Cleaner Technologies Substitutes Assessment:

Lithographic Blanket Washes

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Design for the Environment
U.S. EPA

Developed by the Design for the Environment Program in Cooperation with:

The University of Tennessee Center for Clean Products and Clean Technologies,

Printing Industries of America,

The Environmental Group (formerly, the Environment Conservation Board of the Graphic Communications Industry), and

The Graphic Arts Technical Foundation

NOTICE

This document has been reviewed by the U.S. Environmental Protection Agency (EPA) and approved for publication. The information contained here was developed by the EPA Design for The Environment (DfE) Program's Lithography Project in collaboration with partners from the printing industry and the University of Tennessee. Mention of trade names or commercial products does not imply endorsement or recommendation for use. Information on cost and product usage was provided by individual product vendors and was not independently corroborated by EPA.

Discussion of federal environmental statutes is intended for information purposes only; this is not an official guidance document and should not be relied upon by companies to determine applicable regulations.

A draft of the *Cleaner Technologies Substitutes Assessment: Lithographic Blanket Washes* was released for public comment in July 1996. A Federal Register Notice of Availability for Comment was published August 7, 1996, establishing a 45-day comment period. Written comments were received from three parties. These comments were reviewed and incorporated as appropriate.

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PREFACE

This document is designed to be the repository for the technical information developed through the DFE Lithography Project. A summary booklet intended for printing industry professionals has been developed entitled *Solutions for Lithographic Printers: An Evaluation of Substitute Blanket Washes (EPA/744-F-96-009)* that captures much of this information in a simpler, more user-friendly format. It is available from the Pollution Prevention Information Clearinghouse at the address listed below.

Other documents developed through the DfE Lithography Project include:

- Lithography Project Fact Sheet
  (EPA/744-F-95-005)
- Solutions for Lithographic Printers: An Evaluation of Substitute Blanket Washes
  (EPA/744-F-96-009)
- Managing Solvents and Wipes, Lithography Project Case Study #1
  (EPA/744-K-93-001)
- Working Together for Pollution Prevention, Lithography Project Case Study #2
  (EPA/744-F-96-001)
- Substitute Blanket Washes—Making Them Work, Lithography Project Bulletin #1
  (EPA/744-F-96-002)
- Workplace Practices Make the Difference, Lithography Project Bulletin #2
  (EPA/744-F-96-008)
- Vegetable Ester Substitute Blanket Washes, Lithography Project Bulletin #3
  (EPA/744-F-96-014)
- A Worksheet to Help You Choose a Better Blanket Wash, Lithography Project Bulletin #4
  (EPA/744-F-96-015)

To obtain any of these documents or for further information about the DfE Program contact:

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http://www.epa.gov/dfe

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Executive Summary

I. INTRODUCTION

The *Cleaner Technologies Substitutes Assessment* (CTSA): *Lithographic Blanket Washes* is a technical report that presents the performance, cost and risk information developed by the EPA Design for the Environment (DfE) Lithography Project on 37 blanket washes solutions (36 substitute washes and a baseline wash) that are used to remove ink and debris from the printing press rollers. The assessment focuses on small print shops that use sheetfed, non-heat set lithographic presses less than 26 inches wide and that clean their presses manually. It includes all the technical information gathered during the Project, including the methodologies used to develop the performance, cost, and environmental information.

The goal of the DfE Lithography Project is to work with the printing industry to develop a comparative assessment of blanket washes used by lithographers. The assessment is intended to provide lithographers with information that can assist them in making decisions that incorporate environmental concerns along with cost and performance information when purchasing blanket washes. Although the Lithography Project was designed to assist small printers who may have limited time or resources to compare blanket washes, the primary audience for the CTSA is environmental health and safety personnel, chemical and equipment manufacturers and suppliers in the lithographic printing industry, and other technically informed decision makers. The information contained in the CTSA will form the basis of a variety of user-friendly information products designed specifically for small business printers who are interested in choosing a new blanket wash. These products will include case studies, bulletins, and brochures.

The information in the CTSA was developed from a variety of sources. Data on performance and cost were derived from real world performance demonstrations conducted both in the laboratory and in actual printing facilities. The laboratory tests provided information on the chemical characteristics of the blanket washes such as blanket swell and wipability. Demonstrations at print shops provided field data for the performance and cost assessments. Exposure, hazard, and risk assessments for the chemical components of the blanket washes were made by the EPA based on available data and modeling where data were not available. All assumptions used in developing the information in the CTSA, such as number of blankets per press, size of each blanket, or amount of wash used, were reviewed by representatives of the printing industry.

II. DESIGN FOR THE ENVIRONMENT LITHOGRAPHY PROJECT

The DfE Lithography Project is a joint effort of the Office of Pollution Prevention and Toxics (OPPT) and The University of Tennessee Center for Clean Products and Clean Technologies, in a voluntary and cooperative partnership with the Printing Industries of America (PIA), the Environmental Conservation Board of the Graphic Communications Industry (ECB), and the Graphic Arts Technical Foundation (GATF). The DfE Program began working with the printing industry in 1992, when the PIA requested EPA's assistance in evaluating environmental claims for products.

The DfE Lithography Project partners chose to compare the environmental and human health risks of manual blanket washing because traditionally these products are petroleum-based solvents with a high volatile organic compound (VOC) content. For example, a commonly used

What is the Design for the Environment Program ?

The Design for the Environment (DfE) Program harnesses EPA's expertise and leadership to facilitate information exchange and research on risk reduction and pollution prevention efforts. DfE works with businesses on a voluntary basis, and its wide-ranging projects include:

- Assisting businesses in incorporating environmental concerns into decision-making processes.
- Working with specific industries to evaluate the risks, performance, and costs of alternative chemicals, processes, and technologies.
- Helping individual businesses undertake environmental design efforts through the application of specific tools and methods.

DfE partners include:

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

solvent is VM&P naphtha, which is 100 percent volatile. The high VOC-content blanket washes currently used by many printers may pose a potential risk to workers' health and to the environment. In addition, VOCs have been implicated in the formation of ground level ozone. As a result of the potential adverse effects that may result from the release of VOCs from blanket washes and from other applications, the EPA and some states are considering regulations that may impose restrictions on the use and emissions of products containing VOCs and Hazardous Air Pollutants (HAPs). Many states have already implemented regulations aimed at reducing VOC emissions even from small printers. The DfE Lithography Project partners hope that helping printers, large and small, identify effective and competitively-priced blanket washes with lower VOC content will result in improved air quality in both printing facilities and in the ambient air.

The project partners decided that the DfE Lithography Project would focus on the concerns of small printers. Unlike many large printers who may have staff that are familiar with, or have access to, current information about new and developing products and technologies, most smaller printers are unlikely to have the staff, time, or resources to investigate the latest innovations. To respond to the concerns of these smaller printers, the DfE Lithography Project partners agreed that the primary goal of the project would be the assessment of manual blanket washes as they are typically used in smaller print shops.

In order to be evaluated by the Project, the blanket washes had to meet several criteria: (1) they needed to be commercially available, (2) they had to be voluntarily donated by the supplier, and (3) the complete formulations had to be disclosed to EPA for risk assessment purposes (although the exact composition was treated as confidential by EPA and not disclosed to printers or other outside parties). In all, 36 blanket washes and VM&P naphtha (baseline), donated by 19 suppliers, were included in the Project.

To provide a basis for comparison among the blanket washes, a baseline blanket wash was selected. VM&P naphtha, which is composed of 100 percent light aliphatic solvent naphtha, was chosen as the baseline because the Project partners believed that most printers would already be familiar with how VM&P naphtha performs and that it would be a useful point of reference for the evaluation of the substitute washes. VM&P naphtha is highly effective in cleaning blankets and relatively inexpensive and, therefore, provides an excellent standard against which to compare the cost and performance of the substitute blanket washes.

III. CLEANER TECHNOLOGIES SUBSTITUTES ASSESSMENT

Summary of Results

Based on the hazard and exposure information collected and analyzed for the blanket washes, risk estimates were determined for both the general population, i.e., people living near a printing facility who may be exposed to contaminated air or water, as well as for workers at the printing facilities. Risk estimates associated with the chemicals in the blanket washes were negligible for the general population. Twenty-seven of the 37 blanket washes had some occupational risks associated with them, primarily from dermal exposure. Possible adverse effects from dermal exposure (and some inhalation exposure) included blood abnormalities, reproductive/developmental problems, or the presence of carcinogens. Proper protective equipment would substantially reduce or eliminate these risks to workers.

Prior to demonstration of the blanket washes in a print shop, the 36 substitute blanket washes were tested in the laboratory for blanket swell potential and wipability. Of the 36 washes, 22 were deemed to be satisfactory for demonstrations at volunteer printing shops (two shops demonstrated each blanket wash). The results of the performance demonstrations were highly variable between the two print shops using a particular blanket wash and among the many blanket washes themselves. Performance varied to a great extent based on the amount of ink coverage. Excluding trials with heavy ink coverage, eleven washes gave good or fair performances at both facilities, seven washes gave good or fair performance at one facility but not the other, and the remaining four washes performed poorly at both facilities.

The costs of using the substitute blanket washes were also highly variable even when normalized for costs such as wages, number of blankets cleaned, etc. Compared with the use of the baseline, VM&P naphtha, most of the substitute blanket washes resulted in increased costs; however, five blanket washes did result in lower costs for at least one of the demonstration facilities, and one resulted in lower costs at both facilities. The cost of using the blanket wash was most dependent on the amount of time required to clean the blanket. This cost was likely higher due to the press operators' lack of familiarity with the new products.

Data Collection

Determining the risks of the substitute blanket washes required information on the chemicals in each blanket wash formulation (a blanket wash is usually a mixture of several chemicals including solvents; the exact chemicals and their proportions define the formulation). Specifically, each blanket wash formulation was broken down into its chemical components, and data were gathered on each individual chemical. In order to maintain the confidentiality of the formulations, EPA genericized the specific chemicals in the formulations into chemical categories (Chapter 2, Section 1). For example, if a formulation contained dodecyl benzenesulfonic acid or sodium xylene sulfonate, both of these chemicals were designated by the chemical category alkyl benzene sulfonates. Similarly, if one formulation contained solvent naphtha and another formulation contained xylene, both of these chemicals would be categorized as aromatic hydrocarbons. Although the actual percentage of each component in the mixture was used in the assessment, this information was not provided in the CTSA to maintain the confidentiality of the proprietary formulations. The actual composition of the formulations was thus kept confidential while still providing an indication of the type of chemical that could pose a hazard.

<u>Chemical Information</u>

For each of the 56 chemicals included in the 37 blanket wash formulations, the chemical properties and selected environmental fate properties were determined and are presented in Chapter 2, Section 2. Properties that were measured or estimated (using a variety of standard

Project Considerations

There are limitations associated with the analysis that was conducted in the project. Some of the global limitations are listed below, other limitations, specific to a particular portion of the assessment, are given in the applicable sections.

- This assessment focuses on the use of manual blanket washes in small lithographic printing facilities using only one press with four color units. Exposure estimates related to blanket wash use in larger facilities may be higher.
- The exposure and risk estimates reflect a small portion of the potential exposures within a lithographic printing facility. Many of the chemicals found in these formulations may also be present in the inks or other cleaning solvents used in a shop. Incremental reduction of exposures from blanket wash use will reduce cumulative exposures from all sources in a printing facility.
- The risks associated with volatile organic compound (VOC) releases were not examined in this assessment. Because VOC releases are a driving factor behind current regulations affecting printers, VOC content for the formulations are given at the request of industry participants. The concerns associated with VOC releases are addressed by federal, state, and local regulations and were not re-evaluated here.
- The regulatory information contained in the CTSA may be useful in moving away from chemicals that trigger compliance issues, however this document is not intended to provide compliance assistance. If the reader has questions regarding compliance concerns they should contact their federal, state, or local regulatory authorities.
- The 37 blanket wash formulations assessed in this report were voluntarily submitted by participating suppliers and are not intended to be representative of the entire blanket wash market.
- The performance and cost data are not based on rigorous scientific studies. This information is subjective and is based on limited data points.
- Screening-level risk characterization techniques were used. The risk characterization results, therefore, contain limitations regarding confidence.

EPA methods) included melting point, solubility, vapor pressure, soil sorption coefficient, octanol water partition coefficient, boiling point, and flash point. Presentation of these properties allows for the determination of the environmental fate of these chemicals when they are released to the various media such as landfills, publicly-owned treatment works, surface waters, and soil.

Health Hazard Assessments

Inherent in determining any risk associated with these chemicals is a determination of the hazard or toxicity of the chemical as presented in Section 2.3. Many of the chemicals in the blanket wash formulations have been studied to determine their health effects. In order to determine those chemicals for which testing data were available, literature searches were conducted of on-line databases including the EPA's Integrated Risk Information System (IRIS), the National Library of Medicine's Hazardous Substances Data Bank (HSDB), TOXLINE, TOXLIT, GENETOX, and the Registry of Toxic Effects of Chemical Substances (RTECS).

For many of the chemicals, EPA has identified chemical concentrations that are known to be hazardous (e.g., no- or lowest-observed adverse effect level [NOAEL or LOAEL]) or levels that are protective of human health (reference concentration or reference dose). These values were taken from published literature. For those chemicals lacking toxicity data, EPA's Structure-Activity Team estimated human health concerns based on analogous chemicals. The adverse effects associated with these chemicals include cancer, chronic effects on various organs such as the liver or kidney, effects on developing fetuses, genetic mutations or aberrations, gastrointestinal effects, effects on blood, nervous system, and respiratory system, and effects on the reproductive capabilities of males or females. The toxicity values, route of exposure, and adverse effects for each chemical are listed in Table 2-3. This information is combined with estimated exposure levels to develop an estimate of the risk associated with each chemical.

Ecological Hazard Assessments

Similar information was gathered on the ecological effects that may be expected if these chemicals are released to water. Acute and chronic aquatic toxicity values were estimated by EPA using structure-activity relationship software developed for that purpose and verified by comparison with data in the available literature. For discrete organic chemicals such as xylene, a structure-activity relationship was used to predict the acute and chronic toxicity to fish, aquatic invertebrates, and algae. For petroleum products such as mineral spirits, which are mixtures and have undefined compositions, toxicity values were determined by estimating the toxicity of each individual constituent and then evaluating the hazard of the product based on the constituents. Aquatic toxicity values were identified from on-line database searches (TOXLINE and AQUIRE) for comparison. Based on the toxicity values, the 56 chemicals were ranked according to their hazard concern as high (8 chemicals), moderate (29 chemicals), or low (19 chemicals). Aquatic toxicity data for the one inorganic chemical in the formulations, sodium hydroxide, indicated that the lowest chronic aquatic toxicity value was 100 mg/L, and therefore, of low aquatic toxicity concern.

Federal Regulatory Status

Several regulatory lists were searched for blanket wash chemicals that might trigger federal regulatory requirements. The presence of federally-regulated chemicals in a blanket wash formulation may influence a printer's decision to use that formulation. Ten of the 56 chemicals in the blanket wash formulations are subject to various federal environmental regulations. These chemicals are 1,2,4-trimethyl benzene, cumene, diethanolamine, diethylene glycol monobutyl ether, dodecylbenzene sulfonic acid, N-methylpyrrolidone, sodium bis(ethylhexyl) sulfosuccinate, sodium hydroxide, Stoddard solvent, and xylene. Among the regulations that apply to one or more of these chemicals are the Clean Water Act, the Clean Air Act, CERCLA, SARA, and RCRA. Reporting and other requirements may affect the use, storage, and disposal of these chemicals under these or other statutes.

Safety Hazards

Because of the many volatile, or otherwise hazardous chemicals in the blanket wash formulations, four safety factors are provided for each formulation. Safety data on the reactivity, flammability, ignitability, and corrosivity of the actual blanket wash formulations containing these chemicals are included in Section 2.6. This information was obtained from Material Safety Data Sheets provided by the suppliers. Factors are based on the National Fire Protection Association's ranking for reactivity and flammability.

Results

In order to characterize the general population and occupational risks associated with the blanket wash chemicals, exposure information was estimated and then combined with the hazard information identified in Chapter 2. Exposure levels used in the risk assessment were based on estimated environmental release data. Releases from a model printing facility were estimated based on models and the resulting exposures to the general population were then developed. Occupational exposure to the blanket washes were also determined. The specific methods and results of the exposure and risk assessments are described below.

Exposure Assessment

In order to assess the risks, it is important to understand not only the hazards posed by the chemicals or blanket wash formulations, but also to know how people or the environment may be exposed to the chemicals from their use as blanket washes. EPA used a materials balance approach for calculating releases of lithographic blanket washes from printing facilities (Chapter 3, Section 1). This approach assumes that: (1) 160 gallons of blanket wash are purchased per year by a facility, (2) all of the blanket wash is either released to air in the shop (and eventually to the outdoors) or is left on the cleaning wipes which are laundered with subsequent releases to water, and (3) release of the blanket wash to air is dependent on the vapor pressure of the chemicals in the formulation. Depending on the composition of the blanket wash (i.e., VOC content and density of the components), potential environmental releases to air and water were calculated for each of the chemicals in the formulations. Releases to air ranged from non-existent to 0.07 g/sec for terpenes in Formulation 25. Releases to water ranged from non-existent to as much as 604 kg/year for fatty acid derivatives in Formulation 26.

Potential worker exposures were evaluated (Chapter 3, Section 2). As with the environmental release estimates, certain assumptions must be made such as the number of times a worker cleans the blankets per shift, the length of time required to clean a blanket and the amount of wash used. To assure that these assumptions were indicative of "real world" print shops, they were reviewed by lithographic industry representatives and adjusted as necessary. Chemicals with vapor pressures of less than 10^{-3} mm mercury were assumed to have no inhalation potential because they would not volatilize. Inhalation exposures were negligible for most of the formulations; however, some formulations that contained chemicals such as petroleum distillate hydrocarbons, aromatic hydrocarbons, and terpenes did have significant inhalation potential (up to 240 mg/day). Dermal exposures from contact with the blanket wash solution during cleaning activities were estimated based on the type of operation and the concentration of the wash (some washes were diluted prior to use). Dermal exposure tended to be high for all formulations, with levels exceeding 3,000 mg/day for certain chemicals in 12 formulations. All dermal exposures would be negligible if proper protective clothing was worn.

General population exposure based on the environmental releases described above were examined. Such exposure may occur by a variety of routes including breathing vapors of the formulations in air near the printing facilities or drinking contaminated water (Chapter 3, Section 3). Exposures for the general population were determined based on atmospheric modeling and surface water modeling and were used to develop the risk characterizations.

Two atmospheric exposure scenarios were used: local and regional. In the local scenario, releases from only a single "model" printing facility in normal operations were considered. Based on the atmospheric dispersion model, the lifetime average daily dose for an adult ranged from $1x10^{-4}$ mg/kg/day to $4.6x10^{-3}$ mg/kg/day. Denver, Colorado was chosen to evaluate the cumulative effects from several facilities in a community. Assumptions used in this exposure included: (1) 235 lithographers in Denver, (2) the 1990 population was approximately 470,000, (3) the area of Denver is 277 square kilometers. The resulting average daily doses for the population of Denver ranged from $1x10^{-5}$ to $1.3x10^{-3}$ mg/kg/day.

In addition to exposure from atmospheric releases, doses to people as a result of surface water releases from one printing facility (local) and all printers in the City of Denver (regional) were also estimated. These estimates were based on laundry cleaning of print shop towels containing blanket washes. All water releases were assumed to go to the local publicly owned treatment works before release to a water body. Assumptions regarding human intake included: (1) people drink an average of two liters of water a day, (2) some chemicals bioaccumulate in fish, and (3) people eat an average of 16.9 grams of fish per day. For a population around a single facility, daily human doses based on fish ingestion were generally 2 to 3 orders of magnitude greater than for ingestion of contaminated drinking water (0 to 0.1 mg/year for water compared with 0 to 500 mg/year for fish). Daily doses for residents of Denver fluctuated greatly, although the doses were consistently greater for fish ingestion compared with drinking water ingestion.

Risk Characterization

By combining the hazard information presented in Chapter 2 with the exposure data for the blanket wash formulations from Section 1 of Chapter 3, the risks posed by these mixtures was characterized. The risks determined for the formulations (or the chemicals that compose them) may then be compared with established risk values for the various chemicals such as Reference Doses, Reference Concentrations, NOAELs, and LOAELs. A ratio of the estimated risk to the known risk provides a margin of exposure. General population risks were found to be non-existent whether exposure resulted from drinking water, fish ingestion, or inhalation of ambient air. Worker risks were generally associated with one or two chemicals in a given blanket wash formulation. Twenty-seven of the 37 blanket washes posed some risk from dermal exposures. The concern for risks tended to be for blood effects, some reproductive or developmental effects, and the possible presence of carcinogens. In some cases, the margin of exposure was less than 10 suggesting that adverse health effects were of concern under realistic exposure situations. Worker inhalation risks were very low as a result of the relatively low exposure levels; only formulation 3 posed any inhalation concerns.

Risks in the workplace associated with dermal exposure to the blanket washes may be substantially reduced by the use of proper protective equipment and clothing such as gloves, goggles, and aprons. Inhalation risks may be reduced by proper ventilation of the facility and the use of blanket washes with low VOC content.

Two chemicals contained in the blanket wash formulations may present risks to aquatic organisms. The two chemicals were alkyl benzene sulfonates, present in Formulations 3, 4, 6, 8, 11, 18, and 20, and ethoxylated nonylphenols, present in Formulations 4, 5, 7, 8, 9, 17, 24, and 40. Risks to plants (other than aquatic algae) and wildlife were not examined.

Performance Demonstrations

In order to be a viable substitute for existing blanket wash formulations, the alternative formulations must effectively clean the press blankets. To determine how effective the 36 blanket washes were compared to the baseline wash, the Project partners decided that both laboratory testing and field demonstration were necessary. The laboratory tests, conducted by the Graphic Arts Technical Foundation, focused on the physical properties of the blanket wash formulations such as flash point, VOC content, and pH (as distinct from the individual chemicals components of the mixtures discussed in Chapters 2 and 3). Also to ensure that presses at the volunteer facilities would not be damaged, blanket swell potential and wipability tests were also conducted. Any wash where the blanket swell exceeded 3 percent or where more than 100 strokes were required to clean the test blanket were eliminated for consideration for field testing. Based on the results of the laboratory testing, 22 formulations went on to be demonstrated by volunteer printing shops.

In the laboratory tests, the flash points of the blanket washes ranged from 50°F to greater than 230°F; the VOC content ranged from 0.05 lbs/gallon to 7.2 lbs/gallon (0.6 to 99% VOC, respectively); and the pH ranged from 3.4 to 9.9. There was no correlation between the three properties in the formulations. Blanket swell was measured at 1 and 5 hours with 13 formulations having greater than 3 percent swelling at 5 hours. Wipability was tested using both wet ink and dry ink films. Two formulations required more than 100 strokes to clean dry ink.

Field demonstrations were conducted at 17 printing facilities in the Boston, Baltimore, and Washington, DC areas. Each formulation was used by pressmen in two facilities for 1 week. DfE "observers" provided background information to the printers and collected information during the first day's use of the blanket wash. The trade names were removed and each formulation was assigned a number. Neither the pressman nor the observer knew the company supplying the formulation or its components. Each pressman used the baseline wash, VM&P naphtha, for 2-4 cleanings and then began use of the substitute for the remainder of the week. The printers recorded amount of effort and a qualitative assessment of performance as compared to the baseline. They also collected volume used per wash, ink coverage, amount of effort, time required, and a qualitative assessment of performance during the one-week trial. At the end of the week, the observer conducted a follow-up interview with the printer. Results of these performance demonstrations in the laboratory and in the field are detailed in Chapter 4, Section 1.

The circumstances under which the blanket wash formulations were demonstrated at printing facilities were highly variable (i.e., operating conditions, types of print jobs, staff attitudes and aptitude, application method) and the short time during which the formulations were used preclude making generalizations regarding the long-term performance of the blanket washes. In Chapter 4, the performance evaluations for each of the blanket washes are summarized with an indication of how the product performed at each printing facility. Some printers used a particular substitute blanket wash on only four blankets before indicating that the product gave unacceptable results. However, some print shops cleaned more than 30 blankets (one shop tested 61 blankets). In several cases, there was considerable variation between the results obtained for the two facilities testing a single formulation. For example, Blanket Wash 3 gave good results compared with the baseline wash at one facility which used it on ten blankets and found that it gave good performance with light or medium ink coverage, whereas the second facility which tested it on four blankets thought that it gave poor performance compared with the baseline wash without indicating the level of ink coverage.

Of the blanket washes demonstrated, nine were found to give good or fair performance at both facilities with light to moderate ink cover when compared with the baseline wash, although poor results were frequently seen with heavy ink cover. Five of the formulations gave poor results at both testing facilities regardless of the ink cover and eight were found to give good or fair results at one facility and poor results at the second facility. Performance was not correlated with VOC content; however the baseline wash which has a very high VOC content generally gave good results. An in-depth description of the performance of each blanket wash at each test facility is described and compared with the baseline wash (VM&P naphtha) in Chapter 4, Section 1.

<u>Cost Analyses</u>

Data collected during the performance demonstrations and from the suppliers were used to estimate the relative costs of using the blanket wash substitutes and the baseline in a lithographic printing facility. Data was collected on both the baseline wash and the substitute washes in terms of volume of wash used and the time required for cleaning the blanket. Several assumptions, similar to the estimates in Chapter 3, had to be made in order to develop cost information. These assumptions included:

(1) there were four blankets per press;
(2) each blanket was washed ten times per shift;
(3) there were five 8-hours shifts per week for 50 weeks per year;

Based on these assumptions, it was possible to estimate the total cost/wash; total cost/press; and total cost/press/shift/year for each formulation.

The cost calculations were comprised of several factors:

(1) labor costs (i.e., time spent to clean blankets) as a function of average wage rate;
(2) cost of the amount of wash used per blanket; and
(3) cost of the leased cloth wipes (cost of disposable wipes were not included).

Suppliers provided information on the purchase cost per gallon of the baseline and substitute blanket washes if purchased in a 55-gallon quantity. These costs ranged for $2.85/gallon for Formulation 32 to $20.00/gallon for Formulation 11 (the baseline formulation cost was $5.88/gallon).

When the cost of using the substitute blanket washes was compared with the cost of the baseline wash, most of the substitute blanket washes resulted in increased costs to at least one of the two printing facilities. The increased costs ranged from relatively insubstantial (4%) to more than twice the cost of the baseline (maximum increase 179%). Only five blanket washes resulted in lower costs at one facility, and of these, only one (Formulation 37) showed lower costs at both demonstration facilities. These costs, however, must be used with caution as in many cases the number of demonstrations on which the costs were based were extremely limited. In addition, conditions vary at each facility; what works in one may not work in another.

The driving factor for the cost estimates was the time needed to clean the blanket. No considered in this analysis is that the time required to clean the blanket potentially may decrease as the press operators become more familiar with using an alternative product.

IV. OTHER ISSUES

Many factors influence a printer's decision to use a particular blanket wash. These considerations include performance, cost, and risk, but other factors may also play a role in individual situations. Some of these other factors, such as resource and energy conservation, were examined in the CTSA. In Chapter 5, situations where opportunities for reducing energy and resources consumption in the manufacturing, use and disposal of blanket washes are discussed in terms of product life cycle. For some factors, such as whether the use of reusable or disposable wipes is more likely to conserve resources, definite answers cannot be given. For other aspects of the blanket washes, such as chemical composition (petroleum versus vegetable-derived) and packaging (diluted versus concentrated formulation), it is more clear how resource conservation can be achieved. Many printers are concerned with waste disposal, and recycling appears to be a viable solution to reducing waste, in some circumstances.

In a recent survey, over 75 percent of responding printers indicated that they had tried one or more substitute blanket washes and almost half of them had altered their workplace practices to prevent pollution. Some of the techniques that these printers found useful are described in Chapter 6. Many of these practices had the added benefit of saving time, reducing costs, or both. Among the workplace practices and potential benefits described in Chapter 6 are raising employee awareness of the need for and use of protective equipment and pollution prevention practices, better management of materials (e.g., reducing amount of blanket wash used), improving processes (e.g., minimizing the amount of ink used or the length of a run), and management of waste (e.g., storing rags appropriately).

Techniques for recycling used solvent are the focus of Section 6.2. Extraction methods consisting of hand-operated wringers or explosion-proof centrifuges can be used to recover the solvent from wipes used during blanket washing. Once the solvent is extracted, it may be reused for less exacting cleaning needs. If a better quality solvent is desired, then the distillation or ultrafiltration techniques described here may be used to yield near virgin-quality solvent.

Chapter 7 provides summaries of the information developed in this CTSA, examines that information in a qualitative benefit/cost discussion, and presents the information on a formulation-by-formulation basis.

V. CONCLUSIONS

When the DfE Lithography Project was initiated, it was hoped that the Project partners would be able to provide guidance to lithographers, particularly small printing facilities, on the trade-offs among risk, performance, cost, and other factors associated with blanket washes. The Project partners realized that each print shop is different and that judgments on whether one blanket wash is better than another need to be made by individual printers; therefore, no rankings of the blanket wash formulations were made. Instead, the CTSA is a repository of all of the technical information on the blanket washes developed by the Project. It forms the basis for outreach products designed to convey these results to lithographic printers in simple, easy-to-use formats. The CTSA will, therefore, be a resource for those seeking in-depth information on blanket washes and their chemical components, as well as on other issues surrounding the use of manual blanket washes for lithographic printers.

Chapter 1
Introduction

This chapter introduces the Design for the Environment (DfE) Cleaner Technologies Substitutes Assessment (CTSA) for the lithographic printing industry. Section 1.1 contains background materials on the project, partners involved in the project, and the methodologies and assumptions used to create this CTSA. Section 1.2 discusses general aspects of the lithographic printing industry, such as what types of products are printed, how they are printed, and how the printing presses are washed. Section 1.3 discusses both traditional blanket washes and alternative blanket washes, and includes details on prices of the washes. Section 1.4 reviews the blanket wash market. Lists of blanket wash manufacturers and typical blanket wash components are presented. Section 1.5 describes the automatic blanket washing technology. The potential performance, cost, environmental impacts, and health and safety issues associated with using an automatic blanket washer are described.

Chapter Contents

1.1 PROJECT BACKGROUND

1.1.1 Design for the Environment Lithography Project

The Design for the Environment (DfE) Lithography Project is a unique voluntary partnership between the lithographic printing industry and the U.S. Environmental Protection Agency (EPA) dedicated to helping printers improve their efforts to protect the environment. Because the printing industry is characterized by small companies that rarely have the time or resources to gather information on alternatives to their current products and processes, few printers have access to sufficient information to choose safer or lower risk chemicals, work practices, and technologies. The DfE Lithography Project aims to help fill this information gap. The goal of the project is to provide printers with pollution prevention and chemical risk information on product and technology substitutes, so that printers are better equipped to incorporate environmental concerns into their day-to-day business decisions. Specifically, the efforts of the DfE Lithography Project have focused on the risks, costs, and performance of alternatives to the traditional, highly volatile cleaners typically used for washing the press blankets.

What is Design for the Environment?

The Design for the Environment (DfE) Program harnesses EPA's expertise and leadership to facilitate information exchange and research on risk reduction and pollution prevention efforts. DfE works with businesses on a voluntary basis, and its wide-ranging projects include:

- ■ Encouraging business to change their general business practices to incorporate environmental concerns into decision-making processes.
- ■ Working with specific industries to evaluate the risks, performance, and costs of alternative chemicals, processes, and technologies.
- ■ Helping individual businesses undertake environmental design efforts through the application of specific tools and methods.

DfE partners include:
Industry ■ Professional Institutions ■ Academia
Environmental Groups ■ Public Interest Groups ■ Other Government Agencies

1.1.2 Document Overview

Chapter 1 of the CTSA of Lithographic Blanket Washes provides background information on the DfE Lithography Project and the blanket wash industry. Chapter 2 describes the chemicals used in blanket washes and the human health and environmental hazards associated with these chemicals. Chapter 3 presents the environmental and occupational risks of the traditional and alternative blanket washes that were evaluated in the DfE Lithography Project. Chapter 4 describes the results of the performance demonstrations of the alternative blanket washes, a cost analysis for each product, and information on international trade issues. Chapter 5 looks at the energy and natural resource issues associated with each of the alternatives evaluated. Chapter 6 provides information on pollution prevention opportunities in blanket washing. Finally, Chapter 7 summarizes the evaluation of the trade-offs and presents a cost and benefits analysis.

This document is the result of a collaborative effort between EPA staff and printing industry representatives and experts. Each segment of this document was reviewed by the Technical Review Team (members are listed in the acknowledgment section) as it was developed. A complete draft, incorporating the earlier comments, was reviewed by the team and then the second round of comments were also incorporated prior to the printing of the final draft. Where significant disagreement among commentators occurred, the differing opinions are presented in the text.

What is a *Cleaner Technologies Substitutes Assessment*?

This technical document, referred to as a *Cleaner Technologies Substitutes Assessment* (CTSA), is intended to provide industry with the information needed to systematically compare the trade-offs associated with traditional and alternative products, processes, and technologies. Specifically, these trade-offs include the cost, performance, and environmental concerns such as risk, environmental releases, energy impacts, and resource conservation associated with a product or technology. This CTSA addresses blanket washes used in lithography and serves as the repository for all technical information developed by the DfE Lithography Project.

Project Considerations

The focus of this assessment was specifically defined by the project partners and has many limitations. Some of the global limitations are listed below, other limitations, specific to a particular portion of the project, are given in the applicable sections.

- This assessment focuses on the use of manual blanket washes in small lithographic printing facilities using only one press with four color units. Exposure estimates related to blanket wash use in larger facilities may be higher.
- The exposure and risk estimates reflect a small portion of the potential exposures within a lithographic printing facility. Many of the chemicals found in these formulations may also be present in the inks or other cleaning solvents used in a shop. Incremental reduction of exposures from blanket wash use will reduce cumulative exposures from all sources in a printing facility.
- The risks associated with volatile organic compound (VOC) releases were not examined in this assessment. Because VOC releases are a driving factor behind current regulations affecting printers, VOC content for the formulations are given at the request of industry participants. The concerns associated with VOC releases are addressed by federal, state, and local regulations and were not re-evaluated here.
- The regulatory information contained in the CTSA may be useful in moving away from chemicals that trigger compliance issues, however this document is not intended to provide compliance assistance. If the reader has questions regarding compliance concerns they should contact their federal, state, or local regulatory authorities.
- The 37 blanket wash formulations assessed in this report were voluntarily submitted by participating suppliers and are not intended to be representative of the entire blanket wash market.
- The performance and cost data are not based on rigorous scientific studies. Some of this information is subjective and is based on limited data points.
- Screening-level risk characterization techniques were used. The risk characterization results, therefore, contain limitations regarding confidence.

1.1.3 DfE Lithography Project Methodology

The DfE Program began working with the printing industry when the Printing Industries of America (PIA) requested the EPA's assistance in evaluating some of the environmental claims of products used by printers. This effort ultimately grew into three projects, each aimed at preventing pollution in a different sector of the printing industry: Screen Printing, Lithography, and Flexography. Each project addresses a specific area of environmental concern in the printing process. The screen printing project focuses on screen reclamation, the flexography project concentrates on the various ink systems used, and the lithography project examines the blanket washing process.

To thoroughly evaluate alternative blanket washes, the DfE Lithography Project sought to form partnerships with industry representatives. The DfE Lithography partners include PIA and its regional affiliates, the Graphic Arts Technical Foundation (GATF), the Environmental Conservation Board of the Graphic Communications Industry, the University of Tennessee's Center for Clean Products and Clean Technologies, and individual printers and suppliers.

How To Use This Document

For Printers:

■ While this document does present all of the technical information collected on blanket washes through this project, it is not intended as a guidance document for a small business person to use to make decisions. For the small printer, more concise, user-friendly information products will be developed that present the specific information needed to help the printer in the decision-making process. These information products may include summary brochures, case studies, data matrices, guidance manuals, and training videos. After reviewing these more targeted information products, a printer may choose to return to the CTSA to obtain more technical details on a specific alternative that is of interest to their printing operation.

■ The methods used to evaluate the blanket washes in this project, particularly the performance methodology, may also be of interest to printers. Although the CTSA focuses on blanket washes, printers can use the methodologies described in this document to conduct their own evaluations of other alternative products or processes.

For Suppliers:

■ Suppliers may be interested in using the comparative risk, performance, and cost analyses presented in this document as a tool in identifying which blanket wash formulations are best suited for the current market where printers' environmental concerns are continually increasing.

■ The environmental and human health data on the chemicals used in blanket wash formulations may be useful input to suppliers who are developing new blanket washes specifically designed to reduce environmental and human health risks.

■ Suppliers may be interested in all of the methodologies used to evaluate the alternative blanket washes, particularly the risk methodology.

For Other Readers:

■ For technical assistance programs, the CTSA can provide background information on lithography, blanket washes, and the DfE Lithography Project.

■ The comparative information on cost, risk, and performance of alternative blanket washes can be useful when working with printers to reduce VOC emissions and hazardous wastes and guide printers toward products that might reduce risks or pollution.

Focus on Blanket Washes

The decision to focus on blanket washes was made by the DfE Lithography Project partners based on the input from printers. To make sound purchasing choices, printers expressed a need for more consistent information on the performance, costs, and environmental and human health risks associated with different blanket washes. To address these concerns, the project partners decided that a complete evaluation of commercially available blanket washes was needed. All blanket washes submitted were evaluated using the same criteria. This consistency allows printers to compare the trade-offs of one alternative with another to determine which products may be best suited for their particular printing operation.

For the first time, printers can access performance, risk, and cost analyses of a variety of alternative blanket washes, all evaluated using the same methodology.

The project partners were particularly concerned about the environmental and human health risks of blanket washes because traditionally these products are petroleum-based solvents with a volatile organic compound (VOC) content of greater than 60%. While these high VOC washes leave the blanket dry after cleaning, the quick-drying properties come from the VOCs that evaporate into the air where they may pose a potential risk to workers' health and to the environment. VOCs can have an adverse impact on ambient air quality because of their contribution to the formation of ground level ozone. Using the expertise of EPA, the DfE Lithography Project examined the risks of the alternative blanket washes by collecting health hazard and environmental release information (e.g., releases to air, water, land) associated with the use of the potential substitute blanket washes.

Concentrate on the Needs of Smaller Printers

The project partners were aware that although many large printers already have access to information about new and developing systems and technologies, smaller printers may not have the time or resources to investigate the latest technology and products. To respond to the needs of smaller printers, the DfE Lithography Project partners agreed that the primary efforts of the project should focus on the manual blanket washes as they are typically used in smaller print shops; i.e., on sheetfed, non-heatset presses that are less than 26" wide. Much of the information presented here is applicable or translatable to larger facilities.

Identify Alternative Blanket Washes

All blanket washes evaluated in this project were commercially available products, voluntarily donated by suppliers. Nineteen suppliers participated in the project, submitting a total of 36 substitute formulations to be compared with a baseline formulation.

Choice of VM&P Naphtha as the Baseline Formulation

In the initial stages of the Lithography Project, the Project partners chose VM&P naphtha as the baseline against which to compare the 36 substitute washes. Varnish Makers & Painters (VM&P) Naphtha, composed of 100% solvent naphtha, light aliphatic and referred to as Formulation 28 in certain sections of the text, was chosen primarily because it is well known among lithographers as an effective blanket wash. Many lithographers have used VM&P naphtha in their shops and know how well it works in their applications and what it costs. VM&P naphtha is known to be highly effective at very low cost, however, because of its high VOC content (100%), printers are searching for formulations to replace it.

Conduct Performance Demonstrations

The performance demonstrations were conducted in two phases: laboratory testing and field demonstrations. Laboratory testing of each blanket wash was conducted by GATF in Pittsburgh to ascertain certain chemical characteristics, including flash point, VOC content, and pH. Additional laboratory tests (described in Chapter 4 of this document) were conducted to determine the effectiveness of each wash and the potential for adverse effects on the blanket. Only those washes meeting minimum performance standards were used in the field demonstrations.

Once the Performance Demonstration was underway, certain suppliers who originally submitted blanket washes, later chose to withdraw from the demonstration. Their reasons included not wishing to reveal to EPA their complete formulations or concern over the potential results of the performance tests. The formulations that were withdrawn after work had already begun were numbers 2, 13, and 15. For this reason, those numbers are missing from all of the tables in the CTSA.

> To respond to the needs of smaller printers, the DfE Lithography Project partners agreed that the primary efforts of the project should focus on the manual blanket washes as they are typically used in smaller print shops: on sheetfed, non-heatset presses that are less than 26" wide.

While the laboratory test was being conducted, DfE project partners identified lithographic printers who would volunteer their time and their shops to test blanket washes. In order to best demonstrate the performance of all the blanket washes under actual printing conditions, printers and project partners requested that field demonstrations be conducted. Seventeen printers agreed to participate in the performance demonstrations conducted between November of 1994 and February of 1995. Each substitute wash was assigned to a facility. Then, to get baseline information, every participating facility first cleaned the press with the baseline wash. Then the substitute wash was used for one week. During the week, press operators were asked to record the amount of product used, the length of time needed to clean the press, and their opinion of how well the product worked each time they used it, as compared to the baseline blanket wash, VM&P Naphtha.

Analyze the Costs of Using Alternative Blanket Washes

After the performance demonstrations, a cost analysis for each alternative product was developed using supplier data, industry statistics, and information collected during the performance demonstration. For each product, the cost of using the alternative product was compared to the cost of using the baseline product. Blanket washing costs were estimated based on the costs of labor, the blanket wash product, and cloth wipes. Each of these cost factors included:

Labor Costs: The time spent to clean the blanket was recorded for each product during the performance demonstrations. Labor costs were calculated by multiplying the time to clean the blanket by industry reported statistics for lithographic press operators' wages, including fringe rate, and overhead.

Blanket Wash Product Costs: The quantity of blanket wash used per blanket cleaning was recorded during the performance demonstration. To calculate the blanket wash product cost, the average quantity used per blanket was multiplied by the unit cost of each product. Product costs were provided by each participating manufacturer.

Cloth Wipes Costs: The wipes used for blanket washing are typically cloth wipes that are leased through a contract with an industrial laundry, which picks up dirty wipes for laundering and drops off clean wipes for blanket cleaning. Materials costs were calculated by multiplying the number of wipes used per blanket washing, as recorded in the performance demonstrations, by the lease price per wipe.

Evaluate the Health and Environmental Risks

Technical evaluation of the human health and environmental concerns associated with each blanket wash began while the demonstrations were still in progress. Suppliers submitted chemical formulation information to PIA for each of their products demonstrated. PIA removed all trade names and each formulation was assigned a number to mask its identify before being passed on to EPA. The EPA used the actual formulations (in their masked format) as the basis for the evaluation of health and environmental concerns, though the data appearing in this document have been reported by chemical family to conceal

> The health and environmental concerns associated with each blanket wash were evaluated based on the actual chemical formulations of each product.

proprietary formulation data. While specific methods were developed by the DfE Lithography Project team for conducting the performance demonstration and the cost analysis, the standard methodologies of the EPA Office of Pollution Prevention and Toxics (OPPT) Existing Chemicals Program were used for the Human Health Hazards, Environmental Hazards, Environmental Releases and Occupational Exposure Assessment, General Population Exposure Assessment, and Risk Assessment sections of the CTSA.

Identify Conservation and Additional Improvement Opportunities

The project partners were interested in identifying energy and natural resource issues and improvement opportunities associated with using the various substitute blanket washes. Although the blanket washing process is not particularly energy- or resource-intensive, a printer can still help conserve energy and resources through his or her choice of blanket washing products and the manner in which the products are used.

There are a variety of techniques which may be employed at lithographic print shops to prevent pollution, to reduce chemical consumption, and to minimize waste. Results of a pollution prevention survey which asked lithographers to identify what activities they currently employ to achieve a more environmentally friendly workplace are presented. In addition, options for recycling solvents and for extracting solvents from press wipes are addressed, as are methods for treating spent solvents so that they may be reused. Solvent recycling systems used in conjunction with brush-based automatic blanket wash systems are also discussed.

Evaluate Trade-Off Issues

The trade-off issues associated with the environmental and human health risk, cost, performance, and other analyses undertaken by the project partners are evaluated. This includes a social benefit and cost discussion and a summarization of the project's findings.

1.2 OVERVIEW OF LITHOGRAPHIC PRINTING

1.2.1 Products Printed

Lithography is currently the most prevalent printing technology in the United States. According to an estimate by A.F. Lewis & Co., Inc., a market research firm specializing in the graphic arts industry, there are over 53,000 establishments employing printing presses, and approximately 49,000 of these use lithographic presses. Lithographic printers are primarily small businesses, with roughly 85% of the plants employing fewer than 20 people. The success of lithographic printing is due to the ability of the process to produce high quality text and illustrations cheaply and effectively in short, medium, and high volume production runs. Consequently, lithography dominates the printing of books and newspapers, as well as magazines and other periodical publications. Some other applications of the lithographic printing process include advertising, envelopes, labels and tags, stationery, greeting cards, and packaging. Lithography accounts for almost 50% of the commercial printing market; however, the ascendancy of the lithographic process may soon be challenged by both improvements in flexography and relatively new plateless technologies which make up the fastest growing sector of the printing industry.

1.2.2 Printing Mechanism

The lithographic printing process involves a plate on which the image and non-image areas are on the same plane, as opposed to being either raised or indented. In this type of single plane, or planographic, printing, the image is maintained by taking advantage of the mutual repulsion of oil and water. Plates are treated so that the non-image area attracts water, while the image area becomes receptive to oil (ink). Water applied to the hydrophilic (water-loving) portion of the plate confines the ink within the oleophilic (oil-loving) image area. The water is applied in the form of a fountain solution which consists primarily of water with chemical additives that lower the surface tension of the water and control the pH. Ink is applied to the plate cylinder from the ink fountain. The image is transferred from the plate to a rubber or plastic blanket cylinder, and subsequently transferred to the substrate in a process known as offset printing. Lithography is the only major printing sector to use offset printing rather than direct printing, a process in which the image is transferred from the plate to the print medium without the use of an intermediate cylinder.

1.2.3 Types of Lithography

The lithographic printing process is divided into three separate sub-processes: sheetfed offset, heatset web offset, and non-heatset web offset. Sheetfed offset is a basic offset lithographic process in which paper is fed into the machine in individual sheets and the ink dries in an oxidative polymerization process. Sheetfed presses, used primarily for short term printing runs of commercial products, constitute the large majority (92%) of plants with lithographic presses and are the focus of the DfE Lithography Project. The web offset processes are so named because of their use of rolls of paper which are continuously fed into the press. The web is cut into individual sheets in post-press operations. Only 11% of lithographers use the web offset process, and, despite the tendency of lithographic shops to be small, almost 60% of those plants which utilize web-fed presses employ over 20 people.

In heatset web offset printing, inks are dried using a recirculating hot air system. This type of printing is very useful for high-volume, high-speed production runs (up to 40,000 impressions per hour); however, the ink drying process involved may result in VOC emissions that must be controlled. In contrast, the non-heatset web offset process often uses inks that do not require assisted drying. This type of lithographic printing is commonly employed in high speed production of newspapers, magazines, and journals. Each of these sub-processes has some distinct environmental and human health impacts; however, the chemicals used to clean the presses are very similar regardless of which process is used.

1.2.4 Blanket Washing

For job changes and to maintain image quality in the offset printing process, the intermediate blanket cylinder must be cleaned. Blanket wash is used to remove ink, paper dust, and other debris from the blanket cylinder. If the blanket is not cleaned regularly, built up debris will damage the blanket and/or impact print quality adversely. The severity of ink and paper build up will vary depending on the product printed, the length of the printing run, the coverage of the image, and the colors printed. For color changes, the series of rollers that transfer the ink from the ink tray to the printing plate must also be cleaned. Some printers use the blanket wash product to clean the rollers, while others find that using two separate cleaners, a blanket wash and a roller wash, is more effective.

Blanket cleaning can be accomplished manually or automatically. Manual cleaning involves wiping down the blanket cylinder with a cloth wipe or a disposable wipe, dampened with blanket wash solution. Automatic blanket cleaners are mechanical devices that clear the blanket of debris by applying blanket wash and/or scrubbing the blanket mechanically. Excess wash is either wiped off automatically, or some systems simply allow paper to run through the press to absorb excess inks and solvents. The focus of the DfE Lithography Project effort is on evaluating manually applied blanket washes.

Blanket washes consist of varying types of solvent, some of which can pose risks to human health and the environment. New, potentially less harmful blanket washes are appearing on the market, giving printers the opportunity to reduce impacts on the environment and minimize risk to workers. As these alternatives to the traditional solvents become more widespread, printers have had more questions about where to find comparative risk, performance and cost information. The DfE Lithography Project addresses these concerns by providing this comparative information on a wide variety of blanket wash formulations.

1.3 PROFILE OF THE BLANKET WASH USE CLUSTER

1.3.1 Traditional Blanket Washes

Traditional lithographic blanket washes are petroleum-based solvents, often mixed with detergent and/or water. Petroleum-based cleaners typically remove ink quickly and evaporate rapidly, requiring minimal down time for the press. The advantages of these conventional cleaners, however, come at a price. Petroleum-based cleaners often contain greater than 60% VOCs. VOCs, defined as any volatile compound containing the element carbon, have health and safety concerns associated with their use, and have been implicated in the formation of ground level ozone. Still, conventional cleaners continue to dominate the market because of their effectiveness as well as their low cost.

The price of a petroleum-based blanket wash will vary according to the quantity purchased as well as the prevailing price of crude oil. At least two major U.S. manufacturers of blanket washes in the United States have product lines dominated by petroleum-based, water-miscible solvents. Prices for these blanket washes range from $8/gallon to $10/gallon and average $9/gallon when purchasing a 55-gallon drum. The market is very fractured, as the largest producers of blanket cleaner in the United States are estimated to control less than 10% of the total U.S. market. The market share attained by the largest blanket wash manufacturers is limited by competition from the many small blanket wash producers serving local markets.

Large printing operations will often benefit from bulk pricing, storing large quantities of wash in on-site storage tanks. Medium-sized printers tend to purchase blanket wash by the drum (55-gallons), while small operations typically pay the highest per unit costs by purchasing cases of single gallon containers. Per gallon prices can decrease by as much as 30% when purchasing a 55-gallon drum versus a single gallon container.

1.3.2 Alternative Blanket Washes

Petroleum-based blanket washes currently dominate the market; however, as concerns regarding the release of VOCs and potential health impacts mount, increasing pressure will be placed on blanket wash manufacturers to develop alternatives. Current evidence suggests that industry has responded to concerns regarding VOC releases, with some blanket wash manufacturers devoting 100% of product development time to the production of products that are lower in hazardous materials and VOCs.[1] Alternative blanket cleaners have not been fully accepted, however, and printers have voiced several concerns regarding their performance. In addition, low VOC washes typically cost more than “traditional,” petroleum-based cleaners due to higher ingredient costs. EPA’s *Control Techniques Guideline for Offset Lithographic Printing* (CTG) estimates that lower VOC cleaners (low VOCs cleaners are defined in the CTG as products with a VOC content of less than 30% by weight as measured by EPA’s test method 24) that do not contain hazardous air pollutants (HAPs) cost $0.91 per pound versus $0.69 per pound for a “traditional” cleaner.[2] Alternative washes discussed below include: water miscible solvents, vegetable oil-based cleaners, and terpene-based cleaners.

Water Miscible Solvents

One approach to reducing VOCs in blanket washes has been to use water miscible solvents, thereby allowing a certain degree of water dilution. Reductions in VOC content are accomplished by substituting volatile solvents with water. It is important to note that not all water miscible cleaners contain less than 30% VOCs, however, many water miscible cleaners have a vapor pressure of less than 10 mm of mercury (Hg) at 20°C, which in some cases is considered to be as acceptable as a low VOC formulation.

Vegetable Oil-Based Blanket Washes

Some manufacturers are marketing vegetable oil-based cleaners that do not contain any petrochemical solvents, and that have VOC contents as low as five percent. While the list price for this type of cleaner can be significantly higher than for many of the petroleum-based cleaners on the market, printers calculating a cost-per-wash-up must consider that the product is sold in a highly concentrated form. The advantages of vegetable oil-based cleaners over “traditional” cleaners include: lower VOC levels, lack of odor, no special storage requirements, unprocessed wipes may be non-hazardous waste, and the blankets are conditioned by the cleaner. There may also be benefits to worker health and safety. Unlike highly volatile, petroleum-based cleaners, however, vegetable oil-based cleaners do not rapidly flash off from the blanket cylinder, and therefore a greater effort may be required to wipe off the blanket.

Terpene Cleaners

Terpenes are derived primarily from wood and citrus products and have long been used as solvents for a variety of organic compounds. The Montreal Protocol recommends the use of terpene solvents as an alternative to chlorinated solvents because they are not an upper atmosphere (stratospheric) ozone depleting substance and have zero global warming potential. Several terpene-based products are available on the market that provide an alternative to traditional, petroleum-based cleaners. According to an industry representative, terpene cleaners based on citrus tend to be very volatile in price; in 1995, the price per pound ranged from $1.26 to over $2.60. In addition, the odor of these solvents can be irritating or nauseating to press operators.[3]

Water-washable Ink System

Another type of vegetable oil-based blanket cleaning system has been developed recently which differs from the vegetable oil-based blanket washes described above in that the blanket wash is one part of an “ink system.” The ink is vegetable oil-based and can be converted into a water-soluble form after printing is complete. Once the conversion has occurred, the water-soluble ink can be removed with a water-based blanket solution, thereby eliminating the need for traditional cleaning solvents containing VOCs. These ink systems are not available for all types of printing and have been utilized primarily in the business forms industry.

1.4 MARKET PROFILE

1.4.1 Blanket Wash Market

Currently, lithographic printing is the dominant printing technology in the United States, accounting for 79% of printing industry shipments.[4] According to Bruno's *Status of Printing*, lithography's share of the total U.S. market is expected to decline in the future. He estimates that lithography will control only 35% of the U.S. market by the year 2025, due to competition from flexography and plateless printing technologies.[5] Industry contacts indicated, however, that plateless printing will find its market "niche" and will not result in a market decline for the lithographic blanket wash industry.[6]

The lithographic blanket wash industry is extremely fragmented, made up of many small firms producing a host of blanket wash products, and is highly price competitive. In general, blanket wash manufacturers are chemical formulators that market a variety of pressroom products including type wash, press wash, alcohol replacers, and fountain solutions.

In response to concerns regarding the release of VOCs, blanket wash manufacturers have developed and are currently marketing low VOC alternatives to traditional, petroleum-based cleaners. For example, low VOC cleaners currently constitute a very small percentage of company sales for one of the leading producers of blanket cleaners in the United States. Their research efforts, however, are focused almost exclusively on the development of low VOC cleaners.[7] Small to medium size companies have had greater success in providing low VOC cleaners to the marketplace.[8,9]

A.F. Lewis & Company, Inc., a market research firm specializing in the graphics arts industry, has estimated the number of plants operating offset lithographic presses, and therefore the number of facilities requiring blanket wash solvents, to be 49,218 as of June 1995. A.F. Lewis also reports the total number of plants with presses (whether offset lithographic, gravure, flexographic, or letterpress) to be 53,205 plants as of June 1995.[a] Plants with offset lithographic presses, therefore, account for roughly 92% of printing facilities, providing some indication of the demand for blanket wash. The states with the greatest number of plants containing offset presses are: California (6,075 plants, 12.5% of the U.S. total), New York (3,617 plants, 7.4%), Illinois (3,027, 6.2%), Texas (2,947, 6.0%), Pennsylvania (2,452, 5.0%), Ohio (2,436, 5.0%), Florida (2,318, 4.8%), New Jersey (1,876, 3.9%), Michigan (1,691, 3.5%), and Massachusetts (1,388, 2.9%).[10]

1.4.2 Blanket Wash Manufacturers

Minimal documentation exists that specifically characterizes the lithographic blanket wash industry. The Standard Industrial Classification (SIC) system, established by the Bureau of the Census to track the flow of goods and services within the economy, has not assigned a specific code to the blanket wash industry, nor does the Department of Commerce specifically track the industry.[11] In addition, many companies that produce printing equipment also manufacture blanket washes or private label another manufacturer's wash, making it difficult to identify them specifically as blanket wash manufacturers. With multiple product lines for the industry, it is currently not possible to identify the portion of revenues attributable solely to blanket wash production.

The companies listed in Table 1-1 are known to be producers of blanket wash solvents or products based upon the input of several printing industry trade organizations. This list is not exhaustive of the total number of companies producing blanket washes. The relative market share held by each of the companies listed below is not known. Petroleum distillate producers, such as Ashland, Exxon, and Shell, also sell directly to larger printers.[12]

[a] *Plants with presses are firms that possess any printing press or duplicator/photocopier and engage in printing as their primary business.*

1.4.3 Blanket Wash Components

Blanket wash manufacturers combine a wide range of ingredients to produce their final product. Some of the leading ingredients of high VOC washes include: solvent 140, aromatic 100, aromatic 150, and naphthal spirits. Low VOC washes include ingredients such as fatty acid derivatives or terpenes. A survey of three blanket wash manufacturing companies, estimated to represent 70% of the blanket wash market, was conducted in 1992. Table 1-2 presents the estimated annual quantity of 24 chemicals used in the manufacture of blanket wash and roller wash. While not comprehensive, these volumes provide an idea of the size of the industry and the range of chemicals currently utilized in the production of blanket wash.

Table 1-1. Lithographic Blanket Wash Manufacturers*

Company	Location of Headquarters
AM Multigraphics*	Mount Prospect, IL
Anchor/Lithkemko*	Orange Park, FL
Ashland Chemical*	Columbus, OH
Bingham Company	Wood Dale, IL
BLI Manufacturing	Winston Salem, NC
Dupont Printing and Publishing*	Wilmington, DE
Electro Sprayer Systems, Inc.	Elk Grove Village, IL
Environmental Scientific, Inc.*	Research Triangle Park, NC
Environmental Solvents, Inc.*	Jacksonville, FL
Fine Organics Corporation*	Chicago, IL
Flint Ink	Detroit, MI
HMI Environmental Products*	Encinitas, CA
Hurst Graphics, Inc.*	Los Angeles, CA
Inland Technology Inc.*	Tacoma, WA
Litho Research Inc.	Chicago, IL
MacDermid, Inc.*	Waterbury, CT
Printex Products Corporation*	Rochester, NY
Prisco/Printers' Service, Inc.*	Newark, NJ
RBP Chemical Corporation*	Milwaukee, WI
Rycoline Products, Inc.*	Chicago, IL
Siebert, Inc.*	Lyons, IL
Tower Products Inc.*	Palmer, PA
Unichema Corporation*	Chicago, IL
Varn International	Oakland, NJ
Witco*	New York, NY

* Indicates those manufacturers that participated in this Project; this is not an exhaustive list of manufacturers.

Table 1-2. Blanket Wash and Roller Wash Components

Ranking	Chemical	CAS Number	Annual Quantity
1	Solvent Naphtha (petroleum), medium aliphatic*	64742-88-7	655,722
2	Solvent Naphtha (petroleum), light aromatic*	64742-95-6	633,000
3	Naphtha (petroleum), hydrotreated heavy*	64742-48-9	606,125
4	Solvent Naphtha (petroleum), light aliphatic*	64742-89-8	468,508
5	2-Butoxyethanol	111-76-2	288,000
6	Solvent Naphtha (petroleum), heavy aliphatic	64742-96-7	146,497
7	Mineral Spirits (straight run naphtha)*	64741-41-9	140,000
8	Methylene Chloride	75-9-2	125,003
9	Xylene*	1330-20-7	76,503
10	1,1,1-Trichloroethane	71-55-6	66,000
11	Isopropyl Alcohol	67-63-0	60,000
12	Acetone	67-64-1	55,000
13	Mineral Spirits (light hydrotreated)*	64742-47-8	51,943
14	Toluene	108-88-3	51,000
15	Solvent Naphtha (petroleum), heavy aromatic*	64742-94-5	49,815
16	Propylene Glycol Methyl Ether Acetate	108-65-6	38,000
17	2-Propoxyethanol	2807-30-9	27,932
18	d-Limonene*	5989-27-5	22,000
19	Dipropylene Glycol Methyl Ether*	3459-94-8	12,000
20	Kerosene	8008-20-6	10,000
21	Ethyl Acetate	141-78-6	2,000
22	Perchloroethylene	127-18-4	2,000
23	Diethylene Glycol Monobutyl Ether*	112-34-5	1,879

* Indicates those chemicals found in the formulations assessed in this project.
Note: Information is based upon a 1992 survey of three blanket wash producers and is estimated to represent 70% of the industry.

1.4.4 Market Conditions

Based on discussions with industry representatives, the lithographic blanket wash industry is characterized by thin profit margins and extreme price competition. Blanket wash manufacturers, seeking to maximize the efficiency of their operations, will often subcontract with off-site blending companies to combine the raw material inputs of their formulations in large mixing tanks. Blanket wash manufacturers with the largest market areas are most likely to blend off-site to avoid the transportation costs associated with hauling their product to distant markets. Because freight costs tend to consume profits, foreign competition of products produced outside the U.S. has been limited in the United States market.[13,14]

The Association for Suppliers of Printing and Publishing Technologies (NPES) tracks an estimated 90% of the total U.S. market for graphic art supplies; this information is reported in the NPES *Monthly Statistics Report and Quarterly Economic Forecast*. Shipments data include information on various papers, films, plates, chemicals, and other graphic arts supplies. The chemicals category includes three subcategories: photographic chemicals, plate chemicals, and press chemicals. Blanket cleaners are included within the press chemicals subcategory; however, financial data are not made available for the chemicals category in order to avoid disclosure of individual company figures. The report does indicate that 1994 chemical shipments are estimated to rise 2.2% compared to 1993 and are projected to increase 4% in 1995 and 1996.[15] No basis is available to estimate what percentage blanket washes may represent within the broader chemical category. Industry contacts, however, estimate that blanket wash sales generate $60-70 million annually in the United States.[16]

1.5 ALTERNATIVE TECHNOLOGY - AUTOMATIC BLANKET WASHERS

Technology Description

An alternative to washing blankets manually is to use automatic or mechanized blanket washers. Automatic blanket washing is a technology that uses a spray, brush, and/or cloth system to clean the rubber blankets with little or no human assistance while the press is running. Automatic blanket washers are becoming increasingly available as standard equipment on new web and sheet fed presses, and as a retrofit on older presses.

Although usually marketed as cost and labor saving devices, automatic blanket washers may also provide environmental benefits by reducing VOC solvent use and the need for wipe rags. Some systems also have solvent reclamation systems, and are designed to minimize fugitive emissions in the workplace. In addition, automatic blanket washers may mitigate some health and safety concerns for press operators because they reduce a press operator's contact with solvent, rags, and the moving press cylinders. It is important to note, however, that even presses equipped with automatic blanket washers still require occasional manual blanket washing, particularly for end-of-run applications.

Depending on the blanket washing system, all automatic washers use a certain amount of the paper running through the press to help remove ink from the blanket during the wash cycle. Three basic forms of automatic blanket wash systems are currently available including; spray systems, brush roller systems, and cloth-based systems. Each system is discussed below.

Spray application systems are available for web presses, and operate by applying cleaning solvent directly to the blanket. The web continues to feed through the press, carrying away excess ink and debris dissolved by the solvent. Spray systems typically involve a relatively small capital investment relative to other blanket wash systems.

Brush roller systems, unlike spray systems, actively scrub blanket surfaces with a rotating and oscillating brush. Two types of brush systems are available: dry-type and wet-type. Wet-type brush systems dispense a controlled quantity of solvent onto the brush. Solvent is not applied directly to the blanket. Dry-type brush systems mechanically clean the blanket surface but are not wetted with cleaning solution. Dry-type systems are used only on coldset presses.

Cloth-based systems operate by applying a web of cloth to the rotating blanket, depositing excess ink and debris onto the cloth. After completing the cycle, the spent cloth advances and a fresh section of cloth is left in its place. Cleaning solvents are applied to the cloth and not directly to the blanket.

<u>Performance Issues</u>

Reports on the performance of automatic blanket washers run the gamut from printers who say that their automatic washers work faster and better than manual washing, to those who have given up and actually removed the blanket washers from their presses. Clearly, the type of blanket washer and the type of printing being done play large roles in determining the effectiveness of the blanket washer.

Automatic blanket washers appear to be more prevalent on web presses, where they can be used for blanket washing during a press run. Some printers report that automatic blanket washers do not clean the blankets thoroughly enough to use them for end of run washing. Blanket washers seem to be less popular for sheet-fed presses, where relatively shorter run lengths allow printers to coordinate manual blanket washing with the end of production runs.

<u>Economics</u>

The potential ***savings*** associated with using an automatic blanket washer instead of manually cleaning blankets include the following:

- In most cases, wash for wash, automatic blanket washers reportedly use less solvent than manual washing, which translates into lower solvent costs for the printer.
- Because the automatic blanket washer allows the press operator to perform other tasks during the wash cycle, there may be significant labor savings associated with automatic blanket washing.
- Make-ready time is shortened because the press does not stop during the blanket washing process.
- Wipe rag use is reduced, which confers savings in the area of rag purchasing or in rag leasing contracts. For cloth based systems, disposal or laundering of the spent cloth may be a concern.
- Some printers claim that blanket life is prolonged through the use of automatic blanket washers.

The potential ***costs*** of automatic blanket washers include the following:

- The blanket washing system itself is a significant added cost, particularly when a retrofit is under consideration. On many new presses, however, automatic blanket washers are standard equipment.

- Maintenance costs may also be a factor. This would include routine maintenance as well as brush and other parts replacement.

Based on information collected from two of the major firms manufacturing automatic blanket wash systems, it appears that blanket washers are in widespread use on the larger, newly purchased presses. One or two unit presses, measuring less than 20 inches, are unlikely to be purchased with an automatic blanket washer. The cost of a brush roller system or cloth-based system ranges from $7,000 to $22,000 per unit, depending upon press size and the number of press units. These prices do not include the cost of installation, which varies according to the type of system required and location of the printing facility. Per unit costs decrease as the number of press units increases. A spray system, which involves the smallest capital investment, has been estimated to cost roughly half the price of a brush roller or cloth-based system, ranging from $3,500 to $11,000 per unit depending upon press size.[17,18] Currently, automatic blanket wash systems are typically not affordable for small presses (32" or less), although some manufacturers indicate they intend to market a cloth-based blanket wash system specifically designed for smaller presses, making it possible for small press operators to invest in automatic blanket cleaning technology.[19]

The retrofit market is more difficult to characterize and industry contacts could not provide a clear sense of how widespread the use of automatic blanket wash systems may be on existing presses. This said, the retrofit market does constitute a significant portion of automatic blanket wash system sales.[20,21] When considering a retrofit purchase, printers must weigh the benefits of increased productivity and worker safety against the significant capital investment required to purchase a cleaning system. In some cases, printers are operating older, outdated presses that do not justify the significant capital investment required to purchase an automatic blanket cleaner. The price of a retrofit blanket wash system is the same as that of a system purchased with a new press. In either case the procedure would be the same, that is the manufacturer of the blanket wash system would install the unit at the printing facility.[22,23]

<u>Environmental Impacts</u>

Environmental benefits and costs associated with automatic blanket washers may include:

- On a per wash basis, automatic blanket washing conserves solvent as compared to manual blanket washing. Because automatic blanket washing is more convenient than manual washing, however, press operators may clean blankets more frequently. Currently, there are insufficient data to assess whether total solvent use increases or decreases in practice.

- VOC-soaked rag waste is reduced. For cloth based systems, disposal or laundering of the spent cloth may be a concern.

- Because a large amount of paper is wasted in manual blanket washing due to press start up and shut down, automatic blanket washing may conserve paper.

- Low VOC solvents may be used with some systems.

Health/Safety Issues

Worker safety issues associated with automatic blanket washers may include:

- Direct worker dermal exposure to solvent is reduced.
- With some systems, much of the solvent can be reclaimed for re-use.
- Diminished fugitive VOC emissions in the workplace.
- Workers can lessen exposure to potentially dangerous moving press cylinders associated with manual blanket cleaning.

Automatic Blanket Wash System Manufacturers

Manufacturers of automatic blanket washers include: AM Multigraphics; Baldwin Technology; Oxy-Dry Corporation; Printex Products Corporation; Heidelberg Harris, Inc.; and Web Printing Controls Company Inc. This list was compiled based upon discussions with industry contacts as well as the NPES *Directory of International Suppliers of Printing & Publishing Technologies*. This list is not exhaustive.

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Chapter 2
Data Collection

Chapter Contents

This chapter contains information used to evaluate the health, environmental and regulatory concerns associated with the individual chemicals found in the lithographic blanket washes, and discusses how this information was obtained. Section 2.1 addresses the organization of the 56 specific chemicals that compose the blanket washes into generic chemical categories. Section 2.2 includes information on the physical and chemical properties of each specific chemical. Melting point, vapor pressure and the bioconcentration factor are among the many properties detailed in this section. Section 2.3 presents known human health toxicological data for each chemical. Information on the exposure routes, toxicity endpoints (such as carcinogenicity, developmental toxicity and neurologic effects), and exposure levels of concern for the chemicals are included in this section. Section 2.4 contains environmental effects data for each of the 56 chemicals. Included here is information on the chemical's acute and chronic aquatic toxicity levels for fish, invertebrates and algae, and an environmental hazard ranking for each chemical. Section 2.5 identifies which of the specific chemicals are subject to federal environmental regulations and describes each of the regulations that apply. The focus in Section 2.6 shifts from specific chemicals to the actual blanket wash formulations submitted by suppliers. In this section, safety hazard classifications for reactivity, flammability, ignitability and corrosivity have been assigned to each of the blanket washes.

2.1 CATEGORIZATION OF BLANKET WASH CHEMICALS FOR GENERICIZING FORMULATIONS

The chemical formulations of commercial products containing distinct chemical mixtures are frequently considered proprietary. Manufacturers of these products typically prefer not to reveal their chemical formulations because a competitor can potentially use the disclosed formulation to sell the product, often at a lower price, since the competitor did not have to invest in research and development. In addition, the performance of products may vary depending on use and shop conditions, and suppliers were concerned about the characterization of the performance of their products. The EPA was concerned about appearing to endorse brand name products that fared well in the CTSA evaluation. Due to these concerns, the Lithography Project partners developed a system to genericize the blanket wash formulations discussed in the CTSA.

In order to participate in the Project, each supplier was required to submit their product and its exact formulation to Printing Industries of America (PIA), who replaced the product brand name with a blanket wash number. The EPA completed the risk characterization using the exact formulations but without knowledge of the supplier or the brand name. The numbering system assigned by PIA is used throughout the CTSA. In addition, to maintain the confidentiality of the formulations, the CTSA reports the results using the categorization system shown below in Table

2-1. Each chemical in the blanket wash formulations was grouped into a category and the categories are used to report the results (i.e., estimated environmental release) for each formulation. The percentages of each component in a given formulation are not listed. If a printer wishes to determine the manufacturer who produces a given formulation, a list of participating manufacturers appears in the front of the document. Each participating manufacturer is aware of his or her assigned product number as well as their genericized formulation.

