Chapter VII
Cost/Benefit, Energy & Trade Issues

International Trade Issues

According to Marci Kinter of SPTF, screen reclamation in other parts of the world does not vary greatly from screen reclamation in the United States. There is some evidence that the size of screen printing shops in Europe may be larger; there are expensive automatic screen washers produced and sold there which were apparently unable to find a market in the US. Otherwise, screen reclamation products are basically the same as those used here. In addition, there is much growth occurring in the Asia-Pacific market.[1]

Many of the screen reclamation products used in the US are produced in Europe, including both traditional and alternative products.

Energy and Natural Resource Issues

Thus far, this CTSA has focused primarily on the trade-offs between risk, performance and cost of alternative screen reclamation chemicals and methods. When designing products or processes with the environment in mind, however, conservation of energy and natural resources (e.g., materials) should also be a goal. This section identifies the areas where energy and materials are consumed as a result of the screen reclamation process.

Screen Reclamation Processes

Table VII-1 presents the process steps performed in the four manual screen reclamation methods described in Figure I-2. Each time a process step is performed, whether it involves the application of a chemical or a water wash, it results in the use of energy or natural resources (e.g., chemicals derived from natural resources, water, disposable shop towels, etc.).

Energy is consumed when mechanized equipment is used, including hot water heaters and pressurized water-spray units. Any use of materials results in the consumption of natural resources, whether the material is water, chemicals, or shop towels. Although it is true that materials can frequently be reclaimed once used, the reclamation process results again in the use of energy and natural resources.

[1]SPAI. 1993. Screen Print '93 International Convention and Exposition. Screen Printing Association International, Fairfax, VA. p104.

Table VII-1
Steps Performed in Manual Screen Reclamation Methods

Screen Reclamation Step	Screen Reclamation Method 1	2	3	4
Ink Removal Chemical	✓	✓	✓	×
Degreaser/Degradant Chemical	×	×	✓	×
Water Wash	Optional	Optional	Optional	✓
Emulsion Removal Chemical	✓	✓	✓	✓
Water Wash	✓	✓	✓	✓
Haze Removal Chemical	×	✓	×	✓
Water Wash	×	✓	×	✓

Key: ✓ - Step performed
× - Step not performed

Collecting Data on Energy and Natural Resources Consumption

The first step in an analysis of energy and natural resources consumption is to select the life cycle stages on which to focus. The life cycle of a typical product system begins with the acquisition of the raw materials used to make the product and continues on through manufacture, transportation, use, recycling, and disposal of the product. Energy and natural resources consumption can occur during each of these life cycle stages, but may be much more significant in one life cycle stage as compared to another. For example, studies of the life cycle of the automobile have shown that the vast majority of the energy consumption of a typical auto comes from the product use stage.

For screen cleaning and reclamation chemicals, the DfE Screen Printing Project elected to focus on energy and natural resource consumption during the use stage, when printers are actually cleaning and reclaiming their screens. We focused on this life cycle stage, and not the other life cycle stages, for the following reasons:

- The amount of energy and natural resources consumed during the use of the chemical products will vary depending on the relative amounts of chemical products used, the types of equipment used to apply the products and reclaim the screens, the temperatures at which the cleaning steps are conducted, and the duration of the various cleaning steps. Since this life cycle stage could be significant, it was decided to collect data on energy and natural resources consumption during the performance evaluation.

- Manufacturers of screen reclamation products indicated that the same basic process is used to formulate screen cleaning and reclamation products, regardless of the types of ingredients. Therefore, no significant differences between products were expected in energy and natural resources consumption during the product formulation process.

- Significant differences could exist in the amounts of energy and natural resources consumed when the chemical ingredients are manufactured. For example, chemical ingredients manufactured from petroleum not only use energy during the chemical manufacturing process, they also have an equivalent energy value. The amounts of each individual chemical ingredient used in screen cleaning and reclamation products is small, however, relative to the total consumption of these chemicals in other industries or products. For this reason, and because of the limited resources available to this project, no data were collected on the amounts of energy and natural resources consumed during chemical ingredient manufacturing.

