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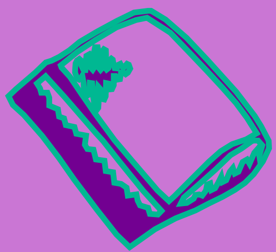
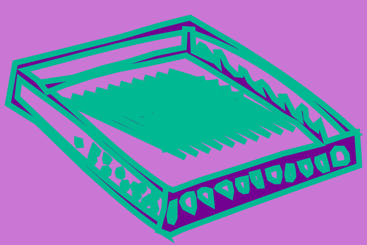
Designing Solutions for Screen Printers
An Evaluation of
Screen Reclamation Systems





Design for the Environment
U.S. EPA

Disclaimer

Designing Solutions for Screen Printers -- An Evaluation of Screen Reclamation Systems is based on the draft Cleaner Technologies Substitutes Assessment: Screen Printing. Information on cost and product usage was provided by individual product vendors and has not been independently corroborated by EPA. The use of specific trade names or the identification of specific products or processes is not intended to represent an endorsement by the EPA or the U.S. Government. The discussion of environmental statutes potentially affecting the commercial printing industry is intended for information purposes only; this is not an official EPA guidance document and should not be relied on by companies in the printing industry to determine applicable regulatory requirements.

Performance Demonstration Participants

The performance demonstration was successful due to the voluntary participation and cooperation of the following screen printing facilities. We appreciate their valuable efforts.

Action Graphics, Louisville, KY

Artcraft, Portland, OR

Burlington Graphic Systems, Union Grove, WI

Coburn Corporation, Lakewood, NJ

Fastamps and Fasigns, Randolph, MA

Gangi Studios, N. Hollywood, CA

Gillespie Decals Inc., Wilsonville, OR

Identification Products, Bridgeport, CT

Ivey-Seright International, Inc., Seattle, WA

Karagraphic, Kent, WA

Leading Edge Graphics, Minnetonka, MN

M&M Displays Inc., Philadelphia, PA

Masterscreen Products Inc., Portland, OR

Mobius, Inc., Eugene, OR

Modagraphics, Rolling Meadows, Il

Morrison & Burke, Inc., Santa Ana, CA

Nameplate & Panel Technology, Carol Stream, Il

Paramount Screen Printing, Milwaukee, WI

Philadelphia Decal, Philadelphia, PA

Phillips Plastics Co., Fredonia, WI

Quantum Graphics, Redmond, WA

Royal Label, Boston, MA

Screen Process Specialists, Plymouth, WI

DESIGNING SOLUTIONS FOR SCREEN PRINTERS

An Evaluation of Screen Reclamation Systems

Developed by the Design for the Environment Screen Printing Project

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We appreciate the participation of the following screen printing manufacturers in various aspects of the Project, including the performance demonstration. These manufacturers can be contacted through the information given below. A particular thanks is extended to our performance demonstration co-chair, Neil Bolding, from Autotype Americas.

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You may also contact the DfE home page at http://www.epa.gov/dfe or the SGIA home page at http://www.sgia.org.

What is Design for the Environment?

The Design for the Environment (DfE) Program harnesses EPA's expertise and leadership to facilitate information exchange and research on risk reduction and pollution prevention opportunities. DfE works with both large and small businesses on a voluntary basis, and its cooperative projects attempt to:

- Work with specific industries to evaluate the risk, performance, and costs of alternative chemicals, processes, and technologies.
- Change general business practices to incorporate environmental concerns.
- Help individual businesses undertake environmental design efforts through the application of specific tools and methods.

DfE partners include:

- Industry
- Professional Institutions
- Academia
- Environmental and Public Interest Groups
- Other Government Agencies

Screen Printing Project

Introduction

The goals of this document are:

- to help you make more informed decisions about the screen reclamation products that you use in your shop
- to provide you with a starting place for thinking about substitute screen reclamation systems that you may be able to use in your facility

As a screen printer, you know that there are a variety of chemical screen cleaning products which are commercially available. You have many options. However, these chemical products can often be smelly, hazardous, and unpleasant to work with. The question you face: which products will get a screen clean and still allow you to operate a facility which is safer for workers, cost effective, and environmentally sound? In response to this question, the U.S. Environmental Protection Agency (EPA), in partnership with the screen printing industry, developed the Design for the Environment (DfE) Screen Printing Project. The project is a unique cooperative effort dedicated to identifying and evaluating screen reclamation procedures, products, and technologies that can help screen printers do their job in the most effective manner.

The DfE Screen Printing Project is entirely voluntary and involves EPA and almost all sectors of the screen printing industry.

Screen Printing Project Partners:

- Screen printers;
- U.S. manufacturers of screen reclamation products;;
- Screenprinting and Graphic Imaging Association International (SGIA);
- Screen Printing Technical Foundation (SPTF);
- The University of Tennessee Center for Clean Products and Clean Technologies; and
- EPA's DfE Program

Project Goals

The DfE Screen Printing Project partners are aware that although many large commercial printers already have access to information about new and developing systems and technologies, smaller printers may not have the time or the resources to keep up with all the latest technology, nor do they have the ability to test new systems without jeopardizing their current operations. To respond to the needs of smaller printers, the DfE Screen Printing Project brought printers, the EPA, system manufacturers, and the SGIA together to evaluate the environmental and human health impacts of a variety of commercial screen reclamation systems and technologies. The Project has developed information on the important trade-off issues associated with the environmental and human health risk, performance, and cost of 16 substitute screen reclamation systems and technologies. The results of the Project are compiled in a full technical report called the Cleaner Technologies Substitutes Assessment (CTSA): Screen Printing, which was published in draft form by EPA in September 1994.

By developing and distributing this type of information, the Project partners hope that screen printers, particularly smaller printers, will be better equipped to make decisions on whether the costs, benefits, and risks of these substitute systems make them possible for use in their own shops. Each print shop has unique needs and operations -- a system that will work for you may not work for another printer. This booklet is designed to encourage printers to discuss with their suppliers some of these substitute systems. It should also alert printers to some of the considerations that may reduce the costs and risks of screen cleaning while improving or maintaining performance. Due to the variability in print shops and the lack of familiarity with use of the screen reclamation systems, the suppliers who donated systems requested that the trade or brand names of their products not be used; therefore all of the systems are identified by code names.

The CTSA contains information on :

- Individual chemicals in the systems
- Population and occupational risk
- Cost
- Performance
- Pollution prevention
- Use and disposal of waste
- Energy and natural resource impacts
- Environmental releases

How to Use this Booklet

The first part of this booklet provides you with background information on the DfE Screen Printing Project. It also describes the factors that were used to evaluate the screen reclamation systems. The next part of the booklet, Table 1 ("Summary of Screen Reclamation Systems"), briefly presents the results of the unique evaluation factors for each system. You may use this summary chart to select the systems that you might be interested in learning more about.

The 2-page system profiles, or "fact sheets," which follow the table, provide you with additional information on the systems that are of interest to you. Immediately following the system profiles is a section entitled, "More Information About Evaluation Methods." This section is designed to give you more detailed information about the evaluation of the screen reclamation systems. Only refer to this section if you want more technical information about the way the evaluations were conducted.

Remember, the goals of this booklet are: 1) to help you make more informed decisions about the screen reclamation products that you use in your shop; and 2) to provide you with a starting place for thinking about substitute screen reclamation systems that you may be able to use in your facility.

What the Project did not do:

- rank a product as better or worse than another
- recommend "green" products

Evaluations of Systems

All of the screen reclamation systems evaluated in the Project are commercially available. The screen reclamation systems were divided into four basic methods that are used by printers. The methods and the substitute systems that were included in each method are shown in the box "Screen Reclamation Methods." In addition, to help you compare the various evaluation results of the substitute systems, two baseline systems were also evaluated: Baseline System 1 and Baseline System 2. Each of these baseline systems are traditional solvent-based screen reclamation systems that you may currently be using in your shop.

Screen Reclamation Methods

Method 1	Method 2	Method 3	Method 4	Other Methods
Ink Removal	Ink Removal	Ink Removal	Ink Removal	Automatic Screen Washing
Emulsion Removal/ Water Wash	Emulsion Removal/ Water Wash	Ink Degradent Water Rinse	Emulsion Removal	Disposal of Screen Mesh
	Haze Removal/ Water Wash	Screen Degreasing	High Pressure Water Blast	
		Emulsion Removal/ Water Wash	Haze Removal/ High Pressure Rinse	
System Baseline, Chi, Beta	System Baseline, Alpha Chi, Delta, Epsilon, Gamma, Mu, Phi, Omicron-AE, Omicron-AF, Zeta	System Omicron	System Theta	

Evaluation Factors

All of the screen reclamation systems and technologies were evaluated using the same factors. These evaluation factors were:

- Chemical composition
- Performance in a print shop or testing facility
- Cost
- Occupational risk and exposure
- Regulatory concerns
- Ecological risks
- General population health risks
- Safety issues

Three evaluation factors were found to be relatively consistent between systems: ecological risks, occupational safety, and general population risks. Therefore, they are not discussed in this section or in the system profiles. Rather, the results of the evaluation of these three factors are listed in the last section of this booklet entitled "More Information About Evaluation Methods."

Unique Evaluation Factors

The other evaluation factors which were found to be unique to each system are discussed below. Table I, "Summary of Screen Reclamation Systems," briefly presents the findings of these evaluation factors for each system. The system profiles which follow the table provide more details on these findings.

Unique Evaluation Factors:

- Chemical Composition
- Performance
- Cost
- Occupational Risk and Exposure
- Regulatory Concerns

Chemical Composition

Each system profile lists the chemical constituents or chemical class in the system. If you are interested in trying a substitute system, you may use this chemical composition information as the basis of a discussion with your supplier to assess your current system and the substitute system. In order to maintain the confidentiality of the screen reclamation systems, some of the actual chemicals that compose the systems have been classified into chemical categories such as dibasic esters; these chemical categories are used to identify many of the chemicals in system profiles. Table 2 at the back of this booklet provides a list of chemicals in the screen reclamation systems and the categories into which they were classified. Information on the percent of volatile organic compounds in the system and the vapor pressure of the system components was taken directly from the Material Safety Data Sheets provided by the supplier.

Performance

Performance evaluations gathered information on how well the systems performed both under laboratory conditions at the Screen Printing Technical Foundation (SPTF) and in an actual print shop. The performance information documents the printers' experiences with and opinions of the substitute systems and technologies during production runs at the various facilities. Keep in mind that the print shops compared the performance of the substitute systems with the system they typically use, not the baseline systems.

Specific performance information in the profiles includes:

The type of ink used on the screen to be reclaimed or recommended by the supplier;
The number and size of screens cleaned by the printers;
The printer's estimation of how well the system or technology cleaned a screen; and
The results of laboratory testing conducted by the Screen Printing Technical Foundation.

Cost

The cost of using each substitute system was determined based on information obtained from performance demonstrations at printing facilities. For some systems, costs were based on a limited number of screens reclaimed. The cost estimate in each system profile includes purchasing as well as actually using the substitute system in a print shop (e.g, labor hours required to reclaim a screen, cost of rags, volume of product used, etc). Because baseline systems were not included in the performance demonstrations, the costs of these two systems were estimated. In order to compare costs between systems, costs are based on normalized values for product usage, number of screens cleaned, and number of rags laundered, to reflect the screen size and number of screens cleaned per day. Based on the cost information provided in this booklet, you may determine whether your shop might save money by using a substitute system.

