepared by one or more of the following processes: singeing, scouring, desizing, bleaching, or mercerizing. Fabric may also enter the process with no processing since it left the loom (referred to as the "loom" or "greige" state).

Woven fabric is defined as "a fabric made by interlacing two or more systems of yarns at essentially right angles to each other."[2] This right-angle pattern distinguishes woven fabric from braid, lace, and plaited fabrics. In woven fabric the system of yarns running lengthwise is known as warp; the system running from selvage to selvage is known as filling or weft. The three basic types of weaves are plain, twill, and satin. In plain weave, the first warp yarn is woven over the first fill yarn and under the second, while the second warp yarn is woven under the first fill yarn and over the second. In twill weave, the first warp yarn is woven over two fill yarns, then under two, with successive warp yarns progressing one fill yarn on the weave, forming a 45-degree twill line. A satin weave has either many more warp or many more fill yarns showing, because two to eight consecutive yarns are woven in the same pattern, yielding a fabric with fewer interlacings than plain or twill.

Knitted material is made by using a single continuous thread of yarn to create individual loops and to chain each individual loop to neighboring loops.[3] In machine knitting a row of loops is formed and chained to a previously formed row of loops in one operation. Each loop is formed on an individual needle that is also used to draw the loop through the previous loop.

Screen printing machines are predominantly, but not exclusively, used for nonapparel or bottom weight apparel fabrics. Most fabric that is roller printed is woven, and wide rotary print machines (100- to 130-inch printing width) almost exclusively print woven fabric. Only 5 to 10 percent of knit fabrics are printed.

3.2.2 Print Pastes

A major consideration in the manufacturing or purchase of any textile product is color. Consumers are commonly more concerned with color than with fiber or fabric characteristics. One method of imparting color to fabric is printing. The importance of print paste selection, therefore, cannot be overemphasized.

Pigments and dyes are the common colorants in the color concentrate, which is used to apply a color to a fabric. Pigments are insoluble particles that are physically bound to fabric, usually by a polymerized binder. Typically, dyes are applied as a solution and impart color by becoming chemically or physically incorporated into individual fibers. Print pastes generally have three or four major components: a coloring agent, a clear thickening agent to give proper paste consistency, a solvent (aqueous or organic) to act as a carrier and, in pigment printing, a low crock or binder.

Pigments and dyes have been classified in several ways. Type of hue produced, chemical class, method of application, and type of fiber to which the color can be successfully applied are all categories into which pigments and dyes have been classified. Most authorities on textiles prefer to classify dyes and pigments by the type of fiber to which they can successfully be applied. Classes of dyestuffs, the types of fibers for which the dyestuffs are specific, and the chemical functional nature of typical dyestuffs are presented in Table 3-1.

Clear concentrates are used to extend the color of the color concentrate to allow light and dark shades to be obtained. Defoamers and resins are included in the clear concentrate to help increase the color fastness. Thickening agents are present to prevent thinning of the print paste with the addition of clear concentrate. A thickener should

TABLE 3-1. SUMMARY OF FIBER SUITABILITY AND CHEMICAL FUNCTIONAL NATURE OF FABRIC PRINTING DYE STUFFS

Type of dye stuff	Fiber	Chemical functional nature
Direct	Cellulosic, protein	No premordant treatment, applied as a solution
Azoic	Cellulosic, polypropylene, nylon acrylic, polyester	Formed in-situ by reaction of a diazo compound
Acid	Protein, acrylic, nylon, polyester	Anionic attraction, dye molecule negatively charged
Metallized	Protein, acrylic, nylon,	Applied as an organometallic dye complex
Cationic	Acrylic, nylon, polyester	Dye molecule is positively charged
Disperse	Acetate, polyester, acrylic, nylon	Aqueous dispersions
Pigment	No direct affinity, additional agent needed to fix color to fiber	Insoluble in water or mineral spirits
Vat	Cellulosic, synthetics	Redox reaction product of a sulfuric acid ester or leuco compound
Sulfur	Cellulosic	Applied in an alkaline solution, dye is insoluble in water
Reactive	Cotton, cellulosics, nylon, wool, silk, acrylics	Produce a covalent dye-fiber bond

not degrade during the drying or curing process, but it should be completely removable from the fabric during washing. Thickening agents are usually long-chain polysaccharide polymers and carbipols. Typical monomer groups include glucose, mannose, galactose, xylose, and arabinose. Thickeners are selected to affect the desired print sharpness, yarn and fabric penetration, color value, and brightness. Fiber, fabric construction, dye class, and fixation conditions all dictate the thickener selection.[4]

The remaining portion of the print paste is the solvent, which acts as the carrier for the coloring agent and the thickener.[4] The solvent may be aqueous, organic, or a mixture of the two. The organic solvent concentration in print pastes may vary from 0 to 70 percent by volume, with no consistent ratio of organic solvent to water. Organic solvents are multifunctional in aqueous-organic based print pastes: they maintain proper viscosity; aid in dye and binder dispersion; and adjust color value, sharpness of mark, and brightness of shade. Organic solvents used in the fabric printing industry are usually Varsols and vary widely in their physical properties. The average Varsol has a molecular weight of 155 g/mol, a boiling point of 145° C (293° F), and a vapor pressure of 0.011 atm (8.41 mm Hg). The most commonly used Varsols in textile printing have a boiling point range of 152° to 210° C (305° to 410° F).

3.2.3 Printing Equipment

Two types of mechanical printing are of interest in NSPS development in the fabric printing industry, roller and screen. These are discussed below.

3.2.3.1 Roller Printing. Roller printing is an intaglio process in which an engraved plate or roller is used to print from lines cut into the metal. A print paste is applied to the engraved roller, the excess paste is removed with a doctor blade, and the fabric is placed in contact with the roller. The pressure between the roller and the central cylinder acts to transfer the print paste from the incised surface of the roller to the fabric.

Figure 3-2 is a diagram of a typical roller printer. Fabric, padded by a rubber blanket, lapping or sometimes by a back gray which acts as a blotter to absorb color which penetrates the fabric, is contin-

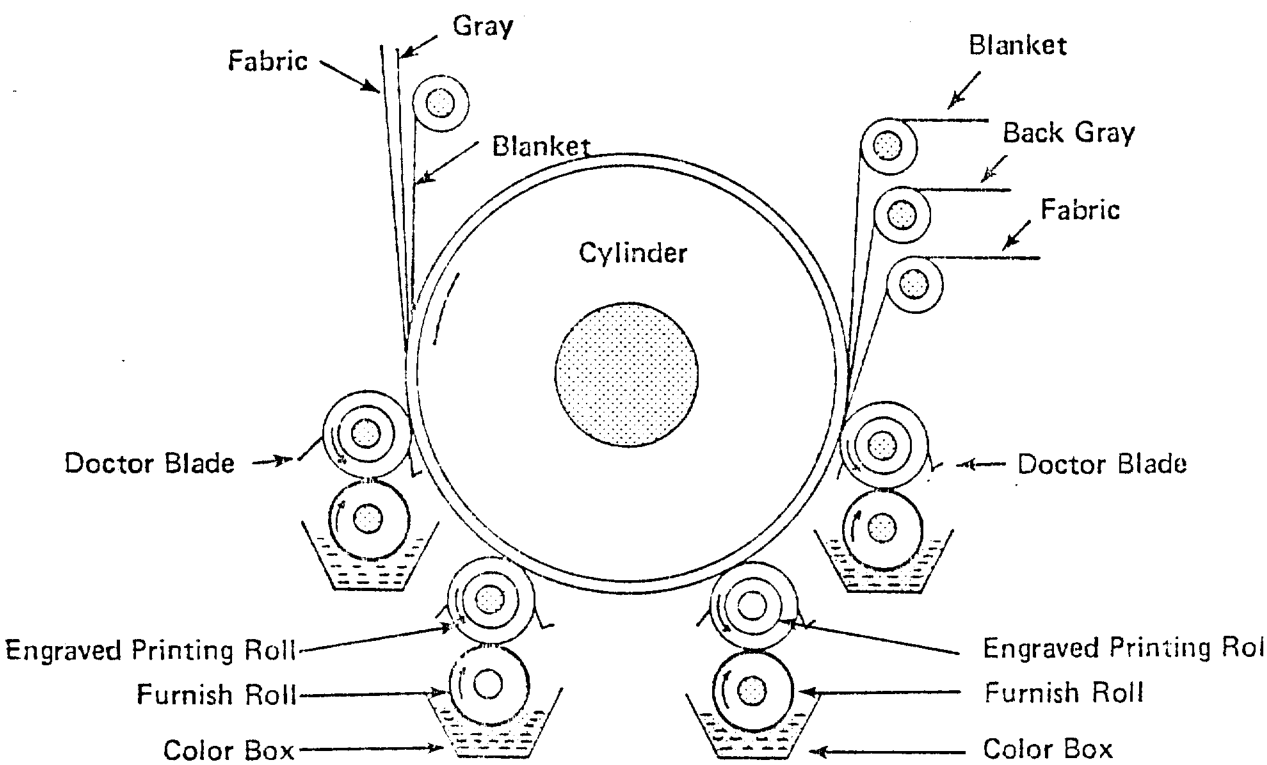

Figure 3-2. Diagrammatic view of a roller-printing system.

uously fed into the printer. The fabric passes between the central cylinder and a set of printing rollers. A single-color print paste is applied to each printing roller via separate furnish rollers that dip into separate color boxes. Each printing roller then applies a single color of the pattern onto the fabric. As many as 14 colors can be applied to a fabric on a single roller printing machine; however, a typical machine has the capacity to apply 8 colors. After printing, the fabric passes into the drying and/or curing processes.

Standard roller widths are 45 to 50 inches, although many machines are now being widened to 60 inches to accommodate wider broadwoven fabric. The cylinders commonly used for roller printing are copper-coated steel. A pattern can either be engraved or acid-etched on these copper surfaces. Sometimes, the engraved copper surface is plated with chrome to create a longer lasting surface.

Roller printing has several advantages over screen printing:

- More cost effective for long runs.
- Sharper mark and finer line.
- More accurate register or fit.
- Finer gradation of tone.
- Smoothness of blotch prints.
- Better color bloom.[5]

Many of these advantages are attributable to the use of medium-to-high organic solvent print pastes. These advantages make roller printing the most appealing method for printing designer and fashion apparel fabrics.

There are several sources of VOC emissions from roller printing. It is theorized that small amounts of fugitive VOCs evaporate from open print paste barrels and printing troughs. Additional VOCs probably evaporate from the printed fabric before it enters the drying oven. Print paste strikethroughs and overprints on the back gray or rubber blanket may account for some air emissions from evaporation and some water emissions when the backings are washed. The fabric drying operation is believed to be the greatest source of VOC emissions. In roller printing, drying typically uses steam cans that are open to the room atmosphere, but that room is exhausted directly to the outside.

Roller printing is highly dependent on the artistic talents of the printer. By watching the printed fabric as it comes off the roller, the printer can adjust the machine parameters accordingly to obtain the desired quality. Longitudinal and crosswise registration, roller pressure, and the angle of the doctor blades all affect the quality of the print. Changing the colors and patterns between print runs requires large amounts of time and accounts for the low operating efficiencies of roller printing, typically 30 to 50 percent.

3.2.3.2 Flat Screen Printing. Flat screen printing is a semicontinuous process. The fabric is placed on a belt, the belt and fabric are moved into position under the flat screen, and the belt is stopped. The flat screen, on which print paste has been applied, is mechanically lowered onto the fabric. A squeegee moves across the screen, forcing print paste through holes in the screen onto the fabric, thus forming part of a pattern. The screen is then raised, and the fabric and belt are indexed to the next position to receive another screen and another color of the pattern. A different screen is used for each color; patterns may consist of up to 17 colors.

A screen is prepared for printing by covering it with a light-sensitive chemical, attaching a film positive of the design pattern, and exposing the sandwich to light. An insoluble lacquer forms on the areas of the screen exposed to light. The remainder of the screen is then cleaned, leaving a porous screen surface in the desired pattern. Since a different screen is needed for each color of a particular pattern, several screens must be used in consecutive order to construct a complete pattern.

Flat screen printing can print a continuous piece of fabric if there is high precision in the indexing and registration of the process. For the purpose of NSPS development, the unit printing of terry cloth towels will be the only flat screen printing process considered.

Depending on the length of the print run, the operating efficiency of a flat screen print machine varies from 50 to 75 percent. Downtime for changeover of print runs is a major factor affecting the operating efficiency. Common production rates are 90 to 120 dozen towels per hour (while operating).

There are believed to be several sources of VOC emissions from flat screen printing. As in roller printing, small amounts of fugitive VOCs may evaporate from open print paste barrels, printing troughs, and from the printed fabric before it reaches the drying process. In towel printing there is little strike-through or overprint; therefore, emissions from these sources should be very small. As in roller printing, the fabric drying operation is believed to be the greatest source of VOC emissions.

3.2.3.3 Rotary Screen Printing. Figure 3-3 is a diagrammatic view of a rotary screen printer. Fabric moves into the printer from left to right. The screens rotate at the same velocity as the fabric moves, and the fabric is pressed between a screen and a backing material as the process progresses. Print paste is pumped from drums into a dispenser, which distributes the flow over the entire width of the application area. A stationary doctor blade forces the print paste through the screen and onto the fabric. Rotary screens are commonly made of nickel or nickel alloys.

To construct rotary screens, the same photogrammatic principle as flat screen printing is used, except that the screen is rolled into a tube similar to roller printing. The use of tubes, usually several consecutively, allows the printing process to be continuous. Screens are usually purchased or made and then treated at the printers to make the design.

Rotary screen machines are usually grouped as wide or narrow. Most wide machines have printing widths in the range of 100 to 130 inches; narrow machines are typically between 60 and 80 inches wide. Wide machines commonly print sheeting, upholstery, domestic fabrics, industrial fabrics, and some wide apparel fabrics. Most apparel fabrics are printed on narrow machines. Some machines can print 16 color patterns, but 12 colors is the maximum for most machines.

The production rates in rotary screen printing range from 10 to 100 yards per minute and are a function of the type of paste used, the type of fabric printed, and the intricacy of the pattern. Wet colors are normally run at 10 to 20 yards per minute, but pigments can be run at 100 yards per minute. As in flat screen printing, changeover of print

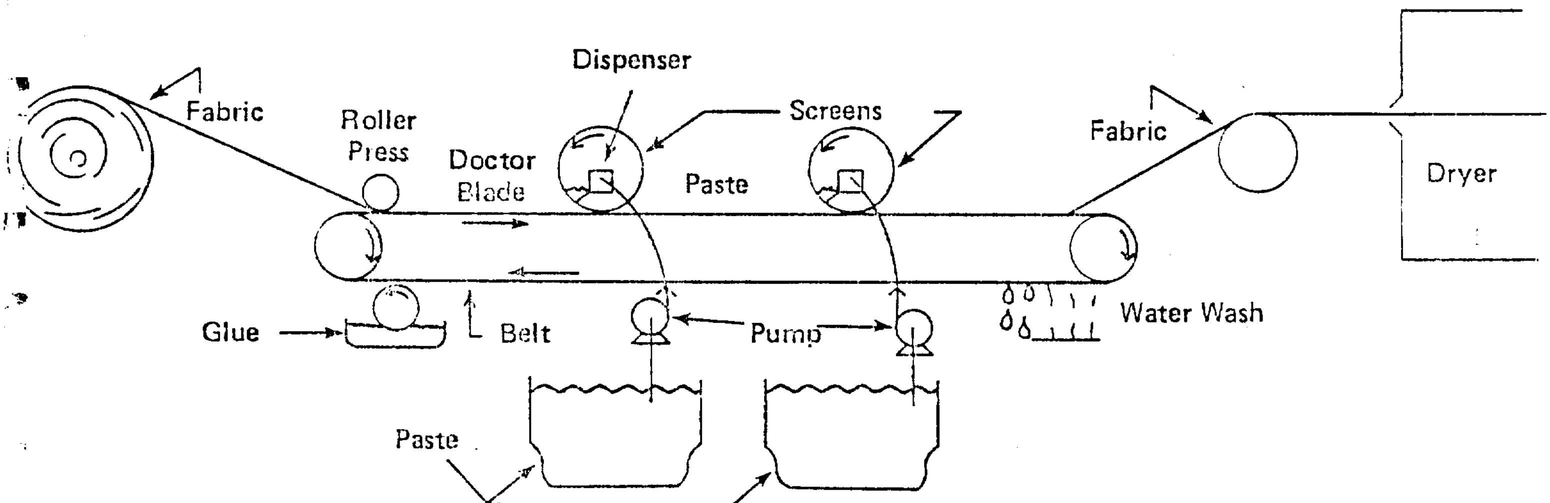

Figure 3-3. Rotary screen print machine.

runs is the major cause of downtime, accounting for efficiencies of 50 to 75 percent.

As in the other printing methods discussed, evaporation from open print paste barrels and from the fabric before it reaches the drying oven are believed to be sources of fugitive VOC emissions. Emissions from strikethrough and overprints may be somewhat greater than in flat screen printing.

3.2.3.4 Dryers and Curers. After the printing process, fabrics are dried and usually cured. Drying drives off volatile compounds (mostly water and organic solvents) so that the colors can be fixed on the fabric. Color-fixing occurs during curing, which may be an entirely separate process or merely a separate segment of the drying process. Resin-bonded pigment pastes require curing, while dye pastes are color-fixed after drying. Some color-fixed dyes require aging in a high-heat, high-humidity environment. After the fabric passes through the dryer (and possibly the curer), it is washed to remove unfixed dyes or pigments and dried again. Drying and heat setting after washing may be accomplished on a tenter frame.

Sheeting is usually dried and cured in different zones of the same oven. Decorative and apparel fabrics are usually dried and cured in separate ovens. For apparel fabrics one curer often serves several print lines.

Drying is accomplished by convection or conduction. Convection dryers are heated by pressurized steam coils or by natural gas combustion. Screen printed fabrics are usually dried in convection dryers, because knit fabrics can be dried without tension and terry towels can be conveyed through the dryer on racks. Fabrics requiring a soft hand, such as apparels, are usually dried by conduction on steam cans. Conduction drying is by direct contact of the fabric with the steam cans. Roller-printed fabrics are usually dried on steam cans because they are less expensive to install and operate, and they dry fabric quicker than convection dryers.

Convection dryer temperatures range from 149° to 176° C (300° to 350° F). The surface temperature of steam cans ranges from 90° to 135° C (200° to 280° F). Fabric residence time is 2 to 4 minutes in convection dryers and 1 to 2 minutes on steam cans. Exhaust air rates range from 2,831 to 9,438 L/s (6,000 to 20,000 ft^3/min), depending on residence time, temperature, fabric weight, and organic solvent content. Exceptions to these parameters occur for printed terry towels that are dried at lower temperatures and for longer residence times.

Curers are also heated by pressurized steam cans or natural gas burners. Steam-can curers usually operate at atmospheric pressure under saturated steam conditions and temperatures of 163° to 190° C (325° to 375° F). Natural gas fired curers operate at 1,416 to 3,304 L/s (3,000 to 7,000 ft^3/min). Fabric residence times for curers are 18 seconds to 5 minutes depending on method, fabric, etc.

3.3 BASELINE EMISSIONS

No specific regulations currently exist to control VOC emissions in the fabric printing industry. There are no Control Techniques Guidelines (CTG) to help States prepare their State Implementation Plans (SIP), and therefore no reasonably available control technology (RACT) regulations exist which States must meet. SIP regulations on organic solvent oven emissions exist, but none are applied to the fabric printing industry, probably because of previous exemptions for waterborne coatings and nonphotochemically reactive solvents.

Lack of government agency data led to the use of an American Textile Manufacturers Institute (ATMI) survey[6] on organic solvent use in the fabric printing industry and information from two printers[7 8] to determine baseline emissions. From the data provided, averages were determined for each of the printing categories. Roller printers were estimated to use print pastes containing an average of 26 percent organic solvent and had emissions of 0.142 kg VOC per kg of fabric printed. Rotary screen printers were estimated to use print pastes containing an average of 3 percent organic solvent and had emissions of 0.023 kg per kg of fabric printed. Data averaging can be misleading since few, if any, textile printers use these average rates. This is discussed further in Chapter 6. According to data provided by two towel printers, flat screen printers used print pastes containing 23 percent organic solvent and had emissions of 0.181 kg VOC per dozen terry towels printed.

State air pollution control agencies are currently revising their SIPs, but as of June 1980 not all of the State plans had been approved. None of these SIPs contain regulations for fabric printers. The Control Techniques Guideline (CTG) for fabric printing is being developed concurrently to the NSPS. Lack of data from SIPs or a CTG precludes the establishment of a more reasonable baseline than that described above.

3.4 REFERENCES

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DRAFT

4. EMISSION CONTROL TECHNIQUES

Historically, attention to pollution abatement in the textile industry has focused on wastewater treatment, and only in recent years on air pollution control. These efforts have been in response to state opacity and odor standards that reduce emissions of particulates and "blue haze" (mist containing oils and other organic materials used in the making and finishing of fabrics). At this point, however, VOC emissions in the fabric printing segment of the textile industry are not controlled.

Methods available for VOC emission control in fabric printing fall into two general categories, namely, process modifications and add-on systems. Process modifications include heat transfer printing and printing with radiation-curable print pastes, foams, and other low-solvent or solvent-free print pastes. Add-on systems include incineration, adsorption, condensation, and absorption. Of the four add-on systems, incineration can provide a substantial amount of process heat, while the other three systems incorporate means for solvent recovery. One drawback to the use of add-on controls is the fact that VOC levels in printing exhaust streams can vary widely. Large amounts of water vapor are also present.

Each of these VOC control methods has its advantages and disadvantages, and each differs in applicability, efficiency, and cost. Detailed discussions of these methods follow.

4.1 PROCESS MODIFICATIONS

The fabric printing industry has made considerable progress in reducing or eliminating the consumption of mineral spirits solvents and, therefore, the emission of VOCs into the atmosphere. This is due, in part, to the rise in the cost of petroleum products as well as to compliance with wastewater regulations.

One proven solvent-free process employed in the fabric printing industry is heat transfer printing,[1,2] in which a pattern is printed in mirror-image form on a strip of paper and transferred to fabric under heat and pressure in a special print machine. A familiar example of heat transfer printing is the use of iron-on decals for T-shirts. However, since disperse dyes are used in heat transfer printing, its applicability is limited to manmade fibers, particularly polyester, and to light shades and pastel colors.

Radiation-curable print pastes[3] contain pigments and a special resin binder that are cured at room temperature with ultraviolet or electron-beam radiation. These print pastes require about one-tenth the heat needed to dry and cure conventional print pastes. The equipment and the binder needed for the use of radiation-curable print pastes in fabric printing are presently prohibitively expensive. However, this process modification may become economically attractive as the costs of organic solvents and energy increase.

In the past, printers have preferred print pastes consisting largely of a water-and-oil emulsion thickener, which can contain over 50 percent organic solvent. These pastes have given superior performance in terms of fine mark, color value, and soft hand, and they require no afterwash. However, according to one report,[4] good results are now attainable with all-aqueous print pastes used in conventional printing machines. These all-aqueous print media are now practical because of the advent of water-soluble synthetic materials that serve as thickeners.

Some print paste developers and manufacturers[5,6,7,8,9] have indicated that aqueous print pastes with a foam thickener will be available for general use within the next two years. An advantage of these new pastes will be greatly reduced water content and subsequent reduction in drying costs. One print paste manufacturer claims that results from foam pastes are not reproducible. Others indicate that present problems are merely mechanical and should be resolved in the near future. These manufacturers maintain that foam printing is the wave of the future.

4.2 INCINERATION

Incineration has been used successfully in many industries to control a wide variety of organic vapor emissions, and at least one fabric printer has installed an incinerator. A typical small thermal incinerator (or direct-fired afterburner), accommodating a gas flow of 1.88 m^3/sec (4,000 scfm), is a refractory-lined steel cylinder 1 m (3.2 ft) in diameter and 4.6 m (15 ft) long.[10]

A burner at the inlet end maintains a temperature of 650° to 815° C (1200° to 1500° F).[11] Contaminated air enters through the burner flame zone and is retained in the combustion zone for about 0.5 seconds. This residence time is dictated by the oxidation kinetics of organic vapors, the longest step of which is the conversion of CO to CO_2.[12]

Control efficiencies and analyses of emissions from small and large thermal incinerators are given in Tables 4-1a and 4-1b.[13] The main disadvantage of incineration is the large amount of fuel required to maintain the high temperatures necessary for essentially complete oxidation of VOCs. To satisfy safety and insurance requirements, VOC concentration in dryer exhaust streams should be maintained at or below 25 percent of the lower explosive limit (LEL). The VOC concentration in the exhaust stream may also fluctuate widely in the course of normal daily plant operations. The average caloric value of this highly-diluted stream is therefore quite low, hence the large fuel requirement. Although oil may be used in some applications or in an emergency, natural gas is the preferred fuel due to its clean burning characteristics. Several means have been devised to reduce incinerator fuel consumption and to conserve energy, among which are venting to steam boilers and heat recovery.

Boilers and other direct-fired heaters can be used as incinerators under the proper conditions. However, the potential for problems is very great, since such fireboxes are not generally designed to burn VOCs in addition to their primary fuel. The advantages and disadvantages of this control method are presented in Table 4-2.[14]

In a catalytic incinerator, VOCs are oxidized on the surface of a catalyst at temperatures of 370° to 480° C (700° to 900° F).[11] The catalyst is ordinarily platinum or palladium deposited on heat-resisting metal alloy ribbons or on a ceramic support structure in such a manner that a large surface area is presented to the airstream. Since high temperatures are not required, fuel consumption is lower than that of

TABLE 4-1a. TYPICAL ANALYSIS OF EMISSIONS ENTERING AND LEAVING SMALL DIRECT-FIRED AFTERBURNER

	Temperature			
	704° C (1300° F)		760° C (1400° F)	
	In	Out	In	Out
CO_2, ppm	1,950	19,000	2,000	23,500
CO, ppm	8	110	9	24
Organics as CO_2, ppm	521	122[a]	480	33[a]
Volume (dry basis), m^3/sec (scfm)	1.06 (2,240)	1.04 (2,200)	1.06 (2,240)	1.04 (2,200)
Organics (as carbon), kg/h (lb/h)	1.00 (2.21)	0.23 (0.50)	0.79 (1.74)	0.06 (0.14)
Afterburner efficiency, %	77		92	

[a]Includes increase of CO across afterburner.

TABLE 4-1b. TYPICAL ANALYSIS OF EMISSIONS ENTERING AND LEAVING LARGE DIRECT-FIRED AFTERBURNER

	Temperature			
	760° C (1400° F)		815° C (1500° F)	
	In	Out	In	Out
CO_2, ppm	6,300	22,000	6,600	27,000
CO, ppm	59	230	65	21
Organics as CO_2, ppm	1,568	235[a]	1,591	70[a]
Volume (dry basis), m^3/sec (scfm)	5.64 (11,950)	5.57 (11,800)	5.66 (12,000)	5.57 (11,800)
Organics (as carbon), kg/h (lb/h)	16.1 (35.6)	2.39 (5.26)	16.4 (36.2)	0.73 (1.6)
Afterburner efficiency, %	85		96	

[a]Includes increase of CO across afterburner.

TABLE 4-2. ADVANTAGES AND DISADVANTAGES OF USING A BOILER AS AN AFTERBURNER RATHER THAN A CONVENTIONAL DIRECT-FIRED AFTERBURNER

Advantages	Disadvantages
• Large capital expenditure is not required.	• If air volumes are relatively large, boiler fuel cost may be excessive.
• Boiler serves a dual purpose as a source of process steam and as an air pollution control device.	• High maintenance cost may be required because of burner and boiler tube fouling.
• Auxiliary fuel is not required for operation of air pollution control device.	• Boiler must be fired at an adequate rate at all times when effluent is vented to the firebox, regardless of steam requirements.
• Operating and maintenance costs are limited to one piece of equipment.	• Normally, two or more boilers must be used, one as standby during shutdowns.
• Fuel saving, if effluent, has some caloric value (rare instances).	• Pressure drop through boiler may be excessive if large volume of effluent introduced into boiler causes back pressure on exhaust system.

thermal incineration. However, low fuel costs must be balanced against the high cost of the catalyst bed and the additional maintenance necessary to keep it functioning properly. Because catalyst surfaces can become "masked", or covered by resins or oxides, they must be inspected and cleaned periodically. Abnormally high temperatures can cause loss of the catalyst by evaporation. In addition, certain materials such as mercury, arsenic, zinc, and lead can "poison" the catalyst, rendering it useless. Even under ideal conditions, the efficiency of the catalyst deteriorates over time, necessitating replacement of the bed every few months to two years, depending on the application of the unit.[14] Efforts have been made to reduce the cost of maintaining and replacing catalysts. One example is the development of an incineration system using a low-cost catalyst material in a fluidized bed.[15]

Probably the most effective means of reducing the fuel costs associated with incineration is by recovery of useful heat from the incinerator unit. Some applications of this heat include:

- Preheating the dryer inlet air.
- Preheating the dryer exhaust before it enters the incinerator.
- Building heating and producing steam.

In most industries, heat is recovered through recuperative shell-and-tube, air-to-air heat exchangers and by regenerative heat wheels. However, shell-and-tube heat exchangers are inefficient except in multi-pass configurations and they are prone to leaks. Heat wheels can crack, necessitating replacement.

In recent years an improved regenerative thermal incineration system[16] has been developed. Its properties include 85-90 percent heat recovery, corresponding fuel savings, an operating temperature of 980° C (1800° F) or higher, low pressure drop, retention time of up to two seconds, long life, and low maintenance. It is available in different sizes and configurations to accommodate a wide range of effluent flow rates. Because of its flexibility and efficiency, this or a similar regenerative thermal incinerator is worthy of consideration as an add-on control system for fabric printing. However, due to the highly variable nature of fabric printing exhaust streams, as well as the presence of water vapor, the performance of even the most efficient incineration system may prove unsatisfactory.

4.3 ADSORPTION

Adsorption theory states that molecules of a vapor are attracted to and held on a solid (adsorbent) surface by Van der Waals forces. Of the available adsorbents, activated carbon is the most widely used for VOC emission control and solvent recovery, since it is an inexpensive, porous material with a very large surface area per unit volume. Carbon adsorber systems have been used in chemical industries and printing facilities, among others, for recovering solvents and other valuable organic materials from gas streams. Cycling fixed-bed units and continuous fluidized-bed systems are available.

As shown in Figure 4-1,[17] a typical installation consists of two (or more) fixed-bed adsorbers. While one unit adsorbs VOCs from a process exhaust stream, the other unit is being stripped by low-pressure steam, which heats the bed to release the VOCs and also acts as a nonflammable carrier gas. The VOC-laden steam is then condensed and the two liquid phases separated in a decanter.[18] If the VOC is a useful solvent, it can be reused immediately.

Two common forms of fixed-bed units are a vertical drum with circular perforated trays containing activated carbon granules and a horizontal torpedo shape holding a conical bed.[19] Peripheral equipment required includes ductwork and piping for handling the air, steam, and liquids; a filter for removing particulates that could coat the bed; facilities for handling recovered solvent and wastewater; a supply of low-pressure steam; condensers; decanters; and an automatic sequencing controller and valves.