Table 2-1. Categorization of Blanket Wash Chemicals

Category	Chemicals from Blanket Wash Use Cluster in Category
Alkali/salts	Sodium Hydroxide; Tetrapotassium pyrophosphate; Ethylenediaminetetraacetic acid, tetrasodium salt
Alkanolamines	Diethanolamine
Alkoxylated alcohols	Alcohols, C_{12}-C_{15} , ethoxylated; Oxirane, methyl, polymer with oxirane, monodecyl ether; Polyethoxylated isodecyloxypropylamine; Poly(oxy-1,2-ethanediyl), α-hexyl-ω-hydroxy-; Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives
Alkyl benzene sulfonates	Benzenesulfonic acid, dodecyl-; Benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol; Benzenesulfonic acid, dodecyl-, compounds with 2-propanamine; Benzenesulfonic acid, (tetrapropenyl)-, compounds with 2-propanamine; Benzenesulfonic acid, C_{10}-C_{16}-alkyl derivatives, compounds with 2-propanamine; Sodium xylene sulfonate
Dibasic esters	Dimethyl adipate; Dimethyl glutarate; Dimethyl succinate;
Ethylene glycol ethers	Diethylene glycol monobutyl ether
Ethoxylated nonylphenol	Ethoxylated nonylphenol
Fatty acid derivatives	Fatty acids, C_{16}-C_{18}, methyl esters; Fatty acids, C_{16}-C_{18} and C_{18}-unsatd, compounds with diethanolamine; Sorbitan, mono-9-octadecanoate; Sorbitan, monolaurate; Soybean oil, methyl ester; Soybean oil, polymerized, oxidized; Tall oil, special; Fatty acids, tall oil, compounds with diethanolamine
Glycols	Propylene glycol

Category	Chemicals from Blanket Wash Use Cluster in Category
Hydrocarbons, aromatic	Benzene, 1, 2, 4-trimethyl-; Cumene; Solvent naphtha (petroleum), heavy aromatic; Solvent naphtha (petroleum), light aromatic; Xylene
Hydrocarbons, petroleum distillates	Distillates (petroleum), hydrotreated middle; Mineral spirits (light hydrotreated); Naphtha (petroleum), hydrotreated heavy; Solvent naphtha (petroleum), light aliphatic (VM&P Naphtha); Solvent naphtha (petroleum), medium aliphatic; Stoddard solvent
Esters/lactones	Butyrolactone; Propanoic acid, 3-ethoxy-, ethyl ester; Sodium bis(ethylhexyl) sulfosuccinate; Sorbitan tri-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivatives
Nitrogen heterocyclics	N-methyl pyrrolidone
Propylene glycol ethers	Dipropylene glycol monobutyl ether; Dipropylene glycol methyl ether; Propylene glycol monobutyl ether;
Terpenes	Hydrocarbons, terpene processing by-products; *d*-Limonene; Linalool; Nerol; 2-Pinanol; Plinols; α-Terpineol; Terpinolene;

2.2 CHEMICAL INFORMATION

This section discusses the physical nature of the 56 specific chemicals used in blanket wash formulations. First, there is a description of the types of information that are provided for each chemical, including a glossary of chemical properties terms presented in Table 2-2. This includes their chemical and physical properties, safety hazard factors, and environmental fate. Following these descriptions, Table 2-3 lists the name, Chemical Abstracts Service (CAS) Registry Number, and common synonyms for each of the chemicals. The chemical and physical properties and safety hazard factors are then listed in the Chemical Properties and Information summary for each chemical.

2.2.1 Chemical Properties and Information

For each blanket wash chemical, there is a corresponding Chemical Properties and Information summary. All of the information in these summaries, except for the Safety Hazard Factors, was obtained by searching standard references, listed at the end of this chapter. This summary contains information on the following chemical and physical properties:

Table 2-2. Glossary of Chemical Properties Terms

Term	Definition
Chemical Abstracts Service Registry Number (CAS #)	A unique identification code, up to ten digits long, assigned to each chemical registered by the Chemical Abstract Service. The CAS # is useful when searching for information on a chemical with more than one name.
Synonyms	Alternative names commonly used for the chemical.
Molecular weight	A summation of the individual atomic weights based on the numbers and kinds of atoms present in a molecule of a chemical substance. For polymers, this may include molecular weight distributions, ranges, and averages. Typical unit is g/mole.
Melting point	The temperature at which a substance changes from the solid to the liquid state. It indicates at what temperature solid substances liquify. Typical unit is °C.
Water solubility	The maximum amount of a chemical that can be dissolved in a given amount of pure water at standard conditions of temperature and pressure. Typical unit is g/L.
Vapor pressure	The pressure exerted by a chemical in the vapor phase in equilibrium with its solid or liquid forms. It provides an indication of the relative tendency of a substance to volatilize. Typical unit is mm Hg.
Octanol-water partition coefficient ($Log_{10}K_{ow}$)	Provides a measure of the extent of a chemical partitioning between water and octanol (as a surrogate for lipids or other organics) at equilibrium. It is an important parameter because it provides an indication of a chemical's water solubility and its propensity to bioconcentrate in aquatic organisms or sorb to soil and sediment.
Soil sorption coefficient ($Log_{10}K_{oc}$)	Provides a measure of the extent of chemical partitioning between the solid and solution phases of a two-phase system, especially soil, sediment or activated sludge. Usually expressed on an organic carbon basis, as the equilibrium ratio of the amount of chemical sorbed per unit weight of organic carbon in the soil, sediment or sludge to the concentration of the chemical in solution. The higher the K_{oc}, the more likely a chemical is to bind to soil or sediment than to remain in water.
Bioconcentration factor (Log_{10} BCF)	Provides a measure of the extent of chemical partitioning at equilibrium between a biological medium such as fish tissue or plant tissue and an external medium such as water. The higher the BCF, the greater the accumulation in living tissue is likely to be.
Henry's Law Constant	Provides a measure of the extent of chemical partitioning between air and water at equilibrium; estimated by dividing the vapor pressure of a sparingly water soluble chemical substance by its water solubility. The higher the Henry's Law constant, the more likely a chemical is to volatilize than to remain in water.
Publicly Owned Treatment Works (POTW) overall removal rate	The extent to which a chemical substance is removed from influent wastewater by typical POTWs employing activated sludge secondary treatment. Expressed as 100 minus that percentage of the material originally present that remains in the liquid effluent after treatment.
Chemistry of use	The primary use of the chemical in the lithographic printing industry.

Molecular formula and physical structure of the chemical	A description of the number and type of each atom in the chemical and a description of how the atoms are arranged and the types of bonds between atoms.
Boiling point	The temperature at which a liquid under standard atmospheric pressure (or other specified pressure) changes from a liquid to a gaseous state. It is an indication of the volatility of a substance. The distillation range in a separation process, the temperature at which the more volatile liquid of a mixture forms a vapor, is used for mixtures in the absence of a boiling point. Typical unit is °C.
Density	The mass of a liquid, solid, or gas per unit volume of that substance, i.e., the mass in grams contained in 1 cubic centimeter of a substance at 20°C and 1 atmosphere pressure. Typical unit is g/cm^3.
Flash point	The minimum temperature at which a liquid gives off sufficient vapor to form an ignitible mixture with air near the surface of the liquid or within the test vessel used.
Safety hazard factors	Discussed in detail below.

Any of the property values acquired from the standard references have been designated as measured (M), since the data in these sources have been experimentally determined for the specific chemical in question. (Please note that synonyms, molecular weight, chemistry of use, and structure have no such designation since these are not values that can be measured, but rather are attributes intrinsic to the chemical in question.)

For some chemicals there was little or no information in the standard references and significant data gaps existed. Therefore, the values for the physical and chemical properties of these chemicals needed to be estimated. These estimations were obtained using several programs accessed through the Estimation Programs Interface (EPI), available from Syracuse Research Corporation. EPI uses the structure of the chemical for input to eight chemical property estimation programs. The programs used to complete the individual Chemical Properties and Information summaries are as follows:

- Octanol-Water Partition Coefficient Program (LOGKOW). (Meylan WM and PH Howard. 1995. Atom/fragment contribution method for estimating octanol-water partition coefficients. J. Pharm. Sci. 84: 83-92.)

- Henry's Law Constant Program (HENRY). (Meylan WM and PH Howard. 1991. Bond contribution method for estimating Henry's Law constants. Environ. Toxicol. Chem. 10:1283-1293.)

- Soil Sorption Coefficient Program (PCKOC). (Meylan WM, PH Howard and RS Boethling. 1992. Molecular topology/fragment contribution method for predicting soil sorption coefficients. Environ. Sci. Technol. 26:1560-1567.)

- Melting Point, Boiling Point, Vapor Pressure Estimation Program (MPBPVP).

- Water Solubility Estimation Program (WSKOW). (Meylan WM, PH Howard and RS Boethling. 1996. Improved method for estimating water solubility from octanol/water coefficient. Environ Toxicol. Chem. 15(2):100-106.)

- Sewage Treatment Plant Model (STP), a fugacity model for estimating the efficiency of pollutant removal. (Clark B, JG Henry and D Mackay. 1995. Fugacity analysis and model of organic chemical fate in a sewage treatment plant. Environ. Sci. Technol. 29:1488-1494.)

The accuracy of these programs has not been established in all cases, but the listed programs are considered to be the best methods currently available. In addition to the journal articles discussing the development and use of these programs found at the end of this section (with the exception of the MPBPVP program), a user's guide also is available for the EPI and each program. Any property values determined using these programs have been designated as estimated (E). It should be noted that the water solubility estimation program has an anticipated margin of error of plus or minus one order of magnitude. The LOGKOW is expected to be accurate to 0.1 log units for most compounds, although the PCKOC is likely to be somewhat less accurate due to the complex nature of the soil/sediment sorption phenomena.

For several chemicals, no data were available in any of the primary sources, and EPI estimation methods were not performed because the complex nature of the chemical (e.g., chemicals with ranges of carbon atoms) skewed the estimation results. For these chemicals, chemical and physical data had to be estimated based on structure-activity relationships (i.e., comparison with analogous chemicals with known properties). In addition, some properties were estimated from best chemical judgment based on the class of compounds to which the chemical in question belongs. For example, chemical and physical property values for benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol have been estimated based on similarities with the other benzenesulfonic dodecyl- blanket wash chemicals. Any property values determined by this comparison method have been designated by an (E), estimated. Any chemical and physical property values that still could not be estimated have been designated as not available.

2.2.2 Safety Hazard Factors

In addition to the physical and chemical properties of a chemical discussed above, there are other chemical attributes that are important for the handling, use and storage of a chemical in the workplace. These attributes have been designated as Safety Hazard Factors and they include chemical reactivity, flammability, ignitability and corrosivity. Information used to determine the Safety Hazard Factors was taken from the following sources (if information was not available for particular factor it was not included in the Chemical Properties and Information summary):

- National Fire Protection Association's (NFPA) Fire Protection Guide to Hazardous Materials (10th edition), Quincy, Massachusetts.

- 40 CFR §261.20 (Protection of Environment, RCRA, Identification and Listing of Hazardous Waste), Characteristic of Ignitability.

- Department of Transportation's Hazardous Materials Table 49 CFR §172.101.

The reactivity and flammability values are taken from the National Fire Protection Association's (NFPA) Fire Protection Guide to Hazardous Materials (10th edition). For reactivity, materials are ranked on a scale of 0 through 4:

0 - materials that are normally stable, even under fire exposure conditions, and that do not react with water; normal fire fighting procedures may be used.

1 - materials that are normally stable, but may become unstable at elevated temperatures and pressures and materials that will react with water with some

release of energy, but not violently; fires involving these materials should be approached with caution.

2 - materials that are normally unstable and readily undergo violent chemical change, but are not capable of detonation; this includes materials that can rapidly release energy, materials that can undergo violent chemical changes at high temperatures and pressures, and materials that react violently with water. In advanced or massive fires involving these materials, fire fighting should be done from a safe distance of from a protected location.

3 - materials that, in themselves, are capable of detonation, explosive decomposition, or explosive reaction, but require a strong initiating source or heating under confinement; fires involving these materials should be fought from a protected location.

4 - materials that, in themselves, are readily capable of detonation, explosive decomposition, or explosive reaction at normal temperatures and pressures. If a material having this Reactivity Hazard Rating is involved in a fire, the area should be immediately evacuated.

For flammability, materials are ranked on a scale of 0 through 4:

0 - any material that will not burn.

1 - materials that must be preheated before ignition will occur and whose flash point exceeds 200°F (93.4°C), as well as most ordinary combustible materials.

2 - materials that must be moderately heated before ignition will occur and that readily give off ignitible vapors.

3 - flammable liquids and materials that can be easily ignited under almost all normal temperature conditions. Water may be ineffective in controlling or extinguishing fires in such materials.

4 - includes flammable gases, pyrophoric liquids, and flammable liquids. The preferred method of fire attack is to stop the flow of material or to protect exposures while allowing the fire to burn itself out.

Chemicals not ranked by NFPA were not assigned a reactivity or a flammability value.

For ignitability, the blanket wash chemicals have been classified as either ignitable "Y", or not ignitable "N". The determination of ignitability is based upon the standard outlined in 40 CFR §261.20 (Protection of Environment, RCRA; Identification and Listing of Hazardous Waste), Characteristic of Ignitability. Under this standard, a chemical is considered ignitable if it "is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has a flash point less than 60°C (140°F) as determined by a Pensky-Martens Closed Cup Tester...a Setaflash Closed Cup Tester...or an equivalent test method." The flash points for these chemicals were taken from the NFPA Fire Protection Guide to Hazardous Materials, and if no flash point existed for a chemical, no ignitability designation was assigned.

For corrosivity, the blanket wash chemicals have been categorized as either corrosive or not corrosive. Any chemical with a designation in the corrosivity column is listed in the Department of Transportation's Hazardous Materials Table in 49 CFR §172.101. This table lists all required labels a chemical must have affixed to its container prior to shipping. Chemicals which require a corrosive shipping label have been designated by "Y", while chemicals which do not require this label have been designated by "N". Chemicals not listed in the DOT Hazardous Materials Table have not been assigned a corrosivity designation.

2.2.3 Chemical Properties and Information Summaries

In Table 2-3, each of the 56 blanket wash chemicals are listed along with their common synonyms and the Chemical Abstracts Service Registry Number. Immediately following the table are the individual Chemical Properties and Information summaries for each chemical.

Table 2-3. Chemicals in Blanket Wash Formulations

Chemical Name	CAS Number	Synonym
Alcohols, C_{12}-C_{15}, ethoxylated[c]	68131-39-5	EMUL/Mix[b]
Benzene, 1,2,4-trimethyl-	95-63-6	Pseudocumene
Benzenesulfonic acid, dodecyl-[c]	27176-87-0	Dodecyl benzene sulfonic acid[b]
Benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol	26836-07-7	Dodecylbenzenesulfonic acid, ethanolamine salt
Benzenesulfonic acid, dodecyl-, compounds with 2-propanamine[c]	26264-05-1	Isopropylamine salt of dodecylbenzenesulfonic acid[b]
Benzenesulfonic acid, (tetrapropenyl)-, compounds with 2-propanamine	157966-96-6	Isopropylamine salt of (tetrapropenyl) benzenesulfonic acid
Benzenesulfonic acid, C_{10}-C_{16}- alkyl derivatives, compounds with 2-propanamine[c]	68584-24-7	Benzenesulfonic acid, C_{10}-C_{16}- alkyl derivatives, compounds with isopropylamine
Butyrolactone	96-48-0	2(3H)-Furanone, dihydro[b]
Cumene[a]	98-82-8	Benzene, (1-methylethyl)-[b]
Diethanolamine[a]	111-42-2	Ethanol, 2,2'-iminobis-[b]
Diethylene glycol monobutyl ether	112-34-5	Ethanol, 2-(2-butoxyethoxy)-[b]
Dimethyl adipate	627-93-0	Dimethyl hexanedioate; methyl adipate; dimethyl ester adipic acid
Dimethyl glutarate	1119-40-0	Glutaric acid, dimethyl ester; pentanedioic acid, dimethyl ester
Dimethyl succinate	106-65-0	Succinic acid, dimethyl ester; butanedioic acid, dimethyl ester; methyl succinate
Dipropylene glycol monobutyl ether	29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-[b] DGMBE
Dipropylene glycol methyl ether	34590-94-8	DPGME
Distillates (petroleum), hydrotreated middle[c]	64742-46-7	Hydrotreated middle distillate[b]

Chemical Name	CAS Number	Synonym
Ethoxylated nonylphenol	9016-45-9 26027-38-3 68412-54-4	Ethoxylated nonylphenol[b], α-(nonylphenyl)-ω-hydroxy-, branched and unbranched isomers[c]; NP-6[b]; NP-9[b]
Ethylenediaminetetraacetic acid, tetrasodium salt	64-02-8	Tetrasodium EDTA
Fatty acids, C_{16}-C_{18}, methyl esters[c]	67762-38-3	Fatty acid methyl esters[b]
Fatty acids, C_{16}-C_{18} and C_{18}-unsatd, compounds with diethanolamine[a]	68002-82-4	Diethanolamine tallate[b]
Fatty acids, tall oil, compounds with diethanolamine	61790-69-0	Diethanolamine tallate
Hydrocarbons, terpene processing by-products[c]	68956-56-9	
d-Limonene[a]	5989-27-5	Cyclohexene, 1-methyl-4-(1-methylethenyl)-[b]; Terpenes[b]
Linalool[a]	78-70-6	1,6-Octadien-3-ol, 3,7-dimethyl-[b]
Mineral spirits (light hydrotreated)	64742-47-8	Petroleum distillate[b]
N-Methylpyrrolidone	872-50-4	NMP
Naphtha (petroleum), hydrotreated heavy[c]	64742-48-9	Aliphatic petroleum distillate C_9-C_{11}[b]
Nerol[a]	106-25-2	2,6-Octadien-1-ol, 3,7-dimethyl-[b]
Oxirane, methyl, polymer with oxirane, monodecyl ether[c]	37251-67-5	Linear alkyl ethoxylate[b]
2-Pinanol[a]	473-54-1	Bicyclo[3.1.1]heptan-2-ol, 2,6,6-trimethyl-[b]
Plinols[b]	72402-00-7	Cyclopentanol, 1,2-dimethyl-3-(1-methylethenyl)-[c]
Polyethoxylated isodecyloxypropylamine[b]	68478-95-5	Poly(oxy-1,2-ethanediyl), α,α'-(iminodi-2,1-ethanediyl)bis[ω-hydroxy]-, N-[3-(branched decyloxy)propyl] derivatives[c]
Poly(oxy-1,2-ethanediyl), α-hexyl-ω-hydroxy-[c]	31726-34-8	Ethoxylated hexyl alcohol
Propanoic acid, 3-ethoxy-, ethyl ester[a]	763-69-9	Ethyl-3-ethoxy propionate
Propylene glycol	57-55-6	1,2-Propanediol
Propylene glycol monobutyl ether	5131-66-8	2-Propanol, 1-butoxy-[b]
Sodium bis(ethylhexyl) sulfosuccinate[b]	577-11-7	Butanedioic acid, sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt[c]
Sodium hydroxide	1310-73-2	Caustic soda

Chemical Name	CAS Number	Synonym
Sodium xylene sulfonate[b]	1300-72-7	Benzenesulfonic acid, dimethyl-, sodium salt[c]
Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Aromatic 150[b]
Solvent naphtha (petroleum), light aliphatic	64742-89-8	VM&P naphtha[b]
Solvent naphtha (petroleum), light aromatic	64742-95-6	Aromatic petroleum distillate C_8-C_{11}[b]
Solvent naphtha (petroleum), medium aliphatic[c]	64742-88-7	Solvent 140[b]
Sorbitan, mono-9-octadecenoate[c]	1338-43-8	Sorbitan mono-oleate (crillet 4)[b]
Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives[c]	9005-64-5	Laurate of polyoxyethylenic sorbitan[b]
Sorbitan, monolaurate	5959-89-7	D-Glucitol, 1,4-anhydro-, 6-dodecanoate[b]
Sorbitan, tri-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivatives[c]	9005-70-3	Ethoxylated sorbitan tri-oleate (crillet 45)[b]
Soybean oil, methyl ester[c]	67784-80-9	Soybean based methyl esters[b]
Soybean oil, polymerized, oxidized[c]	68152-81-8	Oxidized soybean oil[b]
Stoddard solvent[a]	8052-41-3	Mineral spirits
Tall oil, special	68937-81-5	Special tall oil[b] methyl stearate, methyl oleate
α-Terpineol[a]	98-55-5	3-Cyclohexene-1-methanol, α,α, 4-trimethyl-[b]
Terpinolene[a]	586-62-9	Cyclohexene, 1-methyl-4-(1-methylethylidene)-[b]
Tetrapotassium pyrophosphate[b]	7320-34-5	Diphosphoric acid, tetrapotassium salt[a]
Xylene	1330-20-7	Dimethyl benzene

[a] Indicates that the name was chosen from the CHEMID Files.
[b] Indicates name supplied by industry.
[c] Indicates that the name was chosen from the TSCA Inventory.

Alcohols, C_{12}-C_{15}, Ethoxylated

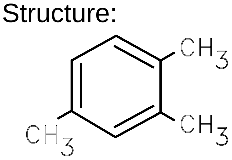
CAS# 68131-39-5

Chemical Properties and Information	
Synonyms: ethoxylated fatty alcohols; EMUL/Mix Molecular weight: >200 Melting Point: <50°C (E) Water Solubility: Dispersable (n=3 to 10) (E) Vapor Pressure: <0.01 mm Hg (E) $Log_{10}K_{ow}$: 3.40 (E) $Log_{10}K_{oc}$: 3.97 (E) $Log_{10}BCF$: 2.35 (E) Henry's Law: <1.00X10^{-8} atm-m^3/mol (E) POTW Overall Removal Rate (%): 83-99 (E) Chemistry of Use: Dispersant	Molecular formula varies Structure: $R(OCH_2CH_2)_nOH$ $R = C_{12}$ to C_{15} Boiling Point: Decomposes (E) Density: 0.95 g/cm^3 (E) Flash Point: >100°C (E) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

Benzene, 1,2,4-Trimethyl

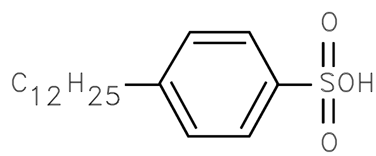
CAS# 95-63-6

Chemical Properties and Information	
Synonyms: 1,2,4-trimethyl benzene; pseudocumene; trimethyl benzene; asymmetrical trimethyl benzene Molecular weight: 120.19 Melting Point: -43.78°C (M) Water Solubility: 0.02 g/L (E) Vapor Pressure: 10.34 torr (at 54.4°C) (M) $Log_{10}K_{ow}$: 3.78 (M) $Log_{10}K_{oc}$: 2.86 (M) $Log_{10}BCF$: 2.53 (E) Henry's Law: 6.58X10^{-3} atm-m^3/mole (M) POTW Overall Removal Rate (%): 97-99 (E) Chemistry of Use: Solvent component	C_9H_{12} Structure:  Boiling Point: 169 -171°C (M) Density: 0.876 g/cm^3 (M) Flash Point: 54.4°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: N

Above data are either measured (M) or estimated (E)

Benzenesulfonic Acid, Dodecyl-

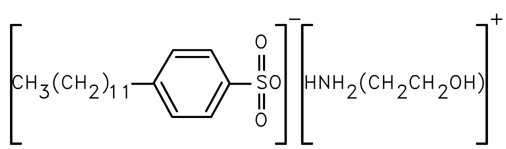
CAS# 27176-87-0

Chemical Properties and Information	
Synonyms: DDBSA Molecular weight: 326 Melting Point: Not available Water Solubility: Miscible (E) Vapor Pressure: $<10^{-4}$ mm Hg (E) $Log_{10}K_{ow}$: 4.78 (E) $Log_{10}K_{oc}$: 4.23 (E) $Log_{10}BCF$: 3.41 (E) Henry's Law: $6.27X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 99.82-99.98 (E) Chemistry of Use: Surfactant	$C_{18}H_{30}SO_3$ Structure:  Boiling Point: 204.5°C (M) Density: 1.00 g/cm^3 (M) Flash Point: 149° C (open cup) (M) Safety Hazard Factors: Corrosivity: Y

Above data are either measured (M) or estimated (E)

Benzenesulfonic Acid, Dodecyl-, Compounds with 2-Aminoethanol

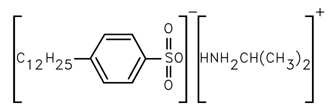
CAS# 26836-07-7

Chemical Properties and Information	
Synonyms: Dodecylbenzensulfonic acid, ethanolamine salt Molecular weight: 387.59 Melting Point: Not available Water Solubility: Dispersible (E) Vapor Pressure: $<10^{-6}$ mm Hg (E) Log_{10} K_{ow}: Not available Log_{10} K_{oc}: Not available Log_{10} BCF: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 50-90 (E) Chemistry of Use: Dispersant	$C_{20}H_{37}NO_4S$ Structure:  Boiling Point: Decomposes (E) Density: 1 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Benzenesulfonic Acid, Dodecyl-, Compounds with 2-Propanamine

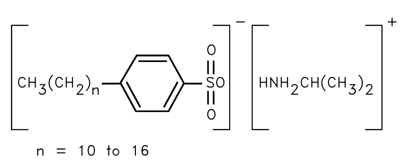
CAS# 26264-05-1

Chemical Properties and Information	
Synonyms: isopropylamine salt of dodecylbenzenesulfonic acid Molecular weight: 385.5 Melting Point: Not available Water Solubility: Dispersible (E) (surfactant) Vapor Pressure: $<10^{-5}$ mm Hg (E) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Dispersant	$C_{21}H_{39}NO_3S$ Structure:  Boiling Point: Decomposes (M) Density: 1.03 g/cm^3 (M) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Benzenesulfonic Acid, C_{10}-C_{16}-Alkyl Derivatives, Compounds with 2-Propanamine

CAS# 68584-24-7

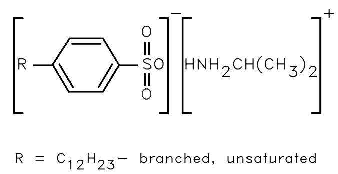
Chemical Properties and Information	
Synonyms: benzenesulfonic acid, C_{10-16}-alkyl derivatives, compounds with isopropylamine Molecular weight: 357-441 Melting Point: Not available Water Solubility: Dispersible (surfactant) (E) Vapor Pressure: $<10^{-5}$ mm Hg (E) $Log_{10}K_{ow}$: 4.78 (E) $Log_{10}K_{oc}$: 4.23 (E) $Log_{10}BCF$: 3.41 (E) Henry's Law: 6.27×10^{-8} atm-m^3/mole (E) POTW Overall Removal Rate (%): 83-99 (E) Chemistry of Use: Dispersant	$C_{n+9}H_{2n+15}NSO_3$ (n=10-16) Structure:  Boiling Point: Decomposes (E) Density: 1.05 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Benzenesulfonic Acid, (Tetrapropenyl)-, Compound with 2-Propanamine

CAS# 157966-96-6

Chemical Properties and Information

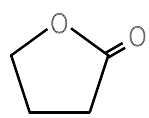
Synonyms: Isopropylamine salt of (tetrapropenyl) benzenesulfonic acid Molecular weight: 383.5 Melting Point: Not available Water Solubility: Dispersible (E) (surfactant) Vapor Pressure: <10^{-5} mm Hg (E) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Dispersant	$C_{21}H_{37}NO_3S$ Structure:  Boiling Point: Decomposes (E) Density: 1.0 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Butyrolactone

CAS# 96-48-0

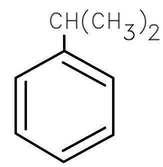
Chemical Properties and Information

Synonyms: γ-butyrolactone; dihydro-2(3H)-furanone; 1,2-butanolide; 1,4-butanolide; γ-hydroxybutyric acid lactone; 3-hydroxybutyric acid lactone; 4-hydroxybutanoic acid lactone Molecular weight: 86 Melting Point: -44°C (M) Water Solubility: miscible (M) Vapor Pressure: 3.2 mm Hg (25° C)(M) $Log_{10}K_{ow}$: -0.640 (M) $Log_{10}K_{oc}$: 0.85 (E) $Log_{10}BCF$: -0.72 (E) Henry's Law: 1.81 x 10^{-5} atm-m^3/mole (E) POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Solvent	$C_4H_6O_2$ Structure:  Boiling Point: 204°C (M) Density: 1.125 g/mL (M) Flash Point: Open cup: 98°C (M) K_{oc}: 53 (E) Physical state: Liquid Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Cumene

CAS# 98-82-8

Chemical Properties and Information	
Synonyms: benzene, (1-methylethyl)-; Isopropylbenzene Molecular weight: 120.19 Melting Point: -96°C (M) Water Solubility: Insoluble (M) Vapor Pressure: 3.53 mm Hg (M) $Log_{10}K_{ow}$: 3.66 (M) $Log_{10}K_{oc}$: 2.91 (E) $Log_{10}BCF$: 2.39 (E) Henry's Law: $1.23X10^{-2}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 97-99 (E) Chemistry of Use: Solvent component	C_9H_{12} Structure:  Boiling Point: 152-153°C (M) Density: 0.862 g/cm^3 (M) Flash Point: 39°C (closed cup) (M) Safety Hazard Factors: Reactivity: 1 Flammability: 3 Ignitability: Y

Above data are either measured (M) or estimated (E)

Diethanolamine

CAS# 111-42-2

Chemical Properties and Information	
Synonyms: ethanol, 2,2'-iminobis-; Iminodiethanol; 2,2'-dihydroxyethylamine; Molecular weight: 105.14 Melting Point: 28°C (M) Water Solubility: Very soluble Vapor Pressure: Not available $Log_{10}K_{ow}$: -1.43 (M) $Log_{10}K_{oc}$: -0.85 (E) $Log_{10}BCF$: -1.53 (E) Henry's Law: <$1.00X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 83.36-96.61 (E) Chemistry of Use: Solvent	$C_4H_{11}NO_2$ Structure: $HOCH_2CH_2NHCH_2CH_2OH$ Boiling Point: 270°C (M) Density: 1.0881_4^{θ} g/mL (M) Flash Point: 137°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Diethylene Glycol Monobutyl Ether

CAS# 112-34-5

Chemical Properties and Information	
Synonyms: 2-(2-butoxyethoxy) ethanol; butyl ethyl Cellosolve; diethylene glycol butyl ether; butyl Carbitol; Dowanol DB; Poly-Solv DB; butoxydiglycol, butyl digol, butyl diicinol Molecular weight: 162.2 Melting Point: -68°C (M) Water Solubility: Miscible (E) Vapor Pressure: 0.02 mm Hg (E) (20° C) $Log_{10}K_{ow}$: 0.56 (M) $Log_{10}K_{oc}$: -0.55 (E) $Log_{10}BCF$: 0.46 (E) Henry's Law: <1.00X10^{-8} atm-m^3/mole (E) POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Solvent	$C_8H_{18}O_3$ Structure: $C_4H_9OCH_2CH_2OCH_2CH_2OH$ Boiling Point: 231° C (M) Density: 0.954 g/mL (M) Flash Point: Open cup: 110°C (M) Closed cup: 78°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Dimethyl Adipate

CAS# 627-93-0

Chemical Properties and Information	
Synonyms: dimethyl hexanedioate; methyl adipate; dimethyl ester adipic acid Molecular weight: 174.25 Melting Point: 8°C (M) Water Solubility: 0.1 g/L (E) Vapor Pressure: 0.06 mm Hg (25°C)(E) $Log_{10}K_{ow}$: 1.39 (E) $Log_{10}K_{oc}$: 1.04 (E) $Log_{10}BCF$: 0.82 (E) Henry's Law: 1.28 x 10^{-7} atm-m^3/mole (E) POTW Overall Removal Rate (%): 85-97 (E) Chemistry of Use: Solvent	$C_8H_{14}O_4$ Structure: $(CH_3O)CO(CH_2)_4CO(OCH_3)$ Boiling Point: 193.7°C (at 760 mm Hg)(E) Density: 1.063 g/mL (M) Flash Point: 107°C (M) Physical state: Colorless, odorless liquid Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

Dimethyl Glutarate

CAS# 1119-40-0

Chemical Properties and Information	
Synonyms: glutaric acid, dimethyl ester; pentanedioic acid, dimethyl ester Molecular weight: 160.17 Melting Point: -42.5°C (M) Water Solubility: 1 g/L (E) Vapor Pressure: 0.1 mm Hg (E) $Log_{10}K_{ow}$: 0.90 (E) $Log_{10}K_{oc}$: 0.77 (E) $Log_{10}BCF$: -0.14 (E) Henry's Law: $9.09X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 97 (E) Chemistry of Use: Solvent	$C_7H_{12}O_4$ Structure: $CH_3O_2C(CH_2)_3CO_2CH_3$ Boiling Point: 214°C (M) Density: 1.088 g/cm^3 (M) Flash Point: 100°C (E) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

Dimethyl Succinate

CAS# 106-65-0

Chemical Properties and Information	
Synonyms: succinic acid, dimethyl ester; butanedioic acid, dimethyl ester; methyl succinate Molecular weight: 146.14 Melting Point: 19°C (M) Water Solubility: 8.3 g/L (M) Vapor Pressure: 0.1 mm Hg (E) $Log_{10}K_{ow}$: 0.19 (M) $Log_{10}K_{oc}$: 0.48 (E) $Log_{10}BCF$: Not available Henry's Law: $5.8X10^{-6}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 97 (E) Chemistry of Use: Solvent	$C_6H_{10}O_4$ Structure: $CH_3O_2C(CH_2)_2CO_2CH_3$ Boiling Point: 196.4°C (M) Density: 1.12 g/cm^3 (M) Flash Point: 100°C (E) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

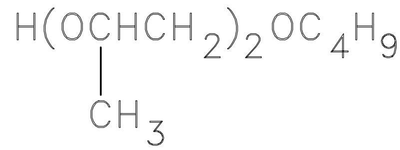
Dipropylene Glycol Monobutyl Ether

CAS# 29911-28-2

Chemical Properties and Information

Synonyms: 2-propanol, 1-(2-butoxy-1-methylethoxy)-; DGMBE
Molecular weight: 190.3
Melting Point: -73°C (M)
Water Solubility: Miscible (E)
Vapor Pressure: 0.044 mm Hg (M)
$Log_{10}K_{ow}$: 1.13 (E)
$Log_{10}K_{oc}$: -0.15 (E)
$Log_{10}BCF$: 0.63 (E)
Henry's Law: $<1.00 \times 10^{-8}$ atm-m^3/mole (E)
POTW Overall Removal Rate (%): 83-97 (E)
Chemistry of Use: Solvent

$C_{10}H_{22}O_3$
Structure:



Boiling Point: 229°C (M)
Density: 0.913 g/cm^3 (M)
Flash Point: 118° C (open cup) (M)
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Dipropylene Glycol Methyl Ether

CAS# 34590-94-8

Chemical Properties and Information

Synonyms: glycol ether DPM; Dowanol DPM
Molecular weight: 148.2
Melting Point: -80°C (M)
Water Solubility: Miscible (E)
Vapor Pressure: 0.4 mm Hg (M) (25°C)
$Log_{10}K_{ow}$: -0.35 (E)
$Log_{10}K_{oc}$: 1.00 (E)
$Log_{10}BCF$: -0.49 (E)
Henry's Law: $<1.00 \times 10^{-8}$ atm-m^3/mol (E)
POTW Overall Removal Rate (%): 83-97 (E)
Chemistry of Use: Solvent

$C_7H_{16}O_3$
Structure: $CH_3CHOHCH_2OCH_2CH(OCH_3)CH_3$
Boiling Point: 188.3°C (M)
Density: 0.951 g/mL (M)
Flash Point: 75°C (M)
Physical state: Liquid
Safety Hazard Factors:
Reactivity: 0
Flammability: 2
Ignitability: N

Above data are either measured (M) or estimated (E)

Distillates (Petroleum), Hydrotreated Middle

CAS# 64742-46-7

Chemical Properties and Information

Synonyms: hydrotreated middle distillate
Molecular weight: Varies
Melting Point: -70°C (E)
Water Solubility: 0.003 g/L (E)
Vapor Pressure: 2 mm Hg (E)
$Log_{10}K_{ow}$: 5.25 (E)
$Log_{10}K_{oc}$: 3.24 (E)
$Log_{10}BCF$: 3.76 (E)
Henry's Law: 5.3 atm-m^3/mole (E)
POTW Overall Removal Rate (%): ≈ 100 (E)
Chemistry of Use: Solvent

C_nH_{2n+2} and C_nH_{2n} (cycloparaffin)
Structure: No definite structure. Mixture of normal-, branched-, and cyclo-paraffins.
Boiling Point: 180-210°C (E)
Density: 0.78 g/cm^3 (E)
Flash Point: 50°C (E)
Safety Hazard Factors:
Ignitability: Y

Above data are either measured (M) or estimated (E)

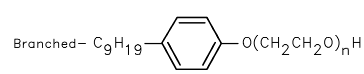
Ethoxylated Nonylphenol

CAS# 9016-45-9, 26027-38-3, 68412-54-4

Chemical Properties and Information

Synonyms: poly(oxy-1,2-ethanediyl), α-(nonylphenyl)-Ω-hydroxy-; Antarox; polyethylene glycol mono (nonylphenyl) ether
Molecular weight: 630 (for n=9.5) (typical range 500 - 800)
Melting Point: -20 to +10°C (E)
Water Solubility: Soluble (M)
Vapor Pressure: <10^{-6} mm Hg (E)
$Log_{10}K_{ow}$: 3.93 (E) (np = 7)
$Log_{10}K_{oc}$: -0.19 (E) (np = 7)
$Log_{10}BCF$: Not available
Henry's Law: 1.81X10^{-22} atm-m^3/mole (E) (np = 7)
POTW Overall Removal Rate (%): 95 (M)[a]
Chemistry of Use: Nonionic surfactant

$C_{34}H_{62}O_{10}$ (for n=9.5)
Structure:



n = 9.5 (for screen printing formulation product)

Boiling Point: >300°C (E) (decomposes)
Density: 0.8 g/cm^3 (E)
Flash Point: 200 - 260°C (E)
Safety Hazard Factors:
Ignitability: N

Above data are either measured (M) or estimated (E)

[a] *Based on testing data (Weeks, J.A. et al. 1996. Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain. Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-91.) the original estimate of POTW removal has been changed from 100% to 95% in the final report. This revision results in increased estimates of the releases from POTWs to surface waters as described in section 3.3. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24, and 40) present concerns to aquatic species that were not reported in the draft CTSA.*

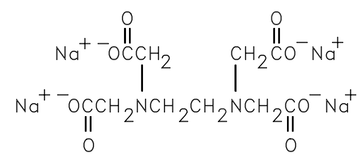
Ethylenediaminetetraacetic acid, tetrasodium salt

CAS# 64-02-8

Chemical Properties and Information

Synonyms: Glycine, N,N'-1,2-ethanediylbis[N-(carboxymethyl)-, tetrasodium salt; Tetrasodium EDTA
Molecular weight: 380.20
Melting Point: >300°C (M)
Water Solubility: 1030 g/L (M)
Vapor Pressure: $<10^{-7}$ mm Hg (E)
$Log_{10}K_{ow}$: Not available
$Log_{10}K_{oc}$: Not available
$Log_{10}BCF$: Not available
Henry's Law: Not available
POTW Overall Removal Rate (%): 83.3-96.6 (E)
Chemistry of Use: Chelating agent

$C_{10}H_{12}NaN_2O_8$
Structure:



Boiling Point: Decomposes (E)
Density: 0.83 g/cm^3 (E)
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

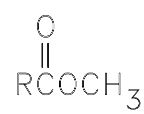
Fatty Acids, C_{16}-C_{18}, Methyl Esters

CAS# 67762-38-3

Chemical Properties and Information

Synonyms: fatty acid methyl esters
Molecular weight: 270-298
Melting Point: 27-36°C (M)
Water Solubility: <0.1 g/L (E)
Vapor Pressure: $<10^{-3}$ mm Hg (E)
$Log_{10}K_{ow}$: 7.74 (E)
$Log_{10}K_{oc}$: 4.53 (E)
$Log_{10}BCF$: 5.65 (E)
Henry's Law: 2.00×10^{-2} atm-m^3/mole (E)
POTW Overall Removal Rate (%): 94-100 (E)
Chemistry of Use: Solvent

$C_{n+2}H_{2n+4}O_2$ (n=15 to 17) and
$C_{n+2}H_{2n+2}O_2$ (n=17)
Structure:



R = C_{15-17}, and unsaturated C_{17}

Boiling Point: 325°C (E)
Density: 0.88 g/cm^3 (E)
Flash Point: 200°C (E)
Safety Hazard Factors:
Ignitability: N

Above data are either measured (M) or estimated (E)

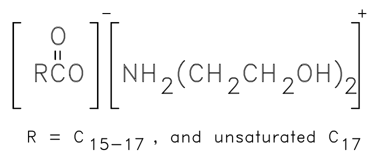
Fatty Acids, C_{16}-C_{18} and C_{18}-unsatd., Compounds with Diethanolamine

CAS# 68002-82-4

Chemical Properties and Information

Synonyms: diethanolamine tallate
Molecular weight: 361-390
Melting Point: Not available
Water Solubility: Dispersible (E)
Vapor Pressure: <10^{-6} mm Hg (E)
$Log_{10}K_{ow}$: 7.45 (E)
$Log_{10}K_{oc}$: 3.80 (E)
$Log_{10}BCF$: 5.43 (E)
Henry's Law: 5.23×10^{-5} atm-m^3/mol (E)
POTW Overall Removal Rate (%): 83-100 (E)
Chemistry of Use: Dispersant

$C_{n+5}H_{2n+13}NO_4$(n=15 to 17) and $C_{22}H_{45}NO_4$
Structure:



Boiling Point: Decomposes (E)
Density: >1 g/cm^3 (E)
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

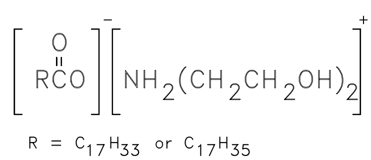
Fatty acids, tall oil, Compounds with Diethanolamine

CAS# 61790-66-7

Chemical Properties and Information

Synonyms:
Molecular weight: 387 - 389
Melting Point: Not available
Water Solubility: Dispersible (E)
Vapor Pressure: <10^{-6} mm Hg (E)
$Log_{10}K_{ow}$: Not available
$Log_{10}K_{oc}$: Not available
$Log_{10}BCF$: Not available
Henry's Law: Not available
POTW Overall Removal Rate (%): 83-100 (E)
Chemistry of Use: Dispersant

$C_{22}H_{45}NO_4$ and •$C_{22}H_{47}NO_4$
Structure:



Boiling Point: Decomposes (E)
Density: >1 g/cm^3 (E)
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Hydrocarbons, Terpene Processing By-Products

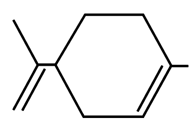
CAS# 68956-56-9

Chemical Properties and Information	
Synonyms: Molecular weight: ≥136 Melting Point: -40 to -60°C (E) Water Solubility: 0.02 g/L (E) Vapor Pressure: 1 mm Hg (E) $Log_{10}K_{ow}$: 4.83 (E) $Log_{10}K_{oc}$: 3.12 (E) $Log_{10}BCF$: 3.44 (E) Henry's Law: $3.80X10^{-1}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 98-100 (E) Chemistry of Use: Solvent	$C_{10}H_{16}$ and larger Structure: Mixture of C_{10} and larger terpenes. Boiling Point: 165 - 180°C (E) Density: 0.84 - 0.87 g/cm^3 (E) Flash Point: 30 - 50°C (E) Safety Hazard Factors: Corrosivity: N

Above data are either measured (M) or estimated (E)

d-Limonene

CAS# 5989-27-5

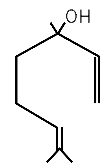
Chemical Properties and Information	
Synonyms: 1-methyl-4-(1-methylethenyl) cyclohexene; (+)-carvene; citrene; 1,8-*p*-menthadiene; 4-isopropenyl-1-methylcyclohexene cinene; cajeputene; kautschin Molecular weight: 136 Melting Point: -74°C (M) Water Solubility: 0.014 g/L (M) Vapor Pressure: 5 mm Hg (E) (25°C) $Log_{10}K_{ow}$: 4.83 (E) $Log_{10}K_{oc}$: 3.12 (E) $Log_{10}BCF$: 3.44 (E) Henry's Law: $3.80X10^{-1}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): >99 (E) Chemistry of Use: Solvent	$C_{10}H_{16}$ Structure:  Boiling Point: 176°C (M) Density: 0.84 g/mL (M) Flash Point: 48°C (M) K_{oc}: 1,000 - 4,800 (E) Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Linalool

CAS# 78-70-6

Chemical Properties and Information

Chemical Properties and Information	
Synonyms: 1,6-octadien-3-ol, 3,7-dimethyl- Molecular weight: 154.24 Melting Point: Not available Water Solubility: Practically insoluble (M) Vapor Pressure: 0.29 mm Hg (M) $Log_{10}K_{ow}$: 3.38 (E) $Log_{10}K_{oc}$: 1.75 (E) $Log_{10}BCF$: 2.34 (E) Henry's Law: $4.23X10^{-5}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): 93-99 (E) Chemistry of Use: Solvent	$C_{10}H_{18}O$ Structure:  Boiling Point: 198-200°C (M) Density: 0.8622 g/cm^3 (M) Flash Point: 74°C (E) Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: N

Above data are either measured (M) or estimated (E)

Mineral Spirits (Light Hydrotreated)

CAS# 64742-47-8

Chemical Properties and Information	
Synonyms: many trade names by companies including Amsco, Apco, Epesol, Exxon, Phillips, Shell, etc., most of which include "mineral spirits" in the name Molecular weight: 86 for n-hexane; 112 for ethycyclohexane, for example Melting Point: -60°C (E) Water Solubility: 0.001 g/L (E) Vapor Pressure: 0.5-1 mm Hg (E) (25°C) $Log_{10}K_{ow}$: 3.90 (M) $Log_{10}K_{oc}$: 2.17 (E) $Log_{10}BCF$: 2.73 (E) Henry's Law: 1.71 atm-m^3/mole (E) POTW Overall Removal Rate (%): >99 (E) Chemistry of Use: Solvent	Molecular formula: C_nH_{2n+2} (paraffin) and C_nH_{2n} (cycloparaffin) Structure: Typical structures include normal paraffins, $CH_3(CH_2)_nCH_3$, branched paraffins, and cycloparaffins Boiling Point: 140-180°C (M) Density: 0.78 g/mL (M) Flash Point: <43°C (M) Physical State: Liquid Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: Y

Above data are either measured (M) or estimated (E)

Naphtha (Petroleum), Hydrotreated Heavy

CAS# 64742-48-9

Chemical Properties and Information

Synonyms: aliphatic petroleum distillate C_9-C_{11}; naphthol spirits (aliphatic); hydrated lightstream cracked naphtha residuum (petroleum)
Molecular weight: 86 for n-hexane; 112 for ethylcyclohexane, for example
Melting Point: -80°C (E)
Water Solubility: 0.001 g/L (E)
Vapor Pressure: 1 mm Hg at 25°C (E)
$Log_{10}K_{ow}$: 4.27 (E)
$Log_{10}K_{oc}$: 2.70 (E)
$Log_{10}BCF$: 3.01 (E)
Henry's Law: 3.01 atm-m^3/mol (E)
POTW Overall Removal Rate (%): 99-100 (E)
Chemistry of Use: Solvent

C_nH_{2n+2} (paraffin) and C_nH_{2n} (cycloparaffin)
Structure: No definite structure. Mixture of normal-, branched-, and cyclo-paraffins
Boiling Point: 66-230°C (M)
Density: 0.8 g/ml (E)
Flash Point: 60°C (M)
Safety Hazard Factors:
- Reactivity: 0
- Flammability: 4
- Ignitability: Y
- Corrosivity: N

Above data are either measured (M) or estimated (E)

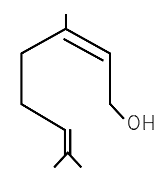
Nerol

CAS# 106-25-2

Chemical Properties and Information

Synonyms: 2,6-octadiene-1-ol, 3,7-dimethyl-,
Molecular weight: 154.24
Melting Point: <-15.4°C (M)
Water Solubility: Insoluble (E)
Vapor Pressure: 0.06 mm Hg (M)
$Log_{10}K_{ow}$: 3.47 (E)
$Log_{10}K_{oc}$: 1.85 (E)
$Log_{10}BCF$: 2.41 (E)
Henry's Law: 5.89X10^{-5} atm-m^3/mole (E)
POTW Overall Removal Rate (%): 94-99 (E)
Chemistry of Use: Solvent

$C_{10}H_{18}O$
Structure:

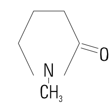


Boiling Point: 224-225°C (M)
Density: 0.8756 g/cm^3 (M)
Flash Point: 77°C (M)
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

N-Methylpyrrolidone

CAS# 872-50-4

Chemical Properties and Information	
Synonyms: N-methylpyrrolidone [1-methyl-2-pyrrolidone; 1-methylazacyclopenta-2-one; N-methyl-γ-butyrolactam]; NMP Molecular weight: 99.13 Melting Point: <-17 to -23°C (M) Water Solubility: Miscible (M) Vapor Pressure: 0.334 mm Hg (E) (25°C) $Log_{10}K_{ow}$: -0.38 (M) $Log_{10}K_{oc}$: 1.32 (E) $Log_{10}BCF$: -0.31 (E) Henry's Law: $3.16X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 97 (E) Chemistry of Use: Solvent	C_5H_9NO Structure:  Boiling Point: 202°C (M) Density: 1.03 g/mL (M) Flash Point: 96°C (M) Safety Hazard Factors: Reactivity: 1 Flammability: 3 Ignitability: Y

Above data are either measured (M) or estimated (E)

Oxirane, Methyl-, Polymer with Oxirane, Monodecyl Ether

CAS# 37251-67-5

Chemical Properties and Information	
Synonyms: ethoxylated propoxylated decyl alcohol Molecular weight: Varies Melting Point: <-50°C (E) Water Solubility: Dispersible (n=3 to 10) (E) Miscible (n>10) (E) Vapor Pressure: $<10^{-4}$ mm Hg (E) $Log_{10}K_{ow}$: 3.26 (E) $Log_{10}K_{oc}$: 6.67 (E) $Log_{10}BCF$: 2.25 (E) Henry's Law: $<1.00X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 1-95 (E) Chemistry of Use: Dispersant	Molecular formula varies Structure: $C_{10}H_{21}(OCH_2CH(CH_3))_m(OCH_2CH_2)_nOH$ Boiling Point: Decomposes (E) Density: <1 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

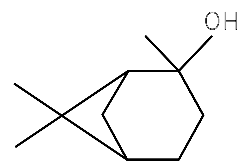
2-Pinanol

CAS# 473-54-1

Chemical Properties and Information

Synonyms: bicyclo[3.1.1]heptan-2-ol, 2,6,6-trimethyl-
Molecular weight: 154.24
Melting Point: 60 - 80°C (M)
Water Solubility: <0.1 g/L (E)
Vapor Pressure: 1.9×10^{-2} mm Hg (E)
$Log_{10}K_{ow}$: 2.85 (E)
$Log_{10}K_{oc}$: 1.73 (E)
$Log_{10}BCF$: 1.94 (E)
Henry's Law: 1.90×10^{-6} atm-m^3/mole (E)
POTW Overall Removal Rate (%): 88-98 (E)
Chemistry of Use: Solvent

$C_{10}H_{18}O$
Structure:



Boiling Point: 220°C (M)
Density: 1.01 g/cm^3 (E)
Flash Point: 65°C (E)
Safety Hazard Factors:
Ignitability: N

Above data are either measured (M) or estimated (E)

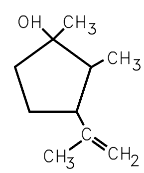
Plinols

CAS# 72402-00-7

Chemical Properties and Information

Synonyms: cyclopentanol, 1,2-dimethyl-3-(1-methylethenyl)-
Molecular weight: 154.24
Melting Point: 93°C (M)
Water Solubility: Very slightly soluble (E)
Vapor Pressure: <0.01 mm Hg (E)
$Log_{10}K_{ow}$: 3.34 (E)
$Log_{10}K_{oc}$: 1.74 (E)
$Log_{10}BCF$: 2.31 (E)
Henry's Law: 1.34×10^{-5} atm-m^3/mole (E)
POTW Overall Removal Rate (%): 11-99 (E)
Chemistry of Use: Solvent

$C_{10}H_{18}O$
Structure:



Boiling Point: 220°C (E)
Density: 0.92 g/cm^3 (E)
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

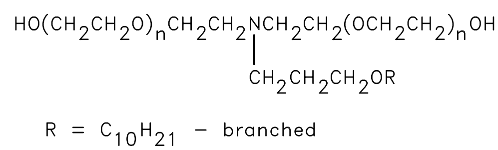
Polyethoxylated Isodecyloxypropylamine

CAS# 68478-95-5

Chemical Properties and Information

Synonyms: poly(oxy-1,2-ethanediyl), α,α´-(iminodi-2,1 ethanediyl) bis[ω-hydroxy]-, N-[3-(branched decyloxy)propyl] derivatives
Molecular weight: >400
Melting Point: Not available
Water Solubility: Dispersible or soluble (depending on degree of ethoxylation) (E)
Vapor Pressure: $<10^{-6}$ mm Hg (E)
$Log_{10}K_{ow}$: 0.92 (E)
$Log_{10}K_{oc}$: -1.43 (E)
$Log_{10}BCF$: 0.47 (E)
Henry's Law: $<1.00X10^{-8}$ atm-m^3/mole (E)
POTW Overall Removal Rate (%): 85-97 (E)
Chemistry of Use: Dispersant

Molecular formula varies
Structure:



Boiling Point: Decomposes (E)
Density: Not available
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Poly (Oxy-1,2-Ethanediyl), α-Hexyl-ω-Hydroxy-

CAS# 31726-34-8

Chemical Properties and Information

Synonyms: ethoxylated hexyl alcohol
Molecular weight: >278
Melting Point: -10°C (E)
Water Solubility: Dispersible (n=3 to 10), Miscible (n>10) (E)
Vapor Pressure: <0.005 mm Hg (E)
$Log_{10}K_{ow}$: 0.73 (E)
$Log_{10}K_{oc}$: 1.58 (E)
$Log_{10}BCF$: 0.32 (E)
Henry's Law: $<1.00X10^{-8}$ atm-m^3/mole (E)
POTW Overall Removal Rate (%): 83-97 (E)
Chemistry of Use: Dispersant

$C_{2n+6}H_{4n+14}O_{n+1}$ (n>3)
Structure: $C_6H_{13}O(CH_2CH_2O)_nH$ (n>3)
Boiling Point: >270°C (E)
Density: >0.95 g/cm^3 (E)
Flash Point: >150°C (E)
Safety Hazard Factors:
Ignitability: N

Above data are either measured (M) or estimated (E)

Propanoic Acid, 3-Ethoxy-, Ethyl Ester

CAS# 763-69-9

Chemical Properties and Information	
Synonyms: ethyl-3-ethoxy propionate; ethyl-β-ethoxy propionate Molecular weight: 146.1 Melting Point: -100°C (M) Water Solubility: Slightly soluble (1 g/L) (E) Vapor Pressure: 0.9 mm Hg (at 20°C) (M) $Log_{10}K_{ow}$: 1.08 (E) $Log_{10}K_{oc}$: 0.61 (E) $Log_{10}BCF$: 0.59 (E) Henry's Law: $4.77X10^{-7}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 84-97 (E) Chemistry of Use: Solvent	$C_7H_{14}O_3$ Structure: $CH_3CH_2OOCCH_2CH_2OCH_2CH_3$ Boiling Point: 170°C (M) Density: 0.9496 g/cm^3 (M) Flash Point: 82°C (open cup) (M) Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Propylene Glycol

CAS# 57-55-6

Chemical Properties and Information	
Synonyms: 1,2-propanediol; methyl glycol; 1,2-dihydroxypropane; methylethylene glycol; trimethyl glycol Molecular weight: 76.10 Melting Point: -60°C (M) Water Solubility: Miscible Vapor Pressure: 0.2 mm Hg at 20°C (M) $Log_{10}K_{ow}$: -0.92 (M) $Log_{10}K_{oc}$: 0.00 (E) $Log_{10}BCF$: -0.82 (E) Henry's Law: $1.74x10^{-7}$atm-m^3/mole (E) POTW Overall Removal Rate (%): 97 (E) Chemistry of Use: Solvent	$C_3H_8O_2$ Structure: $HOCH(CH_3)CH_2OH$ Boiling Point: 187.3°C (M) Density: 1.038 g/mL (M) Flash Point: 101°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Propylene Glycol Monobutyl Ether

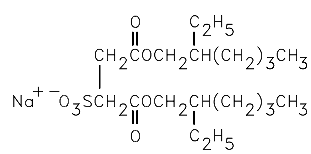
CAS# 5131-66-8

Chemical Properties and Information	
Synonyms: 2-propanol, 1-butoxy- Molecular weight: 132 Melting Point: -100°C (M) Water Solubility: 64 g/L (M) Vapor Pressure: <0.98 mm Hg at 20°C (M) $Log_{10}K_{ow}$: 0.98 (E) $Log_{10}K_{oc}$: 0.11 (E) $Log_{10}BCF$: 0.52 (E) Henry's Law: $4.88X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Solvent	$C_7H_{16}O_2$ Structure: $C_4H_9OCH_2CH(CH_3)OH$ Boiling Point: 170°C (M) Density: 0.89 g/cm^3 (E) Flash Point: 59 (closed cup) (M) Safety Hazard Factors: Ignitability: Y

Above data are either measured (M) or estimated (E)

Sodium bis(Ethylhexyl) Sulfosuccinate

CAS# 577-11-7

Chemical Properties and Information	
Synonyms: butanedioic acid, sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt; sodium sulfosuccinate; Docusate sodium Molecular weight: 444.37 Melting Point: Not available Water Solubility: 15 g/L (at 25°C) (M) Vapor Pressure: <10^{-6} mm Hg (E) $Log_{10}K_{ow}$: 6.10 (E) $Log_{10}K_{oc}$: 5.02 (E) $Log_{10}BCF$: 4.40 (E) Henry's Law: <$1.00X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): nearly 100 (E) Chemistry of Use: Surfactant	$C_{20}H_{37}NaO_7S$ Structure:  Boiling Point: Not available Density: Not available Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Sodium Hydroxide

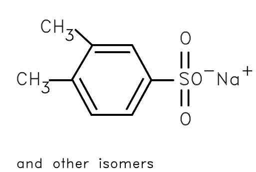
CAS# 1310-73-2

Chemical Properties and Information	
Synonyms: caustic soda; lye; sodium hydrate; soda lye Molecular weight: 39.9 Melting Point: 323°C (M) Water Solubility: 1,180 g/L (E) Vapor Pressure: Negligible (E); 1 mm Hg (M) (739°C) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): Not available Chemistry of Use: Caustic	NaOH Structure: NaOH Boiling Point: 1390°C (M) Density: 2.13 g/mL (M) Flash Point: Not applicable Physical State: Deliquescent orthorhombic white powder Safety Hazard Factors: Reactivity: 1 Flammability: 0 Ignitability: N Corrosivity: Y

Above data are either measured (M) or estimated (E)

Sodium Xylene Sulfonate

CAS# 1300-72-7

Chemical Properties and Information	
Synonyms: benzenesulfonic acid, dimethyl-, sodium salt Molecular weight: 208.09 Melting Point: Not available Water Solubility: Very soluble (E) Vapor Pressure: <10^{-6} mm Hg (E) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Hydrotrope	$C_8H_9NaSO_3$ Structure:  Boiling Point: Not available Density: Not available Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Solvent Naphtha (Petroleum), Heavy Aromatic

CAS# 64742-94-5

Chemical Properties and Information	
Synonyms: Aromatic 150; Comsolv 150 Molecular weight: 128 for naphthalene Melting Point: -80°C (E) Water Solubility: 0.03 g/L (M) for naphthalene Vapor Pressure: 0.5 mm Hg (E) (25°C) $Log_{10}K_{ow}$: 4.45 (M) $Log_{10}K_{oc}$: 4.31 (E) $Log_{10}BCF$: 3.15 (E) Henry's Law: $2.56X10^{-5}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 96 (E) Chemistry of Use: Solvent	$C_{10}H_8$ for naphthalene Structure: Consist chiefly of aromatic hydrocarbons, including small fused-ring compounds such as naphthalene Boiling Point: 150-290°C (E) Density: 0.87 g/mL (E) Flash Point: 38°C (E) Physical State: Liquid Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: Y Corrosivity: N

Above data are either measured (M) or estimated (E)

Solvent Naphtha (Petroleum), Light Aliphatic

CAS# 64742-89-8

Chemical Properties and Information	
Synonyms: VM&P #66; lacolene; rubber solvent; petroleum ether; naphtha; varnish makers' and painters' solvent; VM&P Naphtha Molecular weight: 86 for n-hexane; 112 for ethycyclohexane, for example Melting Point: <-80°C (M) Water Solubility: 0.001 g/L (E) Vapor Pressure: 20 mm Hg (E) (25°C) $Log_{10}K_{ow}$: 3.44 (M) $Log_{10}K_{oc}$: 2.22 (E) $Log_{10}BCF$: 2.18 (E) Henry's Law: $2.55X10^{-1}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): >94 (E) Chemistry of Use: Solvent	Molecular Formula: C_nH_{2n+2} (paraffin) and C_nH_{2n} (cycloparaffin) Structure: Typical structures include normal paraffins, $CH_3(CH_2)_nCH_3$, branched paraffins, and cycloparaffins Boiling Point: 35-160°C (M) Density: 0.7 g/mL (E) Flash Point: 0°C (E) Physical State: Liquid Safety Hazard Factors: Reactivity: 0 Flammability: 3 Ignitability: Y Corrosivity: N

Above data are either measured (M) or estimated (E)

Solvent Naphtha (Petroleum), Light Aromatic

CAS# 64742-95-6

Chemical Properties and Information	
Synonyms: Comsolv 100 Molecular weight: 128 for naphthalene Melting Point: -80°C (E) Water Solubility: 0.03 g/L (M) for naphthalene Vapor Pressure: 0.5 mm Hg (E) (25°C) $Log_{10}K_{ow}$: 3.30 (M) $Log_{10}K_{oc}$: 3.26 (E) $Log_{10}BCF$: 2.28 (E) Henry's Law: $3.70X10^{-4}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): >92 (E) Chemistry of Use: Solvent	$C_{10}H_8$ for naphthalene Structure: Consist chiefly of aromatic hydrocarbons, including small fused-ring compounds such as naphthalene Boiling Point: 135-210°C (E) Density: 0.87 g/mL (E) Flash Point: 38°C (E) Physical State: Liquid Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: Y Corrosivity: N

Above data are either measured (M) or estimated (E)

Solvent Naphtha (Petroleum), Medium Aliphatic

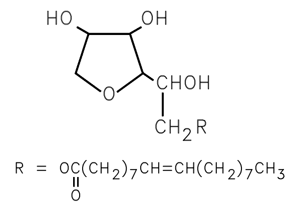
CAS# 64742-88-7

Chemical Properties and Information	
Synonyms: Solvent 140 Molecular weight: 86 for n-hexane; 112 for ethycyclohexane, for example Melting Point: -60°C (M) Water Solubility: 0.001 g/L (E) Vapor Pressure: 1 mm Hg at 25°C (E) $Log_{10}K_{ow}$: 5.64 (M) $Log_{10}K_{oc}$: 3.77 (E) $Log_{10}BCF$: 4.51 (E) Henry's Law: 9.35 atm-m^3/mol (E) POTW Overall Removal Rate (%): 99.98-100 (E) Chemistry of Use: Solvent	C_nH_{2n+2} (paraffin) and C_nH_{2n} (cycloparaffin) Structure: No definite structure. Mixture of normal-, branched-, and cyclo-paraffins. Boiling Point: 176-210°C (M) Density: 0.787 g/mL (M) Flash Point: 60°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: Y Corrosivity: N

Above data are either measured (M) or estimated (E)

Sorbitan, Mono-9-Octadecenoate,

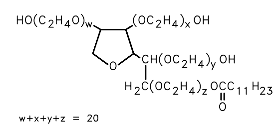
CAS# 1338-43-8

Chemical Properties and Information	
Synonyms: sorbitan mono-oleate, (crillet 4) Molecular weight: 428.44 Melting Point: <20°C (E) Water Solubility: Dispersible (M) Vapor Pressure: $<10^{-6}$ mm Hg (E) $Log_{10}K_{ow}$: 5.89 (E) $Log_{10}K_{oc}$: 2.75 (E) $Log_{10}BCF$: 4.24 (E) Henry's Law: $<1.00X10^{-8}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): 99.98-100 (E) Chemistry of Use: Dispersant	$C_{24}H_{44}O_6$ Structure:  Boiling Point: Not available Density: 1.0 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Sorbitan, Monododecanoate, Poly(Oxy-1,2-Ethanediyl) Derivatives

CAS# 9005-64-5

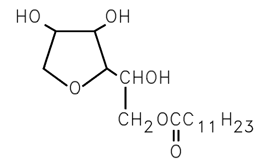
Chemical Properties and Information	
Synonyms: polysorbate - 20; polyoxy ethylene (20) sorbitan monolaurate; Tween 20; Laurate of polyoxyethylenic sorbitan Molecular weight: 1,180 Melting Point: Not available Water Solubility: Completely soluble (M); 1000 g/L (E) Vapor Pressure: $<10^{-6}$ mm Hg (E) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 83-97 (E) Chemistry of Use: Dispersant	$C_{54}H_{114}O_{26}$ Structure:  Boiling Point: Not available Density: 1.1 g/cm^3 (M) Flash Point: 148°C (closed cup) (M) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

Sorbitan, Monolaurate

CAS# 5959-89-7

Chemical Properties and Information

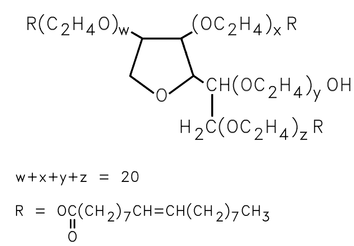
Synonyms: D-glucitol; 1,4-anhydro-, 6-dodecanoate Molecular weight: 358.34 Melting Point: <20°C (E) Water Solubility: Insoluble (M) Vapor Pressure: $<10^{-6}$ mm Hg (E) $Log_{10}K_{ow}$: 3.15 (E) $Log_{10}K_{oc}$: 1.16 (E) $Log_{10}BCF$: 2.17 (E) Henry's Law: $<1.00X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 90-98 (E) Chemistry of Use: Dispersant	$C_{18}H_{34}O_6$ Structure:  Boiling Point: 393°C (M) Density: 1.0 g/cm^3 (E) Flash Point: Not available Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

Sorbitan, Tri-9-Octadecenoate, Poly(Oxy-1,2-Ethanediyl) Derivatives

CAS# 9005-70-3

Chemical Properties and Information

Synonyms: sorbitan tri-oleate (crillet 45) Molecular weight: 1,836 (n=20) Melting Point: Not available Water Solubility: Completely soluble (E) Vapor Pressure: $<10^{-6}$ mm Hg (E) $Log_{10}K_{ow}$: Not available $Log_{10}K_{oc}$: Not available $Log_{10}BCF$: Not available Henry's Law: Not available POTW Overall Removal Rate (%): 99.98-100 (E) Chemistry of Use: Dispersant	$C_{100}H_{188}O_{28}$ (n=20) Structure:  Boiling Point: Not available Density: 1.1 g/cm^3 (E) Flash Point: 160°C (E) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

Soybean Oil, Methyl Ester

CAS# 67784-80-9

Chemical Properties and Information	
Synonyms: soybean based methyl esters Molecular weight: 295 Melting Point: -30°C (E) Water Solubility: Insoluble (E) Vapor Pressure: 0.01 mm Hg (E) $Log_{10}K_{ow}$: 7.80 (E) $Log_{10}K_{oc}$: 4.79 (E) $Log_{10}BCF$: 5.70 (E) Henry's Law: $2.03X10^{-3}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): 94-100 (E) Chemistry of Use: Solvent	$C_{19}H_{36}O_2$and $C_{19}H_{34}O_2$ Structure: $RCOOCH_3$ (R = $C_{17}H_{33}$ or $C_{17}H_{31}$) Boiling Point: Decomposes (E) Density: 0.883 g/cm^3 (E) Flash Point: 160-180°C (E) Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Soybean Oil, Polymerized, Oxidized

CAS# 68152-81-8

Chemical Properties and Information	
Synonyms: oxidized soybean oil Molecular weight: Varies Melting Point: Not available Water Solubility: Insoluble (E) Vapor Pressure: <10^{-5} mm Hg (E) $Log_{10}K_{ow}$: 15.33 (E) $Log_{10}K_{oc}$: 13.73 (E) $Log_{10}BCF$: 11.42 (E) Henry's Law: $1.00X10^{-8}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): 99.98-100 (E) Chemistry of Use:	Molecular formula varies Structure: No definite structure Boiling Point: Decomposes (E) Density: Not available Flash Point: Not available Safety Hazard Factors: Reactivity: 0 Flammability: 1 Ignitability: N

Above data are either measured (M) or estimated (E)

Stoddard Solvent

CAS# 8052-41-3

Chemical Properties and Information	
Synonyms: Rule 66 mineral spirits; quick-dry mineral spirits; 140 solvent; VM&P naphtha; dry cleaners' solvent. Molecular weight: 86 for n-hexane; 112 for ethylcyclohexane, for example Melting Point: -70°C (M) Water Solubility: Insoluble (M) Vapor Pressure: 1 mm Hg at 25°C (E) $Log_{10}K_{ow}$: 5.25 (E) $Log_{10}K_{oc}$: 3.24 (E) $Log_{10}BCF$: 3.58 (E) Henry's Law: 5.3 atm-m^3/mole (E) POTW Overall Removal Rate (%): ≈ 100 (E) Chemistry of Use: Solvent	C_nH_{2n+2} (paraffins), C_nH_{2n} (cycloparaffins) Structure: No definite structure. Mixture of normal-, branched-, and cyclo-paraffins Boiling Point: 157-196°C (M) Density: 0.787 (M) Flash Point: 60°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: Y

Above data are either measured (M) or estimated (E)

Tall Oil, Special

CAS# 68937-81-5

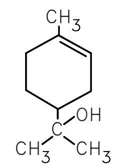
Chemical Properties and Information	
Synonyms: fatty acids, C_{18} and C_{18}-unsatd., methyl esters, methyl stearate, methyl oleate Molecular weight: 296-298 Melting Point: 36-39°C (E) Water Solubility: Insoluble (M) (<0.1 g/L) (E) Vapor Pressure: $<10^{-3}$ mm Hg (E) $Log_{10}K_{ow}$: 7.74 (E) $Log_{10}K_{oc}$: 4.53 (E) $Log_{10}BCF$: 5.65 (E) Henry's Law: $2.00X10^{-2}$ atm-m^3/mole (E) POTW Overall Removal Rate (%): nearly 100 (E) Chemistry of Use: Solvent	$C_{19}H_{36}O_2$ and $C_{19}H_{38}O_2$ Structure: $CH_3(CH_2)_{16}COOCH_3$ and $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOCH_3$ Boiling Point: 325°C (E) Density: 0.88 g/cm^3 (E) Flash Point: 200°C (E) Safety Hazard Factors: Ignitability: N

Above data are either measured (M) or estimated (E)

α-Terpineol

CAS# 98-55-5

Chemical Properties and Information

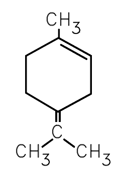
Synonyms: 3-cyclohexene-1-methanol, α,α,4-trimethyl-; p-menth-1-en-8-ol Molecular weight: 154.24 Melting Point: 2°C (M) Water Solubility: Slightly soluble (M) Vapor Pressure: 0.12 mm Hg (M) $Log_{10}K_{ow}$: 3.33 (E) $Log_{10}K_{oc}$: 1.76 (E) $Log_{10}BCF$: 2.30 (E) Henry's Law: $3.15X10^{-6}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): 86-98 (E) Chemistry of Use: Solvent	$C_{10}H_{18}O$ Structure:  Boiling Point: 214-224°C (M) Density: 0.9338 g/cm^3 (M) Flash Point: 90°C (M) Safety Hazard Factors: Reactivity: 0 Flammability: 2 Ignitability: N

Above data are either measured (M) or estimated (E)

Terpinolene

CAS# 586-62-9

Chemical Properties and Information

Synonyms: cyclohexene, 1-methyl-4-(1-methylethylidene)-; p-mentha-1,4(8)-diene Molecular weight: 136.16 Melting Point: Not available Water Solubility: Insoluble (M) Vapor Pressure: 0.49 mm Hg (M) $Log_{10}K_{ow}$: 4.88 (E) $Log_{10}K_{oc}$: 3.12 (E) $Log_{10}BCF$: 3.48 (E) Henry's Law: $6.00X10^{-2}$ atm-m^3/mol (E) POTW Overall Removal Rate (%): 90.06-99.95 (E) Chemistry of Use: Solvent	$C_{10}H_{16}$ Structure:  Boiling Point: 183-185°C (M) Density: 0.864 g/cm^3 (M) Flash Point: 37.2°C (closed cup) (M) Safety Hazard Factors: Ignitability: Y Corrosivity: N

Above data are either measured (M) or estimated (E)

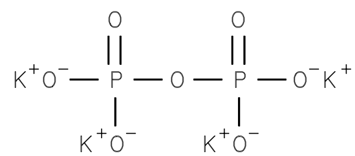
Tetrapotassium Pyrophosphate

CAS# 7320-34-5

Chemical Properties and Information

Synonyms: diphosphoric acid, tetrapotassium salt; TKPP
Molecular weight: 330.34
Melting Point: 1090°C (M)
Water Solubility: 1,870 g/L (M)
Vapor Pressure: <10^{-6} mm Hg (E)
$Log_{10}K_{ow}$: Not available
$Log_{10}K_{oc}$: Not available
$Log_{10}BCF$: Not available
Henry's Law: Not available
POTW Overall Removal Rate (%): 0-25 (E)
Chemistry of Use: Sequestering agent

$K_4O_7P_2$
Structure:



Boiling Point: Decomposes (E)
Density: 2.33 g/cm^3 (M)
Flash Point: Not available
Safety Hazard Factors: Not available

Above data are either measured (M) or estimated (E)

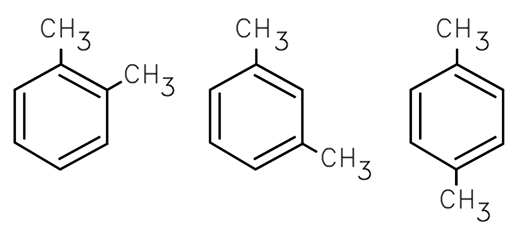
Xylene

CAS# 1330-20-7

Chemical Properties and Information

Synonyms: dimethylbenzene; methyltoluene; xylol
Molecular weight: 106.2
Vapor Pressure: 10 mm Hg (E) (25°C)
Water Solubility: 0.1 g/L (E)
Melting Point: o: -25°C (M)
m: -48°C (M)
p: 13°C (M)
$Log_{10}K_{ow}$: 3.15 (M)
$Log_{10}K_{oc}$: -0.69 (E)
$Log_{10}BCF$: 2.16 (E)
Henry's Law: 1.81X10^{-8} atm-m^3/mole (E)
POTW Overall Removal Rate (%): 94 (E)
Chemistry of Use: Solvent

C_8H_{10}
Structure:



o−xylene m−xylene p−xylene

Boiling Point: 137-140°C (M)
Density: 0.864 g/mL (M)
Flash Point: o: 17°C (M)
m: 29°C (M)
p: 27°C (M)
Physical State: Colorless liquid
Safety Hazard Factors:
Reactivity: 0
Flammability: 3
Ignitability: Y
Corrosivity: N

Above data are either measured (M) or estimated (E)

2.3 HUMAN HEALTH HAZARD INFORMATION

Table 2-4 summarizes human health effects information obtained to date on chemicals used in lithographic blanket washes. Initial literature searches were limited to secondary sources such as EPA's Integrated Risk Information System (IRIS), the National Library of Medicine's Hazardous Substances Data Bank (HSDB), TOXLINE, TOXLIT, GENETOX, and the Registry of Toxic Effects of Chemical Substances (RTECS). The results of these literature searches are in the Administrative Record. These databases are established by other organizations as well as EPA, and are available by computerized online searching. They contain numeric and textual information that was used in developing the human health hazard summaries. These sources are considered secondary and no attempt has been made to verify the information contained in these sources. References typically are made to the database itself except for information taken from abstracts in TOXLINE and TOXLIT; in these cases, the author is cited with a notation to the database included in the text. Additionally, toxicologic data developed under the Office of Pollution Prevention and Toxics' Chemical Testing Program are incorporated in the human health hazard summary. Unpublished data submitted under TSCA §§ 8(d) and 8(e) are being reviewed and will be incorporated as appropriate in the final version of this document.

