Chapter IV
Screen Reclamation Products: Functional Groups

The intent of this chapter is to define the characteristics associated with each ink remover, emulsion remover and haze remover. Because of the specific functions these three types of products perform, they have been designated as functional groups in a screen reclamation system. Information on the characteristics associated with each of these functional groups is presented in a format that will allow comparison of several types of products within each functional group. For example, given a hazard summary, purchase cost, exposure analysis and risk characterization for several different types of ink removers, decisions regarding which one of these products would work best in an individual facility could be made. However, to gain a better understanding of all the issues associated with the ink removers, performance information in Chapter V should be referenced. In this chapter information about the different ink removers is combined with emulsion and haze removers, forming a product system by which they are typically sold. In this way the variables of performance and total cost can be fully evaluated.

In the sections below, characteristics of many of the different formulations associated with ink, emulsion and haze removers are described. However, these formulations are not all-inclusive; other formulations may be available commercially. These particular formulations were selected by a workgroup consisting of screen printing manufacturers who participated in the performance demonstration, SPAI and DfE staff. For the purposes of this document, an ink remover has been defined as any chemical, set of chemicals, process or technology that removes ink from the screen surface. Ink removers can also be referred to as ink degradants. Because the final screen reclamation process is being considered, not press-side in-process activities, some of the ink removers may also remove emulsions. An emulsion or stencil remover has been defined as any chemical, set of chemicals, process or technology that removes an emulsion from the screen surface. Lastly, a haze remover has been defined as any chemical, set of chemicals, process or technology that can remove the residual pigment and resin in screen mesh so as to eliminate ghost images.

Each functional group is evaluated as follows:

- Hazard Summary and Cost
- Occupational Exposure
- Occupational Risk Conclusions and Observations
- Environmental Releases in Screen Cleaning Operations
- Ecological Risks from Water Releases
- General Population Exposure Conclusions and Observations

At the end of this chapter is a brief discussion of the process of manufacturing screen reclamation chemical products and a general source release assessment on product formulation. Energy and natural resources use in product formulation is also discussed. Information on these areas could not be discussed for each formulation or technology due to limited data availability.

Information about pollution prevention opportunities through workpractice changes and equipment modifications is discussed in Chapter VI.

Ink Removal Function

Substitute Comparative Assessment

Table IV-1 below lists some of the chemical ink removers that are available to screen printers. In addition to chemical ink removers, specific technologies, such as high-pressure water wash systems, are commercially available. Reference Method 4 in Chapter V for a discussion of this option. In Table IV-1, a brief hazard summary and a list of purchase prices is included for each ink remover. For information on the chemical properties and industrial synthesis of the bulk chemicals, refer to Chapter II and for performance information on these products in a given system see Chapter V. Market information on the volume of specific ink remover products sold is not available.

Table IV-1
Hazard Summaries and Costs: Ink Removers

Formulation	% VOC Flash Pt. V.P.[a]	Hazard Summary: Health Effects Description	Hazard Summary: Aquatic Hazard Rankings[b]	Purchase Cost
Traditional Systems				
System 1 100% Mineral spirits	100 % 109 F 1 mm Hg	limited hazard data	High	$4.00/gallon
System 2 100% Acetone	100 % 0 F 185 mm Hg	neurotoxicity; chronic toxicity	Low	$3.00/gallon
System 3 & System 4 100% Lacquer Thinner, consisting of: 30% Methyl ethyl ketone 15% Butyl acetate 5% Methanol 20% Naphtha, light aliphatic 20% Toluene 10% Isobutyl isobutyrate	100 %	developmental toxicity; genetic toxicity?; neurotoxicity; chronic toxicity	Low Medium Low High Medium Medium	$3.50/gallon
Alternative Systems				
Alpha Aromatic solvent naphtha Propylene glycol series ethers	100 % 101 F < 4 mm Hg	developmental toxicity; neurotoxicity	Low Low/Medium	$18.18/gallon (5 gallons/ $91 55 gallons/ $850)
Beta 2-Octadecanamine, N,N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid Water	0 % 205 F NA[c]	limited hazard data	High	$15.10/gallon (estimated)
Chi Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol	96 % < 200 F < 0.1 mm Hg	developmental toxicity; reproductive toxicity; neurotoxicity; chronic toxicity	Low/Medium Low/Medium Low Medium	$31.20/gallon (5 gallons/$156 55 gallons/$1,315)
Delta Dibasic esters Propylene glycol series ethers Ethoxylated nonylphenol	94 % < 200 F < 1.0 mm Hg	developmental toxicity; chronic toxicity	Medium Low/Medium Medium	$20.00/gallon (5 gallons/$100 55 gallons/$900)

Table IV-1
Hazard Summaries and Costs: Ink Removers

Formulation	% VOC Flash Pt. V.P.[a]	Hazard Summary		Purchase Cost
		Health Effects Description	Aquatic Hazard Rankings[b]	
Epsilon Cyclohexanone Methoxypropanol acetate Diethylene glycol Benzyl alcohol Diacetone alcohol Aromatic solvent naphtha Derivatized plant oil	65 % 115 F unknown	developmental toxicity; reproductive toxicity; genetic toxicity; neurotoxicity; chronic toxicity	Low Medium Low Medium Low Medium Low/High	$7.80/gallon (5 gallons/$39)
Gamma Tripropylene glycol methyl ether Diethylene glycol butyl ether acetate Dibasic esters Fatty alcohol ethers Derivatized plant oil	40 % 76 F 10.9 mm Hg	developmental toxicity; chronic toxicity	Low Medium Medium Medium/High Low/High	$10.90/gallon (25 liters/$72)
Mu Dibasic esters Methoxypropanol acetate d-Limonene Ethoxylated nonylphenol Derivatized plant oil	50 % 131 F < 0.3 mm Hg	developmental toxicity; chronic toxicity	Medium Medium Medium High Low/High	$7.76/gallon (20 liters/$41)
Phi Dibasic esters	NA < 160 F NA	developmental toxicity; chronic toxicity	Medium	$24.95/gallon
Omicron AE & Omicron AF Diethylene glycol butyl ether Propylene glycol	30 % 214 F 0.04 mm Hg	developmental toxicity; chronic toxicity	Low Low	$13.40/gallon (5 gallons/$67 55 gallons/$540)
Zeta Propylene glycol series ethers	100 % 101 F 0.4-10.5 mm Hg	developmental toxicity; neurotoxicity; chronic toxicity	Low/Medium	$23.00/gallon

[a]V.P. means vapor pressure.
[b]The hazard rankings shown identify the categories (low, medium, or high) into which the individual components of the product system fall. The aquatic hazard ranking for each chemical is listed on the same line as the chemical name. When an alternative system includes chemicals from a chemical category (see Table II-2), the hazard ranking shown is the range of the rankings of all of the individual chemicals comprising the category. This analysis did not estimate the aquatic hazard ranking of the product systems as mixtures.
[c]NA means not available.