Occupational Risk and Exposure

Exposure Categories
High
Moderate
Low

The health risks and exposure potential for workers using the ink, emulsion, and haze removers in each screen reclamation system are presented in this section of the profiles. The risks associated with inhaling the chemicals or from skin/eye contact have been categorized as "clear," "possible," "negligible," or "not quantified." The risks are based on information collected by EPA on the adverse effects that may be caused by specific chemicals in the screen reclamation systems. The specific chemicals that are associated with health effects are identified. However, the presence of these chemicals in the screen reclamation systems does not necessarily mean that a worker will experience adverse effects, but only that such effects may occur in some or all workers.

Risk Categories
Clear
Possible
Negligible
Not quantified

In addition to the risks for each system, we also have determined the potential for skin, eye, and inhalation exposure. Exposure potentials are based on the use of the chemicals in the print shop, the vapor pressure of the chemicals, and other factors. Exposure may be substantially reduced, however, or even eliminated, by the use of proper protective equipment such as gloves, goggles, and other protective clothing, and proper ventilation of the print shop. Even if one of the substitute product systems is not used in your print shop, the system you are using may contain some of the same chemicals. You can use this booklet to help you identify recommended safety precautions. Specific chemicals that are of concern in the systems and appropriate protective equipment to prevent exposure to the chemicals are presented in each of the individual system profiles. The risk information is based only on the use of screen reclamation systems. For example, it does not include risks associated with the use of solvents elsewhere in your facility.

Regulatory Concerns

Federal Environmental Regulations

CWA	SARA
CAA	RCRA
CERCLA	

Many of the chemical components of the screen reclamation systems are subject to federal environmental regulations. The disposal of chemicals, or rags containing the chemicals, may be restricted by air, water and solid waste regulations; printing facilities themselves may need to report releases of the chemicals under EPA's Toxic Release Inventory program. In each system profile, the federal environmental regulations that may apply to the system are indicated along with the names of the chemicals that are subject to regulatory requirements; however, this information is not intended to address compliance issues. For specific information on regulatory issues that may be associated with screen reclamation, please contact your local, state, or federal environmental agency.

Table 1. Summary of Screen Reclamation Systems[a]

System	Ink Type[b]	Performance: Ink Remover	Emulsion Remover	Haze Remover
Method 1				
Baseline 1		Not demonstrated.	Not demonstrated.	Not part of this method.
Chi	Solvent, UV, Water	System Chi was demonstrated with the ink remover/emulsion remover combination instead of haze remover.		Not part of this method.
Beta	Solvent, UV, Water	Additional wiping required. Left oily residue. Could deteriorate stencil.	Not demonstrated.	Not part of this method.
Method 2				
Baseline 2		Not demonstrated	Not demonstrated	Not demonstrated
Alpha	Solvent, UV	Removed ink effectively, but required moderate level of additional scrubbing.	Dissolved stencil, but required additional scrubbing; also left tint.	Lightened or removed ink stain, but left haze.
Chi	Solvent, UV, Water	Performance varied across ink types. Generally required additional effort.	Worked well. More time required to remove capillary film emulsions.	Ink remover used. Several applications lightened stain.
Delta	Solvent, UV, Water	Fair to good overall performance. Best with solvent/UV.	Easily dissolved stencil regardless of ink type.	Ink remover used. Removed residue, but left stain.
Epsilon	Solvent, UV, Water	Removed ink effectively. Extra time needed to remove water-based ink.	Quickly and easily removed stencil without scrubbing.	Lightened ink stain and usually removed the haze.
Gamma	Solvent, UV, Water	Required more time, effort, and product. Could deteriorate stencil.	Easily dissolved stencil regardless of ink type.	At facilities, did not remove ink haze. In lab, left light ink stain.
Mu	Solvent, UV, Water	Required more effort and product for some ink. Could deteriorate stencil.	Quickly and easily removed stencil with scrubbing; left no ink or emulsion residue.	Did not lighten stain (solvent-based ink). Better with UV/water.
Phi	Solvent, UV	Inconsistent performance across ink types. Could deteriorate stencil.	Easily removed stencil with very little scrubbing.	Removed ink residue, but only lightened stain. Did not remove haze.
Omicron-AE	Solvent, UV, Water	Required more effort and, in some cases (water-based ink), more product.	Inconsistent performance across ink types. Left some stain or residue.	Some ink stain remained after application.
Omicron-AF	Solvent, UV, Water	Required moderate to high level of effort. Could deteriorate stencil.	Easily dissolved stencil. May require some scrubbing; may leave ink stain.	Lightened stains, but did not remove haze or residue.
Zeta	Solvent, UV, Water	Poor performance overall, even after application method was modified.	Dissolved stencil with effort and modification of application method.	Did not effectively remove haze or ink stain.
Other Methods				
Omicron		Not demonstrated.	Not demonstrated.	Not part of this method.
Theta (High Pressure Water Blaster)	Solvent, UV, Water	Not part of this method.	After application and water blasting, stencil dissolved; left some ink stain.	Immediately dissolved ink stain.
Automatic Screen Washer		Commercially available technologies that remove ink (or in some cases, ink, emulsion, and haze) by focusing appropriate reclamation products on a screen mesh surface within a fully enclosed unit. Not demonstrated.		
Screen Disposal		Not demonstrated		

[a] Significant environmental effects were only associated with Method 1, Baseline system. Cumulative releases from this system pose a risk to aquatic species. All other product systems had negligible effects when released to a water treatment facility, and therefore, these effects have not been included in the table. Impacts of volatile organic compound releases were not quantified.
[b] Ink type indicates those inks that were used by SPTF for the performance demonstrations.

Table 1. Summary of Screen Reclamation Systems[a] (continued)

System	Exposure Potential and Health Risks[c]: Ink Remover	Exposure Potential and Health Risks[c]: Haze Remover	Regulatory Concerns[d]	Cost Range[e] ($/Screen)
Method 1				
Baseline 1	*Risk*: inhalation: clear/skin: clear *Exposure*: inhalation: low/skin: high	Not part of this method.	Y	$3.63
Chi	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: high	Not part of this method.	N	$1.95 - $2.83
Beta	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: high/skin: high	Not part of this method.	N	$7.97
Method 2				
Baseline 2	*Risk*: inhalation: clear/skin: clear *Exposure*: inhalation: high/skin: high	*Risk*: inhalation: clear/skin: clear *Exposure*: inhalation: moderate/skin: high	Y	$6.27
Alpha	*Risk*: inhalation: possible/skin: possible *Exposure*: inhalation: moderate/skin: high	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: high	N	$5.92 -$9.37
Chi	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: high	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: high	N	$3.25 - $3.89
Delta	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: moderate	N	$3.28 - $7.66
Epsilon	*Risk*: inhalation: possible/skin: possible *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: high	Y	$3.08 - $5.28
Gamma	*Risk*: inhalation: NQ/skin: clear *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: NQ/skin: negligible *Exposure*: inhalation: low/skin: moderate	Y	$5.06 - $5.61
Mu	*Risk*: inhalation: possible/skin: possible *Exposure*: inhalation: low/skin: high	*Risk*: inhalation: NQ/skin: negligible *Exposure*: inhalation: low/skin: moderate	Y	$4.79 - $9.33
Phi	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: negligible/skin: possible *Exposure*: inhalation: low/skin: moderate	N	$6.10 - $7.82
Omicron-AE	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: moderate	N	$5.49 - $10.85
Omicron-AF	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: moderate	*Risk*: inhalation: NQ/skin: NQ *Exposure*: inhalation: low/skin: moderate	N	$3.89 - $4.45
Zeta	*Risk*: inhalation: possible/skin: possible *Exposure*: inhalation: high/skin: high	*Risk*: inhalation: negligible/skin: negligible *Exposure*: inhalation: low/skin: moderate	N	$5.39 - $8.99
Other Methods				
Omicron	*Risk*: inhalation: negligible/skin: clear *Exposure*: inhalation: low/skin: moderate	Not part of this method.	Y	$5.57
Theta (High Pressure Water Blaster)	Not part of this method.	*Risk*: inhalation: negligible/skin: possible *Exposure*: inhalation: low/skin: moderate	Y	$4.53
Automatic Screen Washer	*Risk*: inhalation: possible/skin: clear *Exposure*: inhalation: high/skin: high	Not assessed for exposure or risk.	Y	$4.13 - $10.14
Screen Disposal	No risks associated with screen reclamation products.		N	$49.43

[c] Exposure has been categorized by: low, moderate, and high. Risk has been categorized as: NQ (not quantified), negligible, possible, or clear. Risk and exposure for the emulsion remover were not included as they are the same for all systems, i.e., they cause severe eye and skin irritation.

[d] Y/N = indicates systems for which there are/are not applicable federal environmental regulations as cited in the CTSA.

[e] Normalized values adjust product usage, number of screens 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. Normalization allows a comparison between the baseline and facility results.

Baseline System 1 (Method 1)

Chemical Composition*

Ink Remover	100% Lacquer thinner, consisting of: 30% Methyl ethyl ketone 15% n-Butyl acetate 5% Methanol 20% Naphtha, light aliphatic 20% Toluene 10% Isobutyl isobutyrate VOC: 100% Vapor Pressure: Not applicable
Emulsion Remover	1% Sodium periodate 99% Water VOC: 0% Vapor Pressure: Not applicable

*This is not a proprietary formulation, and therefore, the exact percent composition is provided.

Performance

The performance of this system, which consists of an ink and emulsion remover, was not demonstrated at the SPTF or at volunteer printing facilities. Because this system is commonly used in many screen printing shops, the project partners decided to use the limited resources available for a performance demonstration to evaluate substitutes to the traditionally used product systems. This method is referred to as Traditional System 4, Method 1 in the CTSA.

Although this system was not tested, its components are identical to components in other systems that were tested for the CTSA, and those results are presented here. The laboratory reported that the ink remover (lacquer thinner) was very difficult to work with when removing solvent-based and UV-cured inks from screens and was incompatible with water-based ink systems. The emulsion remover did not perform well when it was applied at the diluted quantity recommended by the manufacturer. However, when the emulsion concentration was increased, it performed better at both facilities, although the improvement was not consistent.

Cost

For the ink remover, time and volume information were taken from SPTF laboratory testing. Price information was calculated from prices reported in response to a questionnaire that was prepared and distributed by SGIA and the University of Tennessee. Time, volume, and price information for baseline emulsion removal was based on information obtained from the performance demonstrations. The cost per screen for Baseline System 1 was $3.63 and the estimated annual cost of using the complete product system is approximately $5,446.

Risk and Exposure

Clear concerns for risks to worker health may exist when this ink remover is used on a daily basis. This ink remover may pose high inhalation exposures and clear concerns for risks from both toluene and methyl ethyl ketone. Skin contact can also lead to high exposures and clear concerns for risks from toluene and methyl ethyl ketone.

This emulsion remover can cause severe skin and eye irritation.

All skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA U-list	RCRA F-list
Methyl ethyl ketone		X	X	X	X	X
n-Butyl acetate	X		X			
Methanol		X	X	X	X	
Toluene	X	X	X	X	X	X

CWA = Clean Water Act; CAA = Clean Air Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; SARA 313 = Superfund Amendments and Reauthorization Act, Section 313; RCRA = Resource Conservation and Recovery Act: U-list - discarded commercial chemical products, off specification species, container residues, and spill residues thereof; F-list - hazardous waste from non-specific sources

Product System Beta (Method 1)

Chemical Composition

Ink Remover	2-Octadecanamine, N, N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid/water VOC: 0% Vapor Pressure: Not applicable
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: Not applicable

Performance

The manufacturer of Product System Beta submitted an ink remover only. Although the ink remover was sent to three facilities for demonstration, only one facility was able to participate in the demonstration. This facility used the ink remover and its standard emulsion remover to reclaim their screens. (The performance of the facility's standard emulsion remover was not reported.) During the three-week demonstration period, the facility recorded the performance of the Beta ink remover on 17 screens with solvent-based inks. The facility reported that the ink remover removed the ink on most screens, but left an oily residue on the screen. The printer found that wet ink could be removed fairly easily. Removal of dried ink, however, required much greater time and effort.

In the laboratory, ink remover Beta was tested on three screens (one with a solvent-based ink, one with a UV-cured ink, and one with a water-based ink). Laboratory results indicated that while ink remover Beta dissolved the ink effectively, a fair amount of wiping was required.

Cost

For ink remover Beta, cost information was based on the performance demonstration. The quantity of emulsion remover used and cost per screen were taken from performance demonstration results for Product System Zeta. The adjusted cost per screen for Product System Beta was estimated at $7.97 in comparison to an estimated $3.63 for the baseline system. Switching to System Beta would lead to an estimated increase in costs of $6,500 a year, primarily due to an increase in labor costs.

Risk and Exposure

High inhalation exposures can occur when this ink remover is used on a daily basis, although specific concerns for risks could not be quantified. High exposures to skin can also occur, although again specific concerns for risks could not be quantified.

This emulsion remover can cause severe skin and eye irritation.

All skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

None of the chemicals used in this system are currently subject to federal environmental regulation.

Product System Chi (Method 1)

Chemical Composition

Ink Remover	Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol VOC: 96% Vapor Pressure: <0.1 mm Hg
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: Not applicable

Performance

The performance of Product System Chi, Method 1 was demonstrated at two volunteer facilities and at the SPTF laboratory (on all three ink types). Product System Chi does not include a haze remover. Only one of the two volunteer facilities used Product System Chi as an ink remover/emulsion remover system, without a haze remover. This facility reclaimed 48 screens while testing System Chi, Method 1 and found that using only the ink and emulsion remover combination yielded acceptable results. This facility reported that all screens could be reused for future jobs and noted that it performed particularly well when used for the removal of metallic inks. When using this system under Method 2, the ink remover must be reapplied after the emulsion remover to act as a haze remover. Please see Product System Chi, Method 2 for additional details of Method 2 performance evaluations.

Cost

Cost information for alternative System Chi was obtained from the performance demonstration. The adjusted per screen cost was $1.95. When compared to a baseline cost of $3.63, switching to Product System Chi would yield estimated annual savings of $2,500.

Risk and Exposure

Negligible concerns for risks to worker health may result from using this ink remover on a daily basis. This ink remover may pose low inhalation exposures and negligible concerns for risks. Skin contact can lead to high exposures with clear concerns for risks from the diethylene glycol series ethers and possible concerns for risks of reproductive toxicity from N-methylpyrrolidone.

This emulsion remover can cause severe skin and eye irritation.

All skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CAA
Glycol ethers	X

CAA = Clean Air Act

Baseline System 2 (Method 2)

Chemical Composition*

Ink Remover	100% Lacquer thinner, consisting of: 30% Methyl ethyl ketone 15% n-Butyl acetate 5% Methanol 20% Naphtha light aliphatic 20% Toluene 10% Isobutyl isobutyrate VOC: 100% Vapor Pressure: Not available
Emulsion Remover	1% Sodium periodate 99% Water VOC: 0% Vapor Pressure: Not applicable
Haze Remover	10% Xylene 30% Acetone 30% Mineral spirits 30% Cyclohexanone VOC: 100% Vapor Pressure: Not available

*This is not a proprietary formulation, and therefore, the exact percent composition is provided.

Performance

The performance of this system was not demonstrated at the SPTF or at volunteer printing facilities. Because this system is commonly used in many screen printing shops, the project partners decided to use the limited resources available for a performance demonstration to evaluate substitutes to the traditionally used product systems. This method is referred to as Traditional System 4, Method 2 in the CTSA.

Although this system was not tested, some components are identical to components in other systems that were tested for the CTSA. The laboratory reported that the ink remover (lacquer thinner) was very difficult to work with when removing solvent-based and UV-cured inks from screens, and incompatible with water-based ink systems. The emulsion remover did not perform well when it was applied at the diluted quantity recommended by the manufacturer. However, when the emulsion concentration was increased, it performed better at both facilities, although the improvement was not consistent. The haze remover was never tested at SPTF due to concerns about volatility and potential hazard. Instead, a commonly used and commercially available haze remover containing potassium hydroxide and tetrahydrofurfuryl alcohol was used.

Cost

To determine the costs of using the ink remover, time and volume information were taken from SPTF testing. Price information was calculated from prices reported in a questionnaire prepared and distributed by SGIA and the University of Tennessee. Time, volume, and price information for Baseline 2 emulsion removal was based on information obtained from the System Zeta performance demonstrations. Time and volume information for the four-chemical Baseline 2 haze remover was not available from the performance demonstrations and had to be estimated based on the SPTF evaluation of another haze remover (Product System Alpha's haze remover), which was not similar in chemical composition, but provided the best available information. Price information for the Baseline 2 haze remover was quoted by a manufacturer. The adjusted cost per screen for the Baseline System 2 is $6.27 and the estimated annual cost of using the system is $9,400.

Risk and Exposure

Clear concerns for risks to worker health may be expected when this ink remover is used on a daily basis. This ink remover can pose high inhalation exposures and clear concerns for risks from both toluene and methyl ethyl ketone. Skin contact can also lead to high exposures and clear concerns for risks from toluene and methyl ethyl ketone.

This emulsion remover can cause severe skin and eye irritation.

Clear concerns for risks to worker health may exist when this haze remover is used on a daily basis. This haze remover may cause moderate inhalation exposures and high concerns for risks from acetone. Skin contact can lead to high exposures and clear concerns for risks from acetone.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA U-list	RCRA F-list
Methyl ethyl ketone		X	X	X	X	X
n-Butyl acetate	X		X			
Methanol		X	X	X	X	
Toluene	X	X	X	X	X	X
Xylene	X	X	X	X	X	X
Acetone			X	X	X	X
Cyclohexanone			X		X	X

CWA = Clean Water Act; CAA = Clean Air Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; SARA 313 = Superfund Amendments and Reauthorization Act, Section 313; RCRA = Resource Conservation and Recovery Act: U-list - discarded commercial chemical products, off specification species, container residues, and spill residues thereof; F-list - hazardous waste from non-specific sources

Product System Alpha (Method 2)

Chemical Composition

Ink Remover	Aromatic solvent naphtha Propylene glycol series ethers VOC: 100% Vapor Pressure: <4 mm Hg
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: Not applicable
Haze Remover	Alkali/caustic Tetrahydrofurfuryl alcohol Water VOC: <15% Vapor Pressure: Not applicable

Performance

Product System Alpha consisted of an ink remover, an emulsion remover, and a haze remover. This system was both laboratory- and field-tested. It was demonstrated at three facilities, all of which used solvent-based inks during the demonstration. One facility also reclaimed several screens that contained UV-curable ink. The system was laboratory-tested on two screens (one with a solvent-based ink and one with a UV-curable ink). This product system is not recommended for use with water-based inks. During the demonstrations, one facility reclaimed 13 screens over a two-week period, another reclaimed 36 screens in a three-week period, and the third facility reclaimed 48 screens in a four-week period.

The facility that reclaimed the fewest screens reported that this ink remover removed ink less effectively than was expected. The facility that reclaimed the highest number of screens reported that the ink remover usually worked well, but was inconsistent and required some extra scrubbing. The remaining facility noted that this ink remover worked as well as their usual product and worked particularly well with vinyl inks. During laboratory tests, the ink remover worked well with solvent-based inks, and even better with UV-curable inks.

The facility that reclaimed the fewest screens found that the emulsion remover did not work as efficiently (because it required extra time for dissolving the stencil and scrubbing) as their regular product. At the facility that reclaimed the highest number of screens, the emulsion remover was reported to work satisfactorily only after the screen had been rinsed with hot water. The remaining facility, however, reported that this emulsion remover worked as well as their regular product and required less effort. During the laboratory testing, the emulsion remover worked well on screens with both types of ink.

The haze remover performance varied across the three facilities. At the facility that reclaimed the greatest number of screens, the haze remover worked effectively on about 80% of the screens. The remaining two facilities, however, were not satisfied with the performance of the haze remover.

One facility reported that this product did not work as well as their usual haze remover, while the other reported that it did not work at all. In laboratory testing, this haze remover effectively removed or significantly lightened haze on screens with both solvent-based and UV-cured inks.

Cost

The adjusted cost per screen ranged from $5.92 to $9.37. The baseline cost, by comparison, is $6.27 per screen. The major cost difference was found in the labor used to apply the products. Switching to System Alpha would lead to an estimated annual savings of $500 for the facility that reclaimed 36 screens. For the other two facilities, this switch would result in an estimated increase in annual costs ranging from $780 for the facility that reclaimed the highest number of screens to $4,700 for the facility that cleaned the fewest screens.

Risk and Exposure

Possible concerns for risks to worker health may be expected when this ink remover is used on a daily basis. This ink remover can pose moderate inhalation exposures and possible concerns for risks of reproductive toxicity from the propylene glycol series ethers. Skin contact may lead to high exposures and possible concerns for risks from the propylene glycol series ethers.

This emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures can occur when this haze remover is used on a daily basis, although specific concerns for risks could not be quantified. High exposures to skin may result from daily use, although again specific concerns for risks could not be quantified. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	CAA
Alkali/caustic	X	X	
Glycol ethers			X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act;
CAA = Clean Air Act

Product System Chi (Method 2)

Chemical Composition

Ink Remover	Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol VOC: 96% Vapor Pressure: <0.1 mm Hg
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: Not available
Haze Remover	Same as Ink Remover VOC: 94% Vapor Pressure: <0.1 mm Hg

Performance

The performance of Product System Chi, Method 2 was demonstrated at two facilities and at the SPTF laboratory. When using this substitute system under Method 2, the ink remover is also used as a haze remover. A degreaser accompanied this product system; however, performance testing of this product was not within the scope of our project. Both facilities used only solvent-based inks. During the four-week demonstration period, one facility reclaimed 47 screens and the other reclaimed 48 screens. In the laboratory, the system was tested on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink).

While one facility found the performance of the ink remover to be satisfactory, it also noted that the substitute required greater time and extra effort than their usual product. The other facility had better results and considered the performance of the ink remover to be generally very good. The second facility noted that, like its standard ink remover, the substitute product did not perform well with cover/flux or clear cover coats and required additional scrubbing when used on coarse (low-mesh count) screens. Laboratory results indicated that the substitute ink remover worked best on the screen with a UV-curable ink. After its application to the screen with water-based ink, some ink residue remained. In-laboratory removal of solvent-based ink with this substitute required more effort than the other ink types and an ink residue remained on the screen.

Both facilities were quite pleased with the performance of the emulsion remover. One facility reported that the substitute worked as well as its standard product, while the other facility noted that the substitute worked much better than their standard product. When tested in the laboratory, this emulsion remover easily dissolved the stencil on all three screens.