Other adsorption configurations are in use besides the two-unit cycling system described above. For small operations where odor control is the main consideration, throw-away units are available.[20] With these units, no attempt is made to recover the VOCs; when saturated, the bed is simply discarded as a solid waste. At the other end of the spectrum are continuously operating systems. One example, shown in Figure 4-2,[17] employs a rotating cylindrical fixed bed. Adsorption occurs at the top and desorption at the bottom, half a revolution later. A more sophisticated application for very large users employs a fluidized bed for maximum efficiency.[21] Activated carbon granules circulate from the

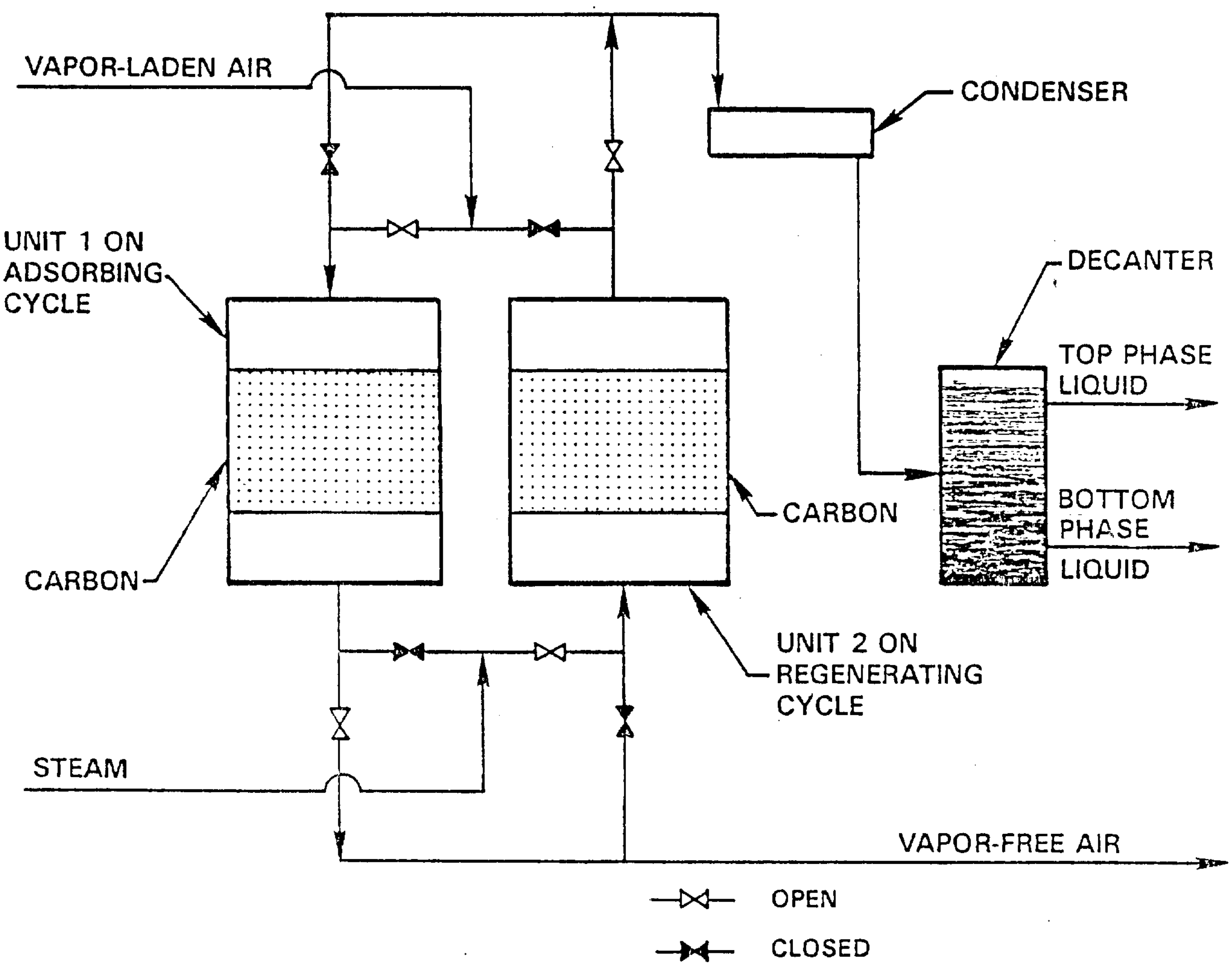

Figure 4-1. Diagrammatic sketch of a two-unit, fixed-bed adsorber.

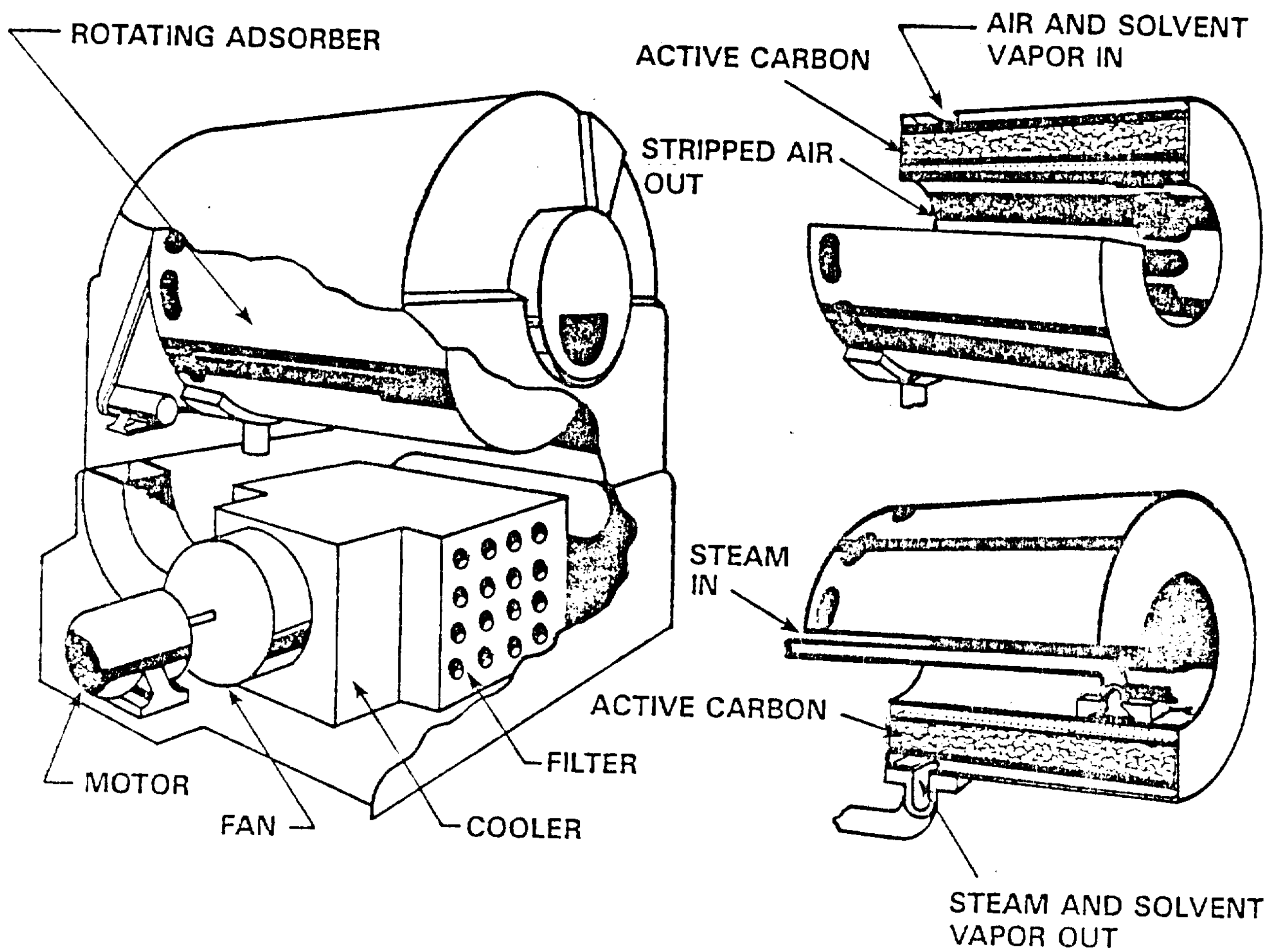

Figure 4-2. Left: Diagrammatic sketch of a rotating fixed-bed continuous adsorber showing the path of the vapor-laden air to the carbon bed. Right: Cut of continuous adsorber showing path of steam during regeneration (Sutcliffe, Speakman Canada, Ltd., Hamilton, Ontario).

bottom of an adsorption tower to a separate stripping vessel and then back to the top of the tower.

Solvent recovery by adsorption works best with single-compound solvents like xylene or perchloroethylene. Adsorption of mixtures like the mineral spirits (Varsols) used in fabric printing is more complicated. At the start of a cycle with a fresh bed, all the components of the organic vapor mixture are equally adsorbed. As the concentration of the higher boiling constituents adsorbed increases, the more volatile components are spontaneously desorbed and escape into the atmosphere.[22] Although this problem can be partially alleviated by stopping the cycle at the first breakpoint, the loss of even a small amount of volatiles could significantly change the composition of the solvent over several recovery cycles.

Other problems that may be encountered using adsorption include:

- Danger of fire or explosion. Since an adsorber concentrates organic vapors, it is important to keep flames and sparks away, to prevent a rise in temperature during adsorption, and to exclude air during the desorption phase.

- Clogging. Like the catalyst bed in a catalytic incinerator, the surfaces of activated carbon particles can become coated by lint, dust, and resins present in the contaminated airstream, resulting in impaired ability to adsorb vapors and increased pressure drop. Where clogging is a potential problém, filters are commonly used upstream to protect carbon beds.

- Water vapor. Extra energy is required to process a moist exhaust stream, cycling times are shortened, and when solvent levels drop, the decanter may become overloaded with water.

4.4 CONDENSATION

In a condensation system for solvent recovery, vapors in the contaminated airstream are liquefied by cooling. The droplets are then collected as the airstream passes through a fiber bed demister. Two types of condensers--surface and contact--are in use.[23] Surface condensers, in which the coolant never comes in contact with the airstream, usually take the form of the familiar shell-and-tube arrangement. In a contact condenser, the coolant is sprayed directly into a vessel through which the airstream passes. Such units can also function as scrubbers or absorbers. Water is the most commonly used coolant in both types of condensers.

Condensation has been used to recover solvents and to control blue haze in textile finishing operations. In a dyeing plant[24], dryer exhaust flows through a filter (to remove lint), across cooling coils, through a demister, and out the stack. In a finishing plant[25], vapors of 1,1,1-trichloroethane are recovered in two stages, the first using water-cooled coils and the second, a 5-horsepower refrigeration unit. In another two-stage operation used in Germany,[26] vapors are recovered from a tenter frame exhaust stream. The first stage uses a regenerative heat wheel and the second, a water-cooled recuperative heat exchanger.

Conventional condensation methods may not be cost-effective for use in fabric printing due to the large amounts of energy required to condense the mixture of mineral spirits and water vapors. A new energy saving method has been described,[27] however, in which liquid nitrogen is used as a contact coolant, and over 99 percent solvent recovery is reported. Gaseous nitrogen evolved in the process is injected into the oven to maintain an inert atmosphere, reducing the danger of fire. In a trial of the process on a fabric coating line, considerable net savings were reported in heating costs and credits for recovered solvents, taking into consideration the cost of the liquid nitrogen used.

4.5 ABSORPTION

Absorption is a major chemical engineering process whereby one or more constituents of a vapor are removed from a gas stream by direct contact with a liquid absorbent in a suitable vessel, often called a scrubber.[28] In the steel industry, absorption is used in coke oven byproduct plants to remove light oil from coke oven gas. It is also used in petroleum production to recover natural gasoline from wellhead gas streams, and to recover methyl ethyl ketone in the manufacture of fiberglass bathtubs.[29] In these applications, the absorbing liquid is a light nonvolatile oil, which might also be used in the event absorption technology were transferred to fabric printing.

In an absorber, the air or gas stream to be scrubbed flows upward through a tower containing perforated trays or ceramic packing as the absorbent trickles down from the top in countercurrent flow. This provides a large surface area for contact between the vapor and the absorbing liquid. At the bottom of the tower, the liquid flows to a

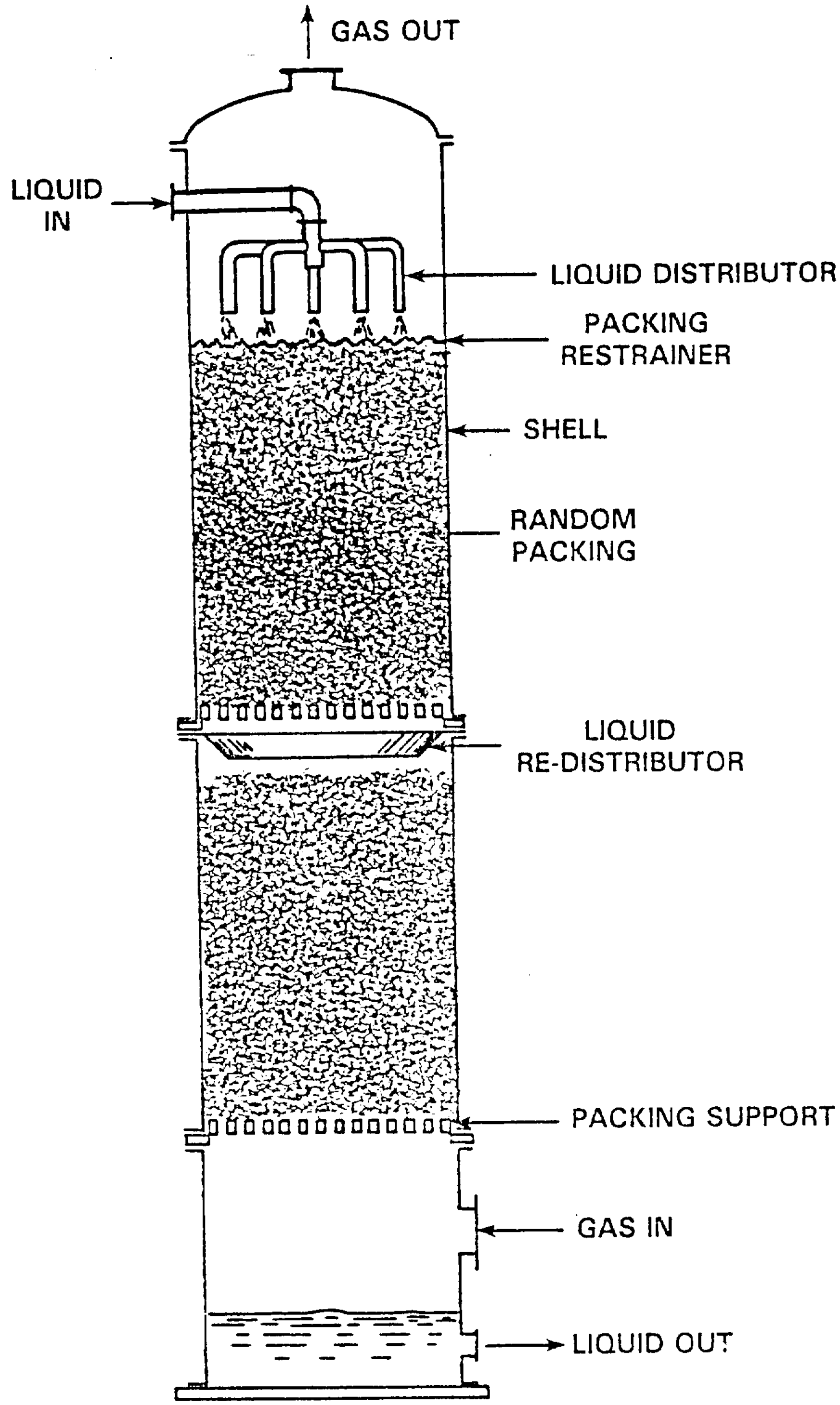

Figure 4-3. Schematic diagram of a packed tower (Treybal, 1955, p. 134).

stripper and a condenser for recovery of the solvent. A packed tower is illustrated in Figure 4-3.[30 31]

In 1973 a Brazilian patent was awarded for an interesting variation of this process. "Kerosene evaporated with water from freshly printed textiles is recovered by passing the exhausted atmosphere into a packed tower to break the emulsion formed in the droplets. The recovery level is about 96 percent and the kerosene is recycled to the printing process."[32] This method is, therefore, less sensitive to water vapor.

4.6 CONCLUSIONS

A number of available methods for VOC emission control in fabric printing has been discussed in this chapter. Of these, process modifications show particular promise due to efforts within the industry to develop aqueous print pastes in several forms.

Technology transfer must be employed for the application of add-on systems. With the exception of the use of incineration at one U.S. printing plant and a Brazilian effort (of unknown scale) to recover solvents with a packed tower, such add-on methods have not been used in fabric printing. Considerable experience has been gained in the use of add-ons by other industries; however, the exhaust streams studied have a relatively constant VOC level and a low water vapor content, unlike fabric printing exhaust.

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5. MODIFICATION AND RECONSTRUCTION

5.1 BACKGROUND

New Source Performance Standards (NSPS) apply primarily to newly constructed facilities, although existing facilities that undergo modification or reconstruction are also subject to these standards. An existing facility is defined as one that commences construction or modification after the proposal date of the performance standard. The decision on whether a change in an existing facility constitutes reconstruction is made on a case-by-case basis by the appropriate enforcement authority. This chapter describes typical changes to fabric printing facilities that could be termed modifications or reconstructions.

5.2 MODIFICATIONS

Section 60.14 of the Code of Federal Regulations states that:

a) ... any physical or operational change to an existing facility which results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification within the meaning of Section 111 of the Act. Upon modification, an existing facility shall become an affected facility for each pollutant to which a standard applies and for which there is an increase in the emission rate to the atmosphere.

c) The addition of an affected facility to a stationary source, as an expansion to that source or as a replacement for an existing facility, shall not by itself bring within the applicability of this part any other facility within that source.

d) A modification shall not be deemed to occur if an existing facility undergoes a physical or operational change where the owner or operator demonstrates to the Administrator's satisfaction...that the total emission rate of any pollutant has not increased from all facilities within the stationary source...

e) The following shall not, by themselves, be considered modifications under this part:

1) Maintenance, repair, and replacement which the Administrator determines to be routine for a source category...

2) An increase in production rate of an existing facility, if that increase can be accomplished without a capital expenditure on that facility.

3) An increase in the hours of operation.

4) Use of an alternative fuel or raw material if . . . the existing facility was designed to accommodate that alternative use.

5) The addition or use of any system or device whose primary function is the reduction of air pollutants . . .

6) The relocation or change in ownership of an existing facility.[1]

The owner or operator of any source classified as an existing facility must notify the U.S. Environmental Protection Agency (EPA) of any physical or operational change that could increase emissions of an air pollutant for which a performance standard applies.[2]

5.2.1 Increase in Production Rate

The rate at which a fabric can be printed on a particular printing line is typically dependent upon product specifications (fabric type, pattern complexity, and the number of colors) and drying requirements. Whereas, changes in product specifications may lead to a faster production rate, they may also result in increased emissions. However, if no capital expenditure is required for these changes, they will not be termed modifications. Similarly, changes in drying requirements (such as increased temperature or air flow within the existing dryer) that require no capital expenditure will not be termed modifications.

If a capital expenditure is required to increase dryer capacity that in turn results in increased production rates and increased emissions, the Administrator may determine that a modification has occurred. Such an increase in capacity could be achieved by adding a predryer or lengthening an existing dryer.

5.2.2 Improvement in Operating Efficiency

During a regular, operating schedule, the fabric printing line is often shut down for maintenance and in-production adjustments. The longest interruptions occur when the line is shut down to change patterns and/or colors and to clean up between print runs. Careful scheduling of print runs could increase operating efficiency, leading to a corresponding increase in production and, consequently, emissions. If no capital expenditure is required, this change will not be considered a modification.

5.2.3 Change in Print Paste Formulation

A change in print paste formulation could result in increased solvent emissions. In such an instance, the Administrator would determine if the change constituted a modification.

5.2.4 Increase in Printing Width

Over the past two decades the average width of broadwoven fabric has increased, necessitating an increase in the printing width of many existing roller print machines. Since the widening of a roller print machine may involve a capital expenditure, this could be considered a modification. However, if the capital expenditure involved exceeds the minimum for reconstruction, the printing facility might be considered a reconstruction rather than a modification.

5.2.5 Relocation or Change in Ownership

Very few new roller print machines are currently being produced. Typically, a fabric printing plant that adds a roller printing line purchases a used print machine. The Administrator might not judge this to be a modification, although the capital expenditure involved could be large enough to consider the facility reconstructed.

5.2.6 Small Capital Expenditure

If a capital expenditure is less than the "product of the applicable 'annual asset guideline repair allowance percentage' specified in the latest edition of Internal Revenue Service Publication 534 and the existing facility's basis, as defined by Section 1012 of the Internal Revenue Code,"[3] and if the expenditure increases capacity with a resulting increase in emissions, a modification is not considered to have occurred.

5.3 RECONSTRUCTION

Reconstruction is defined under Section 60.15 of the Code of Federal Regulations as follows:

a) An existing facility, upon reconstruction, becomes an affected facility, irrespective of any change in emission rate.

b) "Reconstruction" means the replacement of components of an existing facility to such an extent that:

1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable, entirely new facility, and

2) It is technologically and economically feasible to meet the applicable standards set forth in this part.

c) "Fixed capital cost" means the capital needed to provide all the depreciable components.

d) If an owner or operator of an existing facility proposes to replace components, and the fixed capital costs of the new components exceed 50 percent of the fixed capital cost that would be required to construct a comparable, entirely new facility, he shall notify the Administrator of the proposed replacements.[4]

The purpose of this final provision is to discourage the perpetuation of a facility that, in the absence of a regulation, would normally have been replaced.[4]

Some of the changes mentioned in Section 5.2 could be costly enough to qualify as reconstruction. Specifically, the widening of a roller print machine or the addition of a used roller print machine would likely qualify, particularly if the used machine is widened at the time it is installed. The lengthening of a dryer could qualify as a reconstruction, especially if the printing line is modified in some other fashion at the time of installation.

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6. MODEL PLANTS AND REGULATORY ALTERNATIVES

6.1 GENERAL

Chapter 4 describes and evaluates the performance of individual control technologies that can be used to reduce volatile organic compound (VOC) emissions from the fabric printing industry. This chapter identifies several practical regulatory alternatives based on those previously described control technologies. The relative effectiveness of each alternative is assessed by its application to three model plants that were developed to represent plants that will be subject to the proposed standard. The environmental and economic impacts of the several regulatory alternatives are discussed in Chapters 7 and 9, respectively.

6.2 MODEL PLANTS

The model fabric printing lines defined herein are considered representative of new or modified lines that might be installed in the 1981-1986 period. Three types of printing lines appear to be appropriate for designation as affected facilities in the fabric printing industry: (1) the roller printing line (including fabric feed, roller print machine, and steam drying cans or oven), (2) the rotary screen printing line (including fabric feed, rotary screen print machine, and drying oven, drying/curing oven, or steam cans), and (3) the flat screen printing line used in the unit-printing of terry towels (including flat screen print machine and drying or drying/airing oven).

Any particular piece of fabric would be printed on one printing line, with the type of printing line being dependent predominantly on the end use of the fabric. Most fashion apparel fabric is printed on roller printing lines, though some bottom-weight apparel fabric, domestic fabric (such as upholstery, curtains, and drapes), and industrial fabric is printed on roller printing lines. Rotary screen printing lines are used to print some fashion apparel fabric, though sheeting, domestic fabrics, industrial fabrics and bottom-weight apparel fabrics constitute most of the fabric printed on rotary screen printing lines. Since flat screen print machines are being replaced by rotary screen print machines, the only flat screen printing process considered for NSPS development is the unit printing of terry towels.

6.2.1 Model Plant Parameters

Table 6-1 presents a parametric description of each of the three model fabric printing lines. The rotary screen and roller printing lines are intended to be representative of lines printing fashion apparel fabrics (most fabrics for other markets are printed with aqueous or low-organic solvent print pastes). The flat screen line is representative of a line printing terry towels. The types of fabrics being printed and fabric widths and weights are based on information obtained from fabric printing industry sources and from the Department of Commerce publications.[1 2 3]

VOC emission rates are dependent on three basic parameters: (1) organic solvent content of the print pastes; (2) print paste consumption (a function of pattern coverage and fabric weight); and (3) rate of fabric processing (a function of line speed while operating, and operating efficiency). The organic solvent (mineral spirits) contents of the print pastes are representative of the quantities of mineral spirits used in screen or roller printing of fashion apparel fabrics and in screen printing of terry towels. Data for these parameters were provided by fabric printing industry sources. Print paste consumption (and therefore organic solvent consumption) was derived from estimates of the average quantity (kilograms) of print paste consumed per kilogram of fabric printed for each type of fabric printing process. These estimates were based on 8 responses to Section 114 letters and information collected during 12 plant visits, which in summary provide data on 15 fabric printing plants. The line speeds and operating efficiencies also are based on information obtained during plant visits.

Department of Commerce publications[4] are the source of the capacity utilization data for the rotary screen and roller printing model plants. The capacity utilization rate for the flat screen printing of terry towels was provided by towel printers.[5 6] The production capacity of each model

TABLE 6-1. MODEL FABRIC PRINTING LINES

A. Inputs to printing process

Plant number	Type of printing machine	Type of fabric: Knitted (percent)	Woven (percent)	Chiefly cotton fiber (percent)	Chiefly manmade fiber (percent)	Average fabric width (m)[a]	Fabric weight (kg/m)	Organic solvent consumption (thousand kg/yr)[b]	Print paste consumption (thousand kg/yr)	Print paste organic solvent content (weight percent)[b]
1	Rotary screen	23	77	15	85	1.143	.1439	269.9	729.4	37.0
2	Flat screen	0	100	100	Neg	0.991	NA	29.8	124.3	24.0
3	Roller	14	86	41	59	1.143	.1439	292.5	495.8	59.0

B. Print paste application: Production capacity (thousand m/yr)[c]	Capacity utilization (percent)	Operating efficiency (percent)	Printing line speed while operating (m/s)[d]	C. Drying process: Type of drying	Fuel	Temperature (° C)	Air flow (m^3/s)[e]	D. VOC emissions: Wastewater organic solvent loss (thousand kg/yr)	Air fugitive (thousand kg/yr)	Air point source (thousand kg/yr)
8,888	96	60	0.686	Oven	Natural gas	163	4.720	26.4	4.8	238.7
248,690	64	65	1.7	Oven	Natural gas	163	3.776	0.9	0.5	28.4
6,373	97	44	0.671	Steam cans	No. 6 fuel oil	116	3.964	18.1	5.8	269.1

[a] The printing width of Model Plant No. 1 is 1.82 m, of Model Plant No. 2 is 1.52 m, and of Model Plant No. 3 is 1.52 m.

[b] Includes the organic solvent content of the clear and color concentrates.

[c] Model Plant No. 2 production capacity in dozen towels per year.

[d] Model Plant No. 2 average printing line speed while operating in dozen towels per minute.

[e] Maintains average organic solvent concentration at approximately 9% of the LEL in Model Plant No. 1, 2% of the LEL in Model Plant No. 2, and 16% of the LEL in Model Plant No. 3.

plant is derived from the capacity utilization, operating efficiency, and average line speed while operating parameters for each model plant.

The drying process parameters are based on information obtained during plant trips and from vendors of printing equipment. Direct-fired ovens typically are used in drying screen printed fabric. Natural gas must be used as the fuel to prevent soiling the fabric. Most roller printed fabric is dried on steam cans, probably because most roller printed fabric is woven and can be placed in tension without stretching.

The VOC emission parameters for each model plant were evaluated by a material balance approach that used information from fabric printing plants to calculate the theoretical fugitive air emissions. Solvent losses in the wastewater reflect waste print paste (that which is left on the printing equipment and in the print paste troughs at the end of a print run) and print paste that penetrates the fabric or is overprinted on width. Fugitive air emissions represent solvent that evaporates from print paste barrels and printing equipment during the application of the print paste and from the printed fabric after application and prior to drying.

Table 6-2 presents the energy requirements for the model fabric printing lines. Electricity is required by the print machine and dryer fan in each model plant. Natural gas is the fuel for the direct-fired drying ovens in Model Plant Numbers 1 and 2. Model Plant Number 3 requires Number 6 fuel oil to fire the boiler that provides steam to the steam cans.

6.2.2 Modifications or Reconstructions

Changes to fabric printing facilities that could be termed modifications or reconstructions are described in Chapter 5. Model Plant Number 3 represents a modification to a fabric printing line. Roller printing capacity typically is added by installing used equipment (there is a surplus of used equipment available because of the large number of plant closings during the past 5 years). When the used roller print machine is installed, it is commonly widened to 1.52 meters (60 inches) or more ["standard" roller printing widths range from 1.14 to 1.27 meters (45 to 50 inches)] to accommodate wider manmade fiber broadwoven fabrics. A widened print machine would constitute a modified or reconstructed facility, depending on the capital expenditure involved.

TABLE 6-2. ENERGY REQUIREMENTS FOR MODEL FABRIC PRINTING LINES

Plant number	Electricity requirement (GJ/yr)[a]	Natural gas or fuel oil requirement (GJ/yr)[b]
1	1,440	9,869
2	979	5,206
3	850	1,802

[a]The electricity requirement is 110 kJ/s (102 kJ/s for the printer and 8 kJ/s for the dryer fan) for Model Plant Number 1; 100 kJ/s (93.5 kJ/s for the printer and 6.4 kJ/s for the dryer fan) for Model Plant Number 2; and 83.7 kJ/s (77 kJ/s for the printer and 6.7 kJ/s for the fan) for Model Plant Number 3.

[b]Natural gas for direct-fired ovens in Model Plant Number 1 and Model Plant Number 2 and No. 6 fuel oil for boiler/steam cans in Model Plant Number 3.

There are no model plants representing modified or reconstructed screen printing lines. If screen printing installations have modifications or reconstructions that bring them within the NSPS guidelines, they will probably use the same control alternatives as new facilities. There will be no differences in costs if low-solvent print pastes are used. Retrofitting add-on control devices will result in some additional costs, such as for longer ducts. However, most new facilities will incur comparable retrofit costs because they will be located in the same buildings as existing printing lines. Therefore, the capital and operating costs will be nearly identical.

6.3 REGULATORY ALTERNATIVES

Since there are no specific current regulations for VOC emissions from the fabric printing industry, the baseline level of control repesents uncontrolled emissions. As was discussed in Chapter 3, based upon 1979 data, this corresponds to the use of print paste containing an average of 26 percent organic solvent in roller printing, 23 percent organic solvent in flat screen printing of terry towels, and 3 percent organic solvent in rotary screen printing.

Although the average organic solvent contents of the print pastes used in rotary screen and roller printing represent medium organic solvent print pastes, very little printing is actually done with print pastes of medium-organic solvent content. The distribution of print paste usage is bimodal, with the arithmetic average falling between the modes. Most fabric is printed with aqueous or low-organic solvent print pastes. In applications where the use of organic solvents is beneficial, print pastes with high organic solvent content are used to derive the full benefit of utilizing the organic solvents. Therefore, the major environmental and economic impacts of the following regulatory alternatives will accrue to the fabric printers using high-organic solvent print pastes.