Exposure Analysis & Risk Characterization

For specific assumptions and details of the occupational exposure, environmental releases and risk assessment, please reference Chapter III.

Table IV-2
Occupational Exposures: Ink Removers

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Traditional Systems						
System 1						
Mineral spirits- light hydrotreated	26	0.1	0	0.3	1560	7280
System 2						
Acetone	539	11	5	38	1560	7280
Systems 3 & 4						
Methyl ethyl ketone	165	5.3	3	20	468	2180
Butyl acetate, normal	44	1.3	1	5.3	234	1090
Methanol	27	4.7	2	15	78	364
Naphtha, light aliphatic	98	1.6	1	6.2	312	1460
Toluene	110	2.3	1	9.2	312	1460
Isobutyl isobutyrate	7	0.4	0	1.7	156	728
Alternative Systems						
Alpha						
Aromatic solvent naphtha	13	0.1	0	0.2	1250	5820
Propylene glycol series ethers	56	0.6	0	2.6	312	1460
Beta						
2-Octadecanamine, N,N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid	292	4.3	3	0	1530	7130
Water	0	0	0	0	31	146
Chi						
Diethylene glycol series ethers	0	0	0	0	312	1456
Propylene glycol series ethers	0	0	0	0	858	4000
N-methylpyrrolidone	3	0	0	0.1	312	1460
Ethoxylated nonylphenol	0	0	0	0	78	364
Delta						
Dibasic esters	2	0	0	0.1	702	3280
Propylene glycol series ethers	0	0	0	0	780	3640
Ethoxylated nonylphenol	0	0	0	0	78	364

Table IV-2
Occupational Exposures: Ink Removers

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Epsilon						
Cyclohexanone	39	0.3	0.2	1.4	468	2180
Methoxypropanol acetate	17	0.4	0.2	1.7	234	1090
Diethylene glycol	0	0	0	0	312	1460
Benzyl alcohol	0.1	0	0	0	101	473
Derivatized plant oil	0.1	0	0	0.2	55	255
Aromatic solvent naphtha	1.6	0.1	0	0.2	156	728
Diacetone alcohol	4.6	0.1	0.1	0.4	234	1090
Gamma						
Diethylene glycol butyl ether acetate	0	0	0	0	62	291
Tripropylene glycol methyl ether	0	0	0	0	780	3640
Derivatized plant oil	0.2	0	0	0.2	62	291
Fatty alcohol ethers	0.4	0	0	0.1	187	873
Dibasic esters	1.3	0	0	0.2	468	2184
Mu						
Dibasic esters	3	0	0	0.2	1014	4728
Methoxypropanol acetate	31	0.4	0	1.7	312	1460
d-Limonene	21	0.6	0	2.4	156	728
Ethoxylated nonylphenol	0	0	0	0	94	437
Derivatized plant oil	0	0	0	0.2	62	291
Phi						
Dibasic esters	4	0	0	0.2	1561	7270
Omicron AE & Omicron AF						
Diethylene glycol butyl ether	0	0	0	0	984	4590
Propylene glycol	17	0.1	0	0.4	576	2690
Zeta						
Propylene glycol series ethers	139	0.6	0	2.8	1560	7280
Method 5 (Automatic Screen Washer)						
Ink remover solvent (mineral spirits or lacquer thinner)[a]	266				3900	

[a]Occupational exposure from automatic screen washers are estimated to be the same for either mineral spirits or lacquer thinner. See traditional system 3 for the composition of lacquer thinner. This analysis did not consider alternative exposure routes for automatic screen washers.

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

Table IV-3
Occupational Risk Conclusions and Observations: Ink Removers

System	Observations
Traditional Systems	
System 1	Dermal exposures to workers using mineral spirits in ink removal can be very high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.
System 2	Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in ink removal.
Systems 3 & 4	Hazard quotient calculations indicate clear concerns for both toluene and methyl ethyl ketone with respect to chronic dermal and inhalation exposures to workers using these chemicals in ink removal. Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using methanol in ink removal.
Alternative Systems	
Alpha	Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using propylene glycol series ethers in ink removal. Possible concerns also exist for chronic dermal exposure to propylene glycol series ethers based on the calculated hazard quotients, which assume 100% dermal absorption. If the actual dermal absorption rate of propylene glycol series ethers is significantly lower, this concern would be significantly reduced or eliminated. Inhalation exposures to propylene glycol series ethers also present possible concerns for developmental toxicity risks, based on margin-of-exposure calculations. Dermal exposures to other chemicals used in ink removal or haze removal can be high, although the risks could not be quantified because of limitations in hazard data.
Beta	Both inhalation and dermal exposures to workers using 2-octadecanamine, N,N-dimethyl-, N-oxide in ink removal can be high, although the risks could not be quantified because of limitations in hazard data.
Chi	Clear concerns exist for chronic dermal exposures to diethylene glycol series ethers used in ink removal based on the calculated margins-of-exposure. Concerns exist for developmental toxicity risks from dermal exposures to N-methylpyrrolidone based on the calculated margin-of-exposure. Similar calculations for inhalation exposures to N-methylpyrrolidone indicate very low concern. Inhalation exposures to other ink remover components are very low. Dermal risks from other ink remover components could not be quantified because of limitations in hazard data, but exposures can be high.
Delta	Although no risks could be quantified because of limitations in hazard data, relatively high dermal exposures to ink remover components could occur. Inhalation exposures to all components are very low.

