

APPENDIX F

CHEMICAL VOLUME ESTIMATES: SCREEN PRINTING CTSA

Volumes for chemicals used within screen reclamation were estimated. Volumes of the chemicals produced within the nation, export volumes, and import volumes were estimated from information obtained from the following sources: Chemical Economics Handbook¹, US ITC², Manville³, US EPA reports⁴, Kirk-Othmer⁵, and industry sources. In some cases, volumes reported represent broader categories than the individual chemical. Volumes for the portion of the chemicals used within screen reclamation was not readily available.

The Workplace Practices Questionnaire⁶, SPAI's 1990 Survey⁷, and expert opinion estimates were used to develop an estimate of the chemical volumes. The following methodology summarizes the assumptions and calculations used to estimate the annual national totals of chemicals used in screen reclamation.

The information needed to develop the estimates included the average screen size, the per screen volume of each type of reclamation product, market shares, the number of screens cleaned yearly, and the number of screen printing operations. This information is summarized in Table F-1.

The screen size, in conjunction with the amount of product used or purchased and the number of screens cleaned, was used to determine the per screen product usage. Typical formulations were then used to determine the chemical breakdown of the reclamation products. Combining this information resulted in estimates of the volumes of chemicals used for screen reclamation. Additional detail of the methodology is given below.

¹ SRI. Selected reports from 1985 to 1993. *Chemical Economics Handbook*. SRI International, Menlo Park, CA.

² USITC. 1993 and 1994. Synthetic Organic Chemicals: United States Production and Sales, 1991. U.S. International Trade Commission, Washington, DC.

³ Manville. Selected reports from 1990 - 1993. Manville Chemical Products Corporation, Ashbury Park, NJ.

⁴ US EPA reports, including the Toxic Substances Control Act Chemical Substance Inventory (1985), "Aqueous and Terpene Cleaning" (1990), "Economic analysis of final Test Rules for DGBE and DGBA" (1987), "Glycol Ethers: An Overview" (1985).

⁵ Kirk-Othmer, 1981, "Oils, essential." Kirk-Othmer Encyclopedia of Chemical Technology, 3rd ed., vol 16. New York: Wiley.

⁶ The Workplace Practices Questionnaire was developed by EPA, SPAI and the University of Tennessee in 1993. It contains information on 115 screen printing facilities' operating and work practices characteristics. See Appendix B for a reproduction of the blank questionnaire and Appendix C for a summary of responses.

⁷ Screen Printing Association International, 1990 Industry Profile Study, Fairfax, VA 1991.

AVERAGE SCREEN SIZE

Estimated from the Workplace Practices survey, observations were weighted by the number of screens cleaned per day. This is a normalization technique which incorporates the frequency of screen cleaning as well as the size of the screens. The average screen size was estimated to be 2,916 square inches. This value differs from the average in the appendix due to this normalization to incorporate incomplete responses.

PER SCREEN PRODUCT USAGE

Usage levels for three types of reclamation products were calculated using information collected through the Workplace Practices survey: ink remover, emulsion remover, and haze remover. Information used included average screens printed per day, volumes of products purchased each year, and the unit price of the products. Certain observations such as those from facilities carrying out in-plant recycling, were excluded from the calculations as these would distort the average volume used per screen of one-time ink removal operations. The average volume used per screen was calculated by dividing the annual amount of product purchased by the number of screens cleaned per year (assuming 252 working days and the midpoint of the range of screens cleaned per day).

DERIVATION OF MARKET SHARE OF TRADITIONAL AND ALTERNATIVE SCREEN RECLAMATION PRODUCTS

Current use of screen reclamation products is divided between *traditional* products, generally high VOC solvents, and *alternative* products, usually low or no VOC content products. To calculate the market share represented by each type of product, data was collected from the Work Practices Survey for Screen Printers (see Appendix A). In the calculation, market share is not based on volume used but rather on total screen area cleaned since traditional and alternative products may require very different quantities to clean the same screen area.

The formula used to calculate market share is as follows:

$$\text{Market Share}_{\text{Alt}} = A_{\text{Alt}} / A_{\text{Alt} + \text{Tra}} \quad \text{Market Share}_{\text{Tra}} = A_{\text{tra}} / A_{\text{Alt} + \text{Tra}}$$

where:

A_{Alt} denotes Alternative Product

A_{Tra} denotes Traditional Product F

$A = \text{total screen area cleaned daily} = \sum_N [\# \text{ of screens cleaned daily} \times \text{area of screens}]$

$F = \text{number of facilities cleaning screens}$

Ink Removers

A simplistic decision rule, based on expert opinion, was used to classify ink removers as alternative or traditional. If the price of an ink remover in the Work Practices survey was below \$5.60/gallon then it was considered traditional. If the unit price was above \$18.90/gallon then the product was considered to be alternative. An additional seven ink removal products were assigned as traditional or alternative based on having a brand name in common with a product assigned using the price thresholds.⁸ As the Work Practices Survey collected brand names, we did not know the composition of the product and had no other method to determine which category the products fit into. Once facilities were identified as using either traditional or alternative products, the screen area cleaned per day for each facility was estimated.⁹ The screen area cleaned per day is then summed across facilities within product types. To estimate market share, the screen area cleaned using each type of product was then divided by the total screen area cleaned daily with both types of products. The results indicate that the percentage of total screen area cleaned using traditional products equals 65.6 percent and the percentage of total screen area cleaned using alternative products equals 34.4 percent.

