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Project Summary

Performance Demonstrations of Alternative Screen Reclamation Products for Screen Printing

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Environmentally preferable products for the screen reclamation process in screen printing were evaluated by printers during month-long demonstrations at 23 printing facilities nationwide. Screen reclamation is the process where the ink and image are removed from the mesh in order to reuse the screen for a different image. Through the Environmental Protection Agency's Design for the Environment program, performance characteristics of alternative screen reclamation products were demonstrated. Manufacturers submitted ten "product systems" for evaluation. Each product system included the three chemical products commonly used to reclaim a screen: an ink remover, a stencil or emulsion remover, and a haze remover. Additionally, one ink remover and two substitute technologies were demonstrated.

Performance of the alternative chemical systems was evaluated in two phases: (1) laboratory testing to ensure the products were generally effective, and (2) in-field demonstrations. Product evaluations from the field were, in large part, subjective and reported results relied on the experience and judgment of the printers using the products. In general, most emulsion removers worked very well, but the success with the ink and haze removers was mixed.

Costs of switching from a baseline reclamation system to an alternative system were estimated. These costs included: chemicals, labor, rag use, and waste disposal. Based on this cost analysis, 14 of the 23 volunteer facilities would realize reduced screen reclamation costs if switched from the baseline to an alternative product system. The other 9 facilities would experience increased costs.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The objective of the Screen Printing Performance Demonstrations was to provide critical information on the performance of environmentally safer screen reclamation products and technologies for the Design for the Environment (DfE) Printing Project. The goal of the DfE Printing Project is to encourage printers to use risk and hazard information, along with performance data, to make informed, environmentally sound decisions about the chemicals and processes they use. This non-regulatory, voluntary project is a cooperative partnership between the EPA, the Screen Printing Association International (SPAI), printers, and manufacturers of printing supplies. As one of the initial tasks for this project, industry representatives selected screen reclamation as the focus area for the DfE project.

In support of the EPA Office of Research and Development (ORD), the DfE staff within the Office of Pollution Prevention and Toxics (OPPT) conducted the

Performance Demonstration portion of the DfE Printing Project. Substitute products, voluntarily supplied by manufacturers, were evaluated for their ability to efficiently and effectively clean screens. This performance information was an essential element the final project report, titled Cleaner Technologies Substitute Assessment (CTSA), EPA document number EPA744R-94-005. The CTSA integrates these performance data with information on the costs, risks, and hazards associated with the products demonstrated.

Performance data on alternative screen reclamation products were collected during demonstrations carried out between January and April 1994 and include information such as time spent on screen reclamation, volume of product used, and appearance of the screen after reclamation. Performance data came from two sources: laboratory demonstrations and field evaluations. This document summarizes the results on the field demonstrations and the cost estimates for each alternative system. It should be noted that the performance demonstrations were not rigorous scientific investigations. Instead, product evaluations are based on the printers' experiences with and opinions of these products as they were used in production at their facilities.

Background

Most printers reclaim their used screens instead of disposing of them due to the high cost of the screen material and the labor required to replace a screen. Screen reclamation techniques vary from one facility to another; however, the three basic steps performed to reclaim a screen are: ink removal, emulsion removal, and haze removal. Typically a different product is used for each step, and in this project the three products (ink remover, emulsion remover, and haze remover) are referred to as a "product system." For the DfE Performance Demonstration Project, manufacturers were encouraged to submit complete product systems to minimize the probability of chemical incompatibilities among the system components. A total of ten product systems and one individual ink remover were submitted.

Ink removal is the first step in reclaiming a screen. In most facilities, an ink remover product is sprayed, poured, or wiped onto the screen. The ink remover chemical and the ink are both wiped off or rinsed off the screen with a water spray. Next, the emulsion is removed. The predominant emulsion removal chemical in use today is sodium metaperiodate. Typically, it is used in an aqueous solution and is sprayed on the emulsion, rubbed in with a brush and is rinsed off with a pressure wash. After the emulsion is removed, a haze from ink residue may remain on the screen. A haze remover is typically brushed onto the affected area then rinsed off with pressurized water. Haze remover chemicals are often caustics and can damage or weaken the mesh if used excessively or if allowed to remain in contact with the mesh for too long.