The "TOX ENDPOINT" column in Table 2-4 lists adverse toxicological effects that have been reported in the literature for animal or human studies. This is simply a qualitative listing of reported effects and does not imply anything about the severity of the effects nor the doses at which the effects occur. Furthermore, an entry in this column does not necessarily imply that EPA has reviewed the reported studies or that EPA concurs with the authors' conclusions. Toxicological effects are abbreviated as follows:

car = carcinogenicity
chron = chronic effects not otherwise listed. Target organ toxicity such as liver and kidney effects may be manifested by changes in size, structure, or function of the organ. For example, organ weight changes, changes in cell size or shape, or changes in enzyme activity associated with a particular organ are commonly reported endpoints in chronic toxicity studies.
dev = developmental toxicity, i.e., adverse effects on the developing embryo, fetus, or newborn
gene = genetic toxicity, such as point mutations or chromosomal aberrations
g.i. = gastrointestinal effects
hema = hematological effects, i.e., adverse effects on blood cells. Blood effects may involve changes in the number of blood cells as well as effects on their structure or function.
neuro = adverse neurological effects; includes a wide range of effects from serious neuropathology to transient CNS depression commonly seen with high exposures to solvents
repro = reproductive toxicity, i.e., adverse effects on the ability of either males or females to reproduce
resp = respiratory effects
LD_{50} = the dose (usually from a single dosing or short-term exposure) lethal to 50% of a test population

The "RfD/RfC" is the EPA Reference Dose (RfD) or Reference Concentration (RfC). The RfD is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious noncancer effects during a lifetime. The RfD is usually expressed as an oral dose in mg/kg/day. The RfC is an analogous value for continuous inhalation exposure, usually expressed in mg/m^3. The RfD/RfC values listed in Table 2-4 are used in the Hazard Quotient calculations shown in Section 3.4.

The "NOAEL/LOAEL" is the no-observed-adverse-effect level or the lowest-observed-adverse-effect level, respectively. The NOAEL is an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects in the exposed population. The LOAEL is the lowest exposure level at which adverse effects have been shown to occur. The NOAEL/LOAEL values listed in Table 2-4 are used in the Margin of Exposure calculations shown in Section 3.4.

Table 2-4. Human Health Hazard Summary

Chemical Name	Ref No.[*]	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Alcohols, C_{12}-C_{15}, ethoxylated	33	68131-39-5	dermal				
			inhalation	neuro, g.i.			toxic effects based on acute or subacute (no. of doses not specified) oral study; the surfactant activity of this chemical will result in lung and eye irritation
Benzene, 1, 2, 4-trimethyl-	21	95-63-6	dermal			L - 5.71 mg/kg/day (urinary tract and enzyme effects)[a]	Included in TSCA Section 4 testing of C_9-hydrocarbons; 8(e) data available
			inhalation	neuro, chron[b]		L - 20 mg/m^3 (urinary tract and enzyme effects)	
Benzenesulfonic acid, dodecyl-	21	27176-87-0	dermal				
			inhalation				oral LD_{50} - 650 mg/kg[c]
Benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol	31	26836-07-7	dermal	g.i.		N - 5 mg/kg/day (dermal)	data from dodecylbenzenesulfonic acid, triethanolamine salt studies
			inhalation				
Benzenesulfonic acid, dodecyl- compounds with 2-propanamine	32	26264-05-1	dermal				SAT report[k]; the surfactant activity of this chemical will result in lung irritation
			inhalation				
Benzenesulfonic acid, (tetrapropenyl)-, compounds with 2-propanamime	32	157966-96-6	dermal	neuro (amine salt)			SAT report; the surfactant activity of the chemical will result in lung irritation
			inhalation				
Benzenesulfonic acid, C_{10}-C_{16} -alkyl derivatives, compounds with 2-propanamine	32	68584-24-7	dermal	sensitizer			SAT report; the surfactant activity of the chemical will result in lung irritation
			inhalation				

Chemical Name	Ref No.[*]	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Butyrolactone	21	96-48-0	dermal			L - 500 mg/kg/day[d] (fetotoxicity)	
			inhalation	dev, repro, resp		L - 500 mg/kg/day[d] (fetotoxicity)	toxic effects based on oral studies
Cumene	29	98-82-8	dermal	chron, g.i.	0.4 mg/kg/day (chron)[d]		toxic effects based on acute or subacute study (no. of doses not specified)
			inhalation	dev, repro, neuro, chron, resp	1.4 mg/m^3 (chron)[d]		TSCA §4, SIDS data available
Diethanolamine	17	111-42-2	dermal	repro, neuro, chron, g.i., hema		L - 32 mg/kg/day (chron, hema)	
			inhalation	repro, neuro, chron, hema		L - 14 mg/kg/day (chron, hema, decreased body weight gain)[d]	toxic effects based on oral studies; TSCA §4 review, SIDS dossier available
Diethylene glycol monobutyl ether	27 28	112-34-5	dermal	hema		N - 191 mg/kg/day	TSCA §4, SIDS reviews available
			inhalation	dev, repro, chron, hema		N - 14 ppm	no effects observed
Dimethyl adipate	4	627-93-0	dermal			L - 5.71 mg/kg/day (resp)[a]	TSCA §4 review available
			inhalation	resp		L - 20 mg/m^3 (resp)	toxic effects based on study using mixture of dibasic esters
Dimethyl glutarate	4	1119-40-0	dermal			L - 5.71 mg/kg/day (resp)[a]	TSCA §4 review available
			inhalation	resp		L - 20 mg/m^3 (resp)	toxic effects based on study using mixture of dibasic esters

Chemical Name	Ref No.*	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Dimethyl succinate	4	106-65-0	dermal			L - 5.71 mg/kg/day (resp)[a]	TSCA §4 review available
			inhalation	resp		L - 20 mg/m^3 (resp)	toxic effects based on study using mixture of dibasic esters
Dipropylene glycol monobutyl ether	21	29911-28-2	dermal	neuro			dermal LD_{50} - 5860 µL/kg[c]
			inhalation				oral LD_{50} - 1620 µg/kg[c]
Dipropylene glycol methyl ether	9 30	34590-94-8	dermal			N - (5 mL/kg) 4750 mg/kg/day	TSCA §4 dermal testing planned
			inhalation	neuro, chron, resp		L - (200 ppm) 1213 mg/m3 (increased kidney weight)[e]	
Distillates (petroleum), hydrotreated middle	22	64742-46-7	dermal				equivocal skin tumor response in mice through dermal exposure, positive Ames assay in multiple strains, with and without activation. No increased frequency of micronuclei in mouse bone marrow cells
			inhalation				
Ethoxylated nonylphenol	13 25	9016-45-9 26027-38-3 68412-54-4	dermal	chron, resp, g.i.		N - 500 mg/kg/day (dev/repro)	possible endocrine disrupter
			inhalation	dev, chron		N- 30 mg/kg/day[d]	
Ethylenediaminetetraacetic acid, tetrasodium salt	32	64-02-8	dermal				SAT report - low to moderate concern; poor skin absorption
			inhalation				
Fatty acids, methyl esters[l]	32	68002-82-4 67762-38-3 61790-69-0	dermal				SAT report; the surfactant activity of this chemical will result in eye and lung irritation
			inhalation				
Hydrocarbons, terpene processing by-products	32	68956-56-9	dermal				SAT report - low concern
			inhalation				

Chemical Name	Ref No.[*]	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
d-Limonene	16	5989-27-5	dermal			N - 250 mg/kg/day (increased hepatocyte nuclei and cytomegaly in male mice)[d]	
			inhalation	dev, repro, neuro, chron, hema		N - 250 mg/kg/day (increased hepatocyte nuclei and cytomegaly in male mice)[d]	
Linalool	18	78-70-6	dermal			L - 500 mg/kg/day (increased liver weight)[d]	
			inhalation	neuro, chron		L - 500 mg/kg/day (increased liver weight)[d]	toxic effects based on oral study
Mineral Spirits (light hydrotreated)	7 20	64742-47-8	dermal				dermal LD_{50} >5000mg/kg (rabbits)[c] limited evidence for carcinogenicity (IARC); appearance of papillomas at 50 mg for 80 weeks, no control data
			inhalation				oral LD_{50} - 8532 mg/kg[c]
N-Methylpyrrolidone	1 10	872-50-4	dermal	dev, repro		N - 237 mg/kg/day (dev, repro)	TSCA §4 review available
			inhalation	chron, resp, hema		N - (10 ppm) 40.5 mg/m^3[e] (chron)	
Naphtha (petroleum), hydrotreated heavy	32	64742-48-9	dermal				SAT report - low moderate concern
			inhalation	resp, neuro			SAT report - low moderate concern; lung irritation

Chemical Name	Ref No.*	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Nerol	22	106-25-2	dermal				SAT report; dermal LD_{50} > 5000 mg/kg[c]
			inhalation	dev			SAT report; oral LD_{50} - 4500 mg/kg[c]
Oxirane, methyl, polymer with oxirane, monodecyl ether	32	37251-67-5	dermal				SAT report
			inhalation				
2-Pinanol	32	473-54-1	dermal				SAT report
			inhalation				
Plinols	32	72402-00-7	dermal				no information available
			inhalation				no information available
Polyethoxylated isodecyloxypropylamine	32	68478-95-5	dermal				SAT report
			inhalation				
Poly(oxy-1,2-ethanediyl), α -hexyl-ω-hydroxy-	32	31726-34-8	dermal				SAT report
			inhalation				
Propanoic acid, 3-ethoxyethyl ester	22	763-69-9	dermal				dermal LD_{50} - 10000 mg/kg
			inhalation				oral LD_{50} - 5000 mg/kg[c]
Propylene glycol	11 21 29	57-55-6	dermal		20 mg/kg/day (hema)[d]		no evidence of carcinogenic effects by dermal exposure; questionably positive Salmonella test (host-mediated) with Strains G46 and TA1530; positive for chromosome aberrations in hamster fibroblasts, negative in other mammalian cells
			inhalation	chron, hema	20 mg/kg/day (hema)		toxic effects based on oral studies; no evidence of carcinogenic effects by oral exposure

Chemical Name	Ref No.*	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Propylene glycol monobutyl ether	6 15	5131-66-8	dermal			N - 11.40 mg/kg/day	no systemic effects at highest dose
			inhalation	chron, g.i.		N - 400 mg/kg/day[d,f]	toxic effects based on oral studies
Sodium bis(ethylhexyl) sulfosuccinate	12	577-11-7	dermal			N - 50 mg/kg/day [d] (repro/dev)	sensitizer
			inhalation	dev, neuro, g.i.		N - 50 mg/kg/day[d] (repro/dev)	toxic effects based on oral studies
Sodium hydroxide	32	1310-73-2	dermal	corrosive			
			inhalation	resp			
Sodium xylene sulfonate	32	1300-72-7	dermal				SAT report
			inhalation				
Solvent naphtha (petroleum), heavy aromatic	32	64742-94-5	dermal				SAT report - moderate concern
			inhalation				SAT report - moderate concern
Solvent naphtha (petroleum), light aliphatic	32	64742-89-8	dermal	hema		N - 370 mg/kg/day[a] (hema)	SAT report
			inhalation			1300 mg/m^3 (hema)	
Solvent naphtha (petroleum), light aromatic	26	64742-95-6	dermal			L - 140 mg/kg/day (repro, dev)[a,g]	
			inhalation	dev, repro		L - (100 ppm) 491 mg/m^3 (repro, dev)[e,g]	
Solvent naphtha (petroleum), medium aliphatic	5	64742-88-7	dermal	neuro, resp		L - 481 mg/kg/day (increased leucocytes)[a,h]	
			inhalation	neuro, chron, resp, hema		L - (294 ppm) 1683 mg/m^3[e] (increased leucocytes)[h]	

Chemical Name	Ref No.*	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
Sorbitan, mono-9-octadecanoate	8	1338-43-8	dermal			N - 125 mg/kg/day (liver, kidney effects)[d]	
			inhalation	chron, g.i., hema		N - 125 mg/kg/day (liver, kidney effects)[d]	toxic effects based on oral studies
Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives	19	9005-64-5	dermal			N - 500 mg/kg/day (maternal tox/repro)[d]	
			inhalation	chron, g.i., hema		N - 500 mg/kg/day (maternal tox/repro)	toxic effects based upon oral studies
Sorbitan, monolaurate	32	5959-89-7	dermal				SAT report
			inhalation	chron, g.i., hema			
Sorbitan, tri-9-octadecanoate, poly(oxy-1,2-ethanediyl) derivatives	32	9005-70-3	dermal				SAT report
			inhalation	chron, g.i., hema			
Soybean oil, methyl ester	32	67784-80-9	dermal				SAT report
			inhalation				
Soybean oil, polymerized, oxidized	32	68152-81-8	dermal				SAT report
			inhalation				
Stoddard solvent	2	8052-41-3	dermal	chron, g.i., hema		L - 137 mg/kg/day (hema)[a,i]	
			inhalation	dev, neuro, chron, resp, g.i.		L - (84 ppm) 481 mg/m^3 (hema)[e,i]	
Tall oil, special	32	68937-81-5	dermal				SAT report
			inhalation				

Chemical Name	Ref No.*	CAS No.	Worker Exposure	Toxicity Endpoint	RfD/RfC	NOAEL (N) or LOAEL (L)	Comment
α-Terpineol	21	98-55-5	dermal				SAT report - low moderate concern
			inhalation				oral LD_{50}s - 5170 mg/kg (rats) and 1208 mg/kg (mice) (mice-RTECS Search, 1995)
Terpinolene	21	586-62-9	dermal				SAT report; oral LD_{50} - 4390 mg/kg (rats)[c]
			inhalation				
Tetrapotassium pyrophosphate	23	7320-34-5	dermal			N - 1250 mg/kg/day (chron)[d,j]	
			inhalation	chron		N - 1250 mg/kg/day (chron)[j]	toxic effects based on oral studies
Xylene	3 14 29	1330-20-7	dermal		2 mg/kg/day (neuro)[d]	L - 150 mg/kg/day (increased liver weight)[d]	TSCA §4 review available
			inhalation	dev, neuro, chron, resp	(2 mg/kg/day) 7 mg/m^3 (neuro)[d]	L - 50 mg/m^3 (dev)	RfD based on oral study

[a] Dermal NOAEL/LOAEL or RfD based upon inhalation data
[b] Chron - refers to chronic effect not otherwise listed; commonly includes target organ toxicity such as liver and kidney effects
[c] Available LD50's given only for those chemicals for which no other toxicity information was found
[d] Inhalation or dermal LOAEL/NOAEL or RfD based upon oral data
[e] Original data given in ppm, converted to mg/m^3 using the following conversion:

$$mg/m^3 = \frac{ppm \times molecular\ weight\ (grams)}{24.45}$$

[f] NOAEL based upon subacute study
[g] Molecular weight of 120 based upon C9 fraction
[h] Molecular weight of 40 based upon average molecular weight of components
[i] Molecular weight of 140 based upon average molecular weight of components
[j] For rats: ppm in diet x 0.05 = mg/kg/day
[k] SAT reports are generated by the OPPT Structure-Activity Team to predict toxicity based on analog data and/or structure-activity considerations.
[l] Fatty acids refers to: Fatty acids, C_{16}-C_{18}, methyl esters; Fatty acids, C_{16}-C_{18} and C_{18}-unsatd., compounds with diethanolamine; and, Fatty acids, tall oil, compounds with diethanolamine

* The following references (with the exception of Nos. 24, 26, 27, 28, 29, and 32) were developed from online database searches conducted between February and May 1995. The toxicity data from these references are reported in Table 2-3 and in most cases the primary references were not reviewed.

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2.4 ENVIRONMENTAL HAZARD INFORMATION

The chemicals in lithography are divided into three groups: (1) discrete organic chemicals, (2) petroleum products, and (3) inorganic chemicals. While the assessment process is the same for all three groups, the methodology used to provide estimates of the aquatic toxicity of the chemicals varies.

2.4.1 Methodology

The EPA Environmental Effects Branch uses a standard assessment process (see Appendix A) for assessing the hazards of chemicals to the aquatic environment. The process has been described in several publications, both inside and outside the Agency. A summary of the hazard assessment process and references are in Appendix A. The methodology involves the development of a standard hazard profile for each chemical consisting of three acute toxicity values and three chronic values for aquatic species. The standard hazard profile consists of the following toxicity values:

- Fish acute value (usually a fish 96-hour LC_{50} value)
- Aquatic invertebrate acute value (usually a daphnid 48-hour LC_{50} value)
- Green algal toxicity value (usually an algal 96-hour EC_{50} value)
- Fish chronic value (usually a fish 28-day early life stage no effect concentration (NEC))
- Aquatic invertebrate chronic value (usually a daphnid 21-day NEC)
- Algal chronic value (usually an algal 96 hour NEC value for biomass)

For the acute values, the LC_{50} (mortality) (EC_{50}) (effects) refers to the concentration that results in 50 percent of the test organisms affected at the end of the specified exposure period. The chronic values represent the concentration of the chemical that results in no statistically significant effects on the test organism following a chronic exposure.

The toxicity values may be obtained from the results of standard toxicity tests reported to the Agency, published in the literature, or estimated using predictive techniques. For this study, discrete organic chemicals were assessed using predictive equations called Structure Activity Relationships (SARs) to estimate the inherent toxicity of these chemicals to aquatic organisms. The literature sources that were searched to confirm these estimates are located in the Administrative Record. No data were found to conflict with these estimates. The toxicity values are for the discreet chemical only; interactions between chemicals within a formulation are not considered.

Although measured values are preferred, in the absence of test data, SAR estimates, if available for the chemical class, can be used. The predictive equations, i.e., quantitative structure-activity relationships, are used in lieu of test data to estimate toxicity values for aquatic organisms within a specific chemical class. The equations are derived from correlation and linear regression analysis based on measured data, however, the confidence interval associated with the equation is not used to provide a range of toxicity values. Thus, the hazard profile may consist of only measured data, only predicted values, or a combination of both. Also, the amount of data in the hazard profile may range from a minimum of one acute or chronic value to the full compliment of three acute values and three chronic values.

Some petroleum products such as mineral spirits and solvent naphtha are mixtures and do not lend themselves readily to the standard hazard assessment process using SARs. The chemical constituents and the percentage of each in the mixture varies. The constituents in these products include linear and branched paraffins, and cyclic paraffins with the total number of carbons varying between 5 and 16. The toxicity of the petroleum products were determined by estimating the toxicity of each individual constituent. Absent adequate description and characterization, the assumption is made that each component is present as an equal percentage in the product and the geometric mean of the range of estimates provides the best estimate of the toxicity. These assumptions many not be representative of the mixture currently on the market, but can be used for screening level hazard assessments. The toxicity of the individual components of the petroleum products is based on tests using pure samples. The potential by-products or impurities of petroleum distillation that are typically found in these mixtures were not incorporated in this hazard assessment.

The concentration of concern was also derived for each chemical. This value is derived by dividing the lowest of the three chronic values by a factor of 10. If the discharge of a chemical to the aquatic environment results in a concentration equal to or greater than the concern concentration set, then the chemical would be hazardous to aquatic organisms.

Assessment factors were used to incorporate the concept of uncertainty into the concern concentrations. Assessment factors account for laboratory tests versus field data and measured versus estimated data, as well as species sensitivity. In general, if only one toxicity value is available, there is a large uncertainty about the applicability of this value to other organisms in the environment and a large assessment factor, i.e., 1000, is applied to cover the breadth of sensitivity known to exist among and between organisms in the environment. Conversely, the more information that is available results in more certainty about the toxicity values, and requires the use of a smaller assessment factor. For example, if toxicity values are derived from field tests, then an assessment factor of 1 is used. Assessment factors of 1, 10, 100 and 1000 are generally applied for chronic risk depending on the amount and type of toxicity data in the hazard profile.

2.4.2 Results

The results of the estimated aquatic toxicity determinations are summarized in Table 2-5. The chemicals are listed alphabetically. No valid published literature were found to conflict with the estimated values. The full literature searches conducted are available in the Administrative Record. For each chemical, the estimated toxicity values in mg/L (ppm) for acute and chronic effects of fish, daphnid and algae are given. The last column shows the concern concentration set for the chemical in the water. Based on the methodology described in the previous section, the hazard potential of the various products are discussed in the following paragraphs.

<u>Mineral Spirits</u>

Mineral spirits consist of linear and branched paraffins and cyclic paraffins. Based on the information provided, the assessment was based on the estimated toxicity for n-hexane and ethylcyclohexane. The linear form of n-hexane is approximately two times more toxic than cyclic hexane. The lowest chronic value for n-hexane is 0.004 mg/L for fish and the lowest chronic value for ethylcyclohexane is 0.09 mg/L for fish.

<u>Naphtha Solvents</u>

The monomers associated with the various naphtha mixtures include linear and branched paraffins, cyclic paraffins and aromatics such as naphthalene. The carbon chain lengths vary from product to product and span the range from 5 to 16.

Table 2-5. Estimated Aquatic Toxicity Values of Blanket Wash Chemicals Based on SAR Analysis (mg/L)

Chemical	Acute Toxicity			Chronic Toxicity			Concern Concentration
	Fish	Invert	Algal	Fish	Invert	Algal	
Alcohols, C_{12}-C_{15}, ethoxylated	1.0	1.0	1.0	0.1	0.1	0.1	0.01
Benzene, 1,2,4-trimethyl	0.97	1.2	0.84	0.17	0.15	0.28	0.02
Benzenesulfonic acid, dodecyl	2.6	2.6	0.007	0.4	0.4	0.005	0.001
Benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol	2.6	2.6	30.0	0.4	0.3	10.0	0.03
Benzenesulfonic acid, dodecyl-,compounds with 2-propanamine	2.6	2.6	0.007	0.4	0.4	0.005	0.001
Benzenesulfonic acid, (tetrapropenyl)-, compounds with 2-propanamine	2.6	2.6	0.007	0.4	0.4	0.005	0.001
Benzenesulfonic acid, C_{10}-C_{16}-alkyl derivatives, compounds with 2-propanamine	0.75	0.75	0.002	0.12	0.12	0.001	0.001
Butyrolactone	140	>1000	>1000	14	>100	>100	1.4
Cumene	2.1	2.6	1.8	0.37	0.28	0.48	0.03
Diethanolamine	>1000	220	130	>100	22	12.8	1.3
Diethylene glycol monobutyl ether	>1000	>1000	860	140	40	40	4.0
Dimethyl adipate	140	>1000	11	14	>100	8.4	0.84
Dimethyl glutarate	245	>1000	18	24	>100	13.6	1.4
Dimethyl succinate	165	>1000	12.5	16	>100	9.3	0.9
Dipropylene glycol monobutyl ether	400	410	250	50	17	19	1.7
Dipropylene glycol methyl ether	>1000	>1000	>1000	184	149	877	14.9
Distillates (petroleum), hydrotreated, middle	1.8	2.2	1.5	0.31	0.23	0.38	0.02
Ethoxylated nonylphenol	2.0	2.0	2.0	0.2	0.2	0.2	0.001[1]
Ethylenediaminetetraacetic acid, tetrasodium salt	430	100	3.0	10.0	23.0	0.88	0.09
Fatty acids, C_{16}-C_{18} methyl esters	*[2]	*	*	*	*	*	*
Fatty acids, C_{16}-C_{18} and C_{18}-unsatd, compounds with diethanolamine	140	120	70	20	20	40	2.0
Fatty acids, tall oil, compounds with diethanolamine	160	200	100	20	30	20	2.0
Hydrocarbons, terpene processing by-products	0.86	1.1	0.76	0.16	0.14	0.27	0.01
d-Limonene	0.81	1.0	0.72	0.15	0.14	0.27	0.01
Linalool	45	50	32	6.1	3.0	4.1	0.3
Mineral spirits (light hydrotreated)	1.8	2.2	1.5	0.31	0.23	0.38	0.02
N-Methylpyrrolidone	1000	1000	1000	100	370	260	30
Naptha (petroleum), hydrotreated heavy	*	*	*	0.006	0.013	0.03	0.001
Nerol	28	31	20	4.0	2.1	3.0	0.21
Oxirane, methyl, polymer with oxirane, monodecyl ether	16	16	20	1.6	1.6	5.0	0.16
2-Pinanol	31	35	22	4.4	2.3	3.2	0.23
Pinols	170	180	112	21	8.5	10.0	0.85
Polyethoxylated isodecyloxypropylamine	13	13	13	1.3	1.3	1.3	0.13
Poly(oxy-1,2-ethanediyl), α-hexyl-ω-hydroxy	320	320	300	32	32	40	3.2

Chemical	Acute Toxicity			Chronic Toxicity			Concern Concen-tration
	Fish	Invert	Algal	Fish	Invert	Algal	
Propanoic acid, 3-ethoxy-, ethyl ester	60	650	4.7	6.0	70	3.5	0.35
Propylene glycol	>1000	>1000	>1000	>100	>100	>100	>10
Propylene glycol monobutyl ether	>1000	>1000	>1000	>100	>100	>100	>100
Sodium bis(ethylhexyl) sulfosuccinate	3	3	3	5	5	3	0.05
Sodium hydroxide	>1000	>1000	>1000	>100	>100	>100	>10
Sodium xylene sulfonate	>1000	>1000	>1000	>100	>100	>100	>10
Solvent naphtha (petroleum), heavy aromatic	0.6	0.77	0.55	0.12	0.12	0.23	0.012
Solvent naphtha (petroleum), light aliphatic	3.3	3.9	2.6	0.53	0.36	0.58	0.036
Solvent naphtha (petroleum), light aromatic	5.5	6.5	4.4	0.88	0.59	0.93	0.059
Solvent naphtha (petroleum), medium aliphatic	*	*	*	0.001	0.002	0.005	0.001
Sorbitan, mono-9-octadecenoate	20	20	20	3	3	5	0.3
Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives	20	20	20	3	3	3	0.3
Sorbitan, monolaurate	11	20	0.93	2	3	0.69	0.07
Sorbitan, tri-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivatives	20	20	20	3	3	3	0.3
Soybean oil, methyl ester	*	*	*	*	*	*	*
Soybean oil, polymerized, oxidized	*	*	*	*	*	*	*
Stoddard solvent	1.8	2.2	1.5	0.31	0.23	0.38	0.02
Tall oil, special	*	*	*	*	*	*	*
α-Terpineol	33	37	24	4.7	2.4	3.3	0.24
Terpinolene	0.81	1.0	0.72	0.15	0.14	0.26	0.014
Tetrapotassium pyrophosphate	>100	>100	<1.0	>10	>10	0.06	0.006
Xylene	3.5	4.1	2.8	0.57	0.40	0.64	0.04

[1] There is a concern that this chemical may degrade to nonylphenol. Evidence suggests that nonylphenol may be an endocrine disrupter. Until such time as conclusive evidence resolves this issue, the concern concentration is set at 0.001 mg/L.
[2] * = No effects expected in a saturated solution during prescribed exposure period.

For the purpose of an overall assessment, the listed chemicals can be ranked according to the estimated chronic value. This hazard ranking, developed by the EPA Environmental Effects Branch, is based on scoring the chemicals as High, Moderate or Low concern for chronic effects according to the following criteria:

≤ 0.1 mg/L . . . . High
≥ 0.1 to ≤ 10 mg/L . . . . Moderate
> 10 mg/L . . . . Low

See Appendix A for the basis and citations supporting these criteria and hazard rankings.

The results of this ranking are summarized in Table 2-6. The chemicals are ranked from the highest hazard potential to the lowest, based on lowest of the three estimated chronic values for each chemical. The petroleum products are rated as high hazard to aquatic organisms and the concern is for chronic effects. This relative ranking of toxicity provides guidance to the selection and use of chemicals that are less hazardous to aquatic organisms. In addition to this ranking system used by OPPT, other aquatic hazard ranking systems exist that could be applied.

Table 2-6. Environmental Hazard Ranking of Blanket Wash Chemicals[1]

Chemical	CAS Number	Lowest Chronic Value (mg/L)	Hazard Rank
Ethoxylated nonylphenol	various given		H[2]
Benzenesulfonic acid, C_{10}-C_{16}-alkyl derivatives, compounds with 2-propanamine	68584-24-7	0.001	H
Solvent naphtha (petroleum), medium aliphatic	64742-88-7	0.001	H
Benzenesulfonic acid, dodecyl-	27176-87-0	0.005	H
Benzenesulfonic acid, dodecyl,(tetrapropenyl)-, compounds with 2-propanamine	157966-96-6	0.005	H
Benzenesulfonic acid, dodecyl-, compounds with 2-propanamine	26264-05-1	0.005	H
Naphtha (petroleum), hydrotreated heavy	64742-48-9	0.006	H
Alcohols, C_{12}-C_{15}, ethoxylated	68131-39-5	0.1	H
Solvent naphtha (petroleum), heavy aromatic	64742-94-5	0.12	M
Hydrocarbons, terpene processing by-products	68956-56-0	0.14	M
d-Limonene	5989-27-55	0.140	M
Terpinolene	586-62-95	0.140	M
Tetrapotassium pyrophosphate	7320-34-57	0.140	M
Benzene, 1,2,4-trimethyl	95-63-69	0.150	M
Stoddard solvent	8052-41-38	0.230	M
Mineral spirits, light hydrotreated	64742-47-8	0.23	M
Distillates (petroleum), hydrotreated. middle	64742-46-7	0.23	M
Cumene	98-82-8	0.28	M

Chemical	CAS Number	Lowest Chronic Value (mg/L)	Hazard Rank
Benzenesulfonic acid, dodecyl-, compounds with 2-aminoethanol	26836-07-7	0.30	M
Solvent naphtha (petroleum), light aliphatic	64742-89-8	0.36	M
Xylene	1330-20-7	0.4	M
Sodium bis(ethylhexyl) sulfosuccinate	577-11-7	0.5	M
Solvent naphtha (petroleum), light aromatic	64742-95-6	0.59	M
Sorbitan, monolaurate	5959-89-7	0.69	M
Ethylenediaminetetraacetic acid, tetrasodium salt	64-02-8	0.88	M
Polyethoxylated isodecyloxypropylamine	68478-95-5	1.3	M
Oxirane, methyl, polymer with oxirane, monodecyl ether	37251-67-5	1.6	M
Nerol	106-25-2	2.1	M
2-Pinanol	473-54-1	2.3	M
α-Terpineol	98-55-5	2,4	M
Sorbitan, mono-9-octadecenoate	1338-43-8	3.0	M
Linalool	78-70-6	3.0	M
Sorbitan, tri-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivatives	9005-70-3	3.0	M
Sorbitan, monododecanoate, poly(oxy-1,2-ethanediyl) derivatives	9005-64-5	3.0	M
Propanoic acid, 3-ethoxy-, ethyl ester	763-69-9	3.5	M
Dimethyl adipate	627-93-0	8.4	M
Pinols	72402-00-7	8.5	M
Dimethyl succinate	106-65-0	9.3	M
Diethanolamine	111-42-2	13	L
Dimethyl glutarate	1119-40-0	13	L
Butyrolactone	96-48-0	14	L
Dipropylene glycol monobutyl ether	29911-28-2	17	L
Propylene glycol monobutyl ether	5131-66-8	20	L
Fatty acids, C_{16}-C_{18}, compounds with diethanolamine	68002-82-4	20	L
Fatty acids, tall oil, compounds with diethanolamine	61790-69-0	20	L
Poly(oxy-1,2-ethanediyl), α-hexyl- -hydroxy	31726-34-8	32	L
Diethylene glycol monobutyl ether	112-34-5	40	L
Propylene glycol	57-55-6	100	L
Sodium xylene sulfonate	1300-72-7	100	L

Chemical	CAS Number	Lowest Chronic Value (mg/L)	Hazard Rank
Sodium hydroxide	1310-73-2	100	L
N-Methylpyrrolidone	872-50-4	100	L
Dipropylene glycol methyl ether	34590-94-8	149	L
Tall oil, special	68937-81-5	*[3]	L
Fatty acids, C_{16}-C_{18}, methyl esters	67762-38-3	*	L
Soybean oil, methyl esters	67784-80-9	*	L
Soybean oil, polymerized, oxidized	68152-81-8	*	L

[1] Ranking based on the lowest estimated chronic value; H = High, M = Moderate, L = Low.
[2] There is a concern that this chemical may degrade to nonylphenol. Evidence suggests that nonylphenol may be an endocrine disrupter. Until such time as conclusive evidence resolves this issue, a "high" aquatic hazard ranking is automatically assigned whenever a compound contains nonylphenol.
[3] * = No effects in a saturated solution during the prescribed test duration.

2.5 FEDERAL REGULATORY STATUS

This section describes the federal environmental regulations that may affect the use of blanket wash chemicals. Information on the OSHA PELs is provided for informational purposes only. Discharges of blanket wash chemicals may be restricted by air, water and solid waste regulations; in addition, facilities may be required to report releases of some blanket wash products subject to the federal Toxic Release Inventory (TRI) program. Table 2-7 identifies federal regulations that govern releases of specific blanket wash chemicals; in addition, emissions or disposal of some chemicals may be regulated under general provisions. **This discussion of environmental statutes potentially affecting blanket wash chemicals is intended for information purposes only. Therefore, it should not be relied on by companies in the printing industry to determine applicable regulatory requirements.**

Table 2-7. Blanket Wash Use Cluster Chemicals Which Trigger Federal Environmental Regulations[a]

Chemical	CAS#	CWA 311 RQ (lbs)	CAA 112B Hazardous Air Pollutant	CERCLA RQ (lbs)	SARA 313 (TRI)	OSHA PEL (ppm)[b]	RCRA
Benzene, 1,2,4-trimethyl	95-63-6				X		
Cumene	98-82-8		X	5,000	X	50	U055
Diethanolamine	111-42-2		X		X		
Ethylene glycol ethers[c]	see below		X		X	100[d]	
Dodecylbenzene sulfonic acid	27176-87-0	1,000		1,000			
N-Methylpyrrolidone	872-50-4				X		
Sodium bis(ethylhexyl) sulfosuccinate	577-11-7					2[e]	
Sodium hydroxide	1310-73-2	1,000		1,000		2[e]	
Stoddard solvent	8052-41-3					100	
Xylene	1330-20-7	1,000	X	1,000	X	100	U239

[a] See following pages for a description of each acronym and regulation.
[b] Permissible Exposure Limit (PEL) as an eight-hour Time Weighted Average concentration (ppm).
[c] The generic chemical category Glycol ethers is listed as a CAA 112B Hazardous Air Pollutant (HAP) and on SARA 313 TRI. The only glycol ether found in these blanket washes that is considered a HAP is diethylene glycol monobutyl ether (CAS No. 112-34-5). The propylene glycol ethers are not included in the glycol ether category under this law and are not considered HAPs.
[d] Dipropylene glycol methyl ether has a PEL of 100 ppm.
[e] OSHA ceiling value.

The applicability of many federal regulations is determined in part by the chemicals being used at a facility. This section covers chemicals that the printing industry has identified as being used in the lithographic blanket wash process. However, individual facilities have their own chemical use patterns, which means that a particular facility may use chemicals that are not listed on Table 2-7, or may use some but not all of them. As a result, each facility must identify the universe of rules that apply to it by examining the regulations themselves.

This section only discusses federal environmental statutes. However, implementation of many federal programs is delegated to states that have programs at least as stringent as the applicable federal program. Thus, even where federal regulations apply, state laws may impose additional requirements that are not addressed here. There may also be state or local requirements where no federal regulations exist. This section provides an overview of federal regulations affecting the lithography sector of the commercial printing industry and of the specific chemicals used in the blanket wash use cluster that may trigger particular regulatory requirements.

<u>Clean Water Act</u>

The Clean Water Act (CWA) is the basic Federal law governing water pollution control in the United States today.

Part 116 of the Federal Water Pollution Control Act (FWPCA) designates hazardous substances under Section 311(b)(2)(a) of the Clean Water Act, and Part 117 of the FWPCA establishes the *Reportable Quantity* (RQ) for each substance listed in Part 116. When an amount equal to or in excess of the RQ is discharged, the facility must provide notice to the Federal government of the discharge, following Department of Transportation requirements set forth in 33 Code of Federal Regulations (CFR) 153.203. This requirement does not apply to facilities that discharge the substance under a National Pollution Discharge Elimination System (NPDES) permit or a Part 404 Wetlands (dredge and fill) permit, or to a Publicly Owned Treatment Works (POTW), as long as any applicable effluent limitations or pretreatment standards have been met.

The NPDES permit program contains regulations governing the discharge of pollutants to waters of the United States. The NPDES program requires permits for the discharge of "pollutants" from any "point source" into "navigable waters". The Clean Water Act defines all of these terms broadly, and a source will be required to obtain an NPDES permit if it discharges almost anything directly to surface waters. A source that sends its wastewater to a publicly owned treatment works (POTW) will not be required to obtain an NPDES permit, but may be required to obtain an industrial user permit from the POTW to cover its discharge.

In addition to other permit application requirements, facilities in the industrial category of Printing and Publishing, and/or in Photographic Equipment and Supplies, will need to test for all 126 *priority pollutants* listed in 40 CFR 122 Appendix D. Each applicant also must indicate whether it knows or has reason to believe it discharges any of the other hazardous substances, or non-conventional pollutants located at 40 CFR 122 Appendix D. Quantitative testing is not required for the other hazardous pollutants; however, the applicant must describe why it expects the pollutant to be discharged and provide the results of any quantitative data about its discharge for that pollutant. Quantitative testing is required for the non-conventional pollutants if the applicant expects them to be present in its discharge.

For the purpose of reporting on effluent characteristics in permit applications, there exists a small business exemption (40 CFR 122.21 (g)(8)) for all applicants for NPDES permits with gross total annual sales averaging less than $100,000 per year (in second quarter 1980 dollars). This exempts the small business from submitting quantitative data on certain organic toxic pollutants (see 40 CFR 122.21 Table II, Appendix D). However, the small business must still provide quantitative data for other toxic pollutants (metals and cyanides) and total phenols, as listed in 40 CFR 122.21 Table III, Appendix D. The same regulations apply to the small business concerning the other hazardous pollutants and non-conventional pollutants as for the larger facilities (see previous paragraph).

Clean Air Act

The Clean Air Act (CAA), with its 1990 amendments, sets the framework for air pollution control. Part 112 of the Clean Air Act establishes requirements that directly restrict the emission of 189 hazardous air pollutants. The EPA is authorized to establish Maximum Achievable Control Technology (MACT) standards for source categories that emit at least one of the pollutants on the list.

Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (also known as CERCLA, or more commonly as Superfund) is the Act that created the Superfund and set up a variety of mechanisms to address risks to public health, welfare, and the environment caused by hazardous substance releases.

Substances deemed hazardous by CERCLA are listed in 40 Code of Federal Regulations (CFR) 302.4. Based on criteria that relate to the possibility of harm associated with the release of each substance, CERCLA assigns a substance-specific reportable quantity (RQ); RQs are either 1, 10, 100, 1000, or 5000 pounds (except for radionuclides). Any person in charge of a facility (or a vessel) must immediately notify the National Response Center as soon as a person has knowledge of a release (within a 24-hour period) of an amount of a hazardous substance that is equal to or greater than its RQ.[b] There are some exceptions to this requirement, including exceptions for certain continuous releases and for Federally permitted releases.

Superfund Amendments and Reauthorization Act, Section 313

CERCLA was enacted in 1980 and, among other amendments, was amended in 1986 by Title I of the Superfund Amendments and Reauthorization Act (SARA). Under SARA Section 313, a facility that has more than 10 employees and that manufactures, processes or otherwise uses more than 10,000 or 25,000 pounds per year of any toxic chemical listed in 40 Code of Federal Regulations (CFR) 372.65 must file a toxic chemical release inventory (TRI) reporting form (EPA Form R) covering releases of these toxic chemicals (including those releases specifically allowed by EPA or State permits) with the EPA and a State agency. The threshold for reporting releases is 10,000 or 25,000 pounds, depending on how the chemical is used (40 CFR 372.25). Form R is filed annually, covers all toxic releases for the calendar year, and must be filed on or before the first of July of the following year. Table 2-7 lists chemicals used by facilities in lithographic blanket washes that are listed in the Toxic Release Inventory (TRI). Individual facilities may use other chemicals which are listed in the TRI, but are not in Table 2-7.

Superfund Amendments and Reauthorization Act, Section 110

SARA Section 110 addresses Superfund site priority contaminants. This list contains the 275 highest ranking substances of the approximately 700 prioritized substances. These chemical substances, found at Superfund sites, are prioritized based on their frequency of occurrence,

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

toxicity rating, and potential human exposure. Once a substance has been listed, the Agency for Toxic Substances and Disease Registry is mandated to develop a toxicological profile that contains general health/hazard assessments with effect levels, potential exposures, uses, regulatory actions, and further research needs.

Occupational Safety and Health Act

The Occupational Safety and Health Administration (OSHA) was established in 1970 under the Occupational Safety and Health (OSH) Act to reduce the occurrence of occupational health hazards, and to develop health and safety standards and training programs.

As authorized by Sections 6(a) of the OSH Act, which enables OSHA to promulgate existing Federal standards and national consensus standards as OSHA standards, the Health Standards program of OSHA established permissible exposure limits (PELs) for general industry Air Contaminants (29 CFR 1910.1000). A PEL is a total weighted average (TWA) concentration that is not to be exceeded in an 8 hour workday of a 40 hour work week, assuming a 50 week work year and 40 years of work. The majority of PELs were adopted from the Walsh-Healey Public Contracts Act which adopted standards from the 1968 Threshold Limit Values (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH).

On June 7, 1988, in an effort to increase the protection of the American workers, OSHA proposed to revise the PELs by adding 164 substances to the list and lowering the PEL for 212 of the 600 substances currently listed. OSHA also wanted to establish skin designations, short term exposure limits (STELs) and ceiling limits for these substances. Before the proposed changes went into effect, the ruling in the case of AFL-CIO v. OSHA in the 11th Circuit Court of Appeals rendered the revised PELs, STELs and ceiling limits invalid, reasoning that the PELs were generic health standards, not individual standards. Therefore, the 212 currently listed substances are enforced at the 1971 PELs and the 164 newly proposed PELs are not enforceable by OSHA. However, the "general duty clause" in Section 5(a)(1) of the OSH Act may be considered when the "unofficial" PELs of the 164 added substances are exceeded. The ruling prompted OSHA to begin developing individual PELs, STELs and ceiling limits for the substances included in the Health Standards program.

Resource Conservation and Recovery Act

One purpose of the Resource Conservation and Recovery Act (RCRA) of 1976 (as amended in 1984) is to set up a cradle-to-grave system for tracking and regulating hazardous waste. The EPA has issued regulations, found in 40 CFR Parts 260-299, which implement the Federal statute. These regulations are Federal requirements. As of March 1994, 46 states have been authorized to implement the RCRA program and may include more stringent requirements in their authorized RCRA programs. In addition, non-RCRA-authorized states (Alaska, Hawaii, Iowa and Wyoming) may have state laws that set out hazardous waste management requirements. A facility should always check with the state when analyzing which requirements apply to their activities.

Assuming the material is a solid waste, the first evaluation to be made is whether it is also considered a hazardous waste. Part 261 of 40 Code of Federal Regulations (CFR) addresses the identification and listing of hazardous waste. The waste generator has the responsibility for determining whether a waste is hazardous, and what classification, if any, may apply to the waste. The generator must examine the regulations and undertake any tests necessary to determine if the wastes generated are hazardous. Waste generators may also use their own knowledge and familiarity with the waste to determine whether it is hazardous. Generators may be subject to enforcement penalties for improperly determining that a waste is not hazardous.

Wastes can be classified as hazardous either because they are listed by EPA through regulation and appear in the 40 CFR Part 261 or because they exhibit certain characteristics. Listed wastes are specifically named, e.g., discarded commercial toluene, spent non-halogenated solvents. Characteristic wastes are defined as hazardous if they "fail" a characteristic test, such as the RCRA test for ignitability.

There are four separate lists of hazardous wastes in 40 CFR 261. If any of the wastes from a printing facility is on any of these lists, the facility is subject to regulation under RCRA. The listing is often defined by industrial processes, but all wastes are listed because they contain particular chemical constituents (these constituents are listed in Appendix VII to Part 261). Section 261.31 lists wastes from non-specific sources and includes wastes generated by industrial processes that may occur in several different industries; the codes for such wastes always begin with the letter "F." The second category of listed wastes (40 CFR 261.32) includes hazardous wastes from specific sources; these wastes have codes that begin with the letter "K." The remaining lists (40 CFR 261.33) cover commercial chemical products that have been or are intended to be discarded; these have two letter designations, "P" and "U." Waste codes beginning with "P" are considered acutely hazardous, while those beginning with "U" are simply considered hazardous. Listed wastes from chemicals that are commonly used in the lithographic blanket washes are shown in Table 2-7. While these exhibits are intended to be as comprehensive as possible, individual facilities may use other chemicals and generate other listed hazardous wastes that are not included in Table 2-7. Facilities may wish to consult the lists at 40 CFR 261.31-261.33.[c]

Generator status defines how to dispose of a listed or characteristic waste. The hazardous waste generator is defined as any person, by site, who creates a hazardous waste or makes a waste subject to RCRA Subtitle C. Generators are divided into three categories:

- Large Quantity Generators - These facilities generate at least 1000 kg (approximately 2200 lbs.) of hazardous waste per month, or greater than 1 kg (2.2 lbs) of acutely hazardous waste[d] per month.

- Small Quantity Generators (SQG) — These facilities generate greater than 100 kg (approx. 220 lbs.) but less than 1000 kg of hazardous waste per month, and up to 1 kg (2.2 lbs) per month of acutely hazardous waste.

- Conditionally exempt small quantity generators (CESQG) — These facilities generate no more than 100 kg (approx. 220 lbs) per month of hazardous waste and up to 1 kg (2.2 lbs) per month of acutely hazardous waste.

Large and small quantity generators must meet many similar requirements. 40 CFR 262 provides that SQGs may accumulate up to 6000 kg of hazardous waste on-site at any one time for up to 180 days without being regulated as a treatment, storage, or disposal (TSD) facility and thereby having to apply for a TSD permit. The provisions of 40 CFR 262.34 (f) allow SQGs to store waste on-site for 270 days without having to apply for TSD status provided the waste must be transported over 200 miles. Large quantity generators have only a 90-day window to ship wastes off-site without needing a RCRA TSD permit. Keep in mind that most provisions of 40 CFR 264

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[c] Lists of the "F, P, K and U" hazardous wastes can also be obtained by calling the EPA RCRA/Superfund/EPCRA Hotline at (800) 424-9346.

[d] The provisions regarding acutely hazardous waste are not likely to affect printers. Acutely hazardous waste includes certain "F" listed wastes that do not apply to printers, and "P" listed wastes, none of which were identified as in use in the commercial lithographic industry. (See 40 CFR 261.31-33 for more information).

and 265 (for hazardous waste treatment, storage and disposal facilities) do not apply to generators who send their wastes off-site within the 90- or 180-day window, whichever is applicable.

Hazardous waste generators that do not meet the conditions for conditionally exempt small quantity generators must (among other requirements such as record keeping and reporting):

- Obtain a generator identification number;
- Store and ship hazardous waste in suitable containers or tanks (for storage only);
- Manifest the waste properly;
- Maintain copies of the manifest, a shipment log covering all hazardous waste shipments, and test records;
- Comply with applicable land disposal restriction requirements; and
- Report releases or threats of releases of hazardous waste.

2.6 SAFETY HAZARD BY FORMULATION

Table 2-8 contains Safety Hazard Factors for the 36 blanket wash formulations and the baseline used in the lithography industry. There are four Safety Hazard Factors addressed in this table: reactivity, flammability, ignitability, and corrosivity. As was described in Section 2.2 Chemical Information for the individual chemicals used in the blanket wash formulations, they were derived as follows.

Where applicable, the reactivity and flammability values were extracted directly from section one of the blanket wash formulation's Material Safety Data Sheets (MSDSs). This section contains the National Fire Protection Association (NFPA) values on both reactivity and flammability. For reactivity, NFPA ranks materials on a scale of 0 through 4:

0 - materials that are normally stable, even under fire exposure conditions, and that do not react with water; normal fire fighting procedures may be used.

1 - materials that are normally stable, but may become unstable at elevated temperatures and pressures and materials that will react with water with some release of energy, but not violently; fires involving these materials should be approached with caution.

2 - materials that are normally unstable and readily undergo violent chemical change, but are not capable of detonation; this includes materials that can rapidly release energy, materials that can undergo violent chemical changes at high temperatures and pressures, and materials that react violently with water. In advanced or massive fires involving these materials, fire fighting should be done from a safe distance of from a protected location.

3 - materials that, in themselves, are capable of detonation, explosive decomposition, or explosive reaction, but require a strong initiating source or heating under confinement; fires involving these materials should be fought from a protected location.

4 - materials that, in themselves, are readily capable of detonation, explosive decomposition, or explosive reaction at normal temperatures and pressures. If a

material having this Reactivity Hazard Rating is involved in a fire, the area should be immediately evacuated.

For flammability, NFPA ranks materials also on a scale of 0 through 4:

0 - any material that will not burn.

1 - materials that must be preheated before ignition will occur and whose flash point exceeds 200°F (93.4°C), as well as most ordinary combustible materials.

2 - materials that must be moderately heated before ignition will occur and that readily give off ignitible vapors.

3 - Flammable liquids and materials that can be easily ignited under almost all normal temperature conditions. Water may be ineffective in controlling or extinguishing fires in such materials.

4 - includes flammable gases, pyrophoric liquids, and flammable liquids. The preferred method of fire attack is to stop the flow of material or to protect exposures while allowing the fire to burn itself out.

For formulations whose MSDs did not contain NFPA rankings, no reactivity or flammability values were assigned. However, please note the following exceptions. For Blanket Wash Formulation #19, NFPA reactivity and flammability values for a major chemical constituent, dipropylene glycol butyl ether, have been included in the table. In addition, for Blanket Wash Formulations #32, #36, and #37, a reactivity designation of "Y" has been given. Based on product composition, it has been determined that these blanket wash formulations are reactive, though no NFPA value has been listed in their MSDSs.

For ignitability, the formulations have been classified as either ignitable, "Y" or not ignitable, "N". Ignitability has been determined based on the flash point of the formulation, as outlined in 40 CFR (Protection of Environment, RCRA), Part 261, Identification and Listing of Hazardous Waste, §261.21, Characteristic of Ignitability. Under this standard, a chemical is considered ignitable if it "is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has a flash point less than 60°C (140°F) as determined by a Pensky-Martens Closed Cup Tester...a Setaflash Closed Cup Tester...or an equivalent test method." The flash points for these formulations have been determined by the Graphic Arts Technical Foundation, an independent testing laboratory.

For corrosivity, the formulations have been classified as either corrosive, "Y" or not corrosive, "N". Corrosivity for these product formulations has been determined based on the pH of the product as outlined in 40 CFR (Protection of Environment, RCRA), Part 261, Identification and Listing of Hazardous Waste, §261.22, Characteristic of Corrosivity. According to this standard, a chemical is corrosive if it "is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5." As with the flash points, the pH of the various blanket wash formulations have been determined by the Graphic Arts Technical Foundation.

Table 2-8. Safety Hazard Factors for Blanket Wash Formulations[1]

Formulation Number	Reactivity	Flammability	Ignitability	Corrosivity
1	0	0	N	N
3			Y	N
4			Y	N
5			Y	N
6			N	N
7	0	2	N	N
8			Y	N
9			N	N
10			N	N
11			N	N
12			Y	N
14			N	N
16	0	2	N	N
17			N	N
18			N	N
19	0[2]	2[2]	N	N
20			N	N
21			Y	N
22			N	N
23			Y	N
24			Y	N
25			N	N
26			N	N
27	0	2	N	N
28	0	2	Y	N
29			N	N
30			Y	N
31			Y	N
32	Y		N	N
33			Y	N
34			Y	N
35			Y	N
36	Y		N	N
37	Y		Y	N
38			N	N

Formulation Number	Reactivity	Flammability	Ignitability	Corrosivity
39			N	N
40			N	N

[1]A blank space in this table indicates that there was not enough information available to develop a Safety Hazard Factor ranking.
[2]Reactivity and flammability data values are for dipropylene glycol butoxy ether.

References

1. The Hazardous Substances Data Bank (HSDB), developed and maintained by: The National Library of Medicine, Washington, D.C.

2. The Physical/Chemical Property Database (PHYSPROP) and the Environmental Fate Data Base (EFDB), both of which were developed and maintained by: Syracuse Research Corp. (SRC), Environmental Science Center, Merrill Lane, Syracuse, New York.

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Chapter 3
Risk

This chapter addresses the exposures and associated risks that may result from using the substitute blanket washes. Section 3.1 contains information on environmental releases. Potential releases to air, and land and water are discussed for each blanket wash. Section 3.2 examines potential occupational exposures. The dermal and inhalation exposures that can occur as a result of working with a blanket wash are presented. Section 3.3 addresses exposures for the general population (i.e., people not working in the print shop), and includes information on human exposures to blanket wash chemicals released to both air and surface water. In all three sections, the methodologies and models used for estimating releases and exposures are described along with the associated assumptions and uncertainties. Section 3.4 moves from exposures to the risks and concerns associated with such exposures. Descriptions of how risk characterizations are made and the types of risks examined (such as carcinogenic, chronic and developmental), are followed by discussions of the risks assigned to the environmental, occupational and general population exposures discussed earlier in the chapter. In Section 3.5, methods of reducing worker risk are discussed. Topics such as employee training, proper handling of chemicals, and use of personal safety equipment and equipment safeguards are reviewed.

Chapter Contents

3.1 ENVIRONMENTAL RELEASE ESTIMATES

Estimated environmental releases associated with lithography blanket wash chemicals and the methodology, assumptions and uncertainties associated with the release calculations are discussed below. Releases to air result from volatilization of volatile blanket wash constituents during fluid (blanket wash) transfers and from waste rags used to wipe blanket wash liquid off of the blankets. Releases to water result primarily from the laundering of dirty reusable rags. Releases to land result from the disposal of non-reusable rags.

Methodology - Environmental Releases

The material balance approach was used to calculate releases from lithography blanket washes. Figure 3-1 decribes the overall material balance:

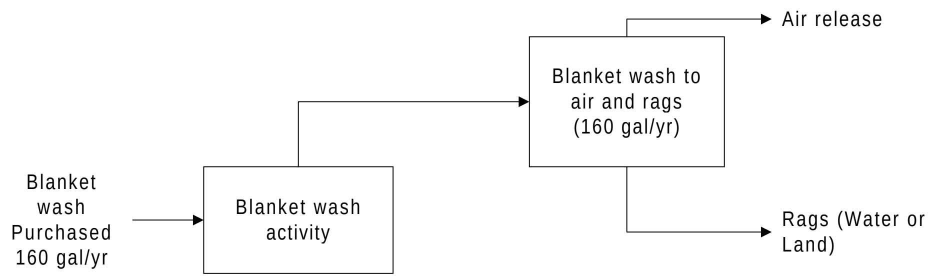

Figure 3-1. Material Balance

General facility assumptions were developed specifically for the scenarios of this assessment. These assumptions were developed by EPA in conjunction with Gary Jones of the Graphic Arts Technical Foundation (GATF) and were released for review during the ECB/GATF Environmental Affairs Conference held in Oakbrook, Illinois in March 1994. Those assumptions were as follows:

Assumption	Value
Number of presses per facility	1-19"x 26"
Number of units per press	4
Number of times each blanket is washed per day	10 (40 total for the press)[1]
Number of hours per operating day	8
Number of operating days per year	250
Average amount of wash used per blanket	2 oz.
Area of 1 blanket	3.4 ft^2
Amount of blanket wash used per year	160 gallons

[1] Industry commentators noted during a later review of draft results that washing the blanket 10 times per day may be high for this type of facility. If this assumption is high, using 10 blanket washes per day may overestimate exposures.

An average of 160 gallons of blanket wash is assumed to be used per year per facility (rounded to two significant figures). The 160 gallons is either released to air or is left on the rag for disposal or laundering.

A typical shop may either use reusable rags, which are laundered, or dispose of rags as municipal solid waste. Volatile chemicals ($>10^{-3}$ mm Hg vapor pressure) were assumed to be released to air whether reusable or disposable rags are used. Non-volatile chemicals ($\leq 10^{-3}$ mm

Hg vapor pressure[a]) were assumed to remain on the rags. Chemicals remaining on reusable rags were released to water and chemicals remaining on disposal rags were released to land. **The model does not take into account the releases of ink constituents that are being removed in the blanket wash.**

The material balance calculations are conducted as follows for each formulation:

- Calculate the average density of the formulation using the normalized weight percent; (see sample calculation)
- Multiply the average density by the volume released (160 gallons) to get the total mass of blanket wash released;
- Multiply the total mass by the weight percentage of each chemical in the formulation to determine individual chemical masses;
- If the vapor pressure of a chemical constituent is > 10^{-3} mm Hg, then the chemical is assumed to be released to air; and
- If the vapor pressure is $\leq 10^{-3}$ mm Hg, then the chemical will not volatilize and is assumed to be released to water or land. Releases to water occur when the rags are laundered, and to land when they are disposed of.

Sample Calculation

Example Formulation	Density (g/cm^3)	Weight Percent	Vapor Pressure (mmHg)
Ethoxylated nonylphenol	0.8	42.9%	$<10^{-6}$
Solvent naphtha, heavy	0.87	33.3%	0.5
Propylene glycol monobutyl ether	0.89	19.0%	<0.98
Tetrapotassium pyrophosphate	2.33	4.8%	$<10^{-6}$

[a] *An industry reviewer commented that the 10^{-3} mm Hg cutoff may be low. This figure was developed by EPA's Health and Environmental Effects Division for the New Chemicals Review Program to be protective of human health. Below 10^{-3} mm Hg no further concern for inhalation risks is warranted. Above 10^{-3} mm Hg there may or may not be concerns.*

In this example:

- The average density of the blanket wash is 0.867 g/cm

$$\sum_{I=1}^{n} \frac{\text{weight fraction}_i}{\text{density}_i} = \sum_{i=1}^{n} \frac{\frac{g_i}{g_{formulation}}}{\frac{g_i}{cm^3_i}} = \sum_{i=1}^{n} \frac{cm^3_i}{g_{formulation}}$$

$$= \frac{cm^3_{formulation}}{g_{formulation}}$$

The reciprocal of this value is the average density of the blanket wash in g/cm$^{3.}$

In this example, we have

$$\frac{1}{\left[\frac{0.429}{0.8} + \frac{0.333}{0.87} + \frac{0.19}{0.89} + \frac{0.48}{2.33}\right]} = 0.867 \text{ g/cm}^3$$

- Using the average density, the total mass of blanket wash per year is calculated to be 525,196 g/yr.

- The mass of each chemical component is calculated, the vapor pressure is evaluated to determine the release route and the following release rates are calculated:

Example Formulation	Release to Air* (g/site/sec)	Release to Water or Land (kg/site/yr)
Ethoxylated nonylphenol	0	225.3
Solvent Naphtha, heavy	0.024	0
Propylene glycol monobutyl ether	0.014	0
Tetrapotassium pyrophosphate	0	25.2
Total:	0.038	251

* The time units for releases to air are calculated using 250 days per year and 8 hours per day. The environmental releases for each blanket wash formulation are provided in Table 3-1.

<u>Assumptions - Environmental Releases</u>

The material balance used in this report assumes that releases to air equal the total air release of chemicals from the following:

- Volatilization of blanket wash formulation constituents from blankets during cleaning;

- Emissions from transfer operations; and
- Volatilization of blanket wash constituents from dirty rags.

As described on page 3-2, the following assumptions and sources of information were used in the material balance model:

- Chemicals with a vapor pressure ≤ 10^{-3} mm Hg will not volatilize;
- Chemicals that do not volatilize will remain on the cleaning rags.
- The general facility assumptions listed above.

<u>Uncertainties - Environmental Releases</u>

Determining environmental releases associated with lithography blanket washes requires making assumptions about the cleaning process, the workplace environment and waste management practices. Uncertainties about the amounts of releases to the environment stem from the estimated total released per year (160 gallons). This total will vary in actual printing facilities based on:

- type of blanket wash used;
- amount of blanket wash applied;
- amount of unused blanket wash disposed;
- compliance with waste management procedures;
- equipment operating time;
- temperature conditions (ambient and solvent);
- chemical properties.

Table 3-1. Environmental Releases: Lithographic Blanket Washes

Form. Number	Formulation**	Environmental Releases: Air (g/sec)	Environmental Releases: Water or Land (kg/yr)
1	Fatty acid derivatives	0.062	0
	Alkoxylated alcohols	0.014	0
3	Hydrocarbons, petroleum distillates	0.021	0
	Fatty acid derivatives	0	152
	Hydrocarbons, aromatic	0.025	0
	Alkyl benzene sulfonates	0	38
4	Terpenes	0.059	0
	Ethoxylated nonylphenol	0	77
5	Water	N/A	N/A
	Hydrocarbons, aromatic	0.021	0
	Ethylene glycol ethers	0.010	0
	Ethoxylated nonylphenol	0	50
	Alkyl benzene sulfonates	0	30
	Alkoxylated alcohols	0	15
	Alkali/salts	0	5
6	Fatty acid derivatives	0	329
	Hydrocarbons, petroleum distillates	0.018	0
	Hydrocarbons, aromatic	0.006	0
	Alkyl benzene sulfonates	0	25

Form. Number	Formulation**	Environmental Releases	
		Air (g/sec)	Water or Land (kg/yr)
7	Terpenes	0.071	0
	Ethoxylated nonylphenol	0	15
	Alkoxylated alcohols	0	15
8	Water	N/A	N/A
	Hydrocarbons, aromatic	0.018	0
	Propylene glycol ethers	0.012	0
	Alkyl benzene sulfonates	0	91
	Ethoxylated nonylphenol	0	43
	Alkoxylated alcohols	0	13
	Alkali/salts	0	4
9	Fatty acid derivatives	0	405
	Water	N/A	N/A
	Ethoxylated nonylphenol	0	15
10	Fatty acid derivatives	0	140
	Water	N/A	N/A
11	Fatty acid derivatives	0	249
	Hydrocarbons, petroleum distillates	0.028	0
	Hydrocarbons, aromatic	0.005	0
	Alkyl benzene sulfonates	0	23
12	Hydrocarbons, petroleum distillates	0.033	0
	Water	N/A	N/A
14	Fatty acid derivatives	0	54
	Propylene glycol ethers	0.008	0
	Water	N/A	N/A
16	Terpenes	0.075	0
17	Ethoxylated nonylphenol	0	11
	Glycols	0.002	0
	Fatty acid derivatives	0	5
	Alkali/salts	0	3
	Water	N/A	N/A
18	Fatty acid derivatives	0	225
	Hydrocarbons, petroleum distillates	0.022	0
	Hydrocarbons, aromatic	0.005	0
	Dibasic esters	0.009	0
	Esters/lactones	0.003	0
	Alkyl benzene sulfonates	0	23
19	Fatty acid derivatives	0	182
	Propylene glycol ethers	0.051	0
	Water	N/A	N/A
20	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.010	0
	Hydrocarbons, aromatic	0.007	0
	Alkyl benzene sulfonates	0	25

Form. Number	Formulation**	Environmental Releases Air (g/sec)	Environmental Releases Water or Land (kg/yr)
21	Hydrocarbons, aromatic	0.014	0
	Hydrocarbons, petroleum distillates	0.021	0
	Fatty acid derivatives	0	257
22	Fatty acid derivatives	0	288
	Hydrocarbons, aromatic	0.017	0
	Water	N/A	N/A
23	Terpenes	0.034	0
	Nitrogen heterocyclics	0.021	0
	Alkoxylated alcohols	0.021	0
	Water	N/A	N/A
24	Terpenes	0.013	0
	Ethylene glycol ethers	0.003	0
	Ethoxylated nonylphenol	0	23
	Alkyl benzene sulfonates	0	35
	Alkali/salts	0	23
	Water	N/A	N/A
25	Terpenes	0.072	0
	Esters/lactones	0.003	0
26	Fatty acid derivatives	0	604
	Esters/lactones	0	256
27	Terpenes	0.12	0
28	Hydrocarbons, petroleum distillates	0.059	0
29	Fatty acid derivatives	0	533
30	Hydrocarbons, aromatic	0.049	0
	Propylene glycol ethers	0.008	0
	Water	N/A	N/A
31	Hydrocarbons, aromatic	0.010	0
	Hydrocarbons, petroleum distillates	0.058	0
32	Hydrocarbons, petroleum distillates	0.066	0
33	Hydrocarbons, petroleum distillates	0.018	0
	Hydrocarbons, aromatic	0.018	0
	Propylene glycol ethers	0.004	0
	Water	N/A	N/A
34	Water	N/A	N/A
	Terpenes	0.015	0
	Hydrocarbons, petroleum distillates	0.012	0
	Alkoxylated alcohols	0	42
	Fatty acid derivatives	0	42
35	Hydrocarbons, petroleum distillates	0.010	0
	Hydrocarbons, aromatic	0.058	0
36	Fatty acid derivatives	0	376
	Hydrocarbons, petroleum distillates	0.013	0
	Hydrocarbons, aromatic	0.007	0
	Propylene glycol ethers	0.003	0

Form. Number	Formulation**	Environmental Releases	
		Air (g/sec)	Water or Land (kg/yr)
37	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.034	0
	Hydrocarbons, aromatic	0.003	0
38	Hydrocarbons, petroleum distillates	0.048	0
	Alkoxylated alcohols	0.012	0
	Fatty acid derivatives	0	0
39	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.015	0
	Propylene glycol ethers	0.008	0
	Alkanolamine	0	17
	Ethylene glycol ethers	0.004	0
40	Hydrocarbons, aromatic	0.009	0
	Hydrocarbons, petroleum distillates	0.012	0
	Fatty acid derivatives	0	346
	Ethoxylated nonylphenol	0	22

**Formulation compositions were adjusted to equal 100 percent.
N/A - Not applicable

3.2 OCCUPATIONAL EXPOSURE ESTIMATES

Inhalation and dermal exposure associated with lithography blanket wash chemicals and the methodology, assumptions and uncertainties associated with the estimates are discussed below. The scenario described below was modelled to assess inhalation and dermal exposures for workers at these shops. Table 3-2 presents the inhalation and dermal exposures for lithographic blanket washes.