The four regulatory alternatives evaluated for the fabric printing NSPS include:

- Not promulgating an NSPS,
- Reducing total nationwide emissions from affected facilities by approximately 40 percent from the no-NSPS baseline,

- Reducing total nationwide emissions from affected facilities by approximately 60 percent from the no-NSPS baseline,

- Reducing total nationwide emissions from affected facilities by approximately 85 percent from the no-NSPS baseline.

The no-NSPS regulatory alternative is discussed above. It represents uncontrolled emissions.

The second regulatory alternative could be achieved through the use of print pastes containing a weighted average of 24 percent organic solvent (weight) in rotary screen and roller printing applications presently utilizing high-organic solvent content print paste.

The third regulatory alternative could be achieved through the use of print pastes containing a weighted average of 12 percent organic solvent (weight) in rotary screen and roller printing applications presently utilizing medium-or high-organic solvent print pastes and in the flat screen printing of terry towels.

The fourth regulatory alternative could be achieved through the use of an add-on control device with a removal efficiency of 95 percent to control drying process air emissions from any affected rotary screen, roller, or flat screen printing line utilizing print pastes containing organic solvents.

Table 6-3 displays the estimated total nationwide VOC emissions in 1986 by type of printing process under each regulatory alternative, assuming NSPS proposal in 1981.

TABLE 6-3. SUMMARY OF PROJECTED TOTAL NATIONWIDE VOC EMISSIONS (METRIC TONS) FROM AFFECTED FACILITIES IN 1986 BY TYPE OF FABRIC PRINTING PROCESS AND REGULATORY ALTERNATIVE, ASSUMING NSPS PROPOSAL DURING 1981

	Regulatory alternative I	Regulatory alternative II	Regulatory alternative III	Regulatory alternative IV
Roller	7,521	3,738	2,441	948
Rotary screen	3,358	2,690	2,073	536
Unit flat screen	836	836	418	82
Total	11,715	7,264	4,932	1,566

TABLE 7-6. ESTIMATE OF ANNUAL ENERGY CONSUMPTION: 1977, 1981, 1986

Printing process	Production (Mg)[a]			Annual energy consumption (TJ)[b]					
						1986			
	1977	1981	1986	1977	1981	I	II	III	IV
Rotary screen	240.0	249.5	261.5	2,743	2,853	2,991	2,963	2,938	3,570
Flat screen	16.0	17.9	20.4	770	862	978	978	957	1,127
Roller	162.7	169.2	177.3	1,596	1,660	1,740	1,543	1,476	2,312
				5,109	5,375	5,709	5,484	5,371	7,009

[a]Production data:

1977: Flat screen production is in millions of dozens of terry towels.[1] Printed broadwoven fabric production is reported by the Bureau of the Census[2] in linear yards. The conversion was made to kilograms using the following factors derived from information provided by ATMI:[3] 7.14 meters per kilogram of roller printed fabric; 4.03 meters per kilogram of screen printed fabric. Knit fabric production is reported by the Bureau of the Census[4] in pounds. It was assumed that 10 percent of the knit fabric is printed,[5] and that 30 percent of printed knit fabric is done on roller print machines with the remaining 70 percent rotary screen printed.

1981 and 1986: Estimated by assuming 1 percent annual growth (simple, 1977 base) in roller and rotary screen production and 3 percent annual growth (simple, 1977 base) in printed terry towel production.[6]

[b]Annual energy consumption:

1977 and 1981: Rotary screen and flat screen printing energy requirements include natural gas for the drying oven, electricity for the printing machine and drying process fan and organic solvents contained in the print pastes (44 MJ per kg of mineral spirits). Roller printing energy requirements include steam for the steam drying cans, electricity for the printing machine, and organic solvents contained in the print pastes. Energy requirements were calculated assuming the distribution of rotary screen printed fabric production by organic solvent content of print paste is as follows: 12 percent of production is printed with 37 percent organic solvent content print paste; 5.7 percent of production is printed with 7 percent organic solvent content print paste; 26.7 percent of production is printed with 3 percent organic solvent content print paste; and the remaining production is printed with print pastes containing 2 percent organic solvent. The distribution of roller printed fabric production by print paste organic solvent content is assumed to be as follows:[10] 53 percent of production is printed with 59 percent organic solvent content print paste and the remaining production is printed with 7 percent organic solvent content print paste. All terry towels are assumed to be printed with print pastes containing 24 percent organic solvent.

1986: Assumes that 5 percent of 1977 screen printing capacity is replaced (subject to NSPS) each year after 1981 proposal and that 5 percent of 1977 roller printing capacity is modified each year after 1981 proposal. Also assumes that all growth in rotary screen and roller printed fabric production between 1981 and 1986 will be accommodated by new sources and that the distributions of printed fabric production by organic solvent content of the print pastes will remain the same.

I: No NSPS.

II: Achieved through the use of print pastes containing a weighted average of 24 percent organic solvent in rotary screen and roller printing applications presently utilizing high-organic solvent content print pastes.

III: Achieved through the use of print pastes containing a weighted average of 12 percent organic solvent in rotary screen and roller printing applications presently utilizing high-organic solvent print pastes and in the flat screen printing of terry towels.

IV: Achieved through the use of an incinerator with a destruction efficiency of 95 percent to control drying process air emissions from any affected facility utilizing print pastes containing organic solvents.

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7. ENVIRONMENTAL IMPACT

Fabric printing lines utilizing print pastes containing organic solvents are stationary point sources of organic solvent emissions. The drying process is the primary source of these emissions. Secondary sources include fugitive air emissions from the application area--screens or rollers, print paste barrels and troughs--and the printed fabric prior to drying. Other sources of fugitive emissions are plant wastewater containing excess print paste, used cleaning solvent, and detergent solutions in which printed fabrics are washed.

In this chapter, the air and water pollution, solid waste, and energy impacts are examined for the four regulatory alternatives described in Chapter 6; they are summarized in Table 7-1. The impacts are estimated for each of the three model plants presented in Chapter 6 and for the United States as a whole, based on projections of plant growth, replacement, and modification. Table 7-2 summarizes model fabric printing line parameters (developed in Chapter 6) relevant to the calculation of pollution impacts.

7.1 AIR POLLUTION IMPACT

As mentioned earlier, drying process VOC emissions constitute the primary air pollution impact of printing fabric with print pastes containing organic solvents. The regulatory alternatives (II and III) limiting the average organic solvent content of print paste will result in a reduction of VOC emissions from all sources. Regulatory alternative IV will reduce only drying process emissions (estimated to represent 90 percent of the total VOC emissions from fabric printing operations). Table 7-3 presents estimates of the annual VOC emissions per model plant under each regulatory alternative. For Regulatory Alternative I, these figures were obtained by multiplying print paste consumption by average print paste organic solvent content (from Table 7-2) for each model plant, respectively.

TABLE 7-1. SUMMARY OF REGULATORY ALTERNATIVES

Regulatory alternative	Model plants affected	Emission reduction (%)	Implementation method
I	None	0	No NSPS
II	Rotary screen Roller	40	Limiting print paste average organic solvent content to 24 percent
III	Rotary screen Roller Unit flat screen (terry towels)	60	Limiting print paste average organic solvent content to 12 percent
IV	Rotary screen Roller Unit flat screen (terry towels)	85	Requiring a 95 percent reduction in drying process emissions.

TABLE 7-2. RELEVANT MODEL FABRIC PRINTING LINE PARAMETERS

Plant number	Type of printing machine	Organic solvent consumption (Mg/yr)	Print paste consumption (Mg/yr)	Average print paste organic solvent content (% by weight)	Wastewater organic solvent loss (Mg/yr)	Air VOC fugitive emissions (Mg/yr)	Air VOC print source emissions (Mg/yr)
1	Rotary screen	269.9	729.4	37.0	26.4	4.8	238.7
2	Flat screen	29.8	124.3	24.0	0.9	0.5	28.4
3	Roller	292.5	495.8	59.0	18.1	5.3	269.1

TABLE 7-3. ANNUAL VOC EMISSIONS FOR MODEL PLANTS UNDER EACH REGULATORY ALTERNATIVE

Plant number	Regulatory alternative I: No NSPS (Mg/yr)	I: No NSPS (percent reduction)	II: Average 24 percent organic solvent print paste (Mg/yr)	II (percent reduction)	III: Average 12 percent organic solvent print paste (Mg/yr)	III (percent reduction)	IV: 95 percent reduction in drying process air emissions (Mg/yr)	IV (percent reduction)
1	269.9	0	175.1	35	87.5	68	43.1	84
2	29.8	0	29.8	0	14.9	50	2.8	91
3	292.5	0	119.0	59	59.5	80	36.9	87

For Regulatory Alternatives II and III, print paste consumption was multiplied by the average organic solvent content limits imposed by each Regulatory Alternative (24 percent in II and 12 percent in III). In the case of Regulatory Alternative IV, emissions were calculated using Equation 7-1,

$$M_{e_1} = M_{e_0} \; [.05 \; F + (1-F)] \qquad (7\text{-}1)$$

where

M_{e_1} = controlled emissions (Mg)

M_{e_0} = uncontrolled emissions (Mg) (Regulatory Alternative I)

.05 = 1.0 - emission reduction factor (.95)

F = capture rate (.885 for rotary screen, .95 for flat screen, and .92 for roller print machines).

Equation 7-1 takes into account fugitive and other emissions that are not affected (captured) by the add-on control device.

In addition, estimates of nationwide VOC emissions were made for 1981--the year of proposal--and for 1986 under each regulatory alternative. For a historical perspective on these estimates, nationwide VOC emissions for the industry for 1977 were also estimated. Table 7-4 shows these estimates.

There are some potential inaccuracies in the assumptions made in developing Table 7-4 due mainly to a lack of detail in the available data. For instance, the separate calculations of emissions from each of the print paste solvent content modes in each of the model plant categories carry an underlying implication that the usage of each type of print paste in each plant is constant. In fact, individual printing lines within a plant may use different types of print paste (with respect to solvent content), and solvent usage per line, as well as per plant, can change from month to month according to changes in the fabric printing orders that are received. Unfortunately, information on the distribution of print paste usage by solvent content is not available in sufficient detail to permit more precise calculations of emissions.

TABLE 7-4. ANNUAL NATIONWIDE VOC EMISSIONS
Estimates: 1977, 1981, 1986

Printing process	Production (10^3 Mg)[a] 1977	1981	1986	Annual VOC emissions (10^3 Mg)[b] 1977	1981	1986 I	1986 II	1986 III	1986 IV
Rotary screen	240.0	249.5	261.5	8.4	8.7	9.2	8.5	7.9	7.6
Flat screen	16.0	17.9	20.4	3.3	3.7	4.2	4.2	3.8	3.5
Roller	162.7	169.2	177.3	25.1	26.1	27.3	23.5	22.2	20.7
				36.8	38.5	40.7	36.2	33.9	31.8

[a]Production data:

1977: Flat screen production is in millions of dozens of terry towels.[1] Printed broadwoven fabric production is reported by the Bureau of the Census[2] in linear yards. This was converted to kilograms using the following factors derived from information provided by ATMI:[3] 7.14 linear meters per kilogram of roller printed fabric; 4.03 linear meters per kilogram of screen printed fabric. Knit fabric production is reported by the Bureau of the Census[4] in pounds. It was assumed that 10 percent of the knit fabric is printed,[5] and that 30 percent of printed knit fabric is done on roller print machines with the remaining 70 percent rotary screen printed.

1981 and 1986: Estimated by assuming 1 percent annual growth (simple, 1977 base) in roller and rotary screen production and 3 percent annual growth in printed terry towel production.[6]

[b]VOC emissions data:

1977 and 1981: It is assumed that the NSPS will be proposed in 1981. Uncontrolled emissions were calculated using the following emission factors: 35 kilograms of VOC per thousand kilograms of rotary screen printed fabric, 154 kilograms of VOC per thousand kilograms of roller printed fabric, and 209 kilograms of VOC per thousand dozen printed towels. The rotary screen and roller printing emission factors are based on the results of ATMI's VOC usage survey,[3] revised to account for the estimated average. VOC contribution of 2 percent from the supplier-formulated clear and color concentrates.[7] The terry towel printing emission factor is based on information provided by two terry towel printers.[8] [9]

1986: Assumes that 5 percent of 1977 screen printing capacity is replaced (subject to NSPS) each year after 1981 proposal and that 5 percent of 1977 roller printing capacity is modified each year after 1981 proposal. Also assumes that all growth in rotary screen and roller printed fabric production between 1981 and 1986 will be accommodated by new sources and that the distributions of printed fabric production by organic solvent content of the print pastes will remain the same as the 1979 distributions (derived from information provided by ATMI.[10] [11]).

The distribution of rotary screen printed fabric production by organic solvent content of print paste is assumed to be as follows:[10] 12 percent of production is printed with 37 percent organic solvent content print paste; 5.7 percent of production is printed with 7 percent organic solvent content print paste; 26.7 percent of production is printed with print paste containing 3 percent organic solvent; and the remaining production is printed with print pastes containing 2 percent organic solvent (the contribution of the clear and color concentrates).

The distribution of roller printed fabric production by organic solvent content of print paste is assumed to be as follows:[11] 53 percent of production is printed with 59 percent organic solvent content print paste and the remaining production is printed with 7 percent organic solvent content print pastes.

All terry towels are assumed to be printed with 24 percent organic solvent content print paste.

I: No NSPS.

II: Achieved through the use of print pastes containing a weighted average of 24 percent organic solvent in rotary screen and roller printing applications presently utilizing high-organic solvent content print pastes.

III: Achieved through the use of print pastes containing a weighted average of 12 percent organic solvent in rotary screen and roller printing applications presently utilizing high organic solvent content print pastes and in the flat screen printing of terry towels.

IV: Achieved by reducing drying process emissions by 95 percent from any affected facility using print pastes with organic solvents.

Secondary environmental impacts are defined as those impacts which are not normally associated with an uncontrolled facility but result after the addition of pollution control equipment (as in Regulatory Alternative IV). In the case of fabric printing facilities, the added controls are presumed to be incinerators.

The addition of an incinerator to a fabric printing line can potentially result in the formation of carbon monoxide (CO) and nitrogen oxides. Carbon monoxide results from incomplete combustion of the VOC materials. The amount of CO in the incinerator effluent gas is dependent on the incineration temperature and the residence time. At temperatures above 760° C (1400° F), an incinerator should oxidize over 90 percent of all hydrocarbons to carbon dioxide.[12] Because aromatic fuels are more resistant to combustion, they require higher firebox temperatures than aliphatic fuels.[13]

Nitrogen oxide formation in combustion units is primarily dependent on two variables: (1) excess oxygen levels and (2) firebox temperatures. The formation of NO_x results from oxidation of fuel (solvent-bound nitrogen) and from thermal fixation. The concentration of oxides of nitrogen (NO_x) in incinerator stack gases is about 18 to 22 ppm for natural gas-fired noncatalytic incinerators and 40 to 50 ppm for oil-fired noncatalytic incinerators at a temperature of 815° C (1500° F), assuming no nitrogen-containing compounds are incinerated.[14] For most solvents the nitrogen content is very low, and therefore, the emission rate should be low.

7.2 WATER POLLUTION IMPACTS

There are about 700 textile industry plants using wet processes, discharging wastewater.[15] Wet textile-mill operations consist of fabric preparation, dyeing, printing, and finishing. The wastewater producing operations are sizing of the fibers, kiering (alkaline cooking), desizing the woven cloth, bleaching, rinsing, mercerizing, dyeing, and printing. The major water pollution parameters measured to monitor pollution from these processes are solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrient chemicals, temperature, toxic organics, heavy metals, pH, alkalinity, acidity, oil and grease, sulfides, and coliform bacteria.

Wastewater from the textile industry has been thoroughly studied,[16 17 18] but most of the data provided are from the final combined effluent from a textile operation. Only a few data from these studies are specifically from fabric printing operations, but they indicate that printing process waste is an insignificant addition to the total waste load.[16] It is known that the hydrocarbon solvents commonly used in printing are a concentrated source of BOD, because these solvents are composed of carbon and hydrogen. The small percentage of these solvents that are used dilutes their concentrations in the process stream.

The few data available for fabric printing operations indicate that if 14 percent of the cloth is printed, 150 lb BOD, 34 lb suspended solids, and 200 lb of total dissolved solids would result from the processing of 20,000 lb of cloth.[16] The BOD may be divided into 16 to 23 percent from color shop wastes, 54 to 68 percent from soap wash after printing, and 16 to 23 percent from detergent wash after printing.[17]

Each of the NSPS regulatory alternatives calls for a reduction in the quantity of organic solvent used in the industry, except for the no-NSPS and incineration options, which call for no change in organic solvent usage. For this reason, there will be no additional quantity of organic solvent, or the resulting BOD, added to the wastewater from fabric printing operations.

Water based print pastes are currently being developed to meet some specific needs of fabric printers. Insufficient data are available to determine the water quality impacts of these developing products, but since printing process wastes are such a small portion of the entire textile wastewater, the impact should be small.

7.3 SOLID WASTE

The solid wastes from fabric printing plants are not significant sources of VOCs. The small amounts of solvent present in wastewater would not appear in the sludge generated in wastewater treatment. Other solid wastes include empty drums and other containers, spoiled fabric, and wiping rags. None of the regulatory alternatives will impact the quantity of solid waste produced.

7.4 ENERGY IMPACT

Table 7-5 presents estimates of the annual energy consumption, by type of energy, for each model plant under each regulatory alternative.

TABLE 7-5. ESTIMATES OF ANNUAL ENERGY CONSUMPTION FOR MODEL PLANTS

Plant number	Type of energy[1]	Energy Consumption (GJ per year) No NSPS	Average 24 percent organic solvent print paste	Average 12 percent organic solvent print paste	95 percent reduction in drying process air emissions
1	Natural gas	9,868	10,075	10,342	15,985
	Electricity	1,440	1,440	1,440	2,059
	Mineral spirits	11,876	7,703	3,852	11,876
	TOTAL	23,184	19,218	15,634	29,920
2	Natural gas	5,205	5,205	5,258	11,718
	Electricity	979	979	979	1,276
	Mineral spirits	1,311	1,311	656	1,311
	TOTAL	7,495	7,495	6,893	14,305
3	Natural gas	0	0	0	7,449
	Fuel oil	1,802	1,802	1,802	1,802
	Electricity	850	850	850	1,490
	Mineral spirits	12,870	5,235	2,618	12,870
	TOTAL	15,522	7,887	5,270	23,611

[1]The natural gas requirement for plants 1 and 2 includes fuel for the drying oven under each regulatory alternative, plus fuel for the incinerator under regulatory alternative IV. The natural gas requirement for plant 3 under regulatory alternative IV is fuel for the incinerator. The fuel oil requirement for plant 3 is for the boiler generating steam for the steam drying cans. The electricity requirement for each plant is for the printing machine, the drying process fan, and the incinerator fan under regulatory alternative IV. The mineral spirits requirement for each plant is for print paste organic solvents.

TABLE 7-6. ESTIMATE OF ANNUAL ENERGY CONSUMPTION: 1977, 1981, 1986

Printing process	Production (Mg)[a]			Annual energy consumption (TJ)[b]					
						1986			
	1977	1981	1986	1977	1981	I	II	III	IV
Rotary screen	240.0	249.5	261.5	2,743	2,853	2,991	2,963	2,938	3,570
Flat screen	16.0	17.9	20.4	770	862	978	978	957	1,127
Roller	162.7	169.2	177.3	1,596	1,660	1,740	1,543	1,476	2,312
				5,109	5,375	5,709	5,484	5,371	7,009

[a]Production data:

1977: Flat screen production is in millions of dozens of terry towels.[1] Printed broadwoven fabric production is reported by the Bureau of the Census[2] in linear yards. The conversion was made to kilograms using the following factors derived from information provided by ATMI:[3] 7.14 meters per kilogram of roller printed fabric; 4.03 meters per kilogram of screen printed fabric. Knit fabric production is reported by the Bureau of the Census[4] in pounds. It was assumed that 10 percent of the knit fabric is printed,[5] and that 30 percent of printed knit fabric is done on roller print machines with the remaining 70 percent rotary screen printed.

1981 and 1986: Estimated by assuming 1 percent annual growth (simple, 1977 base) in roller and rotary screen production and 3 percent annual growth (simple, 1977 base) in printed terry towel production.[6]

[b]Annual energy consumption:

1977 and 1981: Rotary screen and flat screen printing energy requirements include natural gas for the drying oven, electricity for the printing machine and drying process fan and organic solvents contained in the print pastes (44 MJ per kg of mineral spirits). Roller printing energy requirements include steam for the steam drying cans, electricity for the printing machine, and organic solvents contained in the print pastes. Energy requirements were calculated assuming the distribution of rotary screen printed fabric production by organic solvent content of print paste is as follows: 12 percent of production is printed with 37 percent organic solvent content print paste; 5.7 percent of production is printed with 7 percent organic solvent content print paste; 26.7 percent of production is printed with 3 percent organic solvent content print paste; and the remaining production is printed with print pastes containing 2 percent organic solvent. The distribution of roller printed fabric production by print paste organic solvent content is assumed to be as follows:[10] 53 percent of production is printed with 59 percent organic solvent content print paste and the remaining production is printed with 7 percent organic solvent content print paste. All terry towels are assumed to be printed with print pastes containing 24 percent organic solvent.

1986: Assumes that 5 percent of 1977 screen printing capacity is replaced (subject to NSPS) each year after 1981 proposal and that 5 percent of 1977 roller printing capacity is modified each year after 1981 proposal. Also assumes that all growth in rotary screen and roller printed fabric production between 1981 and 1986 will be accommodated by new sources and that the distributions of printed fabric production by organic solvent content of the print pastes will remain the same.

I: No NSPS.

II: Achieved through the use of print pastes containing a weighted average of 24 percent organic solvent in rotary screen and roller printing applications presently utilizing high-organic solvent content print pastes.

III: Achieved through the use of print pastes containing a weighted average of 12 percent organic solvent in rotary screen and roller printing applications presently utilizing high-organic solvent print pastes and in the flat screen printing of terry towels.

IV: Achieved through the use of an incinerator with a destruction efficiency of 95 percent to control drying process air emissions from any affected facility utilizing print pastes containing organic solvents.

Table 7-6 displays the estimated annual energy usage in the fabric printing industry. In the table, the estimated energy used in 1977 is contrasted with projections of energy use for 1981 and for 1986, assuming the imposition of the various regulatory alternatives. The projections are based on energy consumption per kilogram of fabric printed by each process and by solvent mode within each process.

Table 7-6 shows a decrease in nationwide energy usage under Regulatory Alternatives II and III, ranging from approximately 4 percent for Regulatory Alternative II up to almost 6 percent for Regulatory Alternative III. Although reducing the solvent content of the print paste leads to a greater energy requirement for the drying process, this is more than offset by the reduced usage of organic solvents in the print paste. Nationwide energy usage by the fabric printing industry is estimated to increase by 37 percent under Regulatory Alternative IV due to the fuel requirement of the incinerator.

7.5 OTHER ENVIRONMENTAL IMPACTS

Fabric printing is not a significant source of such forms of pollution or nuisances as noise, radiation, or visible emissions. Any odors generated would be controlled by Regulatory Alternatives II through IV.

7.6 REFERENCES

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DRAFT

8. COSTS

8.1 COST ANALYSIS OF REGULATORY ALTERNATIVES

Costs of complying with various regulatory alternatives are presented and analyzed in this section. The control options upon which the regulatory alternatives are based are discussed in Chapter 4 and the regulatory alternatives are described in Chapter 6.

The first regulatory alternative--not promulgating an NSPS--corresponds to uncontrolled emissions. The emissions estimates for this alternative are based on the baseline emission rates developed in Chapter 3.

The second regulatory alternative--reducing total nationwide emissions from affected facilities by 40 percent from the no-NSPS baseline--is based on the use of print pastes containing a weighted average of 24 percent organic solvent (weight)* in rotary screen and roller printing applications presently utilizing high-organic solvent content print pastes. Towel printers currently use print pastes containing a weighted average of 24 percent organic solvent in flat screen printing.

The third regulatory alternative--reducing total nationwide emissions from affected facilities by 60 percent from the no-NSPS baseline--is achievable through the use of print pastes containing a weighted average of 12 percent organic solvent in rotary screen and roller printing applications presently utilizing medium- or high-organic solvent content print paste and in the flat screen printing of terry towels. The use of print pastes containing a weighted average of 12 percent organic solvent has been demonstrated in printing fabrics, with the exception of terry towels, for all markets.

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*All percentages are by weight unless otherwise stated.

The fourth regulatory alternative--reducing total nationwide emissions from affected facilities by 85 percent from the no-NSPS baseline--is based on reducing drying process VOC air emissions from any affected facility utilizing print pastes containing organic solvents by 95 percent. This regulatory alternative would result in the greatest VOC emission reduction, but would also lead to the greatest cost of control.

8.1.1 New Facilities

The costs applicable to new fabric printing lines are summarized in this section. The model plants presented in Chapter 6 form the basis for all cost analyses in this section. Tables 8-1 through 8-4 present the estimated installed capital and annualized costs for each model fabric printing line under Regulatory Alternatives I through IV, respectively.

8.1.1.1 Capital Costs

The installed capital cost for a rotary screen printing line is based on confidential quotes from three vendors of turnkey installations. The installed capital cost of a flat screen printing line is based on a confidential quote from one vendor and a quote from a fabric printing industry source.[1] Included in each direct cost is a factor for site preparation and provision of utilities.[2] Each indirect cost covers a subcontractor's installation fee and is based on confidential quotes from vendors and information from a fabric printing industry source.[3] The installation fee covers engineering and supervision, field expenses, startup, performance test, and contingencies.

The installed capital cost of a roller printing line is based on information from a fabric printer[4] that recently installed a roller printing line consisting of overhauled, used equipment. The direct cost includes a factor for site preparation and provision of utilities and the indirect cost covers a contractor's installation fee, as explained above for screen printing. The installed capital cost of a roller printing line is based on used equipment because this is the typical method of adding roller printing capacity. A roller printing machine has an expected life of 60 to 75 years, many used machines are in storage because of plant closings, and no new roller printing machines are being produced that perform as well as the old machines.

TABLE 8-1. INSTALLED CAPITAL AND ANNUALIZED 1980 COSTS FOR MODEL FABRIC PRINTING LINES UNDER REGULATORY ALTERNATIVE I

Costs	Costs per model plant ($1000s)		
	Plant 1	Plant 2	Plant 3
Installed capital costs			
Printing equipment[a]	450	370	180
Indirects[b]	50	50	50
Total capital costs	500	420	230
Annualized costs			
Raw materials[c]	624	123	705
Operating and supervision labor[d]	292	198	311
Printer utilities[e]	48	28	26
Maintenance--labor and materials[f]	25	21	12
Indirects[g]	101	85	46
Total annualized costs	1,090	455	1,100

[a]Fabric infeed, printing machine, and drying oven or steam cans, plus site preparation and provision of utilities.

[b]Subcontractor installation fee, including engineering and supervision, field expenses, startup, performance test, and contingencies.

[c]Print paste, plus annual cost of screens or rollers and back grey for model plant number 3.

[d]Four operators, one-third of print department head's salary, and one-third of second and/or third shift supervisors' salaries for screen printing. Three operators, one-sixth of print department head's salary and one-sixth of second and third shift supervisors' salaries for roller printing.

[e]Electricity and gas for screen printing; electricity and steam for roller printing. Use of water other than in mixing print paste (included under raw materials) is negligible.

[f]Five percent of total installed capital costs.

[g]Capital charge assuming 10-year depreciation period and 10 percent interest, plus 4 percent of total installed capital costs for overhead, property tax, insurance, and administration.

TABLE 8-2. INSTALLED CAPITAL AND ANNUALIZED 1980 COSTS FOR MODEL FABRIC PRINTING LINES UNDER REGULATORY ALTERNATIVE II

Costs	Costs per model plant ($1000s)		
	Plant 1	Plant 2	Plant 3
Installed capital costs			
Printing equipment[a]	450	370	180
Indirects[b]	50	50	50
Total capital costs	500	420	230
Annualized costs			
Raw materials[c]	592	123	650
Operating and supervision labor[d]	292	198	311
Printer utilities[e]	49	28	26
Maintenance--labor and materials[f]	25	21	12
Indirects[g]	101	85	46
Total annualized costs	1,059	455	1,045

[a]Fabric infeed, printing machine, and drying oven or steam cans, plus site preparation and provision of utilities for printing line.

[b]Subcontractor installation fee, including engineering and supervision, field expenses, startup, performance test, and contingencies.

[c]Print paste, plus annual cost of screens or rollers and back grey for model plant number 3.

[d]Four operators, one-third of print department head's salary, and one-third of second and/or third shift supervisors' salaries for screen printing. Three operators, one-sixth of print department head's salary and one-sixth of second and third shift supervisors' salaries for roller printing.

[e]Electricity and gas for screen printing; electricity and steam for roller printing. Use of water other than in mixing print paste (included under raw materials) is negligible.

[f]Five percent of total installed capital costs.

[g]Capital charge assuming 10-year depreciation period and 10 percent interest, plus 4 percent of total installed capital costs for overhead, property tax, insurance, and administration.

TABLE 8-3. INSTALLED CAPITAL AND ANNUALIZED 1980 COSTS FOR MODEL FABRIC PRINTING LINES UNDER REGULATORY ALTERNATIVE III

Costs	Costs per model plant ($1000s)		
	Plant 1	Plant 2	Plant 3
Installed capital costs			
Printing equipment[a]	450	370	180
Indirects[b]	50	50	50
Total capital costs	500	420	230
Annualized costs			
Raw materials[c]	560	118	628
Operating and supervision labor[d]	292	198	311
Printer utilities[e]	49	29	26
Maintenance--labor and materials[f]	25	21	12
Indirects[g]	101	85	46
Total annualized costs	1,027	451	1,023

[a] Fabric infeed, printing machine, and drying oven or steam cans, plus site preparation and provision of utilities.

[b] Subcontractor installation fee, including engineering and supervision, field expenses, startup, performance test, and contingencies.

[c] Print paste, plus annual cost of screens or rollers and back grey for model plant number 3.

[d] Four operators, one-third of print department head's salary, and one-third of second and/or third shift supervisors' salaries for screen printing. Three operators, one-sixth of print department head's salary and one-sixth of second and third shift supervisors' salaries for roller printing.

[e] Electricity and gas for screen printing; electricity and steam for roller printing. Use of water other than in mixing print paste (included under raw materials) is negligible.

[f] Five percent of total installed capital costs.

[g] Capital charge assuming 10-year depreciation period and 10 percent interest, plus 4 percent of total installed capital costs for overhead, property tax, insurance, and administration.

TABLE 8-4. INSTALLED CAPITAL AND ANNUALIZED 1980 COSTS FOR MODEL FABRIC PRINTING LINES UNDER REGULATORY ALTERNATIVE IV

Costs	Costs per model plant ($1000s)		
	Plant 1	Plant 2	Plant 3
Installed capital costs			
Printing equipment[a]	450	370	180
Control device[b]	481	415	457
Indirects[c]	50	50	50
Total capital costs	981	835	687
Annualized costs			
Raw materials[d]	624	115	705
Operating and supervision labor[e]	292	198	311
Printer utilities[f]	48	28	26
Control device utilities[g]	26	24	30
Maintenance--labor and materials[h]	49	42	34
Indirects[i]	199	169	139
Total annualized costs	1,238	576	1,245

[a] Fabric infeed, printing machine, and drying oven or steam cans, plus site preparation and provision of utilities for printing line.