Table IV-3
Occupational Risk Conclusions and Observations: Ink Removers

System	Observations
Epsilon	Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to cyclohexanone and benzyl alcohol during ink removal. Similar calculations for inhalation exposures to cyclohexanone and benzyl alcohol indicate low concern. Margin-of-exposure calculations indicate a marginal concern for developmental toxicity risk from inhalation exposures to cyclohexanone during ink removal. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified. Hazard quotient calculations indicate marginal concerns for chronic dermal exposures and low concern for chronic inhalation exposures to methoxypropanol acetate. Risks from other ink remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Gamma	Clear concerns exist for chronic dermal exposures to diethylene glycol butyl ether acetate used in ink removal based on the calculated margin-of-exposure. Developmental toxicity risks from dermal exposures to diethylene glycol butyl ether acetate are very low based on the calculated margin-of-exposure. Risks from other ink remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high. Inhalation exposures to all components are very low.
Mu	Concerns exist for chronic risks from both inhalation and dermal exposures to *d*-limonene during ink removal based on the calculated margins-of-exposure. Hazard quotient calculations for methoxypropanol acetate used in ink removal indicate a marginal concern for chronic dermal exposures and low concern for chronic inhalation exposures. Margin-of-exposure calculations show possible concerns for developmental toxicity risks from inhalation exposures to methoxypropanol acetate. Risks from other ink remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Phi	Risks from ink remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high. Inhalation exposures to all components are very low.

Table IV-3
Occupational Risk Conclusions and Observations:
Ink Removers

System	Observations
Omicron AE & Omicron AF	Margin-of-exposure calculations indicate clear concerns for chronic dermal exposures to workers using diethylene glycol butyl ether in ink removal. Margin-of-exposure calculations also show possible concerns for developmental toxicity risks from dermal "immersion" exposures to diethylene glycol butyl ether. Routine dermal exposures, however, represent a very low concern for developmental toxicity risks. Hazard quotient calculations for inhalation and dermal exposures to propylene glycol during ink removal indicate very low concern. Inhalation exposures to other components are very low. Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Zeta	Hazard quotient calculations indicate marginal concerns for chronic inhalation exposure to workers using propylene glycol series ethers in ink removal. Possible concerns also exist for chronic dermal exposure to propylene glycol series ethers based on the calculated hazard quotients, which assume 100% dermal absorption. If the actual dermal absorption rate of propylene glycol series ethers is significantly lower, this concern would be significantly reduced or eliminated. Inhalation exposures to propylene glycol series ethers also presents possible concerns for developmental toxicity risks, based on margin-of-exposure calculations. Inhalation exposures to other components are very low. Risks from other ink remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table IV-3
Occupational Risk Conclusions and Observations:
Ink Removers

System	Observations
Method 5 (Automatic Screen Washer)	Mineral spirits Inhalation exposures were significantly lower (reduced by about 70%) than the exposures during manual use of this system. Risks could not be quantified because of limitations in hazard data. Dermal exposures can still be relatively high. Lacquer Thinner Hazard quotient calculations indicate marginal concerns for chronic inhalation exposures to toluene, methyl ethyl ketone, and methanol. Hazard quotient calculations indicate clear concerns for chronic dermal exposures to toluene and methyl ethyl ketone and marginal concerns for dermal exposures to methanol. The risks described above are slightly lower than the corresponding risks during manual use of this system. Risks from other components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table IV-4
Environmental Releases in Screen Cleaning Operations:
Ink Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Traditional Systems							
System 1							
Mineral spirits - light hydrotreated	54	0	1050	0.2	0.1	0.6	1350
System 2							
Acetone	1120	0	0	22	11	80	1270
Systems 3 & 4							
Methyl ethyl ketone	344	0	0	11	5.7	42	363
Butyl acetate, normal	92	0	80	2.6	1.5	11	191
Methanol	57	0	0	9.8	4.1	30	37
Naphtha, light aliphatic	204	0	25	3.2	1.7	13	257
Toluene	229	0	0	4.8	2.6	19	251
Isobutyl isobutyrate	15	0	100	0.8	0.5	3.4	132
Alternative Systems							
Alpha							
Aromatic solvent naphtha	27	0	473	0.1	0.1	0.5	1080
Propylene glycol series ethers	117	0	8	1.3	0.7	5.4	265
Beta							
2-Octadecanamine, N,N-dimethyl-, N-oxide or a modified amine from unsaturated soy bean oil fatty acid	609	0	0	9.1	6.3	0	0
Water	0	0	12	0	0	0	0
Chi							
Diethylene glycol series ethers	0.1	0	138	0	0	0	270
Propylene glycol series ethers	0.1	0	381	0	0	0	742
N-methylpyrrolidone	6.8	0	132	0.1	0	0.2	270
Ethoxylated nonylphenol	0	0	35	0	0	0	67
Delta							
Dibasic esters	3.7	0	319	0	0	0.2	608
Propylene glycol series ethers	0.1	0	359	0	0	0	675
Ethoxylated nonylphenol	0	0	36	0	0	0	67

Table IV-4
Environmental Releases in Screen Cleaning Operations: Ink Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Epsilon							
Cyclohexanone	82	0	126	0.7	0.4	2.9	402
Methoxypropanol acetate	36	0	68	0.8	0.5	3.6	199
Diethylene glycol	0	0	138	0	0	0	270
Benzyl alcohol	0.2	0	45	0	0	0	88
Derivatized plant oil	0.2	0	24	0.1	0	0.3	47
Aromatic solvent naphtha	3.2	0	66	0.1	0.1	0.5	135
Diacetone alcohol	9.6	0	94	0.2	0.1	0.8	202
Gamma							
Diethylene glycol butyl ether acetate	0	0	28	0	0	0	54
Tripropylene glycol methyl ether	0.1	0	355	0	0	0	675
Derivatized plant oil	0.3	0	28	0.1	0	0.3	54
Fatty alcohol ethers	0.8	0	84	0	0	0.1	162
Dibasic esters	2.7	0	210	0	0	0.3	405
Mu							
Dibasic esters	5.1	0	446	0	0	0.3	877
Methoxypropanol acetate	64	0	75	0.8	0.5	3.6	266
d-Limonene	43	0	27	1.2	0.7	5.1	130
Ethoxylated nonylphenol	0	0	42	0	0	0	81
Derivatized plant oil	0.3	0	27	0.1	0	0.3	54
Phi							
Dibasic esters	8.1	0	766	0	0	0.3	1349
Omicron AE & Omicron AF							
Diethylene glycol butyl ether	0	0	440	0	0	0	852
Propylene glycol	35	0	222	0.2	0.1	0.7	497
Zeta							
Propylene glycol series ethers	290	0	375	1.4	0.8	5.8	1345
Method 5 (Automatic Screen Washer) Using Mineral Spirits							
Mineral Spirits	15.1	NA[a]	NA	NA	NA	NA	NA