Table 3-2. Inhalation and Dermal Exposures: Lithographic Blanket Washes

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
1	Fatty acid derivatives	0.23	1,100-3,300
	Alkoxylated alcohols	0.026	200-590
3	Hydrocarbons, petroleum distillates	7.2	730-2,200
	Fatty acid derivatives	negligible	390-1,200
	Hydrocarbons, aromatic	14.8	121-360
	Alkyl benzene sulfonates	negligible	61-180
4	Terpenes	74	1,100-3,400
	Ethoxylated nonylphenol	negligible	159-480

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
5	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.54	340-1,000
	Ethylene glycol ethers	0.010	170-510
	Ethoxylated nonylphenol	negligible	100-300
	Alkyl benzene sulfonates	negligible	54-162
	Alkoxylated alcohols	negligible	27-81
	Alkali/ salts	negligible	7-20
6	Fatty acid derivatives	negligible	910-2,700
	Hydrocarbons, petroleum distillates	5.4	290-880
	Hydrocarbons, aromatic	0.82	58-180
	Alkyl benzene sulfonates	negligible	37-110
7	Terpenes	2.42	1,225-3,750
	Ethoxylated nonylphenol	negligible	37-110
	Alkoxylated alcohols	negligible	37-110
8	Water	N/A	N/A
	Hydrocarbons, aromatic	0.52	290-870
	Propylene glycol ethers	0.67	180-530
	Alkyl benzene sulfonate	negligible	196-580
	Ethoxylated nonylphenol	negligible	87-260
	Alkoxylated alcohols	negligible	23-70
	Alkali/ salts	negligible	6-17
9	Fatty acid derivatives	negligible	990-3,000
	Water	N/A	N/A
	Ethoxylated nonylphenol	negligible	25-76
10	Fatty acid derivatives	negligible	270-820
	Water	N/A	N/A
11	Fatty acid derivatives	negligible	670-2,000
	Hydrocarbons, petroleum distillates	7.5	540-1,600
	Hydrocarbons, aromatic	0.63	54-160
	Alkyl benzene sulfonates	negligible	34-100
12	Hydrocarbons, petroleum distillates	1.68	650-1,960
	Water	N/A	N/A
14	Fatty acids derivatives	negligible	98-290
	Propylene glycol ethers	0.009	98-290
	Water	N/A	N/A
16	Terpenes	2.55	1300-4000
17	Ethoxylated nonylphenol	negligible	23-68
	Propylene glycol	0.008	23-68
	Fatty acid derivatives	negligible	11-34
	Alkali/ salts	negligible	6-17
	Water	N/A	N/A

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
18	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Dibasic esters Esters/lactones Alkyl benzene sulfonates	negligible 5.8 0.62 0.194 0.68 negligible	640-1,900 430-1,300 57-170 108-330 36-110 36-110
19	Fatty acid derivatives Propylene glycol ethers Water	negligible 0.021 N/A	100-290 260-780 N/A
20	Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	N/A 0.36 0.12 negligible	N/A 130-400 100-300 33-100
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives	2.2 7.1 negligible	260-780 390-1,200 650-2,000
22	Fatty acid derivatives Hydrocarbons, aromatic Water	negligible 0.73 N/A	720-2,100 260-780 N/A
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols Water	0.83 0.037 0.001 N/A	92-280 57-170 57-170 N/A
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkali/salts Water	2.3 0.002 negligible negligible negligible N/A	210-620 52-160 52-160 78-230 52-160 N/A
25	Terpenes Esters/lactones	2.11 2.4	1,248-3,840 52-160
26	Fatty acid derivatives Esters/lactones	negligible negligible	1,219-3,758 45-135
27	Terpenes	4.69	1,300-3,900
28	Hydrocarbons, petroleum distillates	240	1,300-3,900
29	Fatty acid derivatives	negligible	1,300-3,900
30	Hydrocarbons, aromatic Propylene glycol ethers Water	1.9 0.026 N/A	910-2,700 130-390 N/A
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	0.88 11	200-590 1,100-3,300
32	Hydrocarbons, petroleum distillates	24	1,300-3,900

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
33	Hydrocarbons, petroleum distillates	0.93	310-920
	Hydrocarbons, aromatic	0.44	310-920
	Propylene glycol ethers	0.068	34-100
	Water	N/A	N/A
34	Water	N/A	N/A
	Terpenes	3.3	230-680
	Hydrocarbons, petroleum distillates	0.56	170-510
	Alkoxylated alcohols	negligible	85-250
	Fatty acid derivatives	negligible	85-250
35	Hydrocarbons, petroleum distillates	11	200-590
	Hydrocarbons, aromatic	0.88	1,100-3,300
36	Fatty acid derivatives	negligible	900-2,700
	Hydrocarbons, petroleum distillates	4.1	230-680
	Hydrocarbons, aromatic	1.0	110-340
	Propylene glycol ethers	0.37	57-170
37	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	1.67	625-1,840
	Hydrocarbons, aromatic	0.064	32-97
38	Hydrocarbons, petroleum distillates	10	980-2,900
	Alkoxylated alcohols	0.022	200-590
	Fatty acid derivatives	negligible	130-390
39	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.60	220-670
	Propylene glycol ethers	0.31	110-330
	Alkanolamines	negligible	30-89
	Ethylene glycol ethers	0.003	52-160
40	Hydrocarbons, aromatic	1.4	130-380
	Hydrocarbons, petroleum distillates	4.0	190-570
	Fatty acid derivatives	negligible	950-2,800
	Ethoxylated nonylphenol	negligible	38-110

[1] Formulation compositions were adjusted to equal 100 percent.
[2] The inhalation exposures are based on a "what if" scenario.
[3] The dermal exposures are bounding estimates and assume that no gloves or barrier creams are used by the workers.
[4] In situations where the chemical is corrosive (e.g., sodium hydroxide), dermal exposure to workers using the appropriate gloves is zero.

Negligible - Inhalation exposures to chemicals with vapor pressures <10^{-3} mmHg were assumed negligible.

N/A - Not applicable

Scenario

Based on the general facility assumptions listed in Section 3.1, a press operator is assumed to wash 40 blankets per shift. Each wash lasts two minutes. The worker squirts 2 ounces of wash solution onto a rag using a squirt bottle. The blanket is wiped with the wet rag and then wiped again with a dry rag. All rags are disposed of in closed storage containers.

Inhalation exposures result from the volatilization of chemicals from the blanket during washing and from the rags used to wash the blanket. Unvolatilized materials that remain on the rags are assumed to be disposed of as solid waste or to be removed at a laundry facility. Inhalation exposures to vapors from opening the containers storing the disposed rags are assumed to be negligible. Inhalation exposures to chemicals with a vapor pressure $< 10^{-3}$ mm Hg are also assumed to be negligible.

Dermal exposures result from contact with the blanket wash solution during blanket washing activities. Dermal exposures are estimated based on type of operations and wash formulation concentrations.

Methodology - Inhalation Exposures

Inhalation exposures were estimated from the scenario described above using a material balance inhalation exposure model[b]. The inhalation exposure assessment falls under the "what if" category (see uncertainties section).

The material balance model assumes that the amount of a chemical in a room equals the amount of chemical generated in the room minus the amount of chemical leaving the room. The model is valid for estimating the displacement of vapors from containers and for estimating the volatilization of liquids from open surfaces. The assumptions used in this model include:

- Incoming room air is contaminant-free;
- Vapor generation and ventilation rates are constant over time;
- Room air and ventilation air mix ideally;
- Raoult's Law is valid (i.e., regarding the volatilization and interaction of vapors);
- Ideal gas law applies (i.e., regarding the interaction of vapors); and
- "Typical case" ventilation parameters are valid (actual ventilation conditions are unknown).

The inhalation exposure model[1] estimates the evaporation of chemicals from open surfaces, such as the surface of a blanket, using the following equations:

[b] *Source: U.S. Environmental Protection Agency, Chemical Engineering Branch (CEB) Manual for the Preparation of Engineering Assessments, (February 28, 1991), p. 4-1 through 4-39.*

$$G_i = \frac{0.02MX_iP_i}{RT}\sqrt{\frac{D_{ab}v_z}{\pi z}} \qquad (1)$$

where:

G_i	=	Volatilization rate of subsurface i, $g/m^2 \cdot sec$
M	=	Molecular weight, g/mol
P_i^*	=	Vapor pressure of pure substance i, mm Hg
X_i	=	Mole fraction of substance i in solution, dimensionless
R	=	Gas constant, 0.0624 mm $Hg \cdot m^3/mol \cdot K$
T	=	Temperature, K
D_{ab}	=	Diffusivity, cm^2/sec
v_z	=	Air velocity, m/sec
z	=	Distance along contaminated surface, m

The air velocity v_z is assumed to be 100 feet per minute (ft/min). Since the diffusivity (D_{ab}) is not available for many of the chemicals used in blanket washing formulations, the following equation is used to estimate diffusivity:

$$D_{ab} = \frac{4.09 \times 10^{-5} T^{1.9} (1/29 + 1/M)^{0.5} M^{-0.33}}{P_t} \qquad (2)$$

D_{ab}	=	Diffusivity, cm^2/sec
T	=	Temperature, K
M	=	Molecular weight, g/mol
P_t	=	Total pressure, atm

Equation 2 is based on kinetic theory and generally gives values of D_{ab} that agree closely with experimental data. The volatilization rate (G_i), calculated in Equations 1 and 2 above, is used in the following mass balance equation to calculate the airborne concentration of a substance in the breathing zone:

$$C_v = \frac{1.7 \times 10^5 \; TGiA}{MQk} \qquad (3)$$

where:

C_v	=	Airborne concentration, ppm
T	=	Ambient temperature, K
G_i	=	Volatilization rate of substance i, $g/m^2 \cdot sec$
M	=	Molecular weight, g/mol
A	=	Area of surface, m^2
Q	=	Ventilation rate, ft^3/min
k	=	Mixing factor, dimensionless

The mixing factor (k) accounts for slow and incomplete mixing of ventilation air with room air. The CEB Manual sets this factor at 0.5 for a typical case and at 0.1 for a worst case.

The CEB Manual commonly uses ventilation rates (Q) of 500 to 3,500 ft^3/min. An effective ventilation rate of 1,500 ft^3/min was used in the model. This rate is equal to the mixing factor of 0.5 multiplied by the "typical case" ventilation rate (3,000 ft^3/min). The value of C_v from Equation 3 is converted to mass/volume units using the following equation:

$$C_m = C_v \frac{M}{V_m} \tag{4}$$

where:

C_m	=	Airborne concentration, mg/m^3
C_v	=	Airborne concentration, ppm
M	=	Molecular weight, g/mol
V_m	=	Molar volume of an ideal gas, L/mol

At 25°C, V_m has a value of 24.45 L/mol. Since a worker can be assumed to breathe about 1.25 m^3 of air per hour, an inhalation exposure can be computed once C_m has been determined. Equations 3 and 4 can be combined to yield the following equation, given the "typical case" choice of ventilation parameters:

$$I = 0.48GAt \tag{5}$$

where:

I	=	Total amount of substance inhaled, mg/day
G	=	Vapor generation rate, $g/m^2{\cdot}sec$
A	=	Area of surface, m^2
t	=	Duration of exposure, sec/day

The following variables for the lithography model shop are based on the Chemical Engineering Branch Manual (EPA, 1991)[11]

- v_z = 100 ft/min (air velocity)
- T = 298 K (temperature)
- Q = 3,000 ft^3/min (ventilation rate)
- k = 0.5 (mixing factor, dimensionless)
- $P_i = X_i{\cdot}P_i^*$ (Raoult's Law)

The following variables are based on the assumptions presented on page 3-2. These assumptions were reviewed during the ECB/GATF Environmental Affairs Conference held in Oakbrook, Illinois in March, 1994.

- z = 26 in (distance along contaminated surface)
- A = 494 in^2 (area of surface)
- The average time to wash one blanket is 2 minutes.

- The average number of blankets washed per shift is 40.
- The average worker is exposed to wash vapors 80 minutes per day (t = 4,800 seconds per day).
- Dilutions with water are accounted for in formulation compositions.
- Adjusted values were used for the formula compositions because they did not always sum to 100%.

<u>Sample Calculation - Inhalation Exposures</u>

Example Formulation (compositions are percent by weight):

Range	Adjusted*	
35-45%	42.9%	Ethoxylated nonylphenol
25-35%	33.3%	Solvent naphtha (petroleum), heavy aromatic
15-20%	19.0%	Propylene glycol monobutyl ether
0-5%	4.8%	Tetrapotassium pyrophosphate
75-105%	100%	Total

* In cases where the maximum range values of the chemical compositions did not add up to 100%, the values were adjusted to 100%.

The diffusivity is calculated using Equation 2, as follows:

$$D_{ab} = \frac{4.09 \times 10^{-5}\, T^{1.9} (1/29 + 1/M)^{0.5}\, M^{-0.33}}{P_t}$$

The following values are obtained from the Basic Chemical Data Report for solvent naphtha (petroleum), heavy aromatic:

T = 298 K
M = 128 g/mol
P_t = 1 atm

$D_{ab} = 0.085\ cm^2/sec$

Using the above value for diffusivity, the volatilization rate can be calculated using Equation 1, as follows:

$$G_i = \frac{0.02MX_iP_i}{RT}\sqrt{\frac{D_{ab}v_z}{\pi z}}$$

where:

M	=	128 g/mol
P_{*i}	=	0.5 mm Hg
X_i	=	0.5346 (mole fraction)
R	=	0.0624 mm Hg·m^3/mol·K
T	=	298 K
D_{ab}	=	0.0852 cm^2/sec
v_z	=	100 ft/min = 0.508 m/sec
z	=	26 in = 0.6604 m

G_i = 0.0053 g/m^2·sec

Using this value for G_i, the exposure may be calculated using Equation 5, as follows:

$$I = 0.48GAt$$

where:

G	=	0.0053 g/m^2·sec
A	=	494 in^2 = 0.3187 m^2
t	=	80 min = 4,800 sec/day

I = 3.9 mg/day

Using the same method for each chemical in the Example Formulation, the following results are obtained:

Chemical	Inhalation Rate
Ethoxylated nonylphenol	Negligible
Solvent naphtha (petroleum), heavy aromatic	3.9 mg/day
Propylene glycol monobutyl ether	4.3 mg/day
Tetrapotassium pyrophosphate	Negligible

Methodology - Dermal Exposures

Dermal exposure is caused by contact with a material. For the blanket press operators, contact with the material includes touching the damp rags and manually applying the rags to the blanket to remove ink. Routine contact with two hands was modeled for the dermal exposure assessment.

The dermal contact model[1] was used to calculate dermal exposure estimates for blanket washing activities by adjusting the concentration of the chemical in the mixture. This model provides bounding estimates and assumes that no gloves or barrier creams are used by the workers. In situations where the chemical is corrosive (e.g., sodium hydroxide), dermal exposure to workers using the appropriate gloves is negligible. Also, for other chemicals, if the appropriate gloves are worn exposure to workers will be negligible.

Assumptions used in the dermal model[1] include:

- The concentrations of the chemicals in the mixture are constant (i.e., no evaporation) throughout the time of absorption;
- No dermal protection, administrative, work practice, or other controls are used to limit dermal exposure;
- The surface area of two hands is 1300 cm^2;
- The amount that is actually absorbed is not determined;
- The quantity remaining on the hand is 1-3 mg/cm^2; and
- A single contact with the chemical results in exposure for a complete work day. That is, the duration of exposure is estimated at 1-4 hours or longer, but it is assumed the worker washes up at meal time, and if the duration is reported for a full day, the potential dose should total only the estimate for a single contact.

Sample Calculation - Dermal Exposures

Using the Example Formulation:

Ethoxylated nonylphenol = 42.9% (Adjusted weight %)

The dermal exposure to blanket washes for routine dermal contact (2 hands) is 1,300 to 3,900 mg/day[1]. (e.g., 1-3 mg/cm^2 x 1300 cm^2/day)

The dermal exposure to ethoxylated nonylphenol is 42.9% of the total blanket wash exposure, or 560 to 1,700 mg/day.

Using the same method for each chemical in the Example Formulation, the following results are obtained:

Chemical	Dermal Exposure
Ethoxylated nonylphenol	560 to 1,700 mg/day
Solvent naphtha (petroleum), heavy aromatic	430 to 1,300 mg/day
Propylene glycol monobutyl ether	250 to 740 mg/day
Tetrapotassium pyrophosphate	62 to 190 mg/day

Uncertainties - Occupational Exposures

Any determination of the occupational exposure levels associated with blanket washing activities requires making assumptions about the washing processes, workplace environment, health and safety practices, and waste management practices.

EPA has published Guidelines for Exposure Assessment in the *Federal Register*. These guidelines provide the basic terminology and principles by which the Agency conducts exposure assessments. If the exposure assessment methodology allows an assessor to in some way quantify the spectrum of exposure, the assessor should assess typical exposures, as well as high-end exposures or bounding exposures. **Typical** exposures refer to exposures of a typical person to a particular substance. **High-end** exposures refer to exposures of a person exposed to amounts of a substance higher than exposures received by 90 percent of the people (or ecological species of interest) exposed to the substance. **Bounding** exposures are judgments assuming that no one will be exposed to amounts of substance higher than the calculated amount. However, in many cases, only a picture of what the exposure would be under a given set of circumstances, without a characterization of the probability of these circumstances, can be calculated. These pictures are called **"What if"** scenarios,[c] and they do not try to judge where on the exposure scale the estimate actually falls. The inhalation exposure assessments calculated for the blanket press operators fall under the "what if" category and the dermal exposure assessments are bounding exposures.

Although the blanket washing process is relatively straightforward, occupational exposure levels will differ in shop environments because of many variables, including:

- Volatility of blanket wash used;
- Amount of blanket wash applied;
- Application of chemicals to blanket and rags;
- Use of personal protective equipment and safety procedures;
- Blanket washing time;
- Ventilation conditions and shop layout;
- Number of blankets cleaned;
- Temperature conditions (ambient and solvent);
- Average size of blankets; and
- Number of presses per facility.

[c] *A "what-if scenario" is a scenario developed to assess potential exposure under a set of hypothetical conditions or under a set of conditions for which actual exposure parameter data are incomplete or nonexistent. The calculated exposures are not intended to provide information about how likely the combination of exposure parameter values might be in the actual population or approximately how many, if any, persons might actually be subjected to the calculated exposure.*

3.3 GENERAL POPULATION EXPOSURE ESTIMATES

The purpose of this general population exposure assessment is to determine non-occupational exposures to lithography blanket wash chemicals. This determination addresses contact by people who are not directly involved in the lithography process. People who live near a printing facility may breathe air containing small amounts of vapors from evaporation of products at the printing facility. Residues from the blanket wash products enter the environment when facilities, either printer facilities or laundries washing the rags, discharge the products down the drain, either to a publicly-owned treatment works (POTW) or through a septic system. Once the chemicals enter surface water, they may travel downstream and enter a drinking water facility. People could then be exposed by drinking this water. People may also drink well water that contains contaminants that have migrated from a landfill where wastes, especially rags and empty containers, are disposed. For each of these contact routes, the amount of exposure depends on several factors: distance from the facility, the actual routes of contact (such as drinking, breathing, touching), the length of time the chemical has been in the environment, and the way that the chemical moves through the environment. The potential exposures also depend on environmental conditions, including the weather and the volume of water in the stream or river which receives the facility's discharges.

The general population exposure assessment should not be compared to the occupational health standards to determine if an exposure is reasonable or not. Many occupational standards are based on technological feasibility, rather than ideal risk reduction. Furthermore, measuring internal facility contaminant levels may not be sufficient to determine significant general population exposure. Certain types of controls simply move the chemical from inside the plant to the outdoors, creating higher concentrations outside the facility than inside the facility. Some pathways of exposure, such as the drinking water path, do not exist for workers. It is also important to note that some chemicals may have a more significant impact on a specific segment of the general population, such as children, than on a typical worker.

Chapter 2 contains summaries for the fate of all of the chemicals identified as being used in blanket wash products. The fate of the chemical in the environment is how we refer to the breakdown (transformation) and mobility of the chemical through air, water, and land. Chemical fate differs for release through a waste water treatment facility as opposed to an air release or a landfill release. Definitions of the terms used to describe the fate are also included in Chapter 2. For this assessment, the percent removal during wastewater treatment and the half-life of the chemical in air are the primary elements taken from the fate assessment. The other properties and processes listed were used to derive or estimate these values.

This assessment addresses two perspectives: local and regional. The local point of view considers a single facility in normal operation. It will have certain releases that affect a specific area and specific local population. Since information is not available for each lithography facility, a "model facility" approach is used to calculate typical releases and environmental concentrations. This approach will not allow us to specify the number of people around the facility because the population varies considerably depending on the location of the printing facility. The regional perspective provides insight into the overall impact of releases from all of the printing facilities for the general population. While one facility may not be releasing very much of any given chemical, the cumulative effect of all of the printers in an area could be serious. The regional perspective was modeled using facilities located in a single city, Denver, Colorado, to provide an example of cumulative exposures.

This exposure assessment should be used in conjunction with the health assessment to provide a balanced picture of risk. The specific effects of a chemical, such as acute (short-term) effects or chronic (long-term) effects, determine what period(s) of exposure to consider. For long-term (chronic) effects, such as carcinogenicity, it is most helpful to have average, or typical, exposures, since the effect depends on the cumulative exposure. For acute effects, which can include things such as eye irritation, a peak exposure estimate would be more helpful. This can then be compared with levels at which the chemical is known to cause immediate health problems. Since the information which would allow peak exposures to be calculated is not available, average concentrations are calculated in this assessment.

Uncertainty

Estimating exposures is a science where many pieces are approximated, leading to some uncertainty in the results of the estimates. In this assessment we used a model facility approach, where the model facility was not an actual printing facility which exists. In our modeling, we have fixed certain data points to specific values. Although we have previously used weather data specifically for San Bernardino, this does not mean that the concentration results have no meaning for a different location. Many locations would have roughly the same concentration results as San Bernardino, and no locations would have concentrations of less than one tenth of the results for San Bernardino. Often, data parameters are fixed because we know what selecting this combination of values does to the relative value of the risk. The building height, temperature and the exit velocity in air modeling are examples of these types of parameters. We have set them to maximize the average concentrations close to the facility. Some people would call this a worst case, or a bounding estimate. In actuality, since we have presented a scenario for modeling, but do not know how often those exposure levels (or, potential doses) actually exist, the exposure estimates should be labeled a "What if." These What if estimates answer a question similar to "What happens if the building is always three meters tall, the air escaping has little exit velocity, and is ambient temperature?" It is a very good basis for comparing risk between formulations.

Overview by Media

The following sections provide an overview of general population exposures that may occur via air, surface water, septic systems, and landfills.

Air

Local Exposure: Releases to air result from evaporation of chemicals during the blanket wash process. Activities include allowing blankets to dry, using shop towels during blanket cleaning, or opening the containers that hold the blanket wash. These vapors are then carried by and mixed with outside air. The resulting air concentration will depend on weather conditions. Stagnant conditions will not move vapors away quickly, so local concentrations of the chemical will be higher than the concentrations farther from the plant. Under windy conditions, the vapors will be carried away faster, reducing the local concentrations. The number of people may increase or decrease with distance from the facility. The location of the printing facility will also influence the exposure. If the location is known, the exposure assessor will use a computer program to determine weather patterns. The number of people around a known facility will be determined by using census data.

For our model facility, we assume a building height of three meters, and a width of 10 meters. This is a building approximately the size of a one-car garage. We then pick sample weather conditions to determine what the air concentration of a chemical will be at a set distance from the printing facility. San Bernardino is used because the weather conditions there will result in the highest average concentrations around the facility of any of the approximately 500 weather stations in the United States. The average concentrations around San Bernardino are within an order of magnitude (power of ten) of concentrations expected anywhere else in the country. If the San Bernardino average concentration were estimated as 10 $\mu g/m^3$, then the average concentration anywhere in the country would be greater than 1 $\mu g/m^3$.

The model used is called Industrial Source Complex Long Term (ISCLT). It was developed as a regulatory model by the EPA's Office of Air and Radiation. The Office of Pollution Prevention and Toxics uses an implementation of ISCLT in the Graphical Exposure Modeling System (GEMS). Appendix B contains an example of an input file for this model. Except for items identified, the parameters entered are the regulatory defaults. The model will calculate more than one chemical at a time and is run in urban 3 mode. Also entered into the model is the decay rate of the chemical. To convert from the half-life of the chemical (given in the fate summaries in Chapter 2) to the decay rate in inverse seconds, divide 0.693 (the natural log of 2) by the half-life in seconds.

The amount released, given in this document in units of grams per second, is calculated in grams per second per meter squared. Since our model facility is 10 meters per side, or 100 meters square, the release is divided by 100.

In order to obtain the concentration at 100 meters, a special polar grid was entered. The ring distances specified were 100 meters, 200 meters, 300 meters, 400 meters, 500 meters, 600 meters, 700 meters, 800 meters, 900 meters and a kilometer. The air dispersion model calculates the average air concentrations of the chemical vapors in the specified sectors. The sectors are defined by the rings and the compass points, forming an arc-shaped area. There were three calculations per sector. The compass point with the highest concentration at 100 meters was then used to determine exposure. The location was at 90°, that is, east.

From the concentration in the air, the amount with which an individual may actually come in contact can be calculated by knowing the breathing rate. A moderately active adult breathes 20 m^3 per day. The formula for an annual dose is:

$$\text{Annual Dose} = \text{Concentration} \times \text{Daily Inhalation Rate} \times \text{Days per year}$$

where the concentration is in $\mu g/m^3$, and the breathing rate is in cubic meters per day. The potential dose normalized for body mass calculated per day for the entire lifetime, is called the Lifetime Average Daily Dose or LADD (Table 3-3). The formula for this dose rate is:

$$\text{LADD} = \frac{\text{Concentration} \times \text{Daily Inhalation Rate} \times 0.001\ \text{mg}/\mu\text{g}}{\text{Average Body Weight}}$$

The average body weight used in this assessment is 70 kg (an average adult). Since there is no ratio for the percentage of days spent breathing air containing evaporated blanket wash chemicals, this calculation assumes that a person will be breathing this concentration every day of their life.

Uncertainty

Within our scenario, there are specific parameters which affect final concentrations and therefore final exposures more than others. Since we are using the estimates for comparison, the single most important factor is the amount of the substance released per formulation. This is true for both air and water.

Air releases have many factors which fold into the behavior of the chemical. A stronger fan will increase the number of people outside the facility who come in contact the chemical, because the chemical will stay concentrated farther. A higher temperature will cause the chemical to rise in the air. The relative differences between these things is not as significant to the final concentration as is the amount released.

Table 3-3. Single Facility 100 Meter Air Concentrations and Residential Population Potential Dose Rates[1]

Form. Number	Chemical Components	100 Meter Concentration (μg/m³)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
1	Fatty acid derivatives Alkoxylated alcohols	10 3	80 20	3×10^{-3} 8×10^{-4}
3	Hydrocarbons, petroleum distillates Fatty acid derivatives Hydrocarbons, aromatic Alkyl benzene sulfonates	4 4.2	30 28.7	1×10^{-3} 1.29×10^{-3}
4	Terpenes Ethoxylated nonylphenol	10	70	3×10^{-3}
5	Water Hydrocarbons, aromatic Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkoxylated alcohols Alkali/salts	 4 2	 30 10	 1×10^{-3} 5×10^{-4}
6	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 3 1	 20 7	 9×10^{-4} 3×10^{-4}
7	Terpenes Ethoxylated nonylphenol Alkoxylated alcohols	12	95	4.5×10^{-3}
8	Water Hydrocarbons, aromatic Propylene glycol ethers Alkyl benzene sulfonates Ethoxylated nonylphenol Alkoxylated alcohols Alkali/salts	 3 2	 20 20	 9×10^{-4} 6×10^{-4}
9	Fatty acid derivatives Water Ethoxylated nonylphenol			
10	Fatty acid derivatives Water			
11	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 5 9×10^{-1}	 40 7	 1×10^{-3} 3×10^{-4}
12	Hydrocarbons, petroleum distillates	5.9	47	1.3×10^{-3}
14	Fatty acid derivatives Propylene glycol ethers	 1	 9	 4×10^{-4}
16	Terpenes	12.5	100	4.6×10^{-3}

Form. Number	Chemical Components	100 Meter Concentration (μg/m³)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
17	Ethoxylated nonylphenol Glycols Fatty acid derivatives Alkali/salts Water	 5×10^{-1}	 4	 1×10^{-4}
18	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Dibasic esters Esters/lactones Alkyl benzene sulfonates	 4 9×10^{-1} 1.8 6×10^{-1}	 30 7 12 4	 1×10^{-3} 3×10^{-4} 6×10^{-4} 2×10^{-4}
19	Fatty acid derivatives Propylene glycol ethers	 9	 70	 3×10^{-3}
20	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	2 1	10 9	5×10^{-4} 3×10^{-4}
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives	3 4	20 30	7×10^{-4} 1×10^{-3}
22	Fatty acid derivatives Hydrocarbons, aromatic	 3	 20	 9×10^{-4}
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols	6 4 4	40 30 30	2×10^{-3} 1×10^{-3} 1×10^{-3}
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkali/salts	2 6×10^{-1}	20 4	7×10^{-4} 2×10^{-4}
25	Terpenes Esters/lactones	12.3 6×10^{-1}	93 4	4.4×10^{-3} 2×10^{-4}
26	Fatty acid derivatives Esters/lactones			
27	Terpenes	21	140	6.3×10^{-3}
28	Hydrocarbons, petroleum distillates	10	70	3×10^{-3}
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic Propylene glycol ethers	9 1	60 10	2×10^{-3} 4×10^{-4}
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	2 10	10 70	5×10^{-4} 3×10^{-3}
32	Hydrocarbons, petroleum distillates	10	90	3×10^{-3}
33	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	3 3 6×10^{-1}	20 20 4	9×10^{-4} 9×10^{-4} 2×10^{-4}

Form. Number	Chemical Components	100 Meter Concentration (µg/m³)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
34	Water			
	Terpenes	3	20	7×10^{-4}
	Hydrocarbons, petroleum distillates	2	20	6×10^{-4}
	Alkoxylated alcohols			
	Fatty acid derivatives			
35	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
	Hydrocarbons, aromatic	10	70	3×10^{-3}
36	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates	2	20	7×10^{-4}
	Hydrocarbons, aromatic	1	8	3×10^{-4}
	Propylene glycol ethers	6×10^{-1}	4	2×10^{-4}
37	Water			
	Hydrocarbons, petroleum distillates	12	80	4×10^{-3}
	Hydrocarbons, aromatic	5	40	1×10^{-3}
38	Hydrocarbons, petroleum distillates	8	60	2×10^{-3}
	Alkoxylated alcohols	2	20	6×10^{-4}
	Fatty acid derivatives			
39	Water			
	Hydrocarbons, petroleum distillates	3	20	7×10^{-4}
	Propylene glycol ethers	1	10	4×10^{-4}
	Alkanolamines			
	Ethylene glycol ethers	7×10^{-1}	5	2×10^{-4}
40	Hydrocarbons, aromatic	2	10	5×10^{-4}
	Hydrocarbons, petroleum distillates	2	20	6×10^{-4}
	Fatty acid derivatives			
	Ethoxylated nonylphenol			

[1] A blank space in the table indicates that there were no air releases for the chemical because the chemical would not evaporate readily.

Regional Exposure: For the second approach, the overall general population exposure picture resulting from multiple printing facilities was sought. The total residential population exposed to blanket wash chemicals was not available, since the locations of all the lithography facilities across the country are not known. Instead, a single city was used and all known facilities within that city were modeled to provide a general idea of exposures that might result from cumulative releases. Denver was chosen as an example city (Table 3-4). Within the city limits of Denver, Dun and Bradstreet report 235 lithographers. The example assumes that all of the lithographers in Denver use each blanket wash formulation at the same time. The average concentration for the city of Denver is then calculated, using local weather data. The 1990 population for the city of Denver is approximately 470,000.

In this case, the model used is BOXMOD, also implemented in the Graphical Exposure Modeling System. It uses a parameter called the Time Constant to account for chemical degradation. The time constant is the inverse of the rate of decay used for the ISCLT model. This is also the half-life in air divided by 0.693. The other parameter needed to run the model is the size of the area being modeled. Denver is 277.13 square kilometers, or 16.65 kilometers on a side. An example of a BOXMOD run is located in Appendix B.

Table 3-4. Denver Average Air Concentrations and Residential Population Potential Dose Rates[1]

Form. Number	Chemical Components	100 Meter Concentration (μg/m^3)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
1	Fatty acid derivatives Alkoxylated alcohols	1 4 x 10^{-1}	9 3	3 x 10^{-4} 1 x 10^{-4}
3	Hydrocarbons, petroleum distillates Fatty acid derivatives Hydrocarbons, aromatic Alkyl benzene sulfonates	6 x 10^{-1} 6.5 x 10^{-1}	4 5	2 x 10^{-4} 1.45 x 10^{-4}
4	Terpenes Ethoxylated nonylphenol	1	8	3 x 10^{-4}
5	Water Hydrocarbons, aromatic Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkoxylated alcohols Alkali/salts	 6 x 10^{-1} 2 x 10^{-1}	 4 1	 2 x 10^{-4} 6 x 10^{-5}
6	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 5 x 10^{-1} 2 x 10^{-1}	 4 1	 1 x 10^{-4} 6 x 10^{-5}
7	Terpenes Ethoxylated nonylphenol Alkoxylated alcohols	1.72	12.6	4.56 x 10^{-4}
8	Water Hydrocarbons, aromatic Propylene glycol ethers Alkyl benzene sulfonates Ethoxylated nonylphenol Alkoxylated alcohols Alkali/salts	 5 x 10^{-1} 3 x 10^{-1}	 4 2	 1 x 10^{-4} 9 x 10^{-5}
9	Fatty acid derivatives Water Ethoxylated nonylphenol			
10	Fatty acid derivatives Water			
11	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 8 x 10^{-1} 1 x 10^{-1}	 6 7 x 10^{-1}	 2 x 10^{-4} 3 x 10^{-5}
12	Hydrocarbons, petroleum distillates	9 x 10^{-1}	6.7	2.3 x 10^{-4}
14	Fatty acid derivatives Propylene glycol ethers	 2 x 10^{-1}	 1	 6 x 10^{-5}
16	Terpenes	1.89	13.3	5.2 x 10^{-4}

Form. Number	Chemical Components	100 Meter Concentration (μg/m^3)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
17	Ethoxylated nonylphenol			
	Glycols	4×10^{-2}	3×10^{-1}	1×10^{-5}
	Fatty acid derivatives			
	Alkali/salts			
	Water			
18	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates	6×10^{-1}	4	2×10^{-4}
	Hydrocarbons, aromatic	1×10^{-1}	7×10^{-1}	3×10^{-5}
	Dibasic esters	2.6×10^{-1}	2	8×10^{-5}
	Esters/lactones	8×10^{-2}	6×10^{-1}	2×10^{-5}
	Alkyl benzene sulfonates			
19	Fatty acid derivatives			
	Propylene glycol ethers	1	9	4×10^{-4}
20	Hydrocarbons, petroleum distillates	3×10^{-1}	2	9×10^{-5}
	Hydrocarbons, aromatic	2×10^{-1}	1	6×10^{-5}
	Alkyl benzene sulfonates			
21	Hydrocarbons, aromatic	4×10^{-1}	3	1×10^{-4}
	Hydrocarbons, petroleum distillates	6×10^{-1}	4	2×10^{-4}
	Fatty acid derivatives			
22	Fatty acid derivatives			
	Hydrocarbons, aromatic	5×10^{-1}	4	1×10^{-4}
23	Terpenes	8×10^{-1}	6	2×10^{-4}
	Nitrogen heterocyclics	5×10^{-1}	4	1×10^{-4}
	Alkoxylated alcohols	6×10^{-1}	4	2×10^{-4}
24	Terpenes	3×10^{-1}	2	9×10^{-5}
	Ethylene glycol ethers	8×10^{-2}	6×10^{-1}	2×10^{-5}
	Ethoxylated nonylphenol			
	Alkyl benzene sulfonates			
	Alkali/salts			
25	Terpenes	1.63	12.4	4.59×10^{-4}
	Esters/lactones	8×10^{-2}	6×10^{-1}	2×10^{-5}
26	Fatty acid derivatives			
	Esters/lactones			
27	Terpenes	3	23	7.9×10^{-4}
28	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic	1	9	4×10^{-4}
	Propylene glycol ethers	2×10^{-1}	1	6×10^{-5}
31	Hydrocarbons, aromatic	3×10^{-1}	2	9×10^{-5}
	Hydrocarbons, petroleum distillates	2	10	6×10^{-4}
32	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
33	Hydrocarbons, petroleum distillates	5×10^{-1}	4	1×10^{-4}
	Hydrocarbons, aromatic	5×10^{-1}	4	1×10^{-4}
	Propylene glycol ethers	8×10^{-2}	6×10^{-1}	2×10^{-5}

Form. Number	Chemical Components	100 Meter Concentration ($\mu g/m^3$)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
34	Water			
	Terpenes	3×10^{-1}	2	9×10^{-5}
	Hydrocarbons, petroleum distillates	3×10^{-1}	2	9×10^{-5}
	Alkoxylated alcohols			
	Fatty acid derivatives			
35	Hydrocarbons, petroleum distillates	3×10^{-1}	2	9×10^{-5}
	Hydrocarbons, aromatic	2	10	5×10^{-4}
36	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates	4×10^{-1}	3	1×10^{-4}
	Hydrocarbons, aromatic	2×10^{-1}	1	6×10^{-5}
	Propylene glycol ethers	8×10^{-2}	6×10^{-1}	2×10^{-5}
37	Water			
	Hydrocarbons, petroleum distillates	1.8	14	6×10^{-4}
	Hydrocarbons, aromatic	8×10^{-1}	6	2×10^{-4}
38	Hydrocarbons, petroleum distillates	1	9	4×10^{-4}
	Alkoxylated alcohols	3×10^{-1}	2	9×10^{-5}
	Fatty acid derivatives			
39	Water			
	Hydrocarbons, petroleum distillates	4×10^{-1}	3	1×10^{-4}
	Propylene glycol ethers	2×10^{-1}	1	6×10^{-5}
	Alkanolamines			
	Ethylene glycol ethers	9×10^{-2}	7×10^{-1}	3×10^{-5}
40	Hydrocarbons, aromatic	3×10^{-1}	2	9×10^{-5}
	Hydrocarbons, petroleum distillates	3×10^{-1}	2	9×10^{-5}
	Fatty acid derivatives			
	Ethoxylated nonylphenol			

[1] A blank space in the table indicates that there were no releases to air because the chemical would not evaporate readily.

Surface Water

Releases to surface water are those releases discharged through a drain at a printing facility, or at a laundry facility laundering rags from the printing facility that end up going to public sewers or Publicly Owned Treatment Works (POTWs). This discharge is treated before being released. The effectiveness of the treatment determined so that the amount actually getting through to the receiving water body can be calculated. The receiving water will dilute the discharge from the POTW, and a stream concentration can be calculated using stream flow information. Stream in this context means the receiving body of water, and are creeks and rivers as well as streams.

Average stream concentrations are used to calculate average drinking water consumption. Many public water supplies are drawn from the local streams and rivers; the concentration in the stream is the concentration which people will ingest. People on average drink two liters of water a day. Remember that many commercially-prepared beverages are still made with local water at the bottling plant.

Since there are many chemicals which accumulate in living organisms (bioaccumulation), the amount of the chemical from eating fish living in the same streams and rivers is calculated. The ability of a chemical to bioaccumulate may be measured or estimated, and that property is called the bioaccumulation factor. For certain kinds of chemicals, food consumption may deliver very high doses because of the cumulative nature. We use the bioconcentration factor and the average amount of fish eaten per person per day to calculate an average amount of chemical ingested by people on a daily basis (Table 3-5).

The other issue for surface water is the effect that a chemical may have on aquatic organisms, from algae to fish. If the food chain is broken in a stream, the consequences are dire. No algae, no fish. A healthy stream with many organisms will have a better ability to handle chemical releases than one whose quality is already compromised. The organisms lower on the food chain, such as algae, tend to have shorter lives, making shorter exposure time periods more critical. Since concentrations will vary with the stream flow, there may be periods of lower flow conditions where the same amount released as on a regular flow situation will cause problems. We use historical stream data to try to predict how often this will happen. For lithographers, since most do not need to have their own wastewater permit and more typically send their water to the local treatment plant, we use the information for the wastewater treatment plants to calculate the concentrations.

Local Exposure: For the single facility impact to be calculated for a real facility, the stream to which the local POTW discharges should be known. Just as there are variations in facility sizes, there are variations in stream flows, and stream flows vary with time. The impact of this on this assessment is that more than one concentration needs to be calculated. Chronic effects, such as cancer, require average concentrations to be used. Since the average (mean) stream flows depends on what stream is being used, we select two averages to calculate - the average concentration for an mid-sized stream (50th percentile mean flow), and the average concentration for a small stream (10th percentile mean flow). For acute concerns and for ecological concerns, we calculated high concentrations which occur under low flow conditions. Specifically, low flow is the lowest flow that continues for seven consecutive days in ten years. However, we only calculate the low for small streams (10th percentile low flow).

The actual flows used in this assessment are 499 million liters per day for the 50th percentile harmonic mean flow, 66 million liters per day for 10th percentile mean flow, and 1 million liters per day for 10th percentile low flow.

Since an individual may ingest both drinking water and fish, there are multiple potential doses to evaluate.

To calculate stream concentration in μg/L, use the following formula:

$$\text{Stream Concentration} = \frac{\text{Release in kg/site/day x (1-Removal) x 1000}}{\text{Streamflow in million liters per day}}$$

or,

$$\text{Stream Concentration} = \frac{\text{Release after treatment in kg/site/day x 1000}}{\text{Streamflow in million liters per day}}$$

Because the flow data we use are measured by the U.S. Geological Survey (USGS) below any discharger on that segment of the stream (technically at the bottom of the reach), it already includes water from any POTW on that segment. For large streams this is not an important consideration, but for POTWs on small streams, it becomes contentious. A POTW with an internal plant flow of 10 million liters per day releasing to a stream which has a low flow of 10 million liters per day is not insignificant; it is all of the receiving stream's water. Based on the data, there are a significant number of POTWs for which this appears to be the case.

To calculate how much a person will ingest through drinking water in mg per year, use the formula:

Yearly Potential Dose Rate = Stream concentration in µg per liter x 2 liters of water per day x Days of release per year x 0.001

To calculate the potential amount taken through eating seafood in mg per year, use the following formula:

Yearly Potential Dose Rate = Stream concentration in µg per liter x Bioconcentration factor x 16.9 grams of fish per day x Days of release per year x 10^{-6}

The formula above does not consider removal during drinking water treatment. Public drinking water treatment is designed primarily to prevent biological contamination of drinking water and does not necessarily remove chemicals from the water. For most chemicals, drinking water treatment is not an effective mechanism. An exception to this is where an activated charcoal filter is used, such as on a private residential tap, which will remove a significant portion of the organic chemicals in the water.

The bioconcentration factor is a chemical-specific property. It is calculated with the environmental fate properties. The chemicals are assumed to be released 250 days per year.

Cumulative releases to the same POTW may be estimated by counting the number of lithographers in an area and distributing the releases across all the POTWs in the area. We have to assume that the releases are for the same products, or very similar products. As for air, this cumulative number is expected to be far more significant than the amount for any single lithographer. Again, Denver is the city used as an example (Table 3-6). Releases from all of the 235 lithographers in the city of Denver are assumed to go from the Denver Metro Wastewater Reclamation District into the South Platte River. The concentrations are calculated for harmonic mean flow of 875 million liters per day - which is the average or typical flow for the river, and for the low flow of 590 million liters per day - the lowest flow for seven consecutive days in ten years. Downstream from the discharge are drinking water intakes for the City of Broomfield and the City of Thornton.

Uncertainty

Within our scenario, there are specific parameters which affect final concentrations and therefore final exposures more than others. Since we are using the estimates for comparison, the single most important factor is the amount of the substance released per formulation. For water releases, the second most uncertain factor is the volume of water in the receiving stream, followed by the amount of substance removed in waste water treatment. In actuality, river flows vary continuously, so even a constant and steady flow of a specific chemical into the water will have variations in concentration. Some waste water treatment plants will remove more of a chemical than others, and even vary within the same plant at different times. The difference that this

Table 3-5. Stream Concentrations and Residential Population Potential Doses from Single Facility Blanket Wash Releases

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment [1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
1	Fatty acid derivatives									
	Alkoxylated alcohols									
3	Hydrocarbons, petroleum distillates									
	Fatty acid derivatives	6.1×10^{-1}	3.6×10^{-2}	7×10^{-5}	6×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	1×10^{2}	1×10^{3}
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.5×10^{-1}	2.6×10^{-2}	5×10^{-5}	4×10^{-4}	3×10^{-2}	3×10^{-2}	2×10^{-1}	6×10^{-1}	4
4	Terpenes									
	Ethoxylated nonylphenol[3]	1.56	8×10	2×10^{-4}	1.0×10^{-3}	8.0×10^{-2}	8×10^{-2}	6×10^{-1}		
5	Water									
	Hydrocarbons, aromatic									
	Ethylene glycol ethers									
	Ethoxylated nonylphenol[3]	2.0×10^{-1}	1×10^{-2}	2×10^{-5}	2×10^{-4}	1.0×10^{-2}	1×10^{-2}	8×10^{-2}		
	Alkyl benzene sulfonates	1.2×10^{-1}	2.4×10^{-3}	5×10^{-6}	3.9×10^{-5}	2.6×10^{-3}	2.6×10^{-3}	2.5×10^{-2}	1×10^{-2}	1×10^{-2}
	Alkoxylated alcohols	6.0×10^{-2}	5.9×10^{-2}	1×10^{-4}	9×10^{-4}	6×10^{-2}	6×10^{-2}	5×10^{-1}	9×10^{-2}	7×10^{-1}
	Alkali/salts	2.0×10^{-2}	0	0	0	0	0	0	0	0
6	Fatty acid derivatives	1.3	7.9×10^{-2}	2×10^{-4}	1×10^{-3}	8×10^{-2}	8×10^{-2}	6×10^{-1}	3×10^{2}	2×10^{3}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.0×10^{-1}	3.0×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}	0	0
7	Terpenes									
	Ethoxylated nonylphenol[3]	6.0×10^{-2}	3×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}		
	Alkoxylated alcohols	6.0×10^{-2}	9×10^{-3}	2×10^{-5}	1×10^{-4}	9×10^{-3}	9×10^{-3}	7×10^{-2}	0	0
8	Water									
	Hydrocarbons, aromatic									
	Propylene glycol ethers									
	Ethoxylated nonylphenol[3]	1.7×10^{-1}	9×10^{-3}	2×10^{-5}	1×10^{-4}	9.0×10^{-3}	9×10^{-3}	6×10^{-2}		
	Alkyl benzene sulfonates	3.64×10^{-1}	5.332×10^{-2}	1.11×10^{-4}	8.08×10^{-4}	4.95×10^{-2}	4.95×10^{-2}	3.7×10^{-1}	1×10^{-2}	9×10^{-2}
	Alkoxylated alcohols	5.2×10^{-2}	5.1×10^{-2}	1×10^{-4}	8×10^{-4}	5×10^{-2}	5×10^{-2}	4×10^{-1}	8×10^{-2}	6×10^{-1}
	Alkali/salts	1.6×10^{-2}	0	0	0	0	0	0	0	0

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment[1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
9	Fatty acid derivatives	1.6	9.7×10^{-2}	2×10^{-4}	1×10^{-3}	1×10^{-1}	1×10^{-1}	7×10^{-1}	4×10^{2}	3×10^{3}
	Water									
	Ethoxylated nonylphenol[3]	6.0×10^{-2}	3×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}		
10	Fatty acid derivatives	5.6×10^{-1}	3.4×10^{-2}	7×10^{-5}	5×10^{-4}	3×10^{-2}	3×10^{-2}	3×10^{-1}	1×10^{2}	1×10^{3}
	Water									
11	Fatty acid derivatives	1.0	6.0×10^{-2}	1×10^{-4}	9×10^{-4}	6×10^{-2}	6×10^{-2}	5×10^{-1}	2×10^{2}	2×10^{2}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	9.2×10^{-2}	1.6×10^{-2}	3×10^{-5}	2×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	0	0
12	Hydrocarbons, petroleum distillates									
14	Fatty acid derivatives	2.2×10^{-1}	1.3×10^{-2}	3×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	1×10^{-1}	5×10^{1}	4×10^{2}
	Propylene glycol ethers									
16	Terpenes									
17	Ethoxylated nonylphenol[3]	4.4×10^{-2}	2×10^{-3}	4×10^{-6}	3×10^{-5}	2×10^{-3}	2×10^{-3}	2×10^{-2}		
	Glycols									
	Fatty acid derivatives	2.0×10^{-2}	1.2×10^{-3}	2×10^{-6}	2×10^{-5}	1×10^{-3}	1×10^{-3}	9×10^{-3}	5	3
	Alkali/salts	1.2×10^{-2}								
	Water									
18	Fatty acid derivatives	9.0×10^{-1}	5.4×10^{-2}	1×10^{-4}	8×10^{-4}	5×10^{-2}	5×10^{-2}	4×10^{-1}	2×10^{2}	2×10^{3}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Dibasic esters									
	Esters/lactones									
	Alkyl benzene sulfonates	9.2×10^{-2}	1.6×10^{-2}	3×10^{-5}	2×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	0	0
19	Fatty acid derivatives	7.3×10^{-1}	4.4×10^{-2}	9×10^{-5}	7×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	2×10^{2}	1×10^{3}
	Propylene glycol ethers									
20	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.0 x 10	3.9×10^{-2}	8^{-1}x 10^{-5}	6×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	0	0
21	Hydrocarbons, aromatic									
	Hydrocarbons, petroleum distillates									
	Fatty acid derivatives	1.0	1.0 x 10	2×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	8×10^{-2}	$^{-2}$ 4×10^{1}	3×10^{2}

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release[1] After POTW Treatment (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
22	Fatty acid derivatives Hydrocarbons, aromatic	1.2	6.9 x 10	$1^{2} \times 10^{-4}$	1×10^{-3}	7×10^{-2}	7×10^{-2}	5×10^{2}	3×10^{2}	2×10^{3}
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols									
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol[3] Alkyl benzene sulfonates Alkali/salts	 9.2×10^{-2} 1.4×10^{-1} 9.2×10^{-2}	 5×10^{-3} 4.2×10^{-3} 1.6×10^{-2}	 9×10^{-6} 8×10^{-6} 3×10^{-5}	 7×10^{-5} 6×10^{-5} 2×10^{-4}	 5×10^{-3} 4×10^{-3} 2×10^{-2}	 5×10^{-3} 4×10^{-3} 2×10^{-2}	 4×10^{-2} 3×10^{-2} 1×10^{-1}	 0 0	 0 0
25	Terpenes Esters/lactones									
26	Fatty acid derivatives Esters/lactones	6.1 1.03×10^{-1}	1.241×10^{-1} 4.1×10^{-3}	2.08×10^{-4} 8×10^{-6}	2.06×10^{-3} 6×10^{-5}	1.04×10^{-1} 4×10^{-3}	1.04×10^{-1} 4×10^{-3}	9.3×10^{-1} 3×10^{-2}	5.006×10^{2} 0	3.005×10^{3} 0
27	Terpenes									
28	Hydrocarbons, petroleum distillates									
29	Fatty acid derivatives	2.1	1.3×10^{-1}	3×10^{-4}	2×10^{-3}	1×10^{-1}	1×10^{-1}	1	5×10^{2}	4×10^{3}
30	Hydrocarbons, aromatic Propylene glycol ethers									
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates									
32	Hydrocarbons, petroleum distillates									
33	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers									
34	Water Terpenes Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	 1.7×10^{-1} 1.7×10^{-1}	 2.9×10^{-2} 1.7×10^{-2}	 6×10^{-5} 3×10^{-5}	 4×10^{-4} 3×10^{-4}	 3×10^{-2} 2×10^{-2}	 3×10^{-2} 2×10^{-2}	 2×10^{-1} 1×10^{-1}	 0 2×10^{-2}	 0 2×10^{-1}

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment[1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic									
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	1.5	9.0×10^{-2}	2×10^{-4}	1×10^{-3}	9×10^{-2}	9×10^{-2}	7×10^{-1}	3×10^{2}	3×10^{3}
37	D. I. Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic									
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives									
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	6.8×10^{-2}	1.2×10^{-2}	2×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	9×10^{-2}	0	0
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol[3]	1.4 8.8×10^{-2}	0 4×10^{-3}	0 9×10^{-6}	0 7×10^{-5}	0 4×10^{-3}	0 4×10^{-3}	0 3×10^{-2}	0	0

[1] A blank space in these columns indicates that there were no releases to water expected for this chemical in this formulation.

[2] A blank in the drinking water columns of this table indicates that there are no exposures expected from this chemical due to people drinking water. This may be due to either no releases to water expected, or the chemical may be completely removed during wastewater treatment, and therefore, is not expected to be released to the stream or river from the POTW. An additional blank in the Fish Ingestion columns means that a bioaccumulation factor was not available for this chemical.

[3] Based on testing data (Weeks, A.J. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.), the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of the releases from POTWs to surface waters of ethoxylated nonylphenols. When the releases to surface water are compared with the concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24, and 40) present concerns to aquatic species that were not reported in the draft CTSA.

Table 3-6. Stream Concentrations and Residential Population Potential Dose Rates from Denver Lithography Blanket Wash Releases

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
1	Fatty acid derivatives						
	Alkoxylated alcohols						
3	Hydrocarbons, petroleum distillates						
	Fatty acid derivatives	1.4×10^{2}	8.6	1×10^{-2}	1×10^{-2}	5	2×10^{4}
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	36	6.1	7×10^{-3}	1×10^{-2}	3	80
4	Terpenes						
	Ethoxylated nonylphenol[3]	73	3.7	4×10^{-3}	6×10^{-3}	2	
5	Water						
	Hydrocarbons, aromatic						
	Ethylene glycol ethers						
	Ethoxylated nonylphenol[3]	47	2.4	3×10^{-3}	4×10^{-3}	1	
	Alkyl benzene sulfonates	28	5.6×10^{-1}	7×10^{-4}	9×10^{-4}	2.8×10^{-1}	2
	Alkoxylated alcohols	14	14	2×10^{-2}	2×10^{-2}	8	10
	Alkali/salts	4.7	0.0	0	0	0	
6	Fatty acid derivatives	3.1×10^{2}	19	2×10^{-2}	3×10^{-2}	10	4×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	24	7.1×10^{-1}	8×10^{-4}	1×10^{-3}	4×10^{-1}	
7	Terpenes						
	Ethoxylated nonylphenol[3]	14	0.7	8×10^{-4}	1×10^{-3}	0.4	
	Alkoxylated alcohols	14	2.1	2×10^{-3}	4×10^{-3}	1	
8	Water						
	Hydrocarbons, aromatic						
	Propylene glycol ethers						
	Alkyl benzene sulfonates	85	12.22	1.2×10^{-2}	2.4×10^{-2}	7.07	2
	Ethoxylated nonylphenol[3]	40	2.0	2×10^{-3}	3×10^{-3}	1	
	Alkoxylated alcohols	12	12	1×10^{-2}	2×10^{-2}	7	10
	Alkali/salts	3.8	0.0	0	0	0	
9	Fatty acid derivatives	3.8×10^{2}	23	3×10^{-2}	4×10^{-2}	10	5×10^{4}
	Water						
	Ethoxylated nonylphenol[3]	14	0.7	8×10^{-4}	1×10^{-3}	4	
10	Fatty acid derivatives	1.3×10^{2}	7.9	9×10^{-3}	1×10^{-2}	5	2×10^{4}
	Water						
11	Fatty acid derivatives	2.3×10^{2}	14	2×10^{-2}	2×10^{-2}	8	3×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	22	3.7	4×10^{-3}	6×10^{-3}	2	
12	Hydrocarbons, petroleum distillates						
14	Fatty acid derivatives	51	3.0	3×10^{-3}	5×10^{-3}	2	7×10^{3}
	Propylene glycol ethers						
16	Terpenes						

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
17	Ethoxylated nonylphenol[3]	10	0.5	6×10^{-4}	8×10^{-4}	0.3	
	Glycols						
	Fatty acid derivatives	4.7	2.8×10^{-1}	3×10^{-4}	5×10^{-4}	2×10^{-1}	6×10^{2}
	Alkali/salts						
	Water						
18	Fatty acid derivatives	2.1×10^{2}	13	1×10^{-2}	2×10^{-2}	7	3×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Dibasic esters						
	Esters/lactones						
	Alkyl benzene sulfonates	22	3.7	4×10^{-3}	6×10^{-3}	2	
19	Fatty acid derivatives	1.7×10^{2}	10	1×10^{-2}	2×10^{-2}	6	2×10^{4}
	Propylene glycol ethers						
20	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	24	9.2	1×10^{-2}	2×10^{-2}	5	
21	Hydrocarbons, aromatic						
	Hydrocarbons, petroleum distillates						
	Fatty acid derivatives	2.4×10^{2}	2.4	3×10^{-3}	4×10^{-3}	1	6×10^{3}
22	Fatty acid derivatives	2.7×10^{2}	16	2×10^{-2}	3×10^{-2}	9	4×10^{4}
	Hydrocarbons, aromatic						
23	Terpenes						
	Nitrogen heterocyclics						
	Alkoxylated alcohols						
24	Terpenes						
	Ethylene glycol ethers						
	Ethoxylated nonylphenol[3]	22	1.1	1×10^{-3}	2×10^{-3}	6×10^{-1}	
	Alkyl benzene sulfonates	33	9.9×10^{-1}	1×10^{-3}	2×10^{-3}	6×10^{-1}	
	Alkali/salts	22	3.7	4×10^{-3}	6×10^{-3}	2	
25	Terpenes						
	Esters/lactones						
26	Fatty acid derivatives	5.66×10^{2}	2.896×10^{1}	3.1×10^{-2}	5.2×10^{-2}	20.5	6.008×10^{4}
	Esters/lactones	2.36×10^{2}	9.6×10^{-1}	1×10^{-3}	2×10^{-3}	5×10^{-1}	0
27	Terpenes						
28	Hydrocarbons, petroleum distillates						
29	Fatty acid derivatives	5.0×10^{2}	30	3×10^{-2}	5×10^{-2}	20	6×10^{4}
30	Hydrocarbons, aromatic						
	Propylene glycol ethers						
31	Hydrocarbons, aromatic						
	Hydrocarbons, petroleum distillates						
32	Hydrocarbons, petroleum distillates						
33	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Propylene glycol ethers						

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
34	Water						
	Terpenes						
	Hydrocarbons, petroleum distillates						
	Alkoxylated alcohols	39	6.7	8×10^{-3}	1×10^{-2}	4	
	Fatty acid derivatives	39	3.9	5×10^{-3}	7×10^{-3}	2	3
35	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
36	Fatty acid derivatives	3.5×10^{2}	21	2×10^{-2}	4×10^{-2}	10	5×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Propylene glycol ethers						
37	Water						
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
38	Hydrocarbons, petroleum distillates						
	Alkoxylated alcohols						
	Fatty acid derivatives						
39	Water						
	Hydrocarbons, petroleum distillates						
	Propylene glycol ethers						
	Alkanolamines	16	2.7	3×10^{-3}	5×10^{-3}	2	
	Ethylene glycol ethers						
40	Hydrocarbons, aromatic						
	Hydrocarbons, petroleum distillates						
	Fatty acid derivatives	3.3×10^{2}	0.0	0	0	0	0
	Ethoxylated nonylphenol[3]	21	1.1×10^{-3}	1.2×10^{-3}	1.9×10^{-3}	0.6	

[1] A blank space in these columns indicates that there were no releases to water expected for this chemical in this formulation.

[2] A blank in the drinking water columns of this table indicates that there are no exposures expected from this chemical due to people drinking water. This may be due to either no releases to water expected, or the chemical may be completely removed during wastewater treatment, and therefore, is not expected to be released to the stream or river from the POTW. An additional blank in the Fish Ingestion columns means that a bioaccumulation factor was not available for this chemical.

[3] Based on testing data (Weeks, J.A. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.), the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of the releases from POTWs to surface waters of ethoxylated nonylphenols. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24, and 40) present concerns to aquatic species that were not reported in the draft CTSA.

makes in the final concentration is not as significant as the volume of the chemical released, i.e. the difference between fifty percent and sixty percent removal of a chemical.

Septic Systems

When examining the business census data for lithographers and the EPA's data for waste water treatment facilities, it was noted that there are counties which do not have any POTWs. While some of the Agency's data is probably in error, there are still a significant minority of lithographers who do not appear to release water to a waste water treatment plant. These printers are assumed to release to septic systems or have no water releases at all. The releases of this type are not modeled in this assessment. Some general guidelines may be used to determine if there will be exposure to any of the blanket wash chemicals from septic system seepage. Each chemical will have an estimated potential migration to ground water, usually used for landfill assessments. This can be directly applied to septic systems, because the potential to migrate to ground water will be the same. Of course the individual characteristics of the system will determine the actual speed that each chemical travels into the ground water. If the septic system is relatively leaky, and the ground water table is relatively high, the time that a chemical takes to get into the ground water will be shorter than for a septic system which is well sealed and where the ground water table is low.

Landfill

Our usual techniques for estimating cumulative exposures from landfill releases are not applicable to printing. For large-scale industrial processes, we assume that one facility sends waste to a landfill via a waste handler. For the printing industry, it is not reasonable to simplify the situation to that extent. A lack of data limits the determination of exposures. For instance, we do not know how many printers are sending what types of wastes to any given landfill. Some printers send part of their wastes to a hazardous waste handler, and another portion to the county landfill. For these reasons, although the exposures from landfill releases may be significant, we cannot calculate exposures from landfill seepage and migration into ground water. However, we can give the expected fate for the chemical in the landfill - will the chemical migrate to ground water rapidly, moderately or negligibly.

3.4 RISK CHARACTERIZATION

3.4.1 Background

Assessment of the human health risks presented by chemical substances includes the following components of analysis:

1) Hazard Identification is the process of determining whether exposure to a chemical can cause an adverse health effect and whether the adverse health effect is likely to occur in humans.

2) Dose-response Assessment is the process of defining the relationship between the dose of a chemical received and the incidence of adverse health effects in the exposed population. From the quantitative dose-response relationship, toxicity values are derived that are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at different exposure levels.

3) Exposure Assessment identifies populations exposed to a chemical, describes their composition and size, and presents the types, magnitudes, frequencies, and durations of exposure to the chemical.

4) Risk Characterization integrates hazard and exposure information into quantitative and qualitative expressions of risk. A risk characterization includes a description of the assumptions, scientific judgments, and uncertainties embodied in the assessment.

Quantitative Expressions of Hazard and Risk

The manner in which estimates of hazard and risk are expressed depends on the nature of the hazard and the types of data upon which the assessment is based. For example, cancer risks are most often expressed as the probability of an individual developing cancer over a lifetime of exposure to the chemical in question. Risk estimates for adverse effects other than cancer are usually expressed as the ratio of a toxicologic potency value to an estimated dose or exposure level. A key distinction between cancer and other toxicologic effects is that most carcinogens are assumed to have no dose threshold, i.e., no dose or exposure level can be presumed to be without some risk. Other toxicologic effects are generally assumed to have a dose threshold, i.e., a dose or exposure level below which a significant adverse effect is not expected.

Cancer Hazard and Risk

EPA employs a "weight-of-evidence" approach to determine the likelihood that a chemical is a human carcinogen. Each chemical evaluated is placed into one of the five weight-of-evidence categories listed below.

Group A --	human carcinogen
Group B --	probable human carcinogen. B1 indicates limited human evidence; B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
Group C --	possible human carcinogen
Group D --	not classifiable as to human carcinogenicity
Group E --	evidence of noncarcinogenicity for humans

When the available data are sufficient for quantitation, EPA develops an estimate of the chemical's carcinogenic potency. EPA "slope factors" express carcinogenic potency in terms of the estimated upper-bound incremental lifetime risk per mg/kg average daily dose. "Unit risk" is a similar measure of potency for air or drinking water concentrations and is expressed as risk per $\mu g/m^3$ in air or as risk per µg/L in water for continuous lifetime exposures.

Cancer risk is calculated by multiplying the estimated dose or exposure level by the appropriate measure of carcinogenic potency. For example an individual with a lifetime average daily dose of 0.3 mg/kg of a carcinogen with a potency of 0.02 mg/kg/day would experience a lifetime cancer risk of 0.006 from exposure to that chemical. In general, risks from exposures to more than one carcinogen are assumed to be additive, unless other information points toward a different interpretation.

Chronic Health Risks

Because adverse effects other than cancer and genetic toxicity are generally assumed to have a dose or exposure threshold, a different approach is needed to evaluate toxicologic potency and risk for these "systemic effects." "Systemic toxicity" means an adverse effect on any organ system following absorption and distribution of a toxicant to a site in the body distant from the toxicant's entry point. EPA uses the "Reference Dose" approach to evaluate chronic (long-term) exposures to systemic toxicants. The Reference Dose (RfD) is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime" and is expressed as a mg/kg/day dose. The RfD is usually based on the most sensitive known effect, i.e., the effect that occurs at the lowest dose. EPA calculates a comparable measure of potency for continuous inhalation exposures called a Reference Concentration or RfC, expressed as a mg/m^3 air concentration. Although some RfDs and RfCs are based on actual human data, they are most often calculated from results obtained in chronic or subchronic animal studies. The basic approach for deriving an RfD or RfC involves determining a "no-observed-adverse-effect level (NOAEL)" or "lowest-observed-adverse-effect level (LOAEL)" from an appropriate toxicologic or epidemiologic study and then applying various uncertainty factors and modifying factors to arrive at the RfD/RfC. Each factor represents a specific area of uncertainty. For example, an RfD based on a NOAEL from a long-term animal study may incorporate a factor of 10 to account for the uncertainty in extrapolating from the test species to humans and another factor of 10 to account for the variation in sensitivity within the human population. An RfD based on a LOAEL typically contains another factor of 10 to account for the extrapolation from LOAEL to NOAEL. An additional modifying factor (between 1 and 10) is sometimes applied to account for uncertainties in data quality.

RfDs and RfCs can be used to evaluate risks from chronic exposures to systemic toxicants. EPA defines an expression of risk called a "Hazard Quotient" which is the ratio of the estimated chronic dose/exposure level to the RfD/RfC. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. However, it is important to remember that the Hazard Quotient is not a probabilistic statement of risk. A quotient of 0.001 does not mean that there is a one-in-a-thousand chance of the effect occurring. Furthermore, it is important to remember that the level of concern does not necessarily increase linearly as the quotient approaches or exceeds unity because the RfD/RfC does not provide any information about the shape of the dose-response curve.

An expression of risk that can be used when an RfD/RfC is not available is the "Margin-of-Exposure (MOE)." The MOE is the ratio of a NOAEL or LOAEL (preferably from a chronic study) to an estimated dose or exposure level. Interpretation of an MOE employs the same approach to uncertainty as the RfD does. An MOE value high enough to account for the uncertainties in extrapolating from the experimental data to a likely no-effect level in humans implies a low level of concern. For example, MOE values such as values greater than 100 for a NOAEL-based MOE (to account for interspecies and intraspecies variability) or 1000 for a LOAEL-based MOE (to account for interspecies and intraspecies variability and LOAEL to NOAEL extrapolation) indicate low concern. As the MOE decreases, the level of concern increases. As with the Hazard Quotient, it is important to remember that the MOE is not a probabilistic statement of risk.

Developmental Toxicity Risks

Because of the many unique elements associated with both the hazard and exposure components of developmental toxicity risk assessment, these risks are treated separately from other systemic toxicity risks.

EPA defines developmental toxicity as adverse effects on the developing organism that may result from exposure prior to conception, during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the life span of the organism. The major manifestations of developmental toxicity include: (1) death of the developing organism, (2) structural abnormality, (3) altered growth, and (4) functional deficiency.

There is a possibility that a single exposure may be sufficient to produce adverse developmental effects. Therefore, it is assumed that, in most cases, a single exposure at any of several developmental stages may be sufficient to produce an adverse developmental effect. In the case of intermittent exposures, examination of the peak exposure(s) as well as the average exposure over the time period of exposure is important.

EPA has derived RfDs and RfCs for developmental toxicants in a similar manner to the RfDs and RfCs for other systemic toxicants. The RfD_{DT} or RfC_{DT} is an estimate of a daily exposure to the human population that is assumed to be without appreciable risk of deleterious developmental effects. The use of the subscript DT is intended to distinguish these terms from the more common RfDs and RfCs that refer to chronic exposure situations for other systemic effects.

Developmental toxicity risk can be expressed as a Hazard Quotient (dose or exposure level divided by the RfD_{DT} or RfC_{DT}) or Margin-of-Exposure (NOAEL or LOAEL divided by the dose or exposure level), with careful attention paid to the exposure term, as described above.

NOTE: The closely related area of reproductive toxicity is also an important aspect of systemic toxicity. For purposes of this report, toxicity information on adult male and female reproductive systems will be assessed as part of the chronic toxicity risk.

Decision Criteria

"Concerns" are cases in which the estimated hazard quotient is ten or greater or in which the estimated margin-of-exposure (MOE) is much less than 100 (based on a no-observed adverse effect level (NOAEL)) or much less than 1000 (based on a lowest-observed adverse effect level (LOAEL)).

"Possible concerns" are cases in which the estimated hazard quotient is between one and ten or in which the estimated margin-of-exposure is slightly less than 100 (based on a no-observed adverse effect level) or slightly less than 1000 (based on a lowest-observed adverse effect level) or cases in which the concern is mitigated by other considerations such as absorption rates.

"Low or negligible concerns" are cases in which the estimated hazard quotient is less than one or in which the MOE_{NOAEL} is greater than 100 or the MOE_{LOAEL} is greater than 1000.

Assumptions and Uncertainties

Estimated doses assume 100 percent absorption. The actual absorption rate may be significantly lower, especially for dermal exposures to relatively polar compounds. The assessment used the most relevant toxicological potency factor available for the exposure under consideration. In some cases the only potency factor available was derived from a study employing a different route of exposure than the exposure being evaluated, e.g., oral RfD values were sometimes used to calculate Hazard Quotients for inhalation and dermal exposures. Most of the Margin-of-Exposure calculations presented in the assessment are based on toxicity data that have not been formally evaluated by the Agency. Because of the small contribution of inhalation exposure to the total dose (<1% for most chemicals), combined dose MOEs were not calculated.

Worker dermal exposure values should be regarded as “bounding estimates,” i.e., calculated exposures are expected to be higher than any actual exposure levels. Exposure estimates for all other pathways (worker inhalation, general population exposure via ambient air, drinking water and fish) should be regarded as “what if” estimates. The “what if” scenarios are based on information on product usage and work practices obtained from industry surveys. No actual measures of chemical release or exposure were available. The scenarios are intended to represent a plausible set of circumstances under which exposures could occur. However, not enough information is available to estimate the probability of these circumstances actually occurring. Thus, it is not possible to predict where the calculated values fall in the exposure distribution, i.e., the resulting exposure and risk estimates cannot be characterized as “central tendency,” “high end,” etc.

A number of the chemicals of concern have only a limited toxicologic data base. The calculated risks for trimethylbenzene, light aromatic naphtha, linalool, butyrolactone, Stoddard solvent, and diethanolamine are based on LOAEL values from studies that did not reach a NOAEL. The available studies on these chemicals are generally limited in scope and do not address all major toxicologic endpoints.

3.4.2 Ecological Risk

The basic elements of ecological risk assessment are similar to those employed in human health risk assessment. Because of the limited toxicological data available for the lithographic blanket wash chemicals, this report will only address ecological risks to aquatic species. Risks to terrestrial species will not be assessed. Quantitative evaluation of aquatic risks involves comparing a predicted ambient water concentration to a "concern concentration" for chronic exposures to aquatic species. The concern concentration may be based either on actual toxicologic test data on the subject chemical or on quantitative structure-activity relationship analysis of test data on similar chemicals. The concern concentration is typically expressed as a mg/L water concentration. Exposure concentrations below the concern concentration are assumed to present low risk to aquatic species. Exposures that exceed the concern concentration indicate a potential for adverse impact on aquatic species. The level of concern increases as the ratio of exposure concentration to concern concentration increases.

A number of formulations present concerns with respect to potential impacts on aquatic species resulting from water releases. Only two chemical classes had estimated concentrations in a hypothetical receiving stream (a relatively small stream at low flow conditions) that exceeded the “concern concentration” for that chemical class. Predictions based on actual streamflow data for the South Platte River support these conclusions. Most of the excesses in the hypothetical stream are also excesses in the South Platte River, in some cases at mean flow as well as low flow conditions.

The following two chemicals exceeded the aquatic concern concentrations: alkyl benzene sulfonates and ethoxylated nonylphenols, which are present in Formulations 3, 5, 6, 8, 11, 18, 20, and 24, and in Formulations 4, 5, 7, 8, 9, 17, 24, and 40, respectively.

A table of the concern concentration estimates for aquatic species follows (Table 3-7):

<u>Assumptions and Uncertainties</u>

All estimated water concentrations are based on release estimates developed from “what if” scenarios constructed from industry surveys and assumptions reviewed by industry experts of product usage and work practices. No actual measures of chemical release or exposure levels were available.