[b] Cost of incinerator plus 66 percent of capital cost to account for engineering, installation, startup, etc.

[c] Subcontractor installation fee for installing the process equipment, including engineering and supervision, field expenses, startup, performance test, and contingencies.

[d] Print paste, plus annual cost of screens or rollers and back grey for model plant number 3.

[e] Four operators, one-third of print department head's salary, and one-third of second and/or third shift supervisors' salaries for screen printing. Three operators, one-sixth of print department head's salary and one-sixth of second and third shift supervisors' salaries for roller printing.

[f] Electricity and gas for screen printing; electricity and steam for roller printing. Use of water other than in mixing print paste (included under raw materials) is negligible.

[g] Natural gas for incinerator and electricity for fan. Credit for primary heat recovery (85 percent effectiveness) on each printing line.

[h] Five percent of total installed capital costs.

[i] Capital charge assuming 10-year depreciation period and 10 percent interest, plus 4 percent of total installed capital costs for overhead, property tax, insurance, and administration.

The incinerator installed capital costs are based on a budgetary proposal submitted by a vendor of control systems.[5] A factor of 0.66 of the basic equipment cost has been added to cover direct and indirect installation costs.

8.1.1.2 Annualized Costs

The annualized costs of the various regulatory alternatives are discussed in this section. Included are the annualized capital costs and the operating costs for raw materials, labor, and utilities.

1. Capital recovery factors

   - A 10-year amortization period and a 10 percent interest rate added to a 4 percent allowance for overhead, taxes, insurance, and administration

   - 20.3 percent of installed capital cost

2. Raw materials costs

   - For print paste, an oil-in-water color concentrate formulation[6] served as the basis for the estimate of print paste costs. The formulation was modified slightly to incorporate information on color, emulsifier, and auxiliary resin content obtained through telecons with six suppliers of printing chemicals. Price lists (Spring 1980) provided by Blackman Uhler Chemical Division and Inmont Corporation were used to derive the unit costs ($/kg) of print paste.

     - 59 percent organic solvents: $0.86/kg ($0.39/lb) of print paste

     - 37 percent organic solvents: $0.79/kg ($0.36/lb) of print paste

     - 24 percent organic solvents: $0.75/kg ($0.34/lb) of print paste

     - 12 percent organic solvents: $0.71/kg ($0.32/lb) of print paste

     - 7 percent organic solvents: $0.68/kg ($0.31/lb) of print paste

   - $225 material and preparation cost/1.83-m (72-in) wide rotary or flat screen[7]

   - $250/roller central cylinder[8] (assuming customer pays for copper plating and engraving)

- $1.05/m ($1.15/yd) of back grey[9] required (1 m of back grey per 30 m of fabric) in roller printing of lightweight fabrics

3. Labor costs

- $7.00/h for screen printing operating labor
- $9.50/h for roller printing operating labor (with the exception of the printer)
- $12.90/h for roller printer
- $35,000/yr salary for head of print department
- $20,000/yr salary for second and third shift supervisors
- 57 percent of total wages and salaries added to cover benefits

4. Utility costs

- $2.84/GJ ($3.00/million Btu) of natural gas
- $0.01/MJ ($0.05/kWh) of electricity
- $7.94/MJ ($9.42/thousand lb) of steam[10]

In making engineering estimates of the utility costs, the following assumptions were made:

- The normal operating schedule for a fabric printing line is 6,000 hours per year
- The electricity requirement is 110 kW[11 12] (102 kW for the printer and 8 kW for the dryer fan) for a 72-inch printing width rotary screen printing line, 100 kW (93.5 kW for the printer and 6.5 kW for the dryer fan) for a flat screen printing line, and 77 kW for a roller printing machine[13] and 6.7 kW for the fan
- For the purpose of calculating dryer fuel requirements, print paste is composed of organic solvent (varsol), water, and 8 percent solids
- The heat of combustion of varsol is 19,000 Btu/lb
- The specific heat of varsol is 0.5 Btu/lb-°F
- The latent heat of varsol is 180 Btu/lb
- Dryers go into a low fire mode (25 percent of normal average fuel requirement) during printing downtime.

8.1.1.3 Cost Effectiveness

Cost effectiveness is a common measure of the economic efficiency of a pollution control system and may be defined as the annualized cost of removing a unit of pollutant. The concept of cost effectiveness is valuable for comparing various proposed control options for a given industrial source with controls on other industrial sources. It can also serve as a tool in selecting a control option where a clearcut decision on the basis of plant affordability cannot be made.

Marginal cost effectiveness is a measure of the economic efficiency of additional increments of control. Because the alternatives under consideration in this study represent different control technologies rather than varying degrees of control within the same technology, the concept of marginal cost effectiveness is not directly applicable here. That is, a specific control technology cannot be selected by a plant operator strictly on the basis of capital and operating costs.

The cost effectiveness of the various control options applied to each of the three model plants is shown in Tables 8-5 through 8-7. The emissions reductions associated with Regulatory Alternatives II and III are attributable to changes in print paste formulation. In determining the control costs associated with these regulatory alternatives, it was assumed that the entire difference in annualized costs between the control option under consideration and the base case (Regulatory Alternative I) was the cost of the "control system."

The tables reveal that, while incineration (Regulatory Alternative IV) is relatively cost ineffective, reducing the organic solvent content of the print paste (Regulatory Alternatives II and III) results in a cost reduction. When the organic solvent content of the print paste is reduced, the drying cost increases, but this is more than offset by the lower cost of print paste.

8.1.2 Modified/Reconstructed Facilities

As was discussed in Chapter 6, Model Plant Number 3 represents a modified or reconstructed roller printing line. Modified or reconstructed screen printing lines will probably use the same control options as new printing lines. There will be no differences in costs if low-organic

TABLE 8-5. COST EFFECTIVENESS FOR CONTROL OPTIONS APPLIED TO MODEL PLANT 1

Regulatory alternative	Control cost (savings) above regulatory alternative I ($ thousands/yr)	Emission reduction from regulatory alternative I (Mg/yr)	Cost (savings) per unit of VOC removal ($ thousands/Mg)
II	(31)	94.8	(.33)
III	(63)	182.4	(.35)
IV	148	226.8	.65

TABLE 8-6. COST EFFECTIVENESS FOR CONTROL OPTIONS APPLIED TO MODEL PLANT 2

Regulatory alternative	Control cost (savings) above regulatory alternative I ($ thousands/yr)	Emission reduction from regulatory alternative I (Mg/yr)	Cost (savings) per unit of VOC removal ($ thousands/Mg)
II	0	0	---
III	(4)	14.9	(.27)
IV	121	27.0	4.48

TABLE 8-7. COST EFFECTIVENESS FOR CONTROL OPTIONS APPLIED TO MODEL PLANT 3

Regulatory alternative	Control cost (savings) above regulatory alternative I ($ thousands/yr)	Emission reduction from regulatory alternative I (Mg/yr)	Cost (savings) per unit of VOC removal ($ thousands/Mg)
II	(55)	173.5	(.32)
III	(77)	233.0	(.33)
IV	145	255.6	.57

solvent print pastes are used. Since most new facilities will be in the same buildings as existing printing lines, the capital and operating costs of add-on control systems also should be nearly identical.

8.2 OTHER COST CONSIDERATIONS

This section summarizes, to the extent possible, the cost impacts of requirements imposed on the fabric printing industry by other environmental regulations. Areas of other major regulations pertinent to fabric printing include water pollution, resource conservation and recovery, toxic substances control, occupational exposure to toxic and hazardous substances by employees, and air pollution.

8.2.1 The Clean Water Act

The fabric printing industry is generally subject to effluent discharge regulations imposed by the Federal Water Pollution Control Act Amendments of 1972, as amended by the Clean Water Act of 1977 ("the Act").[14] The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The objective is to be carried out through the development of effluent limitations both for new and existing facilities that discharge liquid directly into navigable waters. In addition, new and existing facilities that discharge to publicly owned treatment works (POTWs) are also to be subject to new pretreatment standards.

Estimates of compliance costs for Water Act regulations applying to the textile industry were published in EPA's Development Document for Effluent Limitations Guidelines and Standards for the Textile Mills Point Source Category.[15] Total investment costs for all of the proposed regulations (BCT, BAT, NSPS, PSES, PSNS) were estimated to be approximately $86 million. Associated annualized costs (including interest, depreciation, operation, and maintenance) were estimated to be approximately $40 million. As many as 39 plant closures with an associated loss of 6,290 jobs could result from complaince with these regulations. The contribution of fabric printing to the total amount of textile wastewater effluent is small; however, a plant with other preparation and finishing operations could incur a significant cost in complying with the proposed regulations.

8.2.2 The Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act was enacted by Congress in September 1976. In the spring of 1980 (February 26 and May 19), EPA issued final hazardous waste regulations to provide "cradle to grave" tracking of hazardous wastes from the point of generation to the point of disposal and for 30 years thereafter. EPA estimates that the cost to industry will be $16 million to $21 million per year plus about $7.3 million for filing the initial reporting forms that were due in August 1980.[16] The cost of compliance for the textile industry has not been determined.

8.2.3 Toxic Substances Control

The Toxic Substances Control Act (TSCA)[17] gives the EPA Office of Toxic Substances the authority to regulate the manufacture, importation, processing, use, and disposal of substances that present unreasonable risk to health or the environment. The only direct effect of TSCA on the fabric printing industry is on firms that manufacture their own chemicals. The impact of this regulation appears to be small.

8.2.4 Occupational Safety and Health Act

The responsibility of regulating contaminant levels within the plant working area belongs to the Occupational Safety and Health Administration (OSHA). Under Subpart Z,[18] Toxic and Hazardous Substances, permissible employee exposure limits are defined for numerous substances, some of which apply to the fabric printing industry, though mineral spirits are not specifically listed. Many regulations concerning specific chemicals and toxic substances are in the formative stage. No costs associated with meeting these regulations have been determined.

8.2.5 The Clean Air Act

Section 110 of the Clean Air Act[19] gives the individual states the responsibility for developing standards regulating air emissions from existing sources to insure attainment and maintenance of each national ambient air quality standard within each air quality control region. A Control Techniques Guideline (CTG) is presently being developed by EPA which will be used by the states in revising State Implementation Plans (SIPs). No costs of complying with these standards have been developed, though only fabric printing plants in nonattainment areas will be affected.

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DRAFT

9.1 INDUSTRY CHARACTERIZATION

9.1.1 General Profile

The textile printing industry is, by nature, inextricably tied to and a subset of the textile finishing industry. In addition to printing, most printing plants perform several textile finishing operations, generally incorporating the process steps of preparation (desizing, bleaching, mercerizing, etc.), decorative enhancement (dyeing, printing, plisseing, felting, etc.), and functional enhancement or finishing (permanent press, softening, soil resistence, etc.). Appendix A contains a list of plants in the United States that perform fabric printing. Appendix B contains a list of textile companies for which financial information is available.

Although the percentage of all finished fabrics that are printed varies from year to year, any production profile of textile printing should begin with an overall view of the textile finishing industry. The textile finishing industry consists largely of four Standard Industrial Classification codes (SICs): SIC 2261 (Finishing plants, cotton), SIC 2262 (Finishing plants, synthetic), SIC 2269 (Finishing plants, not elsewhere classified [NEC]), and SIC 2231 (Weaving and finishing mills, wool). Two of these, SICs 2261 and 2262, are dominant for this study and will be emphasized.

Data were collected and analyzed for cotton and manmade fiber broadwoven fabric, woven terry towels, and knit fabrics. Other fabrics (nonwoven, narrow, wool, etc.) were not included because they comprise an insignificant portion of the fabrics printed by the textile printing industry. For example, in 1977, less than 1 percent of total broadwoven fabric production was wool.[1] Narrow fabrics accounted for just over 3.5 percent of the total fibers consumed (by weight) in producing woven fabrics in 1977.[2] Nonwoven fabrics are weblike materials manufactured by bonding or interlacing of fibers. The main disposable nonwoven products are diapers, sanitary napkins, tampons, medical packs and gowns, industrial fibers, and industrial and consumer wipes,[3] none of which are printed. Tables 9-1, 9-2, and 9-3 present summaries of finished broadwoven goods production, knit fabric production, and woven terry towel production, respectively, for recent years.

TABLE 9-1. FINISHED BROADWOVEN FABRICS, COTTON AND MANMADE FIBER, 1963-1977[4]

Year	Finished linear yards (billion)			Year	Finished linear yards (billion)		
	Finished total[a]	Finished cotton	Finished manmade		Finished total[a]	Finished cotton	Finished manmade
1977	8.2	3.3	4.9	1969	9.7	5.2	4.5
1976	8.3	3.5	4.8	1968	10.9	6.5	4.4
1975	8.0	3.5	4.6	1967	10.7	6.9	3.8
1974	8.4	3.6	4.7	1966	11.0	7.4	3.6
1973	9.7	4.5	5.2	1965	11.0	7.7	3.3
1972	10.1	5.1	5.0	1964	10.5	7.5	3.0
1971	9.7	5.2	4.5	1963	10.1	7.4	2.7
1970	9.7	5.2	4.5				

[a]Figures may not add to total due to rounding.

TABLE 9-2. KNIT FABRIC PRODUCTION: 1967-1977[5]
(billions of pounds)

Year	Total fabric	Warp knits	Circular, weft, and other
1977	1.72	0.40	1.32
1976	1.83	0.39	1.44
1975	1.96	0.43	1.53
1974	2.01	0.43	1.58
1973	2.05	0.41	1.64
1972	1.73	0.47	1.26
1971	1.81	0.56	1.25
1970	1.29	0.50	0.79
1969	1.16	0.44	0.72
1968	1.11	0.46	0.65
1967	0.96	0.46	0.53

TABLE 9-3. WOVEN TERRY TOWEL PRODUCTION: 1967-1977[6]

Year	Terry woven towels (thousands of dozens)	Year	Terry woven towels (thousands of dozens)
1977	47,083	1971	45,319
1976	45,556	1970	46,599
1975	41,442	1969	47,039
1974	42,153	1968	48,863
1973	47,558	1967	48,276
1972	47,675		

Tables 9-1, 9-2, and 9-3 reveal some important characteristics of the textile finishing industry. Since the mid 1960s there has been a substantial decrease in the amount of cotton broadwoven fabric produced and a shift to manmade fiber fabrics. Knit fabric production, particularly circular knit fabric production, has shown strong growth since the "knitting revolution" of the late 1960s, which reflects the influence of fashion trends on industry production as well as significant technological developments. The effect of the economic recession of 1974-1975 is evident also; as noted in Tables 9-1, 9-2, and 9-3, production of all three classes of fabrics fell from pre-1974 levels.

In addition, Table 9-4 reveals some of these characteristics for broadwoven fabrics finished in SIC 2261 (Finishing plants, cotton) and SIC 2262 (Finishing plants, synthetic). In particular, Table 9-4 shows that finished cotton broadwoven fabric production declined from 5,628.2 million linear yards in 1967 to 3,518.7 million linear yards in 1977. Of this total, commission finishing of cotton broadwoven fabric dropped from 3,878.7 million linear yards in 1967 to 2,085.6 million linear yards in 1977; commission printing declined proportionally more--from 1,231.2 linear yards in 1967 to 626.3 in 1977.

The production of broadwoven finished fabrics of manmade and silk fibers increased, rather than decreased, from about 3,800 million linear yards in 1967 to 4,939 million linear yards in 1977. However, commission finishing of these fabrics actually declined slightly; most of the increase was in noncommission finishing. Printed fabric production increased from 1967 to 1977, but commission printing of fabric has declined since 1972.

Table 9-5 provides data for broadwoven printed fabrics, both cotton and manmade. The trend for printing is similar to that of the fabric finishing industry in general; printed broadwoven cotton fabric production declined sharply from 1967 to 1977, while production of printed broadwoven fabrics of manmade fibers increased from 1967 to 1972 and declined in 1977, but not to 1967 levels.

Table 9-6 provides additional data for the cotton and manmade finishing industries, which, when combined with Table 9-4 data, provide an overview of the structure of the textile fabric finishing industry in the aggregate for

TABLE 9-4. FINISHED COTTON, MANMADE AND SILK BROADWOVEN FABRICS, QUANTITY AND VALUE OF SHIPMENTS BY ALL PRODUCERS: 1977, 1972, AND 1967[7]

Product	1977 Product shipments, including interplant transfers		1972 Product shipments, including interplant transfers		1967 Product shipments, including interplant transfers	
	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value (million dollars)
Finishing plants, cotton--SIC 2261						
Total finished cotton broadwoven fabrics, including commission receipts for job finishing	(X)	699.3	(X)	959.4	(X)	1,087.9
Finished cotton broadwoven fabrics, excluding commission finishing	1,433.1	445.4	1,579.4	590.7	1,749.5	685.3
Printed and finished	43.7	16.4	156.5	65.8	200.8	85.2
Other	1,389.4	428.9	1,422.9	524.9	1,548.7	600.1
Commission finishing of cotton broadwoven fabrics	2,085.6	248.4	3,100.8	352.2	3,878.7	397.0
Printed and finished	626.3	72.1	911.8	117.8	1,231.2	148.9
Other	1,459.3	176.3	2,189.0	234.4	2,647.5	248.1

(continued)

TABLE 9-4 (continued)

Product	1977 Product shipments, including interplant transfers		1972 Product shipments, including interplant transfers		1967 Product shipments, including interplant transfers	
	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value (million dollars)
Finishing plants, manmade fiber and silk fabric--SIC 2262						
Total finished manmade fiber and silk broadwoven fabrics, including commission receipts for job finishing	(X)	2,096.8	(X)	1,492.3	(X)	1,022.7
Finished manmade fiber and silk broadwoven fabrics, excluding commission finishing	2,043.4	1,602.8	1,436.5	958.4	755.5	591.1
Printed and finished	149.8	117.2	94.2	90.9	20.7	20.2
Other	1,893.6	1,485.6	1,342.3	867.5	734.8	570.9
Commission finishing of manmade fiber and silk broadwoven fabrics	2,895.8	492.2	3,735.5	527.0	3,045.0	417.2
Printed and finished	712.0	173.9	1,161.4	197.3	562.9	97.9
Other	2,183.8	318.3	2,574.1	329.8	2,482.1	319.3

(X) = not collected.

[a]Value converted to 1967 dollars using Wholesale Price Indexes[8] and Producer Price Indexes.[9]

TABLE 9-5. PRINTED COTTON, MANMADE AND SILK BROADWOVEN FABRICS, QUANTITY AND VALUE OF SHIPMENTS BY ALL PRODUCERS: 1977, 1972, and 1967[7]

Product	1977 Product shipments, including interplant transfers		1972 Product shipments, including interplant transfers		1967 Product shipments, including interplant transfers	
	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value[a] (million 1967 dollars)	Quantity (mil. fin. lin. yd.)	Value (million dollars)
Printed broadwoven cotton fabrics	670.0	88.6	1,068.3	183.6	1,432.0	234.1
Noncommissioned	43.7	16.4	156.5	65.8	200.8	85.2
Commissioned	626.3	72.1	911.8	117.8	1,231.2	148.9
Printed broadwoven manmade and silk fabrics	861.8	291.2	1,255.6	288.2	583.6	118.1
Noncommissioned	149.8	117.2	94.2	90.9	20.7	20.2
Commissioned	712.0	173.9	1,161.4	197.3	562.9	97.9
Total Broadwoven printed fabrics	1,531.8	379.8	2,323.9	471.8	2,015.6	352.2

[a]Value converted to 1967 dollars using Wholesale Price Indexes[8] and Producer Price Indexes.[9]

TABLE 9-6. SELECTED INDUSTRY STATISTICS FOR SIC 2261 (FINISHING PLANTS, COTTON) AND SIC 2262 (FINISHING PLANTS, SYNTHETICS): 1977, 1972, 1967[10]

Year	All establishments: Total (number)	All employees: Number (1,000)	All employees: Payroll (million dollars)	Production workers: Number (1,000)	Production workers: Wages (million dollars)	Value[a] added by manufacture (million 1967 dollars)	Value[a] of shipments (million 1967 dollars)	New capital expenditures (million dollars)
SIC 2261, Finishing plants, cotton								
1977	213	22.9	231.8	19.1	179.3	169.3	380.3	63.3
1972	196	25.7	177.2	21.7	142.1	268.3	519.4	48.8
1967	216	35.7	193.0	30.0	148.6	313.8	893.9	27.4
SIC 2262, Finishing plants, synthetics								
1977	272	35.4	377.2	28.9	277.5	507.4	1,541.5	63.3
1972	259	35.2	263.2	29.5	200.7	434.6	1,137.7	48.8
1967	233	25.7	159.4	21.4	119.9	271.4	550.2	20.2

[a]Value converted to 1967 dollars using Wholesale Price Indexes[8] and Producer Price Indexes.[9]

the years 1967, 1972, and 1977. Tables 9-7 and 9-8 provide a geographical breakdown for the same years for SIC 2261 (Finishing plants, cotton) and SIC 2262 (Finishing plants, synthetic).

The total value of shipments for establishments included in SIC 2261 amounted to $380 million (base, 1967) in 1977, a decrease of 27 percent from the 1972 figure of $519 million (base, 1967). The value in 1972 indicated a 42 percent decrease from the 1967 value of $894 million. The value of shipments of products classified as primary in SIC 2261 was $699 million (base, 1967) in 1977, a decrease of 27 percent from the 1972 value of $959 million (base, 1967). The value in 1972 represented a 12 percent decrease from the 1967 value of $1,088 million. Value added by manufacture, at $169 million (base, 1967) in 1977, was 36 percent below value added in 1972. The value added by manufacture in 1972 was $266 million (base, 1967), a 15 percent decrease from the 1967 value of $314 million. All payroll, wage, and capital expenditure figures shown are in current dollars; therefore, they are not adjusted for changes in price levels.

In 1977, establishments classified in SIC 2261 had 22.9 thousand employees, a decrease of 11 percent from 25.7 thousand in 1972. The 1972 figure represented a decrease of 28 percent from 35.7 thousand employees in 1967. The leading states in employment were South Carolina, Massachusetts, Georgia, and North Carolina, accounting for approximately 70 percent of the industry's 1977 employment. These same states were in the forefront for 1972, when they accounted for approximately 68 percent of the industry's employment, although there has been some shift in the relative importance of individual states.

SIC 2261 includes establishments primarily engaged in finishing purchased cotton broadwoven fabrics or in finishing such fabrics on a commission basis. These finishing operations include bleaching, dyeing, printing (roller, screen, flock, plisse), and other mechanical finishing operations such as preshrinking, calendering, and napping. This industry also includes the shrinking and sponging of cloth for the trade and chemical finishing for water repellency, fire resistance, and mildew proofing.

The total value of shipments for establishments classified in SIC 2262 amounted to $1,542 million (base, 1967) in 1977, an increase of 36 percent over the 1972 value of $1,138 million (base, 1967). The 1972 value represented a sharp increase of 107 percent over the 1967 value of $550 million. The

TABLE 9-7. SELECTED FINISHING INDUSTRY STATISTICS, SIC 2261, GEOGRAPHICAL DISTRIBUTION, 1967, 1972, 1977[7] [a]

Geographic area	1977: All establishments: Total (number)	All establishments: With 20 employees or more (number)	All employees: Number (1,000)	All employees: Payroll (million dollars)	Production workers: Number (1,000)	Production workers: Wages (million dollars)	Value[b] added by manufacture (million 1967 dollars)	Value[b] of shipments (million 1967 dollars)	New capital expenditures (million dollars)
United States	213	99	22.9	231.8	19.1	179.3	169.3	380.3	39.0
New England Division									
Massachusetts	14	7	2.6	27.6	2.1	22.0	19.1	47.0	7.7
Middle Atlantic Division									
New Jersey	20	14	.9	11.8	.8	9.3	9.9	15.5	.8
South Atlantic Division									
North Carolina	15	10	2.1	20.1	1.8	15.5	15.5	44.2	2.1
South Carolina	17	16	9.1	90.5	7.8	72.2	65.1	168.2	15.9
Georgia	11	9	2.3	19.1	1.9	14.0	12.9	29.0	1.9
All other states	136	43	5.9	62.7	4.7	46.3	46.8	76.3	10.6

Geographic area	1972: All establishments: Total (number)	All establishments: With 20 employees or more (number)	All employees: Number (1,000)	All employees: Payroll (million dollars)	Production workers: Number (1,000)	Production workers: Wages (million dollars)	Value[b] added by manufacture (million 1967 dollars)	Value[b] of shipments (million 1967 dollars)	New capital expenditures (million dollars)	1967: All employees (1,000)	1967: Value added by manufacture (million dollars)
United States, total	190	114	25.7	176.7	21.7	141.3	265.5	518.0	32.4	35.7	313.8
Northeast Region	105	56	6.2	50.1	5.3	38.8	76.3	162.2	6.2	7.8	71.4
New England Division	30	18	3.0	23.8	2.5	17.7	34.8	92.8	3.8	4.2	35.6
Massachusetts	13	8	2.1	16.5	1.7	12.5	22.7	69.4	1.5	2.3	20.1
Middle Atlantic Division	75	38	3.2	26.3	2.8	21.1	41.4	69.4	2.4	3.6	35.7
New York	38	20	1.6	13.5	1.3	10.6	21.3	35.8	.6	1.8	15.7
New Jersey	25	14	1.3	10.7	1.2	8.8	12.5	19.3	1.6	1.2	13.2
Pennsylvania	12	4	.3	2.1	.3	1.7	7.7	14.3	.1	.7	6.8
South Region	65	52	18.7	122.9	16.1	100.3	183.5	343.0	25.6	27.4	236.6
North Carolina	19	17	5.0	33.1	4.1	26.6	48.7	84.2	5.2	5.3	46.8
South Carolina	16	14	8.6	59.3	7.5	49.2	94.9	156.2	12.5	14.7	132.1
Georgia	6	6	1.9	11.2	1.7	9.0	15.1	34.5	(D)	2.3	17.9
Florida	4	2	.1	1.0	.1	.6	1.7	2.3	(D)	(NA)	(NA)

(NA) = Not available.

(D) - Withheld to avoid disclosing figures for individual companies.

[a]Each producing state not shown separately in the above table was withheld either (a) to avoid disclosing figures for individual companies in this or associated industries or areas or (b) because the industry was of relatively minor economic importance in the state.

[b]Value converted to 1967 dollars using Wholesale Price Indexes[8] and Producer Price Indexes.[9]

TABLE 9-8. SELECTED FINISHING INDUSTRY STATISTICS, SIC 2262, GEOGRAPHICAL DISTRIBUTION, 1967, 1972, 1977[7] [a]

Geographic area	1977: All establishments: Total (number)	1977: All establishments: With 20 employees or more (number)	1977: All employees: Number (1,000)	1977: All employees: Payroll (million dollars)	1977: Production workers: Number (1,000)	1977: Production workers: Wages (million dollars)	1977: Value[b] added by manufacture (million 1967 dollars)	1977: Value[b] of shipments (million 1967 dollars)	1977: New capital expenditures (million dollars)
United States	272	184	35.4	377.2	28.9	277.5	507.4	1,541.5	63.3
New England Division									
Massachusetts	16	12	2.0	23.3	1.6	17.6	27.3	43.6	.5
Rhode Island	8	7	1.1	12.2	.9	9.2	12.6	22.9	1.6
Middle Atlantic Division									
New York	45	27	2.0	22.4	1.7	16.8	27.4	59.3	3.2
New Jersey	49	42	3.3	46.2	2.7	37.0	51.1	93.2	7.2
Pennsylvania	16	6	.6	6.3	.4	4.7	5.9	12.5	.4
South Atlantic Division									
North Carolina	34	30	7.7	79.1	6.1	57.3	146.1	339.2	10.2
South Carolina	17	16	9.3	91.7	7.7	68.6	109.1	540.0	(D)
All other states	87	44	9.4	96.0	7.8	66.3	127.8	430.6	(D)

Geographic area	1972: All establishments: Total (number)	1972: All establishments: With 20 employees or more (number)	1972: All employees: Number (1,000)	1972: All employees: Payroll (million dollars)	1972: Production workers: Number (1,000)	1972: Production workers: Wages (million dollars)	1972: Value[b] added by manufacture (million 1967 dollars)	1972: Value[b] of shipments (million 1967 dollars)	1972: New capital expenditures (million dollars)	1967: All employees (1,000)	1967: Value added by manufacture (million dollars)
United States, total	255	188	35.2	263.0	29.4	200.5	419.5	1,115.4	51.7	25.7	271.4
Northeast Region	172	130	16.0	135.5	13.5	103.6	197.3	307.8	17.6	AA	(D)
New England Division	54	43	7.7	59.1	6.3	43.3	92.8	142.8	9.9	AA	(D)
Massachusetts	25	21	3.6	28.4	2.9	20.0	44.5	67.0	5.3	BB	(D)
Rhode Island	13	11	1.6	12.0	1.3	9.1	15.3	28.8	.7	1.8	17.5
Middle Atlantic Division	118	87	8.3	76.3	7.2	60.3	104.6	165.0	7.8	8.7	98.8
New York	47	28	2.5	18.2	2.2	13.9	22.8	36.7	2.3	2.1	22.2
New Jersey	57	48	4.8	50.6	4.1	40.5	72.9	109.7	3.0	6.0	69.0
Pennsylvania	14	11	1.1	7.5	.9	5.8	8.8	18.6	2.4	.7	7.6
North Central Region	6	2	.1	1.0	.1	.4	1.6	2.8	-	-	-
South Region	64	52	18.7	123.8	15.6	94.7	215.1	796.4	33.3	10.6	105.6
North Carolina	21	20	4.9	33.3	4.0	23.7	60.2	173.3	9.3	4.5	46.5
South Carolina	16	15	9.7	65.0	8.3	51.0	103.7	465.1	13.6	AA	(D)
West Region	13	4	.3	2.8	.2	1.8	5.6	8.5	.7	CC	(D)

(D) - Withheld to avoid disclosing figures for individual companies.

[a] General statistics for some producing states have to be withheld to avoid disclosing figures for individual companies. However, for some states, the employment size range for 1967 is indicated by one of the following symbols:

AA 2,500 employees and over
BB 1,000 to 2,499 employees
CC 500 to 999 employees

[b] Value converted to 1967 dollars using Wholesale Price Indexes[8] and Producer Price Indexes.[9]

value of shipments of products classified as primary in SIC 2262 was $2,097 million (base, 1967) an increase of 41 percent from the 1972 value of $1,492 million (base, 1967). The 1972 value represented an increase of 46 percent over the 1967 value of $1,023 million. Value added by manufacture, at $507 million (base, 1967) in 1977, was 17 percent above value added in 1972. The 1972 value added was $435 million (base, 1967), an increase of 61 percent over the 1967 value of $271 million. All payroll, wage, and capital expenditure figures shown are in current dollars; therfore, they are not adjusted for changes in price levels.

In 1977, establishments classified in SIC 2262 had 35.4 thousand employees, an increase of less than 1 percent from 35.2 thousand in 1972. The 1972 employment figure was 37 percent higher than that in 1967 (25.7 thousand). The leading states in employment were South Carolina, North Carolina, Virginia, and New Jersey, accounting for approximately 70 percent of the industry's 1977 employment. Data for Virginia have been withheld to avoid disclosing operations of individual companies.