This system did not include a haze remover; instead, the manufacturer recommended that the ink remover be applied a second time to remove haze. One facility reported that an image still remained on the screen; the second application of the ink remover did not work as well as its standard haze remover. At the other facility, however, the application of ink and emulsion removers alone yielded good results; the second application of the ink remover was required on only one of the 48 screens reclaimed at the facility. During laboratory testing, the second application of the ink remover generally lightened the ink stains, but did not remove them.

Cost

The adjusted cost per screen for Product System Chi was $3.25 for one facility and $3.89 for the other. The facility that experienced better performance of this system has a slightly lesser cost per screen. When compared to the baseline cost of $6.27, switching to System Chi proves to be a cost-effective choice for either facility. Estimated annual savings for one facility could be $3,600, while the facility that experienced better performance could save up to $4,500 in one year.

Risk and Exposure

Negligible concerns for risks to worker health may result from using this ink remover on a daily basis. This ink remover can cause low inhalation exposures and negligible concerns for risks. Skin contact may lead to high exposures with clear concerns for risks from diethylene glycol series ethers and possible concerns for risks of reproductive toxicity from N-methylpyrrolidone.

This emulsion remover can cause severe skin and eye irritation.

Negligible concerns for risks to worker health can be expected when this haze remover is used on a daily basis. This haze remover may pose low inhalation exposures and negligible concerns for risks. Skin contact can result in high exposures with clear concerns for risks from diethylene glycol series ethers and clear concerns for risks of reproductive toxicity from N-methyl-pyrrolidone.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CAA
Glycol ethers	X

CAA = Clean Air Act

Product System Delta (Method 2)

Chemical Composition

Ink Remover	Dibasic esters Propylene glycol series ethers Ethoxylated nonylphenol VOC: 94% Vapor Pressure: <0.1 mm Hg
Emulsion Remover	Sodium Periodate Water VOC: 0% Vapor Pressure: Not applicable
Haze Remover	Same as Ink Remover VOC: 94% Vapor Pressure: <0.1 mm Hg

Performance

Product System Delta consists of an ink remover and an emulsion remover. In place of a separate haze remover product, the manufacturer recommended that the ink remover be reapplied to remove haze. A degreaser accompanied this product system; however, performance testing of this product was not within the scope of our project. Product System Delta was demonstrated at two facilities, both of which used UV-cured inks. One facility reclaimed 17 screens in a three-week period, while the other facility reclaimed nearly twice as many screens (31) over four weeks. In addition, the system was tested in the laboratory on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink).

The facility reclaiming 17 screens found the performance of the ink remover to be fair; a slight ink residue remained on approximately one third of the screens after use of the product. It noted that the ink remover required extra effort and had a strong smell. The facility that reclaimed a higher number of screens had better results. This facility considered the performance of the ink remover to be very good; it consistently and efficiently removed the ink from the screens under most conditions. During laboratory tests, the ink remover worked best with UV-curable and solvent-based inks, but ink residue remained on the screens.

Both facilities reported that the emulsion remover worked very well; each expressed an interest in continuing to use the product after the demonstrations were complete. During the laboratory testing, the emulsion remover easily dissolved the stencil on all three screens, leaving no residue behind. It worked best on the screen with water-based ink.

Neither facility regularly documented the performance of the ink remover used as a haze remover. One facility performed the haze removal step a few times and found that the haze was not removed satisfactorily. The facility that reclaimed a higher number of screens, however, found that the haze removal step was not required. During laboratory testing this step completely removed all ink residue, but ink stains remained.

Cost

The adjusted cost per screen for Product System Delta was $3.28 at the facility that reclaimed the higher number of screens and $7.66 at the other facility. The difference in the cost of using this system at the two facilities may be attributed to a number of factors, including the difference in the number of screens reclaimed over a given period of time, differing work practices, and differences in the amount of product applied at each facility. Given these calculated costs, switching from the baseline to Product System Delta would be cost-effective only for the facility that performed the greater number of tests, where an estimated annual savings of $4,480 would be attained. On the other hand, making the same switch would cost the other facility an additional $2,100 per year.

Risk and Exposure

Low inhalation exposures may occur when this ink remover is used on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate, although again specific concerns for risks could not be quantified.

This emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures can result from using this haze remover on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate, although again specific concerns for risks could not be quantified.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CAA
Glycol ethers	X

CAA=Clean Air Act

Product System Epsilon (Method 2)

Chemical Composition

Ink Remover	Cyclohexanone Propylene glycol series ethers Diethylene glycol Benzyl alcohol Diacetone alcohol Aromatic solvent naphtha Derivatized plant oil VOC: 65% Vapor Pressure: Unknown
Emulsion Remover	Sodium periodate Sulfate salt Water VOC: 0% Vapor Pressure: Unknown
Haze Remover	Alkyl benzene sulfonates Ethoxylated nonylphenol Phosphate salt Alkali/caustic Derivatized plant oil Water Cyclohexanone Propylene glycol series ethers Diethylene glycol Benzyl alcohol Diacetone alcohol Aromatic solvent naphtha VOC: Unknown Vapor Pressure: Unknown

Performance

Product System Epsilon consists of an ink remover, an emulsion remover, and a haze remover. It was demonstrated at two facilities, both of which used solvent-based inks. One facility also used UV-curable inks. The types of stencils used by each facility differed, with one facility using a dual-cured emulsion and the other using a direct photo stencil. During the thirty-day demonstration period, one facility reclaimed 16 screens, while the other reclaimed three times as many (48). In the laboratory, the system was tested on three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

Both facilities reported that the ink remover worked effectively. However, the facility that reclaimed 48 screens found that it took longer than their standard product to break down the ink. In contrast, the other facility had very good results with the ink remover; not only did it remove ink as well as the products the facility currently uses, but less product per screen was required. During laboratory-testing, the ink remover dissolved solvent-based and UV-curable inks quickly and easily, leaving little or no residue. Removal of water-based inks, however, required greater time and effort.

The emulsion remover performed very well at both facilities, dissolving the stencil quickly and easily. The facilities reported that the performance was even better than their standard products. During laboratory-testing, the emulsion remover dissolved the stencil, but required some scrubbing.

The product applied to the screen for haze removal was a mixture of haze remover and ink remover in 1:4 to 1:1 ratios. Both facilities thought that the haze remover's performance was acceptable, and in most cases worked as well as their other products. In the laboratory, the haze remover lightened ink stains on all screens but did not remove them completely; a light ink stain was still visible.

Cost

The adjusted cost per screen for Product System Epsilon ranged from $3.08 at the facility that reclaimed a higher number of screens to $5.29 for the other facility. The difference in costs between facilities is due to differences in the quantity of product applied, the number of rags used, and the labor time required per screen. The baseline cost per screen was $6.27. Upon comparing each facility's calculated cost to the baseline cost, switching to System Epsilon would yield savings for both facilities. Estimated annual savings would range from $1,500 at one facility to $4,800 at the facility that reclaimed a higher number of screens.

Risk and Exposure

Possible concerns for risks to worker health may result from using this ink remover on a daily basis. This ink remover can cause low inhalation exposures and possible concerns for risks of reproductive toxicity from cyclohexanone. Skin contact may lead to moderate exposures and possible concerns for risks from cyclohexanone, benzyl alcohol, and propylene glycol series ethers.

The emulsion remover can cause severe skin and eye irritation.

Negligible concerns for risks to worker health may be expected when this haze remover is used on a daily basis. This haze remover can cause low inhalation exposures and negligible concerns for risks. Skin contact may result in moderate exposures and possible concerns for risks from cyclohexanone, benzyl alcohol, and propylene glycol series ethers. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	RCRA U-list	RCRA F-list	CAA
Cyclohexanone		X	X	X	
Alkali/caustic	X	X			
Glycol ethers					X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; RCRA = Resource Conservation and Recovery Act: U-list - discarded commercial chemical products, off specification species, container residues, and spill residues thereof; F-list - hazardous waste from non-specific sources; CAA = Clean Air Act

Product System Gamma (Method 2)

Chemical Composition

Ink Remover	Propylene glycol series ethers Diethylene glycol series ethers Dibasic esters Fatty alcohol ethers Derivatized plant oil VOC: 40% Vapor Pressure: >10.9 mm Hg
Emulsion Remover	Sodium periodate Sulfate salt Phosphate salt Water VOC: 0% Vapor Pressure: >23.4 mm Hg
Haze Remover	Sodium hypochlorite Alkali/caustic Sodium alkyl sulfonate Water VOC: 0% Vapor Pressure: <0.2 mm Hg

Performance

Product System Gamma consists of an ink remover, an emulsion remover, and a haze remover. It was demonstrated at two facilities over a four-week period, both of which used only solvent-based inks. One facility reclaimed 55 screens but used the ink remover on only seven of these screens and the haze remover on only three. The other facility reclaimed 54 screens but used the ink and haze removers on only approximately half of the screens reclaimed. In addition, the system was laboratory tested on three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

Both facilities found that the ink remover left an unacceptable amount of ink on the screen and required greater physical effort during removal than the products normally used by these facilities. In addition, the facility that reclaimed 54 screens reported that this ink remover required much more time to apply. In laboratory tests, the ink remover performed well on the screens with solvent-based and UV-curable inks. Heavy scrubbing and a greater amount of product, however, were required to remove water-based ink.

Both facilities reported that the emulsion remover worked very well. One facility was able to shorten the period between the time of application and the rinse stage without compromising product performance. The other facility reported that it improved the emulsion remover's performance by wetting the screen before applying the product. Under laboratory conditions, the emulsion remover easily dissolved the stencil with only light scrubbing on all three screens.

Neither facility found the performance of the haze remover to be acceptable. They both reported that since the product did not significantly remove haze, they were forced to use their standard haze remover before the screens could be reused. During laboratory-testing, the haze remover lightened but did not eliminate ink stains.

Cost

The data for determining cost information is based on a limited number of demonstrations. This limits the usefulness of the cost information presented for Product System Gamma. The adjusted cost per screen for Product System Gamma ranged from $5.06 at one facility to $5.61 at the other. Note that these costs may include costs associated with use of the facilities' usual ink and haze removers. Differences in cost may be due primarily to differences in the labor used to apply the products and in the amount of product applied at both facilities.

When compared to a baseline cost of $6.27, switching to Product System Gamma would be cost-effective for both facilities. The estimated annual savings would range from $1,000 at one facility to $1,800 at the other.

Risk and Exposure

Low inhalation exposures may be expected when this ink remover is used on a daily basis, although specific concerns for risks could not be quantified. Skin contact can lead to moderate exposures and clear concerns for risks from diethylene glycol butyl ether.

The emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures may result from using this haze remover on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate with negligible concerns for risks. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	CAA
Alkali/caustic	X	X	
Sodium hypochlorite	X	X	
Glycol ethers			X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; CAA = Clean Air Act

Product System Mu (Method 2)

Chemical Composition

Ink Remover	Dibasic esters Propylene glycol series ethers d-Limonene Ethoxylated nonylphenol Derivatized plant oil VOC: 50% Vapor Pressure: <0.3 mm Hg
Emulsion Remover	Periodic acid Water VOC: 0% Vapor Pressure: Not applicable
Haze Remover	Sodium hypochlorite Alkali/caustic Sodium alkyl sulfonate Water VOC: 0% Vapor Pressure: Not applicable

Performance

Product System Mu consists of an ink remover, an emulsion remover, and a haze remover. It was demonstrated at two facilities and in the SPTF laboratory. During the four-week demonstration period, one facility used primarily UV-curable inks and reclaimed 18 screens. The other facility used solvent-based inks and reclaimed 44 screens. During laboratory-testing, the system was applied to three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

The facility that used UV-curable inks reported that the ink remover worked well, but noted that black UV-cured inks were more difficult to remove than other UV-cured inks. The other facility reported that the ink remover performance was unacceptable for their solvent-based ink system due to remaining ink residue and a high level of physical effort. During the laboratory testing, the ink remover dissolved solvent-based and UV-curable inks effectively. Removal of water-based ink, however, required heavy scrubbing and additional product.