- Significant differences could also exist in the amounts of energy and natural resources consumed when the raw materials used to make chemical ingredients are acquired. For example, petroleum-based chemicals require the pumping of petroleum from deep wells and transportation, usually by pipeline, to a petroleum refinery. Citrus-based products are made from fruit harvested from trees and transported, usually by truck or rail to a chemical manufacturer. For the same reasons mentioned above, however, no data were collected on the amounts of energy and natural resources consumed during the acquisition of raw materials.

- Differences may exist in the amounts of energy and natural resources required to dispose of spent screen cleaning and reclamation chemicals or water contaminated with screen cleaning chemicals. Due to limited resources, however, no data were collected on energy and natural resources use during the treatment and disposal stage of the product life cycle.

To assess energy and natural resources consumption during the performance evaluations, the following data were initially requested from the observers and the volunteer screen printing facilities:

- Equipment nameplate capacity or specifications (e.g., voltage, pressure, etc.);

- Equipment operating parameters, including operating pressure and flow rates for spray or water-blast equipment, and water temperature (if heated water is required);

- The amount (volume) of chemical product consumed during each cleaning/reclamation step, and the amount of dilution with water, if any;

- The amount (volume) of water consumed during each water wash step, calculated from the flow rate and the duration of the water wash step;

- The number of shop wipes required with the ink removal chemical; and

- The size and condition of the screen so that data could be normalized to a single screen size.

Due to the large amount of data required for the performance evaluation, however, some of the energy and natural resources data were not collected; the data requirements were taking too much of the printer's time or the extent of the data requirements were not clear. As a result, quantitative analysis of the energy and natural resources consumed with traditional and alternative products during the screen cleaning/reclamation process was not possible. Listed below, however, is a summary of the areas where energy and natural resources may be consumed as a result of the screen reclamation process.

Energy Impacts of Screen Reclamation

- The use of chemicals products and water has an energy impact. As discussed above, chemical manufacturing, distribution, recycling and disposal all require energy inputs. Chemical use requires an energy input if mechanized equipment is used. By the same token, the cycle of water treatment, distribution, and use followed by wastewater treatment also requires energy inputs.

- During a water wash, the rate of energy use is dependent on the type of equipment used to apply the water and the temperature of the water. Obviously, high-pressure spray washes require more energy and equipment than a non-pressurized water wash, however they may consume less water. Hot or warm water washes are much more energy intensive than those conducted at ambient water temperatures. In fact, it is likely that products requiring the use of heated water would have the greatest energy impact, even if a quantitative analysis was done of all stages of the product life cycle. A life cycle assessment of laundry detergents, for example, found that the greatest environmental impact from using laundry detergents came from producing the energy required to heat the water in hot-water washes.

- If a pressurized water wash is required, spray units can be used that optimize the wetting potential and minimize water flow by using a combined stream of water and air. In some cases, chemicals applied using a rag or brush can supply the abrasive action that would be provided by a pressurized water wash. If the screen is scrubbed manually, less chemical product may be required and a non-pressurized wash can be used to rinse the screen.

Materials Acquisition and Natural Resource Impacts of Screen Reclamation

- Some screen reclamation methods may require the use of greater amounts of chemical products than others, depending on the number of steps requiring chemicals and the volume of chemical used in each step. The former depends on the screen reclamation method selected; the latter depends on a number of factors, including the chemical product used, the extent of ink and stencil on the screen, employee preference, and time allowed for ink to dry before cleaning. The amount of chemicals required to reclaim a screen should be optimized to the extent possible to avoid unnecessary use of resources.

- The amount of water used during screen reclamation also depends on the screen reclamation method and chemical products used. For example, several of the alternative chemicals products evaluated during the performance testing did not require a water wash after use. If a water wash is required, the amount should be optimized to avoid unnecessary use of resources.

- If a water wash is performed, the resulting wastewater should be collected separately from any chemical overspray or chemical run-off collected while the chemical is being applied. This will allow for more efficient chemical recovery and recycling, reduce the concentrations of contaminants in the wastewater, and thus, improve the treatability of the wastewater.