Table IV-4
Environmental Releases in Screen Cleaning Operations:
Ink Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Method 5 (Automatic Screen Washer) Using Lacquer Thinner							
Methyl ethyl ketone	335	NA[a]	NA	NA	NA	NA	NA
Butyl acetate, normal	27.7	NA	NA	NA	NA	NA	NA
Methanol	91.5	NA	NA	NA	NA	NA	NA
Naphtha, light aliphatic	57.7	NA	NA	NA	NA	NA	NA
Toluene	80.7	NA	NA	NA	NA	NA	NA
Isobutyl isobutyrate	4.6	NA	NA	NA	NA	NA	NA

[a]This analysis did not estimate releases to water or land from automatic screen washing.

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

Ecological Risks from Water Releases of Screen Reclamation Chemicals

- Cumulative releases of mineral spirits from Traditional System 1 present a concern for risk to aquatic species. The largest contributor to these releases is the hypothetical commercial laundry that launders the shop rags used by the area's screen printers.

- None of the other components of any of the four traditional systems reached an ecotoxicity concern concentration, even when considering the cumulative releases from all shops in the area.

- None of the single facility releases of either traditional or alternative systems reach an ecotoxicity concern concentration.

General Population Exposure Conclusions and Observations

- Health risks to the general population from both air and water exposures are very low for all of the ink removers evaluated.

Emulsion Removal Function

Substitute Comparative Assessment

Table IV-5 below lists some of the chemical emulsion removers that are available to screen printers. Table IV-5 includes a summary of key physical properties, a brief hazard summary, and a list of purchase prices for each emulsion remover. For information on the chemical properties and industrial synthesis of the bulk chemicals, refer to Chapter II. Market information on the volume of specific emulsion remover products sold is not available.

Table IV-5
Hazard Summaries and Cost: Emulsion Removers

Formulation[a]	% VOC, Flash Pt., V.P.[b], (per formulation)	Hazard Summary: Health Effects Description	Hazard Summary: Aquatic Hazard Rankings[c]	Purchase Cost
Traditional Systems				
Systems 1, 2, & 3 12% Sodium hypochlorite (bleach) 88% Water	0 % NA NA	developmental toxicity; genetic toxicity; chronic toxicity	Medium	$1.80/gallon
System 4 1% Sodium periodate 99% Water (as applied)	0 % NA NA	NA	High	$23.00/gallon (5% sodium periodate)
Alternative Systems				
Alpha Sodium periodate Water	0 % NA	NA	High	$4.00/gallon
Chi Sodium periodate Water	0 % NA NA	NA	High	$32.00/gallon (5 gallons/$160 15 gallons/$438 55 gallons/$1,238)
Delta Sodium periodate Water	0% NA NA	NA	High	$32.00/gallon (5 gallons/$160 15 gallons/$438 55 gallons/$1,238)
Epsilon Sodium periodate Sulfate salt Water	0 % NA unknown	corrosive	High Medium	$13.54/pound (5 kg/$149)
Gamma Sodium periodate Sulfate salt Phosphate salt Water	0 % NA 23.4 mm Hg (water)	chronic toxicity; corrosive	High Medium High	$1.60/pound (15 kg/$53)

Table IV-5
Hazard Summaries and Cost: Emulsion Removers

Formulation[a]	% VOC, Flash Pt., V.P.[b], (per formulation)	Hazard Summary: Health Effects Description	Hazard Summary: Aquatic Hazard Rankings[c]	Purchase Cost
Mu Periodic acid Water	0 % NA NA	NA	High	$10.34/gallon (three 5-liter units/$41 (5 gallons/$51.73))
Phi Sodium periodate Ethoxylated nonylphenol Other Water	0% NA 23.4 mm Hg (water)	NA	High Medium Low	$24.95/gallon
Omicron AE & Omicron AF Sodium periodate Ethoxylated nonylphenol Water	0 % NA 23.4 mm Hg (water)	NA	High Medium	$11.00/gallon (5 gallons/$55 55 gallons/$530)
Theta Sodium periodate Water	0% NA NA	NA	High	$21.95/gallon[e]
Zeta Sodium periodate Water	0 % NA 20 mm Hg	NA	High	$23.00/gallon

[a]While many of these formulations may seem similar, they may vary in the composition of specific components.
[b]V.P. means vapor pressure.
[b]The hazard rankings shown identify the categories (low, medium, or high) into which the individual components of the product system fall. The aquatic hazard ranking for each chemical is listed on the same line as the chemical name. When an alternative system includes chemicals from a chemical category (see Table II-2), the hazard ranking shown is the range of the rankings of all of the individual chemicals comprising the category. This analysis did not estimate the aquatic hazard ranking of the product systems as mixtures.
[d]NA means not available.
[e]Product system also requires a fixed cost of $13,165. Reference Method 4 in Chapter V.

Exposure Analysis & Risk Characterization

For specific assumptions and details of the occupational exposure, environmental releases and risk assessment, please reference Chapter III.