The emulsion remover performance was very good at both facilities, with one facility reporting excellent performance. Emulsion was removed quickly, easily, and completely. Under laboratory conditions, the emulsion remover easily dissolved the stencil with only light scrubbing on all three screens, leaving no ink or emulsion residue behind. A light to moderate ink stain remained, however.

With respect to haze remover performance, the facility that used UV-curable inks reported that the haze remover worked better and faster than one of their usual products, but not as well as the haze remover that was used on difficult stains. The other facility reported that the haze remover did not work at all; for this reason, the facility had to use its standard product before the screens could be reused. In laboratory testing, the haze remover lightened, but did not eliminate, water-based and UV-curable ink stains. During in-laboratory reclamation of the screen with solvent-based ink, the haze remover was unsuccessful at lightening the moderate ink stain.

Cost

The adjusted cost per screen for Product System Mu ranged from $4.79 at the facility that used UV-cured inks to $9.33 at the other facility. The difference in costs between facilities is due to differences in the quantity of product used and the labor time required per screen. The facility with higher costs had a significantly higher labor cost per screen. This facility was the one that found the haze remover performance to be unacceptable. When compared to the baseline cost of $6.27, switching to System Mu would yield an estimated annual savings of $2,200 for the facility that reclaimed fewer screens and had no significant problems with the haze remover. The other facility would incur an estimated annual increase of $4,600 by switching to System Mu.

Risk and Exposure

Possible concerns for risks to worker health may exist when this ink remover is used on a daily basis. This ink remover may pose low inhalation exposures with possible concerns for risks from d-limonene and possible concerns for risks of reproductive toxicity from propylene glycol series ethers. Skin contact may result in high exposures and possible concerns for risks from d-limonene and propylene glycol series ethers.

The emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures may result from using this haze remover on a daily basis, although specific concerns for risks could not be quantified. Skin exposures can be moderate with negligible concerns for risks, although direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks can be controlled if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	CAA
Alkali/caustic	X	X	
Sodium hypochlorite	X	X	
Glycol ethers			X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; CAA = Clean Air Act

Product System Phi (Method 2)

Chemical Composition

Ink Remover	Dibasic esters VOC: Not applicable Vapor Pressure: Not applicable
Emulsion Remover	Sodium periodate Water Ethoxylated nonylphenol Other VOC: 0% Vapor Pressure: 23.4 mm Hg
Haze Remover	N-Methyl pyrrolidone Dibasic esters VOC: Not available Vapor Pressure: 0.195 mm Hg

Performance

Product System Phi consists of an ink remover, an emulsion remover, and a haze remover. Its performance was demonstrated at two facilities, both of which primarily used solvent-based vinyl inks. The facilities also tried System Phi on acrylic vinyl, epoxy, and metallic inks. However, while one facility reclaimed 40 screens during a four-week period, the other reclaimed only 8 screens over two weeks. In addition, the system was laboratory-tested on two screens (one with a solvent-based ink, and one with a UV-curable ink). This product was not recommended for use with water-based inks.

The facility that reclaimed a higher number of screens noted that while the ink remover effectively broke down the ink, it required more effort than the facility's standard ink remover. The other facility reported that the ink remover performance was inconsistent; it worked well on metallic inks, but it did not remove ink from around the stencil when using vinyl ink. Laboratory test results indicated that the ink remover dissolved ink quickly with minimal effort. A fairly high number of rags was required per screen: six rags were needed to remove solvent-based ink and five rags to remove UV-curable ink.

Overall, the emulsion remover performance was very effective, and it easily removed the stencil with very little scrubbing. Both facilities said that the Product System Phi emulsion remover, which removed the emulsion quickly and completely, performed better than their standard products. Under laboratory conditions, the emulsion remover easily dissolved the stencil with only light scrubbing on both screens.

The facility that reclaimed a higher number of screens reported that the haze remover did not completely remove haze, but the remaining haze did not affect future print image quality. The other facility reported that the haze remover left a ghost image; as a result, some screens could not be reused for reverse printing or for printing with transparent inks. Laboratory results indicated that while the haze remover lightened ink stains, it did not eliminate them on either screen. The laboratory technician reported, however, that the haze remover was easy to use and required minimal effort.

Cost

The adjusted cost per screen for Product System Phi ranged from $6.10 for the facility that reclaimed the higher number of screens to $7.82 for the other facility. The difference in costs between facilities is primarily due to differences in the labor time required per screen. The facility with a higher cost per screen might have been able to reduce labor time per screen had it reclaimed a greater number of screens with System Phi, thereby reducing overall costs. When comparing each facility's calculated cost to the baseline cost of $6.27, switching to System Phi would lead to estimated annual savings of $150 for the facility reclaiming the greater number of screens. However, the other facility would face an estimated increase in costs of $2,300.

Risk and Exposure

Low inhalation exposures may occur when this ink remover is used on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate, although again specific concerns for risks could not be quantified.

The emulsion remover can cause severe skin and eye irritation.

Negligible concerns for risks to worker health may result from using this haze remover on a daily basis. This haze remover may pose low inhalation exposures and negligible concerns for risks. Skin contact can lead to moderate exposures and possible risks of reproductive toxicity from N-methylpyrrolidone.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

None of the chemicals used in this system are currently subject to federal environmental regulation.

Product System Omicron AE (Method 2)

Chemical Composition

Ink Remover	Diethylene glycol series ethers Propylene glycol VOC: 30% Vapor Pressure: 0.04 mm Hg
Emulsion Remover	Sodium periodate Ethoxylated nonylphenol Water VOC: 0% Vapor Pressure: 23.4 mm Hg
Haze Remover	Ethoxylated nonylphenol Phosphate surfactant Water Other VOC: Unknown Vapor Pressure: 0.1 mm Hg

Performance

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. The ink and emulsion removers of the two systems are identical, but each has a different haze remover. Despite the similarity of the two systems, each system was evaluated separately. A degreaser accompanied these product systems; however, performance testing of this product was not within the scope of the project.

Omicron-AE is a water-based system. The performance of Omicron-AE was demonstrated at two facilities and in the SPTF laboratory. Performance results based on a satisfactory level of testing were provided by one facility only. The other facility reclaimed four screens, but based on the poor results with the four screens, it withdrew from participation in the project. Please refer to the CTSA for further details on the standard work practices at this facility and the results of the limited testing of the substitute system.

The participating facility reclaimed 30 screens with solvent-based inks using System Omicron-AE over a four-week period. Only seven of the screens, however, were reclaimed with Omicron-AE ink remover and haze remover due to poor performance. System Omicron-AE was also laboratory-tested on three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

The facility reported that the ink remover performed poorly and required considerably more scrubbing than their usual product. The ink remover seemed to work better when used immediately after printing, but the performance was still not acceptable. During laboratory-testing, however, the ink dissolved well, with little effort required to remove solvent-based and UV-curable inks. Extra scrubbing was required to remove water-based ink.

In general, the facility liked the Product System Omicron-AE emulsion remover better than their usual product. When thick ink residue was present, however, the facility noted that the emulsion remover was not as effective. In the laboratory, the emulsion remover dissolved the stencil effectively on all three screens. On the screens with solvent-based and UV-curable inks, moderate scrubbing was required to break up the stencil, and pressure wash was needed to completely remove the stencil.

The participating facility found the haze remover performance to be unacceptable, noting that there was no apparent reduction in haze after application of the product. During laboratory-testing, the haze remover lightened, but did not eliminate, ink stains on all three screens.

Cost

The adjusted cost per screen for Product System Omicron-AE was estimated to be $10.85 for the participating facility. This cost is significantly higher than the baseline cost of $6.27. The major cost differences were in the amount of labor used to apply the products and the amount of product used. By switching to system Omicron-AE, the participating facility would experience an estimated annual increase in costs of $6,900.

Risk and Exposure

Negligible concerns for risks to worker health may exist when this ink remover is used on a daily basis. This ink remover may pose low inhalation exposures and negligible concerns for risks. Skin contact may result in moderate exposures with clear concerns for risks from diethylene glycol butyl ether and possible concerns for risks of reproductive toxicity from diethylene glycol butyl ether during immersion exposures.

The emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures may result from using this haze remover on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate, although again specific concerns for risks could not be quantified.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CAA
Glycol ethers	X

CAA=Clean Air Act

Product System Omicron AF (Method 2)

Chemical Composition

Ink Remover	Diethylene glycol series ethers Propylene glycol VOC: 30% Vapor Pressure: 0.04 mm Hg
Emulsion Remover	Sodium periodate Ethoxylated nonylphenol Water VOC: 0% Vapor Pressure: 23.4 mm Hg
Haze Remover	Ethoxylated nonylphenol Phosphate surfactant Alkali/caustic Water VOC: Unknown Vapor Pressure: <0.1 mm Hg

Performance

Product System Omicron-AE and Product System Omicron-AF were submitted for demonstration by the same manufacturer. The ink and emulsion removers of the two systems are identical, but each has a different haze remover. Despite the similarity of the two systems, each system was evaluated separately. A degreaser accompanied these product systems; however, performance testing of this product was not within the scope of our project.

Product System Omicron-AF is a water-based system. Its performance was demonstrated at two facilities and in the SPTF laboratory. One facility reclaimed 19 screens containing UV-curable inks over a two-week period; the other facility reclaimed 32 screens primarily containing solvent-based inks over four weeks. During laboratory-testing, the system was tested on three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

At the facility that reclaimed UV-curable ink screens, the ink remover removed ink from the mesh satisfactorily. The facility reported, however, that residue remained in the stencil area on most of the screens. The other facility reported that the ink remover performed as well as their standard products. During laboratory-testing, the ink dissolved well and with moderate effort on solvent-based and UV-curable inks. Extra scrubbing, time, and product were required on the screen with the water-based ink.

The emulsion remover worked very well at both facilities and in the laboratory. The facilities reported that it removed the stencil easily and completely. In the laboratory, with moderate scrubbing and a pressure rinse, the emulsion remover dissolved the stencil effectively on all three screens.

The performance of the Product System Omicron-AF haze remover was not acceptable at either facility. The facility that reclaimed screens with UV-curable inks reported that the haze remover was not effective in removing any of the haze, despite vigorous scrubbing and procedural modifications. A ghost image appeared on subsequent print jobs, which required the printer to clean the screens again with his standard product. The other facility had a similar experience: the haze remover left excessive haze under all conditions, and again, the facility had to apply its standard product. During laboratory-testing, the haze remover lightened, but did not eliminate, ink stains on all three screens. The laboratory technician noted that, after using the haze remover, there was a small hole in the screen with solvent-based ink; this hole was not apparent before using the product.