- If the entire screen does not require cleaning or reclamation, reusable rags and brushes can be used to apply chemical products to selected areas of the screen, thus reducing the volume of chemical product used. Reusable rags and brushes save resources compared to disposable products and contribute less to the solid waste stream. The cleaning of reusable products, however, does result in a waste stream and requires inputs of energy and natural resources.

- Disposable shop towels result not only in the consumption of resources, they also generate solid, potentially hazardous, waste and increased disposal cost.

Cost/Benefit Analysis of Alternative Screen Reclamation Processes

The risk assessment conducted as a part of the CTSA analyzed the risk of each alternative screen reclamation system used in each of the alternative methods as well as the screen disposal work practice and the automatic screen washer technology. A cost analysis was also performed to estimate the cost of each alternative screen reclamation method, technology, and work practice evaluated in the CTSA. This section compares the costs and benefits (in terms of reduced human health risks) of switching to alternative screen reclamation products, technologies, and work practices. In addition, this analysis looks beyond just the costs (material, labor, etc.) and benefits (reduced worker health risks) to printing operations of switching to alternative systems and considers the potential for societal benefits. Specifically, it considers the possibility that the use of screen reclamation substitutes could result in reduced health risks to the general population, lower health insurance and liability costs for the printing industry and society, and decreased adverse impacts to the environment. The costs and risk trade-offs associated with the baseline and each method are summarized in Table VII-2.

Exposed Population

Due to resource limitations, it was not possible to quantify changes in individual or population risks, i.e., changes in the incidence of associated health effects. As a result, this analysis does not provide an estimate of risk reductions nor a dollar estimate of the benefits associated with reduced health risks but makes qualitative comparisons of the estimated costs and potential benefits of switching from traditional to alternative screen reclamation methods. Estimates of the worker population potentially exposed to traditional and alternative screen reclamation chemicals, however, are provided based on data collected in the risk assessment and on estimates of numbers of printing facilities from SPAI (see Table VII-3). It has been estimated that for small to medium sized facilities one to three employees are involved in screen reclamation. Combining this information with the total number of print shops in the graphics industry (20,000, SPAI, 1994) yields an estimated exposed worker population of between 20,000 and 60,000.[2] For ink removers it is possible to further refine exposed worker population estimates based on market share data for traditional and alternative ink removers.

[2] Estimates of the exposed general population are not available.

Table VII-2
Costs and Risk Trade-offs of Screen Reclamation Substitutes

System Evaluated		Cost/Screen	Cost/Facility	Risk Trade-offs
Baseline for Method 1 (Traditional System 4 - Haze Remover)		$3.63	$5,446	Clear concern for worker dermal risks and worker inhalation risks
Method 1: Chemical substitutes for ink removal and emulsion removal. No haze removal required.	Chi (no haze remover)	$1.95-2.83	$2,918-4,245	Moderate concern for worker dermal risks and very low concern for inhalation risks
	Beta	$7.97	$11,958	
Baseline for All Other Methods (Traditional System 4)		$6.27	$9,399	Clear concern for worker dermal risks and worker inhalation risks
Method 2: Chemical substitutes for ink removal, emulsion removal and haze removal.	Alpha	$5.92-9.37	$8,886-14,062	Moderate concern for worker dermal risks and low concern for inhalation risks
	Chi	$3.25-3.89	$4,879-5,829	
	Delta	$3.28-7.66	$4,917-11,489	
	Epsilon	$3.08-5.29	$4,624-7,930	
	Gamma	$5.06-5.61	$7,590-8,417	
	Mu	$4.79-9.33	$7,185-13,997	
	Phi	$6.10-7.82	$9,233-11,728	
	Omicron-AE	$5.49-10.85	$8,240-16,278	
	Omicron-AF	$3.89-4.45	$5,836-6,675	
	Zeta	$5.39-8.99	$8,080-13,479	
Method 3: Chemical substitutes for ink removal, degreasing and emulsion removal. No haze removal required.	Omicron	$5.57	$8,358	Moderate concern for worker dermal risks and very low concern for inhalation risks
Method 4: Technology substitute of screen disposal in lieu of reclamation.	Theta	$4.53	$6,797	Marginal concerns for worker dermal risks and very low concerns for worker inhalation risks
Technology Substitute	Automatic Screen Washer	$4.13-10.14	6,198-15,213	Moderate concern for worker dermal risks and very low concern for inhalation risks
Work Practice Substitute	Screen Disposal	$49.43	$74,141	No risks associated with screen reclamation products

Note: Costs presented are normalized costs. Ranges are presented when there was more than one facility using the method and system in the performance demonstration.