Emulsion Removers

As there is little difference among emulsion removers used in the Work Practices survey, no distinction was made between traditional and alternative emulsion removers.

Haze Removers

The market share of haze removers used by printing operations that is considered to be traditional and the market share that is considered to be alternative is not known. Consequently, in the cost analysis, it was assumed that all haze removers currently used are traditional products.

NUMBER OF SCREENS CLEANED

The number of screens cleaned per year was taken from SPAI's 1990 survey, where facilities reported which range they fit into. In order to use this information for our calculations, an average value was chosen to represent each range. For the top range of 41 screens or more, 50 screens per day was used. The remaining figures are reported in Table F-1.

⁸ A substantial portion (~ 70 percent) of screen area reported in the Work Practices survey could not be assigned to traditional or alternative products and were, therefore, not included in the above calculation .

⁹ Data reported in the Work Practices Survey was limited to the total volume of alternative and traditional products purchased annually and the total number of screens cleaned per day at the facility. The number of screens cleaned per day with each type of product was not indicated. As a result, the average price of the ink remover was calculated and used to establish which type of product the facility was using.

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Using an SPAI estimate of 20,000 screen printing facilities (excluding textile printers), the total number of screens cleaned per day can be estimated. For example, 57 percent of facilities clean one to ten screens, or an average of 5.5 a day, resulting in 62,700 screens a day for that particular range. Continuing the analysis results in an estimate of 272,710 screens cleaned per day.

TABLE F-1: INFORMATION FOR SCREEN RECLAMATION CHEMICAL VOLUME ESTIMATES			
Description	Data		
Average screen size ^a	2916 sq. in.		
Per screen product usage ^a	Product	Oz./Screen (Gal./Screen)	
	Ink remover (traditional)	98 (0.7663)	
	Ink remover (alternative)	22 (0.1731)	
	Emulsion remover	8.8 (0.0685)	
	Haze remover	2 (0.0160)	
Ink remover market share ^{a,d}	Traditional - 65.6% Alternative - 34.4%		
Screens cleaner per day ^b	Range of # of Screens	Value Used	% of Facilities
	1 to 10	5.5	57.0
	11 to 20	15.5	23.2
	21 to 30	25.5	9.8
	31 to 40	35.5	4.1
	41 or more	50	5.9
Number of Screen Printing Facilites ^c	20,000		
Number of Screens Cleaned Per Day ^d	272,710		

a) Based on raw data from WPQ for screen printing adjusted for incomplete responses.

b) SPAI's 1990 Industry Profile.

c) SPAI estimate.

d) Calculated value.

NATIONAL ESTIMATES OF SCREEN RECLAMATION PRODUCTS

Multiplying product usage per screen by market share by the total number of screens cleaned per year provides estimates of the amount of screen reclamation products used nationally. All facilities are assumed to use ink remover, emulsion remover, and haze remover; this may result in an overestimate of chemicals used as not all facilities use haze remover, at least not on all screens. Market share estimates, developed by EPA in consultation with industry experts, are provided in Table F-2.

TABLE F-2: ESTIMATED MARKET SHARE FOR SCREEN RECLAMATION PRODUCTS	
Chemical	Market Share (%)
Ink Remover, Traditional Formulations	
Xylene	20
Mineral spirits	20
Acetone	20
Lacquer thinner ^a	40
Ink Remover, Alternative Formulations	
Propylene glycol methyl ether	10
Methoxypropanol acetate	10
Dibasic esters ^b	30
Diethylene glycol	3
Propylene glycol methyl ether acetate	5
Perpineols/d-limonene (50/50)	7
Propylene glycol	5
Pripropylene glycol methyl ether	15
Diethylene glycol butyl ether	10
Cyclohexanone	5
Emulsion Remover	
Bleach (sodium hypochlorite) (12% solution in water)	10
Sodium metaperiodate (4% solution in water)	80
Periodic acid (10% solution in water)	5
Sodium bisulfate (50% solution in water)	5
Haze Remover	
Sodium hydroxide (20% solution in water)	25
Potassium hydroxide (20% solution in water)	25
Sodium hydrochlorite (12% solution in water)	10
Mixture of 65% glycol ethers c and 35% N-methylpyrrolidone	10
Mixture of 10% d-limonene, 20% sodium hydroxide, and 70%	10
Mixture of 10% xylene, 30% acetone, 30% mineral spirits	20

a) The formulation for lacquer thinner is as follows:

(1)	Methyl ethyl ketone	78933	30%
(2)	N-butyl acetate	123-86-4	15%
(3)	Methanol	67561	5%
(4)	Solvent naphtha, light aliphatic	64742-89-8	20%
(5)	Toluene	108883	20%
(6)	Isobutyl isobutyrate	97858	10%

b) This category includes dimethyl glutarate, dimethyl adipate, dimethyl succinate in a 2:1:1 ratio.

c) This category includes propylene glycol methy ether, methoxypropanol acetate, propylene glycol methyl ether acetate, tripropylene glycol methyl ether, and diethylene glycol mono butyl ether in equal portions.