Environmental Concerns Associated with Screen Reclamation

Screen reclamation was selected as the focus area of this project for several reasons:

- **Screen reclamation products often contain highly volatile organic solvents**. In order to meet regulatory requirements and to protect the health of the workers, many printers are looking for less volatile cleaners.
- **Wastewater from screen reclamation typically goes directly down the drain.** According to a 1992 Screen Printing magazine survey, 76 percent of companies reported they send unfiltered waste down the drain. Ink, emulsion, and/or reclamation chemicals are likely to be in the unfiltered rinse water which could lead to health and environmental problems as the water goes to a wastewater treatment facility, or discharged to a waterbody or septic system.
- **Confusion over products that claim to be "biodegradable," or "drain-safe."** Although a given product may itself be safe to rinse down the drain, once it is mixed with ink or emulsion, drain disposal may not be permissible. Also, confusion surrounding the term "biodegradable" is widespread among printers; each manufacturer, regulator, and printer may define the term differently.

Performance Demonstration Methodology

Performance evaluations were conducted in two distinct phases: (1) testing at the Screen Printing Technical Foundations (SPTF) under controlled and consistent laboratory conditions, and (2) demonstrations at volunteer screen printing facilities under the variable conditions of production runs. The testing methodology for both phases of the demonstrations was developed by consensus with the involvement of EPA, SPAI, individual screen printers, and manufacturers and suppliers of screen reclamation products and equipment. Due to the numerous variables associated with screen reclamation, the work group agreed that a rigorous scientific test of screen reclamation product systems would be difficult to develop. The group decided that it would be preferable to rely on the seasoned judgment of screen printers in evaluating the effectiveness of the alternative products. Additionally, the group felt that a month-long demonstration at the volunteer facility was required in order to identify the types of problems that occur only after repeated uses of the product on the same screen.

Manufacturers' cooperation in this project was essential to gather performance information on as many alternative product systems as possible at the start of the project. The DfE project staff contacted all known manufacturers of screen reclamation products designed for printers who use vinyl or plastic substrates, and invited them to submit alternative product systems. To be considered an alternative, products were to contain no stratospheric ozone-depleting substances and no chlorinated compounds. Prior to submitting their products, manufacturers were informed that product trade names would be masked throughout the demonstrations. Neither the volunteer printers nor the DfE observers knew the manufacturer of the products being evaluated. Trade names are not reported out of this project. Product systems are identified only by a generic formulation: a list of the chemical components associated with each individual product.

In initial testing, each product system was evaluated under laboratory conditions. The intent of the laboratory evaluations was to ensure that the product systems sent to printers would provide an acceptable level of performance. A description of the results from the laboratory testing is not included in this project summary; it can be found in both the CTSA and the full ORD report. In the second phase of the project, volunteer printing facilities collected performance information under variable conditions specific to their production runs. Each of the product systems was evaluated in two or three facilities to provide performance data from different operating and ambient conditions, and all facilities were scheduled to use the alternative product systems for one month.

Results

Variability in Results

Performance demonstrations were not scientifically rigorous but were subjective assessments which reflected the conditions and experiences of the reclamation employees at two or three facilities. Table

1 presents the results of product system evaluations from each of the participating facilities. Each system is referred to be a Greek letter code name; actual product trade names are not given. In several cases, two facilities with the same operating parameters using the same reclamation products had very different perceptions of the product performance. Among the reasons why the results of performance demonstrations for one particular product system may differ from one facility to another are:

- **Variability of screen conditions.** Because performance demonstrations were carried out during production runs, many factors which affect the performance of reclamation products were not controlled including: age of screen, ink color, ink coverage, image size, ink type and drying time prior to reclamation.
- **Variability of ambient conditions.** Conditions such as temperature, humidity, and ventilation were recorded but not controlled during demonstrations.
- **Chemical interactions with products used previously on the screen.** Printers and manufacturers have reported that chemicals previously applied to clean a screen can affect the performance of products currently used to clean the screen.
- **Variability of staff involved in performance demonstrations.** At the facilities, several different individuals often conducted the reclamations and recorded the data. Reclaimers' past experience also differs and can affect their perception of performance.
- **Level of cleanliness expected by the facility.** Different facilities often have very different opinions about the cleanliness of a screen. At some facilities, a light haze is acceptable and it does not affect the quality of future prints. Other facilities may require that every screen look new after reclamation.