Table IV-6
Occupational Exposures: Emulsion Removers

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Traditional Product Systems						
Systems 1 & 3 (Bleach)[a]						
Sodium hypochlorite (12%)	0	0	0	0	187	874
Water	0	0	0	0	1370	6410
Systems 2 & 4 (Zeta diluted 1:4)						
Sodium periodate (1%)	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Alternative Systems						
Alpha (diluted to 0.8%)						
Sodium periodate	0	0	0	0	12	58
Water	0	0	0	0	1550	7220
Chi (diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Delta (diluted 1:4)						
Sodium periodate	0	0	0	0	39	182
Water	0	0	0	0	1520	7100
Epsilon (3% chemicals, 97% water)						
Sodium periodate	0	0	0	0	23	109
Sulfate salt	0	0	0	0	23	109
Water	0	0	0	0	1510	7060
Gamma						
Sodium periodate	0	0	0	0	39	182
Sulfate salt	0	0	0	0	16	73
Phosphate salt	0	0	0	0	117	546
Other	0	0	0	0	117	546
Water	0	0	0	0	1270	5930
Mu						
Periodic acid	0	0	0	0	156	728
Water	0	0	0	0	1400	6550
Phi						
Sodium periodate	0	0	0	0	47	218
Water	0	0	0	0	1210	5640
Ethoxylated nonylphenol	0	0	0	0	123	575
Other	0	0	0	0	181	844

Table IV-6
Occupational Exposures: Emulsion Removers

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Omicron AE & Omicron AF						
Sodium periodate	0	0	0	0	47	218
Ethoxylated nonylphenol	0	0	0	0	31	146
Water	0	0	0	0	1480	6920
Zeta (diluted 1:4)						
Sodium periodate	0	0	0	0	16	73
Water	0	0	0	0	1540	7210
Theta (Method 4)[b]						
Sodium periodate	0	0	0	0	1250	5820
Water	0	0	0	0	312	1460
Theta (Method 4) (diluted 1:3)						
Sodium periodate	0	0	0	0	312	1460
Water	0	0	0	0	1250	5820

[a]Dermal exposures presented are worst-case and the use of gloves is expected due to irritation and corrosive effects.
[b]This system can be used with or without diluted emulsion remover, depending on the needs of the facility.
Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

Occupational Risk Conclusions and Observations

All of the systems that employ an emulsion remover use either a strong oxidizer such as hypochlorite or periodate or a strong base such as sodium hydroxide. The haze removers in Alpha, Epsilon, Gamma, Mu, Omicron, and Theta also contain these compounds. All of these materials present a high concern for skin and eye irritation and tissue damage if workers are exposed in the absence of proper protective clothing. None of the emulsion removers present significant inhalation risks.

Table IV-7
Environmental Releases in Screen Cleaning Operations: Emulsion Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Traditional Product Systems							
Systems 1 & 3 (Bleach)							
Sodium hypochlorite	0	75	0	0	0	0	0
Water	0	546	0	0	0	0	0
System 2 & 4 (Zeta diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Alternative Systems							
Alpha (diluted to 0.8%)							
Sodium periodate	0	5	0	0	0	0	0
Water	0	616	0	0	0	0	0
Chi (diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Delta (diluted 1:4)							
Sodium periodate	0	16	0	0	0	0	0
Water	0	605	0	0	0	0	0
Epsilon (diluted to 3%)							
Sodium periodate	0	9	0	0	0	0	0
Sodium salt	0	9	0	0	0	0	0
Water	0	602	0	0	0	0	0
Gamma							
Sodium periodate	0	16	0	0	0	0	0
Sulfate salt	0	6	0	0	0	0	0
Phosphate salt	0	47	0	0	0	0	0
Other	0	47	0	0	0	0	0
Water	0	506	0	0	0	0	0
Mu							
Periodic acid	0	62	0	0	0	0	0
Water	0	559	0	0	0	0	0

Table IV-7
Environmental Releases in Screen Cleaning Operations:
Emulsion Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Phi							
Sodium periodate	0	19	0	0	0	0	0
Water	0	481	0	0	0	0	0
Ethoxylated nonylphenol	0	49	0	0	0	0	0
Other	0	72	0	0	0	0	0
Omicron AE & Omicron AF							
Sodium periodate	0	19	0	0	0	0	0
Ethoxylated nonylphenol	0	13	0	0	0	0	0
Water	0	603	0	0	0	0	0
Zeta (diluted 1:4)							
Sodium periodate	0	6	0	0	0	0	0
Water	0	615	0	0	0	0	0
Theta (Method 4)							
Sodium periodate	0	177	0	0	0	0	0
Water	0	44	0	0	0	0	0
Theta (Method 4) (diluted 1:3)							
Sodium periodate	0	44	0	0	0	0	0
Water	0	177	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

General Population Exposure Conclusions and Observations

○ Health risks to the general population from both air and water exposures are very low for all of the emulsion removers evaluated.

Ecological Risks from Water Releases of Screen Reclamation Chemicals

○ None of the single facility releases of emulsion removers reach an ecotoxicity concern concentration.

Haze Removal Function

Substitute Comparative Assessment

Table IV-8 below lists some of the chemical haze removers that are available to screen printers. Table IV-8 includes a summary of key physical properties, a brief hazard summary, and a list of purchase prices for each emulsion remover. For information on the chemical properties and industrial synthesis of the bulk chemicals, refer to Chapter II. Market information on the volume of specific haze remover products sold is not available.

Table IV-8
Hazard Summaries and Cost: Haze Removers

Formulation	% VOC Flash Pt. V.P.[a]	Hazard Summary Health Effects Description	 Aquatic Hazard Rankings[b]	Purchase Cost
Traditional Product Systems				
<u>Systems 1, 2, 3, & 4</u> 10% Xylene 30% Acetone 30% Mineral spirits 30% Cyclohexanone	100%	developmental toxicity; reproductive toxicity; genetic toxicity; neurotoxicity; chronic toxicity	Medium Low High Low	$5.12/gallon
Alternative Systems				
<u>Alpha</u> Alkali/caustic Tetrahydrofurfuryl alcohol Water	< 15 % 183 F NA[c]	corrosive	Low Medium	$9.39/gallon (5 kg/$50)
<u>Chi</u> Diethylene glycol series ethers Propylene glycol series ethers N-methyl pyrrolidone Ethoxylated nonylphenol	94 % < 200 F < 0.1 mm Hg	developmental toxicity; reproductive toxicity; chronic toxicity	Low/Medium Low/Medium Low Medium	$31.20/gallon (5 gallons/$156 55 gallons/$1,315)
<u>Delta</u> Dibasic esters Propylene glycol series ethers Ethoxylated nonylphenol	94 % < 200 F < 1.0 mm Hg	developmental toxicity; chronic toxicity	Medium Low/Medium Medium	$20.00/gallon (5 gallons/$100 55 gallons/$900)