Allocating between use of traditional and alternative products suggests that between 13,120 and 39,360 workers are exposed to traditional ink removers and 6,880 and 20,640 are exposed to alternative ink removers.[3] As there are few differences among emulsion removers it is assumed that the total population of screen reclaimers are exposed to similar formulations of emulsion removers. Finally, the market share of haze removers used by printing operations that is considered to be traditional and the market share that is considered to be alternative is not known. Consequently, for this cost exercise, it was assumed that all haze removers currently used are traditional products. Not all printers, however, use haze removers. Industry figures indicate that haze removal is performed on between 27 and 80 percent of reclamations. The number of workers exposed to traditional haze removers is, therefore, estimated to be between 5,400 and 48,000.

Table VII-3 also indicates the number of workers that could potentially experience a reduction in risk (column 1) if alternative products were substituted for traditional products in their shop. It should be noted, however, that benefits may be minimized if printers switch to alternatives for some but not all screen reclamation products. A discussion of the potential benefits that might result from reductions in the incidence of an illness (hypertension) linked to exposure to chemicals typically used in screen reclamation (solvents), is presented later in this section as an example of the type and magnitude of benefits that are associated with reductions in health risks.

Table VII-3
Estimates of Exposed Worker Population

	Worker Population Exposed to Traditional Products	Worker Population Exposed to alternative products
Ink Remover	13,120 - 39,360	6,880 - 20,640
Emulsion Remover	20,000 - 60,000	
Haze Remover	5,400 - 48,000	0
Total Exposed Worker Population	20,000 - 60,000	

The following discussion is limited to ink removers and haze removers used in each method since EPA's risk assessment concluded that risks associated with traditional and alternative emulsion removers were virtually the same. Emulsion remover risks include a significant risk of skin irritation and tissue damage from the components of emulsion removers (i.e., either strong oxidizers or strong bases) if screen reclaimers are exposed in the absence of proper protective clothing. None of the traditional or alternative emulsion removers, however, presents significant inhalation risks.

[3] Market share equals 65.6 percent for traditional ink removers and 34.4 percent for alternative ink removers.

Human Health Benefits

The benefits associated with switching to less toxic ink removers and haze removers can be described in terms of reduced risks to both printers and the general public. The results of the EPA risk assessment suggest that, in general, the alternative products are much less volatile than traditional products. While all of the traditional product systems present clear concerns for worker inhalation exposures, only one of the alternative systems (Mu) presents a concern for inhalation exposures to workers. Almost half of the alternative products, however, present clear concerns for unprotected dermal exposures to workers, as do all of the traditional products. Worker dermal exposures to all products, however, can easily be minimized by using proper protective clothing during screen reclamation.

The most significant health risk to the general population from screen reclamation products is associated with the release of volatile organic compounds that contribute to the formation of photochemical smog in the ambient air. Traditional products, due to their greater volatile fraction, are likely to have a much greater impact on ambient air quality, if released, than the alternative products. In addition, the use of an automatic screen washer technology for ink removal may significantly reduce air emissions of certain volatile ink remover components, although the amount of reduction depends on the specific components of the formulation and the type of technology employed. EPA's risk assessment indicates, however, that health impacts to the general population from screen reclamation products are very low for all traditional and alternative products, technologies and work practices evaluated. Consequently, the reduction in risks associated with switching to alternative products, technologies, or work practices are minor.