Costs

Costs were estimated for each reclamation system. The estimates included the cost of: labor time spent to reclaim the screen, the average quantity of reclamation product used, the rags used, and the hazardous waste disposal for RCRA-listed chemicals. To compare the costs of the substitute systems to a known system, a baseline was established using a traditional solvent-based screen reclamation system. The traditional system used in the comparison consisted of lacquer thinner as the ink remover, a sodium periodate solution as the emulsion remover, and a xylene/acetone/mineral spirits/cyclohexanone blend as the haze remover. These chemicals were selected because screen printers indicated they were commonly used in screen reclamation. For all cost estimates, it was assumed that the chemicals were applied manually to 6 screens per day, each 2,127 in^2 (approximately 15 ft^2) in size. Table 2 summarizes the cost estimates of the alternative systems at each demonstration facility.

Since product trade names are not given, the printer must identify the products by their chemical class. Tables 3 and 4 provide printers with a list of the chemicals used in each of the product systems demonstrated. Table 3 lists the formulation of each product system in generic chemical categories. Table 4 describes the chemicals which are included in each generic category. Using the chemical composition information in conjunction with the performance information in Table 1, printers can determine which product system(s) they think would be successful in their facility. Once that determination is made, printers can contact their distributors, inform them of the type of product they are looking for (based on the chemical formulation), and ask for a recommendation on such a product system. A list of the participating manufacturers is given in the CTSA and in the full ORD report. For information on the risks associated with each product system, the printer should refer to the CTSA Screen Reclamation document.

Demonstration of Alternative Technologies

In addition to the demonstration of alternative chemical product systems, the DfE Printing Project evaluated the performance of two alternative screen reclamation technologies: (1) a high pressure water blaster; and (2) a sodium bicarbonate reclaim system.

For the high (3000psi) pressure water blaster technology, an emulsion remover and a haze remover were used, but no ink remover was needed. The system was demonstrated on three screens: one with solvent-based ink, one with UV-curable ink, and one with water-based ink. On all three screens, the observer felt this technology efficiently and effectively cleaned the screen, while reducing the labor, effort, and quantity of chemicals required for reclamation.

The sodium bicarbonate technology consists of an enclosed spray cabinet where pressurized sodium bicarbonate (baking soda) and water are sprayed onto the parts inside the cabinet to clean them. Prior this project, the sodium bicarbonate technology was never tested for screen reclamation applications. The advantage of such a system for screen reclamation is that no hazardous chemicals are used, and the need for ink remover, emulsion remover, and haze remover is eliminated. In preliminary testing, the sodium bicarbonate technology showed potential for removing solvent- or water-based inks. Results on a screen with UV-curable ink, however, were poor. In all cases, further development and testing are needed before the technology could be used practically in a screen printing facility.

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Table 1. *Product System Performance at Volunteer Printing Facilities.*