SIC 2262 includes establishments primarily engaged in finishing purchased manmade fiber and silk broadwoven fabric or in finishing such fabrics on a commission basis. These finishing operations include bleaching, dying, printing (roller, screen, flock, plisse), and other mechanical finishing operations such as preshrinking, calendering, and napping.

For purposes of comparison, it is useful to have production of finished fabrics in square yards (yd^2). In order to estimate true total production (yd^2), information is needed for broadwoven fabric, which documents width of fabric processed, and for knit fabric, which relates pounds to yd^2. Data on the width and weight of broadwoven (gray) fabrics are documented in a special Bureau of the Census report for the first quarters of selected years.[11] It is assumed that widths did not change for subsequent quarters of the years reported. Table 9-9 shows calculations of total production (yd^2) for years for which explicit width data are available.

The adjusted production figures in Table 9-7 reveal that the decline in broadwoven fabric production is not as severe as might be calculated from linear production figures. The real decline for broadwoven fabric between 1968 (one of the industry's best years) and 1977 is 19 percent, not the 25 percent that would be calculated from linear production.

TABLE 9-9. FINISHED BROADWOVEN FABRIC PRODUCTION FOR SELECTED YEARS[4, 11]

Year	Cotton			Manmade			
	Average width (yd)	Linear production (10^9 yd)	Total production (10^9 yd^2)	Average width (yd)	Linear production (10^9 yd)	Total production (10^9 yd^2)	Total production (10^9 yd)
1977	1.25	3.3	4.13	1.57	4.9	7.69	11.82
1972	1.28	5.1	6.53	1.51	5.0	7.55	14.08
1968	1.30	6.5	8.45	1.40	4.4	6.16	14.61
1963	1.22	7.4	9.03	1.38	2.7	3.73	12.76

Data relating pounds to yd^2 for knit fabric are not presented in any government publication. With information obtained directly from industrial plants and through industry and marketing sources, a ratio relating pounds to yd^2 for knit fabrics was derived. The ratio was derived by multiplying average width (61 in) by the average linear yards per pound (1.72). The resulting ratio is 2.91 yd^2/lb. Assuming this ratio to be constant for recent years, Table 9-10 is an adjusted compilation of knit fabric production.

Converting knit fabric production to a yd^2 basis allows us to compare it to total broadwoven fabric production. Knits in 1977 amounted to about 30 percent of total fabric production. This compares to about 18 percent in 1968 and 26 percent in 1972, if it is assumed that the amount of unfinished knit fabric imported equals the amount of unfinished knit fabric exported.

Overall, the total square yardage of finished knit and broadwoven fabric for 1977 has declined about 6 percent since the high production year of 1968 (16.83 billion yd^2 in 1977 vs 17.84 billion yd^2 in 1968). The decline is probably due to the slow recovery from the 1974-1975 recession and to competition with finished imports. However, knits have increased their share of the fabric market since the late 1960s, with some recent declines. Textured woven fabrics, essentially stretch wovens (mostly polyester), behave and feel more like knits than do traditional wovens and should compete with knits. Another factor of importance is the amount of finishing performed per unit fabric. To the degree that more finishing is done per unit fabric than 10 years ago, one would expect increased finishing activity to mitigate partially the overall decline in square yardage of finished fabric over the last 10 years.

Woven terry towel production has increased since 1968 to about 47 to 48 million dozen towels per year; however, considerable fluctuation exists.

The data from Table 9-5 and the conversion factors in Table 9.9 can be used to estimate average prices per square yard for printed broadwoven cotton and manmade and silk fabrics, simply by dividing the dollar value of shipments by the quantity of shipments. The Census of Manufacture[7] does not report data on printed knit fabric, though information is published on finished warp knit fabric (1977 product code 2251 00). The data on dollar value of shipments and quantity of shipments (converted from pounds to square yards using the conversion factor presented above) can be used to derive estimates of the average prices per square yard for finished warp knit fabric. Table 9-11 presents

TABLE 9-10. KNIT FABRIC PRODUCTION, 1967-1977[2]

Year	Total (10^9 lb)	Total (10^9 yd^2)	Year	Total (10^9 lb)	Total (10^9 yd^2)
1977	1.72	5.01	1971	1.81	5.27
1976	1.83	5.33	1970	1.29	3.75
1975	1.96	5.70	1969	1.16	3.38
1974	2.01	5.85	1968	1.11	3.23
1973	2.05	5.97	1967	0.96	2.79
1972	1.73	5.03			

TABLE 9-11. ESTIMATED AVERAGE PRICES FOR PRINTED BROADWOVEN FABRIC AND FINISHED KNIT FABRIC

Product	1977 Product shipments, including interplant transfers: Quantity (mil. fin. sq. yd.)	1977: Value (million 1967 dollars)	1977: Unit price (1967 dollars per fin. sq. yd.)	1972 Product shipments, including interplant transfers: Quantity (mil. fin. sq. yd.)	1972: Value (million 1967 dollars)	1972: Unit price (1967 dollars per fin. sq. yd.)
Printed broadwoven cotton fabrics	837.5	88.6	.11	1,367.4	183.6	.13
Printed broadwoven manmade and silk fabrics	1,353.0	291.2	.22	1,896.0	288.2	.15
Finished warp knit fabric	1,199.2	816.3	.68	1,009.2	690.0	.68

Product	1967 Product shipments, including interplant transfers: Quantity (mil. fin. sq. yds).	1967: Value (million dollars)	1967: Unit price (dollars per fin. sq. yd.)
Printed broadwoven cotton fabrics	1,847.3	234.1	.13
Printed broadwoven manmade and silk fabrics	817.0	118.1	.14
Finished warp knit fabric	669.3	413.0	.62

estimates of the average prices of printed broadwoven cotton and manmade and silk fabrics and of finished warp knit fabric for the years 1977, 1972, and 1967.

9.1.1.1 Production of Printed Fabric. The estimate of total printed fabric production is the sum of the production of its two components: printed broadwoven and printed knit. Printed terry production is presented separately because its units of measure (dozens) are not compatible with those for printed broadwoven and printed knit fabrics (yd^2 and lb).

9.1.1.1.1 Broadwoven fabric. Data on average weight and width of broadwoven fabric are presented in a Bureau of the Census report for the first quarters of the years 1963, 1968, 1972, and 1977.[11] In order to estimate accurately the production of printed broadwoven fabric (yd^2 and lb) for years other than those explicitly stated, linear interpolation was used to derive the average width and weight per unit length for cotton and manmade fiber fabrics. These results are presented in Table 9-12. Caution should be exercised for the estimates for years other than 1963, 1968, 1972, and 1977, since there is some fragmentary evidence that suggests that the changes from year to year are not always linear. However, linear interpolation should provide a reasonable picture of the overall pattern of change.

The shift to manmade fiber fabrics becomes more important when the average fabric width is taken into account for both types of fabric. Not only has there been a shift to manmades, but also the average width of these fabrics has risen about 7 inches since 1963, as compared to a small increase of about 1 inch in the width of cotton broadwoven fabric.

The data in Table 9-12 can be used to calculate the production of printed broadwoven fabric for the years since 1963. Table 9-13 is a compilation of broadwoven fabric printed by roller and screen methods for the years 1964 through 1977. Table 9-14 provides the basis for part of Table 9-10 and also provides data on printed broadwoven fabric by fiber origin as well as machine type. Table 9-15 provides estimates of the number of roller and screen printing machines in place in the United States for the years 1963, 1965, 1973, and 1979. It is surprising to note that the total number of machines has not changed appreciably over the years (741 to 778), while the composition of machines in place has changed considerably. The clear trend is toward rotary screen printing machines and away from flat screen and roller printing machines.

TABLE 9-12. AVERAGE WEIGHT AND WIDTH OF BROADWOVEN FABRICS[11]

	Cotton		Manmade	
Year	Average width (in)	lb/yd	Average width (in)	lb/yd
1977	45.2	0.432	56.4	0.437
1976	45.4	0.434	55.9	0.433
1975	45.5	0.435	55.5	0.428
1974	45.6	0.436	55.1	0.423
1973	45.8	0.437	54.7	0.419
1972	45.9	0.439	54.3	0.414
1971	46.2	0.424	53.3	0.408
1970	46.4	0.409	52.4	0.401
1969	46.6	0.397	51.4	0.395
1968	46.8	0.383	50.4	0.388
1967	56.3	0.377	50.3	0.382
1966	45.7	0.370	50.1	0.376
1965	45.2	0.364	50.0	0.371
1964	44.6	0.358	49.8	0.365
1963	44.1	0.352	49.6	0.359

TABLE 9-13. PRODUCTION OF BROADWOVEN PRINTED FABRIC BY ROLLER AND SCREEN, 1964-1977[4]
(millions)

Year	Roller		Screen		Total	
	yd	yd^2	yd	yd^2	yd	yd^2
1978	1,084	1,553	869	1,340	1,953	2,893
1977	1,085	1,550	820	1,254	1,905	2,804
1976	1,140	1,620	816	1,239	1,956	2,859
1975	1,320	1,875	799	1,210	2,119	3,085
1974	1,315	1,863	635	956	1,950	2,819
1973	1,665	2,331	712	1,060	2,377	3,391
1972	1,622	2,234	670	988	2,292	3,222
1971	1,587	2,145	570	822	2,157	2,967
1970	1,468	1,979	394	558	1,862	2,537
1969	1,675	2,246	320	442	1,995	2,688
1968	1,715	2,284	284	386	1,999	2,670
1967	1,721	2,271	217	291	1,938	2,562
1966	1,783	2,320	201	267	1,984	2,587
1965	1,713	2,198	199	259	1,912	2,457
1964	1,734	2,201	232	301	1,966	2,502

TABLE 9-14. PRODUCTION OF PRINTED BROADWOVEN FABRICS, BY FIBER AND MACHINE TYPE (millions of linear yards)[4, 12]

Year	Cotton			Manmade fiber			Total printed			Percent of total finished woven fabrics
	In-taglio	Screen and other[a]	Total	In-taglio	Screen and other[a]	Total	In-taglio	Screen and other[a]	Total	
1968	1,188	122	1,310	527	162	689	1,715	284	1,999	18
1969	1,089	112	1,201	586	208	794	1,675	320	1,995	19
1970	942	90	1,032	526	304	830	1,468	394	1,862	19
1971	1,032	110	1,142	555	460	1,015	1,587	570	2,157	22
1972	914	102	1,016	708	569	1,277	1,622	671	2,293	23
1973	804	89	893	861	623	1,484	1,665	712	2,377	24
1974	570	61	631	745	574	1,319	1,315	635	1,950	23
1975	576	78	654	744	721	1,464	1,320	799	2,119	26
1976	506	93	599	634	723	1,357	1,140	816	1,956	23
1977	476	100	576	609	720	1,329	1,085	820	1,905	23
1978	483	97	580	601	772	1,373	1,084	869	1,953	22
1979	---	---	528	---	---	1,206	---	---	1,738	20

[a] Includes screen prints (hand or automatic), relief roller, block, or stencil printed fabrics. Excludes "unit" screen printed towels, tablecloths, etc., flock, plisse, moire, or embossed goods.

TABLE 9-15. U.S. ROLLER AND SCREEN PRINTING MACHINES IN PLACE FOR SELECTED YEARS[13 14 15][a b]

	1963	1965	1973	1979
Roller printing machines	460	450	394	249
Screen printing machines				
Flat bed, screen	310	300	211	152
Flat bed, rotary screen	---	20	136	377
Total	770	750	741	778

[a]The number of machines for 1979 was estimated by multiplying the percentage of machines in each category reported in Reference 9 by the number of screen and roller print machines imported in Reference 10.

[b]Does not include carpet equipment.

The data in Table 9-13 reveal the decline in the importance of the roller print machine since the introduction of the rotary screen in the early 1960s. Although fabric widths have increased, the total yd^2 amount of roller printed broadwoven fabric has declined about 30 percent since 1964. Screen printers (flat and rotary) now fill about 45 percent of broadwoven print production, compared to 12 percent in 1964. Overall, there was a decline of about 20 percent in total printed broadwovens between 1973 and 1977. Slow recovery from the 1974-1975 recession, increased imports of finished fabrics and apparel, and increasing amounts of transfer printed fabrics are all probable reasons for the decline.

9.1.1.1.2 Printed knit fabric. The amount of knit fabric that is printed each year is not documented by the Bureau of the Census as is the amount of broadwoven fabric printed. So as to estimate the amount of knit fabric printed by roller and screen methods, a survey was conducted of the literature and of marketing and industry sources. Literature sources revealed no data on industry wide printing; i.e., most information pertains to one type of printed knit product for individual years (men's shirts, women's apparel, etc.). Estimates obtained from ATMI[16] indicate that an average of between 5 and 10 percent of total knit production is printed by roller and screen methods. Assuming 10 percent of total knit production is printed and applying the ratios used in obtaining the data presented in Table 9-10, the values of printed knit production by roller and screen methods presented in Table 9-16 were estimated.

Inferences for years prior to 1974 must be taken somewhat cautiously, however. Because of the assumptions inherent in Table 9-16, the figures presented are arithmetically proportioned to total knit fabric production figures presented in Table 9-10. Another assumption basic to Table 9-16 is that the relative proportion of printed knit finished on roller and screen machines is roughly 30:70. This proportion is a "rule of thumb" and is suggested by the number of machines in place as given in Table 9-15.

9.1.1.2 Production of Printed Woven Terry Towels. The amount of woven terry towels printed each year is reported by the Bureau of the Census.[6] The printed totals, reported as "fancies," were initially reported in 1971. Table 9-17 shows the amount of woven terry towel printed for recent years.

TABLE 9-16. PRINTED KNIT FABRIC PRODUCTION BY ROLLER AND SCREEN METHODS[175]
(millions)

Year	Roller			Screen			Total		
	yd	yd^2	lb	yd	yd^2	lb	yd	yd^2	lb
1977	89	150	52	207	351	120	296	501	172
1976	95	160	55	220	373	128	315	533	183
1975	101	171	59	236	399	137	337	570	196
1974	104	176	60	242	409	141	346	585	201
1973	106	179	62	247	418	143	353	597	205
1972	89	151	52	209	352	121	298	503	173
1971	93	158	54	218	369	127	311	527	181
1970	67	113	39	155	262	90	222	375	129
1969	60	101	35	140	237	81	200	338	116
1968	57	97	33	134	226	78	191	323	111
1967	50	84	29	115	195	67	165	279	96

TABLE 9-17. PRINTED WOVEN TERRY TOWEL PRODUCTION: 1971-1977[6]
(thousands of dozens)

Year	Amount	Year	Amount
1977	16,021	1973	15,885
1976	16,407	1972	15,178
1975	15,304	1971	12,838
1974	12,774		

9.1.1.3 Utilization of Production Capacity. As defined by the Bureau of the Census, practical capacity means the greatest level of output the plant could achieve within the framework of a realistic work pattern. The preferred capacity is the intermediate level of operations between actual operations and practical capacity which the manufacturer would prefer not to exceed due to cost or other considerations.[18] During 1977, the broadwoven fabric finishing industry operated at an average of 77 percent of preferred capacity. Finishers of cotton broadwoven fabric (SIC 2261) operated at 99 percent of capacity, while finishers of manmade fiber and silk broadwoven fabrics (SIC 2262) operated at 96 percent of capacity.[18] The capacity utilization rate of the broadwoven fabric finishing industry was 97.7 in 1976[19] and 91.1 in 1975.[20] Table 9-18 shows the printed broadwoven fabric production capacity for 1975, 1976, and 1977 implied by the capacity utilization data and the production data for SICs 2261 and 2262. Information received from printers of terry towels indicates that utilization of unit-print flat bed, flat screen machine capacity is significantly lower than these rates. One plant reports a capacity utilization rate of only 57.2 percent during 1979.[21] A second plant was estimated to be operating at just over 60 percent of capacity, based on reported hours of operation.[22] Capacity utilization of unit-print flat bed, flat screen machines is assumed to be 64 percent.

9.1.2 Trends

9.1.2.1 Historical Trends. Most of the important trends in the textile fabric finishing (and textile fabric printing) industry have been presented previously. Table 9-19 is a compilation of total wet (roller and screen) printed fabric production of broadwoven and knit manmade fiber and cotton fabrics from 1967 through 1977.

Although the overall production of printed fabrics has been depressed since 1972 and 1973, it has still seen an average annual arithmetic increase of about 2.4 percent since 1967 ($3,205 \times 10^9 yd^2$ for 1967 vs $3,990 \times 10^9 yd^2$ for 1977). The slow period since 1973 is indicative of the strong influences that fashion trends and the general economic situation have on the total amount of fabric printed. These factors work both ways and are also cited as reasons for the big surge in 1972 and 1973.

TABLE 9-18. ANNUAL PRODUCTION, CAPACITY UTILIZATION, AND IMPLIED PRODUCTION CAPACITY, BY SIC, OF THE BROADWOVEN FABRIC PRINTING INDUSTRY: 1975, 1976, 1977[4, 18, 19, 20]

Year	SIC		Printed fabric production (millions of linear yards)	Capacity utilization (%)	Implied production capacity (millions of linear yards)
1975	2261		654	85	769
	2262		1,464	94	1,557
		Total	2,118	91[a]	2,326
1976	2261		599	97	618
	2262		1,357	98	1,385
		Total	1,956	98[a]	2,003
1977	2261		576	99	582
	2262		1,329	96	1,384
		Total	1,905	97[a]	1,966

[a]Average

TABLE 9-19. PRINTED FABRIC PRODUCTION BY PROCESS, EXCLUDING TERRY TOWELS, 1967-1977[23] (millions)

Year	Roller yd^2	Screen yd^2	Total yd^2	Screen share of total (%)
1977	1,700	1,605	3,305	48.6
1976	1,780	1,612	3,392	47.5
1975	2,046	1,609	3,655	44.0
1974	2,039	1,365	3,404	40.1
1973	2,510	1,478	3,988	37.1
1972	2,385	1,340	3,725	36.0
1971	2,303	1,191	3,494	34.1
1970	2,092	820	2,912	28.2
1969	2,347	679	3,026	22.4
1968	2,381	612	2,993	20.5
1967	2,355	496	2,851	17.4

Table 9-5 provides printed broadwoven fabric shipment quantities and values; the trend in these variables has been a decline since 1967 for printed cotton broadwovens and an increase over that time period for printed broadwoven manmade (fiber) fabrics. Production of both cotton and manmade printed broadwovens has declined since 1972, but most of this decline is attributable to the severe economic downturn of 1974-1975, from which many sectors of the textile industry have not yet recovered.

Table 9-13 provides production of broadwoven printed fabric from 1964 through 1977 for both roller and screen (rotary and flat) printing. Roller printing of broadwoven fabrics has steadily declined from 1964 to 1977, particularly since 1973, while screen printing of broadwovens increased dramatically over that time period, from slightly over 300 million yd^2 in 1964 to over 1,250 million yd^2 in 1977. The trend toward screen printing, particularly rotary screen printing, is expected to continue.

Similar trends are shown in Table 9-14, while Table 9-15 shows the strong trend toward increased numbers of screen printing machines, especially rotary screen machines, and the sharp decline in the numbers of roller (intaglio) printing machines. Table 9-16 shows the trend toward increased printing of knit fabrics subsequent to the introduction of rotary screen printing machines in the mid 1960s and up to the decline attributable to the 1974-75 recession.

The nation's fabric printers are located primarily in the states along the Atlantic seaboard. The industry originated in New England and, later, in the Middle Atlantic States. The most recent growth has been in the Southeast (Alabama, Georgia, South Carolina, North Carolina, and Virginia). The older and smaller producers in New England and the Middle Atlantic States are predominantly roller printers, while printers in the Southeast rely mostly on the rotary and flat bed screen machines. Similarly, printers in the Southeast overwhelmingly use pigment pastes, while printers in the Middle Atlantic States and in New England use more nearly equal amounts of pigments and dye print pastes. Table 9-20 summarizes the geographic distribution of printers, machines, and print pastes used.

The tremendous production capacity of printers in the Southeast is highlighted by the data in Table 9-20. The printers in the Southeast comprise less than half of the nation's total printers and produce two-thirds of the nation's output. Industry sources agree that the bulk of the U.S. productive

TABLE 9-20. DISTRIBUTION OF PRINTING IN THE UNITED STATES (1976)[24]

	Printers	Production		Machine type		Print paste type	
		10^6 yd	(%)	Roller (%)	Screen (%)	Pigment (%)	Dye (%)
New England	26	455	17	62	38	59	41
Middle Atlantic	34	400	15	51.5	48.5	56	44
Southeast	53	1,780	67	45	55	79	21
Midwest and West	2	13	1	0	100	77	23
Total	115	2,648	100	48.5	51.5	72	28

capacity has shifted from smaller, decentralized operations in New England and the Middle Atlantic States to larger, more centralized operations in the Southeast. The reason most often cited for this shift is that the intense competition in the market favors large printers because of the greater economy of large-scale production. Further, most industry sources and state regulatory agency officials agree that the trend will continue and that most growth will be in the Southeast.[17]

9.1.2.1 Future Trends. Despite year-to-year fluctuations, the long-term outlook for growth possibilities is good. Most surveys of knitting industry leaders yield optimistic predictions for slow but sustainable growth in printed fabric production through the 1980s.[25 26 27 28] A textile chemical market report predicts growth rates ranging from 7.2 percent to 8.3 percent per year for the processing, finishing, and dyeing chemical market for the period 1975-1985.[29] More specifically, another production study predicts that total linear printed fabric production will reach 3.6 billion yards by 1981.[30] If 15 percent of that total is assumed to be transfer printed, the remaining wet printed fabric production would be 3.06 billion linear yards in 1981, amounting to an increase of better than 4 percent per year over 1977 linear yard production.

Industry sources responding to the above estimates are not generally as optimistic. Many are skeptical of market and production studies and see growth at about 1.0 percent.[16] This growth rate is based on estimates made by the marketing divisions of several companies in the industry and is supported by data on past production. Therefore it is assumed that average annual growth of domestic printed fabric production (excluding terry) will be 1.0 percent (simple, 1977 base) through 1986.

Printed woven terry towel production (see Table 9-17) has shown a strong surge since the low production year of 1974. Production is currently running ahead of pre-1974 levels, and it appears that moderate but steady growth will continue. The average annual arithmetic growth rate since 1971 is almost 4 percent. This figure reflects good years in 1977 and 1976, and a more reasonable estimate of annual growth of printed terry towel production is 3.0 percent.

Table 9-19 lists the percent of the total printed fabric market that is screen printed. The dramatic increase in the screen method's share of the market is the result of the introduction of rotary screen machines in the early 1960s. Industry sources feel that the market share for screen machines has almost peaked and will level off in the future. The reason for small change from the current screen and roller shares lies in the advantages each machine has over the other.

Rotary screen's principal attractions are that (1) it uses less costly screens (compared to engraved copper rollers); (2) it has the ability to print very wide material (up to 130 inches); (3) it accommodates longer pattern repeats (22 to 46 in) because rotary screen circumferences are greater than roller circumferences; (4) it is easier to use for knit fabrics; and (5) it is easy to operate. These advantages make printing of wide fabrics with large repeats favorable for rotary screen machines. Thus, sheeting, upholstery, and domestics (curtains, drapes, etc.) are printed predominantly by the rotary screen method.

Roller is expected to hold its share fairly well in the future because of its advantages over screen, which are that (1) it is more cost effective for long runs; (2) it makes a sharper mark and a finer line; (3) it has a more accurate register, or fit; (4) it is capable of finer gradations of tone; and (5) it results in smoothness of blotch prints. These advantages (most of which are directly dependent on the use of mineral spirits) give roller the predominant share of the apparel market. Thus, unless major breakthroughs occur in rotary screen performance, rollers will probably level off at 43 to 48 percent of the wet printed market.

No new plant construction is expected in the next 5 years. Increases in capacity are expected to be achieved through the addition in existing plants of new or reconstructed printing lines or through the modification of an existing printing line. Because of the high capacity utilization rates in broadwoven fabric finishing plants (97 percent in 1977), it is assumed that all rotary screen and roller printing production increases in the 5 years after the assumed proposal of an NSPS in 1981 will be accommodated by new printing lines. Existing flat bed, flat screen unit printing capacity should be sufficient to accommodate the projected increase in printed terry towel production. However, the estimated life of a rotary screen or flat bed, flat screen print machine is 20 years[31]; therefore, 5 percent (simple, 1977 base) of existing screen print capacity should require replacement each year. The expected life of a roller print machine is 60 to 75 years and usually there are used machines on the market because of plant closings; hence, it is assumed that no existing roller printing lines will be replaced with new equipment. However, roller print machines are being widened to accommodate the increased width of synthetic broadwoven fabrics.[16] It is assumed that the modification rate of roller print machines is 5 percent (simple, 1977 base) per year.

Even though imports (and exports) of textile and apparel products have not been discussed previously, foreign trade in textiles and apparel may well be the single most important issue facing these industries in the future. The massive increase in textile and apparel imports over the years is well known, and the threat to the existence of significant portions of the domestic industry is now well recognized. Recent increases during 1979 of textile and apparel exports from the United States (due both to a declining dollar and to a vastly increased export effort by domestic producers) has stemmed the tide of unfavorable trade balances temporarily, but the future is nonetheless uncertain. Furthermore, in light of increased costs of production (due to regulation, inflation, and stagnant labor productivity), of the financial crisis (especially of working capital) in the textile industry, and of continued low profits in the textile industry, the future of the industry may well rest with its ability to cope with the problems of foreign trade. The following discussion is compiled from industry publications.[32 33 34]

Table 9-21 displays U.S. imports of cotton textile manufactures (millions of equivalent square yards) by calendar year, grouped into yarns, fabrics, apparel, and made-up and miscellaneous. Table 9-22 presents this information for man-made fiber textile manufactures. These data are summarized in Table 9-23. U.S. imports of textile fabrics and apparel in 1979 were 13 percent below 1978 on a square yard equivalent (SYE) basis. It should be remembered, however, that 1978 was a record year for imports of textile fabrics and apparel. On an SYE basis, imports for calendar 1978 were 15 percent above 1977 levels and were the highest since 1972. Fabric imports were up 30 percent; apparel imports rose 17 percent. With the economic climate in 1979 and the high level of imports in 1978 as a basis for comparison, it is then not surprising that

TABLE 9-21. U.S. IMPORTS OF COTTON TEXTILE MANUFACTURERS[34] (millions of equivalent square yards)

Group	1970	1971	1972	1973	1974	1975	1976[a]	1977[a]	1978	1979	1980 Jan-Mar
Yarns[b]	95.9	127.5	158.9	103.2	53.2	44.9	104.5	53.0	122.0	48.5	7.8
Fabrics	624.2	678.5	911.2	847.0	779.3	569.7	945.1	643.4	920.7	695.8	181.4
Apparel[b]	477.8	497.8	545.0	448.9	448.8	540.4	692.4	760.8	941.8	932.8	255.9
Made-up and miscellaneous[b]	338.9	304.7	238.8	193.8	181.2	125.9	181.6	181.5	228.8	213.7	57.4
Total	1,536.8	1,611.2	1,853.8	1,592.9	1,462.5	1,280.9	1,923.7	1,639.0	2,213.3	1,890.8	502.5

[a]Data revised to conform with new 1978 textile and apparel category system.
[b]U.S. Department of Commerce conversion factors used to convert units to square yard equivalent.

NOTE: Product groups may not add to total due to rounding.

SOURCE: U.S. Department of Commerce.

TABLE 9-22. U.S. IMPORTS OF MAN MADE FIBER TEXTILE MANUFACTURES[34] (millions of equivalent square yards)

Group	1971	1972	1973	1974	1975	1976[a]	1977[a]	1978	1979	1980 Jan-Mar
Yarns:	1,733.7	1,773.5	1,105.8	865.5	505.5	709.4	995.3	840.8	384.1	82.7
Textured	509.3	444.5	352.0	147.0	108.8	107.9	169.9	73.8	41.9	7.2
Filament, cellulosic[b]	25.7	56.8	97.8	49.0	47.4	136.9	126.8	126.0	55.2	10.2
Filament, non-celluosic[b]	1,129.7	1,209.0	576.3	628.2	307.9	410.6	577.7	454.9	190.8	33.6
Spun, cellusosic[c]	5.3	1.0	0.3	1.2	0.4	1.7	3.5	2.9	2.0	1.1
Spun, non-cellusosic[c]	40.0	38.9	56.1	22.5	17.4	33.9	90.9	155.4	65.7	23.2
Other	23.7	23.4	23.6	17.3	21.9	18.5	27.2	27.8	28.5	7.4
Fabrics:	851.1	756.7	596.1	442.2	385.5	423.2	457.5	517.5	399.5	109.0
Woven	250.8	262.8	236.9	241.7	230.5	295.2	312.4	383.6	305.7	71.8
Knit	427.4	316.6	224.9	95.3	90.4	72.5	64.9	60.0	29.6	6.0
Other	275.4	173.4	134.3	105.2	56.6	83.2	103.3	73.9	64.2	31.2
Wearing apparel:	1,536.1	1,605.5	1,580.9	1,433.5	1,486.8	1,685.5	1,607.9	1,865.8	1,655.0	438.2
Made-up and miscel-laneous textiles:	102.5	129.5	149.9	120.4	90.8	136.2	144.1	158.5	197.3	17.1
Total	4,223.2	4,265.4	3,432.7	2,861.5	2,468.5	2,954.3	3,204.8	3,382.6	2,635.9	647.0

[a]Data has been revised to conform with new 1978 textile and apparel category system.

[b]Continuous filament yarns with twist.

[c]Non-continuous yarns.

NOTE: U.S. Department of Commerce conversion factors used to convert units to square yard equivalents.

SOURCE: U.S. Department of Commerce.

TABLE 9-23. U.S. IMPORTS OF TEXTILE MANUFACTURES[34]
(millions of equivalent square yards)

Period	Cotton[a]	Man-made fiber[a]	Total[b]
1967	1,485	934	2,419
1968	1,648	1,453	3,101
1969	1,652	1,783	3,435
1970	1,537	2,760	4,297
1971	1,611	4,223	5,834
1972	1,854	4,265	6,119
1973	1,593	3,433	5,026
1974	1,463	2,862	4,325
1975	1,281	2,470	3,751
1976[c]	1,924	2,954	4,878
1977[c]	1,639	3,195	4,834
1978	2,213	3,383	5,596
1979	1,891	2,636	4,527
1980[d]	2,012	2,704	4,716

[a]U.S. Department of Commerce conversion factors used to convert units to square yard equivalents.

[b]Wool floor covering included from 1962-1973.

[c]Data revised to conform with new 1978 textile and apparel category system.

[d]Annual rate based on 1st quarter 1980.

SOURCE: U.S. Department of Commerce.

1979 imports would show decrease. Fabric imports for the first quarter of 1980 are almost identical to 1977 levels. All apparel import is up 15 percent from 1977.

Table 9-24 contains U.S. exports of textile manufactures (million pounds), reported by calendar year and grouped by cotton or man-made fiber into yarn and thread, fabric, apparel, and miscellaneous. The data show exports steadily increasing through the record year of 1979 (36 percent increase over 1978 exports), with the trend continuing through the first quarter of 1980. However, as Table 9-25 shows, the 1979 textile trade deficit (3,973 million dollars) was second only to the 4,954 million dollar trade deficit of 1978.