Table 3-7. Risks to Aquatic Species from Blanket Wash Chemicals

Form. Number	Chemical Components	Stream concentrations (mg/L)			Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
		50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow		
1	Fatty acid derivatives					
	Alkoxylated alcohols					
3	Hydrocarbons, petroleum distillates					
	Fatty acid derivatives	7×10^{-5}	6×10^{-4}	4×10^{-2}	*	
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	5×10^{-5}	4×10^{-4}	3×10^{-2}	1×10^{-3}	3×10^{1}
4	Terpenes					
	Ethoxylated nonylphenol[2]	1.56×10^{-4}	1.182×10^{-3}	7.8×10^{-2}	1×10^{-3}	78
5	Water					
	Hydrocarbons, aromatic					
	Ethylene glycol ethers					
	Ethoxylated nonylphenol[2]	2.0×10^{-5}	1.52×10^{-4}	1.0×10^{-2}	1×10^{-3}	10
	Alkyl benzene sulfonates	5×10^{-6}	3.9×10^{-5}	2.6×10^{-3}	2×10^{-3}	1
	Alkoxylated alcohols	1×10^{-4}	9×10^{-4}	6×10^{-2}	2×10^{-1}	3×10^{-1}
	Alkali/salts	0	0	0		
6	Fatty acid derivatives	2×10^{-4}	1×10^{-3}	8×10^{-2}	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	6×10^{-6}	5×10^{-5}	3×10^{-3}	1×10^{-3}	3
7	Terpenes					
	Ethoxylated nonylphenol[2]	6×10^{-6}	4.5×10^{-5}	3.0×10^{-3}	1×10^{-3}	3
	Alkoxylated alcohols	2×10^{-5}	1×10^{-4}	9×10^{-3}	1×10^{-1}	9×10^{-2}
8	Water					
	Hydrocarbons, aromatic					
	Propylene glycol ethers					
	Alkyl benzene sulfonates	1.11×10^{-4}	8.08×10^{-4}	4.95×10^{-2}	$1\times10^{+1}$	5×10^{-1}
	Ethoxylated nonylphenol[2]	1.7×10^{-5}	1.29×10^{-4}	8.5×10^{-3}	1×10^{-3}	8.5
	Alkoxylated alcohols	1×10^{-4}	8×10^{-4}	5×10^{-2}	2×10^{-1}	3×10^{-1}
	Alkali/salts	0	0	0		
9	Fatty acid derivatives	2×10^{-4}	1×10^{-3}	1×10^{-1}	*	
	Water					
	Ethoxylated nonylphenol[2]	6×10^{-6}	4.5×10^{-5}	3×10^{-3}	1×10^{-3}	3
10	Fatty acid derivatives	7×10^{-5}	5×10^{-4}	3×10^{-2}	*	
	Water					
11	Fatty acid derivatives	1×10^{-4}	9×10^{-4}	6×10^{-2}	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	3×10^{-5}	2×10^{-4}	2×10^{-2}	1×10^{-3}	$2\times10^{+1}$
12	Hydrocarbons, petroleum distillates					
13	Hydrocarbons, petroleum distillates					
	Terpenes					
14	Fatty acid derivatives	3×10^{-5}	2×10^{-4}	1×10^{-2}	*	
	Ethylene glycol ethers					
16	Terpenes					

Form. Number	Chemical Components	Stream concentrations (mg/L)			Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
		50th %ile	10th %ile	10th %ile		
		Mean flow	Mean flow	Low flow		
17	Ethoxylated nonylphenol[2]	$4×10^{-6}$	$3.3×10^{-5}$	$2.2×10^{-3}$	$1×10^{-3}$	2.2
	Propylene glycol ethers					
	Fatty acid derivatives	$2×10^{-6}$	$2×10^{-5}$	$1×10^{-3}$	2	$5×10^{-4}$
	Alkali/salts					
	Water					
18	Fatty acid derivatives	$1×10^{-4}$	$8×10^{-4}$	$5×10^{-2}$	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Dibasic esters					
	Esters/lactones					
	Alkyl benzene sulfonates	$3×10^{-5}$	$2×10^{-4}$	$2×10^{-2}$	$1×10^{-3}$	$2×10^{+1}$
19	Fatty acid derivatives	$9×10^{-5}$	$7×10^{-4}$	$4×10^{-2}$	*	
	Ethylene glycol ethers					
20	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	$8×10^{-5}$	$6×10^{-4}$	$4×10^{-2}$	$1×10^{-3}$	$4×10^{+1}$
21	Hydrocarbons, aromatic					
	Hydrocarbons, petroleum distillates					
	Fatty acid derivatives	$2×10^{-5}$	$2×10^{-4}$	$1×10^{-2}$	*	
22	Fatty acid derivatives	$1×10^{-4}$	$1×10^{-3}$	$7×10^{-2}$	*	
	Hydrocarbons, aromatic					
23	Terpenes					
	Nitrogen heterocyclics					
	Alkoxylated alcohols					
24	Terpenes					
	Ethylene glycol ethers					
	Ethoxylated nonylphenol[2]	$9×10^{-6}$	$7×10^{-5}$	$4.6×10^{-3}$	$1×10^{-3}$	4.6
	Alkyl benzene sulfonates	$8×10^{-6}$	$6×10^{-5}$	$4×10^{-3}$	$3×10^{-2}$	$1×10^{-1}$
	Alkali/salts	$3×10^{-5}$	$2×10^{-4}$	$2×10^{-2}$	$9×10^{-2}$	$2×10^{-1}$
25	Terpenes					
	Esters/lactones					
26	Fatty acid derivatives	$2.08×10^{-4}$	$2.06×10^{-3}$	$1.04×10^{-1}$	$3×10^{-1}$	
	Esters/lactones	$8×10^{-6}$	$6×10^{-5}$	$4×10^{-3}$	$3×10^{-1}$	$1×10^{-2}$
27	Terpenes					
28	Hydrocarbons, petroleum distillates					
29	Fatty acid derivatives	$3×10^{-4}$	$2×10^{-3}$	$1×10^{-1}$	*	
30	Hydrocarbons, aromatic					
	Ethylene glycol ethers					
31	Hydrocarbons, aromatic					
	Hydrocarbons, petroleum distillates					
32	Hydrocarbons, petroleum distillates					
33	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Propylene glycol ethers					

Form. Number	Chemical Components	Stream concentrations (mg/L)			Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
		50th %ile	10th %ile	10th %ile		
		Mean flow	Mean flow	Low flow		
34	Water Terpenes Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	 6×10^{-5} 3×10^{-5}	 4×10^{-4} 3×10^{-4}	 3×10^{-2} 2×10^{-2}	 3×10^{-1} 7×10^{-2}	 1×10^{-1} 3×10^{-1}
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic					
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	2×10^{-4}	1×10^{-3}	9×10^{-2}	*	
37	Water Hydrocarbons, petroleum distillates Aliphatic hydrocarbon Hydrocarbons, aromatic					
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives					
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	 2×10^{-5}	 2×10^{-4}	 1×10^{-2}	 1	 1×10^{-2}
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol[2]	 9×10^{-6}	 6.7×10^{-5}	 4.4×10^{-3}	 1×10^{-3}	 4.4

[1] Low flow concentration/concern concentration; reported as mg/L

[2] Based on testing data (Weeks, J.A. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.) the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of releases to surface water. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24 and 40) present concerns to aquatic species that were not reported in the draft CTSA.

* No effects expected at saturation.

3.4.3 Occupational Risks

Most of the formulations (27/37) present at least some concern for dermal exposures to workers. A wide variety of chemicals trigger these concerns, which appear to be driven primarily by relatively high potential exposure levels. The calculated risks overestimate the actual risks because of the use of bounding estimates of exposure and the assumption of 100% dermal absorption. However, the margins of exposure are so low (below 10 for a number of chemicals) for most of the chemicals of concern that it is very likely that most of the identified concerns would remain if more realistic exposure estimates were available. Also, most of the chemicals of concern, e.g., various petroleum hydrocarbons, glycol ethers, diethanolamine, are probably well-absorbed dermally.

Worker inhalation risks are very low for almost all of the formulations, reflective of the generally low exposure levels as seen in Table 3-8. Only one formulation (formulation number 3) triggered inhalation concerns.

A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 1000 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-2. The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

The calculated risk numbers should be viewed as low-confidence estimates because of the many uncertainties associated with both the hazard and exposure components of the calculation. However, most of the risk conclusions that follow can be regarded with moderate to high confidence because most of the conclusions are based on risk estimates that fall far above or far below standard risk benchmarks. Thus, the “true” risk value could vary substantially from the estimated value without changing the conclusion. In particular, conclusions of low concern generally can be regarded with high confidence because of the conservative approach (i.e. one that overestimates the risk) taken in the assessment. Conclusions based on small excesses of risk benchmarks should be viewed with low confidence, as should any conclusions based primarily on structure-activity predictions.

Table 3-8. Worker Occupational Risk Estimates

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
1	Fatty acid derivatives		
	Alkoxylated alcohols		
3	Hydrocarbons, petroleum distillates		
	Fatty acid derivatives		
	Hydrocarbons, aromatic	10	4464
	Hydrocarbons, aromatic	1	33
	Hydrocarbons, aromatic	0.36 (HQ)	0.02 (HQ)
	Hydrocarbons, aromatic	1 (HQ)	0.02 (HQ)
	Alkyl benzene sulfonates		
4	Terpenes	5	236
	Ethoxylated nonylphenol	135	
	Ethoxylated nonylphenol	159	

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
5	Water		
	Hydrocarbons, aromatic	10	1.8×10^4
	Ethylene glycol ethers	26	1.8×10^5
	Ethoxylated nonylphenol	117	
	Alkyl benzene sulfonates		
	Alkoxylated alcohols		
	Alkyl benzene sulfonates		
	Alkali/salts		
6	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	38	6233
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		
7	Terpenes		
	Terpenes	22	1.8×10^4
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Ethoxylated nonylphenol	318	
	Alkoxylated alcohols		
8	Water		
	Hydrocarbons, aromatic		
	Propylene glycol ethers	200	4.1×10^4
	Alkyl benzene sulfonates		
	Ethoxylated nonylphenol	135	
	Alkyl benzene sulfonates		
	Alkoxylated alcohols		
	Alkyl benzene sulfonates		
	Alkali/salts		
9	Fatty acid derivatives		
	Water		
	Ethoxylated nonylphenol	455	
10	Fatty acid derivatives		
	Water		
11	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	21	4429
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
12	Hydrocarbons, petroleum distillates		
	Hydrocarbons, petroleum distillates	73	7.0×10^{4}
	Water		
14	Fatty acid derivatives		
	Propylene glycol ethers		
	Water		
16	Terpenes	22	1.8×10^{4}
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
17	Ethoxylated nonylphenol	515	
	Propylene glycol ethers	0.05 (HQ)	6×10^{-6} (HQ)
	Fatty acid derivatives		
	Alkali/salts	5208	
	Water		
18	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	26	5803
	Hydrocarbons, aromatic		
	Dibasic esters	4	5405
	Dibasic esters	4	9091
	Dibasic esters	4	5263
	Esters/lactones		
	Alkyl benzene sulfonates		
19	Fatty acid derivatives		
	Propylene glycol ethers		
	Water		
20	Water		
	Hydrocarbons, petroleum distillates	84	9.4×10^{4}
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		
21	Hydrocarbons, aromatic	13	4464
	Hydrocarbons, petroleum distillates	8	1336
	Fatty acid derivatives		
22	Fatty acid derivatives		
	Hydrocarbons, aromatic		
	Water		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
23	Terpenes	63	2.1×10^4
	Nitrogen heterocyclics	98	2.1×10^4
	Alkoxylated alcohols		
	Water		
24	Terpenes	28	7292
	Ethylene glycol ethers	83	7.8×10^5
	Ethoxylated nonylphenol	218	
	Alkyl benzene sulfonates	2	
	Alkali/salts		
	Water		
25	Terpenes		
	Terpenes	22	1.8×10^4
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Esters/lactones	218	1.5×10^4
26	Fatty acid derivatives		
	Esters/lactones	45	
	Fatty acid derivatives	151	
	Esters/lactones		
27	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes	455	3.6×10^5
	Terpenes		
	Terpenes		
28	Hydrocarbons, petroleum distillates	7	110
29	Fatty acid derivatives		
30	Hydrocarbons, aromatic	4	5168
	Propylene glycol ethers		
	Water		
31	Hydrocarbons, aromatic	17	1.1×10^4
	Hydrocarbons, petroleum distillates		
32	Hydrocarbons, petroleum distillates		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
33	Hydrocarbons, petroleum distillates	10	1.0×10^4
	Hydrocarbons, aromatic	11	2.2×10^4
	Propylene glycol ethers	3322	3.6×10^5
	Water		
34	Water		
	Terpenes	26	5147
	Hydrocarbons, petroleum distillates		
	Alkoxylated alcohols	140	
	Fatty acid derivatives		
35	Hydrocarbons, petroleum distillates		
	Hydrocarbons, aromatic	3	1.1×10^4
36	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	50	8014
	Hydrocarbons, aromatic		
	Propylene glycol ethers	1979	6.4×10^4
37	Water		
	Hydrocarbons, petroleum distillates		
	Hydrocarbons, aliphatic		
	Hydrocarbons, aromatic	100	1.5×10^5
38	Hydrocarbons, petroleum distillates		
	Alkoxylated alcohols		
	Fatty acid derivatives		
39	Water		
	Hydrocarbons, petroleum distillates	50	5.6×10^4
	Propylene glycol ethers	200	8.8×10^4
	Alkanolamines	25	
	Ethylene glycol ethers	83	4.5×10^5
40	Hydrocarbons, aromatic		
	Hydrocarbons, petroleum distillates	59	8415
	Fatty acid derivatives		
	Ethoxylated nonylphenol	318	

[1] A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 1000 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-2.

[2] The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

Below is a summary of risks found for each formulation. This summary is intended to convey the risks that these formulations may present under typical conditions of use. A summary of the toxicological endpoints associated with chemicals of concern is shown in Table 3-9.

Blanket Wash 1

Worker Risk

Risks for this formulation could not be quantified due to the unavailability of hazard values[d]. However, overall concern is low because of low inhalation exposure levels, poor dermal absorption, and low to moderate toxicologic concern based on structure-activity analysis.

Blanket Wash 3

Worker Risk - Dermal Exposure

Hazard quotient calculations indicate a concern for exposure to some aromatic hydrocarbons and very low concern for exposure to other aromatic hydrocarbons. However, the hazard values are based upon oral or inhalation studies. Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons. However, the hazard values are based upon inhalation studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Worker Risk - Inhalation Exposure

Hazard quotient calculations indicate very low concern for exposure to aromatic hydrocarbons. However, the hazard value for one of these aromatic hydrocarbons is based upon an oral study. The RfD used to calculate the risk estimate is classified as "low confidence" by IRIS (Integrated Risk Information System). Margin of exposure calculations indicate concern for exposure to certain aromatic hydrocarbons, but very low concern for exposure to others. Due to negligible inhalation exposure, the alkyl benzene sulfonates and fatty acid derivatives used in this formulation present no concern. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values.

Blanket Wash 4

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and low concern for exposure to the ethoxylated nonylphenols. However, the hazard value for terpenes is based upon an oral study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, no concern exists for exposure to the ethoxylated nonylphenols.

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[d]Hazard values refer to NOAELs, LOAELs, RfDs, or RfCs used in calculating hazard quotients or margins of exposure or slope factor used in calculating carcinogenic risk. The specific toxicologic endpoints associated with the chemicals of concern are shown in Table 2-3 "Human Health Hazard Summary"

Blanket Wash 5

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons and ethylene glycol ethers, and very low concern for exposure to ethoxylated nonylphenols. However, the hazard value for aromatic hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to aromatic hydrocarbons and ethylene glycol ethers. Due to negligible exposure, no concern exists for the other chemicals in this formulation.

Blanket Wash 6

Worker Risk - Dermal Exposure

Margins of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon inhalation studies. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The fatty acid derivatives and alkyl benzene sulfonates are of low concern because of their expected low rate of dermal absorption and low to moderate hazard.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, the petroleum distillate hydrocarbons, alkyl benzene sulfonates, and fatty acid derivatives used in this formulation present little or no concern.

Blanket Wash 7

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and very low concern for exposure to ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values, although none of the chemicals present more than a low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Table 3-9. Occupational Risks Summarized by Formulation

Form. Number	Chemicals of Concern*	Toxicologic Concern**
1	None	
3	Hydrocarbons, aromatic (inhalation and dermal exposures)	kidney effects, urinary tract and enzyme effects, reproductive and developmental effects
4	Terpenes	liver effects
5	Hydrocarbons, aromatic Ethylene glycol ethers	reproductive and developmental effects blood effects
6	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
7	Terpenes	liver effects
8	Propylene glycol ethers Hydrocarbons, aromatic	blood effects possible presence of carcinogens
9	None	
10	None	
11	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
12	Hydrocarbons, petroleum distillates	blood effects
14	None	
16	Terpenes	liver effects
17	Fatty acid derivatives	possible concern for diethanolamine component of salt
18	Hydrocarbons, petroleum distillates Dibasic esters	blood effects olfactory effects
19	None	
20	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	reproductive and developmental effects blood effects
22	Hydrocarbons, aromatic	possible presence of carcinogens
23	Terpenes Nitrogen heterocyclics	liver effects developmental effects
24	Alkyl benzene sulfonates Terpenes Ethylene glycol ethers	concern based on MOE from single dose study liver effects blood effects
25	Terpenes Esters/lactones	liver effects developmental effects
26	Esters/lactones	developmental effects

Form. Number	Chemicals of Concern*	Toxicologic Concern**
27	Terpenes	liver effects
28	Hydrocarbons, petroleum distillates	blood effects
29	None	
30	Hydrocarbons, aromatic	reproductive and developmental effects
31	Hydrocarbons, aromatic	reproductive and developmental effects
32	Insufficient data for evaluation	
33	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	reproductive and developmental effects blood effects
34	Terpenes	liver effects
35	Hydrocarbons, aromatic	reproductive and developmental effects
36	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
37	Hydrocarbons, aromatic	reproductive and developmental effects
38	Insufficient data for evaluation	
39	Hydrocarbons, petroleum distillates Propylene glycol ethers Ethylene glycol ethers Alkanolamines	blood effects blood effects blood effects blood effects
40	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens

* Table lists only chemicals that triggered concern. Formulations may also include other chemicals. All concerns are for dermal exposures only unless otherwise specified. Identification of chemicals of concern is based on Hazard Quotient and Margin-of-Exposure estimates shown in Table 3-8. The Hazard Quotient and Margin-of-Exposure estimates do not necessarily apply to all of the toxicologic endpoints listed in this table. Hazard Quotient and Margin-of-Exposure calculations are usually based on a "NOAEL" or the "LOAEL" for the most sensitive endpoint.

** The "Toxicologic Concern" column lists adverse effects that have been reported in the literature for animal or human studies. This is simply a qualitative listing of reported effects and does not imply anything about the severity of the effects nor the doses at which the effects occur. Furthermore, an entry in this column does not necessarily imply that EPA has reviewed the reported studies or that EPA concurs with the authors' conclusions. Toxicologic concerns are described as follows:

blood effects = hematological effects, i.e., adverse effects on blood cells
carcinogens = possible cancer causing agents
developmental effects = adverse effects on the developing embryo, fetus, or newborn
kidney effects = adverse effects on kidney physiology
liver effects = adverse effects on liver physiology
olfactory effects = adverse effects on nasal physiology
reproductive effects = adverse effects on the ability of either males or females to reproduce
"none" = no concern at predicted exposure levels

Blanket Wash 8

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate low concern for propylene glycol ethers and very low concern for ethoxylated nonylphenol. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The other compounds in the formulation present low to moderate hazard concerns.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon a subacute oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Blanket Wash 9

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate a very low concern for ethoxylated nonylphenol. Risks for the fatty acid derivative could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption.

Worker Risk - Inhalation Exposure

Due to negligible inhalation exposure, the chemicals used in this formulation present no concern.

Blanket Wash 10

Worker Risk - Dermal Exposure

Risk for this formulation could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption of the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern.

Blanket Wash 11

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The alkyl benzene sulfonates are of low concern because of their expected low rate of dermal absorption and low to moderate hazard.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Blanket Wash 12

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However the hazard value is based upon an inhalation study. Risk could not be quantified but structure-activity analysis indicates a low to moderate hazard concern.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risk could not be quantified but is expected to be low because of low exposure and low to moderate toxicity.

Blanket Wash 14

Worker Risks - Dermal Exposure

Risks for this formulation could not be quantified but are expected to be low because of structure-activity predictions of low toxicity for both the fatty acid derivatives and the propylene glycol ethers. Also, the fatty acid derivatives are expected to be poorly absorbed.

Worker Risks - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern. Risks for the propylene glycol ether are also expected to be low because of low exposure and its predicted low toxicity.

Blanket Wash 16

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due the unavailability of hazard values. Structure-activity analyses of these compounds indicates low to moderate hazard concerns.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value for terpenes is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low because of low exposures and low to moderate toxicity.

Blanket Wash 17

Worker Risks - Dermal Exposure

Hazard quotient calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon an oral study. Margin of exposure calculations indicate very low concern for ethoxylated nonylphenol and alkali/salts. However, the hazard value for alkali salts is based upon oral values. The alkanolamine component of the fatty acid derivative/alkanolamine salt presents a possible concern. However, dermal absorption of the alkanolamine salt is likely to be lower than that of free alkanolamine.

Worker Risks - Inhalation Exposure

Hazard quotient calculations indicate no concern for glycols. However, the hazard value is based upon an oral study. Due to negligible inhalation exposure, ethoxylated nonylphenol, fatty acid derivatives and alkali/salts present very low concern.

Blanket Wash 18

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and dibasic esters. However, the hazard values are based on inhalation studies. Risk from the alkyl benzene sulfonates could not be quantified but is expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Risk from esters/lactones is also expected to be low based on structure-activity predictions of low toxicity.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and dibasic esters. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Blanket Wash 19

Worker Risk - Dermal Exposure

Risks for this formulation could not be calculated due to the unavailability of hazard values. However, risks are expected to be low based on structure-activity predictions of low toxicity of propylene glycol ethers and poor absorption and low to moderate toxicity of the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives present no concern. Risks for propylene glycol ethers are expected to be low because of low exposure and low hazard concern.

Blanket Wash 20

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Risk from the alkyl benzene sulfonates is expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Blanket Wash 21

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. However, the hazard values are based upon inhalation studies. Risk for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. Due to negligible exposure and predicted low toxicity and absorption, fatty acid derivatives presents no concern.

Blanket Wash 22

Worker Risk - Dermal Exposure

Risks for this formulation could not be calculated due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from the fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Risks could not be quantified but are expected to be low due to low or negligible exposures.

Blanket Wash 23

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate possible concerns for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on low exposure and structure-activity predictions of poor absorption and low to moderate toxicity.

Blanket Wash 24

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for alkyl benzene sulfonates and terpenes, possible concern for ethylene glycol ethers, and very low concern for ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for alkali/salts could not be quantified but are expected to be very low based on structure-activity predictions of no absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes and ethylene glycol ethers. However, the hazard value for terpenes is based upon an oral study. Due to negligible exposure, the other chemicals in this formulation present no concern.

Blanket Wash 25

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and possible concern for exposure to esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to terpenes and esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 26

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for esters/lactones, and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for the fatty acid derivatives could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the chemicals used in this formulation present no concern.

Blanket Wash 27

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for terpenes. However, the hazard value is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 28

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate low concern for petroleum distillate hydrocarbons.

Blanket Wash 29

Worker Risk - Dermal Exposure

Risks for this formulation could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low toxicity for the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the chemicals in this formulation present no concern.

Blanket Wash 30

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for propylene glycol ethers could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low hazard concern for propylene glycol ethers.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for propylene glycol ethers could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low toxicity.

Blanket Wash 31

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

<u>Blanket Wash 32</u>

Worker Risk

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

<u>Blanket Wash 33</u>

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and aromatic hydrocarbons, and very low concerns for propylene glycol ethers. However, the hazard values for petroleum distillate hydrocarbons and aromatic hydrocarbons are based upon an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, aromatic hydrocarbons, and propylene glycol ethers.

<u>Blanket Wash 34</u>

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concerns for terpenes and very low concerns for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for fatty acid derivatives could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Risks for petroleum distillate hydrocarbons could not be quantified. Structure-activity analysis indicates low to moderate hazard concern for these chemicals.

Worker Risk - Inhalation Exposure

Margin of exposure values indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate hazard concern.

<u>Blanket Wash 35</u>

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

<u>Blanket Wash 36</u>

Worker Risk - Dermal Exposure

Margin of exposure calculation indicate concern for petroleum distillate hydrocarbons, and very low concern for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and propylene glycol ethers. Due to negligible exposure, the fatty acid derivatives present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low because of low exposure.

<u>Blanket Wash 37</u>

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate possible concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The petroleum distillate hydrocarbons are considered to present low to moderate hazard concerns according to structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate hazard.

<u>Blanket Wash 38</u>

Worker Risk - Dermal Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. The fatty acid derivatives and alkoxylated alcohols are expected to present low risk because of structure-activity predictions of poor absorption and low or low to moderate toxicity. Petroleum distillate hydrocarbons present low to moderate hazard concern according to structure-activity analysis.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 39

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons, ethylene glycol ethers, and alkanolamines, and possible concerns for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based on an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, propylene glycol ethers, and ethylene glycol ethers. However, the hazard value used for propylene glycol ethers is based on an oral study. Due to negligible exposure, alkanolamines present no concern.

Blanket Wash 40

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for ethoxylated nonylphenol. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Due to negligible exposure, fatty acid derivatives and ethoxylated nonylphenol present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low because of low exposure.

3.4.4 General Population Risks

No concerns were identified for general population exposures through drinking water, fish ingestion, or ambient air as seen in Table 3-10. Predicted exposure levels in these environmental media were extremely low. The calculated risk numbers should be viewed as low-confidence estimates because of the many uncertainties associated with both the hazard and exposure components of the calculation. However, the overall risk conclusion can be regarded with high confidence because all of the risk estimates fall far below standard risk benchmarks. Thus, the “true” risk value could vary substantially from the estimated value without changing the conclusion. In addition, a generally conservative approach (i.e. one that overestimates the risk) was taken in the assessment.

A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater than 100 for a NOAEL-based MOE or 100 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-4. The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

Table 3-10. General Population Risk Estimates for Drinking Water, Fish Ingestion, and Inhalation

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
1	Fatty acid derivatives			
	Alkoxylated alcohols			
3	Hydrocarbons, petroleum distillates			
	Fatty acid derivatives			
	Hydrocarbons, aromatic			1.6×10^5
	Hydrocarbons, aromatic			2.0×10^4
	Hydrocarbons, aromatic			3.0×10^{-5} (HQ)
	Hydrocarbons, aromatic			7.1×10^{-5} (HQ)
	Alkyl benzene sulfonates			
4	Terpenes			8.0×10^4
	Ethoxylated nonylphenol[3]	8.8×10^5		
5	Water			
	Hydrocarbons, aromatic			1.2×10^5
	Ethylene glycol ethers			4.5×10^4
	Ethoxylated nonylphenol[3]	7×10^6		
	Alkyl benzene sulfonates			
	Alkoxylated alcohols			
	Alkyl benzene sulfonates			
	Alkali/salts			
6	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			6.0×10^5
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
7	Terpenes			
	Terpenes			3.0×10^5
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Ethoxylated nonylphenol[3]	2.3×10^7		
	Alkoxylated alcohols			

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
8	Water			
	Hydrocarbons, aromatic			
	Propylene glycol ethers			7.0×10^5
	Alkyl benzene sulfonates	5.0×10^7		
	Ethoxylated nonylphenol[3]	8.1×10^6		
	Alkyl benzene sulfonates			
	Alkoxylated alcohols			
	Alkyl benzene sulfonates			
	Alkali/salts			
9	Fatty acid derivatives			
	Water			
	Ethoxylated nonylphenol[3]	2.3×10^7		
10	Fatty acid derivatives			
	Water			
11	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			4.0×10^5
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
12	Hydrocarbons, petroleum distillates			
	Hydrocarbons, petroleum distillates			2.0×10^6
	Water			
14	Fatty acid derivatives			
	Propylene glycol ethers			
	Water			
16	Terpenes			3.0×10^5
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
17	Ethoxylated nonylphenol[3]	3.2×10^7		
	Glycols			1.0×10^{-5} (HQ)
	Fatty acid derivatives			
	Alkali/salts			
	Water			

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
18	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			4.0×10^5
	Hydrocarbons, aromatic			
	Dibasic esters			3.0×10^4
	Dibasic esters			3.0×10^4
	Dibasic esters			3.0×10^4
	Esters/lactones			
	Alkyl benzene sulfonates			
19	Fatty acid derivatives			
	Propylene glycol ethers			
	Water			
20	Water			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
21	Hydrocarbons, aromatic			2.5×10^5
	Hydrocarbons, petroleum distillates			1.0×10^5
	Fatty acid derivatives			
22	Fatty acid derivatives			
	Hydrocarbons, aromatic			
	Water			
23	Terpenes			1.0×10^5
	Nitrogen heterocyclics			1.0×10^4
	Alkoxylated alcohols			
	Water			
24	Terpenes			4.0×10^5
	Ethylene glycol ethers			1.1×10^4
	Ethoxylated nonylphenol[3]	1.5×10^7		
	Alkyl benzene sulfonates	5.0×10^6		
	Alkali/salts			
	Water			
25	Terpenes			
	Terpenes			3.0×10^5
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Esters/lactones			2.0×10^6

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
26	Fatty acid derivatives			
	Esters/lactones			
	Fatty acid derivatives	1.3×10^8	6.3×10^5	
	Esters/lactones			
27	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			6.0×10^5
	Terpenes			
	Terpenes			
28	Hydrocarbons, petroleum distillates			1.2×10^5
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic			7.0×10^4
	Propylene glycol ethers			
	Water			
31	Hydrocarbons, aromatic			2.5×10^5
	Hydrocarbons, petroleum distillates			
32	Hydrocarbons, petroleum distillates			
33	Hydrocarbons, petroleum distillates			2.0×10^5
	Hydrocarbons, aromatic			1.6×10^5
	Propylene glycol ethers			1.0×10^6
	Water			
34	Water			
	Terpenes			4.0×10^5
	Hydrocarbons, petroleum distillates			
	Alkoxylated alcohols	6.0×10^7		
	Fatty acid derivatives			
35	Hydrocarbons, petroleum distillates			
	Hydrocarbons, aromatic			3.0×10^4
36	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Hydrocarbons, aromatic			
	Propylene glycol ethers			2.0×10^6
37	D. I. Water			
	Hydrocarbons, petroleum distillates			
	Hydrocarbons, aliphatic			
	Hydrocarbons, aromatic			1.2×10^5

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
38	Hydrocarbons, petroleum distillates			
	Alkoxylated alcohols			
	Fatty acid derivatives			
39	Water			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Propylene glycol ethers			1.0×10^6
	Alkanolamines	4.0×10^6		
	Ethylene glycol ethers			1.1×10^5
40	Hydrocarbons, aromatic			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Fatty acid derivatives			
	Ethoxylated nonylphenol[3]	1.6×10^7		

1 A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 100 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Tables 3-4 and 3-5.

2 The absence of HQ or MOE values in this table indicates no exposure is expected by this route or that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

3 Based on testing data (Weeks, A.J. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain*. Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.) the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of releases to surface water. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24 and 40) present concerns to aquatic species that were not reported in the draft CTSA.

3.5 PROCESS SAFETY CONCERNS

Exposure to chemicals is just one of the safety issues that printers may have to deal with during their daily activities. Preventing worker injuries should be a primary concern for employers and employees alike. Work-related injuries may result from faulty equipment, improper use of equipment or bypassing equipment safety features, failure to use personal protective equipment, and physical stresses that may appear gradually as a result of repetitive motions (i.e., ergonomic stresses). Any or all of these types of injuries may occur if proper safeguards or practices are not in place and correctly used. The use of personal safety equipment and the presence of safety guards on equipment can have a substantial impact on business, not only in terms of direct worker safety, but also in reduced operating costs as a result of fewer days of absenteeism, reduced accidents and injuries, and lower insurance costs. Maintaining a safe and efficient workplace requires that employers and employees understand the importance of using personal protective equipment, have appropriate safeguards on mechanical and electrical equipment, store and use chemicals properly, and practice good ergonomic procedures when engaged in physical activity.

Training

A critical element of workplace safety is a well-educated workforce. To help achieve this goal, the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard requires that all employees at printing facilities (regardless of the size of the printing plant) be trained in the use of hazardous chemicals to which they are exposed, therefore, it is recommended that a formal training program be instituted for all workers at lithography plants. Training may be conducted by either facility staff or outside parties who are familiar with the lithography process and the pertinent safety concerns. The training should be held for each new employee, as well as periodic retraining sessions when necessary (for example, if new equipment is to be used), or on a regular schedule. The training program should explain to the workers the types of chemicals with which they work and precautions to be used when handling or storing them; when and how personal protection equipment should be worn; the need for other safety features such as machine guards and their proper use; and how to maintain equipment in good operating condition.

Storing and Using Chemicals Properly

Because lithographic printing requires exposure to and use of a variety of chemicals, it is important that workers know and follow the correct procedures for using and storing the chemicals. Much of the use, disposal, and storage information about blanket wash chemicals may be obtained from the Material Safety Data Sheets provided by the manufacturer for each chemical or formulation. MSDSs will also alert the workers to the need for appropriate personal protection equipment. All chemicals should be stored in appropriate storage space and should be labeled accordingly with all federal, state, and local regulations. Chemicals that are incompatible with other chemicals or that require special precautions in their use should also be appropriately labeled and stored. Because many of the chemicals used in blanket wash formulations are highly flammable, it is recommended that the facility be periodically inspected by the local fire marshall to ensure that the chemicals are stored properly and ventilated, thus reducing the potential for a fire.

Rags or towels that are used to wipe up chemicals or clean blankets may be considered hazardous waste by EPA and state and local agencies if they contain specified hazardous chemicals in sufficient amounts. These towels should be stored and disposed of in accordance with the federal, state, and local regulations. Blanket wash workers should also be aware of the potential for smoldering of the rags, particularly those that contain terpenes. If a printer is uncertain about whether or not the used rags or towels require special treatment as hazardous waste, he or she should contact their local state environmental agency, or state technical assistance program. For further information about the specific safety factors and hazards associated with specific chemicals used in lithography blanket wash formulations, such as flammability and corrosivity, see Section 2.2 Chemical Information.

Use of Personal Safety Equipment

Although EPA developed the Design for the Environment Program to assist industry in determining the environmental effects and risks associated with various industries, worker safety is the responsibility of OSHA. Many printers are already familiar with OSHA's Hazard Communication Standard which covers many aspects of worker safety for a variety of industries, including printing facilities. OSHA has already developed several personal protective equipment standards that are applicable to the printing industry. These standards address general safety requirements (29 CFR Part 1910.132), the use of eye and face protection (Part 1910.133), head protection (Part 1910.135), foot protection (Part 1910.136), and hand protection (Part 1910.138). The standards for eye, face and hand protection are particularly important for the printing industry where there is frequent contact with a variety of chemicals, such as solvents, dispersants, surfactants, and inks, that may irritate or otherwise harm the skin and eyes. In order to prevent or minimize exposure to such chemicals, workers should be trained in the proper use of personal safety equipment. For many blanket wash chemicals, appropriate protective equipment includes goggles to prevent chemical from splashing into the eyes during the transfer of chemicals from large containers to small ones, aprons or other impervious clothing to prevent splashing of chemicals on clothing, and gloves. In some printing facilities with loud presses, hearing protection may be required or recommended.

Other personal safety considerations are the responsibility of the worker. Workers should be discouraged from eating or keeping food near presses or chemicals. Because presses contain moving parts, workers should also be prohibited from wearing jewelry or loose clothing, such as ties, that may become caught in the machinery and cause injury to the worker or the machinery itself. In particular, the wearing of rings or necklaces may lead to injury. Workers with long hair that may also be caught in the machinery should be required to securely pull their hair back or wear a hair net.

Use of Equipment Safeguards

In addition to the use of proper personal protection equipment for all workers, OSHA has developed safety standards that apply to the actual equipment used in printing facilities. These machine safety guards are described in 29 CFR Part 1910.212 and are applicable to all sectors of the industry, including lithography. Among the safeguards recommended by OSHA that may be used for lithographic printers are barrier guards, two-hand trip devices, and electrical safety devices. Safeguards for the normal operation of press equipment are included in the standards for mechanical power-transmission apparatus (29 CFR Part 1910.219) and include belts, pulleys, flywheels, gears, chains, sprockets, and shafts. The National Printing Equipment and Supply Association has made available copies of the American National Standard for Safety Specifications for Printing Press Drive Controls. These safety recommendations address the design of press drive controls specifically, as well as safety signaling systems for web and sheet-fed printing presses. Printers should be familiar with the safety requirements included in these standards and should contact their local OSHA office or state technical assistance program for assistance in determining how to comply with them.

In addition to normal equipment operation standards, OSHA also has a lockout/tagout standard (29 CFR part 1910.147). This standard is designed to prevent the accidental start-up of electric machinery during cleaning or maintenance operations that apply to the cleaning of blankets as well as other operations. This standard has posed particular problems for lithographers during minor, routine procedures such as cleaning the press which requires frequent stops and small movement of the rollers (inching) which may be accomplished without extensive disassembly of the equipment. For such cases, OSHA has granted an exemption for minor servicing of machinery provided the equipment has other appropriate safeguards, such as a stop/safe/ready button which overrides all other controls and is under the exclusive control of the worker performing the servicing. Such minor servicing of printing presses has been determined to include clearing jams, minor cleaning, lubricating, adjusting operations, plate and blanket changing tasks, paper webbing, and roll changing. Rigid finger guards should also extend across the rolls, above and below the area the be cleaned. Proper training of workers is required under the standard whether lockout/tagout is employed or not. For further information on the applicability of the OSHA lockout/tagout standard to printing operations, contact the local OSHA field office or the Printing Industries of America, Inc.

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Chapter 4
Competitiveness

Chapter Contents

This chapter focuses on the performance and cost of each substitute blanket wash. Section 4.1 discusses the results of the performance demonstration of each blanket wash, both in a laboratory setting and in an actual print shop. All 37 blanket washes (including the baseline) were tested at the Graphic Arts Technical Foundation (GATF) laboratory for flash point, volatile organic compound (VOC) content, pH, blanket swell potential and wipability. Of the 36 formulations (plus the baseline) analyzed at GATF, 22 were field tested. Each of these 22 blanket washes was used at two print shops, and evaluated on factors such as how well the ink was cut and how quickly the blanket dried. The limitations of these field evaluations are briefly presented and the results discussed in greater detail. Section 4.2 presents the costs associated with using the 22 field tested blanket washes. For each of the two facilities where a blanket wash was tested, data on cost/wash, cost/press, and cost/press/shift/year were developed and compared with baseline costs using VM&P Naphtha. This section also contains a description of the different variables used to develop the cost data, such as labor costs, blanket wash costs, and other materials costs. Section 4.3 addresses international trade issues for blanket washes in general. Importation and exportation of both petroleum based blanket washes and low VOC blanket washes are discussed, as well as joint ventures between foreign companies.

4.1 PERFORMANCE DATA

4.1.1 Background

This section of the CTSA summarizes performance information collected during laboratory and production run performance demonstrations with substitute blanket washes carried out between November 1994 and January 1995. Performance data collected included information such as quantity of wash used, time spent to wash the blanket, ink coverage, and the effectiveness of the wash. Data from the performance demonstrations, in conjunction with risk, cost and other information presented in other sections of the CTSA, provides a more complete assessment of substitute blanket washes than has otherwise been available from one source.

In a joint and collaborative effort, EPA worked with the Printing Industries of America (PIA), the Graphic Arts Technical Foundation (GATF), and other industry representatives to organize and conduct the performance evaluations of 36 substitute blanket washes and the baseline. The demonstration methodology was developed by consensus and was designed to allow the evaluation of the maximum number of blanket washes given the resources available to the project. Performance data were collected for each product in two distinct phases: 1) a laboratory test of the chemical and physical properties and the efficacy of the substitute products, and 2) evaluations conducted in a production setting at volunteer printing facilities. The intent of the laboratory evaluations was to independently measure some of the properties of the washes, such as volatile organic compound (VOC) content, and to assure that the blanket washes sent to volunteer printers would provide an acceptable level of performance. Facility demonstrations were undertaken at the request of printers participating in the DfE project so that blanket washes could be evaluated under the more variable conditions of production runs at printing facilities. It should be noted that the performance demonstrations are not rigorous scientific investigations. Instead, much of this chapter documents the printers' experiences with and opinions of these products as they were used in production at their facilities.

Participation in the demonstration project was open to all blanket wash manufacturers. Prior to the start of the demonstrations, the DfE project staff contacted nearly 100 blanket wash manufacturers to explain the project goals and request their submission of a product. All those who responded and submitted blanket washes were included in the first phase of the demonstrations.

4.1.2 Methodology

The performance evaluation methodology developed by the workgroup is described below and covers both the laboratory testing protocol and the on-site demonstrations methodology. In developing the methodology, the workgroup agreed that product names would be masked. Neither the volunteer printers nor the DfE observers knew the manufacturer of the products being evaluated. Trade names are not listed in this report, instead the blanket washes are referenced by a numerical code and a genericized chemical formulation. This agreement to mask product names was made for several reasons:

- The chemical formulations of commercial products containing distinct chemicals are frequently considered proprietary. Manufacturers of these products typically prefer not to reveal their chemical formulations because a competitor can potentially use the disclosed formulation to sell the product, often at a lower price, since the competitor did not have to invest in research and development.

- The performance of products may vary depending on use and shop conditions, and suppliers were concerned about the characterization of the performance of their products.

- The EPA was concerned about appearing to endorse brand name products that fared well in the CTSA evaluation.

In the initial stages of the Lithography Project the Project partners chose VM&P Naphtha as the baseline against which to compare the 36 substitute blanket washes. VM&P Naphtha, composed of 100% solvent naphtha, light aliphatic and referred to as formulation 28 in certain sections of the text, was chosen primarily because it is well known among lithographers as an effective blanket wash. Many lithographers have used VM&P in their shops and know how it works in their applications and what it costs. VM&P is known to be highly effective at very low cost, however, because of its high VOC content (100%) printers are searching for formulations to replace it.

As the Performance Demonstration was being conducted, some suppliers who had submitted blanket washes chose to withdraw. Their reasons included not wishing to reveal to EPA their complete formulations or concern over the potential results of the performance tests. The formulations that were withdrawn after work had already begun were numbers 2, 13, and 15. For this reason, those numbers are missing from all the tables in the CTSA.

Laboratory Evaluations

Laboratory testing was carried out by GATF in Pittsburgh, Pennsylvania. A total of 36 products were submitted plus the baseline. For each wash, the flash point, VOC content, and pH were tested. The vapor pressure of the product was not tested, but was submitted by the supplier. Two additional tests, a blanket swell test and a wipability test, were conducted to determine the efficacy of each wash prior to sending it out for field demonstrations. Only products that passed this functional demonstration stage were used in the field demonstration portion of the project. For both of these tests, GATF followed the manufacturer's instructions for diluting or mixing the product.

The blanket swelling potential of each product was tested to determine the effect of the wash on the blankets. The procedure used (detailed in Appendix C) involved measuring the thickness of the blanket test square (2 x 2 inches), maintaining contact between the test square and the wash for one hour, and taking another thickness measurement to calculate the percent swell. Another measurement is taken after 5 hours. Any wash where the blanket swell exceeded 3 percent after 5 hours indicated that the wash may dimensionally distort the blanket and was eliminated from field demonstrations.

Washability of each blanket wash was evaluated using both a wet and a dry ink film (detailed in Appendix C). To measure the washability, a standard volume of ink was evenly applied to a section of a new, clean test blanket. A measured volume of the wash was applied to a cleaning pad. The pad was attached to a mechanized scrubber and the number of strokes required to remove the wet ink were recorded. The procedure was repeated for a dry ink film where the ink was dried with a blow dryer for 20 minutes prior to the cleaning. The dry ink and wet ink tests were repeated for each alternative blanket wash submitted. Any wash where more than 100 strokes were required to clean the blanket (with cleanliness determined by using a reflective densitometer) was eliminated from the field demonstrations.

Based on the results of the blanket swell and the washability tests, 22 of the original 36 products submitted (plus the baseline) qualified for further evaluation through field demonstrations. Prior to shipping substitute blanket washes to printers for these on-site evaluations, each wash was repackaged into a generic container so that those printers demonstrating the products did not know the manufacturer or product name. Masked Material Safety Data Sheets (MSDSs) were also developed and shipped along with the substitute blanket washes to be evaluated.

Printing Facility Demonstrations

PIA affiliates recruited printers located in the Boston, Baltimore, and Washington, D.C. areas, who volunteered their facilities and their time to conduct the field demonstrations of the substitute products. A total of 17 facilities participated. Each substitute product was demonstrated at two facilities and each facility demonstrated a minimum of two and up to five different blanket washes. The product brand name was replaced with a blanket wash number so that the demonstration facilities did not know what product they were using. In addition, the facility names have been replaced with a facility number. A list of participating facilities appears at the front of this document.

To start the on-site demonstration, an "observer" from the DfE project visited each of the volunteer facilities. DfE observers were not EPA employees, but were drawn from staff of the contractor, Abt Associates Inc. The observers called each facility to review the details of their operation, discuss the goals of the project, and to schedule a site visit. The substitute products, a baseline product, MSDSs, application instructions, and a measuring device were shipped to each facility prior to the DfE observer's arrival.

During each one-day site visit, the observer collected information on the background of the facility, as well as data specific to blanket wash performance. Background data included information on the size of the presses, the number of employees, and current blanket washing practices. After collecting the initial background data, the observers documented information on three types of blanket washes: the blanket wash currently used at the facility, a baseline blanket wash, and the substitute wash. All information was recorded on an Observer's Evaluation Sheet (see Appendix D). Starting with their standard wash, the press operator cleaned the blanket while the observer recorded the quantity of wash used, the time required to clean the blanket, the length of the run, the type and color of the ink on the blanket, and the number of wipes used. After restarting the press, the press operator was asked to comment on the effectiveness of the blanket wash and to determine if there were any changes in subsequent print quality that could be attributed to the blanket wash. This procedure was then repeated using Blanket Wash 28, VM&P Naphtha, the selected baseline. Naphtha was used at all participating facilities. By comparing the differences in the performance of the baseline at the two different facilities, any significant effects of facility-specific operating conditions (e.g., the type of ink, size of blanket, and operator's effort) on the performance of the substitute wash were more apparent. After cleaning the blanket with the baseline wash, the press operator then used the substitute wash provided. The observer recorded the same type of information as was recorded for both the current wash and the baseline wash. The total number of washes required varied from one facility to the next, since the observer was on-site for one day and recorded information on as many washes as were required during production that day.

After the observer's visit, the facility continued to use the substitute wash for one week. During the week, the printer at each volunteer print shop was asked to record information on product performance. The data recorded were similar to that collected by the on-site observer. However, the Printer's Evaluation Sheets (Appendix D) were simplified in an effort to minimize volunteer printers' burden and production disruptions. Facility background information such as the press size and type of shop towel used were recorded by the observer only. At the end of the week, the observer interviewed the press operator to obtain an overall opinion of the product. The exit interview information was recorded on another standardized form (Appendix D).

4.1.3 Data Collection, Summary and Analysis

The information summarized in the following section comes from five sources.

- Laboratory results: the chemical characteristics and the results of the blanket swell and washability tests were reported for each wash.

- Facility background information: the observer collected information on operating conditions while on-site at each volunteer print shop.

- Observer's data: DfE observers recorded information on the performance of the facility's current blanket wash, a baseline wash, and the substitute blanket wash.

- Printer's data: press operators recorded performance data for each blanket wash completed during the week-long demonstration of the substitute blanket wash.

- Follow-up interviews: observers interviewed the press operators at the end of the week-long demonstration on their overall opinion of the substitute blanket wash.

For each of the 22 substitute blanket washes in the field demonstrations, data from the sources mentioned above were analyzed and are summarized in this section. The experiences of the two facilities who demonstrated each product are presented individually. As part of the analysis, a number of correlations were attempted for each facility but the results were typically not statistically significant due to small sample size. These analyses were run to determine if variations in the printer's opinion of the effectiveness of the blanket depended on any other variables such as ink coverage, effort and time spent on blanket washing, or run length. Where appropriate, these results are included within the following text summaries of each substitute blanket wash. Additionally, some summary statistics, such as average amount of product used, are presented in accompanying tables (Table 4-1).

4.1.4 Limitations

The widely variable conditions between and within printing facilities, the limited number of facilities, and the short duration of the performance demonstrations does not allow the results to be interpreted as definitive performance testing of the blanket washes. In addition, some facilities did not provide the full complement of evaluation forms because they found the performance of the substitute wash to be unacceptable and they discontinued use before the end of the week.

As mentioned previously, the performance demonstrations are not scientifically rigorous but are subjective assessments which reflect the conditions and experience of two individual print shops. There are a number of reasons why the results of performance demonstrations for any given blanket wash may differ from one facility to another. Among these reasons are:

- Variability in operating conditions. Because performance demonstrations were carried out during production runs, many factors which affect the performance of the blanket washes were not controlled during the evaluations including: ink type, ink coverage, condition of the blanket, the length of the run prior to blanket cleaning, and the ambient conditions such as temperature, humidity, and ventilation.

- Variability of print jobs. Different types of jobs had different requirements for blanket cleanliness. Observers noticed that what one facility considers to be a clean blanket another facility may find unacceptable.

- Variability of staff involved in performance demonstrations. Press operators' attitudes towards alternative blanket washes differ from one operator to the next and can affect their perception of performance. As previously mentioned, some of the information recorded was subjective and varied depending on a variety of factors including the attitude, perception, and previous experiences of the operator. For example, many of the substitute products were low in VOC content and did not evaporate as quickly as some of the more traditional blanket washes. Often, an extra step was needed to wipe the blanket with a dry rag to remove a residue left by some of the substitute washes. While extra cleaning steps can be time consuming and lead to increased production costs, even a minimal extra effort was regarded as an unacceptable burden by some operators. Other operators understood that some changes in their procedures and even some extra effort may be needed in order to effectively clean the blanket with an alternative product.

- Variability in application method. Press operators' overall opinion of the blanket wash could have been affected by their current application method. For example, operators who are accustomed to using high solvent blanket washes where little effort is required may differ in their opinion of "moderate effort" from operators who are currently using an alternative where some extra effort is already required. All manufacturers were asked to supply application procedures for their product. When instructions were supplied, the observer reviewed the procedures with the press operators, verified the correct procedure was used when the observer was on-site, and asked in the interview at the end of the week

Table 4-1. Blanket Wash Laboratory Test Results

Form. No.	Flash Point (°F)	VOC Content[1] (lbs/gal; % by weight)	pH	Blkt Swell		Wet Ink Film				Dry Ink Film			
				1 hr (%)	5 hr (%)	Blanket Density	Ink Density	Blanket Cleaned	Strokes	Blanket Density	Ink Density	Blanket Cleaned	Strokes
1	230+	2.3; 30%	7.8*	1.5	3.0	1.32	1.66	1.38	4	1.32	1.47	1.34	6
3	114	6.4; 91%	3.4*	1.5	4.5	1.33	1.76	1.34	4	1.32	1.49	1.34	4
4	114	6.4; 89%	8.7	3.0	5.2	1.32	1.85	1.33	3	1.32	1.47	1.36	2
5	139	2.5; 30%	4.3	6.1	15.4	1.31	1.79	1.33	9	1.33	1.49	1.37	8
6	152	3.5; 47%	5.5	0.7	1.5	1.32	1.81	1.34	8	1.33	1.52	1.35	6
7	165	3.0; 36%	9.3	3.8	6.8	1.27	1.73	1.36	6	1.31	1.51	1.36	8
8	115	3.3; 41%	4.0	7.7	20	1.32	1.79	1.34	7	1.33	1.47	1.34	9
9	230+	0.77; 10%	4.6	1.5	1.5	1.33	1.74	1.36	19	1.32	1.52	1.44	30
10	230+	0.16; 2%	5.7	0.7	0.7	1.28	1.78	1.42	12	1.28	1.47	1.29	13
11	150	4.3; 61%	5.0*	0.0	1.5	1.32	1.66	1.41	4	1.32	1.46	1.35	5
12	125	1.3; 20%	8.2	0.0	1.5	1.33	1.79	1.36	7	1.32	1.47	1.31	11
14	230+	0.97; 12%	5.0	1.5	3.0	1.28	1.79	1.31	8	1.29	1.51	1.32	10
16	145	7.2; 99%	9.8	4.5	10.6	1.25	1.64	1.30	2	1.30	1.51	1.34	2
17	220+	0.051; 0.6%	9.8	1.5	1.5	1.27	1.62	1.54	100	1.32	1.48	1.48	100
18	150	4.4; 60%	5.5	1.5	4.5	1.32	1.71	1.36	8	1.32	1.55	1.36	7
19	230+	1.8; 22%	4.6	1.5	1.5	1.28	1.79	1.33	11	1.27	1.45	1.30	9
20	170	2.7; 35%	7.1	0.0	1.5	1.30	1.77	1.34	5	1.29	1.52	1.34	7
21	115	3.5; 47%	6.2	0.0	1.5	1.32	1.56	1.41	7	1.31	1.43	1.42	6

Form. No.	Flash Point (°F)	VOC Content[1] (lbs/gal; % by weight)	pH	Blkt Swell		Wet Ink Film				Dry Ink Film			
				1 hr (%)	5 hr (%)	Blanket Density	Ink Density	Blanket Cleaned	Strokes	Blanket Density	Ink Density	Blanket Cleaned	Strokes
22	157(a)	NM; 2.17%	7.4(b)	1.5	[2]1.5	1.28	1.67	1.37	13	1.28	1.48	1.41	13
23	140	0.48; 6%	9.2	0.0	1.5	1.28	1.76	1.31	24	1.28	1.51	1.33	100
24	100	1.5; 19%	9.9	1.5	3.0	1.32	1.77	1.34	15	1.31	1.45	1.34	12
25	220+	4.1; 55%	4.3	3.0	4.5	1.27	1.73	1.36	22	1.33	1.53	1.49	32
26	230+	1.3; 18%	7.8*	0.0	0.0	1.28	1.73	1.33	6	1.32	1.48	1.40	14
27	145	7.2; 93%	3.9	3.0	4.5	1.27	1.67	1.30	3	1.33	1.55	1.35	3
28	50	6.2; 100%	6.6	1.5	3.0	1.33	1.80	1.32	3	1.33	1.51	1.33	8
29	230+	2.1; 30%	7.2	1.5	1.5	1.32	1.74	1.41	9	1.32	1.47	1.39	18
30	100(a)	0.48; 7%	7.6(b)	0.7	1.5	1.29	1.66	1.29	5	1.27	1.50	1.24	11
31	105	6.6; 99%	7.6	1.5	3.0	1.32	1.78	1.31	3	1.32	1.51	1.34	3
32	220	6.5; 99%	8.5	0.1	1.5	1.27	1.71	1.33	5	1.29	1.45	1.40	30
33	105	3.4; 46%	7.2*	4.5	7.6	1.27	1.77	1.28	4	1.31	1.45	1.35	4
34	138	2.8; 39%	6.6	1.5	3.0	1.32	1.79	1.35	10	1.32	1.49	1.35	20
35	105	6.7; 99%	6.0	1.5	6.1	1.32	1.76	1.35	3	1.33	1.46	1.34	5
36	175	3.5; 48%	5.7*	0.7	1.5	1.33	1.78	1.38	4	1.33	1.48	1.37	5
37	82	1.0; 14%	3.9	3.0	3.0	1.33	1.85	1.34	5	1.33	1.49	1.34	8
38	230+	4.9; 65%	5.6	0.0	1.5	1.32	1.76	1.43	9	1.32	1.48	1.37	16
39	155	2.9; 37%	9.2	1.5	3.0	1.29	1.73	1.31	7	1.31	1.50	1.34	10
40	155	3.8; 52%	4.8	1.5	3.0	1.33	1.81	1.39	5	1.33	1.51	1.35	10

(a) full strength (b) 25% NM - not measured * pH fluctuates wildly and may not be valid

[1]VOC content in lbs/gal was measured at GATF; % by weight VOC was calculated based on information submitted by the manufacturer.
[2]VOC content in lbs/gal was not measurable; % by weight VOC was submitted by the manufacturer.

if the application procedures had been modified in any way. If any changes were made, the type of change and the reason for the change are described in the performance summary.

- *Short term nature of the demonstrations.* Printers used the substitute blanket washes in their facilities for one week. Any long term effects such as premature blanket wear or corrosion would not have been apparent.

4.1.5 Blanket Wash Summaries

A summary of the performance of each of the 22 substitute blanket washes follows. Since the trade names of the substitute blanket washes are not given in this document, each blanket wash is identified by a numerical code and a generic chemical formulation. The specific types of chemicals that make up each of the generic formulations are explained in greater detail in Chapter 2. In addition, the facility names have been replaced with a facility number.

Performance of each product is presented separately for the two facilities, and includes a description of the facility's current blanket wash, their past experience in testing alternative blanket washes, their overall opinion of the substitute wash performance, and, if applicable, a summary of the factors that may have influenced performance. A table is also included for each blanket wash which presents the results of the laboratory test of both the substitute blanket wash and the baseline wash. Averages of the volume of wash used, time required, and effort required, as recorded by the printers during field demonstrations are also included in each product performance table. In addition, a summary table is provided that consolidates the results from all products into a single table (Table 4-2).

Table 4-2. Summary of Blanket Wash Performance Demonstrations

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 1				
Facility 3	2.3; 30%	230+	1.1 ± 0.2 [1.0][a]	Based on a sample size of 10 blanket washes: • Good performance for light or medium ink coverage. • Poor performance for heavy ink coverage; the extra time and effort needed were unacceptable. • Left a slight residue that was removed with a dry rag.
Facility 6			1.5 ± 0.6 [1.5][a]	Based on a sample size of 4 blanket washes: • Poor performance. • Print quality problems: image of the previous job was showing.
WASH 6				
Facility 11	3.5; 47%	152	1.0 ± 0.2 [0.7 ± 0.2][a]	Based on a sample size of 11 blanket washes: • Wash left oily residue that interfered with print quality. • Did not readily absorb into rag due to thick consistency; created delays. • Fair performance overall; more effort required with heavy ink coverage.
Facility 15			0.9 ± 0.2 [1.5 ± 0.7][a]	Based on a sample size of 23 blanket washes: • Cut ink well. • Did not readily absorb into rag due to thick consistency; created delays and effort necessary to clean was rated "high." • Did not leave a residue on the blanket.
WASH 9				
Facility 10	0.77; 10%	230+	3.1 ± 0.3 [1.5][a]	Based on a sample size of 4 blanket washes: • Poor performance. • Did not cut ink well, required excessive effort, and did not soak into rag. • Discontinued use of Wash 9 after 4 washes.
Facility 15			0.7 ± 0.1 [1.5 ± 0.7][a]	Based on a sample size of 21 blanket washes: • Poor performance. • Did not soak into the rag. • Required much more effort than the baseline.
WASH 10				
Facility 3	0.16; 2%	230+	1.0 ± 0.0 [1.0][a]	Based on a sample size of 4 blanket washes: • Printer declined to test product due to level of effort required to clean blanket. • Did not absorb well into rag. • Did not cut ink well.
Facility 4			3.0 ± 0.0 [3.0 ± 0.0][a]	Based on a sample size of 4 blanket washes: • Printer declined to test product due to level of effort required to clean blanket. • Did not absorb well into rag. • Did not cut ink well.

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 11				
Facility 1	4.3; 61%	150	2.5 ± 0.6 [2.5 ± 0.0][a]	Based on a sample size of 26 blanket washes: • Good performance for light/medium coverage. • Poor performance for heavy ink coverage; extra time and effort were needed. • Left slight, oily residue on blanket, but it did not affect the print quality.
Facility 2			1.5 ± 1.5 [1.2 ± 0.8]	Based on a sample size of 31 blanket washes: • Good/Fair performance for light/medium cover. • Poor performance for heavy ink coverage; extra product, time and effort were required. • Left slight, oily residue on blanket, but it did not affect the print quality.
WASH 12				
Facility 12	1.3; 20%	125	5.4 ± 0.8 [4.4 ± 1.6]	Based on a sample size of 16 blanket washes: • Was considered equal to baseline wash in overall performance. • Had difficulty cutting paper residue. • Wash was diluted 50% with water.
Facility 13			1.8 ± 0.4 [2.1 ± 0.5]	Based on a sample size of 19 blanket washes: • When not diluted with water, performance surpassed baseline and standard washes. • Averaged over all dilution levels, required slightly less effort than baseline wash. • Overall fair performance rating across ink coverages and dilutions.
WASH 14				
Facility 6	0.97; 12%	230+	1.3 ± 0.6 [1.5]	Based on a sample size of 15 blanket washes: • Good performance; cut ink well. • Extra effort was required to remove the oily residue that the wash left on the blanket.
Facility 16			2.8 ± 0.5 [2.0 ± 0.0]	Based on a sample size of 34 blanket washes: • Did not cut ink as well as the baseline wash. • Black inks and heavy ink build up are especially difficult to clean. • Thick consistency of the wash made it difficult to soak into rag.

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 19				
Facility 18	1.8; 22%	230+	4.8 ± 3.0 [1.5 ± 0.8][a]	Based on a sample size of 5 blanket washes: • Thick consistency of wash made it difficult to soak into rag and resulted in uneven application. • Large quantities were required to cut ink.
Facility 19			2.2 ± 0.5 [0.9 ± 0.2]	Based on a sample size of 8 blanket washes: • Thick consistency of wash was messy and difficult to use. • Cut demonstration short due to extra effort and time required to clean blanket.
WASH 20				
Facility 11	2.7; 35%	170	1.4± 0.6 [0.7± 0.2]	Based on a sample size of 17 blanket washes: • Performance considered fair, but worse than facility and baseline washes. • Left oily residue on blanket that required additional rotations to remove. • Hard to apply to rags due to thick consistency.
Facility 12			3.0 [4.4± 1.6]	Based on a sample size of 1 blanket washes: • Product induced nausea in press operators; Facility declined opportunity to test product.
WASH 21				
Facility 6	3.5; 47%	115	2.0 ± 0.6 [1.5]	Based on a sample size of 6 blanket washes: • Fair performance. • Cut ink well, but oily residue was difficult to remove. • Extra waste sheets required to get back up to color because of residue.
Facility 17			1.6 ± 0.4 [1.5 ± 0.4]	Based on a sample size of 25 blanket washes: • Fair performance. • Oily residue caused print problems if it was not completely removed. • Wash did not absorb into rag easily.
WASH 22				
Facility 12	Not measurable; 2.17%[b]	157	4.4 ± 0.6 [4.4 ± 1.6]	Based on a sample size of 5 blanket washes: • Cut ink as well as baseline wash. • Did not readily soak into rag, creating delays. • Fair performer overall.
Facility 13			3.4 ± 1.7 [2.1 ± 0.5]	Based on a sample size of 17 blanket washes: • Difficult to apply to rag due to thick consistency. • Left blanket slightly streaked and wet, extra drying time necessary to prevent print quality problems. • Cut ink as well as baseline wash, but required greater effort; a fair performer.

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 24				
Facility 16	1.5; 19%	100	2.2 ± 0.6 [2.0 ± 0.0]	Based on a sample size of 28 blanket washes: • Cut ink well, but some extra effort was required to wipe off oily residue. • Oily residue significantly increased the number of copies required to return to print quality.
Facility 17			1.3 ± 0.6 [1.5 ± 0.4]	Based on a sample size of 4 blanket washes: • Cut ink well. • Extra effort to wipe off oily residue. • Thick consistency of wash caused operator to curtail use. • Citrus odor was very strong to operator.
WASH 26				
Facility 5	1.3; 18%	230+	0.5± 0.1 [1.0]	Based on a sample size of 14 blanket washes: • Good performance rating after every wash. • Performed as well as both standard facility wash and baseline wash. • Slight oily residue caused print quality problems when wash was used for roller clean-up.
Facility 15			0.7± 0.1 [1.5± 0.7]	Based on a sample size of 22 blanket washes: • Good performance rating after every wash. • Performed as well as standard facility wash and baseline wash.
WASH 29				
Facility 7	2.1; 30%	230+	1.0 ± 0.0 [1.2 ± 0.0]	Based on a sample size of 3 blanket washes: • Good performance; cut ink well. • Extra effort was required to dry the blanket.
Facility 8			0.8 ± 0.6 [0.7 ± 0.0]	Based on a sample size of 36 blanket washes: • Did not cut ink as well as baseline wash. • Did not cut paper dust or powder. • More effort was required to remove slight oily film on blanket.
WASH 30				
Facility 18	0.48; 7%	100	4.0 ± 0.0 [1.5 ± 0.8]	Based on a sample size of 3 blanket washes: • Good performance; cut ink well. • Worked best with no dilution with water.
Facility 19			0.7 ± 0.0 [0.9 ± 0.2]	Based on a sample size of 8 blanket washes: • Cut ink well. • Required extra effort to dry oily film from blanket. • Thick consistency was difficult to use. • Extra effort was required due to resistance to surface of the blanket.

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 31				
Facility 7	6.6; 99%	105	1.5 ± 0.6 [1.2 ± 0.0][a]	Based on a sample size of 4 blanket washes: • Cut the ink well; slightly more effort needed to remove oily residue on blanket. • Oily residue slightly increased the copies required to return to print quality. • Smell not as strong as facility's standard wash or baseline wash.
Facility 8			1.1 ± 1.5 [0.7 ± 0.0]	Based on a sample size of 61 blanket washes: • Good performance; cut ink well • Performed as well as standard wash. • Slightly more effort was required due to resistance to surface of the blanket.
WASH 32				
Facility 1	6.5; 99%	220	2.5 ± 0.0 [2.5 ± 0.0]	Based on a sample size of 4 blanket washes: • Good performance. • Required slightly higher effort to remove excess wash than with the standard wash.
Facility 5			0.7 ± 0.2 [1.0]	Based on a sample size of 12 blanket washes: • Good performance. • Left slight, oily residue that was removed with dry rags and did not affect print quality.
WASH 34				
Facility 1	2.8; 39%	138	2.5 ± 0.0 [2.5 ± 0.0]	Based on a sample size of 37 blanket washes: • Good performance; best of the 5 substitute washes demonstrated at this facility. • Cut the ink well with the same effort as with the standard wash for light/medium ink coverage. • Slightly more effort needed for heavy ink coverage, but acceptable.
Facility 19			1.2 ± 0.4 [0.9 ± 0.2]	Based on a sample size of 13 blanket washes: • Fair/Poor performance. • Cut the ink well, but did not soak into rag and extra effort was needed to remove the oily residue.
WASH 37				
Facility 3	1.0; 14%	82	1.3 ± 0.6 [1.0]	Based on a sample size of 17 blanket washes: • Longer drying time than baseline and standard facility washes. • Performance rated as good and fair on light and medium coverages, respectively. • Press operators had no problems with wash.
Facility 4			2.2 ± 0.8 [3.0 ± 0.0]	Based on a sample size of 6 blanket washes: • Worked well initially, but caused paper breakup due to blanket tackiness. • Use of wash discontinued.

	Laboratory Results		Field Demonstration Results	
Product/ Facility	**VOC Content** (lbs/gal; % by wt)	**Flash-point** (°F)	**Avg Volume Used** (ounces)	**Performance Evaluation**
WASH 38				
Facility 2	4.9; 65%	230+	2.2 ± 0.6 [1.2 ± 0.8][a]	Based on a sample size of 9 blanket washes: • Oily residue caused print quality problems. • Use of wash discontinued after 1.5 days due to poor performance and print quality problems.
Facility 4			3.7 ± 1.3 [3.0 ± 0.0]	Based on a sample size of 6 blanket washes: • Use of wash discontinued after 6 trials due to print quality problems from oily residue. • Wash cut ink satisfactorily.
WASH 39				
Facility 5	2.9; 37%	155	0.7 ± 0.3 [1.0]	Based on a sample size of 32 blanket washes: • Good overall performance; cut ink well. • Did not dry as quickly as baseline wash and left an oily residue on the blanket. • Product did not work on rollers.
Facility 8			1.0 ± 0.0 [0.7 ± 0.0]	Based on a sample size of 5 blanket washes: • Did not cut ink well and therefore required extra time and effort to clean blankets. • Difficult to get wash to soak into rag. • Left oily residue on blanket.
WASH 40				
Facility 1	3.8; 52%	155	2.5 ± 0.0 [2.5 ± 0.0]	Based on a sample size of 6 blanket washes: • Good performance. • When diluted with water, left residue. No residue problem at full strength.
Facility 10			0.9 ± 0.2 [1.5 ± 0.0]	Based on a sample size of 20 blanket washes: • Good performance; cut ink well. • Required slightly more effort when coverage was heavy.

[a] Bracketed values ([]) are the results using the baseline wash (VM&P Naphtha) to clean the same blanket as was used in the demo at this facility.
[b] VOC content not measurable; % by weight VOC content was reported by manufacturer.

Blanket Wash 1

Composition:
Fatty acid derivatives
Alkoxylated alcohols

VOC Content: 30%; 2.3 lbs/gal
Flashpoint: 230+°F
pH: 7.8 (fluctuates wildly)

Facility 3

Facility 3 used Wash 1 for one week on a two-unit, 18" x 25" press. During the demonstration week, the facility used conventional inks to print letterhead and brochures. The standard blanket wash at Facility 3 contains aliphatic hydrocarbons, aromatic hydrocarbons, and alcohol, according to the MSDS. Facility 3 had recently tried a sample of another substitute blanket wash, but found it to be too oily; they had difficulty removing the residue from the blanket. In their typical cleaning procedure, the press operator pours the wash onto a reusable shop towel from a squirt bottle, and wipes the ink off the blanket. Both the baseline wash and the facility's standard product evaporated quickly and there was no need to remove excess wash.

For light or medium ink coverage, the press operator evaluated the performance of Wash 1 as "fair;" it removed the ink well, but left an oily residue on the blanket. To remove this residue, the press operator had remove the excess wash from the blanket with a dry shop towel. The press operator felt the extra effort of the drying step required for Wash 1 was minimal, and if that were the only disadvantage to Wash 1, he would have considered using the product regularly. However, in the case of heavy ink coverage, performance was considered "poor;" Wash 1 did not cut the ink well, even when the product was applied twice. The press operator felt the effort, time, and product needed to clean a blanket with heavy ink coverage were excessive.

Facility 6

Facility 6 prints credit cards and identification cards on plastic sheets using conventional inks. Wash 1 was used on a single-unit, 18" x 25" press. Currently, this facility cleans their blankets using a wash which, according to the MSDS, consists of aliphatic petroleum distillates, aromatic petroleum distillates, 1,2,4-trimethylbenzene, nonylphenoxypoly (ethyleneoxy) ethanol, diisononyl phthalate, 2,6,-di-tert-butyl-p-cresol. Each blanket is typically wiped down four times during cleaning: three times to remove the ink with reusable shop towels soaked with blanket wash, and once with a shop towel soaked with a more volatile cleaner to thoroughly dry the blanket. Blanket wash is applied to the shop towel using a squirt bottle and the last shop towel from the previous wash is used as the first shop towel on the next wash. The same shop towels are used until there is too much ink build-up on the shop towel to effectively remove ink. The application procedure was modified slightly for both the baseline wash and the substitute wash during the performance demonstration; a dry shop towel was used to dry the blanket rather than a drying solution.

This facility did not use Wash 1 for the full week-long demonstration period. While on-site, the observer recorded the data for four blanket washes. During this time, the performance of Wash 1 was categorized as "good" by the operator; the product cut the ink well and the blanket appeared to be clean. Compared to the baseline product, slightly more effort and time were required for Wash 1 (an average of 4 rotations or 75 seconds) than for the baseline wash (2 rotations or 38 seconds). The operator found the baseline product worked very well; it cut the ink and dried quickly after wiping the blanket with one dry wipe, whereas the substitute wash required at least two drying rotations to fully remove excess wash from the blanket with a dry shop towel.