Table IV-8
Hazard Summaries and Cost: Haze Removers

Formulation	% VOC Flash Pt. V.P.[a]	Hazard Summary		Purchase Cost
		Health Effects Description	Aquatic Hazard Rankings[b]	
Epsilon Alkyl benzene sulfonates Ethoxylated nonylphenol Phosphate salt Sodium hydroxide Derivatized plant oil Cyclohexanone Methoxypropanol acetate Diethylene glycol Benzyl alcohol Diacetone alcohol Aromatic solvent naphtha Derivatized plant oil Water	unknown NA unknown	developmental toxicity; reproductive toxicity; genetic toxicity; neurotoxicity; chronic toxicity; corrosive	Medium Medium High Low Low/High Low Medium Low Medium Low Medium Low/High	$1.09/lb (15 kg/$36)
Gamma Sodium hypochlorite Alkali/caustic Sodium alkyl sulfate Water	0 % NA < 0.2 mm Hg (@ 70 F)	developmental toxicity; genetic toxicity; chronic toxicity; corrosive	Medium Low Medium	$9.39/gallon (25 liters/$62))
Mu Sodium hypochlorite Alkali/caustic Sodium alkyl sulfate Water	0 % NA NA	developmental toxicity; genetic toxicity; chronic toxicity; corrosive	Medium Low Medium	$7.57/gallon (five 5-liter units/$50))
Phi N-methyl pyrrolidone Dibasic esters	NA > 185 F 0.195	developmental toxicity; reproductive toxicity; chronic toxicity	Low Medium	$39.95/gallon
Omicron AE Ethoxylated nonylphenol Phosphate surfactant Other Water	unknown 210 F 0.1 mm Hg	limited hazard data	Medium High Low	$18.00/gallon (5 gallons/$90)
Omicron AF Ethoxylated nonylphenol Phosphate surfactant Alkali/caustic Other Water	unknown unknown < 1 mm Hg	corrosive	Medium High Low Low	$18.00/gallon 5 gallons/$90

Table IV-8
Hazard Summaries and Cost: Haze Removers

Formulation	% VOC Flash Pt. V.P.[a]	Hazard Summary: Health Effects Description	Hazard Summary: Aquatic Hazard Rankings[b]	Purchase Cost
Theta Alkali/caustic Cyclohexanone Furfuryl alcohol	unavailable 171 F NA	developmental toxicity; reproductive toxicity; genetic toxicity; neurotoxicity; chronic toxicity; corrosive	Medium Low Medium	$43.00/gallon[d]
Zeta Alkali/caustic Propylene glycol Water	100 % 101 F 0.4-10.5 mm Hg	corrosive	Low Low	$30.00/gallon

[a]V.P. means vapor pressure.
[b]The hazard rankings shown identify the categories (low, medium, or high) into which the individual components of the product system fall. The aquatic hazard ranking for each chemical is listed on the same line as the chemical name. When an alternative system includes chemicals from a chemical category (see Table II-2), the hazard ranking shown is the range of the rankings of all of the individual chemicals comprising the category. This analysis did not estimate the aquatic hazard ranking of the product systems as mixtures.
[c]NA means not available.
[d]Product system also requires a fixed cost of $13,165. Reference Method 4 in Chapter V.

Exposure Analysis & Risk Characterization

For specific assumptions and details of the occupational exposure, environmental releases and risk assessment, please reference Chapter III.

Table IV-9
Occupational Exposures: Haze Removers

System	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
	I	II	III	IV	Routine	Immersion
Traditional Systems						
Systems 1, 2, 3, and 4						
Xylenes (mixed)	21	0.9	1	0	156	728
Acetone	64	11	5	0	468	2180
Mineral spirits-light hydrotreated	7	0.1	0	0	468	2180
Cyclohexanone	27	0.3	0	0	468	2180
Alternative Systems						
Alpha						
Alkali/caustic[a]	0	0	0	0	390	1820
Tetrahydrofurfuryl alcohol	1	0.1	0	0	234	1090
Water	0	0	0	0	936	4370
Chi						
Diethylene glycol series ethers	0	0	0	0	312	1456
Propylene glycol series ethers	0	0	0	0	858	4000
N-methylpyrrolidone	3	0	0	0	312	1460
Ethoxylated nonylphenol	0	0	0	0	78	364
Delta						
Dibasic esters	2	0	0	0	702	3280
Propylene glycol series ethers	0	0	0	0	780	3640
Ethoxylated nonylphenol	0	0	0	0	78	364
Epsilon						
Cyclohexanone	12	0.3	0.2	0	234	109
Methoxypropanol acetate	5.2	0.4	0.2	0	117	546
Diethylene glycol	0	0	0	0	156	728
Benzyl alcohol	0	0	0	0	51	273
Derivatized plant oil	0	0	0	0	27	127
Aromatic solvent naphtha	0.5	0.1	0	0	78	364
Diacetone alcohol	1.4	0.1	0.1	0	62	291
Alkyl benzene sulfonates	0	0	0	0	140	655
Ethoxylated nonylphenol	0	0	0	0	62	291
Phosphate salt	0	0	0	0	117	546
Alkali/caustic[a]	0	0	0	0	408	1890
Water	0	0	0	0	109	510
Gamma						
Sodium hypochlorite[a]	0	0	0	0	585	2730
Alkali/caustic[a]	0	0	0	0	39	182
Water	0	0	0	0	827	3860
Sodium alkyl sulfate	0	0	0	0	109	510

Table IV-9
Occupational Exposures: Haze Removers

	Inhalation Exposures, by Scenario (mg/day)				Dermal Exposures, (mg/day)	
Mu **System**						
Sodium hypochlorite[a]	0	0	0	0	585	2730
Alkali/caustic[a]	0	0	0	0	39	182
Water	0	0	0	0	827	3860
Sodium alkyl sulfate	0	0	0	0	109	510
Phi						
N-methylpyrrolidone	6	0	0	0	780	3640
Dibasic esters	1	0	0	0	780	3639
Omicron AE						
Other	0	0	0	0	109	510
Ethoxylated nonylphenol	0	0	0	0	16	73
Phosphate surfactant	0	0	0	0	78	364
Water	0	0	0	0	1360	6330
Omicron AF						
Ethoxylated nonylphenol	0	0	0	0	16	73
Alkali/caustic[a]	0	0	0	0	156	728
Phosphate surfactant	0	0	0	0	78	364
Other	0	0	0	0	109	510
Water	0	0	0	0	1200	5610
Zeta						
Alkali/caustic[a]	0	0	0	0	234	1090
Propylene glycol	0	0.1	0	0	62	291
Water	0	0	0	0	1260	5900
Theta (Method 4)						
Alkali/caustic[a]	0	0	0	0	515	2400
Cyclohexanone	25	0.3	0	0	515	2400
Furfural alcohol	0	0	0	0	530	2480

[a]Dermal exposures presented are worst-case and the use of gloves is expected due to irritation and corrosive effects.