The year 1979 saw two major events in textile trade policy. First, there was developed and published an Administration textile program, which led to additional negotiations with a number of U.S. trading partners, in an attempt to strengthen the existing import controls. The program also provided for increased export aid and emphasis for U.S. textile and apparel producers. Second, there was the conclusion, in the summer of 1979, of the long-lasting negotiations at Geneva under the General Agreement on Tariffs and Trade (GATT) for reductions of tariff and nontariff barriers on textile and other products. Here the changes in tariff rates over the coming years and the changes in the rules of trade as they affect subsidies, dumping, government procurement, and other important aspects of the trading environment found textiles playing a key role in the discussions and decisions.

The major uncontrolled supplier at the time the Administration's program was announced was China. A series of negotiations between Peking and Washington over the spring months failed to reach agreement. At the end of May, the Administration imposed unilateral controls on seven sensitive categories of apparel being shipped from China; in the fall, two additional categories were brought under control, and in mid-September one category was embargoed, the annual quota having been filled. In September 1980, the United States signed a bilateral agreement with China which covered eight specific level categories and set up consultative mechanisms for the remainder.

The year's long Multilateral Trade Negotiations (MTN) were approaching conclusion when the Administration textile program was developed. The Administration's program also addressed industry concerns in those negotiations. It provided that a "snapback" clause, effective during the phase-in of any tariff

TABLE 9-24. U.S. EXPORTS OF TEXTILE MANUFACTURES[34]
(million pounds)

Group	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 Jan-Mar
Cotton											
Yarn and thread	17.7	19.2	21.9	20.7	24.0	17.0	18.5	16.9	32.0	34.1	10.4
Fabric	113.9	130.8	174.5	199.8	231.1	217.4	248.4	204.0	192.6	272.9	66.5
Apparel	30.0	30.3	34.3	39.9	40.1	42.5	54.3	65.3	61.8	89.9	44.4
Miscellaneous	37.6	46.0	59.7	74.8	97.3	76.8	92.0	83.3	69.3	80.0	19.9
Total cotton	199.2	226.3	290.4	325.2	292.5	353.7	413.2	369.5	355.7	476.9	140.9
Man-made fiber											
Yarn and thread	12.3	10.4	12.6	34.1	47.6	27.7	36.9	39.5	27.6	42.5	9.7
Fabric	92.5	84.6	95.2	147.2	201.0	184.0	191.2	188.6	239.3	332.1	85.3
Apparel	12.8	16.1	20.8	24.8	33.1	31.8	34.4	39.8	48.6	60.5	29.2
Miscellaneous	29.8	35.5	49.0	82.1	109.0	78.8	89.7	99.2	116.0	161.5	48.0
Total man-made	147.4	146.7	177.6	288.2	390.7	322.4	352.2	367.1	431.5	596.6	172.2
Grand total	346.6	373.0	468.0	613.4	683.2	676.1	765.4	736.6	787.2	1,073.5	313.1

SOURCE: U.S. Department of Agriculture.

TABLE 9-25. U.S. TEXTILE TRADE[34]
F.A.S. VALUES
(millions of dollars)

Period	Imports[a]	Exports[a]	Balance of Textile trade[b]	U.S. balance on current account[c] (seasonally adjusted) quarterly data
1959	744	542	-202	-2,138
1960	866	618	-248	+1,732
1961	773	578	-195	+3,005
1962	1,013	580	-433	+2,404
1963	1,074	583	-491	+3,148
1964	1,132	681	-451	+5,718
1965	1,342	640	-702	+4,251
1966	1,516	679	-837	+1,582
1967	1,460	695	-765	+1,215
1968	1,818	694	-1,124	-1,374
1969	2,125	753	-1,372	-2,017
1970	2,402	776	-1,626	-356
1971	2,913	837	-2,076	-3,957
1972	3,411	993	-2,418	-9,802
1973	3,722	1,497	-2,225	+22
1974	3,952	2,165	-1,787	-5,208
1975	3,780	2,027	-1,753	+18,445
1976	5,269	2,480	-2,789	+4,605
1977	5,926	2,567	-3,359	-14,092
1978	7,857	2,903	-4,954	-13,467
1979:	8,093	4,120	-3,973	+105
1st Q	1,854	918	-936	+274
2nd Q	1,952	1,032	-920	-1,810
3rd Q	2,301	1,014	-1,287	+1,139
4th Q	1,986	1,157	-829	-923
1980:				
1st Q	2,055	1,138	-917	n.a.

[a]Import and export data include textile manufacturers, and clothing (except donated for charity) of all fibers compiled on the basis of the Standard International Trade Classification (division 65 for textiles and 84 for clothing) of the FT-990.

[b]Textile balance of trade represents exports minus imports. Minus sign indicates an excess of imports over exports.

[c]This account includes exports and imports of goods and services and unilateral transfers including U.S. Government pension and non-military grants. Minus sign indicates a deficit in the Balance on Current Accounts.

reductions, would provide for returning to the original textile and apparel tariff levels if the Multifiber Arrangement (MFA) was not renewed upon its expiration in 1981. The program further provided that the Defense Department procurement of textile and apparel items would be excluded from the government procurement code being negotiated in the MTN. Both of these policy decisions were carried through into the final GATT agreement in the summer of 1979.

Tariff reductions were made on a substantial number of textile and apparel items. In general, the cuts were deeper on textile products than on the heavily impacted apparel items. If the two industries are taken together, the cuts amount to a 21 percent reduction of existing duties to be phased in over a 6-year period beginning in January 1982. The tariff reductions, when fully implemented, will leave average textile and apparel tariff rates at 18.3 percent ad valorem, as compared with 23.2 percent in 1976. Other developments during 1979 were the negotiation of new bilateral control agreements with Haiti, the Dominican Republic, Brazil, and Macau.

The MFA was negotiated by the Textiles Committee of GATT in 1973 for a term of 4 years beginning January 1, 1974. The Committee adopted a 4-year renewal protocol in December 1977, which tightened the quota system by providing (largely under EC pressure) for "reasonable departures" from the text of the MFA where necessary. The less developed countries (LDCs) look on the protocol as a one-time thing; developed countries (DCs) want it continued (and strengthened) in 1981. The GATT Textiles Committee will probably begin to address the renewal question early in 1980.

The Textile/Apparel Export Development Program, being implemented by the Department of Commerce, gathered significant momentum this year. Several market surveys have been printed for distribution throughout the industry that identify potential markets overseas for textile products. Two in-depth seminars on the mechanics of exporting were held this fall and were attended by over 300 industry representatives.

The Administration's new reorganization of trade activities, embodied in Reorganization Plan 3, is being implemented. The responsibilities of the office of the Special Trade Representative are being increased, under the leadership of the new U.S. Trade Representative, Reubin Askew, and the new Chief Textile Negotiator, H. Rieter Webb. The Department of Commerce is assuming various functions relating to the administration of countervailing and anti-dumping cases.

9.2 ECONOMIC IMPACTS OF REGULATORY ALTERNATIVES

9.2.1 Introduction

Section 9.2 summarizes the economic impacts expected to result under each of the NSPS regulatory alternatives. Section 9.2.2 establishes the economic and financial baseline of the fabric printing industry and serves as a benchmark for measuring the economic impacts. This profile includes a discussion of the structure, conduct, and performance of the industry. It lays the groundwork for analyzing the industry's expected behavioral and performance responses to the regulatory alternatives.

Following the financial and economic profile of the industry, the economic analysis of the NSPS regulatory alternatives follows in Section 9.2.3. Impacts at the level of the firm, presented in Section 9.2.3.2, include an analysis of changes in profitability and capital structure. Section 9.2.3.3, Industry Impacts, examines three ways in which the industry as a whole may be affected by the regulatory standards, including shifts in competitive advantage among firms in the industry, closure of plants, and import/export effects. Sections 9.2.3.4, 9.2.3.5, and 9.2.3.6 deal respectively with price, employment, and balance of trade effects.

9.2.2 Economic/Financial Profile of the Fabric Printing Industry

The next section provides a description of the competitive structure of the fabric printing industry and of the characteristics of firms comprising the industry. Following this section is an analysis of the conduct of the industry, which explains behavior that reflects the industry's structure. Finally, the performance of the industry in terms of sales, profitability, capital expenditures, and debt/equity ratios is presented.

9.2.2.1 Competitive Structure. Based on several criterion, including number of firms, concentration ratios, imports, and technology improvements, the fabric printing industry is competitive in structure.

It is generally well accepted that the larger the number of firms in an industry and the more evenly the market shares are distributed among firms in that industry, the more competitive the industry will be. In the fabric printing industry, there are a large number of firms: about 180 firms operating approximately 195 establishments in a largely national market. The concentration ratios, provided by the Bureau of Census on a four-digit SIC level,[35/] reflect, in all but one case, low concentration in the four-digit industries that cover fabric printing. The 1972 four-firm concentration ratios for SIC's 2257 and 2258, circular knit and warp knit fabric mills, are 23 percent and 27 percent respectively. The four-firm concentration ratios for SIC's 2261 and 2262, cotton and man-made fiber finishing plants, are 27 percent and 56 percent, respectively. These ratios can be used only as an approximation of concentration in the fabric printing industry since the ratios do not pertain to fabric printing per se but rather to establishments that engage in a wider range of activities, i.e., knitting as well as printing knits and bleaching, dying, and mechanically finishing broadwovens as well as printing them.

Concentration ratios do not reflect the degree of competition versus monopoly power in one important way: they fail to take into account import competition of foreign suppliers. Data on textiles and apparel imports show that imports have been a major factor in inducing an intensely competitive atmosphere in the fabric printing industry. By referring to Table 9-21 in Section 9.1, one can see that imports of cotton fabrics on a square yard basis increased from 1970 to 1978, rising 48 percent. Similarly, imports of cotton apparel increased 97 percent during the same time period. Although imports of cotton fabric and apparel decreased during the business slump of 1979, the first quarter 1980 imports indicate that 1980 imports will return to the 1977-1978 levels.

When considering the import situation for man-made fiber textiles in Table 9-22, one notes that while imports have increased for apparel by 22 percent over the years 1971 to 1978, imports have decreased 35 percent for woven and knit fabrics.

The general conclusion reached when examining the level of imports and trend toward increasing imports is that imports have resulted in stiff competition for the U.S. printing industy. A trade journal article published in September, 1980 states that the growing level of apparel imports is causing market share loss in textiles due to differences in price, fabric type, product quality and style.[36/] Increased demand in the U.S. for foreign-made apparel and international pressures for free trade will probably result in increased imports in the future.[37/] One study projects that by 1983, imports will have reached about 40 percent of the total market for dresses and sport shirts, many of which are prints.[38/]

Given the structure of the industry, it is important to examine the characteristics of the firms comprising the industry and the markets which they serve. The clearest distinctions among firms in the fabric printing industry are drawn between type of firm (commission versus integrated) and type of machine (roller, rotary screen, and flat screen). Both of these distinctions have important ramifications in the evaluation of economic effects of the NSPS regulatory alternatives.

Commission printers purchase already woven or knitted fabrics and perform the sole function of printing it. Integrated firms, on the other hand, perform a wide variety of vertical operations, including preparing the yarn, weaving or knitting it, printing and finishing the material, and manufacturing garments. Based on plant-by-plant data in Appendix B which represent two-thirds of the plants in the industry, there are approximately 77 commission finishing firms and 44 firms that are partially or fully integrated.

A plant was grouped as a commission versus an integrated plant if its manufacturing activities fell into SIC's 2261, 2262, or 2269 (broadwoven finishing - cotton, man-made, and other) or SIC's 2257 and 2258 (warp and circular knit mills). It should be noted that these plants may perform some functions other than printing, such as finishing operations in SIC's 2261, 2262, and 2269 and knitting of material in SIC's 2257 and 2258.

Greater segmentation of markets between integrated and commission producers will likely occur. One industry source predicts that in the 1980's the fully integrated printers will capture a larger share of the high volume, low profit production.[39/] Partially integrated printers will take a larger share of the fashion market where volume is moderate and profits high, while the independents will move into higher priced specialty markets.[40/]

At the same time that segmentation of markets is occurring, there will probably be a trend toward diversification and vertical integration among textile and apparel firms. Many apparel firms have already begun to integrate vertically backwards to secure textile producers, presumably to capture economies of scale in distribution and transportation.[41/]

The type of machine firms use is important because it helps define the markets served. In the printing industry, there are basically three types of machines: roller, rotary screen, and flat screen. Heat transfer printing is another technique used in fabric printing, but it is not covered by this NSPS. The roller machine is used largely in printing apparel, outerwear, and sportswear, whereas the rotary and flat screens predominantly print home furnishings such as draperies, bedspreads, sheets, upholstery, and towels.[42/] Rotary screen machines print apparel in addition to the rollers, with the main advantage of the rotary being its flexibility in short runs, its high productivity, and its achievement of an excellent color bloom.[43/] The roller machine's exclusive advantage in printing apparel has been its fine line engraving, but new rotary screen machines are also achieving fine line engraving.[44/] This partially explains the roller's loss of market share to the rotary screen, given the rotary's other advantages.

The flat screen machine's advantages include variable squeegee action, color control, and longer dwelling time.[45/] However, its slower output has caused its growth to decline and it has lost market share to rotary screen machines.

Based on information in Appendix A, the existing population of machines includes 272 roller, 207 rotary screen, and 74 flat screen machines.

9.2.2.2 Conduct. The conduct or behavior of an industry usually reflects its structure as well as the basic conditions affecting it. An oligopolistic industry, for example, would behave differently than a competitive industry in regard to pricing decisions during a recession when capacity is under-utilized. The purpose of this section is to examine the conduct of the fabric printing industry in regard to pricing policy, closure decision process, and capital budgetary decision process.

Competition from within the U.S. fabric printing industry and from imports has exerted pressure on textile prices with the result that the industry has priced competitively. Despite the fact that many of the costs in fabric printing (such as energy and fiber raw material) have increased at a rate greater than the general inflation rate, prices of textiles and apparel have not increased as fast as prices of all industrial commodities. The Bureau of Labor Statistics producer price index for textile products and apparel for August 1980 is 185.2, greatly surpassed by the industrial commodity index for the same month of 277.3.[46/] Assuming that the commodity index reflects the cost of materials for textile firms, textile prices have not kept pace with the cost of material increases. It appears that textile prices have not increased proportionally to fully cover cost of material increases. Based on Bureau of Census data[47/] for SIC's 2257, 2258, 2261, and 2262 (those SIC's which include printing of knit and broadwoven fabrics), the ratio for cost of materials to value of shipments declined from 1972 to 1976 for all SIC's except one, in which it remained constant.

The pricing policy of fabric printers during recessionary periods especially indicates the industry's competitive structure. Following on the heels of a severe decline in the printing industry in 1976, the industry in early 1977 began operating at 40-50 percent of capacity, and by the end of the year, competition had forced prices down by as much as 50 percent.[48/] Since the fabric printing industry is subject to the swings of the business cycle, recessionary periods may have the effect on the fabric printing industry of driving prices below average prices as each firm strives to increase capacity utilization and cover overhead costs by price shading.

Regarding the closure decision process in the fabric printing industry, there has been a trend towards closing down some of the older, less efficient plants in an era in which excess capacity exists. High cost plants in the long run have no choice but to sell at the long run equilibrium price set by low cost plants. Although in the short run high cost plants may continue to operate by covering variable costs, in the long run they may be forced out of business if unable to raise product prices, decrease input prices, or improve efficiency. Therefore, unless protected by regional markets or other non-price impediments to competition, one might expect to see some plant closures among high cost plants in the fabric printing industry, especially in a time when excess capacity exists.

The evidence on plant closures bears out the above theory. From 1975 to 1980, 25 printing plants operating roller machines closed down, resulting in the loss of 122 machines.[49/] With 242 roller machines currently in place[50/], the plant closings represent a 34 percent loss in machines to the industry. Although the rotary screen machines have gained market share in the printing industry and have increased in number (refer to Table 9-15 in Section 9.1), some screen printers have also gone out of business from 1975 to 1980, resulting in the loss of 24 machines in 11 plants. Thirty-one flat screen machines have been retired in the same time period. Regarding the future, industry sources predict that more marginal plants will close down in the 1980's.[51/]

Roller printing machines in the future, as in the 1970's, will bear a disproportionate share of shutdowns in the fabric printing industry. This is the case for several reasons. Roller printing is an older technology than is rotary screen, and thus many of the plants, built at the turn of the century, discourage managements from spending money for modernization.[52/] These older plants are also more costly to equip with pollution control devices because of design and space limitations.[53/] Regarding the machines themselves, although the roller has advantages in fine line printing and high quality design, the rotary screen is more flexible for short runs.[54/] Also, because of an irreversible trend to wider fabrics, existing roller machines will cease production because most of the existing machines were not built to accommodate the larger widths.[55/]

Based on past trends and current conditions, it is likely that some additional marginal printing plants will close down, especially when excess capacity exists. Douglas Martland of Cranston Print Works states that small printers will survive only if they can remain fiscally solvent to withstand economic slumps.[56/] He also concludes that in order to survive, large roller printers will have to become partially integrated and small roller printers will have to meet specialty demands of the market.[57/]

When examining the question of the capital budgetary decision process of textile firms, one discovers that firms are eager to modernize through capital improvements yet often have inadequate capital resources with which to make these improvements. With many textile stocks selling for considerably less than book value, the possibility of debt financing appears very unlikely.[58/] Internal funds do not appear sufficient to cover the capital improvements most firms are planning. Based on a recent Kurt Salmon Associates' performance profile of 74 publicly held textile firms, total cash flow during fiscal 1978 was $899.3 million. After paying stockholder dividends of $162.1 million and investing over $661 million in capital improvements, mills were left with a deficit of $99 million to meet their working-capital requirement of $175 million.[59/]

In order to raise capital, some plants are turning to tax-exempt bonds and increasing cash flow by shortening the terms of sale and improving accounts-receivable and inventory turns.[60/]

Lack of discretionary capital and poor prospects for earnings have dampened textile industry commitments to new facilities.[61/] A McGraw-Hill survey conducted in 1979 predicted that textile investment would rise to $1.21 billion in 1979, an increase of only four percent over the 1978 level of $1.16 billion, and in real terms, a reduction in outlays.[62/]

Modernization will continue in the fabric printing industry because of competitive pressures to increase productivity. However, the pace of modernization may not be as quick as some industry members would like, due to insufficient internal and external funds. Investments made will likely be in equipment rather than buildings and construction.[63/]

9.2.2.3 Performance. The purpose of this section is to present a financial profile of the fabric printing industry through an analysis of relevant financial and operating parameters. This will provide the necessary background for subsequent analysis of the effects of proposed regulatory alternatives on the financial position of the industry.

Table 9-26 shows aggregate historical data on sales, fixed assets, and capital expenditure levels. Total value of shipments increased by about 32 percent from 1975 to 1977. Total capital expenditures increased by 42 percent over the same period.

Table 9-26 also presents historical financial indicators for the industry. Profitability as measured by return on sales has decreased slightly from 1976 to 1978 levels. Asset productivity, however, has increased gradually over the last four years, as evidenced by the increase in return on assets from 3.5 percent in 1976 to 5.4 percent in 1979. Use of financial leverage has been relatively stable for the past three years, with a debt to capital ratio of 51.1 percent in 1979. Long term debt, however, is only about 10 percent of the total capitalization. Equity comprises a significant proportion (48.9 percent of total 1979 assets) of the industry's capital. Industry-wide interest coverage ratios have experienced a steady decrease from 3.6 times in 1977 to 2.7 times in 1979.

The distribution of sales and capital expenditures between the commission finishing and non-commission, or integrated, finishing sectors of the

TABLE 9-26. FINANCIAL PROFILE OF THE BROADWOVEN FABRIC FINISHING INDUSTRY (SIC's 2261, 2262, AND 2269)

	1975	1976	1977	1978	1979
Sales ($\$10^6$) a/	3,033.3	3,542.1	3,994.4	NA	NA
Fixed Assets ($\$10^6$) a/	1,263.7	1,322.2	NA	NA	NA
New Capital Expenditures ($\$10^6$) a/	91.6	116.8	129.7	NA	NA
Selected Financial Indicators					
Return on Sales (%) b/		1.7	1.5	2.4	1.9
Return on Assets (%) b/		3.6	4.3	4.1	5.4
Return on Equity (%) b/		13.5	11.8	16.2	10.4
Total Debt to Capital (%) c/			49.3	52.8	51.1
Long Term Debt to Capital (%) c/			10.0	7.0	10.7
Coverage Ratio c/			3.6	2.9	2.7

SOURCES:

a/ Bureau of the Census, 1977 Census of Manufacturers, "Dyeing and Finishing Textiles, Except Wool and Knit Goods." Figures presented in current dollars.

b/ Dun and Bradstreet annual reports on eight fabric printing firms.

c/ Robert Morris Associates, Annual Statement Studies, 1977-1979.

NA - not available

industry is presented in Table 9-27. Sales of cotton broadwoven finishing plants ($759.5 million), which comprise 19 percent of total industry shipments, are predominantly composed of sales by commission finishers (66 percent). The remaining 34 percent is accounted for by non-commission finishing sales. Sales of man-made or silk broadwoven fabrics ($2404.3 million) account for 60 percent of total industry sales. About 67 percent of this amount is produced by integrated finishers, with the remaining 33 percent accounted for by commission finishers.

Sales of finished fabrics not classified into the two earlier categories comprise about 21 percent of industry sales. Integrated finishers account for 84 percent of the $830.6 million sales in this category.

Total capital expenditures in the industry amounted to $140.1 million in 1977. Out of this total, 58 percent was invested by finishing plants using synthetic broadwoven fabrics and about 23 percent of total expenditures by cotton broadwoven finishing plants. In this category, more than 80 percent of capital investment has been made by the commission finishing segment of the industry.

9.2.3 Economic Impact Analysis

9.2.3.1 Introduction. The economic analysis which follows examines impacts of the Regulatory Alternatives I-IV on the firm, the industry, prices, employment, and balance of trade. The analysis of regulatory effects on the firm is based on the formulation of three model plants, for which operating parameters and costs are established. Financial data are then developed for the model plants, and changes in profitability and capital structure associated with each regulatory alternative are determined. The analysis of industry impacts covers shifts in competitive advantage, plant closures, and import/export effects.

9.2.3.2 Impacts at the Level of the Firm

9.2.3.2.1 Methodology. The methodology for analyzing the effects of the NSPS regulatory alternatives at the firm level is composed of the following three distinct tasks:

- Model Plant Formulation
- Creation of Pro Forma Statements
- Financial Analysis

TABLE 9-27. 1979 SALES AND CAPITAL EXPENDITURES OF COMMISSION AND NON-COMMISSION FINISHING PLANTS

	Cotton Broadwoven Finishing Plants (SIC 2261)			Man-made Broadwoven Finishing Plants (SIC 2262)			Finishing Plants Using Other Fabrics (SIC 2269)		
	Total	Non-Commission Finishing	Commission Finishing	Total	Non-Commission Finishing	Commission Finishing	Total	Non-Commission Finishing	Commission Finishing
Sales ($\$10^6$)	759.5	257.8	501.6	2,404.3	1,599.1	805.1	830.6	698.7	114.0
Capital Expenditures ($\$10^6$)	32.5	6.3	26.2	81.4	38.7	42.7	26.2	15.9	10.3
New	29.2	5.9	23.2	75.9	37.5	38.3	24.6	14.9	9.7
Used	3.3	0.4	2.9	5.5	1.1	4.4	1.6	1.0	0.6

The starting point in investigating the economic impacts of the regulatory alternatives on the fabric printing industry is based on the formulation of a model plant that represents each of the three fabric printing lines. Operating parameters representing the current state of each fabric technology are established in Section 6. These serve as the basis for estimating plant capital and operating costs, as well as incremental costs resulting from each regulatory alternative. Cost data for Regulatory Alternative I represent the base case against which Alternatives II, III, and IV are compared. Cost effects resulting from each regulatory alternative are used as inputs to the subsequent economic analysis that determines how each representative plant will be affected.

Based on sales data calculated for the model plants, income statements and balance sheets for each fabric printing line are derived. Industry-wide statements are used in conjunction with sales data to establish a baseline financial profile. This is accomplished for both commission and non-commission finishing plants. Capital and operating costs resulting from the three regulatory scenarios are the input variables that determine the extent to which the current financial condition of the model plant will change. These costs will affect both profitability and the capital structure depending on 1) the magnitude of operating cost increase or decrease, and 2) the method by which installed capital costs (i.e., in the incinerator alternative) are financed by the firm.

The final step in the analysis utilizes the financial profiles developed for each model plant. Using relevant financial indicators, evaluations are made about the direction of impacts resulting from the regulations. Effects on the model plant's profitability, capital structure, and financing capability, as related to each regulatory alternative, are examined.

9.2.3.2.2 Model Plant Operating Parameters and Cost Data

In order to estimate the effects of the regulatory alternatives on the model plants, it is necessary to determine the sales levels and incremental costs associated with each model plant. Sales were calculated for the model plants by multiplying production rates by prices of material. Production rates for each model plant, as displayed in Table 9-28, were calculated by multiplying plant production capacity by capacity utilization rates, as presented in Section 6. Prices were calculated for woven and knit, and

TABLE 9-28. TYPE OF FABRIC UTILIZED BY EACH PRINTING MACHINE

	Type of Fabric Used (Percent)[1/]				Production (thousand meters per year)[2/]
	Broadwoven		Knit		
	Cotton	Manmade	Cotton	Manmade	
Rotary Screen	9.7	70.2	5.3	14.8	8532
Flat Bed Screen	100.0	0.0	0.0	0.0	1743[3/]
Roller	40.6	51.9	0.4	7.1	6182

1/ Percentages for cotton versus man-made fabrics were obtained from Table 6-1. Percentages for cotton and man-made broadwoven material were derived from data in Tables 9-14 and 9-16. By subtraction, percentages for cotton and man-made knit material were calculated.

2/ Calculated by multiplying production capacity by capacity utilization, as provided in Table 6-1.

3/ Calculated by multiplying the value in Table 6-1 in dozen towels/year by a conversion rate of 11.98 yards/dozen towels, which was obtained from the Bureau of Census, Current Industrial Reports, series MQ-23X and MC-22T, 1977.

cotton and man-made fabrics from data provided in the 1977 Census of Manufacturers,[64/] which was inflated to 1980 dollars with the Producer Price Indexes for finished and printed fabrics.[65/] Based on the percentage of knitted versus woven, and cotton versus man-made fabric printed by each machine (shown in Table 9-28), weighted average prices were determined in order to calculate sales.

Separate prices were determined for commission versus integrated fabric printers. The price charged by commission printers is assumed to cover only the price of printing and finishing the fabric, whereas the price quoted by integrated printers includes the price of the gray goods as well as of the printing and finishing operations. The three-fold difference in prices between commission and integrated finishers is reflected in the sales figures.

Incremental costs associated with each regulatory alternative as they apply to the model plants are shown in Tables 9-29, 9-30, and 9-31. Regulatory Alternative I results in no additional capital or annualized costs for any of the model plants since it represents the baseline, "no NSPS" option. For all the model plants, there are no incremental capital costs associated with Regulatory Alternatives II and III. Total annualized costs, however, show a decrease in the rotary screen, roller, and flat screen machine model plants. Decreases in annual operating costs for the rotary model plant range from $31,000 for Alternative II to $62,000 for Alternative III. The roller machine plant shows a range of decrease in annual operating costs from $55,000 for Alternative II to $77,000 for Alternative III. The flat screen machine model plant exhibits only a slight decrease of $4,000 in operating expenses for Alternative III.

Alternative IV, which requires the installation of an incinerator to obtain 85 percent reduction in print paste solvent levels, results in both capital and annual operating costs for all model plants. Incremental capital costs are $481,000 for the rotary screen machine model plant, $457,000 for the roller machine plant, and $415,000 for the flat screen machine plant. Increases in annual operating costs of $148,000 for the rotary screen machine plant, $145,000 for the roller machine plant, and $121,000 for the flat screen machine plant would also result under Regulatory Alternative IV.

TABLE 9-29. NSPS REGULATORY ALTERNATIVE
CAPITAL AND ANNUALIZED OPERATING COSTS
FOR THE ROTARY SCREEN MACHINE MODEL PLANT
(THOUSANDS OF 1980 DOLLARS)

	Total Installed Capital Cost 1/	Increase (Decrease) From Base Cost 2/	Total Annualized Cost 1/	Increase (Decrease) From Base Cost 2/
Regulatory Alternative I	500	0	1,090	0
Regulatory Alternative II	500	0	1,059	(31)
Regulatory Alternative III	500	0	1,028	(62)
Regulatory Alternative IV	981	481	1,238	148

1/Refer to Tables 8-1 through 8-4.

2/Represents costs over the baseline case (Regulatory Alternative I).

TABLE 9-30. NSPS REGULATORY ALTERNATIVE CAPITAL AND ANNUALIZED OPERATING COSTS FOR ROLLER MACHINE MODEL PLANT (THOUSANDS OF DOLLARS)

	Total Installed Capital Cost[1/]	Increase (Decrease) From Base Cost[2/]	Total Annualized Cost[1/]	Increase (Decrease) From Base Cost[2/]
Regulatory Alternative I	230	0	1,100	0
Regulatory Alternative II	230	0	1,045	(55)
Regulatory Alternative III	230	0	1,023	(77)
Regulatory Alternative IV	687	457	1,245	145

[1/] Refer to Tables 8-1 through 8-4.

[2/] Represents costs over the baseline case (Regulatory Atlernative I).

TABLE 9-31. NSPS REGULATORY ALTERNATIVE CAPITAL AND ANNUALIZED OPERATING COSTS FOR FLAT SCREEN MODEL PLANT (THOUSANDS OF DOLLARS)

	Total Installed Capital Base Cost 1/	Increase (Decrease) From Cost 2/	Total Annualized Base Cost 1/	Increase (Decrease) From Base Cost 2/
Regulatory Alternative I	420	0	455	0
Regulatory Alternative II	420	0	455	0
Regulatory Alternative III	420	0	451	(4)
Regulatory Alternative IV	835	415	576	121

1/Refer to Tables 8-1 through 8-4.

2/Represents costs over the baseline case (Regulatory Alternative I).

9.2.3.2.3 Financial Impacts. Condensed profit and loss statements as well as balance sheets which detail relative asset size and capital structure are presented in this section. Statements are provided for both commission and non-commission finishing plants because of differences in overall profitability levels for each category. Financial data on the industry indicate slightly higher profitability for non-commission finishing plants (i.e., integrated) as compared to commission finishing plants.

Tables 9-32 through 9-37 present comparative sales and profit data for each of the commission and integrated model plants. Regulatory Alternative I serves as the base level against which the other three alternatives are compared. Each model plant's sales remain constant under all four regulatory alternatives assuming no costs are passed through to the consumer. In this case, the regulatory impacts at the level of the firm are measured by the change in each model plant's profitability levels. Given the competitive structure and conduct of the fabric printing industry, it is likely that the average firm will absorb the full costs of regulation and incur the profitability losses shown in Tables 9-32 through 9-37.

The constant sales assumption facilitates comparison of model plant profitability level changes resulting under each regulatory alternative. One important caveat to this assumption is that plants' revenues may decline as the percent print paste solvent declines under Regulatory Alternatives II and III. Industry sources have stated that solvent level in the print paste is linked to perceived product quality.[66/] The functional relationship between quality and percent solvent in the paste is difficult to quantify because of the following: 1) reduction in print paste solvent level may affect one machine's fabric quality more than another machine's, and 2) reduction in solvent level may affect one plant more than another, depending on how sensitive a plant's market is to changes in quality.