After the observer's visit, the press operator continued to use Wash 1. He recorded information on four more washes, rating the performance as "good." For all of these washes, ink coverage was medium. He found the product had no odor, which he preferred to the unpleasant odor of this facility's standard product. However, after four blanket cleanings, the press operator noticed problems with the subsequent print job. He found that the blanket did not take the ink well and that the image of the previous job was showing up on the next job printed. The press operator felt these problems with print quality were associated with Wash 1 and he discontinued using the product. After switching back to his standard wash, he did not experience further problems with print quality.

Upon interviewing the press operator at the end of the demonstration, he felt that the product's overall performance was "poor." This is not reflected in the data since the printer discontinued using the product before he noticed the print quality problems.

Summary of Performance Demonstrations for Blanket Wash 1

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	pH	Flashpoint (°F)	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 1	2.3; 30%	7.8 (fluctuated during test)	230+	0.1 @ 80°F	1.5	3	4	6
Baseline Wash	6.2; 100%	6.6	50	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 1 at Facility 3	1.1 ± 0.2 (n=10)[a]	2.0 ± 0.0	2.2 ± 0.5	2.5 ± 0.7	Medium	Medium	High	*Based on a sample size of 10 blanket washes:* • Good performance for light or medium ink coverage. • Poor performance for heavy ink coverage; the extra time and effort needed were unacceptable. • Left a slight residue that was removed with a dry shop towel.
Baseline Wash at Facility 3	1.0 (n=1)	NA	1	NA	NA	Medium	NA	• Good performance. • It dried quickly and removing excess wash with a dry shop towel was not required.
WASH 1 at Facility 6	1.5 ± 0.6 (n=4)	NA	4.0 ± 0.0	NA	NA	Medium	NA	*Based on a sample size of 4 blanket washes:* • Poor performance. • Print quality problems: image of the previous job was showing.
Baseline Wash at Facility 6	1.5 (n=1)	NA	2	NA	NA	Low	NA	• Good performance • Cut the ink well without extra effort.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 18.8 sec. at Facility 3 and 13.8 sec. at Facility 6 (based on time recorded by the observer)

Blanket Wash 6

Composition:
Fatty acid derivatives
Hydrocarbons, petroleum distillates
Solvent naphtha (petroleum), heavy aromatic
Alkyl benzene sulfonates
VOC Content: 47%; 3.5 lbs/gal
Flashpoint: 152°F
pH: 5.5

Facility 11

Wash 6 was tested on a 5-unit, 19" x 26" press at Facility 11. During the performance demonstration, conventional and vegetable-based inks were used to produce commercial products such as brochures, publications, and mailings. Facility 11 had tried using alternative blanket washes for worker health and safety or environmental reasons on four occasions prior to the performance demonstration, but use of all four products had been discontinued due to odor problems. Currently, Facility 11 uses a blanket wash which, according to the MSDS, consists of petroleum naphtha, dipropylene glycol methyl ether, and 1,8(9)-nenthadiene. Normal blanket wash procedure consists of three wipes with a reusable shop towel saturated with blanket wash, followed by a single wipe with a clean dry shop towel to remove excess wash and dry the blanket. The blanket wash is applied to the shop towel with a squirt bottle. If possible, the shop towels were used to clean more than one blanket. This standard application method was also used for the performance demonstration.

On average, Wash 6 and the baseline wash received performance ratings of fair on the good-fair-poor scale across all ink coverages. The baseline wash was used on light and medium ink coverages, whereas Wash 6 performance was demonstrated at all levels of ink coverage. Wash 6 cut the ink as well as the baseline wash and required slightly less time (as measured by blanket rotations) to complete the blanket wash procedures. The effort required to remove ink increased for Wash 6 from a medium to high level on heavy coverage jobs, however, while the effort required to wash the blanket was a medium level for the baseline wash on light and medium ink coverages. Press operators commented that Wash 6 had an especially difficult time cutting black inks.

According to press operators, Wash 6 did not soak into the wipe as well as the baseline or standard facility washes, causing some delays in the blanket wash-up procedure, as press operators waited for the wash to slowly absorb into the shop towel material. Press operators also noticed a slight oily film remaining on the blanket from Wash 6, even after the dry wipe step. The oily residue caused problems with print quality; subsequent print jobs required a greater number of copies than usual to reach acceptable print quality. Wash 6 odor was considered slightly strong by press operators.

Facility 15

Facility 15 used Wash 6 on a brand new, 2-unit, 19" x 25" press to print commercial printing products such as brochures with conventional inks. Facility 15 had experimented with an alternative blanket wash for environmental, worker health and safety reasons prior to the performance demonstration, but had not adopted the wash due to its "ferocious" odor. Standard facility blanket wash was a petroleum naphtha-based product, according to the MSDS. Standard blanket washing procedure consisted of a two wipe process: one reusable cloth shop towel is used to apply the blanket wash to the blanket and remove the ink, and another clean and dry reusable cloth shop towel is used to remove the excess wash and dry the blanket. The blanket wash is applied to the reusable shop towel with a squirt bottle; a small (approximately one ounce) and relatively consistent quantity of blanket wash is applied for each cleaning. This standard application process was used throughout the performance demonstration.

The press operator who conducted the week-long demonstration felt that Wash 6 performed worse than both the baseline wash and the facility standard wash. The baseline wash received a good performance rating, whereas Wash 6 received a poor rating on the good-fair-poor scale. The press operator's major complaint was that the thick consistency of Wash 6 caused delays during the wash application process; the viscous substitute wash required time to slowly soak into the shop towel material before blanket washing could begin. The press operator experimented with reducing the quantity of blanket wash in order to minimize delays, but the reduced volume was insufficient to finish a blanket in one wash application. The application shop towels were identical in material and size to other reusable laundered shop towels observed at other facilities. The viscosity problem was the only complaint about the substitute wash, however, as it performed well in all other areas. According to the press operator, Wash 6 cut the ink well, did not leave a residue on the blanket, and did not require a greater overall effort to clean the blanket than the baseline wash. The quantity of Wash 6 used to clean a blanket was also less than that of the baseline wash. In the opinion of the press operator, the effort required to apply the substitute wash to the shop towel outweighed these considerations, however. Wash 6 was categorized as requiring a high level of effort. In comparison, the baseline wash required low effort according to the press operator.

Summary of Performance Demonstrations for Blanket Wash 6

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 6	3.5; 47%	152	5.5	0.2 @ 68°F	0.7	1.5	8	6
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 6 at Facility 11	1.0 ± 0.2 (n=11)[a]	2.5 ± 0.8	2.5 ± 0.6	3.0 ± 0.0	Medium	Medium	High	*Based on a sample size of 11 blanket washes:* • Left oily residue that interfered with print quality. • Did not readily absorb into shop towel due to thick consistency. • Fair performance overall; more effort required with heavy ink coverage.
Baseline Wash at Facility 11	0.7 ± 0.2 (n=4)	3.7 ± 0.6	3.0 ± 0.0	NA	Medium	Medium	NA	• Received good performance rating. • Did not perform as well as facility standard wash.
WASH 6 at Facility 15	0.9 ± 0.2 (n=23)	2.7 ± 0.5	3.6 ± 0.5	3.9 ± 0.4	High	High	High	*Based on a sample size of 23 blanket washes:* •Cut ink well. • Did not readily absorb into shop towel due to thick consistency; created delays and effort necessary to clean was rated "high." • Did not leave a residue on the blanket.
Baseline Wash at Facility 15	1.5 ± 0.7 (n=2)	2.0 ± 0.0	NA	NA	Low	NA	NA	• Cut ink well, with low effort. • Slight odor.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.

Blanket Wash 9

Composition:
Fatty acid derivatives
Water
Ethoxylated nonylphenol
VOC Content: 10%; 0.77 lbs/gal
Flashpoint: 230+°F
pH: 4.6

Facility 10

At Facility 10, performance demonstrations were conducted on a six-unit, 19" x 28" press using conventional inks. This facility primarily prints commercial products, such as brochures, cards, and posters. Currently, Facility 10 uses a naphtha blend as their standard wash. They have tried a few alternative washes, but found that they either did not work as well, or that they cost more than twice as much as their standard blanket wash. Typically, the facility cleans the blanket as follows: wipe the blanket with a wet sponge to remove built-up paper and particles (1-2 rotations); pour blanket wash onto a reusable shop towel from a squeeze bottle; wipe blanket with product (2 rotations); wipe off excess with a clean, dry shop towel (1-2 rotations). The baseline product and Wash 9 were applied using the same procedure.

When using Wash 9, the operator rated the performance as "poor." After the first four blanket washes, the press operator discontinued use of the product. Compared to the baseline wash, which cut the ink well, the substitute wash required excessive effort and time (up to 12 rotations or 3 minutes, compared to 5 rotations or 1.25 minutes with the baseline wash), and still did not cut the ink. Although none of the four blankets washed had heavy ink coverage, Wash 9 still was not able to remove the ink to the satisfaction of the press operator. Before continuing the print job, the operator cleaned all the blankets again with his standard wash. Additionally, the thick, creamy consistency of the wash did not allow it to soak into the shop towel; this made for a messy application as the wash dripped from the blanket onto the floor and onto other parts of the press during the blanket washing procedure. After the four blanket washes, the operator varied the application procedure somewhat in an effort to improve performance. To try to get the wash to soak into the shop towel, the operator tried using a shop towel dampened with water instead of a dry one to apply the wash. This did not improve the absorption of Wash 9 into the shop towel or the performance in cleaning the blanket. Because this facility re-washed the blankets with their standard product before starting the next print job, it is unclear as to whether this blanket wash would have an affect on future print quality or not.

Facility 15

Facility 15 prints commercial products (brochures), direct-mail products, and other publications. Performance demonstrations at this facility were conducted on a two-unit 19" x 25" press using conventional inks. The standard wash contains aromatic hydrocarbons, polyglycol ether, and aliphatic hydrocarbons, according to the MSDS. The press operator noted that while the standard wash cuts the ink well, it does have somewhat of an odor. In the past, Facility 15 tried an alternative blanket wash, but it did not work well and it had a very offensive odor. Recently, this facility installed a new press with an automatic blanket washer. In their standard blanket washing procedure, the press operator at this facility pours the blanket wash on to a reusable shop towel, wipes the ink off the blanket in one rotation, then uses a dry shop towel for one rotation to remove the excess wash. This procedure was used for both the baseline and the substitute wash.

Over the course of the week, Facility 15 washed 21 blankets with the Wash 9. While the baseline wash performance was "good" and cut the ink well with minimal effort, the overall performance of Wash 11 was consistently rated as "poor" at all levels of ink coverage. The press operator noted several reasons for the poor performance: the thickness of the wash prevented it from soaking into the shop towel thoroughly; when applied to the blanket, Wash 9 did not cut the ink well; it required excessive effort (more than twice as much as the baseline product); and, it did not dry well on the blanket. Although the wash did not seem to affect future print quality, the operator felt he had to carefully and thoroughly dry the blanket to avoid print quality problems.

Summary of Performance Demonstrations for Blanket Wash 9

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 9	0.77; 10%	230+	4.6	< 1.0 @ 77°F	1.5	1.5	19	30
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 9 at Facility 10	3.1 ± 0.3 (n=4)[a]	11. ± 1.4	11. ± 1.4	NA	High	High	NA	*Based on a sample size of 4 blanket washes:* • Poor performance. • Did not cut ink well, required excessive effort, and did not soak into shop towel. • Discontinued use of Wash 9 after 4 washes.
Baseline Wash at Facility 10	1.5 (n=1)	NA	NA	5	NA	NA	Medium	• Good performance; cut heavy ink coverage well. • Operator noted a strong odor.
WASH 9 at Facility 15	0.7 ± 0.1 (n=21)	3.6 ± 0.5	3.9 ± 0.4	4.7 ± 0.6	High	High	High	*Based on a sample size of 21 blanket washes:* • Poor performance. • Did not soak into the shop towel. • Required much more effort than the baseline.
Baseline Wash at Facility 15	1.5 ± 0.7 (n=2)	2.0 ± 0.0	NA	NA	Low	NA	NA	• Good performance. • Cut ink well with minimal effort.

NA = Not Applicable; product was not demonstrated under these conditions.
NC = Not calculated; VOC content as a % by weight could not be calculated because a specific gravity was not available.
[a] n = number of washes on which this data is based, as recorded by the observer (Facility 10) and by the printer (Facility 15).
[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 15.0 sec. at Facility 10 and 35.0 sec. at Facility 15 (based on time recorded by the project observer)

Blanket Wash 10

Composition:
Fatty acid derivatives
Water

VOC Content: 2%; 0.16 lbs/gal
Flashpoint: 230+°F
pH: 5.7

Facility 3

Facility 3 used Wash 10 on a 2-unit, 18" x 25" press, using conventional inks to print a variety of commercial products. Facility 3 had used a new blanket wash for health, safety, or environmental reasons on one occasion prior to the performance demonstration, but the wash had not been adopted because it left an oily residue on the blanket and took too long to dry. Normal blanket washing procedure is the following: a squirt bottle is used to apply blanket wash to a reusable shop towel, the shop towel is then used to wipe the blanket as it is manually rotated, and the blanket is allowed to air dry. Standard facility blanket wash was a mixture of aliphatic and aromatic hydrocarbons, according to the MSDS. The application procedure was not changed for the performance demonstration.

The press operator cleaned four blankets with Wash 10 before declining to conduct a performance demonstration of the product due to its poor performance. Wash 10 did not absorb into the application shop towel, creating safety and cleanliness problems in the pressroom as excess wash dripped on the floor and press. A variety of methods were tried to get the wash to absorb into the standard reusable application shop towel, but none were successful. These methods included cupping the shop towel to keep the blanket wash from running off of the surface immediately, applying the blanket wash to the shop towel on a flat surface and then folding the shop towel over the applied wash, and placing the mouth of the applicator bottle directly onto the surface of shop towel to contain the wash until it had fully absorbed. In addition, Wash 10 did not cut the ink well. According to the press operator, 3-4 times the effort required to use the baseline wash was necessary to remove ink from the blanket with Wash 10 under light ink coverage conditions.

Facility 4

Wash 10 was used on a 4-unit, 34" x 40" press at Facility 4 which does most of its business in commercial printing products such as software manuals and calendars. Facility 4 uses a solution of aliphatic hydrocarbons, aromatic hydrocarbons, and surfactants, according to the MSDS, as the standard blanket wash. Blanket wash procedure at Facility 4 consists of a two wipe process. Blanket wash is applied to a clean, dry, and reusable shop towel which is used to wash the blanket. Another clean dry shop towel is then used to remove excess wash and dry the blanket. If ink buildup on the shop towels is not significant, the shop towels are used to wash more than one blanket. If paper coating is deposited on the blanket from the job, the blanket wash shop towel is dipped into a bucket of water before wiping down the blanket. This standard blanket washing procedure was not modified for the performance demonstration.

The press operator at Facility 4 used Wash 10 to clean four blankets before declining to conduct a performance demonstration of the product due to its poor performance. Under medium ink coverage conditions, Wash 10 did not cut the ink well and required considerably more effort then the standard facility wash or baseline wash of the performance demonstration. An average of six blanket rotations were necessary to clean the blanket, two times more than were necessary with the baseline and standard washes. In addition, Wash 10 did not soak well into the standard reusable shop towels at Facility 4, creating further delays. A variety of methods were tried to get the wash to absorb into the application shop towel, but none were successful. These methods included cupping the shop towel to keep the blanket wash from immediately running off of the shop towel surface, applying the blanket wash to the shop towel and then folding the shop towel over the applied wash, and placing the mouth of the applicator bottle directly onto the surface of shop towel to contain the wash until it had fully absorbed. The press operator, who had broken into a sweat from the effort required to use Wash 10, declined to use the product for the week-long performance demonstration.

Summary of Performance Demonstrations for Blanket Wash 10

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 10	0.16; 2%	230+	5.7	17.5 @ 68°F	0.7	0.7	12	13
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 10 at Facility 3	1.0 ± 0.0 (n=4)[a]	2.0 ± 0.0	2.0 ± 0.0	NA	High	High	NA	*Based on a sample size of 4 blanket washes:* • Printer declined to test product due to level of effort required to clean blanket. • Did not absorb well into shop towel. • Did not cut ink well.
Baseline Wash at Facility 3	1.0 (n=1)	NA	1.0 ± 0.0	NA	NA	Medium	NA	• Good performance: cut the ink well. • Slight, unpleasant odor.
WASH 10 at Facility 4	3.0 ± 0.0 (n=4)	NA	6.2 ± 0.5	NA	NA	High	NA	*Based on a sample size of 4 blanket washes:* • Printer declined to test product due to level of effort required to clean blanket. • Did not absorb well into shop towel. • Did not cut ink well.
Baseline Wash at Facility 4	3.0 ± 0.0 (n=2)	NA	3.0 ± 0.0	NA	NA	Low	NA	• Good performance: cut the ink well. • Slight, unpleasant odor.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the observer.

[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 30.0 sec. at Facility 3 and 202.5 sec. at Facility 4 (based on time recorded by the project observer)

Blanket Wash 11

Composition:
Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 61%; 4.3 lbs/gal
Flashpoint: 150°F
pH: 5.0 (fluctuates wildly)

Facility 1

At Facility 1, performance demonstrations were conducted on an eight-unit, 28" x 40" press using vegetable-based inks to print high quality, multi-color, commercial products. Currently, Facility 1 uses a blanket wash which, according to the MSDS, consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons. In the months preceding the demonstrations, the facility had tried two different low-VOC blanket washes; neither worked as well as their standard wash. At this facility, each blanket is typically wiped down twice during cleaning: once with a reusable shop towel saturated in blanket wash to remove the ink, and once with a dry shop towel to remove excess blanket wash. Each saturated shop towel is used to clean two blankets. The same application procedure was used for the baseline and substitute products. The quantity of wash needed to saturate the shop towel and clean the blanket remained constant throughout the demonstration, regardless of the ink coverage or ink build-up on the blanket. There were both positive and negative aspects to this application method. While more wash than was needed may have been used in some cases, the consistency of the application volume made it possible to compare the performance of the standard, baseline, and substitute products under the same conditions.

In the case of light or medium ink coverage, Wash 11 cut the ink well and the press operator generally considered the performance "good" or "fair." For heavy ink coverage, performance of the product was usually evaluated as "poor." The press operator cleaned all blankets using Wash 11 for three days (26 blankets) until he ran out of the substitute wash. Extra time and effort were needed, however, to remove the oily residue from the blanket when compared to the baseline product. Wiping the blanket with one clean, dry shop towel (as was used with their standard blanket wash and with the baseline wash) did not completely remove the residue; oily streaks of wash remained on the blanket. The press operator was able to remove the residue by wiping the blanket with a clean shop towel that was dampened with water, followed by a clean, dry wipe. This extra step reduced the oily residue, but increased the time and effort required to wash the blanket (from 2 rotations or 40 seconds with the baseline wash to 3 - 4 rotations or 60 - 80 seconds with Wash 11).

In the case of heavy ink coverage, the performance of Wash 11 was considered "poor." The substitute wash, did not cut the ink well in cases of heavy coverage or excessive ink build-up. Since this printer has eight unit press, the ink build-up on the last print unit can be especially heavy. Because of this problem with heavy ink coverage, the printer felt this product was not a suitable substitute for his facility.

The printer found the oily residue had no overall affect on the print quality: while it made the blanket less tacky which *reduced* the time to get back up to acceptable quality, the same residue washed out the color somewhat, which *increased* the sheets required to achieve acceptable print quality.

Facility 2

Facility 2 used a three-unit, 13" x 18" press for the performance demonstrations. This facility prints commercial products (brochures, flyers, cards) using both conventional and vegetable oil-based inks. Their standard wash consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons, according to the MSDS. The press operator noted that the standard wash cuts the ink well, but does have somewhat of an odor. In the past, Facility 2 has tried two substitute blanket washes: performance was rated as poor ("it did not work at all") for one product, and the other product they tried was too expensive. In their standard blanket washing procedure, the press operator at this facility pours the blanket wash onto a reusable shop towel from a squirt bottle, wipes the ink off the blanket in one rotation, then uses a dry shop towel for one rotation to remove the excess wash. This application procedure was also used for both the baseline and the substitute washes.

The performance of Wash 11 was considered "good" or "fair" when ink coverage was light or medium. For heavy ink coverage, the wash performance was evaluated as "poor." Facility 2 used Wash 11 for one week , recording information on 31 blanket cleanings. When ink coverage was light or medium, the Wash 11 usually matched the baseline level of performance, which was rated as "good." The baseline wash cut the ink very well; the quantity, effort, and time required were the same as with this facility's standard product. The performance of Wash 11 was comparable to the baseline for light/medium ink coverage requiring an average of two cleaning rotations, two wipes, and approximately one ounce of product to clean the blanket. For heavy ink coverage, however, an average of 8 rotations (ranging from 4 up to 12), 5 wipes, and 4 ounces of Wash 11 were needed to clean the blanket. In addition to the extra time and quantity of product needed, removing the heavy coverage ink required additional physical effort. The overall product performance for removing heavy ink coverage was considered "poor," although Wash 11 ultimately did remove the ink and did not affect print quality.

In all cases, Wash 11 left an oily residue on the blanket which was removed with a dry shop towel. Removing this oily residue did not require any time or effort beyond their standard method where the blanket is wiped with a dry shop towel for one rotation.

Summary of Performance Demonstrations for Blanket Wash 11

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	pH	Flashpoint (°F)	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 11	4.3; 61%	5.0 (fluctuated during test)	150	0.2 @ 68°F	0	1.5	4	5
Baseline Wash	6.2; 100%	6.6	50	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 11 at Facility 1	2.5 ± 0.6 (n=26)[a]	3.0 ± 0.0	3.5 ± 0.7	4.0 ± 0.8	Medium	Medium	High	*Based on a sample size of 26 blanket washes:* • Good performance for light/medium ink coverage. • Extra time and effort needed for heavy ink coverage. • Left slight, oily residue on blanket, but it did not affect the print quality.
Baseline Wash at Facility 1	2.5 ± 0.0 (n=2)	2.0 ± 0.0	2.0 ± 0.0	NA	Medium	Medium	NA	• Good performance. • Required slightly more effort than their standard product to remove excess wash.
WASH 11 at Facility 2	1.5 ± 1.5 (n=31)	2.1 ± 0.6	2.0 ± 1.2	8.2 ± 3.5	Medium	Medium	High	*Based on a sample size of 31 blanket washes:* • Good/fair performance for light/medium ink coverage. • Extra time and effort were required for heavy ink coverage. • Left slight, oily residue on blanket, but it did not affect the print quality.
Baseline Wash at Facility 2	1.2 ± 0.8 (n=3)	2.7 ± 1.1	NA	NA	Medium	NA	NA	• Good performance • Cut ink as well as their standard wash.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 23.2 sec. at Facility 1 and 10.0 sec. at Facility 2 (based on time recorded by the observer)

Blanket Wash 12

Composition:
Hydrocarbons, petroleum distillates
Water

VOC Content: 20%; 1.3 lbs/gal
Flashpoint: 125°F
pH: 8.2

Facility 12

At Facility 12, Wash 12 was used on a 6-unit, 28" x 40" press with conventional inks. A variety of commercial products on a variety of paper types were printed during the performance demonstration: from posters on glossy stock to information cards on cardboard stock. Wash 12 was used approximately thirty times during the week-long performance demonstration. In the typical blanket washing procedure at Facility 12, each blanket is wiped twice: once with a reusable shop towel saturated with blanket wash from a plunger can, and once with a dry reusable shop towel to remove the excess blanket wash. The blanket wash shop towel is often used on more than one blanket, depending on the cleanliness of the shop towel as well as the ink coverage. The standard facility wash is a petroleum naphtha-based product, according to the MSDS. In the performance demonstration, the only change in application procedure was that Wash 12 was directly applied to each shop towel for the application process and the plunger can was not used. Wash 12 was diluted 50% with water at Facility 12.

Wash 12 was considered approximately equal to the baseline wash in overall performance; both received fair ratings on the good-fair-poor scale. According to press operators, Wash 12 required less effort than the baseline wash, but more time to complete the wash procedure. The number of rotations increased from an average of 3.0 for the baseline wash to 4.6 for Wash 12, approximately equal to a time increase of one and a half minutes per blanket at this facility. Wash 12 cut the ink satisfactorily, but not well, at all ink coverages, and did a poor job of cutting through paper residue on the blankets. On print runs that coated the blanket with paper residue, 12 rotations were necessary to clean the blanket, while only 4 rotations were needed for print runs without paper residue. Use of Wash 12 was discontinued on paper residue coated blankets due to this increased time requirement. The problem with paper residue was not related to ink coverage; the major increase in number of rotations occurred on a light coverage job. Some inconsistencies also arose with print quality. In some cases, after the blanket was cleaned, the color came back faster than with the baseline and regular washes (10 impressions instead of 20). At other times, however, Wash 12 may have caused dull spots to appear on the printed image.

Facility 13

Facility 13 used Wash 12 on a 2-unit, 20" x 26" press during the performance demonstration. Performance demonstration print jobs were primarily folders and brochures printed with light conventional ink coverage on glossy enamel paper. The blanket washing procedure at this facility involves two disposable paper shop towels: one is saturated with blanket wash from a squirt bottle and used to clean the blanket; the other is used dry to remove excess wash and dry the blanket. During this process, the blanket is rotated incrementally under manual control. The standard application method was not changed for the performance demonstrations.

Wash 12 was used for two one week trial periods in order to experiment with a variety of dilution ratios, ranging from 50% to 0% water. Averaged over all dilution ratios, Wash 12 required slightly less effort than the baseline wash, but was only considered a fair performer overall by the press operator. The time required to wash the blanket (as measured by number of rotations) was equal for the baseline wash and Wash 12 when averaged across dilution levels. However, as the ratio of blanket wash to water increased, the performance of Wash 12 improved. A 50% mixture of blanket wash and water left the blanket "wet" and solicited a poor performance rating from the press operator under all ink coverages. When the percentage of water was decreased to 25% of the overall mixture, the wash performance was generally rated as fair to good across all print ink coverages. The undiluted blanket wash performed the best. The press operator conducting the trials commented that the undiluted blanket wash performed better than the baseline wash and even surpassed the performance of the standard facility blanket wash in all categories. The undiluted wash received good performance and low effort ratings every time it was used. Product instructions, however, indicate that the blanket wash should be mixed from 1:1 to 1:8 with water. The press operator commented that the blanket wash odor was faint at all dilution levels, but was not disagreeable.

Summary of Performance Demonstrations for Blanket Wash 12

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 12	1.3; 20%	125	8.2	0.7 @ 68°F	0	1.5	7	11
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 12 at Facility 12	5.4 ± 0.8 (n=16)[a]	12.0 ± 0.0	4.0 ± 0.6	4.5 ± 0.6	High	Medium	Medium	*Based on a sample size of 16 blanket washes:* • Caused potential print quality problems. • Was considered equal to baseline wash in overall performance. • Had difficulty cutting paper residue. • Wash was diluted 50% with water.
Baseline Wash at Facility 12	4.4 ± 1.6 (n=6)	4.0 ± 0.0	2.5 ± 1.0	NA	High	High	NA	• Required greater effort than standard wash. • Did not cut ink as well as standard wash.
WASH 12 at Facility 13	1.8 ± 0.4 (n=19)	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	Medium	Medium	Medium	*Based on a sample size of 19 blanket washes:* • When not diluted with water, performance surpassed baseline and standard washes. • At most dilution levels, required slightly less effort than baseline wash. • Overall fair performance rating across ink coverages and dilutions.
Baseline Wash at Facility 13	2.1 ± 0.5 (n=4)	1.0 ± 0.0	1.0 ± 0.0	NA	Medium	High	NA	• Good performance, cut the ink well. • Removed ink in one rotation.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 48.0 sec. at Facility 12 and 62.5 sec. at Facility 13

Blanket Wash 14

Composition:
Fatty acid derivatives
Propylene glycol ethers
Water

VOC Content: 12%; 0.97 lbs/gal
Flashpoint: 230+°F
pH: 5.0

Facility 6

At Facility 6, Wash 14 was used on a single-unit, 18" x 24" press and a single-unit 18" x 25" press with conventional inks to print credit cards, identification cards and other products on plastic substrates. The press operator cleaned all blankets using Wash 14 for the week-long demonstration. At this facility, each blanket is typically wiped down four times during cleaning: three times to remove the ink with reusable shop towels soaked with blanket wash; and once with a shop towel soaked with a more volatile wash to dry the blanket. Currently, this facility cleans their blankets using a wash which contains aliphatic petroleum distillates, aromatic petroleum distillates, 1,2,4-trimethylbenzene, nonylphenoxypoly (ethyleneoxy) ethanol, diisononyl phthalate, and 2,6,-di-tert-butyl-p-cresol, according to the MSDS. The blanket wash is applied to the shop towel using a squirt bottle and the shop towel is resoaked with wash prior to reuse on other blankets. The same shop towels are used until there is too much ink buildup on the shop towel to effectively clean the blanket. During this procedure, the blanket turns automatically at a constant rate. This application procedure was modified for the substitute product demonstration by replacing the Tru-dot cleaner used in the last step with a dry shop towel to dry the blanket.

Overall, the performance of Wash 40 was considered "good" on all ink coverages, although it required almost twice as many rotations (eight rotations) to clean a blanket with heavy ink coverage than to clean a blanket with medium ink coverage. The press operator found that Wash 14 cut the ink well; with about the same effectiveness as the baseline wash which the operator also found to cut the ink well. Some additional time and effort were needed to remove a slight oily residue left by the substitute wash using a clean dry shop towel. The average time required to rotate a blanket was measured to be 22.5 seconds, therefore it required an extra 1.5 minutes to clean the blanket with heavy ink coverage. The amount of extra effort required, however, was considered to be a "medium" amount for light and medium ink coverages and "high" when cleaning a blanket with a heavy ink coverage. The quantity of substitute wash used was slightly lower than the quantity of baseline wash used. At all levels of ink coverage, no print quality problems attributable to Wash 14 were experienced. The press operator also noticed that Wash 14 did not have a strong solvent smell as opposed to the facility's standard wash or the baseline wash.

Facility 16

Facility 16 used a 2-unit 20" x 26" press with conventional inks to print advertisements, cards, and other commercial products. The press operator at Facility 16 used Wash 14 for all jobs during the one-week demonstration. At this facility, each blanket is typically wiped down three times during cleaning: once with a wet sponge to remove paper dust (when needed); once with a reusable shop towel soaked with naphtha (which is also the baseline wash used throughout the demonstrations); and finally with a clean dry shop towel to remove excess wash. This application procedure was also used for the application of the substitute wash. Facility 16 has tried substitute, low-VOC blanket washes in the past, but found that the products were not acceptable because they did not dry on the blanket as fast as their standard wash.

Overall, at Facility 16 the performance of Wash 14 was considered "fair". The press operator found that Wash 14 did not cut ink as well as the baseline wash, especially on black inks and in cases of heavy ink build up. Wash 14 was tested under light and medium ink coverage conditions while the baseline wash was observed only under heavy ink coverage conditions. Because the baseline wash is normally used at the facility, the operator's familiarity with the baseline wash allowed him to make accurate comparisons between the substitute wash and the baseline wash under all ink coverage conditions. The substitute wash required more time and effort to clean the blanket than the baseline wash because additional rotations were required to remove the ink. The substitute wash typically required one extra blanket rotation with a blanket wash soaked shop towel. On average, this press operator required 20.8 seconds per blanket rotation, so the actual time to clean a blanket using Wash 14 was not increased significantly. The press operator found that a larger volume of Wash 14 was also needed to remove the ink in comparison to the baseline wash (2.0 ounces for the baseline wash compared to 2.8 ounces for the substitute wash). The overall time and effort to clean the blankets was also a factor of the thick consistency of the substitute wash which made it difficult for the operator to get the product to soak into the shop towel.

Summary of Performance Demonstrations for Blanket Wash 14

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 14	0.97; 12%	230+	5	17.5 @ 68°F	1.5	3	8	10
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 14 at Facility 6	1.3 ± 0.6 (n=15)[a]	4.3 ± 0.6	4.4 ± 0.5	8.0 ± 0.0	Medium	Medium	High	*Based on a sample size of 15 blanket washes:* • Good performance; cut ink well. • Extra effort was required to remove the oily residue that the wash left on the blanket.
Baseline Wash at Facility 6	1.5 (n=1)	NA	2.0 ± 0.0	NA	NA	Low	NA	• Good performance; cut ink well.
WASH 14 at Facility 16	2.8 ± 0.5 (n=34)	3.2 ± 0.6	4.0 ± 0.5	NA	High	High	NA	*Based on a sample size of 34 blanket washes:* • Did not cut ink as well as the baseline wash. • Black inks and heavy ink build up are especially difficult to clean. • Thick consistency of the wash made it difficult to soak into shop towel.
Baseline Wash at Facility 16	2.0 ± 0.0 (n=3)	NA	NA	3.0 ± 0.0	NA	NA	Low	• Baseline wash is facility's standard wash.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 22.5 sec. at Facility 6 and 20.8 sec. at Facility 16 (based on time recorded by the project observer)

Blanket Wash 19

Composition: Fatty acid derivatives Propylene glycol ethers Water VOC Content: 22%; 1.8 lbs/gal Flashpoint: 230+°F pH: 4.6

Facility 18

At Facility 18, Wash 19 was used on a single-unit 20" x 30" press and a 2-unit, 19" x 26" press with soy oil-based inks. Commercial products such as business forms and brochures were printed. The press operator used Wash 19 for the four days that the presses were operating during the one-week demonstration period which resulted in only five blanket cleanings. At this facility, each blanket is typically wiped down three times during cleaning: twice with a reusable rag soaked with blanket wash, and once with a dry rag to remove excess blanket wash. Blanket wash is applied to the rag using a squirt bottle and the rag is resoaked with wash prior to reuse on other blankets. The same rag is used until it has too much ink build-up to effectively clean the blanket. Currently, this facility cleans their blankets using a wash which contains aliphatic hydrocarbons, according to the MSDS. Other than changing the number of rotations to clean a blanket, this application procedure was not modified during the demonstration of the substitute product. Facility 18 had tried an alternative low-VOC blanket wash, but found that it did not dry as fast as their standard product and was more expensive.

Based on the five blanket cleanings with Wash 19, the press operator at Facility 18 evaluated its performance as "poor". The press operator found that Wash 19 cut ink sufficiently only when applied to the blanket generously. The baseline wash was found to cut the ink well, but required additional effort due to the wash's high resistance to the blanket surface. On average, more than three times as much of Wash 19 was used compared to the baseline wash. The thick consistency of the substitute wash also contributed to the larger quantity of wash needed, as well as increased time and effort to clean a blanket in comparison to the baseline wash. The press operator had difficulty getting the product to soak into the rag, which resulted in a large amount of wash being applied to the blanket on the first few swipes of the rag and a comparatively small amount near the end of the blanket rotation. The press operator would then need to rotate the blanket additional times, applying more substitute wash to ensure that the necessary amount of blanket wash reached all areas of the blanket. This significantly increased the average number of rotations required to clean a blanket, especially in the case of light ink coverage where rotations increased from 2.7 rotations for the baseline wash to 8.0 rotations for the substitute. Because the average time to rotate a blanket was 16.2 seconds at Facility 18, the average blanket cleaning time increased by 1.4 minutes over the baseline wash for light ink coverage. The effort needed to use Wash 19 was evaluated as "high" due to its thick consistency and the extra rotations it required. The press operator observed that the wash cut the ink better on the first few swipes where the wash on the blanket was relatively thick in comparison to other areas with a thinner layer of wash. The press operator also noticed that the ability of the substitute wash to remove ink was better when it was allowed to sit on the blanket for a few minutes before being removed.

Facility 19

Facility 19 used a 2-unit 19" x 26" press also with soy oil-based inks to print brochures, cards, and other commercial products. The press operator at Facility 19 used Wash 19 for three days and then stopped because he found that the product required a significant amount of extra effort, time and quantity of wash to clean the blankets. The operator typically cleans the blanket by pouring the blanket wash onto a clean, reusable rag and wiping the blanket while rotating it manually twice. The blanket is then allowed to dry by evaporation before restarting the press. This application procedure was also used for the application of the baseline wash. When using Wash 19, the press operator modified the application procedure slightly and wiped the blanket with a dry rag before resuming the print job. The standard wash used at this facility contains aromatic hydrocarbons, polyglycol ethers, aliphatic hydrocarbons, and a proprietary combustible chemical, according to the MSDS. Prior to this project, they did some experimenting with another substitute wash, but it did not work as well as their standard product and it was irritating to the skin as well. In the past, they used an automatic blanket washer, hoping to reduce their blanket wash chemical use and labor, but they discontinued using it after they found it required more effort and wasted solvent.

The press operator at Facility 19 evaluated the performance of Wash 19 as "poor". The operator felt that the substitute product did not cut ink as well as the baseline wash. The baseline wash was found to cut the ink well, but required additional effort due to its high resistance to the blanket surface. Some additional time was required to remove the ink using Wash 19 than was required with the baseline wash. In addition, the thick consistency of Wash 19 was found to require extra time, effort and quantity to clean the blankets. The press operator had difficulty getting the product to soak into the rag which resulted in spillage and a "messy" application. When the usual application procedure was used with the Wash 19, an oily residue remained on the blanket which increased the number of copies required to get up to print quality after restarting the press. One or two rotations with a dry rag were needed to remove the residue from the blanket before printing. The quantity of Wash 19 needed to remove the ink more than doubled in comparison to the baseline wash. The press operator rated the effort needed as "high" for both the baseline and the substitute washes. Although the performance of the baseline wash was considered to be good, the effort needed to use the baseline wash was rated as "high" because the operator found it to have high resistance to being dragged across the blanket. The effort to use the substitute wash was rated as "high" due to the extra rotations and the messy application.

Summary of Performance Demonstrations for Blanket Wash 19

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 19	1.8; 22%	230+	4.6	17.5 @ 68°F	1.5	1.5	11	9
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3.0	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 19 at Facility 18	4.8 ± 3.0 (n=5)[a]	8.0 ± 0.0	7.7 ± 2.1	NA	High	High	NA	*Based on a sample size of 5 blanket washes:* • Thick consistency of wash made it difficult to soak into rag and resulted in uneven application. • Large quantities were required to cut ink.
Baseline Wash at Facility 18	1.5 ± 0.8 (n=6)	2.7 ± 0.5	3.5 ± 0.7	NA	Low	Low	NA	• Good performance; cut the ink well.
WASH 19 at Facility 19	2.2 ± 0.5 (n=8)	4.0 ± 0.0	4.0 ± 0.0	4.0 ± 0.0	High	High	High	*Based on a sample size of 8 blanket washes:* • Thick consistency of wash was messy and difficult to use. • Cut demonstration short due to extra effort and time required to clean blanket.
Baseline Wash at Facility 19	0.9 ± 0.2 (n=5)	2.2 ± 0.4	NA	NA	High	NA	NA	• Good performance; cut the ink well. • Required additional effort to drag across the blanket.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 16.2 sec. at Facility 18 and 18.5 sec. at Facility 19 (based on time recorded by the project observer)

Blanket Wash 20

Composition:
Water
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 35%; 2.7 lbs/gal
Flashpoint: 170°F
pH: 7.1

Facility 11

Wash 20 was tested on a 5-unit, 19" x 26" press at Facility 11. During the performance demonstration, conventional and vegetable-based inks were used to produce commercial products such as brochures, publications, and mailings. Facility 11 had tried using alternative blanket washes for worker health and safety or environmental reasons on four occasions prior to the performance demonstration, but use of all four products had been discontinued due to odor problems. Currently, this facility's standard wash consists of petroleum naphtha, dipropylene glycol methyl ether, and 1,8(9)-nenthadiene, according to the MSDS. Normal blanket wash procedure consists of three wipes with a reusable shop towel saturated with blanket wash, followed by a single wipe with a clean dry shop towel to remove excess wash and dry the blanket. The blanket wash is applied to the shop towel with a squirt bottle. If possible, the shop towels were used to clean more than one blanket. This standard application method was also used for the performance demonstration.

Overall, Wash 20 was given a fair performance rating and a medium effort rating. On average, the baseline wash performed better overall, but also required a medium amount of effort. The time required to wash the blanket was slightly less for Wash 20 than for the baseline wash; Wash 20 required 2.8 rotations whereas the baseline wash required 3.5 rotations. However, delays resulted from an oily film sometimes left on the blanket after use of Wash 20. This film had to be removed with a third rotation, thus bringing the average number of rotations close to 3.0 for the performance demonstration. Additional delays resulted from the thick consistency of Wash 20. The press operator often had to wait for the wash to soak into the application shop towel. Greater effort was required to cut ink under heavy ink coverage situations; the press operator gave a greater proportion of high effort ratings to the wash under these conditions. Wash 20 also had difficulty cutting through light inks such as reds and yellows. Press operators did not consider the odor of Wash 20 to be significant.

Facility 12

At Facility 12, Wash 20 was used on a 6-unit, 28" x 40" press with conventional inks. A variety of commercial products on a variety of paper types were printed during the performance demonstration: from posters on glossy stock to information cards on cardboard stock. Wash 20 was used approximately thirty times during the week-long performance demonstration. In the typical blanket washing procedure at Facility 12, each blanket is wiped twice: once with a reusable shop towel saturated with blanket wash from a plunger can, and once with a dry reusable shop towel to remove the excess blanket wash. The blanket wash shop towel is often used on more than one blanket, depending on the cleanliness of the shop towel as well as the ink coverage. According to the MSDS, the standard facility wash is a petroleum naphtha-based product. In the performance demonstration, the only change in application procedure was that Wash 20 was directly applied to each shop towel for the application process and the plunger can was not used.

Press operators at Facility 12 declined to use Wash 20 after experiencing nausea and dizziness after three trials. Wash 20 aggravated a previously existing respiratory condition in one press operator, and caused dizziness in another. These health problems coincided with a strong odor as blanket wash evaporated from the wash shop towel during the wipe process.

Summary of Performance Demonstrations for Blanket Wash 20

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 20	2.7; 35%	170	7.1	1.5 @ 77°F	0	1.5	5	7
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[c] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 20 at Facility 11	1.4 ± 0.6 (n=17)[a]	2.0 ± 0.0	2.7 ± 0.8	4.0 ± 0.8	Medium	Medium	High	*Based on a sample size of 17 blanket washes:* • Performance considered fair, but worse than facility and baseline washes. • Left oily residue on blanket that required additional rotations to remove. • Hard to apply to shop towels due to thick consistency.
Baseline Wash at Facility 11	0.7 ± 0.2 (n=4)	3.7 ± 0.6	3.0 ± 0.0	NA	Medium	Medium	NA	• Good performance. • Slight odor.
WASH 20 at Facility 12	3.0 (n=1)[b]	NA	5.0 ± 0.0	NA	NA	High	NA	*Based on a sample size of 1 blanket wash:* • Product induced nausea in press operators; Facility declined opportunity to test product.
Baseline Wash at Facility 12	4.4 ± 1.6 (n=6)	4.0 ± 0.0	2.5 ± 1.0	NA	High	High	NA	• Required higher effort than standard wash. • Did not cut ink as well as standard wash. • Slight odor.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] n = number of washes this data is based on, as recorded by the observer.
[c c] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 95.7 sec. at Facility 11 and 120.0 sec. at Facility 12 (based on time recorded by the project observer)

Blanket Wash 21

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates
Fatty acid derivatives

VOC Content: 47%; 3.5 lbs/gal
Flashpoint: 115°F
pH: 6.2

Facility 6

Facility 6 prints credit cards and identification cards on plastic sheets using conventional inks. Wash 1 was used on a single-unit, 18" x 25" press. Currently, this facility cleans their blankets using a wash which consists of aliphatic petroleum distillates, aromatic petroleum distillates, 1,2,4-trimethylbenzene, nonylphenoxypoly (ethyleneoxy) ethanol, diisononyl phthalate, 2,6,-di-tert-butyl-p-cresol, according to the MSDS. Each blanket is typically wiped down four times during cleaning: three times to remove the ink with reusable shop towels soaked with blanket wash, and once with a shop towel soaked with Tru-dot cleaner (a more volatile wash) to thoroughly dry the blanket. Blanket wash is applied to the shop towel using a squirt bottle and the last shop towel from the previous wash is used as the first shop towel on the next wash. The same shop towels are used until there is too much ink build-up on the shop towel to effectively remove ink. The application procedure was modified slightly for both the baseline wash and the substitute wash during the performance demonstration; a dry shop towel was used to dry the blanket rather than a drying solution.

The operator rated the performance of Wash 21 as "fair" for all levels of ink coverage. It cut the ink well, but it left an oily residue even after wiping the blanket with a dry shop towel. To remove the residue, the press operator wiped the blanket a second time with another dry shop towel. Even with the extra wiping, the operator felt the residue caused color wash-out on the next job, so that additional waste sheets (approximately 50 percent more) were needed to get back to color. After cleaning six blankets with Wash 21, the press operator switched back to using the standard wash. The operator summarized the product performance as fair: it cut the ink well, but the oily residue resulted in extra effort (to dry the blanket) and extra waste sheets (needed to get the press to color). The operator noticed Wash 21 had an odor, but he felt it was much better than the unpleasant odor of his standard wash.

Performance of the baseline product was considered good; it cut the ink well with minimal effort. Compared to Wash 21, the baseline required less effort and time to clean a blanket with medium ink coverage (2 rotations or approximately 41 seconds for the baseline compared to an average of 3.3 rotations or 61 seconds for Wash 21).

Facility 17

At Facility 17, performance demonstrations were conducted on a two-unit, 19" x 26" press with conventional inks where commercial products such as advertisements and brochures were printed. Currently, this facility uses which contains petroleum naphtha, dichloromethane, and 1,1,1-trichloroethane, according to the product's MSDS. This performance demonstration was their first experience in experimenting with substitute blanket washes. Typically the press operator cleans the blanket by pouring the wash from a squirt bottle onto a reusable shop towel and wiping down the blanket. The wash is allowed to dry by evaporation. Occasionally the operator will mix the wash with water to remove paper dust and paper lines from the blanket.

The overall performance of Wash 21 was rated as "fair;" it cut the ink well, but it left an oily residue on the blanket. Facility 17 used the substitute wash for one week during which 25 washes were recorded by the press operator. Wash 21 cut the ink well, but it was necessary to modify the application procedure slightly and add a drying step to remove the oily residue left on the blanket after applying the wash. Although this step was not required with the facility's standard wash, the operator did not view it as particularly burdensome; level of effort was rated as "low" or "medium." Both Wash 21 and the baseline wash were only used on blankets with light or medium ink coverage; no heavy coverage jobs were run during the demonstration period. The baseline wash cut the ink well with the same level of effort as is required for the facility's standard blanket wash. Compared to the baseline wash, Wash 21 took slightly more time because of the extra drying step.

In addition to the extra effort, the printer noted that the oily residue occasionally caused problems with subsequent print jobs. In two cases, the printer noticed the prints were mottled (fuzzy edges). The printer had to run additional waste sheets to get acceptable, clear print quality. The press operator also commented that the wash did not absorb into the shop towel easily, making it messy to apply. Absorbency was improved somewhat when the wash was applied to a shop towel wet with water.

Summary of Performance Demonstrations for Blanket Wash 21

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	pH	Flashpoint (°F)	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 21	3.5; 47%	6.2	115	< 0.1 @ 68°F	0	1.5	7	6
Baseline Wash	6.2; 100%	6.6	50	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 21 at Facility 6	2.0 ± 0.6 (n=6)[a]	2.0 ± 0.0	3.3 ± 0.6	4.0 ± 0.0	Low	Medium	High	*Based on a sample size of 6 blanket washes:* • Fair performance. • Cut ink well, but oily residue was difficult to remove. • Extra waste sheets required to get back up to color because of residue.
Baseline Wash at Facility 6	1.5 (n=1)	NA	2	NA	NA	Low	NA	• Good performance. • Cut the ink well without extra effort.
WASH 21 at Facility 17	1.6 ± 0.4 (n=25)	1.8 ± 0.4	2.1 ± 0.4	NA	Low	Medium	NA	*Based on a sample size of 25 blanket washes:* • Fair performance • Oily residue caused print problems if it was not completely removed. • Wash did not absorb into shop towel easily.
Baseline Wash at Facility 17	1.5 ± 0.4 (n=5)	1.3 ± 0.5	1.0 ± 0.0	NA	Medium	Medium	NA	• Good performance • Same effort as standard wash required.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 20.5 sec. at Facility 6 and 17.1 sec. at Facility 17 (based on time recorded by the observer)

Blanket Wash 22

Composition:
Fatty acids derivatives
Hydrocarbons,aromatic
Water

VOC Content: Not measured
Flashpoint: 157°F (full strength)
pH: 7.4 (25%)

Facility 12

At Facility 12, Wash 22 was used on a 6-unit, 28" x 40" press with conventional inks. A variety of commercial products on a variety of paper types were printed during the performance demonstration: from posters on glossy stock to information cards on cardboard stock. Wash 12 was used approximately thirty times during the week-long performance demonstration. In the typical blanket washing procedure at Facility 12, each blanket is wiped twice: once with a reusable shop towel saturated with blanket wash from a plunger can, and once with a dry reusable shop towel to remove the excess blanket wash. The blanket wash shop towel is often used on more than one blanket, depending on the cleanliness of the shop towel as well as the ink coverage. The standard facility wash is a petroleum naphtha-based product, according to the MSDS. In the performance demonstration, the only change in application procedure was that Wash 22 was directly applied to each shop towel for the application process and the plunger can was not used.

Overall, the performance of Wash 22 was rated as fair. According to press operators, Wash 22 cut the ink well and performed better than the baseline wash overall, but it's thick consistency caused delays while the press operator waited for the wash to soak into the application shop towel. During the initial observation period, the press operator showed great enthusiasm for Wash 22, rating overall performance as good as the standard facility wash and better than the baseline wash in all trials. Over the course of the week, however, the time delays associated with wash application began to weaken the press operator approval for Wash 22. The difficulty in saturating the wash shop towel may have been due to the squirt bottle application device used in the performance demonstration. The use of a plunger might have decreased the wash application time.

At Facility 12, Wash 22 removed the ink with low or medium effort on all ink coverages and, on average, outperformed the baseline wash. The number of rotations required to wash the blanket (proportional to the amount of time) did not increase dramatically from one ink coverage to another. Wash 22 did not leave streaks or residue on the blanket after wiping with a dry shop towel in the standard procedure. There was no change in print quality attributed to the wash. The wash did not perform as well with metallic inks as it did with conventional inks, however. When used on metallic inks, both the effort required to wash the blanket and the amount of wash required increased.

Facility 13

Facility 13 used Wash 22 on a 2-unit, 20" x 26" press during the performance demonstration. Performance demonstration print jobs were primarily folders and brochures printed with light conventional ink coverage on glossy enamel paper. The blanket washing procedure at this facility involves two disposable paper shop towels: one is saturated with blanket wash from a squirt bottle and used to clean the blanket; the other is used dry to remove excess wash and dry the blanket. During this process, the blanket is rotated incrementally under manual control. The standard application method was not changed for the performance demonstrations.

Overall, press operators rated Wash 22 as a fair performer on the good-fair-poor scale. The baseline and standard washes cut the ink well and were given good performance ratings. Wash 22 cut the ink as well as the baseline and standard washes, but its thick consistency caused delays at the wash application and drying stages. At the blanket wash application stage, the viscous Wash 22 required extra time to soak into the application shop towel before blanket cleaning could begin. After blanket cleaning, Wash 22 left the blanket slightly streaked and wet. Press operators recognized that extra time was necessary to allow excess wash to evaporate and to avoid potential print quality problems. As an indication of this, the number of rotations needed to clean the blanket (considered proportional to the overall time required to wash the blanket) was four times greater for Wash 22 than with the baseline wash. A contributing factor to both of these delays may have been the type of disposable shop towel used by Facility 13 for blanket washing and other press cleaning activities. These disposable paper shop towels were clearly less absorbent than reusable alternatives. The excess wash remaining on the blanket was allowed to evaporate because the disposable shop towels were not absorbent enough to remove it. Overall, press operators at Facility 13 rated the ink cutting ability of Wash 22 as the same as the baseline and standard washes, but felt that the delays in the wash process resulted in greater overall effort and a fair performance rating.

Summary of Performance Demonstrations for Blanket Wash 22

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 22	Not measurable; 2.17%[a]	157	7.4[b]	<1 @ 68°F	1.5	1.5	13	13
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[d] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 22 at Facility 12	4.4 ± 0.6 (n=5)[c]	2.7 ± 1.2	3.0 ± 0.0	4.0 ± 0.0	Low	Medium	Medium	*Based on a sample size of 5 blanket washes:* • Cut ink as well as baseline wash. • Did not readily soak into shop towel, creating delays. • Fair performer overall.
Baseline Wash at Facility 12	4.4 ± 1.6 (n=6)	4.0 ± 0.0	2.5 ± 1.0	NA	High	High	NA	• Required slightly higher effort than standard wash. • Good performer.
WASH 22 at Facility 13	3.4 ± 1.7 (n=17)	4.0 ± 0.0	2.5 ± 1.6	NA	Medium	Medium	NA	*Based on a sample size of 17 blanket washes:* • Difficult to apply due to thick consistency. • Left blanket slightly streaked and wet, extra drying time necessary to prevent print quality problems. • A fair performer: cut ink well, but required greater effort than baseline.
Baseline Wash at Facility 13	2.1 ± 0.5 (n=4)	1.0 ± 0.0	1.0 ± 0.0	NA	Medium	High	NA	• Cut ink well, a good performer. • Dried quickly on blanket.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] VOC content in lbs/gal was not measurable; % by weight VOC was reported by manufacturer.
[b] 25%
[c] n = number of washes on which this data is based, as recorded by the printer.
[d] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 27.5 sec. at Facility 12 and 105.0 sec. at Facility 13

Blanket Wash 24

Composition:
- Terpenes
- Ethylene glycol ethers
- Ethoxylated nonylphenol
- Alkyl benzene sulfonates
- Alkali/salts
- Water

VOC Content: 19%; 1.5 lbs/gal
Flashpoint: 100°F
pH: 9.9

Facility 16

Facility 16 used a 2-unit 20" x 26" press with conventional inks to print advertisements, cards, and other commercial products. The press operator at Facility 16 used Wash 24 for all jobs during the one-week demonstration, with the exception of one job for which there was a concern that the substitute wash would have an effect on the print quality. At this facility, each blanket is typically wiped down three times during cleaning: once with a wet sponge to remove paper dust (when needed); once with a reusable shop towel soaked with naphtha (which is also the baseline wash used throughout the demonstrations); and finally with a clean dry shop towel to remove excess wash. This application procedure was also used for the application of the substitute wash. Facility 16 has tried substitute, low-VOC blanket washes in the past, but found that the products were not acceptable because they did not dry on the blanket as fast as their standard wash.

Overall, the press operator at facility 16 felt that the performance of Wash 24 was "fair". The wash was found to remove the ink well, but a residue was left on the blanket which had an effect on the print quality. Following the manufacturer's instructions, Wash 24 was initially tried at 50% dilution with water. After washing three blankets with the diluted wash, it was apparent that it was not adequately cutting the ink. The baseline wash was found to cut the ink well, but required additional effort due to its resistance to the blanket surface. At full strength, Wash 24 was found to cut the ink with about the same effectiveness as the baseline wash. Wash 24 was tested under light, medium and heavy ink coverage conditions while the baseline wash was observed only under heavy ink coverage conditions. Because the baseline wash is normally used at the facility, the operator's familiarity with the baseline wash allowed him to make accurate comparisons between the substitute wash and the baseline wash under all ink coverage conditions. Under heavy ink coverage conditions, Wash 24 was observed to match the baseline level of performance as measured by blanket rotations. Under light and medium ink coverage conditions, however, Wash 24 was found to require slightly more time than the baseline wash. Overall, the level of effort was rated as "medium" for the substitute wash and "low" for the baseline wash. The press operator considered the effort to be higher than the baseline wash because the substitute wash required extra effort to remove as much of an oily residue as possible and because the thick consistency of the product made it difficult to get it to soak into the shop towel. Most importantly, however, was that this oily residue consistently increased the number of copies needed to return to print quality after restarting the press. Some of this residue would remain on the blanket even after wiping it with a clean dry shop towel.

Facility 17

At Facility 17, Wash 24 was used on a 2-unit, 19" x 26" press with conventional inks to print commercial products such as advertisements and brochures. Facility 17 operates two shifts per day, however, Wash 24 was tested by only one press operator during the first shift. The press operator used Wash 24 for two days and then stopped because he found the amount of effort required to use the substitute wash to be unacceptable. The press operator typically cleans the blankets by going over the blanket once with a shop towel soaked with blanket wash, and then allowing the blanket to dry by evaporation. Occasionally the operator will mix the wash with water to remove paper dust and paper lines from the blanket. Currently, this facility cleans their blankets using a product which consists of petroleum naphtha, dichloromethane and 1,1,1 trichloroethane, according to the MSDS.

Overall, the performance of Wash 24 was considered "poor" by the press operator. Although the product was observed to cut the ink with about the same effectiveness as the baseline wash, it had a thick consistency and left an oily residue, both of which required additional time and effort to clean the blanket. The press operator found the baseline wash to cut the ink well, but some extra effort was required to drag the wash soaked shop towel across the blanket compared to the substitute wash. Wash 24 was demonstrated on blankets with medium ink coverage only. The press operator found that under these conditions the substitute wash required more than twice the number of rotations as the baseline wash, due to the extra steps needed to remove the oily residue using a clean dry shop towel. At this facility, one rotation of the blanket typically took 24.6 seconds, so on average the substitute wash required an extra 37 seconds of cleaning time. Most important to the operator, however, was that the thick consistency of the substitute product made it very difficult to get the product to soak into the shop towel which increased the overall effort to clean the blankets and resulted in significant amounts of wash spilling on the floor and press. The quantity of wash used was about the same for both the substitute wash and the baseline wash. In addition, the press operator was bothered by the strong citrus odor of Wash 24.

Summary of Performance Demonstrations for Blanket Wash 24

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 24	1.5; 19%	100	9.9	<1 @ 25°F	1.5	3.0	15	12
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3.0	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 24 at Facility 16	2.2 ± 0.6 (n=28)[a]	3.1 ± 1.0	3.0 ± 0.0	3.0 ± 0.0	Medium	Medium	Medium	*Based on a sample size of 28 blanket washes:* • Cut ink well, but some extra effort was required to wipe off oily residue. • Oily residue significantly increased the number of copies required to return to print quality.
Baseline Wash at Facility 16	2.0 ± 0.0 (n=3)	NA	NA	3.0 ± 0.0	NA	NA	Low	• Baseline wash was also the facility's standard wash.
WASH 24 at Facility 17[c]	1.3 ± 0.6 (n=4)	NA	2.5 ± 0.6	NA	NA	High	NA	*Based on a sample size of 4 blanket washes:* • Cut ink well. • Extra effort to wipe off oily residue. • Thick consistency of wash caused operator to curtail use. • Citrus odor was very strong to operator.
Baseline Wash at Facility 17	1.5 ± 0.4 (n=5)	1.3 ± 0.5	1.0 ± 0.0	NA	Medium	Medium	NA	• Good performance; cut ink well. • Extra effort was required due to resistance to drag across blanket.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer. [c] Based on observer's data; printer data not received.

[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 21.1 sec. at Facility 16 and 24.6 sec. at Facility 17 (based on time recorded by the project observer)

Blanket Wash 26

Composition:
Fatty acids derivatives
Esters/lactones

VOC Content: 18%; 1.3 lbs/gal
Flashpoint: 230+°F
pH: 7.8 (fluctuates wildly)

Facility 5

At Facility 5, Wash 26 was used on a single-unit, 12" x 18" press to print commercial products such as business cards and advertisements with conventional inks. Facility 5 has tried a variety of substitute blanket washes donated by suppliers but has never adopted one due to performance and cost issues. Currently, this facility uses two different blanket washes. According to the product MSDSs, one wash contains aliphatic hydrocarbons, cyclohexane, n-heptane, methylcyclohexane, toluene, C_6-C_8 paraffins, and C_6-C_8 cycloparaffins) and the other wash contains aromatic hydrocarbons, aliphatic hydrocarbons, 1,2,4-trimethylbenzene, xylene, dipropylene glycol methyl ether, and propylene glycol methyl ether. Typically, the blanket is wiped down twice during cleaning: once with blanket wash to remove the ink, and once with a clean, dry shop towel to remove excess wash. Blanket wash is applied directly to the blanket using a squirt bottle and is then wiped off using a reusable shop towel. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. This application procedure was modified slightly for the baseline wash and substitute wash demonstrations in that the wash was poured onto the shop towel instead of directly on the blanket.

Wash 26 was comparable in performance effectiveness to both the baseline wash and the standard wash used by Facility 5. Wash 26 earned a performance designation of good for every blanket on which it was used during the week-long performance demonstration. The baseline and facility standard washes also received good performance ratings. The effort required to wash the blanket for both the baseline and substitute washes was described as moderate by the press operator. The time required to wash the blanket (as measured by number of rotations) was roughly equal to the baseline wash. Wash 26 cut the ink well across all ink coverages, but left a slight oily residue on the blanket after the initial blanket wiping with wash. This oily residue was removed at the dry wipe step of the blanket washing process and did not cause print quality problems. However, this oily residue did cause problems when Wash 26 was used to wash the press rollers. When used on rollers, the oily residue caused ink splotches to occur. This resulted in time delays during the full press wash procedure as two products were necessary: the standard facility wash for roller cleaning and Wash 26 for blanket cleaning. The press operator commented that the use of the same product for both roller and blanket cleaning is an important cost and effort consideration for his facility.

Facility 15

Facility 15 prints commercial products (brochures), direct-mail products, and other publications. Performance demonstrations at this facility were conducted on a two-unit, 19" x 25" press using conventional inks. The standard wash contains aromatic hydrocarbons, polyglycol ether, and aliphatic hydrocarbons (as stated on the MSDS) and, according to the press operator, cuts the ink well, but does have somewhat of an odor. In the past, Facility 15 tried an alternative blanket wash, but it did not work well and it had a very offensive odor. Recently, this facility installed a new press with an automatic blanket washer. In their standard manual blanket washing procedure, the press operator at this facility pours the blanket wash on to a reusable shop towel, wipes the ink off the blanket in one rotation, then uses a dry shop towel for one rotation to remove the excess wash. This same procedure was used for both the baseline and the substitute wash.

Wash 26 performed as well as the baseline wash and the standard wash used by Facility 15. Wash 26 received a performance rating of good on the good-fair-poor scale from the press operator after every one of its 22 trials in the week-long performance demonstration. The time required to wash the blankets (as measured by the number of rotations) was equal to the baseline wash. The physical effort required to clean the blanket was described as low for all ink coverages. Over the course of the performance demonstration, Wash 26 did not leave a residue on the blanket and did not affect print quality. The press operator who conducted the performance demonstration stated that Wash 26 would be purchased by his facility if appropriately priced, as well as beneficial from an environmental, worker health, and safety standpoint.

Summary of Performance Demonstrations for Blanket Wash 26

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 26	1.3; 18%	230+	7.8[a]	<1 @ 77°F	0	0	6	14
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[c] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 26 at Facility 5	0.5 ± 0.1 (n=14)[b]	2.0 ± 0.0	2.3 ± 0.7	NA	Low	Medium	NA	*Based on a sample size of 14 blanket washes:* • Good performance rating after every wash. • Performed as well as both standard facility wash and baseline wash. • Slight oily residue caused print quality problems when wash was used for roller clean-up.
Baseline Wash at Facility 5	1.0 (n=1)	2.0 ± 0.0	NA	NA	Medium	NA	NA	• Cut ink satisfactorily.
WASH 26 at Facility 15	0.7 ± 0.1 (n=22)	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	Low	Low	Low	*Based on a sample size of 22 blanket washes:* • Good performance rating after every wash. • Performed as well as standard facility wash and baseline wash.
Baseline Wash at Facility 15	1.5 ± 0.7 (n=2)	2.0 ± 0.0	NA	NA	Low	NA	NA	• Cut ink well. • Low effort required. • Good performance rating.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] pH fluctuates
[b] n = number of washes on which this data is based, as recorded by the printer.
[c] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 60.0 sec. at Facility 5 and 30.0 sec. at Facility 15 (based on time recorded by the project observer)

Blanket Wash 29

Composition: Fatty acid derivatives VOC Content: 30%; 2.1 lbs/gal Flashpoint: 230+°F pH: 7.2

Facility 7

At Facility 7, Wash 29 was used on a single-unit 20" x 26" press with conventional inks to print commercial products such as brochures and advertisements. The press operator cleaned only one blanket using Wash 29 after the observer left, and then stopped the demonstration because the substitute wash was found to leave an unacceptable, thick, oily film on the blanket. The following information is, therefore, based on the observer data. At this facility, each blanket is typically wiped down two times during cleaning: once to remove the ink with a reusable shop towel soaked with blanket wash, and once with a clean, dry shop towel to remove excess wash. Blanket wash is applied to the shop towel using a squirt bottle and the shop towel is resoaked with wash prior to reuse on other blankets. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. The standard blanket wash at Facility 7 contains petroleum distillates, 2-butoxyethanol and a proprietary surfactant, according to the MSDS.

Based on the four blanket cleanings with Wash 29, the press operator at Facility 7 found its performance to be "poor". The baseline wash was observed to perform well; cutting the ink well and drying quickly. Although the press operator felt that Wash 29 cut the ink with about the same effectiveness as the baseline wash, the product was very oily, would not dry off of the operator's hands and left an oily residue on the blanket that was very difficult to remove. Additional time and effort were needed to remove as much of the residue as possible using a clean dry shop towel, but some of the oily film was still present after this procedure. Although no difference was noticed between the time to clean the blankets using the baseline wash and Wash 29, the level of physical effort needed to wash the blanket was rated as "high" for the substitute wash compared to "medium" for the baseline wash. The oily film from Wash 29 was observed to slightly increase the number of copies required to return to acceptable print quality after restarting the press. The thick oily consistency of the product also increased overall effort because it made it difficult to get the wash to soak into the shop towel. The press operator did notice, however, that the smell of the product was not as strong as the baseline wash or the facility's standard wash.

Facility 8

Facility 8 used a 6-unit 20" x 26" press with conventional inks to print brochures, advertisements and other commercial products. The press operator at Facility 8 used Wash 29 for all jobs during the one-week demonstration. At this facility, each blanket is typically wiped down two times during cleaning: once with a reusable shop towel saturated with blanket wash, and once with a clean dry shop towel to remove excess wash. The saturated shop towel is typically used to clean all six blankets on the press before being resaturated or sent out for laundering. This application procedure was also used for the application of the baseline wash and the substitute wash. Facility 8 was using a wash which contains aliphatic petroleum distillates, aromatic petroleum distillates, xylene, 2-butoxy ethanol, methylene chloride, diacetone alcohol, diisononyl phthalate, 2,6-di-tert-butyl-p-cresol, ethylbenzene and 1,2,4 trimethylbenzene (according to the MSDS) to clean the blankets prior to and following the blanket wash demonstration. Alternative low-VOC blanket wash were experimented with in the past, but they did not cut the ink well, did not dry fast and left and oily residue on the blanket.

The press operator at Facility 8 evaluated the performance of Wash 29 as "poor". The operator found that Wash 29 did not cut the ink as well as the baseline product and did not remove paper dust and powder. The baseline product was observed to cut the ink well and dry quickly, but required some extra effort to drag it across the blanket surface. Using Wash 29, more time and much more effort were needed to remove the ink than was needed with the baseline product. Under medium ink coverage conditions, the average number of rotations required to clean the blanket using Wash 29 was 4.0 compared to 2.7 for the baseline wash. Because the average time to rotate a blanket was 15.5 seconds at facility 8, the average blanket cleaning time increased by 20 seconds under medium ink coverage conditions over the baseline wash. The press operator rated the effort needed to clean the blankets using both the baseline wash and Wash 29 as "high" under medium ink coverage conditions due to the extra time needed to remove the ink. The effort to use the baseline wash was rated as "high" because the operator found it to have high resistance when dragging it across the blanket and the effort to use the substitute wash was rated as "high" due to the extra rotations needed to remove the ink. The substitute wash was also observed to leave a slight oily film on the blanket, but no effect was observed on the print quality. The press operator noticed that the substitute wash's odor was agreeable and not too strong.

Summary of Performance Demonstrations for Blanket Wash 29

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 29	2.1; 30%	230+	7.2	<1 @ 68°F	1.5	1.5	9	18
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3.0	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 29 at Facility 7[c]	1.0 ± 0.0 (n=3)	NA	2.0 ± 0.0	NA	NA	High	NA	*Based on a sample size of 3 blanket washes:* • Good performance; cut ink well. • Extra effort was required to dry the blanket.
Baseline Wash at Facility 7	1.2 ± 0.0 (n=2)	NA	2.0 ± 0.0	NA	NA	Medium	NA	• Good performance; cut ink well.
WASH 29 at Facility 8	0.8 ± 0.6 (n=36)	4.1 ± 0.8	4.0 ± 0.0	NA	Medium	High	NA	*Based on a sample size of 36 blanket washes:* • Did not cut ink as well as baseline wash. • Did not cut paper dust or powder. • More effort was required to remove slight oily film on blanket.
Baseline Wash at Facility 8	0.7 ± 0.0 (n=4)	NA	2.7 ± 0.5	NA	NA	High	NA	• Good performance; cut ink well. • Extra effort was required due to resistance to being dragged across the blanket.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 27.5 sec. at Facility 7 and 15.5 sec. at Facility 8 (based on time recorded by the project observer)
[c] Based on observer's data; printer data not received.

Blanket Wash 30

Composition: Hydrocarbons, aromatic Propylene glycol ethers Water VOC Content: 7%; 0.48 lbs/gal Flashpoint: 100°F (full strength) pH: 7.6 (25%)

Facility 18

At Facility 18, Wash 30 was used on a single-unit 20" x 30" press and a 2-unit, 19" x 26" press with soy oil-based inks and commercial products such as business forms and brochures were printed. The press operator used Wash 19 for the four days that the presses were operating during the one-week demonstration period which resulted in only three blanket cleanings. At this facility, each blanket is typically wiped down three times during cleaning: twice with a reusable shop towel soaked with blanket wash, and once with a dry shop towel to remove excess blanket wash. Blanket wash is applied to the shop towel using a squirt bottle and the shop towel is resoaked with wash prior to reuse on other blankets. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. Currently, this facility cleans their blankets using a product which contains aliphatic hydrocarbons, according to the MSDS. Other than changing the number of rotations to clean a blanket, this application procedure was not modified during the demonstration of the substitute product. Facility 18 had tried an alternative low-VOC blanket wash, but found that it did not dry as fast as their standard product and was more expensive.

Based on the three blanket cleanings with Wash 30, the press operator at Facility 18 evaluated its performance as "fair". The baseline wash was found to cut the ink well, but required additional effort due to the wash's high resistance to the blanket surface. Wash 30 was only tested under heavy ink coverage conditions and the baseline wash was observed under light and medium coverage conditions. The substitute wash was observed to require about the same amount of time as measured by blanket rotations under heavy ink coverage conditions as the baseline wash required under medium coverage conditions. The press operator found that Wash 30 cut the ink well and overall it performed with about the same effectiveness as the baseline wash. Following the manufacturer's instructions, the substitute wash was tried with 25% dilution with water, but was found to perform better at full strength. The press operator rated the effort needed to clean a blanket with heavy ink coverage as "medium". Although the baseline wash was not tested under those conditions, the operator felt that the amount of physical effort needed to clean the blanket with Wash 30 would be about the same as that of the baseline wash. The press operator also observed that when accidentally spilled on a clear plastic guard on the press, Wash 30 permanently clouded the plastic, necessitating its replacement.