Associated Costs

Per screen costs depend on variations in labor costs, product usage, materials and equipment, and hazardous waste disposal costs (screen size and number of screens cleaned have been normalized to the baseline) at each facility in the performance demonstrations.[4] As shown in Table VII-2, the cost associated with using the baseline traditional screen reclamation system equals \$3.63/screen for method 1 and \$6.27/screen for all other methods (assuming reclamation of 6 screens per day and a screen size of 2,127 in^2) and total facility costs of \$5,446/year and \$9,399/year respectively.[5] Under the alternative systems, costs range from \$1.95/screen (\$2,918 per year) for Method 1 to \$49.43/screen (\$74,141 per year) for the Screen Disposal option. Excluding Screen Disposal, the cost of alternative methods range from \$1.95/screen (Method 1) to \$10.85/screen (Omicron-AE, Method 2). As such, cost savings might be realized by printers switching to any of the methods except screen disposal, depending on the operating conditions of their shop. Based on the performance demonstrations, two out of three facilities in method 1, 14 out of 22 facilities in method 2, one out of two facilities in method 3, the one facility in method 4, and one out of two facilities using the automatic screen washer would experience cost savings from switching to alternative products, technologies, and work practices. Cost savings indicated in the performance demonstrations range from as little

[4] Normalized values adjust product usage, number of screen cleaned, and number of rags laundered at demonstration facilities to reflect the screen size and number of screens cleaned per day under the baseline scenario. Labor costs, however, are not normalized. Normalization allows a comparison between the baseline and facility results.

[5] The baseline system for method 1 does not include a haze remover.

as $0.17/screen to $3.19/screen and are frequently due to differences in labor costs. Alternatively, printers could experience cost increases of between $1.39/screen and $43.16/screen ($4.58/screen excluding screen disposal). It should be noted that these cost estimates do not fully reflect the performance of product systems demonstrated. For example, while performance characteristics such as volume of product and time to clean were considered, other important characteristics such as whether the facility continued using the alternative product and whether the product shortened the life of or destroyed the screen were not considered.

Costs and Benefits by Method

The costs and benefits associated with each method are discussed separately below. For each comparison, traditional system 4 is used as the baseline system. Briefly, human health concerns for the baseline system are related to toluene, methyl ethyl ketone, and methanol for ink removers and acetone, cyclohexanone, and mineral spirits for haze removers. Risks are linked to chronic dermal and inhalation exposures to workers during both ink removal and haze removal. Dermal exposures to workers using mineral spirits in haze removal can be quite high but were not quantified in the risk assessment due to limitations in the data and the fact that these risks are easily mitigated through the use of gloves.

Method 1: Chemical Substitutes for Ink Removal and Emulsion Removal. No Haze Remover Required

The use of Chi and Beta in method 1 significantly reduced worker inhalation risks and moderate worker dermal risks. Clear concern exists, however, for chronic dermal exposures to diethylene glycol series ethers used in ink removal. Moderate concern exists for developmental toxicity risks from dermal exposures to N-methylpyrrolidone. Concern for inhalation exposures to other ink removal chemicals used in this system, however, is very low. Haze remover is not used in this method. Dermal and inhalation risks associated with haze removers are, therefore, completely avoided under this method. In terms of costs, two printers switching to method 1 incurred cost savings of $0.80/screen ($1,201/year) and $1.68/screen ($2,528/year), however, one facility experienced a cost increase of $4.34/screen ($6,512/year).

Method 2: Chemicals Substitutes for Ink Removal, Emulsion Removal and Haze Removal

Ten product systems are included in Method 2. Overall, this method, except for Mu, has significantly reduced worker inhalation risks and moderate worker dermal risks as compared to the baseline system. Concern does exist, however, for chronic dermal exposures to diethylene glycol series ethers, cyclohexanone, benzyl alcohol, d-limonene, and propylene glycol methyl ether used in ink removal. Marginal concerns exist for chronic inhalation exposure to workers using propylene glycol series ethers and d-limonene in ink removal. Moderate concern also exists for developmental toxicity risks from dermal exposures to N-methylpyrrolidone and inhalation exposures to methoxypropanol acetate, propylene glycol series ethers, and cyclohexanone.

Risks associated with other chemicals in product systems Alpha, Beta, Delta, Epsilon, Gamma, Mu, Phi, Zeta, and Omicron could not be quantified due to limitations in the hazard data. It is possible, however, that inhalation and dermal exposures to these chemicals could be high.

Fourteen of the 22 printing facilities using method 2 experienced cost savings of as much as $3.19/screen ($4,775 per year). The remaining eight printing facilities experienced cost increases from $0.24/screen ($373/year) to $4.58/screen ($6,879/year).