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

Table IV-10
Occupational Risk Conclusions and Observations:
Haze Removers

System	Observations
Traditional Product Systems	
Systems 1, 2, 3, & 4	Hazard quotient calculations indicate clear concerns for chronic dermal and inhalation exposures to workers using acetone in haze removal. Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to workers using xylene and cyclohexanone in haze removal. Margin-of-exposure calculations indicate very low concern for developmental and reproductive toxicity risks from inhalation of cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified. Dermal exposures to workers using mineral spirits in haze removal can be very high, although the risks from mineral spirits could not be quantified because of limitations in hazard data.
Alternative Systems	
Alpha	Dermal exposures to other chemicals used in haze removal can be high, although the risks could not be quantified because of limitations in hazard data.
Chi	Clear concerns exist for chronic dermal exposures to diethylene glycol series ethers used in haze removal based on the calculated margins-of-exposure. Concerns exist for developmental toxicity risks from dermal exposures to N-methylpyrrolidone based on the calculated margin-of-exposure. Similar calculations for inhalation exposures to N-methylpyrrolidone indicate very low concern. Inhalation exposures to other haze remover components are very low. Dermal risks from other haze remover components could not be quantified because of limitations in hazard data, but exposures can be high.
Delta	Although no risks could be quantified because of limitations in hazard data, relatively high dermal exposures to haze remover components could occur. Inhalation exposures to all components are very low.
Epsilon	Hazard quotient calculations indicate marginal concerns for chronic dermal exposures to cyclohexanone and benzyl alcohol during haze removal. Similar calculations for inhalation exposures to cyclohexanone and benzyl alcohol indicate low concern. Hazard quotient calculations indicate marginal concerns for chronic dermal exposures and low concern for chronic inhalation exposures to methoxypropanol acetate. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table IV-10
Occupational Risk Conclusions and Observations: Haze Removers

System	Observations
Gamma	Developmental and chronic toxicity risks from dermal exposures to sodium alkyl sulfate in haze remover are very low based on the calculated margin of exposure. Inhalation exposures to all components are very low. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Mu	Developmental and chronic toxicity risks from dermal exposures to sodium alkyl sulfate in haze remover are very low based on the calculated margin of exposure. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Phi	Dermal exposures to N-methylpyrrolidone during haze removal present a concern for developmental toxicity risk based on the calculated margins-of-exposure. Similar estimates for inhalation exposures to N-methylpyrrolidone indicate very low concern. Inhalation exposures to all other components are very low. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Omicron AE	Inhalation exposures to components are very low. Risks from components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Omicron AF	Inhalation exposures to components are very low. Risks from components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.
Zeta	Hazard quotient calculations for chronic inhalation and dermal exposures to propylene glycol during haze removal indicate very low concern. Inhalation exposures to other components are very low. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table IV-10
Occupational Risk Conclusions and Observations:
Haze Removers

System	Observations
Theta (Method 4)	Hazard quotient calculations indicate marginal concerns for chronic dermal exposures and very low concern for chronic inhalation exposures to cyclohexanone during haze removal. Margin-of-exposure calculations show low concern for developmental and reproductive toxicity risks from inhalation exposures to cyclohexanone. Reproductive and developmental toxicity risks from dermal exposures to cyclohexanone could not be quantified. Inhalation exposures to other components are very low. Risks from other haze remover components could not be quantified because of limitations in hazard data, although dermal exposures to all components could be relatively high.

Table IV-11
Environmental Releases in Screen Cleaning Operations: Haze Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Traditional Product Systems							
Systems 1, 2, 3, & 4							
Xylenes (mixed isomers)	44	0	0	1.9	1.1	0	0
Acetone	133	0	0	22	11	0	0
Mineral spirits- light hydrotreated	15	119	0	0.2	0.1	0	0
Cyclohexanone	57	76	0	0.7	0.4	0	0
Alternative Systems							
Alpha							
Alkali/caustic	0	133	0	0	0	0	0
Tetrahydrofurfuryl alcohol	1.5	78	0	0.1	0.1	0	0
Water	0	319	0	0	0	0	0
Chi							
Diethylene glycol series ethers	0.1	104	0	0	0	0	0
Tripropylene glycol series ethers	0.1	286	0	0	0	0	0
N-methylpyrrolidone	6.8	97	0	0.1	0	0	0
Ethoxylated nonylphenol	0	26	0	0	0	0	0
Delta							
Dibasic esters	3.7	239	0	0	0	0	0
Tripropylene glycol series ethers	0.1	269	0	0	0	0	0
Ethoxylated nonylphenol	0	27	0	0	0	0	0
Epsilon							
Cyclohexanone	25	55	0	0.7	0.7	0.4	0
Methoxypropanol acetate	11	29	0	0.8	0.8	0.5	0
Diethylene glycol	0	53	0	0	0	0	0
Benzyl alcohol	0.1	17	0	0	0	0	0
Derivatized plant oil	0.1	9.3	0	0.1	0.1	0	0
Aromatic solvent naphtha	1	26	0	0.1	0.1	0.1	0
Diacetone alcohol	2.9	37	0	0.2	0.2	0.1	0
Alkyl benzene sulfonates	0	48	0	0	0	0	0
Ethoxylated nonylphenol	0	21	0	0	0	0	0
Alkali/caustic	0	138	0	0	0	0	0
Water	0	37	0	0	0	0	0
Phosphate salt	0	21	0	0	0	0	0