Cost

The adjusted cost per screen of using Product System Omicron-AF was similar at both facilities: $4.45 at the facility using UV-curable inks and $3.89 at the facility using solvent-based inks. These costs are considerably lower than the baseline cost of $6.27. Both facilities used less labor to apply Product System Omicron-AF and less product compared to the baseline scenario. Switching to System Omicron-AF would result in estimated annual savings ranging from $2,700 at one facility to $3,600 at the other.

Risk and Exposure

Negligible concerns for risks to worker health may be expected when this ink remover is used on a daily basis. This ink remover can result in low inhalation exposures and negligible concerns for risks. Skin contact may lead to moderate exposures with clear concerns for risks from diethylene glycol butyl ether and possible concerns for risks of reproductive toxicity from diethylene glycol butyl ether during immersion exposures.

The emulsion remover can cause severe skin and eye irritation.

Low inhalation exposures may result from using this haze remover on a daily basis, although specific concerns for risks could not be quantified. Skin exposures may be moderate, although again specific concerns for risks could not be quantified. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn

Regulatory Concerns

TThe following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	CAA
Alkali/caustic	X	X	
Glycol ethers			X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act;
CAA = Clean Air Act

Product System Zeta (Method 2)

Chemical Composition

Ink Remover	Propylene glycol series ethers VOC: 100% Vapor Pressure: 0.4-10.5 mm Hg
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: 20 mm Hg
Haze Remover	Alkali/caustic Propylene glycol Water VOC: 100% Vapor Pressure: 0.4-10.5 mm Hg

Performance

Product System Zeta consists of an ink remover, an emulsion remover, and a haze remover. Its performance was demonstrated to a limited extent at three facilities, which used solvent-based, UV-curable, and water-based inks. The facility using all three ink types reclaimed seven screens, while the second and third facilities reclaimed four and eight screens, respectively. Only a small number of screens were reclaimed due to busy production schedules and discouraging early results; this prevented the facilities from putting extensive effort into altering their application techniques. In addition, the substitute system was laboratory-tested on three screens (one with a solvent-based ink, one with a water-based ink, and one with a UV-curable ink).

All three facilities found the performance of the ink remover to be unsatisfactory. One facility reported that although the substitute ink remover performed poorly in general, it worked well on two out of seven screens (one with UV-cured ink and one with water-based ink). In most cases, the facility had to use its standard ink remover after applying the substitute. A second facility found that when removing solvent-based inks, the ink remover dried on the screen and, as a result, did not remove the ink. The same facility reported, however, that the substitute ink remover was successful in removing UV-curable inks. A third facility reported that the substitute ink remover had to be applied a number of times, required more scrubbing than usual, and required use of the facility's standard product to clean the product satisfactorily.

During laboratory-testing, the ink remover did not satisfactorily remove the ink from any of the three screens when applied according to the manufacturer's specifications. The laboratory technician experimented with various application procedures to see whether they would yield better performance, but these efforts were unsuccessful.

The facilities reclaiming seven and four screens reported that the emulsion remover did not perform well when they applied the diluted quantity recommended by the manufacturer. When the emulsion concentration was increased, the emulsion remover performed better at both facilities, but the improvement was not consistent. The third facility reported the emulsion remover's performance as passable, but their standard product was preferable. This facility reported that the substitute required extra scrubbing, even when applied full strength. Laboratory results indicated that the emulsion remover dissolved the stencil easily, with only moderate scrubbing required on all three screens.

All three facilities and the laboratory reported that the haze remover was unsuccessful in removing the haze. In all cases, facilities had to use their standard product instead. Although ink stains remained on the screens at the SPTF laboratory, SPTF did not believe the stain would affect future print quality and evaluated the product system as acceptable.

Cost

The data for determining cost information is based on a limited number of demonstrations. This limits the usefulness of the cost information presented for Product System Zeta. The adjusted cost per screen for Product System Zeta was $5.39, $6.51, $8.99 for the three facilities. Differences in cost across facilities may be due primarily to differences in the labor used to apply the products and in the amount of product applied at each facility. It is possible that at some facilities labor time required per screen decreases as personnel become more familiar with applying the substitute product. It does not appear that increasing the number of screens reclaimed at each facility during the demonstrations decreases the cost per screen, nor would an additional number of demonstrations bring down labor costs.

When compared to a baseline cost of $6.27, switching to Product System Zeta would be cost-effective for only the facility that reclaimed seven screens; the facility would achieve an estimated annual savings of $1,300. The remaining two facilities would incur additional costs ranging from an estimated annual increase of $400 at the facility that cleaned four screens to $4,100 at the remaining facility.

Risk and Exposure

Possible concerns for risks to worker health may result from using this ink remover on a daily basis. This ink remover may pose high inhalation exposures and possible concerns for risks of reproductive toxicity from the propylene glycol series ethers. Skin contact also may pose high exposures and possible concerns for risk from the propylene glycol series ethers.

The emulsion remover can cause severe skin and eye irritation.

Negligible concerns for risks to worker health may exist when this haze remover is used on a daily basis. This haze remover may pose low inhalation exposures and negligible concerns for risks. Skin contact can lead to moderate exposures and negligible concerns for risk. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	CAA
Alkali/caustic	X	X	
Glycol ethers			X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; CAA = Clean Air Act

Product System Omicron (Method 3)

Chemical Composition

Ink Remover	Diethylene glycol series ethers Propylene glycol VOC: 30% Vapor Pressure: 0.04 mm Hg
Ink Degradant	Diethylene glycol series ethers Propylene glycol VOC: 30% Vapor Pressure: 0.04 mm Hg
Screen Degreaser	Isopropanol Ethoxylated nonylphenol Water VOC: Not available Vapor Pressure: Not available
Emulsion Remover	Sodium periodate Ethoxylated nonylphenol Water VOC: 0% Vapor Pressure: 23.4 mm Hg

Performance

Product System Omicron is classified under Method 3 in the CTSA. Method 3 employs an ink remover, ink degradant, screen degreaser, and emulsion remover to reclaim screens. The use of a haze remover is unnecessary when Method 3 is used. Due to constraints on resources for this project, the effectiveness of Method 3 could not be demonstrated for this assessment. The SPTF is familiar with the performance of Method 3 because they teach it as an alternative method of reclamation, and they should be contacted for information on how this method performs.

Cost

Because the manufacturer of System Omicron supplied a screen degreaser formulation with the product system, this system, minus the haze remover, was used as an example system for Method 3. Cost data per screen for using this substitute system were estimated by using a combination of performance demonstration results for Omicron, as well as information gathered by SPTF for the SPTF workshop process. Assumptions were made for the quantity of product used and the reclamation time required. According to these estimates, the adjusted cost per screen for using this system is $5.57, compared with the baseline cost of $6.27.

Risk and Exposure

Negligible concerns for risks to worker health may result from using this ink remover on a daily basis. This haze remover may pose low inhalation exposures and negligible concerns for risk. Skin contact can lead to moderate exposures with clear concerns for risks from diethylene glycol butyl ether and possible concerns for risks of reproductive toxicity from diethylene glycol butyl ether during immersion exposures.

The emulsion remover can cause severe skin and eye irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	SARA 313	CAA
Isopropanol	X	
Glycol ethers		X

SARA 313 = Superfund Amendments and Reauthorization Act, Section 313; CAA = Clean Air Act

Product System Theta (Method 4)

Chemical Composition

Ink Remover	None
Emulsion Remover	Sodium periodate Water VOC: 0% Vapor Pressure: Not applicable
Haze Remover	Cyclohexanone Furfuryl alcohol Alkali/caustic VOC: Unknown Vapor Pressure: Not applicable
Technology	High-pressure wash system with a 3,000 psi spray applicator.

Performance

This substitute system is classified as Method 4 in the CTSA. This method requires removal of excess ink through the action of a high-pressure water blaster and without the use of a chemical ink remover. Application of the emulsion remover is followed by rinsing the screen with a high-pressure water blaster. The final steps include application of the haze remover, followed by another high-pressure rinse.

The performance of this substitute screen reclamation technology was demonstrated by SPTF staff at a volunteer facility, as the necessary equipment was not available in the laboratory. One manufacturer supplied both the technology and the reclamation chemicals for emulsion and haze removal. SPTF tested System Theta on three screens (one with a solvent-based ink, one with a UV-curable ink, and one with a water-based ink). Several types of emulsion and haze removers are sold with this technology, but the performance evaluation of this technology is based only on those chemicals used in the testing.

In preparing the screen for reclamation, excess ink transferred to the print side of the screen as it was carded off. The ink residue on both sides of the screen does not represent typical printing conditions. Nonetheless, SPTF staff thought this situation could produce useful results. The situation represented a worst-case scenario since the presence of ink on the print side of the screen lengthened the wash time required to remove the ink and emulsion. If the system worked under these circumstances, SPTF believes that the system will perform as well, if not better in a typical screen print shop.

On the screens with the solvent-based and water-based inks, the stencil dissolved easily with the application of the high-pressure water; no scrubbing was needed. On both screens, all of the ink and stencil dissolved after less than four minutes of washing with the high pressure sprayer. There was no emulsion or ink residue left in the screen, but there were ink stains remaining on both screens. Application of the haze remover completely eliminated the stain without a waiting period or pressure wash.

Removal of UV-curable ink required some process experimentation. In most areas of the screen, the stencil dissolved very easily without any scrubbing. The haze remover removed all of the ink, leaving a very light stain; however, the emulsion was still present in approximately one-third of the blocks. To remove the emulsion, the emulsion remover was reapplied and allowed to sit for 20 seconds. After pressure washing the screen again, the emulsion was completely removed.

Cost

Cost information on this substitute system was developed based on equipment specifications provided by the manufacturer and data collected by SPTF during the facility demonstration. The estimated engineering life of the equipment is ten years. The capital cost of this equipment was amortized over its estimated lifetime, annualized, added to the recurring operating and maintenance costs, and divided by the number of screens reclaimed per year to arrive at the per screen equipment costs. Costs of using water, wastewater, and electricity were included in the cost estimate for this system. As in all other cost estimations, the cost of a filtration system was not included.

The adjusted cost per screen for System Theta was $4.53, considerably lower than the baseline cost of $6.27. Thus, a typical screen printing facility, currently using a baseline system, could achieve an estimated annual savings of $2,600 by switching to a system that used a high-pressure water blaster.

Risk and Exposure

Direct skin or eye contact with the emulsion remover will result in severe irritation.

Negligible concerns for risks to worker health may exist when this haze remover is used on a daily basis. This haze remover may pose low inhalation exposures and negligible concerns for risks. Skin contact can lead to moderate exposures and possible concerns for risks from cyclohexanone. Direct skin or eye contact will result in severe irritation.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CERCLA	RCRA U-list	RCRA F-list
Alkali/caustic	X	X		
Cyclohexanone		X	X	X

CWA = Clean Water Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; RCRA = Resource Conservation and Recovery Act: U-list - discarded commercial chemical products, off specification species, container residues, and spill residues thereof; F-list - hazardous waste from non-specific sources

Automatic Screen Reclamation Technology

Process Description

A typical automatic screen washer is a large, fully enclosed metal box into which screens are placed; a pressurized applicator sprays reclamation chemicals onto the screen. Used solvent is often recirculated after filtration. No manufacturers of automatic screen washers chose to participate in the performance demonstration, so information on this technology was limited. A risk assessment was developed for an automatic screen washing system used by a facility that participated in the performance demonstration; this particular screen washer only removed ink. Automatic screen washers that remove emulsion and haze, as well as ink, are commercially available. Experimental parameters for the risk assessment of an automatic screen washing technology were drawn from the data available from this single site. Because the manufacturer of the actual ink remover used in the automatic washer did not participate in the project, mineral spirits and lacquer thinner were instead used as the ink removers to develop a risk assessment. These two ink removers were also assessed as components of Traditional Systems 1 and 4, respectively, in Methods 1 and 2 in the CTSA. The use of lacquer thinner is discussed in Baseline System 1 and 2 of this brochure. See the full CTSA for a more detailed discussion of the use of automatic screen washers.