Method 3: SPAI Workshop Process -- Chemical Substitutes for Ink Removal, Ink Degradent, Degreasing, and Emulsion Removal. No Haze Removal Required

Similar to methods 1 and 2 above, method 3 has significantly reduced worker inhalation risks and moderate worker dermal risks. Clear concern does exist, however, for chronic dermal exposures to workers using diethylene glycol series ethers in ink removal. In addition, there are possible concerns for developmental toxicity risks from dermal "immersion" exposures to diethylene glycol series ethers. Switching from the baseline system to Method 3 resulted in a cost savings of $0.70/screen ($1,041/year).

Method 4: Technology Substitute of High Pressure Wash for Ink Removal, Technology Substitute and Reclamation Products used for Emulsion and Haze Removal

Using a high pressure wash results in only marginal concerns for worker dermal risks and very low concerns for worker inhalation risks. Specifically, there is a marginal concern for chronic dermal exposures and a very low concern for chronic inhalation exposures to cyclohexanone during haze removal. In addition, there is minimal concern for developmental and reproductive toxicity risks from inhalation exposures to cyclohexanone. In terms of costs, the printing facility in the performance demonstration switching to method 4 incurred a cost savings of $1.74/screen ($2,602/year).

Technology Substitute of Automatic Screen Washer for Ink Removal.

Risks from the automatic screen washer were evaluated assuming use of the ink removers from traditional system 1 and traditional system 3. Using traditional system 1 ink remover, inhalation exposures were significantly lower (approximately 70% reduction) than the exposures during the manual use of this ink remover. Using traditional system 3, marginal concerns are for chronic inhalation exposures to toluene, methyl ethyl ketone and methanol are indicated. Additionally, clear concerns for chronic dermal exposures to toluene and methyl ethyl ketone and marginal concerns for dermal exposures to methanol are indicated. While the automatic screen washer was not used by printing facilities in the performance demonstrations estimates of the cost to printers of using the automatic screen washer technology were generated. Based on these estimates, it is expected that printers switching from the baseline product to a low cost ($5,000) automatic screen washer for ink removal would experience a cost savings of $2.14/screen ($3,201/year). Printing operations similar to the model facility switching to a high cost ($95,000) automatic screen washer (more automated than the $5,000 washer) would experience a cost increase of $3.87/screen ($5,814/year).

Work Practice Substitute of Screen Disposal in Lieu of Reclamation.

Under this approach, reclamation does not occur. Rather, the screen is cut out of the frame and disposed. As such, it is considered to be a pollution prevention activity and is discussed more fully in Chapter Six: *Overall Pollution Prevention Opportunities for Screen Reclamation*. It should be noted, however, that the costs associated with this approach are quite high at $49.43/screen and represent a very significant cost increase to printers. Based on discussions with the Screen Printing Technical Foundation, it is suggested that screen disposal is probably only cost effective with smaller screen sizes and/or long production runs, where the number of impressions nears the expected life of the screen.

Additional and Societal Benefits

Potential Benefit of Reducing Hazardous Waste Disposal

In addition to reducing human health risks to screen reclamation workers, switching to alternative products will create social benefits in the form of reducing the amount and toxicity of hazardous wastes which are transported and disposed of in landfills and reducing releases of volatile organic compounds (VOCs) that contribute to the formation of photochemical smog in the ambient air. These benefits include the benefit to society of 1) reduced risk from exposure to hazardous wastes during transport to landfills and in the event of migration of contaminants from the landfill into groundwater and 2) reduced human health risk from exposure to VOCs released into the atmosphere. Because the risk assessment did not link exposures of concern to adverse health outcomes, however, it was not possible to estimate the dollar value of these social benefits. It should also be noted that a reduction in the quantity of hazardous waste generated could reduce the likelihood that a landfill or the generator's facility will require a hazardous waste clean-up in the future, a cost that could ultimately be borne by society.