Table IV-11
Environmental Releases in Screen Cleaning Operations: Haze Removers

System	Release Under Each Scenario (g/day)						
	I			II	III	IV	
	Air	Water	Land	Air	Air	Air	Water
Gamma							
Sodium hypochlorite	0	200	0	0	0	0	0
Alkali/caustic	0	13	0	0	0	0	0
Water	0	282	0	0	0	0	0
Sodium alkyl sulfate	0	37	0	0	0	0	0
Mu							
Sodium hypochlorite	0	200	0	0	0	0	0
Alkali/caustic	0	13	0	0	0	0	0
Water	0	282	0	0	0	0	0
Sodium alkyl sulfate	0	37	0	0	0	0	0
Phi							
N-methylpyrrolidone	12	270	0	0.1	0	0	0
Dibasic esters	3.1	279	0	0	0	0	0
Omicron AE							
Other	0	43	0	0	0	0	0
Ethoxylated nonylphenol	0	6.2	0	0	0	0	0
Phosphate surfactant	0	31	0	0	0	0	0
Water	0	540	0	0	0	0	0
Omicron AF							
Ethoxylated nonylphenol	0	5.6	0	0	0	0	0
Alkali/caustic	0	56	0	0	0	0	0
Phosphate surfactant	0	28	0	0	0	0	0
Other	0	39	0	0	0	0	0
Water	0	428	0	0	0	0	0
Zeta							
Alkali/caustic	0	80	0	0	0	0	0
Propylene glycol	0.7	21	0	0.2	0.1	0	0
Water	0	431	0	0	0	0	0
Theta (Method 4)							
Alkali/caustic	0	291	0	0	0	0	0
Cyclohexanone	53	239	0	0.7	0.4	0	0
Furfural alcohol	0	300	0	0	0	0	0

Scenario I = reclaiming 6 screens per day; each screen is approximately 2100 in^2; Scenario II = pouring 1 ounce of fluid for sampling; Scenario III = transferring chemicals from a 55 gallon drum to a 5 gallon pail; Scenario IV = transferring waste rags from a storage drum to a "laundry bag."

General Population Exposure Conclusions and Observations

○ Health risks to the general population from both air and water exposures are very low for all of the haze removers evaluated.

Ecological Risks from Water Releases of Screen Reclamation Chemicals

○ None of the single facility releases of haze removal chemicals reach an ecotoxicity concern concentration.

Manufacturing of Screen Reclamation Chemical Products

Manufacturing Process

Most screen reclamation chemical products are formulated in facilities outside of the United States.[1] The basic process description that follows is based primarily on conversations with two formulation manufacturers in the United States and may not describe the range of manufacturing processes used by formulation manufacturers elsewhere.[2,3]

Screen reclamation chemical products typically consist of a mixture of two or more liquid and/or solid chemicals. In some cases, the mixture may include water used as a diluent or to dissolve solids and facilitate the spray application of the product. Regardless of whether the product is an ink remover, emulsion remover or haze remover, the basic manufacturing process is the same, as described below.

Chemical ingredients are received from a chemical manufacturer or distributor in small (55 gallon drums or 350 gallon totes) or large (tanker trucks) quantities and stored on-site. Small quantities are typically stored on pallets or racks on the process floor in a designated area without separate ventilation. Large quantities may be stored in dedicated storage tanks.

Chemicals are pumped or emptied by weight into a mixing vessel. The mixing vessel is covered and ingredients are agitated or mixed using turbine or rotary blade/propeller mixing, aeration and shear dispersion. The addition of heat or pressure is not normally required to accomplish the mixing step. Typically, mixing vessels do not have a separate ventilation system (e.g., ventilation is to the process room).

Products are usually packaged in 55 gallon drums, 15 gallon drums, 5 gallon pails and one gallon jugs, although other sizes are available if requested by the customer. Containers are filled manually with a hand-held pump and semi-automated fillers or by pouring from smaller mixing

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[1]Correspondence between Marci A. Kinter, SPAI, and Lori Kincaid, University of Tennessee, June 1994.

[2]Correspondence between Oliver Nichols, Nichols and Associates, and Dean Menke, University of Tennessee, June 1994.

[3]Correspondence between Clark King, Kiwo, and Dean Menke, University of Tennessee, June 1994.

vessels (e.g., 55 gallon drums). Employees wear gloves, goggles, and respirators when needed. Packaged products may be inventoried on the process floor, in a separate designated area or stored outside of the process area pending distribution.

Source Release Assessment: Product Formulation

Process air emissions of volatile organic compounds from product formulation processes can originate from the venting of mixing vessels. Fugitive air emissions can result when process fluid leaks from plant equipment such as pumps, compressors and process valves. Air emissions from storage and handling operations can also occur where screen reclamation products are formulated. Other potential sources of environmental releases or transfers include:

- wastewater discharges from a facility into rivers, streams or other bodies of water or transfers to a publicly-owned treatment works (POTW);
- on-site releases to landfills, surface impoundments, land treatment or another mode of land disposal; and
- transfer of wastes to off-site facilities for treatment, storage or disposal.

Energy and Natural Resources Issues

The use of different chemical products, processes or technologies in a use cluster can result in changes in the rate of energy and natural resources consumption, either in the product use stage, manufacture stage, or other life cycle stages (e.g., extraction of raw materials, transportation, disposal, etc.). The processes used to formulate traditional versus alternative screen reclamation chemical products appear to be similar, however, with no differences that would significantly influence the rate of energy or natural resources consumption during product manufacturing. The following lists potential energy and natural resources issues that should be considered when choosing among alternatives.

- The energy required to manufacture the chemical ingredients of screen reclamation products can vary substantially. For example, the energy required to manufacture solvents derived from plants using a cold-press process may be less than that required in a hot-press process.
- Products manufactured from petrochemicals have an energy equivalence, as do other products with sufficient energy content to be used as fuel. The amount of petrochemicals used to manufacture screen reclamation products, however, is small compared to other uses of petroleum-based products.
- Products manufactured from petrochemicals are also derived from a nonrenewable resource, petroleum. However, products manufactured from renewable resources, such as plants, frequently use petrochemicals at some point in the chemical manufacturing process. In either case, the amount of petrochemicals used to manufacture screen reclamation products is small compared to other uses of petroleum-based products.

- Products that are formulated using heat or pressure to dissolve product ingredients or cause a chemical reaction consume more energy than those manufactured using simple mixing processes.

- Compared to undiluted products, formulations that are diluted with water prior to shipping result in greater energy consumption during transportation of the product from the manufacturer to the printing facility.