Facility 19

Facility 19 used a 2-unit 19" x 26" press also with soy oil-based inks to print brochures, cards, and other commercial products. The press operator at Facility 19 used Wash 30 for the entire one-week demonstration. The operator typically cleans the blanket by pouring the blanket wash onto a clean, reusable shop towel and wiping the blanket while rotating it manually twice. The blanket is then allowed to dry by evaporation before restarting the press. This application procedure was also used for the application of the baseline wash. When using Wash 30, the press operator modified the application procedure slightly and wiped the blanket with a dry shop towel before resuming the print job. The standard wash used at this facility contains aromatic hydrocarbons, polyglycol ethers, aliphatic hydrocarbons, and a proprietary combustible chemical. Prior to this project, they did some experimenting with another substitute wash, but it did not work as well as their standard product and it was irritating to the skin as well. In the past, they used an automatic blanket washer, hoping to reduce their blanket wash chemical use and labor, but they discontinued using it after they found it required more effort and wasted solvent.

The press operator at Facility 19 evaluated the performance of Wash 30 as "fair". The substitute product was found to cut the ink well, but required additional effort because the substitute wash did not evaporate off of the blanket quickly and needed to be wiped off with a clean dry shop towel and the product's thick consistency made it difficult and "messy" to use. The baseline wash was found to cut the ink well, but required additional effort due to the wash's high resistance to the blanket surface. On average, about one extra rotation of the blanket was required with the substitute wash compared to the baseline wash due to the additional step needed to dry the blanket. Because the average time to rotate a blanket was 18.5 seconds at facility 19, the increase in blanket cleaning time was not substantial. The press operator rated the effort needed as "high" for both the baseline and the substitute washes. The effort needed to use the substitute wash was rated as "high" due to the additional drying step, difficulty in getting the wash to soak into a shop towel, and because the operator found it had a slight resistance to the blanket surface. The effort to use the baseline wash was rated as "high" because the operator found the baseline wash had unusually high resistance to the blanket surface. An oily film was noticed on the blanket after using Wash 30, but the operator felt that the film had only a slight effect on the number of copies needed to get back to print quality after restarting the press.

Summary of Performance Demonstrations for Blanket Wash 30

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 30	0.48; 7%	100	7.6	2.2 @ 68°F	0.7	1.5	5	11
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 30 at Facility 18	4.0 ± 0.0 (n=3)[a]	NA	NA	3.3 ± 0.6	NA	NA	Medium	*Based on a sample size of 3 blanket washes:* • Good performance; cut ink well. • Worked best with no dilution with water.
Baseline Wash at Facility 18	1.5 ± 0.8 (n=6)	2.7 ± 0.5	3.5 ± 0.7	NA	Low	Low	NA	• Good performance; cut ink well.
WASH 30 at Facility 19	0.7 ± 0.0 (n=8)	3.0 ± 0.0	3.0 ± 0.0	NA	High	High	NA	*Based on a sample size of 8 blanket washes:* • Cut ink well. • Required extra effort to dry oily film from blanket. • Thick consistency was difficult to use. • Extra effort was required due to resistance to surface of the blanket.
Baseline Wash at Facility 19	0.9 ± 0.2 (n=5)	2.2 ± 0.4	NA	NA	High	NA	NA	• Good performance; cut ink well. • Extra effort was required due to resistance to surface of the blanket.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 16.2 sec. at Facility 18 and 18.5 sec. at Facility 19 (based on time recorded by the project observer)

Blanket Wash 31

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.6 lbs/gal
Flashpoint: 105°F
pH: 7.6

Facility 7

At Facility 7, Wash 31 was used on a single-unit 20" x 26" press with conventional inks to print commercial products such as brochures and advertisements. The press operator at Facility 7 used Wash 31 for all jobs during the one-week demonstration which resulted in only 4 cleanings. At this facility, each blanket is typically wiped down two times during cleaning: once to remove the ink with a reusable shop towel soaked with blanket wash, and once with a clean, dry shop towel to remove excess wash. Blanket wash is applied to the shop towel using a squirt bottle, and the shop towel is resoaked with wash prior to reuse on other blankets. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. The standard blanket wash at Facility 7 contains petroleum distillates, 2-butoxyethanol and a proprietary surfactant, according to the MSDS.

The press operator at Facility 7 evaluated Wash 31 as "fair". Wash 31 was observed to cut the ink well, but did not dry as fast as the baseline wash. The baseline wash was observed to perform well; cutting the ink well and drying quickly. Although not reflected in the data, the operator felt that some additional time and effort were needed to remove the excess wash using a clean, dry shop towel. Under medium ink coverage conditions, no difference was noticed between the time to clean the blankets as measured by the number of rotations using the baseline wash or Wash 31. However, the level of physical effort needed to wash the blanket was rated as "high" for the substitute wash compared to "medium" for the baseline wash. The press operator noticed that the smell of the substitute wash was noticeable, but not disagreeable.

Facility 8

Facility 8 used a 6-unit 20" x 26" press with conventional inks to print brochures, advertisements and other commercial products. The press operator at Facility 8 used Wash 31 for all jobs during the one-week demonstration. At this facility, each blanket is typically wiped down two times during cleaning: once with a reusable shop towel saturated with blanket wash, and once with a clean dry shop towel to remove excess wash. The saturated shop towel is typically used to clean all six blankets on the press before being resaturated or disposed. This application procedure was also used for the application of the baseline wash and the substitute wash. Facility 8 was using a product containing aliphatic petroleum distillates, aromatic petroleum distillates, xylene, 2-butoxy ethanol, methylene chloride, diacetone alcohol, diisononyl phthalate, 2,6-di-tert-butyl-p-cresol, ethylbenzene and 1,2,4 trimethylbenzene, according to the MSDS, to clean the blankets prior to and following the blanket wash demonstration. Alternative low-VOC blanket washes were experimented with in the past, but they did not cut the ink well, did not dry fast, and left an oily residue on the blanket.

Overall, the performance of Wash 31 was considered "good/fair". Wash 31 was tested under light, medium and heavy ink conditions, while the baseline wash was observed only under medium coverage conditions. The press operator observed that the wash cut the ink well, dried quickly and performed about as well as the baseline wash. Under medium coverage conditions, it was observed that the substitute wash required less time to clean the blankets than the baseline wash. Somewhat more of Wash 31 was needed, however, to remove the ink in comparison to the baseline wash (0.7 ounces for the baseline wash compared to 1.1 ounces for the substitute wash). The press operator rated the effort needed to clean the blankets using Wash 31 as "low" under all coverage conditions, although he did note that there was slightly more resistance to the blanket surface. The effort needed to use the baseline wash was rated as "high" because the operator found it to have unusually high resistance to the blanket.

Summary of Performance Demonstrations for Blanket Wash 31

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 31	6.6; 99%	105	7.6	<0.1 @ 68°F	1.5	3.0	3	3
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3.0	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 31 at Facility 7	1.5 ± 0.6 (n=4)[a]	2.0 ± 0.0	2.0 ± 0.0	NA	High	High	NA	*Based on a sample size of 4 blanket washes:* • Cut the ink well; slightly more effort needed to remove oily residue on blanket. • Oily residue slightly increased the copies required to return to print quality. • Smell not as strong as facility's standard wash or baseline wash.
Baseline Wash at Facility 7	1.2 ± 0.0 (n=2)	NA	2.0 ± 0.0	NA	NA	Medium	NA	• Good performance; cut ink well.
WASH 31 at Facility 8	1.1 ± 1.5 (n=61)	2.0 ± 0.0	2.0 ± 0.0	2.1 ± 0.2	Low	Low	Low	*Based on a sample size of 61 blanket washes:* • Good performance; cut ink well • Performed as well as standard wash. • Slightly more effort was required due to resistance to surface of the blanket.
Baseline Wash at Facility 8	0.7 ± 0.0 (n=4)	NA	2.7 ± 0.5	NA	NA	High	NA	• Good performance; cut ink well. • Extra effort was required due to resistance to the surface of the blanket.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 82.5 sec. at Facility 7 and 17.1 sec. at Fac. 8 (based on time recorded by the observer)

Blanket Wash 32

Composition:
Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.5 lbs/gal
Flashpoint: 220°F
pH: 8.5

Facility 1

At Facility 1, performance demonstrations were conducted on an eight-unit, 28" x 40" press using vegetable-based inks to print high quality, multi-color, commercial products. Currently, Facility 1 uses a blanket wash which consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons, according to the MSDS. In the months preceding the demonstrations, the facility had tried two different low-VOC blanket washes; neither worked as well as their standard wash. At this facility, each blanket is typically wiped down twice during cleaning: once with a reusable shop towel saturated in blanket wash to remove the ink, and once with a dry shop towel to remove excess blanket wash. Each saturated shop towel is used to clean two blankets. The same application procedure was used for the baseline and substitute products. The quantity of wash needed to saturate the shop towel and clean the blanket remained constant throughout the demonstration, regardless of the ink coverage or ink build-up on the blanket. There were both positive and negative aspects to this application method. While more wash than was needed may have been used in some cases, the consistency of the application volume made it possible to compare the performance of the standard, baseline, and substitute products under the same conditions.

Overall, the performance of Wash 32 was considered "fair/poor." Although it cut the ink well, more effort was required than with the baseline wash. When using the baseline wash, the operator found it cut it the ink well, but required some more effort than their standard wash. The additional effort to clean the blanket with Wash 32 was needed to remove the oily residue that remained on the blanket. With Wash 32, an average of 4 rotations (approximately 80 seconds) were needed to clean the blanket, whereas with the baseline product, only 2 rotations (40 seconds) were required. After using Wash 32, the residue persisted, even after wiping down the blanket with two dry wipes. The press operator commented that normally a slight residue may not be a problem, but in this case, it caused problems with future print quality. On subsequent images, there was visible "chatter" (faint, inconsistent lines where the color is supposed to be uniformly solid) on the print. Eventually, the residue is picked up in the prints and the chatter is only a temporary problem, however, more impressions are needed to get back up to acceptable quality than with the standard or baseline wash. After eight blanket cleanings (four with the observer present and four more conducted by the printer), Facility 1 decided to discontinue the performance demonstration with Wash 32.

Facility 5

At Facility 5, performance demonstrations were conducted using a single-unit, 12" x 18" press with conventional inks to print commercial products such as business cards and advertisements. According to the MSDSs, this facility currently uses either a blanket wash which contains aliphatic hydrocarbons, cyclohexane, n-heptane, methylcyclohexane, toluene, C_6-C_8 paraffins, and C_6-C_8 cycloparaffins or one that consists of aromatic hydrocarbons, aliphatic hydrocarbons, 1,2,4-trimethylbenzene, xylene, dipropylene glycol methyl ether, and propylene glycol methyl ether. Facility 5 has tried several substitute blanket washes that were donated by their supplier. None of these products were adopted either because they did not work as well as their standard wash (left an oily residue on the blanket) or they were too expensive (up to twice as much as their standard wash). The facility has reduced the quantity of solvent used by reusing the drying shop towel from the previous wash for the application of blanket wash in the subsequent blanket wash procedure. This reduced the amount of solvent used, the number of shop towels sent to the laundry and the associated laundering costs, and the environmental impacts such as laundry wastewater and energy usage. Typically, the blanket is wiped down twice during cleaning: once with blanket wash to remove the ink, and once with a clean, dry shop towel to remove excess wash. Blanket wash is applied directly to the blanket using a squirt bottle and is then wiped off using a reusable shop towel. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. This application procedure was modified slightly for the baseline wash and substitute wash demonstrations in that the wash was poured onto the shop towel instead of directly on the blanket.

Wash 32 was used for one week and 12 washes were recorded by the press operator. Overall, the performance of Wash 32 was rated "good." When compared to the baseline wash (which cut the ink well and cleaned the blanket as well as their standard wash), the effort needed to clean the blanket with Wash 32 was slightly higher because Wash 32 left an oily residue on the blanket. With the baseline or the standard wash, one rotation with a dry shop towel was enough to remove the excess wash. With Wash 32, two or three rotations with the dry wipe were required. On average, the drying time increased from approximately 21 seconds using the baseline or standard wash to approximately 32 seconds using Wash 32. This extra drying step increased the effort required, however, the residue did not affect future print quality. The printer commented that the slight residue came off quickly during the normal waste sheet portion of the next run.

During the demonstration, Wash 32 was used on light, medium, and heavy ink coverage; all with good results. It should be noted that heavy ink coverage for a business card, is not the equivalent of heavy ink coverage for larger print operations. The printer at Facility 5 felt the oily residue could cause some problems on a bigger press with greater ink coverage.

Summary of Performance Demonstrations for Blanket Wash 32

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 32	6.5; 99%	220 8.5	8.5	<1 @ 68°F	0.1	1.5	5	30
Baseline Wash	6.2; 100%	50 6.6	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 32 at Facility 1	2.5 ± 0.0 (n=4)[a]	NA	4.2 ± 0.5	NA	NA	High	NA	*Based on a sample size of 4 blanket washes:* • Good performance. • Required slightly higher effort to remove excess wash than with the standard wash.
Baseline Wash at Facility 1	2.5 ± 0.0 (n=2)	2.0 ± 0.0	2.0 ± 0.0	NA	High	High	NA	• Fair/poor performance. • Oily residue caused "chatter" in subsequent prints.
WASH 32 at Facility 5	0.7 ± 0.2 (n=12)	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0	Low	Medium	Medium	*Based on a sample size of 12 blanket washes:* • Good performance. • Left slight, oily residue that was removed with dry shop towels and did not affect print quality.
Baseline Wash at Facility 5	1.0 (n=1)	2	NA	NA	Low	NA	NA	• Good performance. • Cut ink well with same effort as standard wash.

NA = Not Applicable; product was not demonstrated under these conditions.
NC = Not Calculated; VOC content as a % by weight could not be calculated because specific gravity data was not available.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 20.0 sec at Facility 1 and 10.6 sec at Facility 5 (based on time recorded by the observer)

Blanket Wash 34

Composition:
Water
Terpenes
Hydrocarbons, petroleum distillates
Alkoxylated alcohols
Fatty acid derivatives

VOC Content: 39%; 2.8 lbs/gal
Flashpoint: 138°F
pH: 6.6

Facility 1

At Facility 1, performance demonstrations were conducted on an eight-unit, 28" x 40" press using vegetable-based inks to print high quality, multi-color, commercial products. Currently, Facility 1 uses a blanket wash which consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons, according to the MSDS. In the months preceding the demonstrations, the facility had tried two different low-VOC blanket washes; neither worked as well as their standard wash. At this facility, each blanket is typically wiped down twice during cleaning: once with a reusable rag saturated in blanket wash to remove the ink, and once with a dry rag to remove excess blanket wash. Each saturated rag is used to clean two blankets. The same application procedure was used for the baseline and substitute products. The quantity of wash needed to saturate the rag and clean the blanket remained constant throughout the demonstration, regardless of the ink coverage or ink build-up on the blanket. There were both positive and negative aspects to this application method. While more wash than was needed may have been used in some cases, the consistency of the application volume made it possible to compare the performance of the standard, baseline, and substitute products under the same conditions.

The operator used Wash 34 for one week and cleaned 37 blankets. The wash performance was considered "good;" this facility used five different substitute washes over a two month period for the performance demonstrations project and the press operator considered Wash 34 to be the best performer. During the course of the week, the operator recorded data on the performance of Wash 34 on blankets with all levels of ink coverage. On blankets with light or medium ink coverage, Wash 34 cut the ink well with the same level of effort as was used when cleaning with the baseline or standard wash. For light and medium ink coverage, the operator considered the performance to be "good" for all washes. On blankets with heavy ink coverage, slightly more effort was required than with the standard wash. For the 19 blankets cleaned where ink coverage was heavy, performance was rated as "good" on 12 blankets (63%) and "fair" for 7 blankets (37%). The press operator noticed that the product had a "very dry feel" to it. He found performance and ease of use improved when he wiped the blanket with a sponge soaked with water before applying Wash 34. Wiping the blanket with a wet sponge prior to application of the wash is often done to remove paper build-up, so the printer did not consider this step to be an extra effort.

Performance of Wash 34 was comparable to that of the baseline wash (which cut the ink well, and required the same amount of time as their standard wash, but did require some additional effort to remove the oily residue). Average time required to clean the blanket with the baseline wash was approximately 40 seconds for light or medium ink coverage, and with Wash 34, average cleaning time varied between 40 and 60 seconds.

Facility 19

For the performance demonstrations, Facility 19 used a 2-unit, 19" x 26" press with soy oil-based inks to print brochures, cards, and other commercial products. The standard wash used at this facility contains aromatic hydrocarbons, polyglycol ethers, aliphatic hydrocarbons, and a proprietary combustible chemical, according to the MSDS. Prior to this project, they did some experimenting with another substitute wash, but it did not work as well as their standard product and it was irritating to the skin as well. In the past, they used an automatic blanket washer, hoping to reduce their blanket wash chemical use and labor, but they discontinued using it after they found it required more effort and wasted solvent. Typically, the operator at Facility 19 cleans the blanket by pouring the blanket wash onto a clean, reusable shop towel and wiping the blanket while rotating it manually twice. The blanket is then allowed to dry by evaporation before restarting the press. This application procedure was also used for the application of the baseline wash. When using the substitute Wash 34, the press operator modified the application procedure slightly and wiped the blanket with a dry shop towel before resuming the print job.

This printer considered the performance of Wash 34 to be "fair" or "poor" for light, medium, and heavy ink coverage. Data sheets were completed for 13 blanket washes. The printer found that Wash 34 left a light coating on the blanket, and often "high" effort was needed to remove this residue. The consistency of the wash was another problem: the printer found that the thick consistency of the wash prevented it from soaking into the shop towel easily. Before he could apply the wash, the press operator had to work it into the shop towel, additionally increasing the effort needed to clean the blanket with Wash 34. It took longer to clean the blanket with Wash 34 than with the baseline wash. The baseline wash cut the ink well, but required slightly more effort than their standard wash. Additional effort was due to the increased drag of the shop towel over the blanket; the baseline wash was not as smooth as their standard wash. The printer did note that fewer impressions were needed to get back up to acceptable print quality after cleaning the blanket with the baseline product. When ink coverage was light, the average time to clean the blanket with Wash 34 was approximately 65 seconds; with the baseline wash the average cleaning time was approximately 40 seconds.

Summary of Performance Demonstrations for Blanket Wash 34

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	pH	Flashpoint (°F)	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 34	2.8; 39%	6.6	138	2 @ 68°F	1.5	3	10	20
Baseline Wash	6.2; 100%	6.6	50	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[c] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 34 at Facility 1	2.5 $\pm$ 0.0 (n=37)[a]	2.6 $\pm$ 0.6	2.2 $\pm$ 0.4	3.1 $\pm$ 1.0	Medium	Medium	High	*Based on a sample size of 37 blanket washes:* • Good performance; best of the 5 substitute washes demonstrated at this facility. • Cut the ink well with the same effort as with the standard wash for light/medium ink coverage. • Slightly more effort needed for heavy ink coverage, but acceptable.
Baseline Wash at Facility 1	2.5 $\pm$ 0.0 (n=2)	2.0 $\pm$ 0.0	2.0 $\pm$ 0.0	NA	High	High	NA	• Good performance. • Required slightly more effort than standard wash.
WASH 34 at Facility 19	1.2 $\pm$ 0.4 (n=13)[b]	3.6 $\pm$ 0.6	4.0 $\pm$ 0.0	3.7 $\pm$ 0.5	Medium	Medium	High	*Based on a sample size of 13 blanket washes:* • Fair/Poor performance. • Cut the ink well, but did not soak into shop towel and extra effort was needed to remove the oily residue.
Baseline Wash at Facility 19	0.9 $\pm$ 0.2 (n=5)	2.2 $\pm$ 0.4	NA	NA	High	NA	NA	• Good performance. • Fewer impressions were needed to get back to acceptable print quality than with standard wash.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = # of washes recorded by the printer;

[b] n = # of washes recorded by the observer.

[c] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 20.0 sec at Facility 1 (measured by the observer); 18 sec at Facility 19 (estimated).

Blanket Wash 37

Composition:
Water
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
VOC Content: 14%; 1.0 lbs/gal
Flashpoint: 82°F
pH: 3.9

Facility 3

Facility 3 used Wash 37 on a 2-unit, 18" x 25" press, with conventional inks to print a variety of commercial products. Facility 3 had used a new blanket wash for health, safety or environmental reasons on one occasion prior to the performance demonstration. The wash had not been adopted because it left an oily residue on the blanket and took too long to dry. Normal blanket washing procedure is the following: a squirt bottle is used to apply blanket wash to a reusable shop towel, the shop towel is then used to wipe the blanket as it is manually rotated, and the blanket is allowed to air dry. Standard facility blanket wash was a mixture of aliphatic and aromatic hydrocarbons, according to the MSDS. The application procedure was changed for the performance demonstration. Wash 37 did not dry as quickly as the standard facility wash, so a dry shop towel was used to remove the residue from the blanket after the washing step. For each blanket cleaning, the procedure was to apply only a sufficient amount of wash to the shop towel. Press operators increased the amount of Wash 37 applied to the shop towel as ink coverage on the blanket increased.

Press operators had no problems with Wash 37 during the performance demonstration. Wash 37 drying time was slightly greater than for the baseline and standard facility washes, but, according to press operators, Wash 37 performed as well overall. Wash 37 received good and fair performance ratings on light and medium ink coverage print jobs, respectively, as there were no heavy ink coverage jobs during the week of the performance demonstration. According to press operators, medium ink coverage jobs required more effort to clean than light ink coverage jobs with Wash 37. The baseline wash was considered a good performer, although it was only tested on medium coverage print jobs. Due to the addition of the drying step, the use of Wash 37 doubled the time required to wash the blanket (which is proportional to the number of blanket rotations needed), from one, as required with the baseline, to two rotations on average.

Facility 4

Wash 37 was used on a 4-unit, 34" x 40" press at Facility 4 which does most of its business in commercial printing products such as software manuals and calendars. Facility 4 uses a solution of aliphatic hydrocarbons, aromatic hydrocarbons, and surfactants, as the standard blanket wash, according to the MSDS. Blanket wash procedure at Facility 4 consists of a two wipe process. Blanket wash is applied to a clean, dry, and reusable shop towel which is used to wash the blanket. Another clean dry shop towel is then used to remove excess wash and dry the blanket. If ink buildup on the shop towels is not significant, the shop towels are used to wash more than one blanket. If paper coating is deposited on the blanket from the job, the blanket wash shop towel is dipped into a bucket of water before wiping down the blanket. This standard blanket washing procedure was not modified for the performance demonstration.

Initially, Wash 37 performed well at Facility 4. It cut the ink well, soaked into the application shop towel readily, and required little effort. Then, after a few days of usage, Wash 37 caused uncoated paper to stick to the blankets. The tackiness of the blankets was such that uncoated paper stock was pulled apart during the printing process. Facility 4 discontinued its performance demonstration of Wash 37 and the problems disappeared.

Summary of Performance Demonstrations for Blanket Wash 37

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 37	1.0; 14%	82	3.9	2.3 @ 68°F	3	3	5	8
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 37 at Facility 3	1.3 ± 0.6 (n=17)[a]	2.0 ± 0.0	2.5 ± 0.7	NA	Low	Medium	NA	*Based on a sample size of 17 blanket washes:* • Longer drying time than baseline and standard washes. • Performance rated as good and fair on light and medium coverages, respectively. • Press operators had no problems with wash.
Baseline Wash at Facility 3	1.0 (n=1)	NA	1.0 ± 0.0	NA	NA	Medium	NA	• Good performance: cut the ink well.
WASH 37 at Facility 4	2.2 ± 0.8 (n=6)	NA	2.8 ± 0.4	NA	NA	Medium	NA	*Based on a sample size of 6 blanket washes:* • Worked well initially, but caused paper breakup due to blanket tackiness. • Use of wash discontinued.
Baseline Wash at Facility 4	3.0 ± 0.0 (n=2)	NA	3.0 ± 0.0	NA	NA	Low	NA	• Good performance: cut the ink well. • Slight odor.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes this data is based on, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 24.0 sec. at Facility 3 and 42.0 sec. at Facility 4 (based on time recorded by the project observer)

Blanket Wash 38

Composition: Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives VOC Content: 65%; 4.9 lbs/gal Flashpoint: 230+°F pH: 5.6

Facility 2

Facility 2 used a 3-unit, 13" x 18" press for the performance demonstrations. This facility prints commercial products (brochures, flyers, cards) using both conventional and vegetable oil-based inks. The standard blanket wash consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons (per the MSDS) which, according to the press operator, cuts the ink well, but does have somewhat of an odor. In the past, Facility 2 has tried two substitute blanket washes: performance was rated as poor ("it did not work at all") for one product, and the other product they tested was too expensive. In their standard blanket washing procedure, the press operator at this facility pours the blanket wash onto a reusable rag from a squirt bottle, wipes the ink off the blanket in one rotation, then uses a dry rag for one rotation to remove the excess wash. This procedure was used for both the baseline and the substitute wash.

The use of Wash 38 was discontinued by Facility 2 after 1.5 days of use due to print problems resulting from an oily residue left on the blanket after the blanket wash process. According to press operators, Wash 38 also required more effort to cut the ink and to wipe the blanket than both the standard wash and the baseline wash of the performance demonstration. Performance was especially poor with heavy ink coverage, but Wash 38 was rated as requiring high effort and demonstrating poor performance after every blanket cleaning at Facility 2. The oily film left on the blanket after using Wash 38 caused a noticeable increase in the number of impressions required to reach acceptable print quality after a wash procedure. Press operators experimented with a variety of ways for removing this residue (e.g., dry wipe, water) but were unable to prevent it from affecting print quality.

Facility 4

Wash 38 was used on a 4-unit, 28" x 40" press at Facility 4 with conventional inks to produce a variety of commercial printing products such as software manuals. Facility 4 uses a solution of aliphatic hydrocarbons, aromatic hydrocarbons, and surfactants (according to the information on the MSDS) as the standard blanket wash. Facility 4 has pursued some work practice changes to reduce its use of blanket wash solution. Instead of saturating rags with wash in a plunger can, press operators at Facility 4 are encouraged to apply an appropriate amount of blanket wash on each rag as needed, which reduces the overall quantity of blanket wash used at the facility. Blanket wash procedure at Facility 4 consists of a two wipe process. Blanket wash is applied to a clean, dry, and reusable rag which is then used to wash the blanket. Another clean dry rag is then used to remove excess wash and dry the blanket. If the rags are clean enough, they are used to wash more than one blanket on the 4-unit press. The press blankets rotate automatically during this process. If a significant amount of paper coating is deposited on the blanket from the job, the blanket wash rag is dipped into a bucket of water before wiping down the blanket. This standard blanket washing procedure was not modified for the performance demonstration.

Wash 38 cut the ink well, but left an oily residue on the blanket that increased the number of impressions required to return print quality by 5 to 10 times above that required with the baseline or standard facility washes. Due to this print quality interference, the press operator returned to the standard facility wash after 6 trials. The press operator attempted to remove the oily residue with a dry wipe, but was unable to remove it completely. The oily residue interfered with ink adhesion, especially with red and yellow inks. According to the press operator, Wash 38 cut the ink well but caused sufficient print quality problems to prevent a facility from adopting it for environmental or worker health and safety reasons. The baseline wash was considered a good performer that cut the ink well. Press operators described the odor of the baseline wash as strong.

Summary of Performance Demonstrations for Blanket Wash 38

Laboratory Testing Results

Product	VOC Content (lbs/gal; % by wt)	Flashpoint (°F)	pH	Vapor Pressure (reported, mm Hg)	Blanket Swell (%)		Washability (# strokes)	
					1 hour	*5 hour*	*Wet Ink*	*Dry Ink*
WASH 38	4.9; 65%	230+	5.6	2.0 @ 68°F	0	1.5	9	16
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results

Product/ Facility	Average Volume Used (ounces)	Time required[b] (# rotations)			Physical Effort Required (Low, Medium, or High)			Performance Evaluation
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 38 at Facility 2	2.2± 0.6 (n=9)[a]	3.0 ± 0.0	NA	5.0 ± 0.0	High	NA	High	*Based on a sample size of 9 blanket washes:* • Oily residue caused print quality problems. • Use of wash discontinued after 1.5 days due to poor performance and print quality problems.
Baseline Wash at Facility 2	1.2 ± 0.8 (n=3)	2.7 ± 1.2	NA	NA	Medium	NA	NA	• Wash cut ink satisfactorily. • Did not leave residue on blanket.
WASH 38 at Facility 4	3.7 ± 1.3 (n=6)	NA	3.0 ± 0.0	3.5 ± 0.6	NA	Medium	High	*Based on a sample size of 6 blanket washes:* • Use of wash discontinued after 6 trials due to print quality problems from oily residue. • Wash cut ink satisfactorily.
Baseline Wash at Facility 4	3.0 ± 0.0 (n=2)	NA	3.0 ± 0.0	NA	NA	Low	NA	• Cut the ink well. • Strong odor.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 65.0 sec. at Facility 2 and 45.0 sec. at Fac. 4 (based on time recorded by the observer)

Blanket Wash 39

Composition:
Water
Hydrocarbons, petroleum distillates
Propylene glycol ethers
Alkanolamines
Ethylene glycol ethers

VOC Content: 37%; 2.9 lbs/gal
Flashpoint: 155°F
pH: 9.2

Facility 5

At Facility 5, Wash 39 was used on a single-unit 12" x 18" press, and a single-unit 12" x 18" press with conventional inks and print commercial products such as business cards and advertisements. The press operator at Facility 5 used Wash 39 for most jobs during the one-week demonstration. At this facility, each blanket is typically wiped down two times during cleaning: once with blanket wash to remove the ink, and once with a clean, dry shop towel to remove excess wash. Blanket wash is applied directly to the blanket using a squirt bottle and is then wiped off using a reusable shop towel. The same shop towel is used until it has too much ink build-up to effectively clean the blanket. This application procedure was modified for the baseline wash and substitute wash demonstrations by applying the wash first to the shop towel instead of directly to the blanket. Currently, this facility uses two blanket wash products. According to the MSDSs, one contains aliphatic hydrocarbons, cyclohexane, n-heptane, methylcyclohexane, toluene, C_6-C_8 paraffins, and C_6-C_8 cycloparaffins and the other consists of aromatic hydrocarbons, aliphatic hydrocarbons, 1,2,4-trimethylbenzene, xylene, dipropylene glycol methyl ether, and propylene glycol methyl ether. Facility 5 has tried a variety of substitute blanket washes donated by suppliers. None of these products were adopted either because they did not work as well as their standard wash (left an oily residue on the blanket) or they were too expensive (up to twice as much as their standard wash).

The press operator at Facility 5 evaluated Wash 39 as "good". Although Wash 39 did not dry as fast as the baseline wash, it was found to cut the ink well. The substitute wash was also observed to leave an oily residue on the blanket which required some extra effort to remove with a dry shop towel, but no effect was noticed on the print quality. Wash 39 was tested under light, medium and heavy ink coverage conditions, while the baseline wash was tested under light ink coverage conditions only. Under light coverage conditions, it was observed that Wash 39 required 2.7 rotations to clean the blankets and the baseline wash required 2.0 rotations. The level of physical effort needed to wash the blanket was rated as "medium" for both the substitute wash and the baseline wash. While Wash 39 was found to be effective on the blankets, according to the press operator it could not be used on the rollers. Two products were therefore required to clean up the press, increasing the time and effort needed.

Facility 8

Facility 8 used a 6-unit 20" x 26" press with conventional inks to print brochures, advertisements and other commercial products. The press operator at Facility 8 cleaned five blankets using Wash 39 and then stopped the demonstration because the substitute wash did not cut the ink well and required an unacceptable amount of effort to clean the blankets. At this facility, each blanket is typically wiped down two times during cleaning: once with a reusable shop towel saturated with blanket wash, and once with a clean dry shop towel to remove excess wash.

The saturated shop towel is typically used to clean all six blankets on the press before being resaturated or sent out for laundering. This application procedure was also used for the application of the baseline wash and the substitute wash. Facility 8 was using a wash which, according to the MSDS, contains aliphatic petroleum distillates, aromatic petroleum distillates, xylene, 2-butoxy ethanol, methylene chloride, diacetone alcohol, diisononyl phthalate, 2,6-di-tert-butyl-p-cresol, ethylbenzene and 1,2,4 trimethylbenzene to clean the blankets prior to and following the blanket wash demonstration. Alternative low-VOC blanket washes were experimented with in the past, but they did not cut the ink well, did not dry fast, and left and oily residue on the blanket.

Based on the five blanket cleanings with Wash 39, the press operator at Facility 8 evaluated the performance as "poor". The baseline wash was observed to perform well; cutting the ink well and drying quickly. The operator observed that Wash 39 did not cut the ink well and required a substantial amount of time and effort to get the blankets ready for printing. Wash 39 and the baseline wash were tested under medium ink coverage conditions only. Under these conditions, it was observed that the substitute wash required 6.0 rotations to clean the blanket and only 2.7 rotations using the baseline wash. Because Facility 8 took 17.7 seconds on average to rotate the blanket once, the average increase in blanket cleaning time was about one minute over that of the baseline. Additional time and effort were also needed because the thick consistency of Wash 39 made it difficult to get the wash to soak into the shop towel. The substitute wash left an oily residue on the blanket, but the residue was not observed to have an effect on the print quality. The press operator rated the effort needed to clean the blankets using Wash 39 as "high" primarily due to the extra steps needed to clean the blanket and the difficulty in getting the product to soak into the shop towel. The effort needed to use the baseline wash was also rated as "high" because the operator found it to have unusually high resistance when dragging it across the blanket.

Summary of Performance Demonstrations for Blanket Wash 39

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 39	2.9; 37%	155	4.8	0.6 @ 77°F	1.5	3	7	10
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 39 at Facility 5	0.7 ± 0.3 (n=32)[a]	2.7 ± 0.5	3.3 ± 0.4	4.2 ± 1.0	Medium	Medium	Medium	*Based on a sample size of 32 blanket washes:* • Good overall performance; cut ink well. • Did not dry as quickly as baseline wash and left an oily residue on the blanket. • Product did not work on rollers.
Baseline Wash at Facility 5	1.0 (n=1)	2.0 ± 0.0	NA	NA	Medium	NA	NA	• Good performance; cut ink well.
WASH 39 at Facility 8	1.0 ± 0.0 (n=5)	NA	6.0 ± 0.0	NA	NA	High	NA	*Based on a sample size of 5 blanket washes:* • Did not cut ink well and therefore required extra time and effort to clean blankets. • Difficult to get wash to soak into shop towel. • Left oily residue on blanket.
Baseline Wash at Facility 8	0.7 ± 0.0 (n=4)	NA	2.7 ± 0.5	NA	NA	High	NA	• Cut ink well. • Extra effort was required due to resistance to being dragged across the blanket.

NA = Not Applicable; product was not demonstrated under these conditions.
[a] n = number of washes on which this data is based, as recorded by the printer.
[b] Time required to clean the blanket measured by the number of blanket rotations. Avg. time per rotation = 15.4 sec. at Facility 5 and 17.7 sec. at Facility 8 (based on time recorded by the observer)

Blanket Wash 40

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates
Fatty acid derivatives
Ethoxylated nonylphenol

VOC Content: 52%; 3.8 lbs/gal
Flashpoint: 155°F
pH: 4.8

Facility 1

At Facility 1, performance demonstrations were conducted on an eight-unit, 28" x 40" press using vegetable-based inks to print high quality, multi-color, commercial products. Currently, Facility 1 uses a blanket wash which consists of aromatic hydrocarbons, 1,2,4-trimethylbenzene, and aliphatic hydrocarbons as their standard wash, according to the MSDS. In the months preceding the demonstrations, the facility had tried two different low-VOC blanket washes; neither worked as well as their standard wash. At this facility, each blanket is typically wiped down twice during cleaning: once with a reusable shop towel saturated in blanket wash to remove the ink, and once with a dry shop towel to remove excess blanket wash. Each saturated shop towel is used to clean two blankets. The same application procedure was used for the baseline and substitute products. The quantity of wash needed to saturate the shop towel and clean the blanket remained constant throughout the demonstration, regardless of the ink coverage or ink build-up on the blanket. There were both positive and negative aspects to this application method. While more wash than was needed may have been used in some cases, the consistency of the application volume made it possible to compare the performance of the standard, baseline, and substitute products under the same conditions.

Overall, the performance of Wash 40 was considered "good" when ink coverage was medium, and "good/fair" for heavy ink coverage; no information was recorded on the performance of Wash 40 on a blanket with light ink coverage. The facility used Wash 40 for one week, but recorded information on only 6 washes. The press operator who usually completed the forms was out of the facility for several days, during which time forms were not completed although the product was used. Following the manufacturer's instructions, Facility 1 diluted one part wash with one part water. When used at the diluted concentration, Wash 40 left a greasy residue on the blanket. It usually took two rotations of the blanket while wiping with a dry shop towel to remove this residue. Because of this extra effort, the press operator stopped diluting the wash and tried using it at full strength. At full strength, residue was no longer a problem. Blankets with medium ink coverage on average required one rotation to clean, one rotation to dry, and low effort. When the ink coverage was heavy, the effort increased and three or four rotations and medium effort were needed to clean the blanket. The performance of Wash 40 was comparable to the baseline wash performance. The operator found the baseline wash cut the ink well, but required slightly more effort than their standard wash. As with Wash 40, two blanket rotations were needed to clean the blanket when ink coverage was light or medium; the baseline was not used on a blanket with heavy ink coverage. Since blanket rotation is automatic, each rotation consistently took 20 seconds, resulting in an average cleaning time when using Wash 40 of 40 seconds (2 rotations) for medium ink coverage, and 80 seconds (4 rotations) for heavy ink coverage. The press operator found that Wash 40 was easier to apply when the blanket was wiped with a sponge wet with water prior to application of the blanket wash. In this facility's standard practice, a wet sponge is occasionally used to wipe any paper or particles from the blanket before applying a blanket wash, so this extra step was not seen as particularly burdensome. At all levels of ink coverage, no print quality problems attributable to Wash 40 were experienced.

Facility 10

At Facility 10, Wash 40 was demonstrated on a six-unit, 19" x 28" press using conventional inks to print primarily commercial products, such as brochures, cards, and posters. Currently, Facility 10 uses a naphtha blend as their standard wash, according to the MSDS. They have tried a few alternative washes, but found that they either did not work as well, or that they cost more than twice as much as their standard blanket wash. Typically, this facility uses the following procedure to clean the blanket: wipe the blanket with a water-soaked sponge to remove built up paper and particles (1 - 2 rotations); pour blanket wash onto a reusable shop towel from a squeeze bottle; wipe blanket with product (2 rotations); wipe off excess with a clean, dry shop towel (1 - 2 rotations). Both the baseline product and Wash 40 were applied using the same procedure.

Facility 10 used Wash 40 for one week, recording data for 20 blankets, and the performance was evaluated as "good" Although the manufacturer's instructions indicated that Wash 40 could be diluted with up to 50 percent water, the press operator preferred to try it at full strength first, and if successful, he would dilute the product. At full strength, the wash cut the ink well. Only one blanket with heavy ink coverage was cleaned with Wash 40 during the demonstrations. On this blanket with heavy coverage, the operator found some extra effort was required (4 blanket rotations instead of the 3 rotations required for light and medium coverage, and medium effort instead of the low effort reported for light and medium coverage). Because of this additional effort for heavy ink coverage, the printer felt that the diluted wash would not perform well and he only used Wash 40 at full strength. He did, however, pour the wash onto a shop towel that was slightly dampened with water, instead of a dry shop towel. According to the press operator, the performance of Wash 40 was comparable to the performance of the baseline wash. The operator found the baseline product worked as well, with the same effort required and ability to cut the heavy ink coverage as their standard product, but the odor was strong. There were no problems with print quality attributable to the wash, and there was no odor noticed when using this blanket wash.

Summary of Performance Demonstrations for Blanket Wash 40

Laboratory Testing Results								
Product	**VOC Content (lbs/gal; % by wt)**	**Flashpoint (°F)**	**pH**	**Vapor Pressure (reported, mm Hg)**	**Blanket Swell (%)**		**Washability (# strokes)**	
					1 hour	***5 hour***	***Wet Ink***	***Dry Ink***
WASH 40	3.8; 52%	155	4.8	4.7 @ 77°F	1.5	3	5	10
Baseline Wash	6.2; 100%	50	6.6	15 @ 100°F	1.5	3	3	8

Field Demonstration Results								
Product/ Facility	**Average Volume Used (ounces)**	**Time required[b] (# rotations)**			**Physical Effort Required (Low, Medium, or High)**			**Performance Evaluation**
		Light Coverage	*Medium Coverage*	*Heavy Coverage*	*Light Coverage*	*Medium Coverage*	*Heavy Coverage*	
WASH 40 at Facility 1	2.5 ± 0.0 (n=6)[a]	NA	2.0 ± 0.0	3.7 ± 0.6	NA	Low	Medium	*Based on a sample size of 6 blanket washes:* • Good performance. • When diluted with water, left residue. No residue problem at full strength.
Baseline Wash at Facility 1	2.5 ± 0.0 (n=2)	2.0 ± 0.0	2.0 ± 0.0	NA	High	High	NA	• Good performance. • Required slightly more effort than standard wash to remove the excess wash.
WASH 40 at Facility 10	0.9 ± 0.2 (n=20)	3.0 ± 0.0	3.0 ± 0.0	4.0 ± 0.0	Low	Medium	Medium	*Based on a sample size of 20 blanket washes:* • Good performance; cut ink well. • Required slightly more effort when coverage was heavy.
Baseline Wash at Facility 10	1.5 ± 0.0 (n=2)	NA	NA	5.0 ± 0.0	NA	NA	Medium	• Good performance; cut heavy ink well. • Operator noticed a strong odor.

NA = Not Applicable; product was not demonstrated under these conditions.

[a] n = number of washes on which this data is based, as recorded by the printer.

[b] Time required to clean the blanket measured by the number of blanket rotations: Avg. time per rotation = 20.0 sec at Facility 1 and 11.2 sec at Facility 10 (as measured by the observer)

4.2 BLANKET WASH COST ANALYSIS METHODOLOGY

The methodology described below was used to estimate the cost of using the baseline blanket wash as well as the cost of using 22 substitute blanket washes. The primary source of information for the cost estimates was the performance demonstration conducted during production runs at 17 volunteer facilities in late 1994 and early 1995 and described in section 4.1. This information was supplemented by several other sources, including: 1) industry statistics collected by trade groups such as NAPL; 2) lease prices for cloth printer's wipes from a large east coast industrial laundry; and 3) EPA's risk assessment work presented in chapter 3.

The performance demonstration collected data on the use of donated, substitute blanket wash products and the baseline, VM&P Naphtha. Substitute products were screened for blanket swell and washability; each was then sent to two printing facilities. Each facility also tested the baseline product; results are presented comparing the substitute products to the baseline. Although each facility was to use the substitute product for one week, performance problems and scheduling conflicts resulted in some products being used more than others. Section 4.1.4 provides a discussion of the limitations of the demonstration. Table 4-2 in the previous section summarizes the results.

Certain assumptions were used in this analysis to smooth out the differences among the various facilities participating in the performance demonstration in order to make the results comparable and to remain consistent with assumptions used in other parts of this CTSA. For example, it was assumed that there are four blankets or "units" per press, each of which is washed 10 times per shift. Additionally, it was assumed that work is performed for one 8-hour shift per day, 5 days per week, 50 weeks per year. Using these assumptions, the following costs were estimated for individual facilities involved in the performance demonstrations for the baseline blanket wash and each substitute blanket wash:

- Total cost/wash,
- Total cost/press, and
- Total cost/press/shift/year.

A general description of the cost estimation methodology and data sources used is presented in Section 4.2.1 below. Section 4.2.2 provides a more detailed description of the methodology. Section 4.2.3 provides an example of the calculations described in Sections 4.2.1 and 4.2.2.

4.2.1 General Description of Costing Methodology

In general, the cost estimate for each reclamation method combines product cost and product performance data. Variations in the sample sizes, the value for 'n', found in the labor rate (time), the number of wipes per cleaning, quantity of wash used and number of cleanings used to determine performance are due to differences in the way the data for each factor was collected. For example, in the case of the time required to clean the blanket, only the data collected by the observer on the first day of the demonstration were used in the assessment. In determining the average quantity of blanket wash used, data collected during the entire week were utilized in the assessment resulting in a higher sample size. The final cost estimates are a combination of the three distinct cost elements listed below:

<u>Labor</u>

The time spent to clean the blanket was recorded in the performance demonstrations by the observer on the first day of the demonstration for each product, as it was not feasible for press operators to time themselves while cleaning. Therefore, estimates of time to clean the blanket recorded by observers were used to calculate the labor cost.[a] The labor cost was calculated as the total time spent multiplied by 1) the average wage rate for lithography press operators of $15.52/hour, 2) an industry fringe rate (to account for holiday and vacation) of 1.07, and 3) an industry multiplier of 1.99 to account for overhead costs. All of these cost elements were calculated from industry statistics reported in NAPL's *1993 Cost Study* and are explained in more detail in Section 4.2.2.

Cost Methodology Information Basis Summary

Labor
- Observer time from demonstration
- Wage rate - $15.52/hr
- Fringe rate multiplier - 1.07
- Overhead rate multiplier - 1.99

Blanket Wash
- Recorded quantity used during demonstration
- Adjusted for dilution
- Product cost provided by supplier

Materials - Wipes
- Recorded quantity used during demonstration
- Lease price - $0.11/wipe

Blanket wash products

The quantity of blanket wash used per blanket was recorded during the observer's visit and by the press operator during the week of demonstrations. Average usage per blanket was calculated at each facility for both the baseline product and the 22 substitute products. Multiplying usage per wash, accounting for dilution where necessary, by the unit cost of each product (provided by each participating manufacturer and summarized in Table 4-3) yielded the blanket wash costs.

Materials (i.e., wipes)

The only materials consumed in manual blanket washing are the wipes used by the press operator to wash the blanket. All but one of the print shops participating in the performance demonstration used cloth wipes; the other used disposable wipes. Materials costs were therefore calculated by multiplying the number of wipes used, as recorded in the performance demonstrations, by the lease price of a cloth printer's wipe. (A representative of Standard Uniform Services, one of the largest industrial laundries in Massachusetts, provided an estimated lease price of $0.11 per wipe.)

[a] *An alternative method of determining the labor time was examined, apart from using the average time estimates compiled by observers. Within each facility, observers and press operators collected data on the number of blanket rotations per wash. Because only observers compiled time estimates, the rotations data included more observations and was, therefore, considered as an alternative method for estimating labor time. However, this approach was abandoned after further analysis found poor correlation between time and number of rotations. Although occasionally high correlation was found to exist, the majority of facilities did not show a high degree of correlation. Eight facilities with the greatest number of observations were analyzed separately to determine if time and number of rotations were correlated. Again, poor correlation was found. This is interpreted to mean that there was not a preset cleaning speed for the rotation of the cylinders; we were not, therefore, able to use the number of rotations multiplied by the average time per rotation recorded by the observer to determine the labor time involved with cleaning the cylinders. In addition, the ink coverage changed from one cleaning to the next, adding a variation which affected the cleaning time. However, poor correlation between time and number of rotations was also found to exist for facilities that reported consistent ink coverage.*

The trend in the number of rotations necessary to clean a cylinder was also examined to determine if there was a learning curve involved with using the alternative cleaners. While it is believed that there is a learning curve, the demonstration timetable was too short for this observation, which was further complicated by variable ink coverage.

A summary of the cost comparisons is presented in Table 4-4, followed by a graphical display (Figure 4.1) of the relative cost changes (substitute compared to baseline) at each facility. [b] Figure 4.1 illustrates the range of percentage cost changes (compared to the baseline) measured at each facility. Two points are plotted for each of the substitute products because each was tested at two facilities. Formulations are arranged by ascending VOC content. Cost comparisons for each blanket wash against the baseline are provided at the end of this section; summary paragraphs are followed by tables providing specific results. Absolute and relative cost variations are reported for each substitute. An increase in the time required to clean the blanket, quantity of wash solution used, number of wipes expended, and costs of labor and materials is preceded by a plus sign; conversely, decreases are denoted by a minus sign.

Table 4-3. Substitute Blanket Washes, Manufacturer Pricing

Blanket Wash Number and Type	Product Cost per Gallon ($)** (based on the 55 gallon drum price)($)
Baseline - VM&P Naphtha	5.88
1 - Vegetable Fatty Ester	20.00
6 - Ester/Petroleum + Surfactant	12.35
9 - Ester/Water	10.26
10 - Ester/Water	9.55
11 - Ester/Petroleum + Surfactant	12.15
12 - Petroleum/Water Diluted for Use	16.40
14 - Vegetable Fatty Ester + Glycol	9.55
19 - Vegetable Fatty Ester + Glycol	11.80
20 - Petroleum/Water	10.80
21 - Ester/Petroleum	10.08
22 - Water/Petroleum/Ester	13.15
24 - Terpene	17.85
26 - Vegetable Fatty Ester	12.24
29 - Vegetable Fatty Ester	18.00
30 - Petroleum/Water Diluted for Use	5.00
31 - Petroleum	9.80
32 - Petroleum	2.85
34 - Water/Petroleum/Ester	15.00
37 - Petroleum/Water	14.80
38 - Ester/Petroleum	19.00
39 - Petroleum/Water	8.95
40 - Ester/Petroleum + Surfactant	10.25

** Unit costs supplied by manufacturers participating in the performance demonstrations.

[b] *Products 9, 22, and 32 are not included within Figure 4.1 because VOC content for these products was not available.*

Table 4-4. Summary of Cost Analysis for Blanket Wash Performance Demonstration

Formula Number	Test Facility	Total cost/wash		Total cost/press		Total cost/press/shift/year		Percentage Difference[1]
		Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
1	Facility 3	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 6	0.46	0.87	1.84	3.48	4,600	8,700	+89
6	Facility 11	0.70	0.82	2.80	3.28	7,000	8,200	+17
	Facility 15	0.50	0.77	2.00	3.08	5,000	7,700	+54
9	Facility 10	0.91	2.08	3.64	8.32	9,100	20,800	+129
	Facility 15	0.50	0.92	2.00	3.68	5,000	9,200	+84
10	Facility 3	0.55	0.57	2.20	2.28	5,500	5,700	+4
	Facility 4	0.85	2.20	3.40	8.80	8,500	22,000	+159
11	Facility 1	0.59	1.29	2.36	5.16	5,900	12,900	+119
	Facility 2	0.53	0.68	2.12	2.72	5,300	6,800	+28
12	Facility 12	0.81	0.99	3.24	3.96	8,100	9,900	+22
	Facility 13	0.80	0.83	3.20	3.32	8,000	8,300	+4
14	Facility 6	0.46	1.07	1.84	4.28	4,600	10,700	+133
	Facility 16	0.66	0.82	2.64	3.28	6,600	8,200	+24
19	Facility 18	0.62	1.66	2.48	6.64	6,200	16,600	+168
	Facility 19	0.53	0.89	2.12	3.56	5,300	8,900	+68
20	Facility 11	0.70	1.13	2.80	4.52	7,000	11,300	+61
	Facility 12	0.81	1.58	3.24	6.32	8,100	15,800	+95

Formula Number	Test Facility	Total cost/wash		Total cost/press		Total cost/press/shift/year		Percentage Difference[1]
		Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
21	Facility 6	0.46	1.01	1.84	4.04	4,600	10,100	+120
	Facility 17	0.41	0.58	1.64	2.32	4,100	5,800	+41
22	Facility 12	0.81	0.82	3.24	3.28	8,100	8,200	+1
	Facility 13	0.80	1.51	3.20	6.04	8,000	15,100	+89
24	Facility 16	0.66	0.97	2.64	3.88	6,600	9,700	+47
	Facility 17	0.41	0.88	1.64	3.52	4,100	8,800	+115
26	Facility 5	0.55	0.73	2.20	2.92	5,500	7,300	+33
	Facility 15	0.50	0.47	2.00	1.88	5,000	4,700	-6
29	Facility 7	0.57	0.93	2.28	3.72	5,700	9,300	+63
	Facility 8	0.55	0.89	2.20	3.56	5,500	8,900	+62
30	Facility 18	0.62	1.01	2.48	4.04	6,200	10,100	+63
	Facility 19	0.53	0.62	2.12	2.48	5,300	6,200	+17
31	Facility 7	0.57	1.59	2.28	6.36	5,700	15,900	+179
	Facility 8	0.55	0.59	2.20	2.36	5,500	5,900	+7
32	Facility 1	0.59	1.31	2.36	5.24	5,900	13,100	+122
	Facility 5	0.53	0.43	2.12	1.72	5,300	4,300	-19
34	Facility 1	0.59	0.89	2.36	3.56	5,900	8,900	+51
	Facility 19	0.53	0.95	2.12	3.80	5,300	9,500	+79

Formula Number	Test Facility	Total cost/wash		Total cost/press		Total cost/press/shift/year		Percentage Difference[1]
		Baseline	Alternative	Baseline	Alternative	Baseline	Alternative	
37	Facility 3	0.55	0.48	2.20	1.92	5,500	4,800	-13
	Facility 4	0.85	0.79	3.40	3.16	8,500	7,900	-7
38	Facility 2	0.53	1.08	2.12	4.32	5,300	10,800	+104
	Facility 4	0.85	1.11	3.40	4.44	8,500	11,100	+31
39	Facility 5	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 8	0.55	0.80	2.20	3.20	5,500	8,000	+45
40	Facility 1	0.59	0.79	2.36	3.16	5,900	7,900	+34
	Facility 10	0.91	0.87	3.64	3.48	9,100	8,700	-4

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

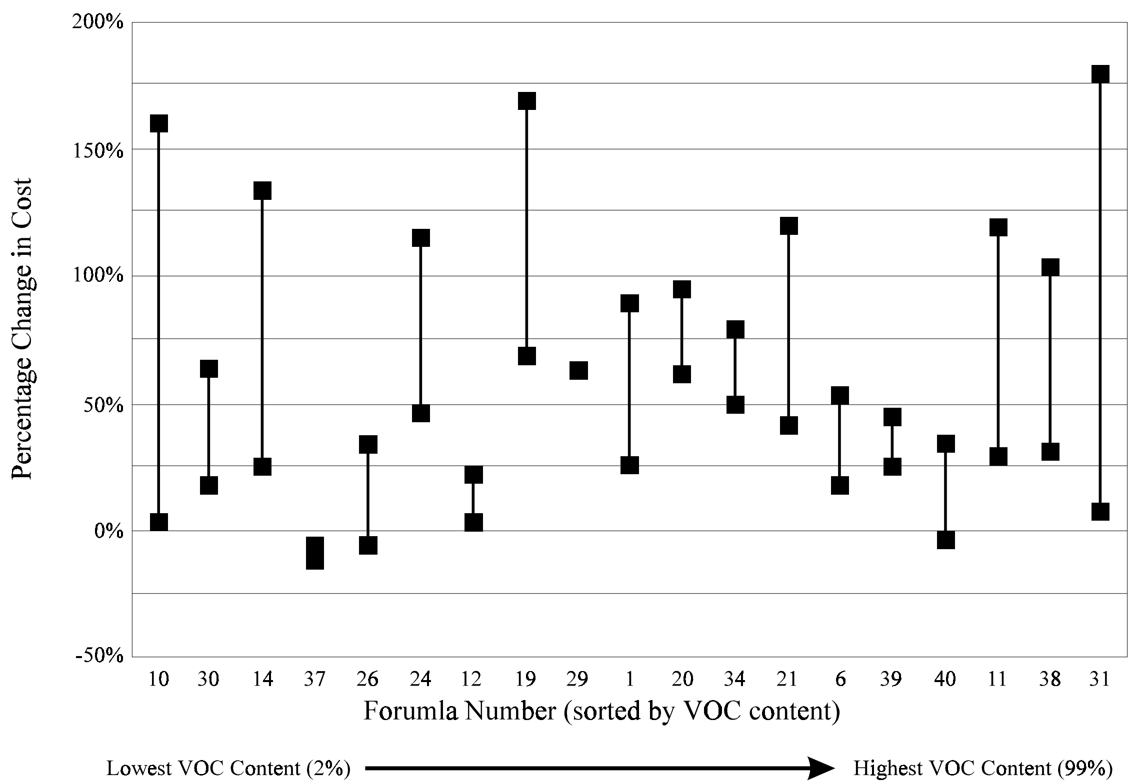


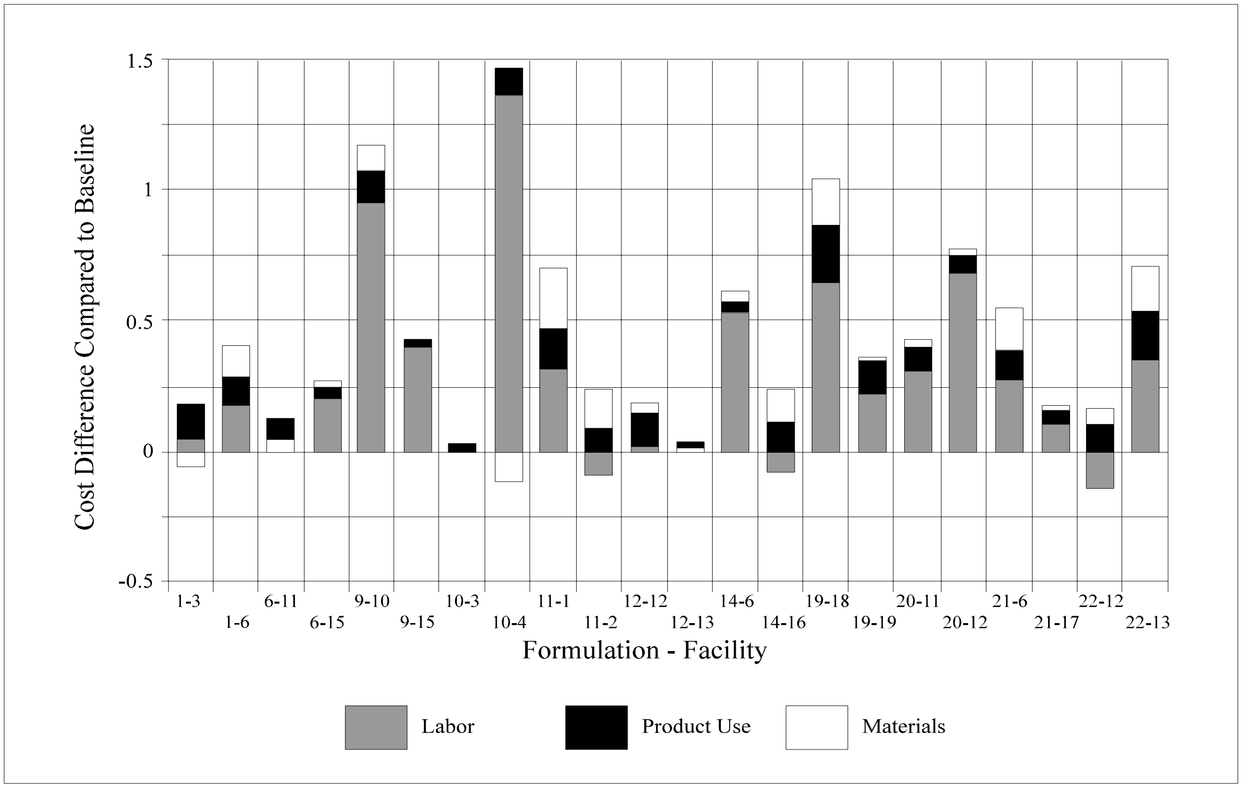
Figure 4.1 Blanket Wash Costs Changes Arranged by Lowest to Highest VOC Content of Formulations

4.2.2 Details Related to Data Sources and Methodological Approach

As mentioned above, the blanket wash cost comparison considered three cost elements when comparing the performance of baseline and substitute blanket cleaners: labor costs (time × wage rate); blanket wash use (quantity × unit price), adjusting for dilution; and material and equipment costs (# wipes × cost per wipe). Each element is described in more detail below. Also, Figure 4.2 presents a graphical display of the relative contribution of labor, product use, and material use to the overall cost differences (compared to the baseline) for each of the substitute products. For example, performance results for product 1, tested at facility 6 indicate that overall costs per wash were $0.41 greater for Blanket Wash 6 compared to the baseline. The $0.41 difference is divided up as follows: costs associated with labor were $0.19 higher than the baseline, costs associated with product use (i.e., price x quantity) were $0.11 greater than the baseline, and costs associated with material and equipment use were $0.11 greater than the baseline.

<u>Labor Costs</u>

The hourly wage and overhead rate for press operators was calculated from the *NAPL 1993 Cost Study*. The NAPL study presents a number of facility-specific characteristics, including



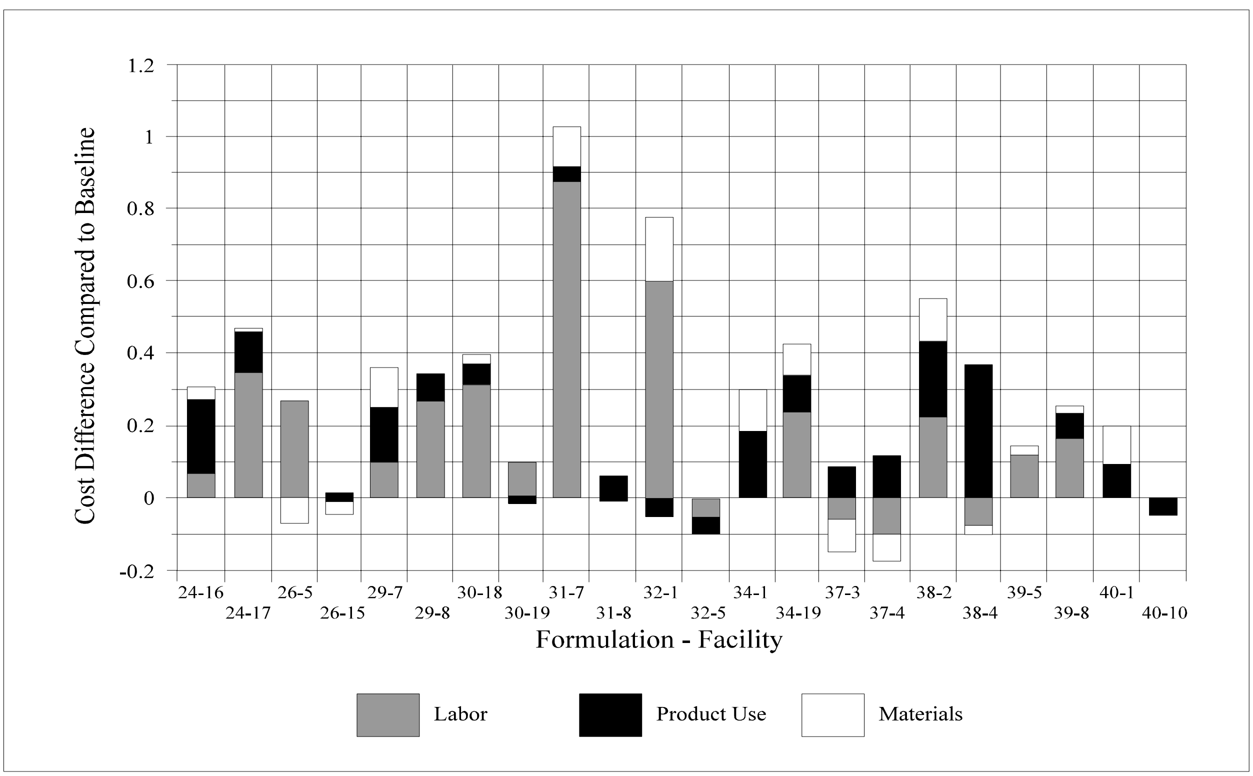


Figure 4.2 Cost Difference Between Substitute and Baseline Blanket Washes

annual wages and overhead costs by press type and brand, number of shifts per day, length of work week, and vacations and holidays allowed. Because of the many variables impacting hourly wages and overhead rates, several assumptions were made to facilitate comparisons along the various alternatives.

Assumptions

- Based on a review of press sizes used in the performance demonstrations as well as discussions with performance demonstration observers, wage rates and overhead expenses for a 26-inch, 2-unit press were used in this analysis.

- The *NAPL 1993 Cost Study* presents three possible employment scenarios (referred to as areas A, B, and C), each with differing wages and overhead costs. The "areas" are defined as follows: 1) area A: 35 hours/week, 4 weeks paid vacation, and 11 paid holidays; 2) area B: 37.5 hours/week, 3 weeks paid vacation, and 10 paid holidays; and 3) area C: 40 hours/week, 2 weeks paid vacation, and 8 paid holidays. It was assumed that press operations at performance demonstrations shops operate under a 40 hour work week and are offered 2 weeks paid vacation and 8 paid holidays per year.

- Annual wages and overhead rates vary according to the number of (eight hour) shifts the press facility operates per day. As the number of shifts increase, the wage rate for all shifts increases and the overhead rate decreases. To estimate average wage and overhead rates for this analysis, hourly wage estimates and overhead rates were weighted according to the proportion of facilities participating in performance demonstrations operating one, two or three shifts per day.

- The NAPL cost study provides overhead expenses for seven brands of presses within the 26-inch, 2-unit press category. Overhead rates were calculated by averaging across the seven brands. Annual wages do not vary across the seven brands of presses.

Hourly wage rate for a press operator

As mentioned above, annual wage rates, presented in the NAPL cost study, do not vary across press type; however, wages do vary according to the number of shifts operated per day. In this analysis, a weighted average of $15.52/hour was calculated given that nine of the facilities that participated in the performance demonstration operate one shift per day, four facilities operate two shifts per day, and four facilities operate three shifts per day. Calculations of the average hourly wage are presented in Table 4-5 below.

Table 4-5. Calculation of Average Hourly Rate

# Shifts (8 hrs.)	Annual Wage	Hourly Wage	Weight (Facilities × shifts)	Wage × Weight
1	$31,200	$15.00	9	$135
2	$64,740	$15.56	8	$124
3	$99,060	$15.88	12	$191
Totals:			29	$450
Total wage × weight:				$450.04
Total/29:				**$15.52**
Source: NAPL 1993 Cost Study				

Fringe rate

To account for costs associated with fringe benefits such as holiday and vacation time, a fringe rate was calculated. The NAPL Cost Study indicates that press operators working a 40 hour week receive eight paid holidays and two weeks vacation per year. To calculate the fringe rate, non-productive hours were subtracted from total hours of operation per year (i.e., 2,080 hours minus 144 hours = 1936 hours). The ratio of total hours to productive hours is equal to the fringe rate applied to each hour worked (2080/1936 = 1.074).

Overhead rate

Overhead rates for this analysis are calculated according to the following formula[c]:

$$\frac{\text{depreciation + rent \& heat + fire \& sprinkler insurance + pension fund + welfare benefits + payroll taxes + workmen's comp. + light \& power + direct supplies + repairs to equipment + general factory + administrative \& selling overhead}}{\text{direct labor + supervisory and misc. labor}}$$

The NAPL cost study provides overhead expenses for seven brands of presses within the 26-inch, 2-unit press category. For the purposes of this analysis, overhead rates were averaged across the seven brands. As with the hourly wage calculations, a weighted average was calculated, accounting for the variability in the number of shifts a facility may operate per day. The overhead rate was estimated to be 1.99.

Total Labor Cost

The total labor cost associated with the use of an individual blanket wash was calculated by multiplying the average cleaning time by the press operator's hourly wage, overhead rate, and fringe rate. For example, the total labor cost for Blanket Wash 1, tested by facility 3, was calculated by multiplying the average time spent cleaning (37.5 seconds) by the wage per second ($15.52/60min/60sec[d]), overhead rate (1.99), and fringe rate (1.074) for a total cost of $0.35 per wash.

Blanket Wash Use

Costs attributable to blanket wash use were calculated by multiplying the average quantity of blanket cleaner used per wash cycle by the price of the appropriate wash. In cases where participants diluted blanket wash with water, the unit price was multiplied by the ratio of cleaner used and not the total quantity of the mixture. For example, if the dilution ratio was 1:1, the unit price of the blanket wash was multiplied by 0.5 to account for dilution and then multiplied by the volume used. As mentioned above, blanket wash prices were provided by manufacturers participating in the performance demonstrations. During the performance demonstrations it was observed that most printing facilities purchased blanket cleaner in 55-gallon quantities. This was assumed to be true of all printing facilities participating in the performance demonstration.

Material and Equipment Costs

Because the performance demonstrations were limited to manual blanket washing, the only materials or equipment affecting the cost of blanket washing were the wipes used by the press operator to remove ink and paper products. The cost of press wipes were calculated by multiplying

[c] *Overhead cost elements were taken directly from the NAPL 1993 Cost Study.*

[d] *The wage rate of $15.52 per hour translates to $0.0043 per second.*

the average number of wipes used per wash by the lease price of a cloth printer's wipe. A representative of Standard Uniform Services, one of the largest industrial laundries in Massachusetts, estimated a lease price of $0.11 per wipe.

Waste Disposal

Because blanket washing wastes may be classified as hazardous wastes by regulations implementing RCRA and therefore require more careful and costly handling and disposal, printers may reduce waste disposal costs if wastes associated with alternative blanket washes do not contain any RCRA listed wastes, eliminating the need to be handled as hazardous waste.[e] Disposal costs were not considered in this cost comparison, however, because all but one of the printers participating in the performance demonstrations use cloth wipes that are leased from an industrial laundry. Industrial laundries currently do not distinguish between hazardous and nonhazardous blanket washes when laundering wipes; it was therefore assumed that there would be no savings in waste handling or processing costs associated with switching to an alternative blanket wash product. In addition, the impact of alternative cleaners on the costs of handling and processing used wipes is unclear. For example, according to the Uniform and Textile Service Association, wipes impregnated with vegetable-oil based cleaners have a higher potential for spontaneous combustion when piled together in a laundry bag. Vegetable-oil based cleaners break down, creating exothermic heat and the potential for spontaneous combustion. In addition, the vegetable oil-based cleaners may make wastewater treatment and permit compliance more difficult for the industrial laundry (Dunlap, 1995).

While there is a potential for reduction in waste treatment and disposal costs attributed to the use of alternative blanket cleaners, the current state of federal regulations is in flux. Also, there are many different state and local regulations which might dictate different treatment for hazardous blanket wash wastes. Specifically, future changes to RCRA and the Clean Water Act (CWA) could potentially create a cost advantage for printers using alternative blanket cleaners. Currently, under RCRA, the mixture rule classifies a non-hazardous waste as hazardous when combined with a listed waste (F, P, K, and U listed wastes). The mixture rule was struck down by a 1991 District of Columbia Circuit Court ruling, but was temporarily reenacted while EPA conducts a review of the rule. EPA has not provided definitive guidance on the treatment of solvent contaminated shop towels, leaving it to each state to provide guidance on the identification and management of press wipes.[f] Many states have responded by recognizing a conditional exemption from the mixture rule for contaminated press wipes. EPA's Office of Solid Waste is currently considering changes to the definition of hazardous and solid wastes that could potentially exempt press wipes from hazardous waste classification. Also, EPA is currently developing categorical standards for the industrial laundry industry that could potentially impact the cost of treating press wipes.

The results of the cost comparisons are presented in section 4.2.4 in both cost summary tables and descriptive paragraphs (for each of the 22 field tested blanket washes). As indicated in the tables, presses of three *standard* sizes were used in the performance demonstrations:

- 19" × 26" -- also recorded by printers as 18" × 25", 19" x 25", 19" x 28", and 20" x 26";
- 11" × 17" -- also recorded by printers as 13" × 18", and 12" × 18"; and
- 40" × 28" -- also recorded by printers as 40" × 34."

[e] *Costs of managing hazardous wastes include placing the waste in a closed and properly labeled container, manifesting shipments and using special shipping arrangements, and shipping to a permitted hazardous waste treatment or disposal facility.*

[f] *The EPA is planning to develop guidance to the States for the use, reuse, transportation, and disposal of shop towels.*

Additionally, ink coverage is reported in the tables as the *average* ink coverage observed on the blanket throughout the demonstrations. Coverage is reported as light, light-medium, medium, medium-heavy, and heavy. Cost savings or increases (absolute and percent differences) associated with using each of the alternatives as compared to the baseline (VM&P Naphtha) are indicated for each facility. A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.