Printing companies may also receive benefits in the form of reduced hazardous waste disposal costs since, for most of these product systems, there would be no hazardous waste associated with disposal of the product, although hazardous constituents in contaminated ink may affect disposal of spent ink remover. Comparing the current cost of disposing of hazardous waste estimated for the baseline facility and for facilities using alternative products in the cost analysis, an estimate of the potential hazardous waste disposal benefit can be estimated. Assuming 20,000 screen printing facilities involved in the graphics industry in the U.S. (SPAI, 1994), the total annual current cost of disposing of hazardous waste is approximately $600,000/year ($0.02/screen x 6 screens/day x 250 work days x 20,000 printing facilities). Because the performance demonstrations were meant to be representative of small and medium size facilities, this hazardous waste disposal cost does not account for any unit cost differences attributed to disposal of hazardous wastes by large printing operations.

For 19 of the 28 printing facilities in the performance demonstrations, the cost of disposing of hazardous waste would fall to $0/screen under an alternative method. It should be noted that determination of hazardous wastes was based on ignitability of chemical constituents and did not include toxicity testing. Where toxicity testing results in classification of the wastes as hazardous, disposal costs would be incurred. In addition, there may be costs associated with State and local regulations. The remaining nine facilities would incur hazardous waste disposal costs of as much as $0.08/screen. The variation in per screen disposal costs ($0.02 versus $0.08) is due to differences in the amount of hazardous waste generated per screen under different options.

Total hazardous waste disposal costs for the entire industry, based on the results of this cost analysis, range from $0/year to $2.4 million/year if printing facilities switch to alternative systems ($0 - 0.08/screen x 6 screens/day x 250 work days x 20,000 printing facilities). Within this range, the resulting cost savings or benefit could amount to as much as $600,000/year. Alternatively, if all printers faced higher waste disposal costs, a total <u>cost</u> of $1.8 million/year would result. As mentioned above, however, more than two thirds of the facilities in the performance demonstrations would experience disposal costs of $0 and only one tenth of facilities would experience disposal costs as high as $0.08/screen if they switched to an alternative system. As such, it is unlikely that total costs would be as high as $1.8 million/year.

Potential Benefit of Avoiding Illnesses Linked to Exposure to Chemicals Commonly Used in Screen Reclamation

As mentioned above, the risk assessment did not link exposures of concern to adverse health outcomes. Data do exist, however, on the cost of avoiding or mitigating certain illnesses that are linked to exposures to screen reclamation chemicals. Such cost estimates indicate potential benefits associated with switching from traditional screen reclamation products to less toxic products. For example, one disease associated with exposures to solvents typically used in screen reclamation is hypertension. Hypertension (persistent high blood pressure) increases the risk of heart attacks and stroke, particularly when coupled with high blood cholesterol levels and enlargement of the heart's left ventricle. Hypertension has also been linked to early mortality and short or long-term damage to the heart, kidneys, brain, eyes, and circulatory system. Treatment for hypertension is largely focused on decreasing blood pressure and controlling other risk factors in an attempt to avoid these more serious health effects. Per-patient lifetime estimates of the direct medical costs of treating hypertension were developed in a previous analysis titled *The Medical Costs of Five Illnesses Related to Exposure to Pollutants* (Abt Associates, 1993). The results of this analysis suggest that avoiding one case of hypertension would result in the avoidance of an average lifetime cost of treating hypertension of between $3,654 to $11,551 (1993 dollars, updated from 1978 dollars using the Consumer Price Index for medical care costs) for men and between $3,094 to $10,186 (1993 dollars, updated from 1978 dollars using the CPI for medical care costs) for women. It should be noted that this estimate is not inclusive of the non-medical direct costs or indirect costs of illness. For example, child care and housekeeping expenses required due to illness considered to be non-medical direct costs are not included. Similarly, indirect costs that reflect both the decreased productivity of patients suffering a disability or death and the value of pain and suffering borne by the afflicted individual and/or family and friends are not included. This estimate does suggest, however, the minimum benefit per affected person that would accrue to society if switching to an alternative screen reclamation product system reduced hypertension cases among workers and other individuals exposed to screen reclamation chemicals. In addition, reductions in illness benefits paid by printing operations may directly affect individual companies through a reduction in liability and health care insurance costs. While reductions in insurance premiums as a result of pollution prevention are not currently widespread, the opportunity exists for changes in the future.