ESTIMATES OF CHEMICAL USAGE FOR SCREEN RECLAMATION

To estimate the amount of individual chemicals used, the product volumes estimated earlier were combined with the market share estimates to determine the amount of individual chemicals used. Chemicals that are solids at room temperature are reported in units of mass (pounds) and those that are liquids are reported in units of volume (gallons). The estimated amount of chemicals is reported in Table F-3. Many of the chemicals do not have estimates; the chemical's specific information provided for this analysis (reported in Table F-1) is an overview and, therefore, did not cover all of the chemicals used in screen reclamation. We were unable to collect volume information directly from reclamation product manufacturers.

TABLE F-3: ESTIMATED ANNUAL AMOUNT OF CHEMICALS CURRENTLY USED IN SCREEN RECLAMATION (Liquids are reported by volume, solids by weight)		
Chemical	Volume (gallons)	Weight (pounds)
Acetone	6,920,000	
Alcohols, C8 - C10, ethoxylated	NA a	NA
Alcohols, C12 - C14, ethoxylated	NA	NA
Benzyl alcohol	NA	NA
2-Butoxyethanol	NA	NA
n-Butyl acetate	1,920,000	
Butyrolactone	NA	NA
Cyclohexanol	NA	NA
Cyclohexanone	270,000	
Diacetone alcohol	NA	NA
Dichloromethane	NA	NA
Diethyl adipate	NA	NA
Diethyl glutarate	NA	NA
Diethylene glycol	122,000	
Diethylene glycol monobutyl ether	420,000	NA
Diethylene glycol butyl ether acetate	NA	NA
Diisopropyl adipate	NA	NA
Dimethyl adipate		2,700,000
Dimethyl glutarate	609,000	5,500,000
Dimethyl succinate	304,000	
Dipropylene glycol methyl ether	NA	NA
Dipropylene glycol methyl ether acetate	NA	NA
Dodecyl benzene sulfonic acid, triethanol amine salt	NA	NA
Ethoxylated castor oil	NA	NA

TABLE F-3: ESTIMATED ANNUAL AMOUNT OF CHEMICALS CURRENTLY USED IN SCREEN RECLAMATION (Liquids are reported by volume, solids by weight)		
Ethoxylated nonylphenol	NA	NA
Ethyl acetate	NA	NA
Ethyl lactate	NA	NA
Ethyl oleate	NA	NA
Fumed silica	NA	NA
Furfuryl alcohol	NA	NA
Isobutyl isobutyrate	2,630,000	
Isobutyl oleate	NA	NA
Isopropanol	NA	NA
d-Limonene		1,100,000
Methoxypropanol acetate	420,000	
Methanol	610,000	
Methyl ethyl ketone	3,720,000	
Methyl Lactate	NA	NA
Mineral spirits	6,920,000	
N-methyl pyrrolidone	38,000	
2-octodecanamine, N, ndimethyl, noxide	NA	NA
Phosphoric acid, mixed ester w/isopropanol & ethoxylated tridecanol	NA	NA
Potassium hydroxide		1,060,000
Propylene carbonate	NA	NA
Propylene glycol	203,000	
Propylene glycol ethyl ether	418,000	
Propylene glycol methyl ether acetate	217,000	
Silica	NA	NA
Silica, fumed (amorphous, crystalline-free)	NA	NA
Sodium bisulfate		2,350,000
Sodium hexametaphosphate	NA	NA
Sodium hydroxide		1,450,000
Sodium hypochlorite	68,000	
Sodium lauryl sulfate	NA	NA
Sodium metasilicate	NA	NA
Sodium periodate		11,700,000
Sodium salt, dodecylbenzene sulfonic acid	NA	NA
Solvent naphtha, heavy aromatic	NA	NA
Solvent naphtha, light aliphatic	2,160,000	

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TABLE F-3: ESTIMATED ANNUAL AMOUNT OF CHEMICALS CURRENTLY USED IN SCREEN RECLAMATION (Liquids are reported by volume, solids by weight)		
Solvent naphtha, light aromatic	NA	NA
Special tall oil	NA	NA
Terpineols		1,100,000
Tetrahydrofurfuryl alcohol	NA	NA
Toluene	2,670,000	
1,1,1-trichloroethane	NA	NA
1,2,4-trimethylbenzene	NA	NA
Triethanolamine salt, dodecyl benzene sulfonic acid	NA	NA
Tripropylene glycol methyl ether	623,000	
Trisodium phosphate	NA	NA
Xylene	6,800,000	

a) Not available. Some chemical amounts were not estimated; sufficient information on the use of those chemicals in the screen printing industry was not available.