As an example, a given reduction in solvent level may decrease the perceived product quality of high quality apparel fabrics printed by roller machines by a greater degree than apparel fabrics printed by rotary screen machines. As a result, sales of roller plants may decline as consumers shift demand toward fabrics printed by rotary screen machines. The degree to which sales will change for each model plant depends on how consumers perceive quality changes in the fabrics printed with low solvent pastes and

TABLE 9-32. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF COMMISSION ROTARY SCREEN MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	2,824	2,824	2,824	2,824
Expenses 2/	2,730	2,699	2,668	2,878
Gross Profit	94	125	156	(54)
Tax 3/	40	53	66	--
Profit After Tax	54	72	90	(54)
Return on Sales 4/	1.9%	2.5%	3.2%	(1.9%)

1/ Sales are calculated by multiplying plant output by a weighted-average price based on the percentage of material that is cotton versus manmade and woven versus knitted (refer to Table 9-28).

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent, based on a sample of textile firms listed in Value Line Data Bases.

4/ Return on sales in the baseline case (Regulatory Alternative I) is determined from a sample of commission fabric printing firms listed with Dun and Bradstreet. By multiplying the return on sales percentage by sales, one calculates the profit after tax. By assuming a 42.5 percent average tax rate, the dependent variables gross profit and expenses are calculated. For Regulatory Alternatives II-IV, expenses are increased or decreased by the annualized cost (refer to Table 9-29) associated with each alternative, with the change reflected in the percent return on sales.

TABLE 9-33. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF INTEGRATED ROTARY SCREEN MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	10,338	10,338	10,338	10,338
Expenses 2/	9,691	9,660	9,629	9,839
Gross Profit	647	678	709	499
Tax 3/	275	288	301	212
Profit After Tax	372	390	408	287
Return on Sales 4/	3.6%	3.8%	3.9%	2.8%

1/ Sales are calculated by multiplying plant output by a weighted average price, as explained in Table 9-32.

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is determined from a sample of Dun and Bradstreet integrated fabric printing firms. For Regulatory Alternatives II-IV, expenses reflect the change in annualized costs (refer to Table 9-29) associated with each alternative. The new percent return on sales figure is then calculated.

TABLE 9-34. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF COMMISSION FLAT SCREEN MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	627	627	627	627
Expenses 2/	606	606	602	727
Gross Profit	21	21	25	(100)
Tax 3/	9	9	11	--
Profit after Tax	12	12	14	(100)
Return on Sales 4/	1.9%	1.9%	2.3%	(15.9%)

1/ Sales are calculated by multiplying plant output by the price for woven cotton fabric (refer to Table 9-28).

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is determined from a sample of Dun and Bradstreet commission printing firms. The change in percent return on sales reflects the change in expenses associated with the annualized costs (refer to Table 9-31) for each regulatory alternative.

TABLE 9-35. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF INTEGRATED FLAT SCREEN MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	1,813	1,813	1,813	1,813
Expenses 2/	1,700	1,700	1,696	1,821
Gross Profit	113	113	117	(8)
Tax 3/	48	48	50	--
Profit after Tax	65	65	67	(8)
Return on Sales 4/	3.6%	3.6%	3.7%	(.4%)

1/ Sales are calculated by multiplying plant output by price of the printed material, as explained in Table 9-34.

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is determined from a sample of Dun and Bradstreet integrated fabric printing firms. The change in percent return on sales reflects the change in expenses associated with the annualized costs (refer to Table 9-31) of each regulatory alternative.

TABLE 9-36. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF COMMISSION ROLLER MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	2,079	2,079	2,079	2,079
Expenses 2/	2,009	1,954	1,932	2,154
Gross Profit	70	125	147	(75)
Tax 3/	30	53	62	--
Profit after Tax	40	72	85	(75)
Return on Sales 4/	1.9%	3.5%	4.1%	(3.6%)

1/ Sales are calculated by multiplying plant output by a weighted-average price based on the percentage of material that is cotton versus manmade and woven versus knitted (refer to Table 9-28).

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is determined from a sample of Dun and Bradstreet commission fabric printing firms. The change in percent return on sales reflects the change in expenses associated with the annualized costs (refer to Table 9-30) of each regulatory alternative.

TABLE 9-37. EFFECTS OF REGULATORY ALTERNATIVES ON PROFITABILITY OF INTEGRATED ROLLER MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

	Regulatory Alternative I	Regulatory Alternative II	Regulatory Alternative III	Regulatory Alternative IV
Sales 1/	7,032	7,032	7,032	7,032
Expenses 2/	6,592	6,537	6,515	6,737
Gross Profit	440	495	517	295
Tax 3/	187	210	220	125
Profit after Tax	253	284	297	170
Return on Sales 4/	3.6%	4.0%	4.2%	2.4%

1/ Sales are calculated by multiplying plant output by a weighted-average price, as explained in Table 9-36 above.

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is determined from a sample of Dun and Bradstreet integrated fabric printing firms. The change in percent return on sales reflects the change in expenses associated with the annualized costs (refer to Table 9-30) of each regulatory alternative.

the extent to which shifts in market share occur as a result of these changes.

The projected changes in model plant profitability must be viewed in light of the above limitation. For purposes of estimating differential impacts brought about by the regulatory alternatives, the constant sales assumption proves to be a useful one.

Tables 9-32 and 9-33 show the changes in profitability of the rotary screen model plant as a result of the regulatory alternatives. Profit margins exhibit slight increases due to the cost reductions associated with Regulatory Alternatives II and III. Under Regulatory Alternative IV, however, profitability declines for both commission and integrated plants. Return on sales decrease, respectively, to -1.9 percent and 2.8 percent from the base cases of 1.9 percent to 3.6 percent.

Tables 9-34 and 9-35, which show the effects of the regulatory alternatives on flat screen model plants, indicate increases in profit margins for Alternatives II and III. The incinerator requirement under Alternative IV, however, indicates a net loss for both the commission and integrated flat screen model plants. Due to incremental operating costs, return on sales for the commission plant decreases to -15.9 percent, compared to 1.9 percent in the base case. The integrated flat bed finisher experiences a net loss under Regulatory Alternative IV, with its after-tax profit declining to -.4 percent from the base case level of 3.6 percent.

Tables 9-36 and 9-37 show slight increases in profit margins under Regulatory Alternatives II and III for both commission and integrated roller model plants. Regulatory Alternative IV results in a decline in profitability due to increased operating costs. For commission finishing, return on sales decreases from 1.9 percent in the base case to -3.6 percent under Regulatory Alternative IV, whereas for the integrated finisher, the return on sales falls to 2.4 percent as compared to 3.6 percent in the base case.

Profitability figures for all of the above model plants were derived using industry median data. The existence of smaller, less profitable firms that deviate from the above norm necessitates the use of more conservative profitability levels for evaluating worst possible regulatory impacts. Table 9-38 shows how Regulatory Alternative IV affects after-tax profits when a profit margin from the lower quartile of the industry is assumed.

TABLE 9-38. EFFECTS OF REGULATORY ALTERNATIVE IV ON COMMISSION MODEL PLANTS, ASSUMING LOW BASELINE PROFIT MARGIN (THOUSANDS OF 1980 DOLLARS)

	Rotary Model Plant		Flat Bed Model Plant		Roller Model Plant	
	Regulatory Alternative I	Regulatory Alternative IV	Regulatory Alternative I	Regulatory Alternative IV	Regulatory Alternative I	Regulatory Alternative IV
Sales[1/]	2,824	2,824	627	627	2,079	2,079
Expenses[2/]	2,770	2,910	615	740	2,039	2,175
Gross Profit	54	(86)	12	(113)	40	(96)
Tax[3/]	23	-	5	-	17	-
Profit after Tax	31	(86)	7	(113)	23	(96)
Return on Sales[4/]	1.1%	(3.0%)	1.1%	(18.0%)	1.1%	(4.6%)

1/ Sales calculated by multiplying plant output by average price (refer to Tables 9-32 through 9-37).

2/ Expenses should represent all expenses incurred by the firm, including cost of goods sold, operating expenses, general and administrative expenses, and interest expenses.

3/ The average tax rate is assumed to be 42.5 percent.

4/ Return on sales for the baseline case is Dun and Bradstreet's profit margin for the lower quartile of the industry. The change in percent return on sales reflects the change in expenses associated with the annualized costs of Regulatory Alternative IV.

Examining Regulatory Alternative IV's costs against the baseline, return on sales has been calculated for the commission finishing segment of the three fabric printing lines.

The diminished profitability levels for all three model plants are magnified in this scenario. Compared to the baseline measure of 1.1 percent, return on sales decreases to -3.0 percent for the rotary screen model plant, to -18.0 percent for the flat screen model plant, and to -4.6 percent for the roller model plant.

Tables 9-39 to 9-44 present for each model fabric printing line comparative balance sheets based on Dun and Bradstreet industry-wide common size balance sheets. In this series of tables, only the alternative involving a change in capital costs, i.e., Regulatory Alternative IV, is compared to base case statements. As in the preceeding income statement analysis, data are provided for both the commission and integrated model plants. Three different levels of debt/equity are presented in order to illustrate how different possibilities for financing the required incinerator investment would affect capital structure. The tables show for each model plant changes in figures for fixed assets, debt to capitalization ratios, return on assets, and return on equity as a result of financing the incinerator investment under each of the three financing schemes.

The figures in Tables 9-39 to 9-44 illustrate the magnitude of the incinerator investment compared to the model plants' current fixed asset bases. For the commission segment of the fabric printing industry, fixed assets following financing of the incinerator increase over baseline levels by 220 percent for the rotary screen, 847 percent for the flat screen, and 284 percent for the roller machine model plant. As compared to the commission printers, fixed assets for the integrated segment of the industry increase to a lesser, but still marked degree -- 130 percent for the rotary screen, 137 percent for the flat screen, and 39 percent for the roller machine model plant.

Because the investment in pollution control equipment represents a non-production asset (i.e., non-revenue generating), one would expect it to have a negative effect on the firm's return on asset performance. Focusing on profitability indicators for each model plant, the negative effects of the incinerator investment are immediately evident. For all model plants

TABLE 9-39. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR COMMISSION ROTARY MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV — Financing Mix		
	Regulatory Alternative I	0% Debt; 100 Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	835	835	835	835
Fixed Assets	219	700	700	700
Other Non-Current Assets	47	47	47	47
Total Assets 1/	1,101	1,582	1,582	1,582
Current Debt	462	462	462	462
Long Term Debt	90	90	331	571
Total Debt 2/	552	552	793	1,033
Net Worth 3/	549	1,030	789	549
Total Capitalization	1,101	1,582	1,582	1,582
Debt to Capitalization Ratio 4/	50.1%	34.9%	50.1%	65.3%
Return on Asset 5/	4.9%	(3.4%)	(3.4%)	(3.4%)
Return on Equity 6/	9.8%	(5.2%)	(6.8%)	(9.8%)

TABLE 9-39 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for the industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

TABLE 9-40. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR INTEGRATED ROTARY MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV		
		Financing Mix		
	Regulatory Alternative I	0% Debt; 100 Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	3,868	3,868	3,868	3,868
Fixed Assets	1,720	2,201	2,201	2,201
Other Non-Current Assets	263	263	263	263
Total Assets 1/	5,851	6,332	6,332	6,332
Current Debt	1,551	1,551	1,551	1,551
Long Term Debt	1,047	1,047	1,288	1,528
Total Debt 2/	2,598	2,598	2,839	3,079
Net Worth 3/	3,253	3,734	3,493	3,253
Total Capitalization	5,851	6,332	6,332	6,332
Debt to Capitalization Ratio 4/	44.4%	41.0%	44.8%	48.6%
Return on Asset 5/	6.4%	4.5%	4.5%	4.5%
Return on Equity 6/	11.4%	7.7%	8.2%	8.8%

TABLE 9-40 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for the industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

TABLE 9-41. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR COMMISSION FLAT SCREEN MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV — Financing Mix		
	Regulatory Alternative I	0% Debt; 100% Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	186	186	186	186
Fixed Assets	49	464	464	464
Other Non-Current Assets	10	10	10	10
Total Assets 1/	245	660	660	660
Current Debt	103	103	103	103
Long Term Debt	20	20	228	435
Total Debt 2/	123	123	331	538
Net Worth 3/	122	537	329	122
Total Capitalization	245	660	660	660
Debt to Capitalization Ratio 4/	50.2%	18.6%	50.2%	81.5%
Return on Asset 5/	4.9%	(15.2%)	(15.2%)	(15.2%)
Return on Equity 6/	9.8%	(18.6%)	(30.4%)	(82.0%)

TABLE 9-41 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

TABLE 9-42. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR INTEGRATED FLAT SCREEN MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV		
		Financing Mix		
	Regulatory Alternative I	0% Debt; 100% Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	678	678	678	678
Fixed Assets	302	717	717	717
Other Non-Current Assets	46	46	46	46
Total Assets 1/	1,026	1,441	1,441	1,441
Current Debt	272	272	272	272
Long Term Debt 2/	184	184	392	599
Total Debt	456	456	664	871
Net Worth 3/	570	985	777	570
Total Capitalization	1,026	1,441	1,441	1,441
Debt to Total Capitalization Ratio 4/	44.4%	31.6%	46.1%	60.4%
Return on Asset 5/	6.3%	(0.6%)	(0.6%)	(0.6%)
Return on Equity 6/	11.4%	(0.8%)	(1.0%)	(1.4%)

TABLE 9-42 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

TABLE 9-43. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR COMMISSION ROLLER MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV		
		Financing Mix		
	Regulatory Alternative I	0% Debt; 100% Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	615	615	615	615
Fixed Assets	161	618	618	618
Other Non-Current Assets	35	35	35	35
Total Assets 1/	811	1,268	1,268	1,268
Current Debt	340	340	340	340
Long Tenn Debt	67	67	296	524
Total Debt 2/	407	407	636	864
Net Worth 3/	404	861	632	404
Total Capitalization	811	1,268	1,268	1,268
Debt to Total Capitalization Ratio 4/	50.2%	32.1%	50.2%	68.1%
Return on Asset 5/	4.9%	(5.9%)	(5.9%)	(5.9%)
Return on Equity 6/	9.9%	(8.7%)	(11.9%)	(18.6%)

TABLE 9-43 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

TABLE 9-44. CHANGES IN BALANCE SHEET FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR INTEGRATED ROLLER MACHINE MODEL PLANT (THOUSANDS OF 1980 DOLLARS)

		Regulatory Alternative IV Financing Mix		
	Regulatory Alternative I	0% Debt; 100% Equity	50% Debt; 50% Equity	100% Debt; 0% Equity
Current Assets	2,631	2,631	2,631	2,631
Fixed Assets	1,170	1,627	1,627	1,627
Other Non-Current Assets	179	179	179	179
Total Assets 1/	3,980	4,437	4,437	4,437
Current Debt	1,055	1,055	1,055	1,055
Long Term Debt	712	712	941	1,169
Total Debt 2/	1,767	1,767	1,996	2,224
Net Worth 3/	2,213	2,670	2,441	2,213
Total Capitalization	3,980	4,437	4,437	4,437
Debt to Total Capitalization Ratio 4/	44.4%	39.8%	45.0%	50.1%
Return on Asset 5/	6.4%	3.8%	3.8%	3.8%
Return on Equity 6/	11.4%	6.4%	7.0%	7.7%

TABLE 9-44 (Continued)

1/ Total assets are calculated by applying a Dun and Bradstreet assets to sales ratio to model plant sales. Other asset figures, as a percent of total assets, are derived from Dun and Bradstreet common size percentages for the baseline case. Fixed assets increase under Regulatory Alternative IV by the amount of investment in the incinerator.

2/ Total debt is calculated by subtracting net worth from total assets. Baseline current and long term debt as a percentage of total debt are computed from Dun and Bradstreet common size percentages. Long term debt increases under Regulatory Alternative IV by the amount of investment times the percentage financed by debt.

3/ Net worth is based on Dun and Bradstreet common size financial statements for industry. Net worth increases under Regulatory Alternative IV by the amount of investment times the percentage financed by equity.

4/ Total debt divided by total capitalization.

5/ Profit after tax (refer to Tables 9-32 to 9-37) divided by total assets.

6/ Profit after tax (refer to Tables 9-32 to 9-37) divided by equity.

but two, the return on assets figures following investment in the incinerator dip below zero, dropping by 169 percent for the rotary screen commission, 410 percent for the flat screen commission, 109 percent for the flat screen integrated, and 220 percent for the roller commission model plant. From the viewpoint of the firm's owners, these changes would represent an unacceptable deterioration in the plant's financial viability.

For the integrated rotary screen and roller model plants, return on assets decreases from 6.4 percent in the base case to 4.5 percent for the rotary and 3.8 percent for the roller integrated plant. Although return on assets does not become negative as it does for the other four model plants, it decreases by a significant degree -- by 30 and 40 percent for the rotary and roller integrated plants, respectively.

The changes in return on equity under the three financing schemes parallel the changes in return on assets. For all the commission model plants and also the integrated flat screen plant, return on equity declines below zero, decreasing by varying amounts for each plant and each financing scheme in the range of 107 to 937 percent. Return on equity for the integrated rotary screen and the integrated roller model plant declines in a range of 23 to 44 percent. Certainly for the three commission plants and the integrated flat screen plant, and most probably for the other two integrated plants as well, the return on equity figures following investment in the incinerator would decline to unacceptable levels in the eyes of equity holders.

In relation to the financing issue, coverage ratios, summarized in Table 9-45, have been calculated for each model plant, using three debt/equity levels. Coverage ratios measure how many times a firm's earnings cover its fixed obligations. The ratios are therefore a good indicator of a firm's ability to meet its interest payments. As a result of Regulatory Alternative IV, all three model plants experience varying degrees of change in solvency position. The largest decrease in coverage occurs with the flat bed model plants. For the flat bed integrated plants, coverage decreases from 8.08 times under Regulatory Alternative I to 1.95 times under Regulatory Alternative IV assuming 100 percent debt financing. The flat bed commission plant shows an even greater change in solvency position. Assuming 100 percent debt financing, earning before interest and taxes

TABLE 9-45. CHANGES IN COVERAGE RATIOS FROM BASELINE TO REGULATORY ALTERNATIVE IV FOR ALL MODEL PLANTS

	Coverage Ratios (times)[1]					
	Integrated Model Plants			Commission Model Plants		
	Rotary	Flat Bed	Roller	Rotary	Flat Bed	Roller
Regulatory Alternative I	4.97	8.08	8.07	8.07	6.43	7.18
Regulatory Alternative IV						
0% Debt Financing	4.90	7.54	7.90	7.65	5.19	6.68
50% Debt Financing	4.15	3.10	5.62	3.71	1.21	3.01
100% Debt Financing	3.61	1.95	4.36	2.45	--[2]	1.94

1/ Baseline coverage ratios are based on data from Almanac of Business and Industrial Financial Ratios, 1979 Edition. The coverage ratios in Regulatory Alternative IV are based on: 1) adjusted interest expense due to the investment and, 2) adjusted earnings of the plant (i.e., net of incremental operating expense).

2/ Figure omitted because value is negative.

falls short of covering required fixed obligations. This rules out the possibility of 100 percent debt financing and dictates the necessity of using other non-debt sources. Coverage ratios for the rotary and roller plants also decline significantly from Alternative I to Alternative IV, indicating that long term debt financing may prove a difficult alternative in raising the required capital. Not only would long term debt financing undermine the firm's capability of repaying its current creditors, but above all, it could deter additional debt financing. These findings are based on an assumption of 100 percent debt financing. In combination with equity sources, coverage ratios will not be affected as radically.

9.2.3.3 Impacts on the Industry

9.2.3.3.1 Differential Effects in Industry/Shifts in Competitive Advantage. The NSPS Regulatory Alternatives II-IV may widen the already existing differences in competitive advantage among the three types of fabric printing machines, roller, rotary screen, and flat screen. As pointed out in Section 9.2.2.2, the trend has already begun in a shift from roller machine to rotary machine, resulting in a substantial reduction in capacity in the roller line of business. Similarly, flat screen machines often are not replaced when they expire, yielding market share to rotary machines. The Regulatory Alternatives II-IV would probably serve to accelerate these already existing trends for several reasons.

First of all, for Regulatory Alternative IV, the costs imposed would most likely have a greater effect on roller and flat screen machine plants than on rotary machine plants. As can be seen from the model plant analysis presented in Section 9.2.3.2, profitability for integrated rotary finishing plants (assuming full absorption of costs) decreases 22 percent from the baseline to Regulatory Alternative IV. Profitability for the integrated flat bed screen and roller screen model plants decreases by a greater degree: 111 percent and 33 percent, respectively. Similarly, for the commission finishing model plants, profitability decreases 200 percent for rotary machines in meeting requirements of Regulatory Alternative IV, but 937 and 289 percent for the flat screen and roller machines, respectively. Thus, to the extent that firms are already considering a switch from roller or flat bed screen machines to rotary, Regulatory Alternative IV would accelerate the changeover.

More importantly, roller machines may be differentially affected by Regulatory Alternatives II and III due to effects on product quality. While industry sources have indicated that rotary and flat screen machines can use low solvent levels in printing apparel, roller machines must use high solvent print pastes in many applications to achieve high quality prints.[67/] The data in Section 7 confirms that rotary screen compared to roller machines currently use much lower solvent level pastes: only 12 percent of rotary screen machines utilize print paste with solvent levels over 7 percent whereas 53 percent of roller machines utilize print paste with 59 percent solvent levels.

Roller printers printing relatively high quality fashion apparel claim that substantially reducing solvent levels in the print paste causes loss in brightness of color and a stiffer feel or "hand" to the fabric.[68/] (See Exhibit 9-1.) According to one industry source who prints high quality fashion apparel with roller machines, there is a threshold value at about 40 percent solvent level, below which quality noticeably suffers.[69/] For this reason, some roller printers have not reduced the solvent level in the high solvent print paste, despite the fact that the rising price of mineral spirits would induce one to utilize lower solvent levels where possible.

Since the advantage of roller machines is in printing sharp, fine lines and dark colors, roller machines can outperform existing rotary machines in the printing of many high quality apparel fabrics. If this advantage were to be lost due to promulgation of Regulatory Alternatives II or III, one would expect to see roller machines sacrificing their niche in the market to rotary machines or, more likely, to imports.

Roller printers could meet Regulatory Alternatives II and III and still print with high solvent print pastes as long as they could print with low solvent pastes frequently enough to achieve the stipulated weighted-average level of the two solvent pastes. Because all-cotton fabrics are printed with aqueous pastes, roller printers, if able to expand production of these fabrics, could possibly meet Regulatory Alternatives II and III by shifting type of fabric printed. However, the difficulty of roller printers increasing the use of aqueous pastes lies with the increased trend toward cotton-polyester blends and saturation of the all-cotton market.

Another differential effect of the Regulatory Alternatives II-IV which may occur is related not to the type of printing machine but to the type of firm. The independent or commission finishing firms would be affected more than the integrated firms for two reasons. For one, as shown in Section 9.2.3.2.3, the commission firms in general have a lower return on sales than do the integrated firms. And secondly, the integrated firms could absorb a loss in their printing lines if other areas of their business were profitable, whereas a commission printing plant would not be able to run an unprofitable operation beyond the short run.

9.2.3.3.2 Closure of Plants. Section 9.2.2.2 sets forth the theoretical basis describing the plant closure process. Promulgation of a NSPS for fabric printers could result in fewer machine replacements and accelerated plant closings. According to information in Section 9.1, firms will modify existing roller printing machines or replace worn out rotary and flat screen machines at a rate of 5 percent a year. Plans for these machine replacements, which will be affected by the NSPS requirements, may be cancelled if financial analysis indicates the investment will result in a loss in profitability for the printing line. Therefore, if firms perceive that operations will remain unprofitable for a printing line following machine replacement, they will choose not to make the replacement, leading to plant closure as machines become obsolete and wear out.

Regarding machine replacement under Regulatory Alternative IV, the model plant analysis presented in Section 9.2.3.2 shows that all commission plants and integrated plants operating flat screen machines are candidates for closure. This is because the costs associated with Regulatory Alternative IV would cause the plants' profitability to decline below zero. Thus, these plants, when faced with the necessity of replacing a machine, would be forced to close down unless they could find a way to increase prices, reduce other costs, or increase efficiency. The only two model plants that could maintain positive profitability after absorbing the costs of Regulatory Alternative IV are the integrated roller and rotary screen plants.

The anticipated number of machine replacements may give one an indication of the number of fabric printing machines to be affected by the NSPS Regulatory Alternative IV on a yearly basis. Based on the 5 percent replacement rate, as given in Section 9.1, and based on the existing population of

272 roller, 207 rotary screen, and 74 flat screen machines (refer to Appendix A), there should be approximately 14 roller, 10 rotary screen, and 4 flat screen machine replacements annually.

The number of replacements determined above do not imply an equivalent number of plant closures. This is because some of the replacements of roller and rotary machines will occur in integrated plants, where profitability remains positive following investment in an incinerator under Regulatory Alternative IV. Also, since most plants operate more than one machine (contrary to the model plant analysis), the decision to close a printing line will not immediately result in plant closure.

Lack of data prohibits one from estimating the number of plant closures that would result if Regulatory Alternative IV were promulgated. In a worst case situation, one might assume that fabric printers would choose not to replace any machines when they wore out or needed modification. This may lead to some plant closings initially, especially among plants operating only one machine; more likely, however, it will lead to future plant closures when several machines reach the age of retirement.

Regulatory Alternatives II and III may also lead to plant closures; however, these closures would probably be confined to roller machine plants, with rotary and flat screen machine plants unaffected. Because approximately 88 percent of fabric produced on rotary screens is printed with pastes with a solvent level of 7 percent or less (refer to Section 7), a NSPS requiring solvent levels of 12 or 24 percent under Regulatory Alternatives II and III would have little effect on rotary screen printers. Plants replacing rotary machines and printing with 12 or 24 percent level pastes should not suffer product quality deterioration, as would roller printers.

Roller printers printing high quality fashion apparel would probably see product quality deteriorate if regulated under Regulatory Alternatives II and III. As indicated in Section 7, about 53 percent of printed fabric produced on roller machines is printed with a 59 percent organic solvent print paste. Lowering the solvent level either to 12 or to 24 percent causes a dulling of color and a stiff feel to the fabric -- deterioration in quality which would probably cause market share loss to imports.[70/] For this reason, it is likely that many fabric printers would choose not to make modifications or replacements of roller machines, eventually losing market share to imports and opening the possibility of plant closures.

9.2.3.3.3 Import/Export Effects. The NSPS regulatory alternatives could increase imports and decrease exports in one of two ways. Loss of capacity may occur as some plants close down, which would invite importers to fill the gap in the market, or loss in product quality resulting from use of low organic solvent print paste may cause buyers to substitute higher quality foreign fabrics for domestic printed fabrics. Increased imports and decreased exports could result under either Regulatory Alternatives II or III if high quality fashion apparel printed by roller machines suffers from reduced quality. Increased imports could also occur for printed fabrics of all types under Regulatory Alternative IV, since costs would increase for all printing machines and any cost pass-through in the form of higher prices to the consumer would marginally increase the attractiveness of imports.

For low to medium quality apparel prints and for domestic and industrial fabrics, on the other hand, the implementation of Regulatory Alternatives II or III could boost exports because of lower costs of printing.

Anticipating the directional change in imports and exports as a result of the regulatory alternatives is difficult, let alone quantifying the effects. Examining a worst-case situation for Regulatory Alternatives II and III, one might assume that all the roller machines affected by the standard will lose their market shares because of reduced quality of the printed fabric. Rotary and flat screens, on the other hand, could be expected to maintain their market shares because fabric quality should not be impaired by a switch to low solvents. If one assumes that imports totally replace market share lost by roller machines, the increase of imports resulting from the regulation can be approximated, as described below.

As shown in Tables 9-14 and 9-16 in Section 9-1, production of printed fabrics by roller machines totalled 1553 million square yards in 1978. It is assumed that this production level will remain constant in the forthcoming years. If five percent of the roller machines, or five percent of production, is displaced each year as a result of Regulatory Alternatives II or III, then 78 million square yards of printed fabric could be lost to imports each year. Over a five year period, this quantity would rise to 388 million square yards. Based on 1978 imports of cotton and man-made fabrics of 1438 million square yards[71/], the yearly increase in imports resulting from Regulatory Alternatives II or III would amount to five percent, cumulating in a 27 percent increase over a five-year period.

Under the above-mentioned scenario, increased imports would plague the roller printing industry, which already suffers from low profitability, inefficiency in some mills, and excess capacity. However, it is doubtful that imports would ever increase to the degree described above. For some products printed by rollers, especially low quality apparel, quality differences resulting from a switch to lower solvents may not be that perceptible. Also, some of the market share potentially lost by rollers could be absorbed by rotary screen machines, further dampening increased imports.

Under Regulatory Alternative IV, which requires installation of an incinerator, imports may increase in all fabric categories due to increased costs in operating roller, rotary, and flat bed machines. The degree of the increase in imports will depend on the following: 1) the extent to which firms raise prices to cover increased costs, 2) the number of plants closing down, leaving demand for particular markets unmet, and 3) the level of import quotas established by future administrations.

9.2.3.4 Price Impacts. The effect of the regulatory alternatives on price levels of printed fabrics depends on the extent to which the producer passes cost increases/ decreases on to the consumer in the form of increased/ decreased prices. Cost pass-through could be determined if one knew the price elasticity of demand of printed fabrics and cross price elasticities of substitute products. Although lacking hard data on the values of these elasticities, it is possible to estimate the degree of price increase in printed fabrics as a result of an increase in producer's costs.

Due to the availability of low-priced printed fabrics produced by foreign countries and also the availability of domestic substitutes for printed fabrics (i.e., dyed materials), it is unlikely that fabric printers will fully pass through costs to the consumer. Commission printers would have difficulty passing costs on to the garment manufacturers because the manufacturers can shift to imports as their source of input. Likewise, integrated firms would be limited in passing costs through to their finished garments, once again because of import pressures. Thus, it is likely that prices of printed fabric will not increase substantially as a result of Regulatory Alternative IV.

In order to determine the maximum possible price increase resulting from Regulatory Alternative IV, one would assume full cost pass-through to the consumer. The usefulness of performing this exercise is the setting of an upper bound for price increases in printed fabrics. One would then expect that actual price increases would fall between the lower and upper bounds, probably closer to the lower bound of no cost pass-through.

Full cost pass-through is calculated for each of the model plants by assuming that baseline profitability levels remain constant, with the result that prices rise to cover costs. Thus, sales increase over the baseline by the amount of the price increase multiplied by output.

Table 9-46 indicates the average price increase over the baseline assuming full pass-through of costs of Regulatory Alternative IV. The price increases, assuming full pass-through of costs, are not insignificant, especially for the commission plants. Prices would increase by 6 percent for the rotary screen and roller commission plants and by 19 percent for the flat screen model plant. For the integrated plants, prices would rise by almost 2 percent for the rotary screen and roller plants and by almost 7 percent for the flat screen plant.

In summary, it is unlikely that printed fabric prices would increase by the amounts specified above under the assumption of full cost pass-through. These numbers serve as an upper bound to price increases. The actual increases would probably be much lower due to competitive pressures exerted on the industry and the availability of substitutes.