Ink Remover Performance	*Emulsion Remover Performance*	*Haze Remover Performance*	*Overall System Performance*
PRODUCT SYSTEM ALPHA *Variable results: removed ink on most screens, but soaking time or extra application were needed.*	*Variable results: removed stencil quickly and easily at one facility, but required a lot of scrubbing effort at another.*	*Variable results: Removed haze on most, but not all screens at one facility and worked well at another.*	*All 3 facilites using this system found that some of their screens had to be cleaned with their standard product before they could be reused.*
INK REMOVER BETA *Removed ink, but required extra time and left an oily reside.*	*Not applicable; this manufacturer submitted an ink remover product only.*	*Not applicable; this manufacturer submitted an ink remover product only.*	*This product was not demon strated as part of a system.*
PRODUCT SYSTEM CHI *Removed ink with some extra time and effort, but worked very well with metallic inks.*	*Removed stencil easily and completely.*	*Lightened, but did not remove haze at one facility; haze remover was not needed at the second facility.*	*All screens could be reused for future print jobs. At the one facility where haze remover was needed, printer was concerned with the effect of possible haze build up over time.*
PRODUCT SYSTEM DELTA *Removed ink well on most screens, but left a residue on some.*	*Removed stencil easily and completely.*	*One facility did not need haze remover. Did not remove the haze at the other facility.*	*Good performance, except one facility found the haze remover did not work.*
PRODUCT SYSTEM EPSILON *Removed the very well, but one of the facilities found several applications were needed on some screens.*	*Removed stencil easily and completely.*	*Removed haze, but sometimes a light ink stain remained.*	*Good performance; all screens could be reused for future print jobs.*
PRODUCT SYSTEM GAMMA *Ink residue and oily film remained in mesh after applying ink remover several times.*	*Removed stencil completely and easily.*	*Did not remove the haze.*	*The facilities discontinued use of the ink and haze removers after 1 - 2 weeks of demonstrations due to poor performance.*
PRODUCT SYSTEM MU *Variable results: Removed ink well with less effort and product needed than with their standard product at one facility; left ink residue at the other facility.*	*Removed stencil completely and easily*	*Variable results: Worked well on moderate haze, but required at least 1 hr wait time at one facility; left ghost image in screen at other facility.*	*Good performance at one facility: all screens could be reused for future print jobs; Fair performance at the other facility: their standard haze remover was applied before the screens could be reused.*
PRODUCT SYSTEM OMICRON-AE *Ink residue remained in the mesh.*	*Removed stencil completely and easily.*	*Lightened the ink stain, but did not remove it.*	*Demonstration discontinued at both facilities due to poor performance.*
PRODUCT SYSTEM OMICRON-AF *Removed the ink well.*	*Removed stencil completely and easily.*	*Reduced the ink residue, but did not remove haze from screen.*	*Good performance for the ink and emulsion removers, but the facilities found the haze remover did not work well.*
PRODUCT SYSTEM PHI *Worked well on metallic inks, but left an ink residue with other ink types.*	*Removed stencil completely and easily.*	*Did not consistently remove the haze.*	*A light stain remained on the screen after reclamation, so the screens could not be reused for all types of printing jobs.*
PRODUCT SYSTEM ZETA *Removed the ink if applied several times, but usually left a residue.*	*Worked well at times, but results were inconsistent and other screens required a lot of scrubbing effort.*	*Seemed to have no effect on haze.*	*The three demonstration facilities discontinued use after a few days due to poor performance.*

Table 2. *Summary of cost estimates for alternative screen reclamation chemicals.*

SYSTEM CODE:	*BASELINE*	*ALPHA*		*CHI*		*DELTA*		*EPSILON*		*GAMMA*	
Facility Code:		*8*	*13*	*14*	*3*	*21*	*10*	*11*	*20*	*24*	*16*	*25*
Total Cost/Screen	*$6.27*	*5.62*	*9.36*	*5.10*	*3.55*	*2.56*	*3.96*	*9.43*	*3.79*	*5.08*	*5.14*	*6.17*
Total [*] *Cost/Screen Normalized*	*$6.27*	*6.79*	*9.37*	*5.92*	*3.89*	*3.25*	*3.28*	*7.66*	*3.08*	*5.29*	*5.06*	*5.61*
Total Cost/Year	*$9,399*	*17,574*	*46,800*	*15,313*	*13,312*	*14,413*	*4,953*	*17,675*	*7,097*	*1,269*	*25,708*	*38,547*
Total Cost/Year [*] *Normalized*	*$9,399*	*10,183*	*14,062*	*8,886*	*5,829*	*4,879*	*4,917*	*11,489*	*4,624*	*7,930*	*7,590*	*8,417*
PRODUCT SYSTEM CODE:	*BASELINE*	*MU*		*OMICRON AE*		*OMICRON AF*		*PHI*		*ZETA*	
Facility Code:		*17*	*22*	*2*	*19*	*4*	*18*	*5*	*23*	*6*	*7*	*15*
Total Cost/Screen	*$6.27*	*4.53*	*10.11*	*13.65*	*4.96*	*3.86*	*3.14*	*3.11*	*5.96*	*6.31*	*7.26*	*8.46*
Total Cost/Screen [*] *Normalized*	*$6.27*	*4.79*	*9.33*	*10.85*	*5.49*	*4.45*	*3.89*	*6.10*	*7.82*	*5.39*	*6.51*	*8.99*
Total Cost/Year	*$9,399*	*28,295*	*30,338*	*20,470*	*86,787*	*5,784*	*9,823*	*1,991*	*5,957*	*19,701*	*9,973*	*9,521*
Total Cost/Year [*] *Normalized*	*$9,399*	*7,185*	*13,997*	*16,278*	*8,240*	*6,675*	*5,836*	*9,233*	*11,728*	*8,080*	*9,772*	*13,479*