Chemical Composition

See Baseline System 1 or 2 for the chemical composition of lacquer thinner used as an ink remover. The percentage of VOCs in the lacquer thinner and mineral spirits is 100%.

Performance

Due to lack of manufacturer participation, performance demonstrations of automatic screen washers were not undertaken. The size and speed of these systems, however, allow for removal of ink, or complete reclamation, in a very short period of time; most systems can clean a screen in under five minutes. The size of an automatic screen washer can be tailored to suit the needs of virtually any facility.

Cost

While the performance of automatic screen washers was not demonstrated, cost estimates were developed with information gathered from manufacturers and printing facilities. Two different cost estimates were generated to reflect the range of equipment available for automatic screen washers removing ink from screens. One estimate was based on a small ink removal unit where screens are loaded and unloaded manually; the price of the ink remover was provided by the equipment supplier. A second estimate was developed for a large capacity unit (maximum screen size) with an automated feed system to move screens through separate wash and rinse areas. This estimate was based on data gathered from equipment purchased second-hand by a facility participating in the performance demonstration; it was assumed that mineral spirits were used in the automatic screen washer. Due to incomplete equipment information, electrical costs were not included in either of the cost estimates.

In comparison to the baseline cost of $6.27, it is expected that printers switching to the low-cost automatic screen washer ($5,000 annually) for ink removal would experience a cost savings of $2.14 per screen, or an estimated annual savings of $3,200. Printing facilities switching to a high-cost automatic screen washer ($95,000 annually) would experience a cost increase of $3.87 per screen, or $5,800 per year. Experiences with the cost of these systems will vary from these presented depending on the number of screens cleaned.

Risk and Exposure

Possible concerns for risks to worker health may occur when lacquer thinner is used with this automatic screen washer on a daily basis. This screen washer may pose high inhalation exposures and possible concerns for risks from toluene, methyl ethyl ketone, and methanol. Skin contact can lead to high exposures and clear concerns for risks from toluene and methyl ethyl ketone.

Inhalation exposures were reduced by 70% (when compared to the manual system) when mineral spirits were used with this automatic screen washer on a daily basis, although specific concerns for risks could not be quantified. Skin contact may result in moderate exposures, although again specific concerns for risks could not be quantified.

Skin exposures and their associated risks will be negligible for all components of this system if appropriate personal protective clothing is worn.

Regulatory Concerns

The following table indicates those chemicals present in this system that are subject to federal environmental regulation. It also indicates chemical categories which may contain chemicals that are subject to federal environmental regulation. The presence of such chemicals and chemical categories may trigger reporting or other statutory requirements.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA U-list	RCRA F-list
Methyl ethyl ketone		X	X	X	X	X
n-Butyl acetate	X		X			
Methanol		X	X	X	X	
Toluene	X	X	X	X	X	X

CWA = Clean Water Act; CAA = Clean Air Act; CERCLA = Comprehensive Environmental Response, Compensation and Liability Act; SARA 313 = Superfund Amendments and Reauthorization Act, Section 313; RCRA = Resource Conservation and Recovery Act: U-list - discarded commercial chemical products, off specification species, container residues, and spill residues thereof; F-list - hazardous waste from non-specific sources

Screen Disposal

During the course of the assessment of various screen reclamation methods, it was proposed that disposal of imaged screens, rather than reclamation, might be a feasible alternative. By disposing of screens, printers might eliminate the high cost of reclamation chemicals, occupational and population exposure to these chemicals, and labor time associated with screen reclamation. However, they would have to dispose of more screens, which could be costly if ink and emulsion components were required to be disposed of as hazardous waste. In addition, the time involved in preparing screens for printing would be increased. Due to difficulty in assessing the pollution prevention potential of screen disposal versus screen reclamation, this comparison was not undertaken. Claims of screen printing performance improving with repeated screen use were also not assessed. Only a cost analysis was undertaken for screen disposal.

Cost

The cost estimate of screen disposal at a representative facility was developed for comparison to other reclamation methods. A number of assumptions were used to estimate the cost of this substitute method, including:

- No other changes in operations or equipment were required.
- Waste screens do not need to be handled as hazardous waste under RCRA (if they were classified as hazardous waste, the estimated cost would be much greater).
- The replacement of screens (after reaching the end of the useful life of the mesh) was not considered in the baseline nor in any of the other reclamation methods; it is estimated to be approximately $0.60/screen reclamation. Consequently, this value was deducted from the total cost of this method.
- The average wage rate of screen stretchers ($6.87), which is slightly higher than for screen reclaimers, was used to calculate labor costs for this method.

It should be noted that screen disposal is most cost effective under two circumstances that have not been included for the model facility's operations:
(1) when the useful life of a screen is exceeded; and
(2) when the size of the screen is relatively small.

Under the assumptions used in the baseline scenario, the total cost per screen of the screen disposal alternative is $49.43, much higher than the baseline cost of $6.27. This would lead to an estimated annual loss of almost $65,000 if the average facility were to fully switch to from reclamation to direct disposal of screens. Printers should not view this as a final analysis, however, because the operations of any one facility can be very different from the assumptions used in generating this cost analysis. Based on this analysis, however, screen disposal is not likely to be a cost-effective option for a majority of screen printing facilities.

Risk and Exposure

There are no dermal or inhalation risks or exposure associated with this method.

Regulatory Concerns

There are no chemicals in this system for which there are federal environmental regulatory concerns. However, disposal of the screens may be subject to solid waste regulations.

More Information About Evaluation Methods

This section provides additional details about how the screen reclamation systems were evaluated in the DfE Screen Printing Project. It includes information about the following evaluation factors: chemical composition, performance, cost, occupational risk and exposure, regulatory concerns, ecological risks, safety issues, and general population risk. Refer to this section only if you want more technical information about the way the evaluations were conducted.

Chemical Composition

Each system profile presents information on the chemicals used in the formulation of the screen reclamation system components, e.g., ink remover, haze remover, or emulsion remover. In some cases, the specific chemical information was proprietary and the chemical is only identified by a generic chemical class, such as dibasic esters. Table 2 lists the chemicals that were considered to be proprietary in the screen reclamation systems and the chemical category to which they were assigned. The chemical composition of each system was provided to assist in determining the risks and regulations that are applicable for each system; however, no comparisons were made among the chemicals in any system and in some cases the exact composition of the system chemicals was not known.

Performance

All screen reclamation systems were voluntarily donated by suppliers for the DfE Screen Printing Project performance demonstrations. Only those substitute systems that are commercially available and do not contain chlorinated compounds were included in the project. (Chlorinated compounds are scheduled to be phased out under the 1990 Clean Air Act Amendments because they contribute to the depletion of the atmospheric ozone layer.) There were no other criteria for including a project in the Project's performance demonstration.

The Project partners evaluated performance in two phases.

- First, the Screen Printing Technical Foundation (SPTF) used the products under controlled laboratory conditions.

- Second, twenty-three printers from across the United states volunteered to evaluate the substitute product systems and technologies for one month in their shops. The print shops did not know the manufacturer or the brand names of the products they evaluated. Each product was evaluated by at least two different print shops. These facilities compared the performance of the substitute system to the performance of the systems that they used regularly in their shops.

In addition to the substitute systems evaluated in the print shops and SPTF laboratory, baseline systems were also identified. These baseline systems are traditional, solvent-based systems. For this reason, they were not tested in any facilities. The project partners felt that most screen printers would be aware of their performance characteristics. The two baseline systems are presented in this booklet: Baseline System 1 for Method 1 which has 2 steps -- ink removal and emulsion removal; and Baseline System 2 for Method 2 which has 3 steps -- ink removal, emulsion removal, and haze removal.

Table 2. Categorization of Screen Reclamation Chemicals

Category	Chemicals from Screen Reclamation Use Cluster in Category
Alkali/caustic	Sodium hydroxide
	Potassium hydroxide
Alkyl benzyl sulfonates	Dodecyl benzene sulfonic acid, triethanol amine salt
	Sodium salt, dodecyl benzene sulfonic acid
Aromatic solvent naphtha	Solvent naphtha (petroleum), light aromatic
	Solvent naphtha (petroleum), heavy aromatic
Derivatized plant oil	Tall oil, special
	Ethoxylated castor oil
Dibasic esters	Diethyl adipate
	Diethyl glutarate
	Diisopropyl adipate
	Dimethyl adipate
	Dimethyl glutarate
	Dimethyl succinate
Diethylene glycol series ethers	Diethylene glycol butyl ether
	Diethylene glycol butyl ether acetate
Fatty alcohol ethers	Alcohols, C8-C10, ethoxylated
	Alcohols, C12-C14, ethoxylated
Phosphate salt	Sodium hexametaphosphate
	Trisodium phosphate
Propylene glycol series ethers	Dipropylene glycol methyl ether
	Propylene glycol methyl ether
	Tripropylene glycol methyl ether
	Propylene glycol methyl ether acetate
	Dipropylene glycol methyl ether acetate
	Ethoxypropanol
	Ethoxypropyl acetate
	Methoxypropanol acetate

Cost

Each system profile presents information on the costs associated with the substitute systems and technologies.

Cost is comprised of several factors. The two most significant are:

- The cost of the product(s) in each substitute system (for the average quantity of reclamation product used)
- The cost of using each substitute system (e.g., labor hours required to reclaim a screen)

Facility performance demonstration data for each substitute system were adjusted so that substitute system cost data would be comparable (1) across facilities and (2) to the baseline cost scenario. Participating facilities differed in several aspects, including types and amounts of inks used, materials printed, size of screens used, number of screens reclaimed daily, and screen printing methods used. In particular, cost data for use of the product systems at each facility were affected by the screen size (i.e., a greater amount of product and/or effort may have been required to clean larger screens) and the number of screens cleaned during the performance evaluation period (i.e., more screens cleaned with a given amount of a substitute product). Therefore, data on product usage values, the number of screens cleaned, and the number of rags laundered during the demonstration period at each participating facility were adjusted to account for these differences.

There were varying levels of participation in the Project across facilities. For example, some facilities stopped using the product after cleaning or attempting to clean only a few screens. Varying levels of participation resulted in varying levels of data across facilities. Thus, the costs of using some substitute systems were based on very limited data and are subject to a greater degree of uncertainty. Although this and other differences between performance evaluations at the participating facilities may add uncertainty to comparability of cost data, the cost analysis procedure described above minimizes overall uncertainty. [Note: the number of screens cleaned with each system is indicated in the performance section of each system profile.]

Lacking real cost data for the baseline systems, the project partners developed cost scenarios for these systems. The baseline cost scenario assumed that six screens were reclaimed daily and that all screens were approximately 15 square feet in size. Adjustments were then made so that comparisons could be made between facilities and the baseline scenarios.