9.2.3.5 Employment Effects of Regulatory Alternatives. The employment effects of the NSPS regulatory alternatives would be based on those printing lines and plants closed down due to requirements of the regulatory alternatives. Referring to Appendix B, which provides employment levels for fabric printing plants that comprise two-thirds of the plants in the industry, employment at commission finishing plants ranges from as few as 20 employees to over 2500 employees. The average commission plant is estimated to employ about 300 people.

A firm's decision to close down a plant or discontinue a printing line would displace a group of both skilled and unskilled workers. The effects

TABLE 9-46. PRINTED FABRIC PRICE INCREASES ASSUMING FULL PASS-THROUGH OF REGULATORY ALTERNATIVE IV COSTS

Model Plant	Baseline Average Price (in dollars per meter)[1/]	Regulatory Alternative IV Average Price (in dollars per meter)[1/]	Average Price Increase over Baseline (in dollars per meter)	Percent Increase over Baseline
Commission Finishing Plants				
Rotary Screen	.33	.35	.02	6.1
Flat Screen	.36	.43	.07	19.4
Roller	.34	.36	.02	5.9
Integrated Finishing Plants				
Rotary Screen	1.21	1.23	.02	1.7
Flat Screen	1.04	1.11	.07	6.7
Roller	1.14	1.16	.02	1.8

1/ Calculated by dividing sales associated with Regulatory Alternative I and IV by output. Refer to Tables 9-28 and 9-32 through 9-37.

of unemployment of mill workers will vary from plant to plant depending on the location of the plant, the number of workers laid off, and the degree to which employee skills can be transferred to a new job. Thus, one would anticipate that displaced unskilled workers at a plant located in a large metropolitan area may be readily absorbed into the market. On the other hand, workers in small rural mill towns may encounter great difficulties locating new jobs.

9.2.3.6 Balance of Trade Effects. This section summarizes the effects of the NSPS regulatory alternatives on the U.S. balance of trade. In the worst case scenario for imports and exports under Regulatory Alternatives II and III, as postulated in Section 9.2.3.3.3, roller printing plants may lose market shares to imports. If five percent of production were displaced each year, 78 million square yards of printing fabric could be lost to imports each year, increasing to 1438 million square yards over a five year period. This increase in imports would comprise an annual increase of 0.17 percent in the 1978 U.S. balance on merchandise trade and 0.41 percent in the balance on current account.[72/] Over a five-year period, the increase would amount to 0.90 percent in the balance on merchandise trade and 2.2 percent in the balance on current account.

The costs associated with Regulatory Alternative IV may tempt fabric printers to raise prices to cover costs, thereby causing a shift among buyers toward imports. However, because of the threat of import competition, it is unlikely that fabric printers would raise prices significantly. Therefore, Regulatory Alternative IV would have very little effect on the U.S. balance of trade.

9.3 POTENTIAL SOCIO-ECONOMIC IMPACTS

This section reviews the fifth year impacts that would arise under the regulatory alternatives. Summarized below are the aggregate economic impacts which would occur five years after the NSPS is imposed, including total annualized costs and inflationary impact on the price of printed fabrics.

Total annualized costs for each NSPS regulatory alternative in the fifth year of the period 1980-1985 are presented in Table 9-47. Regulatory Alternatives II and III result in cost savings for the fabric printing industry. In the roller segment of the industry, the savings range from $2,475,000 to $3,960,000; for the rotary segment, from $1,930,000 to $2,370,000; and for the flat bed segment, from 0 to $7000. Regulatory Alternative IV would result in increased annualized costs to the industry, amounting to $6,525,000 for the roller segment, $4,440,000 for the rotary segment, and $121,000 for the flat bed segment. The annualized costs combined for all plants under Regulatory Alternative IV total $11,086,000.

Annualized costs for the regulatory alternatives in the fifth year are calculated by multiplying the annualized costs of the option, presented in Tables 9-29 to 9-31, by the number of plants affected by the standard in the five year period. The number of plants affected each year is calculated by dividing each industry segment's total output by model plant output. Output for each segment (roller, rotary, and flat screen machines) is calculated based on the assumption that 1977 production grows by a simple rate of one percent for the roller and rotary machines and three percent for the flat screen machine, as presented in Section 9.1.

Inflationary impacts in the fifth year are expected to be very insignificant because competition from substitutes and imports would hold down price increases of printers faced with Regulatory Alternative IV costs. Even if the plants that incur Regulatory Alternative IV costs were to pass these costs on the consumer, the price increases would be trivial. By dividing the fifth year annualized costs of Alternative IV by 1977 output (refer to Tables 9-13, 9-16, 9-3), one determines that the increased price of fabric (in dollars per meter) resulting from Regulatory Alternative IV would be .0047 for the rotary segment, .0061 for the roller segment, and .0002 for the flat screen segment. These increases represent under one-hundredth of a percent of 1977 prices in each segment of the industry.

TABLE 9-47. FIFTH YEAR ANNUALIZED COSTS OF REGULATORY ALTERNATIVES FOR EACH MODEL PLANT[1/] (THOUSANDS OF 1980 DOLLARS)

	Model Plants		
	Rotary Screen	Roller	Flat Screen
Regulatory Alternative I	0	0	0
Regulatory Alternative II	(930)	(2,475)	0
Regulatory Alternative III	(1,860)	(3,465)	(4)
Regulatory Alternative IV	4,440	6,525	121

1/ Annualized costs of each regulatory alternative as presented in Tables 9-29 to 9-31 are multiplied by the number of plants to be affected by the NSPS over the five-year period 1981-1986. It is estimated that 45 roller, 30 rotary screen, and one flat screen machine plants will be affected by the standard.

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APPENDIX A

NAMES, ADDRESSES, AND MACHINES IN PLACE:

U.S. FABRIC PRINTERS

TABLE A-1. NAMES, ADDRESSES, AND MACHINES IN PLACE: U.S. FABRIC PRINTERS

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	Alabama				
Russell Corporation	Alexander City		2		
Westpoint Pepperell, Inc.	Fairfax			5	
Westpoint Pepperell, Inc., Opelika Finish	Opelika		5	1	
	California				
Lorber Industries of California	Gardena		-		
Somitex Prints of California, Inc.	City of Industry			3	
	Connecticut				
Amerbelle Corporation	Rockville	4			
Charter Oak Textile Print, Inc.	Versailles				22
Decorative Screen Printers, Inc.	Norwich		2		
Fleisher Finishing, Inc.	Waterbury		2		
Lisbon Textile Prints, Inc.	Jewett City		3		
Roto-Print, Inc.	Versailles		5	1	
Sirtex Printing Company	Old Mystic				-
Stafford Printers/Gaynor-Stafford Industries, Inc.	Stafford Springs	7	1		
Textile Prints Corporation	Branford	5			
	Delaware				
New London Textile Print Works	Newark		2		
	Florida				
Arosa Knitting Corporation	Opa-Locka				-
Key West Hand Print Fabrics, Inc.	Key West			1	

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	Georgia				
Bibb Company	Juliette		4		
Carter, William, Company	Barnesville	4			
Crystal Springs Textiles/Dan River, Inc.	Chickamauga	6	3		
Dundee Mills, Inc.	Newnan				5
Elm City Plant/Milliken & Company	La Grange	1			
Georgia Hand Prints Company	Carrollton				4
Haight, A. S., & Company	Cartersville	7			
Laurens Park Mill/Mohasco Corporation	Dublin	-			
Printed Fabrics Corporation	Carrollton			5	
Swainsboro Printing & Finishing Company	Swainsboro	8	1	1	
Texprint, Inc.	Macon		2	3	
Transco Textile Industries, Ltd.	Augusta				-
Westpoint Pepperell, Inc.	West Point				
	Illinois				
Artex International, Inc.	Highland			1	
Briggs, R. A., & Company	Lake Zurich				10
Cardinal Products Company	Kincaid				5
Joanna Western Mills Company	Chicago	6			2
	Maine				
Westpoint Pepperell, Inc.	Biddeford				

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine Roller	R Screen	FB Screen	UNS Screen
	Massachusetts				
Arnold Print Works, Inc.	Adams	12	3	3	
Brittany Dye & Print Corporation	New Bedford		3	2	
Capri Textile Processing Company	Fall River		2		
Coronet Print, Inc.	Fall River				
Cranston Print Works Company	Webster	13			
Dartmouth Finishing Corporation	New Bedford	6	2		
Duro Finishing Corporation	Fall River				
Duro Textile Printers, Inc.	Fall River	6	2		
Huntington Fabrics	Lawrence			4	
Malden Mills, Inc.	Lawrence		1	4	
Mastex Industries, Inc.	Holyoke		2		
Photolon Corporation	Worcester	2			
Providence Pile Fabrics Corporation	Fall River				
Riveredge Textile Printers, Inc.	Fall River	3			
Swan Finishing Company, Inc.	Fall River		2		
Textiles, Inc.	Fall River				
	Michigan				
Ford Motor Company	Mt. Clemens	9			
	Minnesota				
Bemis Company	Minneapolis				
Litchfield Woolen Mill Company	Litchfield				

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine: Roller	R Screen	FB Screen	UNS Screen
	Mississippi				
Denton Mills, Inc.	New Albany				-
Intex Dye & Finish/Artex International	West Point	1			4
	Missouri				
Smithson, Inc.	Stover				2
	New Jersey				
Aegis Textile, Inc.	Woodbridge	4			
Applikay Textile Process Corporation	Passaic	8			
ATP Processors, Ltd.	Paterson	6	4		
Bouquet Screen Printing, Inc.	Passaic				-
Brewster Finishing Company, Inc.	Paterson	5	3	3	
Como Textile Prints, Inc.	Paterson		2	2	
Congress Textile Printers	Hawthorne	3			
Craft Textile Printing Company	Paterson		3		
D & S Processing Company	Clifton	1			
Dove Processing Company	Hawthorne	3			
Duramate Textile Printers (formerly Great Eastern)	Mahwah		1		
Kay Line, Inc.	Trenton				
Kroll, Boris, Jacquard Looms, Inc.	Paterson				5
Miss Brenner Prints, Inc.	Clifton		2	3	
Panta-Products/Pantasote Company	Butler	3			
Parra Prints	Passaic	-			-

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	New Jersey (con.)				
Perennial Print Corporation	Paterson	-			
Riverside Novelty Prints	Paterson	5			
Roma Print & Finish Corporation	Paterson		3		
Siltex/Silna Corporation	Moonachie				
Stacy Fusible Fabrics Corporation	Clifton		-		
Sterling Creative Textile Printers, Inc.	Paterson				
Stonehenge Processing Company	Cedar Grove		2	2	
Versailles Textile Printing Company	Weehawken				2
	New York				
Beacon Tex-Print Company	Beacon	6	4		
Cohoes Fabrics Printers, Inc.	Cohoes		2	2	
Colorite Textile Print Works	Brooklyn	2			
Garner Print Corporation	Spring Valley	3			
Kenmark Textile Printing Corporation	Farmingdale				7
Majestic Weaving Corporation	Cornwall		3	5	
Murad Textile Print Works	Brooklyn				4
Pleasant Valley Finishing Corporation	Pleasant Valley				
Printex Corporation	Ossining			3	
Ruby Ray Textile Printing	Yonkers	4			
Screen Modes, Inc.	Brooklyn				2
Screenmasters Textile Prints, Inc.	Brooklyn				-

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	New York (con.)				
Swanson Emblem & Lettering Company	Syracuse				2
Texstyle Creators, Ltd.	Long Island City				5
Textile Prints Corporation	New York	7			
Tops Unlimited/BBM Industries, Inc.	Ronkonkoma				4
Ultra Modern-Tex Screen Printing	New York				-
Wellfleet Products, Inc.	Long Island City				
	North Carolina				
Admiration Hosiery Mill, Inc.	Charlotte	2			
Avanti Knits, Inc.	Hope Mills		1	1	
Bangle Brothers, Inc.	Concord	1			
Beacon Manufacturing Company	Swannanoa		1		
Best Textile Company	Rocky Mount	9			
Blue Ridge Industries/Melville Textile Company	Statesville		1		
Broad River Processing Company, Inc.	Asheville	1			
Burlington Industries, Inc.	Greensboro	1	14		
Cannon Mills Company	Kannapolis		5		
Collins and Aikman Corporation	Cavel, (Roxboro)	2			
Cranston Print Works Company	Fletcher	11			
Dicey Mills, Inc.	Shelby			2	
Foremost Screen Print Plant/Fieldcrest Mills	Stokesdale		2	1	
Granite Knitwear	Granite Quarry				-

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	North Carolina (con.)				
Guilford Mills, Inc.	Greensboro		3		
Guilford-East/Guilford Mills, Inc.	Kenansville				
Hosiery Manufacturing Corporation	Morganton				-
Hydro Prints, Inc.	Charlotte				-
Melville Textile Print Works	Statesville		2	1	
Mount Hope Finishing Company	Butner		1		
Osterneck Company	Lumberton				-
Oxford Printing and Finishing Company	Oxford				
Print Plant, Inc.	Winston-Salem				2
Printmatic, Inc.	Albemarle				-
Quality Mills, Inc.	Mt. Airy	2			
Randolph Mills, Inc.	Concord				
Rice Hosiery Corporation	High Point				-
Royal Carolina Corporation	Greensboro		1	2	
Smithson of Southern Pines, Inc.	Southern Pines				1
Spectra Corporation	Winston-Salem				
Stevens, J. P., & Company, Inc.	Roanoke Rapids				
Superba Print Works, Inc.	Mooresville		3		
Swiss Knits, Inc.	Lincolnton				
Texfi Impressions	Goldsboro		3		
Universal Screen Printing Company, Inc.	Gastonia				6

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine: Roller	Printing Machine: R Screen	Printing Machine: FB Screen	Printing Machine: UNS Screen
	North Carolina (con.)				
Vei-Cord Southern Corporation	Lumberton		1		
Wade Manufacturing Company	Wadesboro	2			
Wansona Manufacturing Corporation	Wadesboro		6		
	Ohio				
Fleischer Mills	Cincinnati				
J & J Screen Printing	Danville				
Leshner Corporation	Hamilton				
Perma-Trans Products	Worthington				18
Velva-Sheen Manufacturing Company	Cincinnati				15
	Pennsylvania				
L & H Manufacturing Company	Chester				7
Printed Terry Finishing Company, Inc.	Lebanon				5
Redmond Finishing Company	East Stroudsburg		1		
Tempo Processing Company, Inc.	Mertztown				3
Textile Printing and Finishing Company, Inc.	Lebanon		3	3	
Valley Screen Printing Company, Inc.	Lebanon				-
Winston Prints, Inc.	Lebanon				
	Puerto Rico				
Puerto Rican Fabrics, Ltd.	Ponce	1			1
	Rhode Island				
Auto Screen Print	Woonsocket				-

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine			
		Roller	R Screen	FB Screen	UNS Screen
	Rhode Island (con.)				
Bradford Dyeing Association	Westerly		2		
Comet Dye Works, Inc.	Johnston				
Consolidated Print Works	Cranston		1		
Consolidated Print Works	Woonsocket			2	
Cranston Print Works Company	Cranston	1	5		
Dursin, M., & Sons, Inc.	Woonsocket				4
Griswold Textile Print, Inc.	Westerly				-
Highland Textile Printers, Inc.	Providence	6			
Kenyon Price Dye Works	Kenyon	1			
Screen Print Corporation	Coventry		1	1	
Slater Screen Print Corporation	Pawtucket		2	2	
Triangle Prints Company, Inc.	West Warwick				-
	South Carolina				
American Fast Print	Spartanburg		8		
Baxter, Kelly, & Faust, Inc., Anderson	Anderson	1			
Beacon Manufacturing Company, Oconee Division	Westminster	1			
Cherokee Finishing Company	Gaffney		6		
Clearwater Finishing/United Merchants and Manufacturers	Clearwater	15	4		
Cone Mills Corporation	Carlisle	12	6	1	
Dixie Prints, Inc.	Una				2
Dubois Dyeing Company/Stem Industries, Inc.	Johnsonville				6

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine Roller	R Screen	FB Screen	UNS Screen
	South Carolina (con.)				
Glenco Association, Inc.	Spartanburg	1			1
Global Prints Inc.	York	2			
Golding Brothers Raytex	Marion		2		
Grace Bleachery/Spring Mills, Inc.	Lancaster		10		
Lyman Print & Finish/M. Lowenstein & Sons	Lyman		11		
Pageland Screen Printers/Abney Mills	Pageland		6	3	
Perennial Print Corporation	Ware Shoals		-		
Riegel Textile Corporation	Ware Shoals		2		
Riegel Textile Corporation, La France Division	La France	1			
Rock Hill Print and Finish Company	Rock Hill	33	7		
Santee Print Works	Sumpter	9	6	2	
Screen Prints, Inc.	Hickory Grove			4	
Society Hill Specialty/Klopman Mills/Burlington Industries	Society Hill				-
Stevens, J. P., & Company, Inc.	Clemson		6	3	
	Tennessee				
Southern Silk Mills	Spring City				-
	Texas				
McKenzie Fabrics	Amarillo				-
Waco Products	Waco				-
	Vermont				
Pleasant Valley Printers	Cambridge				-

(continued)

TABLE A-1. (continued)

Facility	City, State	Printing Machine: Roller	Printing Machine: R Screen	Printing Machine: FB Screen	Printing Machine: UNS Screen
	Virginia				
Bristol Products Corporation	Bristol				-
Brookneal Plant, Burlington Domestics/Burlington Industries	Brookneal				-
Crompton-Shenandoah Company	Waynesboro	2			
Dan River, Inc./Danville Division	Danville		2		
Georgia Bonded Fibers, Inc.	Buena Vista	-			-
Schoolfield Finishers, Inc.	Danville	-			
	Wisconsin				
Medalist-Sand-Knit, Inc./Medalist Industries	Berlin				10

APPENDIX B

LIST OF TEXTILE COMPANIES FOR WHICH FINANCIAL INFORMATION IS AVAILABLE

TABLE B-1. TEXTILE COMPANIES FOR WHICH FINANCIAL INFORMATION IS AVAILABLE

Name and address/parent organization[a]	SIC codes	Sales ($\$10^6$)	Employment	Data notes[b]	Sources[c]
Alabama					
Russell Corporation, Alexander City	2253, 2329, 2339, 2211, 2221	176.0	6,500		1
Westpoint Pepperell, Inc., Opelika Finish	2261	21.9	500-999		5
California					
Lorber Industries, Gardena	2221	25.0	525	Lorprint, Los Angeles, CA[d]	1
Connecticut					
Amerbelle Corporation, Rockville	2262, 2231, 2261, 2295	-	375		2
Charter Oak Textile Print, Inc., Versailles	2262	9.4	35		5,6
Decorative Screen Printers, Inc., Norwich	2262	1.5	20-49		5
Lisbon Textile Prints, Inc., Jewett City	2269	3.6	60		5,6
Pantasote, Incorporated, Greenwich	2341, etc.[e]	137.0	2,900	Panta-Products, Butler, NJ[d]	1
Stafford Printers, Inc., Stafford Springs/ Gaynor-Stafford Industries, Inc.	2262	7.2	150		5,6
Delaware					
New London Textile Print Works, Newark	2261	2.6	80		5,6
Florida					
Arosa Knitting Corporation, Opa-Locka	2221	1.0	90		1
Key West Hand Print Fabrics, Key West	2261	4.0	120		1
Georgia					
Bibb Company, Macon	2281, 2211, 2282, 2221	207.0	6,700	Bibb Company, Juliette, GA[d]	1
Crystal Springs Textiles, Chickamauga/ Dan River, Inc.	2261	9.7	428		5,6
Dundee Mills, Newnan	2261	2.1	100		5,6
Georgia Hand Prints Company, Carrollton	2261	0.9	50		5,6
Printed Fabrics Corporation, Carrollton	2261, 2262, 2269	~4-5	300		2
Swainsboro Printing and Finishing, Swainsboro/Control Data Corp.	2261	15.4	250-499		5
Texprint, Inc., Macon	2261	1.0	200		5,6
Transco Textile Industries, Ltd., Augusta	2262	30.2	250-499		5

See footnotes at end of table.

(continued)

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($10^6)	Employment	Data notes[b]	Sources[c]
Illinois					
Briggs, R. A., & Company, Lake Zurich	2261	31.0	400		1
Cardinal Products, Inc., Kincaid	2261	1.1	35		5,6
Joanna Western Mills Company, Chicago	2391, 2295, etc.[e]	80.0	1,900		1
Maine					
Westpoint Pepperell, Inc., Biddeford	2262	40.3	500-999		5
Massachusetts					
Arnold Print Works, Adams	2251	15.0	830		1
Brittany Dye and Print Corporation, New Bedford	2261	9.3	280		5,6
Carter, William, Company, Needham Hts.	2341, 2322, 2321, 2253	130.0	5,500	Carter, William, Company, Barnesville, GA[d]	1
Coronet Print, Inc., Fall River	2269	1.5	20-49		5
Cranston Print Works Company, Webster	2261	24.6	700		5,6
Dartmouth Finishing Corporation, New Bedford	2261	6.0	200		1
Duro Finishing Corporation, Fall River/ Nortek, Incorporated	2261, 2262	16.0	285		2
Duro Textile Printers, Inc., Fall River	2261	2.4	120		5,6
Huntington Fabrics, Lawrence	2261	1.1	55		5,6
Mastex Industries, Inc., Holyoke	2262	12.9	100-249		5
Providence Pile Fabrics Corporation, Fall River	2211, 2241, etc.[e]	87.0	1,100		1
Riveredge Textile Printers, Inc., Fall River	2261	7.4	180		5,6
Swan Finishing Company, Inc., Fall River	2262	16.0	100-249		5
Michigan					
Ford Motor Company, Dearborn				Ford Motor Company, Mt. Clemens, MI[d]	
Minnesota					
Bemis Company, Minneapolis	2295, 2211, etc.[e]	678.0	13,400	Bemis Company, Minneapolis, MN.[d]	1
Litchfield Woolen Mills Company, Litchfield	2231	2.0	50		1

See footnotes at end of table.

(continued)

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($$10^6$)	Employment	Data notes[b]	Sources[c]
Mississippi					
Denton Mills, Incorporated, New Albany/ Lamb Knit Goods Company		15.0	800		1
New Jersey					
Applikay Textile Process Corporation, Passaic	2261	0.6	65		5,6
ATP Processors, Ltd., Paterson	2261	6.2	130		5,6
Brewster Finishing Company, Paterson	2231	0.8	100-249		5
Como Textile Prints, Paterson	2261	1.1	20-49		5
Congress Textile Printers, Hawthorne	2261	1.4	16		5,6
Craft Textile Printing Co., Paterson	2261	1.1	20-49		5
D & S Processing Company, Inc., Clifton	2261	3.7	100-249		5
Duramate Textile Printers, Mahwah	2262	4.3	45		5,6
Kroll, Boris, Jacquard Looms, Paterson/ B. Kroll Fabrics	2211	-	155		1
Miss Brenner Prints, Inc., Clifton	2262	7.3	50-99		5
Perennial Print Corp., Paterson	2261	2.6	50-99		5
Riverside Novelty Printers, Paterson	2262	5.4	50-99		5
New York					
Allison Mfg. Company, New York City/ Beatrice Foods	2321, 2322	-	1,500	Allison Mfg., Knitting Div., Allentown, PA[d]	2
Amicale Industries, New York City	2283	2.0	450	Anchor Dye & Finish, Philadelphia, PA[d]	2
Beacon Tex-Print Company, Beacon	2261	8.8	175		5,6
Bernard Screen Printing Corporation, New Hyde Park	2396	5.0	143		2
Cohoes Fabrics Printers, Inc., Cohoes	2261	1.1	60		5,6
Colorite Textile Print Works, Brooklyn	2269	2.6	50-99		5

See footnotes at end of table.

(continued)

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($\$10^6$)	Employment	Data notes[b]	Sources[c]
New York (continued)					
Milliken & Company, New York City	2211, 2221, 2231			Elm City Plant, La Grange, GA[d]	2
Mohasco Corporation, Amsterdam	2272, 2271, 2279, 2291, etc.[e]	712.0	17,000	Laurens Park Mill, Dublin, GA[d]	2
Pleasant Valley Finishing Corporation, Pleasant Valley	2262	17.3	100-249		5
Printex Corporation, Ossining/Manhattan Industries	2261	4.8	100-249		5
Texstyle Creators, Ltd., Long Island City	2261	2.6	100		5,6
North Carolina					
Admiration Hosiery Mill, Incorporated, Charlotte	2251		200		3
Beacon Manufacturing Company, Swannanoa	2231	40.9	1000-2499		5
Blue Ridge Industries, Statesville/ Melville Textile Company	2396, 2283	0.9	75		3,5
Broad River Processing Company, Asheville	2392, 2269	1.1	45		3,5
Burlington Industries, Greensboro	2262	22.3	250-499		5
Cannon Mills, Kannapolis	2211, 2261	36.1	2,300		3,5
Cavel Division, Roxboro/Collins & Aikman Company	2211, 2221, 2231	42.3	1,000		3,5
Cranston Print Works, Fletcher/ Cranston Print Works	2261	28.7	650		3,5
Dicey Mills, Incorporated, Shelby	2221	14.0	220		1,3
Foremost Screen Print Plant, Stokesdale/ Fieldcrest Mills	2261		100-250		4
Granite Knitwear, Granite Quarry	2321, etc.	3.0	110		1
Guilford Mills, Inc., Greensboro	2258	160.0	1,800		1,3
Guilford-East, Kenansville/ Guilford Mills	2258		458		3
Hosiery Manufacturing Corporation, Morganton	2251		350		3
Hydro Prints, Incorporated, Charlotte	2261	9.3	220		3,5
Melville Textile Print Works, Statesville/Melville Textile Company	2262	1.8	90		3,5

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($\$10^6$)	Employment	Data notes[b]	Sources[c]
North Carolina (continued)					
Mount Hope Finishing Company, Butner	2261, 2269	11.0	295		1,3
Osterneck Company, Lumberton	2221	7.0	275		1,3
Print Plant, Incorporated, Winston-Salem	2396	3.0	65		1
Printmatic, Incorporated, Albemarle	2261	2.6	62		3,5
Quality Mills, Incorporated, Mt. Airy	2253	41.0	1,900		1
Randolph Mills, Incorporated, Concord	2281, 2269		58		3
Rice Hosiery Corporation, High Point	2251		95		3
Royal Carolina Corporation, Greensboro	2751, 2269	3.8	75		3,5
Smithson of Southern Pines, Southern Pines	2392, 2211		50		3
Stevens, J. P., & Company, Roanoke Rapids/ J. P. Stevens & Company	2261	10.7	250-500		4,5
Superba Print Works, Incorporated, Mooresville	2261	7.2	230		3,5
Swiss Knits, Incorporated, Lincolnton	2256		15		3
Texfi Impression, Goldsboro/ Texfi Industries	2262	4.0	85		3,5
Universal Screen Printing Company, Gastonia	3953, 2261	1.1	47		3,5
Vel-Cord Southern Corporation, Lumberton	2269	9.3	400		3,5
Wade Manufacturing Company, Wadesboro	2211		900		3
Wansona Manufacturing Company, Wadesboro	2269		450		3
Ohio					
I. Fleischer & Sons, Cincinnati/ Fleischer Mills	2299, etc.[e]	-	24		2,6
Leshner Corporation, Hamilton	2211, 2241, 2299, 2392, etc.[e]	32.0	490		2
Leshner Corporation, Hamilton		36.0	710		1

See footnotes at end of table.

(continued)

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($10^6)	Employment	Data notes[b]	Sources[c]
Pennsylvania					
Printed Terry Finishing Company, Lebanon	2261	<1.0	50-60		2
Textile Printing and Finishing Company, Inc., Lebanon	2261	3.7	100-249		5
Valley Screen Printing Company, Lebanon	2261	1.1	40		5,6
Winston Prints, Inc., Lebanon	2261	1.4	45		5,6
Rhode Island					
Bradford Dyeing Association, Inc., Westerly	2262	34.5	275		5,6
Consolidated Print Works, Woonsocket	2262	2.3	20-49		5
Cranston Print Works Company, Cranston	2261	6.0	300		5,6
Griswold Textile Prints, Westerly	2261	2.6	50		5,6
Highland Textile Printers, Providence	2261	6.7	130		5,6
Kenyon Piece Dye Works, Inc., Kenyon/Charbert, Inc.	2262	32.4	375		5,5
Screen Print Corp., Coventry	2261	2.6	50-99		5
Slater Screen Print Corporation, Pawtucket	2261	8.0	41		1
Triangle Printing Co., West Warwick	2261	2.6	22		5,6
South Carolina					
American Fast Print, Spartanburg	2261, 2262	5.7	250-499		5
Cherokee Finishing Company, Gaffney	2261	12.0	450		5,6
Clearwater Finishing, Clearwater/United Merchants and Manufacturers	2262	56.3	1,150		5,6
Dubois Dyeing Company, Inc., Johnsonville/Stem Industries, Inc.	2269, 2231	15.5	250-499		5
Grace Finishing, Lancaster/Springs Mills	2262, 2261	31.4	500-999		5
Pageland Screen Printers, Pageland	2261	1.1	75		5,6
Riegel Textile Corporation, Greenville	2211, 2269, 2392	307.0	9,300		1
Rock Hill Printing and Finishing Company, Rock Hill/M. Lowenstein & Sons	2261	95.4	2,500-9,999		5
Santee Print Works, Inc., Sumter	2261	24.6	500-999		5
Screen Prints, Inc., Hickory Grove	2261	2.6	50-99		5
Stevens, J. P., Clemson	2261, 2211	9.6	250-499		5

See footnotes at end of table.

(continued)

TABLE B-1. (continued)

Name and address/parent organization[a]	SIC codes	Sales ($$10^6$)	Employment	Data notes[b]	Sources[c]
Tennessee					
Southern Silk Mills, Spring City	2258, 2221, 2281, 2341	20.0	650		2
Virginia					
Burlington Domestics, Brookneal	2261, 2231				
Crompton-Shenandoah Company, Waynesboro/ Crompton Company	2261, 2211, 2221	1.0	20-49		5
		-	692		1
Wisconsin					
Medalist Industries, Milwaukee	2329, 2339, etc.[e]	101.0	2,750	Medalist - Sand-Knits, Berlin, WI[d]	1

[a]Plants listed in this table represent only 66 percent of those given in Table A-1.

[b]Unless otherwise indicated, data presented apply only to printing facilities.

[c]Sources are indicated as:

1. Dun and Bradstreet Million Dollar Directory 1980. Parsipanny, N.J.: Dun and Bradstreet Corporation, 1979.
2. Standard and Poor's Register of Corporations, Directors, and Executives 1980. New York: Standard and Poor Corporation, 1980.
3. N.C. State Industrial Directory 1979. New York: State Industrial Directories Corporation, 1978.
4. Directory of N.C. Manufacturing Firms, 1979-80. Raleigh, N.C.: Department of Commerce, Industrial Development Commission, 1978.
5. Economic Information System, Inc. New York, N.Y.: EIS Plants and Non-Manufacturing Establisments, April 4, 1979.
6. Davison's Textile Blue Book. Ridgewood, N.J.: Davison Publishing Company, 1979, pp. 14-196.

[d]Data are for the entire corporation. Printing subsidiary is listed.

[e]One or more SIC codes not related to fabric printing have also been assigned to this plant.