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

Table 3. *Chemical Composition of Alternative Screen Reclamation Systems*

Product System	*Ink Remover*	*Emulsion Remover*	*Haze Remover*
Alpha	*Aromatic solvent naphtha* *Propylene glycol series ethers*	*Sodium periodate* *Water*	*Alkali/caustic* *Tetrahydrofurfuryl alcohol* *Water*
Beta	*2-octadecanamine, N,N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid* *Water*	*Ink remover only*	*Ink remover only*
Chi	*Diethylene glycol series ethers* *Propylene glycol series ethers* *N-methyl pyrrolidone* *Ethoxylated nonylphenol*	*Sodium periodate* *Water*	*Diethylene glycol series ethers* *Propylene glycol series ethers* *N-methyl pyrrolidone* *Ethoxylated nonylphenol*
Delta	*Dibasic esters* *Propylene glycol series ethers* *Ethoxylated nonylphenol*	*Sodium periodate* *Water*	*Dibasic esters* *Propylene glycol series ethers* *Ethoxylated nonylphenol*
Epsilon	*Cyclohexanone* *Methoxypropanol acetate* *Diethylene glycol* *Benzyl alcohol* *Diacetone alcohol* *Aromatic solvent naphtha* *Derivatized plant oil*	*Sodium periodate* *Sulfate salt* *Water*	*Alkyl benzene sulfonates* *Ethoxylated nonylphenol* *Phosphate salt* *Sodium hydroxide* *Derivatized plant oil* *Water*
Gamma	*Tripropylene glycol methyl ether* *Diethylene glycol butyl ether acetate* *Dibasic esters* *Fatty alcohol ethers* *Derivatized plant oil*	*Sodium periodate* *Sulfate salt* *Phosphate salt* *Other* *Water*	*Sodium hypochlorite* *Alkali/caustic* *Sodium alkyl sulfonate* *Water*
Mu	*Dibasic esters* *Methoxypropanol acetate* *d-Limonene* *Ethoxylated nonylphenol* *Derivatized plant oil*	*Periodic acid* *Water*	*Sodium hypochlorite* *Alkali/caustic* *Sodium alkyl sulfonate* *Water*
Phi	*Dibasic esters*	*Sodium periodate* *Water* *Ethoxylated nonylphenol* *Other*	*N-methyl pyrrolidone* *Dibasic esters*
Omicron (AE)	*Diethylene glycol butyl ether* *Propylene glycol*	*Sodium periodate* *Ethoxylated nonylphenol* *Water*	*Ethoxylated nonylphenol* *Phosphate surfactant* *Other* *Water*
Omicron (AF)	*Diethylene glycol butyl ether* *Propylene glycol*	*Sodium periodate* *Ethoxylated nonylphenol* *Water*	*Ethoxylated nonylphenol* *Phosphate surfactant* *Alkali/caustic* *Other* *Water*
Theta	*None*	*Sodium periodate* *Water*	*Alkali/caustic* *Cyclohexanone* *Furfuryl alcohol*
Zeta	*Propylene glycol series ethers*	*Sodium periodate* *Water*	*Alkali/caustic* *Propylene glycol* *Water*

Table 4. *Categorization Of Screen Reclamation Chemicals For Use In Alternative Product System Formulations*

Category	*Chemicals 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, C_8 - C_{10}, ethoxylated, Alcohols, C_{12} - C_{14}, 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*

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The complete report, entitled "Performance Demonstrations of Alternative Screen Reclamation Products for Screen Printing," (Order No. PBX95-230983; Cost: $27.00, subject to change) will be available only from:
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