Occupational Risk and Exposure

In choosing any product system or technology, it is important to consider the health risks that the system may pose to workers or the environment. In determining the risk associated with a given chemical or process, we first analyze how hazardous the chemical is and how likely a person is to be exposed to it. Hazard is a measure of the harmful effects associated with a chemical and the doses or exposure levels that may cause those effects. Exposure is a measure of the amount of a given chemical that a worker may come into contact with during a specific period of time. In order to determine the risk associated with a particular chemical or process, it is necessary to examine both hazard and exposure measurements. Risk is the probability that a harmful event will occur, and it may be expressed in either quantitative or qualitative terms. The more hazardous the chemical (assuming the same exposure), the greater the chances that it will have a harmful effect on human health or the environment.

RISK = HAZARD + EXPOSURE

The risk level has been calculated for each system and is presented in the preceding system profiles. The first sentence in the Occupational Risk and Exposure Section indicated the overall concern for that formulation for inhalation exposure. The chemical that is expected to trigger the risk (if identified) is also mentioned. Dermal exposures are also listed, but in all cases, they would be negligible if appropriate protective clothing and equipment is used. Many of the chemicals used in each system have shown specific adverse effects in animal studies. For these chemicals, we were able to quantify the risks associated with a specific adverse effect, such as chronic liver effects or reproductive problems. However, for some chemicals there was insufficient information available to determine how hazardous a chemical was. The risk associated with these chemicals or systems containing these chemicals was designated as "not quantified." For those chemicals where risk was not quantified, high exposure levels would constitute a reason for concern.

As indicated in the system profiles, the presence of strong oxidizers or strong bases in the emulsion removers for all product systems, (except the automatic screen washer which did not use an emulsion remover, and some of the haze removers in Method 2) pose a clear risk of skin and eye irritation for workers if proper protective equipment clothing is not worn. In all systems, the risk posed by inhalation exposure to the emulsion remover was insignificant.

Risk Categories:

A "clear" risk indicates an inadequate margin-of-safety for the chemical in question under most exposure conditions. [Note: the term "margin-of-safety" is used to describe the difference between the amount of a chemical known to cause an adverse effect (e.g., 1 mg/kg of body weight) and the amount of a chemical to which a worker is likely to be exposed (e.g., 100 mg/kg of body weight). Using this example the margin-of-safety would be 0.01.]

A "possible" risk indicates that the margin-of-safety is slightly less than desirable and may result in adverse effects under some exposure conditions; for example, a margin-of-safety of 0.1 or 1.

A "negligible" risk indicates that an adequate margin-of-safety exists for the chemicals in question under expected conditions of use; for example, a margin-of-safety of 10 or 100 which would indicate that the amount to which the worker is exposed is substantially less (e.g., 1 mg/kg of body weight) than the amount that is known to cause an adverse effect (e.g., 100 mg/kg of body weight).

A "not quantified" risk indicates that for the chemicals in question, there are insufficient data from animal or human studies to quantify the risk. Although the exposure potential may be well characterized, the precise risk associated with any exposure cannot be determined.

Regulatory Concerns

There are several federal environmental regulations that are of concern to screen printers. The presence of the chemicals in Table 3 may trigger reporting requirements or other considerations for the storage or disposal of spent system product containers, cleaning rags, and the chemicals themselves. The table below indicates the chemicals that may be contained in any of the substitute system or baseline systems and the federal regulations that specifically include them. Some of the provisions of each environmental regulation are presented after the table. It should be noted that the descriptions of each regulation are not comprehensive, and printers are urged to familiarize themselves with all applicable regulations. The EPA, SGIA or local environmental authorities should be consulted for specific compliance information.

Clean Water Act (CWA)

The Clean Water Act (CWA) is the primary federal law governing water pollution control. The Federal Water Pollution Control Act (FWPCA) designates hazardous substances under the Clean Water Act, and establishes the Reportable Quantity (RQ) for each substance. When an amount equal to or in excess of the RQ is discharged, the facility must provide notice to the federal government of the discharge, except when the facility discharges the substance under an National Permit Discharge Elimination System (NPDES) Permit or a Part 404 Wetlands (dredge and fill) Permit, or to a Publicly Owned Treatment Works (POTW). Facilities in the industrial category of Printing and Publishing and/or in Photographic Equipment and Supplies may need to test for all 126 priority pollutants listed in 40 Code of Federal Regulations (CFR) 122 Appendix D, which includes dichloromethane, 1,1,1-trichloroethane, and toluene.

Table 3. Screen Reclamation Chemicals Which Trigger Federal Environmental Regulations*

Chemical	CWA Reportable Quanitity (lbs)	CWA Priority Pollutant	CAA Hazardous Air Pollutant	CERCLA Reportable Quantity (lbs)	SARA 313 (TRI)	RCRA Hazardous Waste Code
Acetone				5,000	X	U002
Butylacetate	5,000			5,000		
Cyclohexanone				5,000		U057
Dichloromethane		X	X	1,000	X	U080
Ethyl acetate				5,000		U112
Glycol ethers			X			
Isopropanol					X	
Methanol			X	5,000	X	U154
Methyl ethyl ketone			X	5,000	X	U159 D035**
Potassium hydroxide	1,000			1,000		
Sodium hexametaphosphate	5,000			5,000		
Sodium hydroxide	1,000			1,000		
Sodium hypochlorite	100			100		
Sodium salt, dodecyl benzene sulfonic acid	1,000			1,000		
1,1,1-Trichloroethane		X	X	1,000	X	U208
Triethanol amine salt, dodecyl benzene sulfonic acid	1,000			1,000		
1,2,4-Trimethylbenzene					X	
Trisodium phosphate	5,000			5,000		
Toluene	1,000	X	X	1,000	X	U220
Xylene	1,000		X	1,000	X	U239

* See following pages for a description of each acronym and regulation.

** In addition to being listed as a U waste, methyl ethyl ketone also exhibits a characteristic of toxicity which causes it to be considered hazardous waste.

Clean Air Act (CAA)

The Clean Air Act (CAA) sets the framework for air pollution control. Part 112 of the Clean Air Act establishes requirements that directly restrict the emission of 189 hazardous air pollutants which include several screen reclamation chemicals. The EPA is authorized to establish Maximum Achievable Control Technology (MACT) standards for source categories that emit at least one of the pollutants on the list; however, at present, there is no MACT standard for the commercial screen printing industry.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

CERCLA is the Act that created the Superfund and set up a variety of mechanisms to address risks caused by hazardous substance releases. Substances deemed hazardous by CERCLA are listed in 40 CFR 302.4. Based on criteria that relate to the possibility of harm associated with the release of each substance, CERCLA assigns a reportable quantity (RQ) of up to 5000 pounds. Any person in charge of a facility must immediately notify the National Response Center as soon as a person has knowledge of a release (within a 24-hour period) of an amount of a hazardous substance that is equal to or greater than its RQ.[1]

Superfund Amendments and Reauthorization Act (SARA, Section 313)

CERCLA was enacted in 1980 and was amended in 1986 by Title I of SARA. Under SARA 313, a facility that has more than 10 employees and that manufactures, processes or otherwise uses more than 10,000 or 25,000 pounds per year of any toxic chemical listed in 40 CFR 372.65 must file a toxic chemical release inventory (TRI) reporting form covering releases of these toxic chemicals with the EPA and a State agency. The threshold for reporting releases is 10,000 or 25,000 pounds, depending on how the chemical is used.

Resource Conservation and Recovery Act (RCRA)

One purpose of RCRA is to set up a cradle-to-grave system for tracking and regulating hazardous waste. Assuming the material is a solid waste, the first evaluation to be made is whether it is also considered a hazardous waste. The waste generator has the responsibility for determining whether a waste is hazardous and what classification, if any, may apply to the waste. Wastes can be classified as hazardous either because they are listed by EPA through regulation and appear in the 40 CFR Part 261 or because they exhibit certain characteristics. Listed wastes are specifically named, e.g., discarded commercial toluene, spent non-halogenated solvents. Characteristic wastes are defined as hazardous if they "fail" a characteristic test, such as the RCRA test for ignitability. There are four separate lists of hazardous wastes in 40 CFR 261. If any of the wastes from a printing facility is on any of these lists, the facility is subject to regulation under RCRA.

> Please contact your local environmental authorities, the U.S. EPA, or the SGIA for information on reporting requirements and other compliance concerns regarding the screen printing industry.

Ecological Risks

Ecological risks are those effects that may result from possible releases of screen reclamation product systems. The effects result primarily from releases of the chemicals to air, to land including landfills, and to water, including releases via sewers to publicly-owned treatment works (POTWs). The greatest potential for environmental releases from the screen cleaning process occurs if spent chemicals are poured down drains or vaporize into the printing shop air. However, other releases may occur if products are stored in open containers (volatilization to air), during transfer and sampling operations (spills and volatilization), and from storage and disposal of waste rags. Releases to water may occur at several points during screen cleaning -- direct spills, product poured down drains, or laundering rags containing residues of the product. If the rags are not recycled by laun-

[1] *The national toll-free number for the National Response Center is (800)-424-8802; in Washington, D.C., call (202)-426-2675.*

dering but are disposed of directly as waste, the chemicals in the rag are assumed to be released to landfills. Releases to land may also occur as a result of the disposal of used product containers in landfills.

Only the risks posed by the screen reclamation product systems to aquatic organisms were addressed by the CTSA. Ecological risks to terrestrial organisms and plants, other than algae, were not assessed due to the lack of ecotoxicological data. None of the product systems presented in this document are expected to pose any danger to aquatic organisms, even when the releases from several or all of the shops in an area are combined.

Safety Issues

Although risk and exposure potentials vary between systems, the safety measures that can be used to reduce these risks and exposures are virtually the same for most of the systems. The exposure and subsequent risk posed by the chemicals used in the screen reclamation systems may be minimized by the use of appropriate protective equipment and clothing in the workplace. Protective clothing includes the use of safety glasses (goggles), face shields, gloves, aprons, or more elaborate suiting, to protect eyes, skin and clothing from splashes of the chemicals during cleaning and chemical transfer operations. In addition, proper ventilation will also minimize inhalation exposure and prevent workers from breathing vapors in excess of the OSHA permissible exposure limits (PELs) from screen reclamation systems that contain chemicals such as acetone, solvent naphtha, cyclohexanone, xylene, mineral spirits, and dust. If the concentrations of the OSHA regulated chemicals exceed their designated PELs, a chemical cartridge respirator should be worn.

Because many of the chemicals used in these screen reclamation systems are flammable, they should be stored in a tightly closed container in an appropriate flammable liquid storage cabinet when not in use. Some of the chemicals, such as sodium hypochlorite and sodium periodate, are corrosive and/or strong oxidizing agents and should be stored away from moisture, heat, and light; however, if kept in tightly closed containers, these chemicals can usually be stored in a general chemical storage area. Of course, as will all chemical products, these systems should be treated with caution and good safety practices should be employed.

General Population Risks

General population risks were evaluated for people who are not directly involved in the screen printing process but may be exposed to the screen reclamation chemicals. Exposure would occur primarily from breathing contaminated air or drinking contaminated water. The exposed population includes people living in the surrounding community, local businesses, schools, etc. Based on the releases predicted for the screen reclamation systems from a single printing facility and the environmental fate (i.e., persistence and degradation of a chemical), it was determined that the health risks to the general population from both air and water exposure are very low for the ink removers, emulsion removers, and haze removers for all of the product systems evaluated even when aggregate exposures from several print shops in an area are considered. Risks based on releases from all of the printing facilities in an area were not determined for the substitute screen reclamation systems because the number of facilities that may use a particular system could not be estimated.