4.2.3 Example Calculation

As an example of the cost calculations presented in the cost summary tables, the calculations for alternative Blanket Wash 1, tested by facility 3, are described in full. Total labor cost was calculated by multiplying the average time spent cleaning (37.5 seconds) by the wage per second ($15.52/60min./60sec.), overhead rate (1.99), and fringe rate (1.074) for a total cost of $0.35 per wash. The cost associated with blanket wash use was calculated by multiplying the average quantity used per wash (1.04 ounces or 8.13×10^{-3} gallons) by the unit price of Blanket Wash 1 ($20.00/gallon) for a total cost of $0.16 per wash. The material cost was calculated by multiplying the average number of wipes used per wash (1.6 wipes) by the estimated lease cost per wipe ($0.11/wipe). The total cost per wash for Blanket Wash 1 ($0.69) is simply the sum of the labor, blanket wash, and material costs and is presented at the bottom of the cost summary table for Blanket Wash 1.

<u>Labor Cost</u>
=average cleaning time/wash × wage rate × overhead rate × fringe rate
=37.5 sec × ($15.52/hr × 1hr/60min × 1min/60sec) × 1.99 × 1.074
=$0.35 per wash

<u>Blanket Wash Cost</u>
=average quantity used/wash × unit price of blanket wash
=(8.13×10^{-3} gallons) × $20.00/gallon
=$0.16 per wash

<u>Material Cost</u>
=average number of wipes used/wash × lease cost/wipe
=1.6 wipes × $0.11/wipe
=$0.18 per wash

<u>Total Cost per Wash</u>
=labor cost + blanket wash cost + material cost
=$0.35 + $0.16 + $0.18
=$0.69 per wash

Also presented at the bottom of each table are estimates of total cost per press and total annual costs. The total cost per press ($2.76) for Blanket Wash 1, tested at facility 3, is calculated by multiplying the total cost per wash ($0.69) by the estimated number of blankets per press (4 blankets). The total annual cost ($6,900) is calculated by multiplying the total cost per press ($2.76) by the number of washes per shift (10 washes), the number of shifts per week (5 shifts), and the number of weeks worked per year (50 weeks):

Total Cost per Press
=cost/wash × estimated number of blankets/press
=$0.69 × 4 blankets
=$2.76

Total Annual Cost
=total cost/press × number of washes/shift × number of shifts/week × number of weeks/year
=$2.76/press × 10 washes/shift × 5 shifts/week × 50 weeks/year
=$6,900

Costs of using the baseline product were calculated according to the same procedure used for the alternative blanket washes. The absolute and percentage difference between the costs of the baseline product and Blanket Wash 1 are presented in the cost summary table for Blanket Wash 1. For example, the absolute difference between the labor cost for the baseline product and Blanket Wash 1 is +$0.07 ($0.35 minus $0.28). The positive sign indicates an increased labor cost when using Blanket Wash 1 instead of the baseline (VM&P Naphtha). Labor costs associated with the use of Blanket Wash 1 increase 25% based upon the experience of facility 3. In contrast, the cost associated with material and equipment use for Blanket Wash 1 decreased by four cents or 18%.

4.2.4 Blanket Wash Cost Analysis Results

The results of the cost analysis are summarized in the following paragraphs and tables. It is important to keep in mind several factors when reviewing these results. First, they are based almost entirely on the results of the performance demonstration. For each individual product, the performance demonstrations were subjective assessments reflecting the conditions and experiences of two individual print shops, not scientifically rigorous evaluations. As such, the information derived from the demonstrations are illustrative and are not necessarily reflective of the actual experience of using the various products at a particular facility. The two facilities which tested each product often had very different experiences. As described in the introduction to Section 4.1 - Performance Demonstration, reasons for these differences included variability in operating conditions, type of print jobs, staff involvement, and application method.

The cost factors considered in this analysis were the cost of labor, the cost of the blanket wash, and the cost of the wipes. Among these three factors, the driving factor was the cost of labor, which, on average, contributed 63% of the overall cost of washing the blanket. The time spent to clean the blanket was recorded in the performance demonstrations by the observer on the first day of the demonstration for each product on the first few uses of the substitute. With continued use, the time necessary to clean the blanket may be reduced because of the press operator's familiarity with the substitute product. The wipes contributed, on average, 21% and the blanket wash, on average, 16% of the cost. There were some instances were the cost of the blanket wash was the largest contributor, but there were no instances where consistently the cost of a particular product outweighed the cost of labor or where this trend was seen for a particular facility.

Comparisons of each alternative blanket wash product with the baseline blanket wash, VM&P Naphtha (Blanket Wash 28), for each facility are summarized in the paragraphs below and in more detail in the tables which follow. Absolute and relative cost variations are reported for each alternative. An increase in the time required to clean the blanket, quantity of wash solution used, number of wipes expended, and costs of labor and materials is preceded by a plus sign; conversely, decreases are denoted by a minus sign.

Substitute Blanket Wash 1

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 1 instead of the baseline product at both facilities 3 and 6. Press operators commented that cleaning and drying times were excessive, as reflected in the performance data; performance results indicate a 25 percent increase and a 70 percent increase in cleaning times at facilities 3 and 6, respectively. The costs associated with product use (i.e., volume x price) are also significantly higher for Blanket Wash 1 when compared to the baseline, driven primarily by the product's high price. The manufacturer's price for product 1 is $20/gallon versus $5.88/gallon for the baseline product. Costs associated with product use increased roughly 220 percent and 160 percent for facilities 3 and 6, respectively. Facility 6 did not use alternative product 1 for the full week-long demonstration, discontinuing use after experiencing print quality problems believed to have been attributable to use of the alternative product.

Substitute Blanket Wash 6

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 6 instead of the baseline. Costs for facilities 11 and 15 increased roughly 20 percent and 50 percent respectively when using Blanket Wash 6 instead of the baseline. Operators at both facilities commented that the alternative required more time to be absorbed into the press wipe, causing delays in the wash-up procedure. Performance results indicate an 11 percent increase and a 69 percent increase in cleaning times at facilities 11 and 15, respectively. Press operators at both facilities commented that Blanket Wash 6 cut well. Despite a 30 percent decrease in the average quantity of blanket wash used, facility 15 experienced a 60 percent increase in costs associated with blanket wash use (i.e., volume x price) due to a product cost of more than twice the baseline cost ($12.35/gallon for product 6 compared to $5.88/gallon for the baseline product). Facility 11 experienced a 20 percent increase in product use, with a subsequent increase of 170 percent in costs associated with product use.

Substitute Blanket Wash 9

Blanket washing costs increase significantly when using Blanket Wash 9 as compared to the baseline product at facilities 10 and 15. Both facilities rated the performance of product 9 as poor, indicating that its use requires excess time and effort. Costs increased 129 percent and 84 percent at facilities 10 and 15, respectively, when compared to the baseline. Performance data indicate that increased cleaning times are the driving force behind the cost increases experienced by both facilities. Cleaning times increase 175 percent and 129 percent when compared to the baseline at facilities 10 and 15, respectively. Facility 10 discontinued use of the alternative product 9 after four washes due to its poor performance.

Substitute Blanket Wash 10

Performance data indicate mixed results in the performance of Blanket Wash 10. Blanket washing costs increased 4 percent at facility 3 and 160 percent at facility 4 when Blanket Wash 10 is used rather than the baseline. Although the performance data indicate a small increase in cost at facility 3, the press operator's comments describe difficulty in getting the blanket wash to absorb into the application shop towel. The press operator at facility 4 had similar difficulties. After washing four blankets, the press operators at both facilities 3 and 4 discontinued use of the product.

Substitute Blanket Wash 11

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 11 instead of the baseline. Overall costs per wash at facilities 1 and 2 increased roughly 120 percent and 30 percent, respectively, when using Blanket Wash 11 instead of the baseline. Costs associated with product use (i.e., volume x price) are driven by the higher price of Blanket Wash 11 as compared to the baseline. Blanket Wash 11 is priced at $12.15/gallon compared to $5.88/gallon for the baseline product. Both press operators indicate that a dry shop towel was required to clear the oily residue left by Blanket Wash 11. Material costs (i.e., press wipes) increased by roughly 210 percent and 140 percent at facility 1 and 2, respectively. Press operators at both facilities indicated that Blanket Wash 11 cut the ink well in the case of light or medium ink coverage but was not effective when ink coverage was heavy.

Substitute Blanket Wash 12

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 12 instead of the baseline. Average costs per wash increased roughly 20 percent and 5 percent at facilities 12 and 13, respectively. Facility 12 experienced difficulty with Blanket Wash 12 in cutting through paper residue and discontinued use of the wash on paper residue coated blankets. Facility 13 experimented with a variety of dilution ratios and found that the undiluted product worked best, outperforming both the baseline as well as their standard wash. At a cost of $16.40/gallon, however, Blanket Wash 12 would not be economically competitive with the baseline ($5.88/gallon) unless the average quantity used was significantly lower.

Substitute Blanket Wash 14

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 14 instead of the baseline product at both facilities 6 and 16. Compared to the baseline, total costs per wash increased 133 percent at facility 6 and 24 percent at facility 16. The average cleaning time increased significantly at facility 6 compared to the baseline, requiring an additional minute per wash. Despite a decrease in the average cleaning time, overall costs per wash at facility 16 increase, driven primarily by the product's higher price. Blanket Wash 14 is priced at $9.55/gallon compared to $5.88/gallon for the baseline. The press operator at facility 6 commented that Blanket Wash 14 cut the ink well, however, the press operator at facility 16 commented that Blanket Wash 14 did not cut ink as well as the baseline.

Substitute Blanket Wash 19

The results of the performance data indicate an increased financial cost when using Blanket Wash 19 instead of the baseline at both facilities 18 and 19. Overall costs per wash increased roughly 170 percent and 70 percent at facilities 18 and 19, respectively. Press operators commented that cleaning and drying times were excessive, as reflected in the performance data; performance results indicate a 150 percent increase and a 60 percent increase in cleaning times at facilities 18 and 19, respectively.

Substitute Blanket Wash 20

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 20 instead of the baseline. Average costs per wash increased roughly 60 percent and 95 percent at facilities 11 and 12, respectively. Cleaning times at facility 11 increased from an average of 60 seconds for the baseline to an average of 100 seconds for Blanket Wash 20. The press operator at facility 11 cites two primary reasons for the higher cleaning times: 1) Blanket Wash 20 left an oily residue on the blanket requiring an additional cleaning step, and 2) the product's thick consistency resulted in additional delays as the press operator waited for the wash to soak into the shop towel. After three trials, the press operator at facility 12 began to experience nausea and dizziness and discontinued use of the product. For this reason the contribution of labor to the product cost for Facility 12 is based on only one observation.

Substitute Blanket Wash 21

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 21 instead of the baseline. Costs per wash increase roughly 120 percent at facility 6 and 40 percent at facility 17 when compared to the baseline. Press operators at both test facilities comment that the alternative product left an oily residue on the blanket. Extra wiping was required to clear the blanket as reflected in the performance data --- when compared to the baseline, average cleaning times increased roughly 110 percent for facility 6 and 50 percent for facility 17. Press operators at both facilities commented that Blanket Wash 21 cut the ink well. The press operator at facility 6 discontinued use of Blanket Wash 21 after six washes because the oily residue began to affect subsequent runs.

Substitute Blanket Wash 22

Performance data indicate mixed results for Blanket Wash 22. Total costs per wash increased 89 percent for facility 13, but increased only 1 percent for facility 12. Despite a 34 percent decrease in the average quantity used, costs associated with product use (i.e., volume x price) increased 50 percent for facility 12. Blanket Wash 22 is priced at $13.15/gallon compared to a price of $5.88/gallon for the baseline product. The press operator at facility 13 commented that Blanket Wash 22 cuts the ink as well as the baseline, but its thick consistency resulted in delays during wash application and drying. Average cleaning time increased 67 percent at facility 13 compared to the baseline. The press operator at facility 12 commented that Blanket Wash 22 cut the ink well and performed better than the baseline wash.

Substitute Blanket Wash 24

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 24 instead of the baseline. Costs per wash increased roughly 50 percent at facility 16 and 110 percent at facility 17, when compared to the baseline. Press operators at both facilities commented that Blanket Wash 24 cut the ink well, however, it left an oily residue on the blanket and did not readily absorb into the press wipe. When compared to the baseline, average cleaning times increased 18 percent and 160 percent for facilities 16 and 17, respectively. Despite the fact that facility 17 used a smaller average quantity of Blanket Wash 24 compared to the baseline, the costs associated with blanket wash use (i.e., volume x price) increased due to a much higher price per gallon. The manufacturers price for product 24 is $17.85/gallon versus $5.88/gallon for the baseline product. Costs associated with product use (i.e., volume x price) increased roughly 220 percent and 160 percent for facilities 16 and 17, respectively.

Substitute Blanket Wash 26

Performance data indicate mixed results for Blanket Wash 26. Total costs per wash increased roughly 30 percent for facility 5, but decreased 6 percent at facility 15. Press operators at both facilities rated the performance of Blanket Wash 26 as good on the good-fair-poor scale for every one of its trials. Despite the fact that Blanket Wash 26 is priced higher than the baseline wash, differences in costs associated with product use (i.e., volume x price) did not contribute to the higher overall cost per wash at facility 5. Blanket Wash 26 is priced at $12.24/gallon compared to a price of $5.88/gallon for the baseline. Performance data indicate that the average quantity of blanket wash used at both facilities decreased by roughly 40 percent compared to the baseline. The savings experienced by facility 26 result from a 14 percent decrease in cleaning time compared to the baseline.

Substitute Blanket Wash 29

Using Blanket Wash 29 rather than the baseline, costs per press increased roughly 60 percent at both facilities 7 and 8. Blanket Wash 29 is priced three-times higher than the baseline, contributing significantly to the higher overall costs associated with its use. Costs associated with product use (i.e., volume x price) increase 300 percent and 230 percent at facilities 7 and 8 respectively due primarily to the products higher price. Blanket Wash 29 is priced at $18.00/gallon compared to a price of $5.88/gallon for the baseline. In addition, average cleaning times are higher for Blanket Wash 29 compared to the baseline for both facilities. Cleaning times increased 22 percent for facility 7 and 64 percent for facility 8.

Substitute Blanket Wash 30

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 30 instead of the baseline. Compared to the baseline, costs per wash increased roughly 60 percent at facility 18 and 20 percent at facility 19. Increased cleaning time was the primary contributor to the higher cost per wash for both facilities. According to the performance data, cleaning times at facility 18 increased from an average of 48 seconds for the baseline to an average of 82 seconds for Blanket Wash 30; however, this alternative was only tested under heavy ink coverage conditions and the baseline wash was observed under light and medium coverage conditions. The press operator at facility 19 commented that Blanket Wash 30 evaporated slowly; cleaning times for the alternative increased by roughly 30 percent, compared to the baseline. Press operators at both facilities commented that Blanket Wash 30 cut the ink well.

Substitute Blanket Wash 31

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 31 instead of the baseline. Compared to the baseline, costs per wash increased roughly 180 percent at facility 7 and 7 percent at facility 8. The press operator at facility 7 observed that drying times for Blanket Wash 31 were greater than the baseline; cleaning times averaged 140 seconds for Blanket Wash 31, compared to 45 seconds for the baseline product. The press operator at facility 8 experienced a decrease in cleaning time, but an increase in the quantity of blanket wash used. According to the performance data, cleaning times at facility 8 decreased by 4 percent compared to the baseline. The average quantity of blanket wash used, however, increases roughly 60 percent, off-setting the gains in labor savings. Press operators at both facilities indicated that Blanket Wash 31 cut the ink well.

Substitute Blanket Wash 32

Performance data indicate mixed results in the performance of Blanket Wash 32. Total costs per wash increased roughly 120 percent at facility 1, but decreased 20 percent at facility 5. Material costs (i.e., press wipes) contributed significantly to the higher costs per wash observed at facility 1. Costs associated with material use increased roughly 160 percent compared to the baseline. After eight blanket cleanings, facility 1 discontinued use of Blanket Wash 32 because an oily-residue remained on the blanket affecting subsequent print quality. Facility 5 reported lower cleaning times and reduced blanket wash use for Blanket Wash 32, compared to the baseline. Performance results indicate a 15 percent decrease in cleaning time and a 60 percent decrease in the quantity of blanket wash used for facility 5.

Substitute Blanket Wash 34

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 34 instead of the baseline; average costs per wash increased roughly 50 percent and 80 percent at facilities 1 and 19, respectively. Performance data indicate that costs associated with product use (i.e., volume x price) at facility 1 increased roughly 160 percent; however, the press operator at facility 1 rated the performance of Blanket Wash 34 as good on the good-fair-poor scale. This increase is completely attributable to the alternative product's higher price. Blanket Wash 34 is priced at $15/gallon compared to a price of $5.88/gallon for the baseline. The press operator at facility 19 commented that Blanket Wash 34 leaves a light residue on the blanket and does not readily soak into the press wipe. At facility 19, increased cleaning time is the single largest contributor to the higher average cost per wash of Blanket Wash 34; cleaning times averaged 67 seconds for Blanket Wash 31, compared to 41 seconds for the baseline product.

Substitute Blanket Wash 37

Performance data indicate a reduced financial cost when using Blanket Wash 37 instead of the baseline. Average costs per wash decreased roughly 13 percent and 7 percent at facilities 3 and 4, respectively. Overall costs per wash decreased due to reduced cleaning time and material use (i.e., press wipes). Compared to the baseline, cleaning times decreased roughly 20 percent at both facilities 3 and 4. After several days of usage, however, facility 4 discontinued use of Blanket Wash 37 because it caused uncoated paper to stick to the blankets.

Substitute Blanket Wash 38

Performance data indicate an increased financial cost when using Blanket Wash 38 instead of the baseline. Average costs per wash increased roughly 100 percent at facility 2 and 30 percent at facility 4. Costs associated with product use (i.e., volume x price) contributed significantly to the higher overall costs of using Blanket Wash 38. Specifically, compared to the baseline, costs associated with blanket wash use increased 400 percent at facility 2 and roughly 260 percent at facility 4 due primarily to Blanket Wash 38's high price. Blanket Wash 38 is priced at $19.00/gallon compared to $5.88/gallon for the baseline. Press operators at both facilities commented that Blanket Wash 38 left an oily-residue on the blanket with subsequent affects on print quality. Facility 2 discontinued use of the alternative after 1-1/2 days of use and facility 4 discontinued use of the product after six trials.

Substitute Blanket Wash 39

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 39 instead of the baseline. Costs at facilities 5 and 8 increased roughly 25 percent and 45 percent respectively when using Blanket Wash 39 instead of the baseline. Operators at both facilities commented that the alternative left an oily residue on the blanket, although no effect was noticed on print quality. Performance results indicated roughly a 40 percent increase in cleaning time at both facilities 5 and 8. Despite a 30 percent decrease in the average quantity of blanket wash used, the costs associated with product use (i.e., volume x price) did not vary between Blanket Wash 39 and the baseline. The manufacturer's price for product 39 is $12.35/gallon compared to $5.88/gallon for the baseline product.

Substitute Blanket Wash 40

Performance data indicate mixed results in the performance of Blanket Wash 40. Compared to the baseline, average costs increased roughly 35 percent at facility 1 but decreased 4 percent at facility 10. The higher cost experienced by facility 1 is attributable to Blanket Wash 40's higher price as well as an increase in the average number of press wipes used. The average quantity of blanket wash used by facility 1 is 2.5 ounces for both the alternative as well as the baseline; however, costs associated with blanket wash use (i.e., volume x price) increased roughly 80 percent due to Blanket Wash 40's higher price. The reduced costs experienced by facility 10 are attributable to a reduction in the average quantity of blanket wash used. Costs associated with product use decreased roughly 30 percent for facility 10. Press operators at both facilities commented that Blanket Wash 40 cut the ink well.

Summary of Cost Analysis for Blanket Wash 1

		Facility 3				Facility 6			
Facility Characteristics									
Press size		18" x 25"				18" x 25"			
Average ink coverage		Medium-Heavy				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 3				**Facility 6**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	37.5 (n=4)	+7.5	+25	30 (n=1)	51 (n=4)	+21	+70
	Cost ($)	0.28	0.35	+0.07	+25	0.28	0.47	+0.19	+70
Blanket Wash Use[2]	Average Quantity (oz.)	1.00 (n=1)	1.04 (n=14)	+0.04	+4	1.5 (n=1)	1.14 (n=8)	-0.36	-24
	Post Dilution Cost ($)	0.05	0.16	+0.11	+220	0.07	0.18	+0.11	+157
Materials and Equipment[2]	# wipes	2.0 (n=1)	1.6 (n=14)	-0.4	-20	1.0 (n=1)	2.0 (n=8)	+1.0	+100
	Cost ($)	0.22	0.18	-0.04	-18	0.11	0.22	+0.11	+100
Totals									
Total cost/wash ($)		0.55	0.69	+0.14	+25	0.46	0.87	+0.41	+89
Total cost/press[3] ($)		2.20	2.76	+0.56	+25	1.84	3.48	+1.64	+89
Total cost/press/ shift/year[4] ($)		5,500	6,900	+1,400	+25	4,600	8,700	+4,100	+89

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 6

		Facility 11				Facility 15			
Facility Characteristics									
Press size		19" x 26"				19" x 25"			
Average ink coverage		Medium-Heavy				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 11				**Facility 15**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	61 (n=4)	68 (n=8)	+7	+11	35 (n=2)	59 (n=4)	+24	+69
	Cost ($)	0.56	0.63	+0.07	+11	0.32	0.54	+0.22	+69
Blanket Wash Use[2]	Average Quantity (oz.)	0.73 (n=4)	0.88 (n=19)	+0.15	+21	1.5 (n=2)	1.1 (n=27)	-0.4	-27
	Post Dilution Cost ($)	0.03	0.08	+0.05	+167	0.07	0.11	+0.04	+57
Materials and Equipment[2]	# wipes	1.0 (n=4)	1.0 (n=19)	0	0	1.0 (n=2)	1.1 (n=27)	+0.1	+10
	Cost ($)	0.11	0.11	0	0	0.11	0.12	+0.01	+9
Totals									
Total cost/wash ($)		0.70	0.82	+0.12	+17	0.50	0.77	+0.27	+54
Total cost/press[3] ($)		2.80	3.28	+0.48	+17	2.00	3.08	+1.08	+54
Total cost/press/shift/year[4] ($)		7,000	8,200	+1,200	+17	5,000	7,700	+2,700	+54

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 9

		Facility 10				Facility 15			
Facility Characteristics									
Press size		19" x 28"				19" x 25"			
Average ink coverage		Medium				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 10				**Facility 15**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	60 (n=1)	165 (n=4)	+105	+175	35 (n=2)	80 (n=3)	+45	+129
	Cost ($)	0.55	1.52	+0.97	+175	0.32	0.74	+0.42	+129
Blanket Wash Use[2]	Average Quantity (oz.)	3.0 (n=1)	3.1 (n=4)	+0.1	+3	1.5 (n=2)	0.86 (n=24)	-0.64	-43
	Post Dilution Cost ($)	0.14	0.25	+0.11	+79	0.07	0.07	0	0
Materials and Equipment[2]	# wipes	2.0 (n=1)	2.8 (n=4)	+0.8	+40	1.0 (n=2)	1.0 (n=23)	0	0
	Cost ($)	0.22	0.31	+0.09	+41	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.91	2.08	+1.17	+129	0.50	0.92	+0.42	+84
Total cost/press[3] ($)		3.64	8.32	+4.68	+129	2.00	3.68	+1.68	+84
Total cost/press/shift/year[4] ($)		9,100	20,800	+11,700	+129	5,000	9,200	+4,200	+84

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 10

		Facility 3				Facility 4			
Facility Characteristics									
Press size		18" x 25"				40" x 34"			
Average ink coverage		Medium				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 3				**Facility 4**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	30 (n=4)	0	0	53 (n=2)	203 (n=4)	+150	+282
	Cost ($)	0.28	0.28	0	0	0.49	1.87	+1.38	+282
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	1.0 (n=4)	0	0	3.0 (n=2)	3.0 (n=4)	0	0
	Post Dilution Cost ($)	0.05	0.07	+0.02	+40	0.14	0.22	+0.08	+57
Materials and Equipment[2]	# wipes	2.0 (n=1)	2.0 (n=4)	0	0	2.0 (n=2)	1.0 (n=1)	-1	-50
	Cost ($)	0.22	0.22	0	0	0.22	0.11	-0.11	-50
Totals									
Total cost/wash ($)		0.55	0.57	+0.02	+4	0.85	2.20	+1.35	+159
Total cost/press[3] ($)		2.20	2.28	+0.08	+4	3.40	8.80	+5.40	+159
Total cost/press/shift/year[4] ($)		5,500	5,700	+200	+4	8,500	22,000	+13,500	+159

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 11

		Facility 1				Facility 2			
Facility Characteristics									
Press size		40" x 28"				13" x 18"			
Average ink coverage		Medium				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 1				**Facility 2**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	40 (n=2)	76 (n=7)	+36	+89	40 (n=3)	30 (n=2)	-10	-25
	Cost ($)	0.37	0.70	+0.33	+89	0.37	0.28	-0.09	-25
Blanket Wash Use[2]	Average Quantity (oz.)	2.50 (n=2)	2.61 (n=33)	+0.11	+4	1.17 (n=3)	1.44 (n=33)	+0.27	+23
	Post Dilution Cost ($)	0.11	0.25	+0.14	+127	0.05	0.14	+0.09	+180
Materials and Equipment[2]	# wipes	1.0 (n=2)	3.1 (n=33)	+2.1	+210	1.0 (n=3)	2.4 (n=33)	+1.4	+140
	Cost ($)	0.11	0.34	+0.23	+209	0.11	0.26	+0.15	+136
Totals									
Total cost/wash ($)		0.59	1.29	+0.70	+119	0.53	0.68	+0.15	+28
Total cost/press[3] ($)		2.36	5.16	+2.80	+119	2.12	2.72	+0.60	+28
Total cost/press/shift/year[4] ($)		5,900	12,900	+7,000	+119	5,300	6,800	+1,500	+28

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 12

	Facility 12	Facility 13
Facility Characteristics		
Press size	28" x 40"	20" x 26"
Average ink coverage	Medium	Medium
Dilution ratio (water:wash)	1:1	1:1

Cost Element per Blanket Wash		Facility 12				Facility 13			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	44 (n=6)	48 (n=5)	+4	+9	60 (n=3)	62.5 (n=4)	+2.5	+4
	Cost ($)	0.41	0.44	+0.03	+9	0.55	0.58	+0.03	+4
Blanket Wash Use[2]	Average Quantity (oz.)	4.42 (n=6)	2.54 (n=28)	-1.88	-43	2.33 (n=3)	0.86 (n=23)	-1.47	-63
	Post Dilution Cost ($)	0.20	0.32	+0.12	+60	0.11	0.11	0	0
Materials and Equipment[2]	# wipes	1.8 (n=6)	2.1 (n=27)	+0.3	+17	1.3 (n=3)	1.3 (n=23)	0	0
	Cost ($)	0.20	0.23	+0.03	+15	0.14	0.14	0	0
Totals									
Total cost/wash ($)		0.81	0.99	+0.18	+22	0.80	0.83	+0.03	+4
Total cost/press[3] ($)		3.24	3.96	+0.72	+22	3.20	3.32	+0.12	+4
Total cost/press/shift/year[4] ($)		8,100	9,900	+1,800	+22	8,000	8,300	+300	+4

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.

[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.

[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.

[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 14

		Facility 6				Facility 16			
Facility Characteristics									
Press size		18" x 25"				20" x 26"			
Average ink coverage		Medium				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 6				**Facility 16**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	90 (n=3)	+60	+200	50 (n=2)	42 (n=6)	-8	-16
	Cost ($)	0.28	0.83	+0.55	+200	0.46	0.39	-0.07	-16
Blanket Wash Use[2]	Average Quantity (oz.)	1.50 (n=1)	1.25 (n=18)	-0.25	-17	2 (n=2)	2.8 (n=40)	+0.8	+40
	Post Dilution Cost ($)	0.07	0.09	+0.02	+29	0.09	0.21	+0.12	+133
Materials and Equipment[2]	# wipes	1.0 (n=1)	1.3 (n=18)	+0.3	+30	1.0 (n=2)	2.0 (n=40)	+1.0	+100
	Cost ($)	0.11	0.15	+0.04	+36	0.11	0.22	+0.11	+100
Totals									
Total cost/wash ($)		0.46	1.07	+0.61	+133	0.66	0.82	+0.16	+24
Total cost/press[3] ($)		1.84	4.28	+2.44	+133	2.64	3.28	+0.64	+24
Total cost/press/shift/year[4] ($)		4,600	10,700	+6,100	+133	6,600	8,200	+1,600	+24

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 19

		Facility 18				Facility 19			
Facility Characteristics									
Press size		19" x 26"				19" x 26"			
Average ink coverage		Medium-Heavy				Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 18				**Facility 19**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	48 (n=6)	118 (n=5)	+70	+146	41 (n=5)	66 (n=8)	+25	+61
	Cost ($)	0.44	1.09	+0.65	+146	0.38	0.61	+0.23	+61
Blanket Wash Use[2]	Average Quantity (oz.)	1.5 (n=6)	3.0 (n=10)	+1.5	+100	0.9 (n=5)	1.7 (n=16)	+0.8	+89
	Post Dilution Cost ($)	0.07	0.28	+0.21	+300	0.04	0.16	+0.12	+300
Materials and Equipment[2]	# wipes	1.0 (n=6)	2.6 (n=10)	+1.6	+160	1.0 (n=5)	1.1 (n=16)	+0.1	+10
	Cost ($)	0.11	0.29	+0.18	+164	0.11	0.12	+0.01	+9
Totals									
Total cost/wash ($)		0.62	1.66	+1.04	+168	0.53	0.89	+0.36	+68
Total cost/press[3] ($)		2.48	6.64	+4.16	+168	2.12	3.56	+1.44	+68
Total cost/press/shift/year[4] ($)		6,200	16,600	+10,400	+168	5,300	8,900	+3,600	+68

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 20

		Facility 11				Facility 12			
Facility Characteristics									
Press size		19" x 26"				28" x 40"			
Average ink coverage		Medium-Heavy				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 11				**Facility 12**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	61 (n=4)	96 (n=7)	+35	+57	44 (n=6)	120 (n=1)	+76	+173
	Cost ($)	0.56	0.88	+0.32	+57	0.41	1.11	+0.70	+173
Blanket Wash Use[2]	Average Quantity (oz.)	0.7 (n=4)	1.3 (n=24)	+0.6	+86	4.4 (n=6)	3.0 (n=1)	-1.4	-32
	Post Dilution Cost ($)	0.03	0.11	+0.08	+267	0.20	0.25	+0.05	+25
Materials and Equipment[2]	# wipes	1.0 (n=4)	1.3 (n=24)	+0.3	+30	1.8 (n=6)	2.0 (n=1)	+0.2	+11
	Cost ($)	0.11	0.14	+0.03	+27	0.20	0.22	+0.02	+10
Totals									
Total cost/wash ($)		0.70	1.13	+0.43	+61	0.81	1.58	+0.77	+95
Total cost/press[3] ($)		2.80	4.52	+1.72	+61	3.24	6.32	+3.08	+95
Total cost/press/shift/year[4] ($)		7,000	11,300	+4,300	+61	8,100	15,800	+7,700	+95

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 21

		Facility 6				**Facility 17**			
Facility Characteristics									
Press size		18" x 25"				19" x 26"			
Average ink coverage		Medium				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 6				**Facility 17**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	62 (n=5)	+32	+107	25 (n=5)	38 (n=9)	+13	+52
	Cost ($)	0.28	0.57	+0.29	+107	0.23	0.35	+0.12	+52
Blanket Wash Use[2]	Average Quantity (oz.)	1.5 (n=1)	2.0 (n=6)	+0.5	+33	1.5 (n=5)	1.4 (n=34)	-0.1	-7
	Post Dilution Cost ($)	0.07	0.16	+0.09	+129	0.07	0.11	+0.04	+57
Materials and Equipment[2]	# wipes	1.0 (n=1)	2.5 (n=6)	+1.5	+150	1.0 (n=5)	1.1 (n=34)	+0.1	+10
	Cost ($)	0.11	0.28	+0.17	+155	0.11	0.12	+0.01	+9
Totals									
Total cost/wash ($)		0.46	1.01	+0.55	+120	0.41	0.58	+0.17	+41
Total cost/press[3] ($)		1.84	4.04	+2.20	+120	1.64	2.32	+0.68	+41
Total cost/press/shift/year[4] ($)		4,600	10,100	+5,500	+120	4,100	5,800	+1,700	+41

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 22

		Facility 12				Facility 13			
Facility Characteristics									
Press size		28" x 40"				20" x 26"			
Average ink coverage		Medium-Heavy				Medium			
Dilution ratio (water:wash)		1:4				1:4			
Cost Element per Blanket Wash									
		Facility 12				**Facility 13**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	44 (n=6)	28 (n=4)	-16	-36	60 (n=3)	100 (n=3)	+40	+67
	Cost ($)	0.41	0.26	-0.15	-36	0.55	0.92	+0.37	+67
Blanket Wash Use[2]	Average Quantity (oz.)	4.4 (n=6)	2.9 (n=13)	-1.5	-34	2.3 (n=3)	2.7 (n=20)	+0.4	+17
	Post Dilution Cost ($)	0.20	0.30	+0.10	+50	0.11	0.28	+0.17	+155
Materials and Equipment[2]	# wipes	1.8 (n=6)	2.4 (n=12)	+0.6	+33	1.3 (n=3)	2.8 (n=20)	+1.5	+115
	Cost ($)	0.20	0.26	+0.06	+30	0.14	0.31	+0.17	+121
Totals									
Total cost/wash ($)		0.81	0.82	+0.01	+1	0.80	1.51	+0.71	+89
Total cost/press[3] ($)		3.24	3.28	+0.04	+1	3.20	6.04	+2.84	+89
Total cost/press/shift/year[4] ($)		8,100	8,200	+100	+1	8,000	15,100	+7,100	+89

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 24

		Facility 16				Facility 17			
Facility Characteristics									
Press size		20" x 26"				19" x 26"			
Average ink coverage		Heavy				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 16				**Facility 17**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	50 (n=2)	59 (n=7)	+9	+18	25 (n=5)	64 (n=4)	+39	+156
	Cost ($)	0.46	0.54	+0.08	+18	0.23	0.59	+0.36	+156
Blanket Wash Use[2]	Average Quantity (oz.)	2 (n=2)	2.06 (n=35)	+0.06	+3	1.5 (n=5)	1.3 (n=4)	-0.2	-13
	Post Dilution Cost ($)	0.09	0.29	+0.20	+222	0.07	0.18	+0.11	+157
Materials and Equipment[2]	# wipes	1 (n=2)	1.3 (n=34)	+0.3	+30	1.0 (n=5)	1.0 (n=3)	0	0
	Cost ($)	0.11	0.14	+0.03	+27	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.66	0.97	+0.31	+47	0.41	0.88	+0.47	+115
Total cost/press[3] ($)		2.64	3.88	+1.24	+47	1.64	3.52	+1.88	+115
Total cost/press/shift/year[4] ($)		6,600	9,700	+3,100	+47	4,100	8,800	+4,700	+115

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 26

		Facility 5				Facility 15			
Facility Characteristics									
Press size		12" x 18"				19" x 25"			
Average ink coverage		Medium				Medium-Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 5				**Facility 15**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	60 (n=4)	+30	+100	35 (n=2)	30 (n=3)	-5	-14
	Cost ($)	0.28	0.55	+0.27	+100	0.32	0.28	-0.04	-14
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	0.56 (n=18)	-0.44	-44	1.50 (n=2)	0.85 (n=25)	-0.65	-43
	Post Dilution Cost ($)	0.05	0.05	0	0	0.07	0.08	+0.01	+14
Materials and Equipment[2]	# wipes	2.0 (n=1)	1.2 (n=18)	-0.8	-40	1.0 (n=2)	1.0 (n=25)	0	0
	Cost ($)	0.22	0.13	-0.07	-32	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.55	0.73	+0.18	+33	0.50	0.47	-0.03	-6
Total cost/press[3] ($)		2.20	2.92	+0.72	+33	2.00	1.88	-0.12	-6
Total cost/press/shift/year[4] ($)		5,500	7,300	+1,800	+33	5,000	4,700	-300	-6

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 29

		Facility 7				Facility 8			
Facility Characteristics									
Press size		20" x 26"				20" x 26"			
Average ink coverage		Medium				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 7				**Facility 8**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	45 (n=1)	55 (n=4)	+10	+22	45 (n=4)	74 (n=14)	+29	+64
	Cost ($)	0.41	0.51	+0.10	+22	0.41	0.68	+0.27	+64
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	1.4 (n=8)	+0.4	+40	0.7 (n=4)	0.7 (n=50)	0	0
	Post Dilution Cost ($)	0.05	0.20	+0.15	+300	0.03	0.10	+0.07	+233
Materials and Equipment[2]	# wipes	1.0 (n=1)	2.0 (n=5)	+1.0	+100	1.0 (n=4)	1.0 (n=50)	0	0
	Cost ($)	0.11	0.22	+0.11	+100	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.57	0.93	+0.36	+63	0.55	0.89	+0.34	+62
Total cost/press[3] ($)		2.28	3.72	+1.44	+63	2.20	3.56	+1.36	+62
Total cost/press/shift/year[4] ($)		5,700	9,300	+3,600	+63	5,500	8,900	+3,400	+62

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 30

		Facility 18				Facility 19			
Facility Characteristics									
Press size		19" x 26"				19" x 26"			
Average ink coverage		Medium				Heavy			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 18				**Facility 19**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	48 (n=6)	82 (n=3)	+34	+71	41 (n=5)	52 (n=6)	+11	+26
	Cost ($)	0.44	0.76	+0.32	+71	0.38	0.48	+0.10	+26
Blanket Wash Use[2]	Average Quantity (oz.)	1.53 (n=6)	2.95 (n=6)	+1.42	+93	0.88 (n=5)	0.74 (n=14)	-0.14	-16
	Post Dilution Cost ($)	0.07	0.12	+0.05	+171	0.04	0.03	-0.01	-25
Materials and Equipment[2]	# wipes	1.0 (n=6)	1.2 (n=6)	+0.2	+20	1.0 (n=5)	1.0 (n=14)	0	0
	Cost ($)	0.11	0.13	0.02	+18	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.62	1.01	+0.39	+63	0.53	0.62	+0.09	+17
Total cost/press[3] ($)		2.48	4.04	+1.56	+63	2.12	2.48	+0.36	+17
Total cost/press/shift/year[4] ($)		6,200	10,100	+3,900	+63	5,300	6,200	+900	+17

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 31

		Facility 7				Facility 8			
Facility Characteristics									
Press size		20" x 26"				20" x 26"			
Average ink coverage		Medium				Light-Medium			
Dilution rate (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 7				**Facility 8**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	45 (n=1)	140 (n=3)	+95	+211	45 (n=4)	43 (n=4)	-2	-4
	Cost ($)	0.41	1.29	+0.88	+21	0.41	0.40	-0.01	-4
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	1.0 (n=3)	0	0	0.7 (n=4)	1.1 (n=65)	+0.4	+57
	Post Dilution Cost ($)	0.05	0.08	+0.03	+60	0.03	0.08	+0.05	+167
Materials and Equipment[2]	# wipes	1.0 (n=1)	2.0 (n=2)	+1.0	+100	1.0 (n=4)	1.0 (n=65)	0	0
	Cost ($)	0.11	0.22	+0.11	+100	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.57	1.59	+1.02	+179	0.55	0.59	+0.04	+7
Total cost/press[3] ($)		2.28	6.36	+4.08	+179	2.20	2.36	+0.16	+7
Total cost/press/shift/year[4] ($)		5,700	15,900	+10,200	+179	5,500	5,900	+400	+7

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 32

		Facility 1				Facility 5			
Facility Characteristics									
Press size		40" x 28"				12" x 18"			
Average ink coverage		Medium				Medium			
Dilution rate (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 1				**Facility 5**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	40 (n=2)	105 (n=4)	+70	+162	40 (n=3)	34 (n=4)	-6	-15
	Cost ($)	0.37	0.97	+0.6	+162	0.37	0.31	-0.06	-15
Blanket Wash Use[2]	Average Quantity (oz.)	2.5 (n=2)	2.5 (n=8)	0	0	1.17 (n=3)	0.63 (n=16)	-0.67	-57
	Post Dilution Cost ($)	0.11	0.06	-0.05	-45	0.05	0.01	-0.04	-80
Materials and Equipment[2]	# wipes	1.0 (n=2)	2.5 (n=8)	+1.5	+150	1.0 (n=3)	1.0 (n=13)	0	0
	Cost ($)	0.11	0.28	+0.17	+155	0.11	0.11	0	0
Totals									
Total cost/wash ($)		0.59	1.31	+0.72	+122	0.53	0.43	-0.10	-19
Total cost/press[3] ($)		2.36	5.24	+2.88	+122	2.12	1.72	-0.40	-19
Total cost/press/shift/year[4] ($)		5,900	13,100	+7,200	+122	5,300	4,300	-1,000	-19

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 34

		Facility 1				Facility 19			
Facility Characteristics									
Press size		40" x 28"				19" x 26"			
Average ink coverage		Medium				Medium			
Dilution rate (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 1				**Facility 19**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor	Time spent cleaning (sec.)[2]	40 (n=2)	40 (n=4)	0	0	41 (n=5)	67 (n=13)	+26	+63
	Cost ($)	0.37	0.37	0	0	0.38	0.62	+0.24	+63
Blanket Wash Use	Average Quantity (oz.)	2.5 (n=2)	2.5 (n=41)	0	0	0.88 (n=5)	1.23 (n=13)	+0.35	+40
	Post Dilution Cost ($)	0.11	0.29	+0.18	+164	0.04	0.14	+0.10	+250
Materials and Equipment	# wipes	1.0 (n=2)	2.1 (n=41)	+1.1	+110	1.0 (n=5)	1.8 (n=13)	+0.8	+80
	Cost ($)	0.11	0.23	+0.12	+109	0.11	0.19	+0.08	+73
Totals									
Total cost/wash ($)		0.59	0.89	+0.3	+51	0.53	0.95	+0.42	+79
Total cost/press[3] ($)		2.36	3.56	+1.20	+51	2.12	3.80	+1.68	+79
Total cost/press/shift/year[4] ($)		5,900	8,900	+3,000	+51	5,300	9,500	+4,200	+79

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 37

		Facility 3				Facility 4			
Facility Characteristics									
Press size		18" x 25"				40" x 34"			
Average ink coverage		Medium-Heavy				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 3				**Facility 4**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	24 (n=5)	-6	-20	53 (n=2)	42 (n=5)	-11	-21
	Cost ($)	0.28	0.22	-0.06	-20	0.49	0.39	-0.10	-21
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	1.16 (n=22)	+0.16	+16	3.0 (n=2)	2.14 (n=11)	-0.86	-29
	Post Dilution Cost ($)	0.05	0.13	+0.08	+160	0.14	0.25	+0.11	+79
Materials and Equipment[2]	# wipes	2.0 (n=1)	1.2 (n=22)	-0.8	-40	2.0 (n=2)	1.4 (n=8)	-0.6	-30
	Cost ($)	0.22	0.13	-0.09	-41	0.22	0.15	-0.07	-32
Totals									
Total cost/wash ($)		0.55	0.48	-0.07	-13	0.85	0.79	-0.06	-7
Total cost/press[3] ($)		2.20	1.92	-0.28	-13	3.40	3.16	-0.24	-7
Total cost/press/shift/year[4] ($)		5,500	4,800	-700	-13	8,500	7,900	-600	-7

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 38

		Facility 2				Facility 4			
Facility Characteristics									
Press size		13" x 18"				40" x 34"			
Average ink coverage		Medium				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 2				**Facility 4**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	40 (n=3)	65 (n=6)	+25	+62	53 (n=2)	45 (n=4)	-8	-15
	Cost ($)	0.37	0.60	+0.23	+62	0.49	0.41	-0.08	-15
Blanket Wash Use[2]	Average Quantity (oz.)	1.17 (n=3)	1.68 (n=15)	+0.51	+44	3.0 (n=2)	3.4 (n=10)	+0.4	+13
	Post Dilution Cost ($)	0.05	0.25	+0.20	+400	0.14	0.50	+0.36	+257
Materials and Equipment[2]	# wipes	1.0 (n=3)	2.1 (n=15)	+1.1	+110	2.0 (n=2)	1.8 (n=9)	-0.2	-10
	Cost ($)	0.11	0.23	+0.12	+109	0.22	0.20	-0.02	-9
Totals									
Total cost/wash ($)		0.53	1.08	+0.55	+104	0.85	1.11	+0.26	+31
Total cost/press[3] ($)		2.12	4.32	+2.20	+104	3.40	4.44	+1.04	+31
Total cost/press/shift/year[4] ($)		5,300	10,800	+5,500	+104	8,500	11,100	+2,600	+31

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 39

		Facility 5				Facility 8			
Facility Characteristics									
Press size		12" x 18"				20" x 26"			
Average ink coverage		Medium				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 5				**Facility 8**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	30 (n=1)	43 (n=4)	+13	+43	45 (n=4)	63 (n=4)	+18	+40
	Cost ($)	0.28	0.40	+0.12	+43	0.41	0.58	+0.17	+40
Blanket Wash Use[2]	Average Quantity (oz.)	1.0 (n=1)	0.69 (n=36)	-0.31	-31	0.70 (n=4)	1.22 (n=9)	+0.52	+74
	Post Dilution Cost ($)	0.05	0.05	0	0	0.03	0.09	+0.06	+200
Materials and Equipment[2]	# wipes	2.0 (n=1)	2.2 (n=36)	+0.2	+10	1.0 (n=4)	1.2 (n=9)	+0.2	+20
	Cost ($)	0.22	0.24	+0.02	+9	0.11	0.13	+0.02	+18
Totals									
Total cost/wash ($)		0.55	0.69	+0.14	+25	0.55	0.80	+0.25	+45
Total cost/press[3] ($)		2.20	2.76	+0.56	+25	2.20	3.20	+1.00	+45
Total cost/press/shift/year[4] ($)		5,500	6,900	+1,400	+25	5,500	8,000	+2,500	+45

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.
[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.
[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.
[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

Summary of Cost Analysis for Blanket Wash 40

		Facility 1				Facility 10			
Facility Characteristics									
Press size		40" x 28"				19" x 28"			
Average ink coverage		Light-Medium				Medium			
Dilution ratio (water:wash)		0				0			
Cost Element per Blanket Wash									
		Facility 1				**Facility 10**			
		Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]	Baseline Wash	Alternative Wash	Absolute Difference[1]	Percentage Difference[1]
Labor[2]	Time spent cleaning (sec.)	40 (n=2)	40 (n=4)	0	0	60 (n=1)	60 (n=5)	0	0
	Cost ($)	0.37	0.37	0	0	0.55	0.55	0	0
Blanket Wash Use[2]	Average Quantity (oz.)	2.5 (n=2)	2.5 (n=10)	0	0	3.0 (n=1)	1.2 (n=11)	-1.8	-60
	Post Dilution Cost ($)	0.11	0.20	+0.09	+82	0.14	0.10	-0.04	-29
Materials and Equipment[2]	# wipes	1.0 (n=2)	2.0 (n=10)	+1.0	+100	2.0 (n=1)	2.0 (n=10)	0	0
	Cost ($)	0.11	0.22	+0.11	+100	0.22	0.22	0	0
Totals									
Total cost/wash ($)		0.59	0.79	+0.20	+34	0.91	0.87	-0.04	-4
Total cost/press[3] ($)		2.36	3.16	+0.80	+34	3.64	3.48	-0.16	-4
Total cost/press/shift/year[4] ($)		5,900	7,900	+2,000	+34	9,100	8,700	-400	-4

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the time, quantity, number of wipes, or cost when using the alternative blanket cleaner instead of the base product.

[2] "n" denotes the number of observations used in calculating average time, quantity, and number of wipes.

[3] Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.

[4] The following assumptions were made in generating a total cost/press/shift/year: 1) Each press is washed 10 times per shift, and 2) Work is performed in 8 hour shifts, 5 days per week and 50 weeks per year.

4.3 INTERNATIONAL TRADE ISSUES

Historically, foreign competition within the U.S. lithographic blanket wash industry has been limited due to the dominance of domestic suppliers as well as several barriers to import, including: 1) disparities in petroleum prices favoring U.S. manufacturers; 2) transportation expenses and import duties; and 3) paperwork requirements such as Material Safety Data Sheets (MSDS) and Toxic Substances Control Act (TSCA) reporting requirements.[1] Barriers also exist for U.S. companies seeking to enter foreign markets. U.S. manufacturers will often require a local distributing partner which invariably raises the selling price of the product, further reducing their profit margins.[2]

According to industry sources, very few companies compete on an international basis within the blanket wash industry. International competition within the U.S., however, is anticipated to increase as greater emphasis is placed on low-VOC, environmentally friendly washes.[3,4] Low VOC washes, which do not rely upon the relatively inexpensive raw materials of traditional washes, allow foreign competitors to profitably export blanket wash products to the United States. Upon arrival, concentrated blanket washes are often diluted by local blending companies and shipped to market. According to industry sources, European manufacturers are major competitors in the "green" segment of the blanket wash market, with Denmark leading the conversion to environmentally preferable washes.[5,6]

4.3.1 International Trade of Petroleum-based Blanket Washes

According to industry contacts, high-VOC, petroleum-based washes are the dominant blanket wash product worldwide because of their low cost and good performance. Imports of traditional, petroleum-based blanket washes into the United States, however, have been limited. Industry contacts cite two primary reasons for the limited import of blanket washes: 1) refining capabilities in the United States are sufficient to satisfy domestic production needs and are often superior to foreign capabilities, and 2) prohibitive costs resulting from tariffs and transportation expenses reduce potential profits for imports.[7] The potential for the export of petroleum-based washes from the United States, however, is much greater.

According to industry sources, petroleum-based blanket washes are being exported from the U.S. in significantly greater quantities than are being imported. For example, Varn International is currently generating in excess of fifty-percent of their blanket wash sales from products manufactured in the United States and exported abroad. Varn does not import any cleaning solvents into the U.S. market. The main export destinations for Varn’s blanket wash products include: Mexico, the Caribbean, Central and South America, Japan, Korea, and Taiwan. In addition to Varn, several other U.S. companies are exporting blanket washes to foreign markets, including: Prisco, Printex, Anchor/Lithkemko, Rycoline, and RBP Chemical. These blanket wash manufacturers are exporting their products to various destinations throughout the world. For example, Anchor/Lithkemko exports petroleum-based blanket washes to Europe, Australia, and the Far East; Prisco exports to Europe, Mexico, and Canada; RBP Chemical exports small quantities of blanket washes to Canada and the Philippines, and Printex exports to Europe, Canada, and Korea.[8,9]

The largest markets for printed materials and therefore blanket washes are the United States, Japan, and Germany; however, the fastest growing markets are located in Asia and Central and South America.[10] Recently, Varn has been focusing their foreign trade efforts on Central and South American nations as their governments continue to relax barriers to foreign trade. Significant growth is said to be occurring in these markets, although any growth can be considered significant since current levels of importation are extremely low. The Varn representative also indicated that sales to Pacific Rim nations, such as Korea and Taiwan, are holding steady or increasing because of their expanding markets for printed materials as well as the relaxing of import restrictions.[11] Representatives of both Varn and Anchor identified difficulties in penetrating the Japanese market because of the many import restrictions as well as the strong ethic to purchase locally.[12,13] Foreign companies attempting to enter the Japanese market would require a strong relation with a local distributing partner in order to successfully enter the Japanese market.[14] According to a representative of Varn, sales to Japan are down and have been steadily decreasing over the past several years.[15]

4.3.2 International Trade of "Low VOC" Blanket Washes

Spurred by concerns regarding the release of VOCs as well as health and safety concerns associated with the use of petroleum-based blanket washes, U.S. and foreign blanket wash manufacturers have developed a range of low-VOC washes, providing an alternative to "traditional," petroleum-based washes. A wide range of low-VOC washes are currently available in the United States, several of which are manufactured or developed abroad. According to industry contacts, low-VOC washes are more likely to be imported into the U.S. market than are petroleum-based washes because of the higher valued raw materials that go into their production. Currently, low-VOC, low toxicity washes control a small portion of the total international blanket wash market. Denmark has proven to be leader in the transition to alternative blanket washes, with an estimated 30 percent of their offset-printing shops using vegetable-based washing agents.[16]

Petroleum-based washes dominate the blanket wash market worldwide; however, the European community has made a significant investment in promoting the use of "alternative" blanket washes, with special emphasis on the use of vegetable-oil technology. It is estimated that 30 percent of Danish offset-printing shops and 5-10 percent of German offset-printing shops currently employ vegetable-based washes to some degree. To further promote their use, the European parliament has allocated roughly 2 million European Currency Units (ECU) or approximately $2.7 million to train printers in the use of vegetable-based washes, and collect and disseminate information on technical, ecological, and economic aspects of the substitution of petroleum-based washes. The Subsprint project, which has full responsibility for promoting the vegetable technology, was established in 1993 and is expected to last three years.[17] According to a representative of Varn International, based in the United Kingdom, health and safety concerns have been the primary impetus behind the promotion of vegetable-oil based washes in Europe. This is in contrast to the United States, where air quality concerns have been the driving force behind the development of alternative washes.[18]

4.3.3 Joint Ventures Impacting the International Trade of Blanket Washes

In addition to the export of blanket wash products from the United States, North American companies have penetrated foreign markets through joint ventures with foreign companies. For example, Deluxe Corporation, one of the largest printers in the United States, has entered into an agreement with Coates Lorilleux S.A., a Paris-based company, to manufacture and distribute its Printwise ink system throughout Europe and beyond. The Deluxe ink is a vegetable oil-based lithographic ink that can be converted into a water-soluble form after printing is complete. Once the conversion has occurred, the water-soluble ink can be removed with a water-based blanket cleaning solution; thereby, eliminating the need for traditional cleaning solvents containing VOCs. The vegetable oil-based ink and water-based blanket wash together compose the Printwise ink "system".

Flint Ink, under exclusive agreement with Unichema International, has recently begun marketing a vegetable-oil-based press cleaner. Unichema International, based in the Netherlands, developed the product at its laboratories in the Netherlands and first introduced the wash into the European market in 1993. Recently, Flint Ink entered into an exclusive agreement with Unichema to market the product in the United States.

Conclusions

Few companies are involved in international trade in blanket washes (both petroleum based and lower-VOC washes). By and large, petroleum-based blanket wash products are dominant in both the domestic and international printing industry with relatively little importation of such products into the United States. U.S. manufacturers are currently exporting blanket wash products worldwide with growing markets in Asia and the Americas. Although petroleum-based blanket wash products dominate the blanket wash industry, low-VOC products are also a growth area in response to air quality concerns in the United States and health and safety concerns in Europe. Vegetable-oil-based products are more likely to be imported into the United States because they are competitively priced with similar U.S. made products. The markets for these products are expected to grow as a result of U.S. joint ventures with European manufacturers.

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Chapter 5
Conservation

Chapter Contents

This chapter discusses energy and natural resource issues associated with using the various substitute blanket washes for lithography. The first part of this chapter focuses on the blanket washing process. Standard shop practices such as the amount of blanket wash consumed, the dilution of the blanket wash, the number of shop wipes used, and the method of wipe management are examined in terms of how they affect energy and natural resource consumption. The chapter then moves on to encompass the entire life cycle of the blanket wash formulations. Chemical composition, product formulation and packaging, and waste disposal are all considered part of the blanket wash life cycle, and their impacts on energy and natural resources are discussed. The energy and natural resource trade-offs that exist when considering standard shop practices and life cycle issues are summarized.

5.1 ENERGY AND RESOURCE CONSERVATION DURING THE BLANKET WASHING PROCESS

Energy and resource conservation are increasingly important goals for all industry sectors, particularly as global industrialization creates more demand for limited resources. Although the blanket washing process is not particularly energy- or resource-intensive, a printer can still help conserve energy and resources through his or her choice of blanket washing products and the manner in which the products are used. These choices have environmental implications not only in the lithographic print shop, but also upstream and downstream in the product life cycle. From an environmental perspective, the life cycle of any product begins with the extraction of raw materials from the environment, and continues on through the manufacture, transportation, use, recycle, and disposal of the product. Each stage within this life cycle consumes both energy and natural resources. This section focusses primarily on energy and natural resource conservation during the blanket washing process, but also considers some of the life-cycle energy and natural resource issues associated with alternative blanket wash products.

To assess the effects alternatives have on the rates of energy and natural resource consumption during the blanket washing process, specific data were gathered during performance demonstrations. The following data were initially requested using the performance survey tool presented in Appendix D:

- the amount of chemical product consumed during each blanket washing step
- the dilution of the product
- manual or automatic rotation of blanket during washing
- the number of shop wipes required to attain an adequate level of cleanliness
- the size of the wipe and whether it is disposable or reusable
- the size of the blanket and ink coverage
- method of wipe management
- quantity of waste print run

Though much of these data were collected, statistically meaningful conclusions could not be drawn from the compiled data. Ink coverage, chemical wash volumes applied, and operator variations, just to name a few possibilities, introduced enough uncertainty and variability to prevent the formulation of quantifiable conclusions. Discussed below, however, are energy and resource conservation issues to consider when cleaning the blanket and purchasing blanket washing products.

The primary resources consumed or used during the blanket washing process include the blanket wash product itself, disposable or reusable wipes, and the waste print run required to attain adequate print quality following blanket washing. The use of disposable or reusable wipes and the amount of waste print run also are important from an energy conservation perspective.

Some blanket washing methods may require the use of a greater amount of chemical wash than others. The amount of chemical wash required to clean the blanket should be optimized to the extent possible, whether the process is automated or manual, to avoid unnecessary use of resources. Optimization depends on the chemical product selected for blanket washing, the extent of ink coverage on the blanket, the washing technique employed, the time allowed for the ink to dry before cleaning, as well as other factors. Changes in the standard operating procedures and cleaning techniques should be conducted to identify optimal parameters. Potential changes can be identified through case studies, discussions with other printers at association meetings and seminars, and other sources.

The use of reusable or disposable wipes to wash the blanket is of importance when considering both energy and natural resource consumption. Reusable wipes, though viewed by many as an act of conserving natural resources, consume a considerable quantity of energy, water, and chemical cleaning agents to clean and prepare them for reuse. Cleaning of reusable wipes via dry-cleaning or aqueous processes uses natural resources such as solvents for dry cleaning, water for aqueous laundering, and detergents. Energy to heat the cleaning solutions, as well as dry and press the wipes, all require significant energy inputs. The disposable wipes consume energy and natural resources in their manufacture and natural resources in their single-use applications, as well as create a solid waste disposal issue (addressed below, Disposal).

Without quantifying the rates of energy and resource consumption throughout their life cycles, it is unclear which is the preferred wipe from the perspective of energy and natural resources use. Standard practices within the print shop, however, can minimize the consumption of energy and natural resources. Optimizing the use of wipes (whether reusable or disposable) should be strived for in the shop; proper management of the used wipes should be followed (see Disposal, below); and when using reusable wipes, influencing the supplier to optimize energy, water, and chemical detergent use offers an opportunity for printers to influence the product chain of which they are a part.

Energy consumption during the blanket washing process itself is negligible for the manual blanket cleaning methods employed by small print shops that were the focus of this CTSA. These blanket washing procedures typically rotate the blanket manually while applying and wiping the wash from the blanket to remove the ink. This practice conserves energy while maintaining safe working conditions. Energy and natural resources are consumed, however, during the waste print run. Whether the blanket is washed manually or automatically, a waste print run is required to attain adequate print quality following blanket washing. Minimization of these waste runs will minimize both energy and natural resource consumption.

5.2 ENERGY AND RESOURCE CONSERVATION BASED ON CHEMICAL COMPOSITION, FORMULATIONS, AND PACKAGING

The chemical composition of a blanket wash product, the manner in which the product is formulated, and the type of packaging all influence the overall rates of energy and resource consumption of a blanket washing product. These issues are particularly important from a life-cycle perspective, as discussed below.

Chemical Composition

Chemicals used in the formulations of blanket washing products are derived from a variety of raw materials. Solvents traditionally used in blanket washing products are derived from petroleum or natural gas; categories such as the mineral spirits and aromatic hydrocarbons are examples of these solvents. Other chemicals can be derived from plant products; fatty acid derivatives and select examples of the terpenes categories are examples of these chemicals.

The extraction, processing and transportation of these various raw materials result in different energy consumption and natural resource use issues. Petrochemical raw materials originate from crude oil which must be pumped from reserves deep in the earth. These reserves are typically transferred via pipeline to processing facilities (refineries) where large quantities of energy are used to separate and react the crude oil into various petrochemical products and by-products. The use of petroleum for the production of solvents, however, is small when compared to the amount of petroleum consumed as fuel.

This consumption of energy must be contrasted with the energy used to harvest, transport, and process plants into chemical raw materials. Plants and fruits are seasonally harvested in various regions of the U.S. and abroad. Transport to the processing facilities is by truck or rail. These raw materials are then chemically and mechanically processed to extract the desired chemical products. Some of these processes utilize petrochemical products to extract the desired chemicals from the plant. Some plant and fruit sources are by-products from the food processing industry, and are therefore taken from a stream that may traditionally be viewed as a waste.

The depletion of non-renewable resources, such as petroleum, is of importance when considering natural resource consumption. Renewable resources, such as plant-derived chemicals, do not require extensive use of non-renewable fuels for extraction and production. From the representative generic formulations applied in the performance demonstrations, however, products often mix non-renewable and renewable chemical raw materials in one formulation.

Product Formulation and Packaging

When contacted, manufacturers of blanket washing products indicated that the same basic processes are used to formulate blanket washing products, regardless of the types of ingredients. Therefore, no significant differences between products are expected in energy consumption during the product formulation process. The specific steps required for production (e.g., mixing, application of pressure or heat, etc.) is dependent on the specific product chosen. Differences in the use of natural resources in this formulation step, beyond the formulations themselves, are also expected to be minimal.

Differences in energy and natural resource consumption may exist, however, when the nature of the product and its packaging are considered. Some formulations are concentrated and require dilution with water at the print shop; others already contain water and are ready to use right from the shipping container. (Still others are not diluted with water, either at the manufacturer or at the print shop). The concentrated formulations evaluated in this assessment, such as formulations No. 12, 17, 22, 24, 30, and 33, occupy less volume and therefore require less packaging when shipped to printers when diluted on site. Furthermore, energy consumed during the transportation/distribution of a concentrated product is less than that of a diluted product.

The materials in which the formulations are packaged should also be considered. In general, packaging containing recycled content and which is recyclable reduces resource consumption (and possibly energy use) as compared with disposable packaging materials. Reusable packaging may be even more beneficial than recycled/recyclable packaging depending on the energy required for transport and reuse.

Waste Disposal

Differences may exist in the amounts of energy and natural resources consumed during the disposal of blanket washing waste streams. The use of disposable wipes or shop towels creates a solid waste stream that must be properly managed. A similar waste stream generated by automated systems are the disposable pads used to remove the ink and applied wash; this pad represents consumption of natural resources similar to disposable wipes and must be compared to the use of reusable/disposable wipes. This use of disposable shop towels clearly consumes natural resources. However, from the discussion above, reusable shop towels also consume significant quantities of natural resources for cleaning purposes. Optimizing the use of either wipe alternative is most desirable.

Chemical wash recycling can be accomplished though centrifuging, hand-wringing, or gravity draining wash-soaked wipes. While recycling of waste blanket wash conserves natural resources, it also consumes energy. For example, centrifugation requires the use of equipment which consumes energy. Further processing of the collected chemicals, such as distillation, may be required, and therefore represents further energy consumption. These energy issues, and the issues of natural resource use, should be considered to capture the full life-cycle costs and benefits of blanket wash alternatives and the methods used to apply and manage the materials. Recycling of waste solvents is usually preferred over disposal, as established in the national waste management hierarchy outlined in the Pollution Prevention Act of 1990.

5.3 COMPARISON OF LIFE-CYCLE TRADE-OFF ISSUES

Printers should consider the life cycle of alternative blanket washing products if the goal is to conserve energy and natural resources. Only by considering and comparing the energy use and natural resource consumption of each life cycle stage can a completely informed decision be made. Though a quantitative evaluation of each life-cycle stage is beyond the scope of this CTSA, printers can still consider the life cycle trade-offs to optimize the blanket washing process and the overall consumption of energy and natural resources. There is rarely a clearly preferred choice, however, when considering the life-cycle energy and natural resource impacts of a selected product. Table 5-1 summarizes some of the trade-offs when considering energy consumption and natural resources use.

Table 5-1. Summary of Trade-Offs When Considering Energy Consumption and Natural Resources Use

	Energy Issues	Natural Resource Issues
Standard Shop Practices	no clear distinction between reusable and disposable wipes or shop towels	
	optimizing cleaning process and minimizing waste print run conserves energy and natural resources	
Chemical Composition	no clear distinction between products concerning renewable and non-renewable resources	
Formulation and Packaging	concentrated formulations consume less energy during transport/distribution when diluted on site	concentrated formulations require less packaging thus reducing natural resource consumption
		packaging containing recycled content and which is recyclable reduces natural resource consumption
Disposal	recycling waste blanket wash consumes energy (e.g., centrifugation, distillation, etc.)	collection and reuse/recycling of waste blanket wash conserves natural resources

Chapter 6
Additional Improvement Opportunities

Chapter Contents

This chapter focuses on techniques which may be employed at lithographic print shops to prevent pollution, to reduce chemical consumption, and to minimize waste. Section 6.1 examines results from a pollution prevention survey, which asked lithographers to identify what activities they currently employ to achieve a more environmentally friendly workplace. The most common of these activities and their effects are presented. The pollution prevention benefits that result from changing workplace practices are discussed in detail. Section 6.2 addresses options for recycling solvents and the economic and environmental implications associated with such recycling. Methods for extracting solvents from press wipes are addressed, as are methods for treating spent solvents so that they may be reused. Solvent recycling and distillation systems are also discussed.

6.1 POLLUTION PREVENTION OPPORTUNITIES

Pollution prevention, toxic chemicals reduction, and waste minimization efforts within a print shop can take many and varied forms. The "Workplace Practices Questionnaire for Lithographers" was used to collect information on many such efforts. This survey tool was developed by printers, union representatives, consultants to the printing industry, suppliers, and the University of Tennessee Center for Clean Products and Clean Technologies. The questionnaire was distributed in 1992 by representatives from the Printing Industries of America, the Graphic Communications International Union, the Association of Quick Printers, and printers who helped design the questionnaire. Two-hundred and six questionnaires were completed by printers, and comprise the database from which the following information was drawn. Improved workplace practices, facility programs (e.g., pollution prevention or waste minimization programs), as well as process, equipment, and product changes were the primary categories of pollution prevention opportunities identified in the questionnaire.

6.1.1 Summary of Responses to Workplace Practices Questionnaire

Of the respondents to the questionnaire, 76 percent have tried alternative blanket washing chemicals products, as shown in Table 6-1. This option was the most frequently tried pollution prevention option identified by the respondents to the questionnaire. Changes in workplace practices to prevent pollution were next at 48 percent. Nearly 30 percent of the respondents indicated they had implemented either equipment and/or process changes to improve the blanket washing process.

Table 6-1. Blanket Washing Activities to Prevent Pollution

Pollution Prevention Activity	% Response
Tried Alternative Blanket Wash	76.1%
Implemented Workplace Practices Changes	48.4%
Established Pollution Prevention, Waste Minimization, or Source Reduction Program	36.1%
Implemented Equipment Changes	28.8%
Implemented Process Changes	26.9%

Note: Due to multiple responses, numbers add to more than 100%.

Many printers are realizing that implementing changes such as these can save time and cut costs while preventing pollution. From the results of the Workplace Practices Questionnaire, over 70 percent of the respondents who have implemented changes to reduce the use of blanket wash indicated that materials cost had decreased or remained unchanged. Furthermore, the time required to clean the blanket for these respondents had either remained unchanged or decreased for 61 percent of the respondents. These results are presented in Table 6-2.

Table 6-2. Effects of Pollution Prevention Activities

Parameter	% Response			
	Increased?	Decreased?	No Change?	No Response
Materials Cost	24.6%	36.9%	33.8%	4.6%
Time to Clean Blanket	36.9%	32.3%	29.2%	1.5%
Waste Run After Cleaning	24.6%	21.5%	49.2%	4.6%

The application of alternative chemical products can significantly reduce chemical exposures in the workplace. Many alternative products contain a reduced percentage (< 30%) of volatile organic compounds (VOCs), or are derived from chemical sources other than petrochemical feedstocks. The questionnaire asked printers which alternative products they have implemented or tested; Table 6-3 summarizes the responses. These results show that the alternative products most frequently used were either citrus-based (nearly 53 percent) or low VOC-content (approximately 40 percent) products.

Table 6-3. Alternative Blanket Washing Products Implemented or Tested by Printers

Product Category	% Response
< 30% VOC Content	39.2%
Citrus-Based	52.9%
Oil-Based	10.5%
Surfactant-Based	11.8%

Note: Due to multiple responses, numbers add to more than 100%.

Further investigation into the application of alternative products identified over 50 percent of the respondents were satisfied with the performance of the alternative chemical products, independent of the type of alternative chemical products tried. Forty-four percent found alternative products unsatisfactory. Inadequate product information and operator preference were the two primary reasons identified by those respondents who had not tried alternative chemical products. The evaluation of alternative blanket washing chemical products is the focus of this CTSA; further discussion of pollution prevention opportunities in this section will therefore focus on workplace practices and facility programs to prevent pollution.

6.1.2 Workplace Practices

As the second pollution prevention effort most frequently identified by the respondents of the questionnaire, improved workplace practices can encompass every sector of a print shop. Even when focusing strictly on the blanket washing, workplace practices have the potential to eliminate or minimize sources of pollution and reduce chemical exposure to workers and the public. The Workplace Practices Questionnaire compiled data on many workplace activities. The following discussions summarize common workplace practices to prevent pollution and draw upon the results of the questionnaire for practical examples.

<u>Raising Employee Awareness</u>

Raising employee awareness of pollution prevention benefits is the best way to get employees to actively participate in pollution prevention efforts. Many press operators are reluctant to change from traditional blanket washing chemicals and methods; they simply do not believe the alternative, less polluting chemical products and methods will work. This unwillingness to try new products and new technologies may imply that printers are unaware of the potential benefits. Printers need to understand that pollution prevention can result in improved worker health and safety, an improved working environment, cost savings, and reduced or less toxic waste streams, which means less overall impact on human health and the environment. One printer indicated that his new operators are more conscientious and use less blanket wash; this may illustrate benefits gained from raising employee awareness of the health, safety and environmental issues associated with workplace practices.

Furthermore, many printers are beginning to design and implement programs to teach employees about the benefits of pollution prevention. Thirty-six percent of the respondents to the questionnaire report having a pollution prevention, waste minimization, or source reduction program at their facility. One printer in Kansas City, Missouri is required to prepare a written pollution prevention program as a large quantity hazardous waste generator. He goes on to explain, however, that this program is only the basis of a big-picture, source reduction program implemented at the facility. Similarly, a printer in Kent, Washington, and others, stated they have adopted the corporate pollution prevention and/or waste management program as their facility program. Other printers contacted indicated that their pollution prevention programs were management strategies, rather than written programs.

Table 6-4 lists steps designed to raise employee awareness, including written environmental policies, and the benefits of these activities. Other examples drawn from the questionnaire include a shop owner in Harrisburg, Pennsylvania, who organizes monthly meetings with his print operators to inform them of new products, to review Material Safety Data Sheets, and update printers on the newest waste management strategies. Periodic training is also offered to maintain optimal printing techniques and effective waste minimization/management practices. At another facility in Madison, Wisconsin, printers have commented on the improved working conditions resulting from the implementation of a low-VOC blanket washing product. The headaches and odors associated with the old products have been eliminated with the new product.

Materials Management and Inventory

Materials management and inventory control means understanding how chemicals and materials flow through a facility to identify the best opportunities for pollution prevention. Proper materials management and inventory control is a simple, cost-effective approach to prevent pollution. Keeping track of chemical usage and limiting the amount of chemicals on the process floor gives operators an incentive to use the minimum amount of chemical required to do the job. This was one benefit identified by a printer who now purchases non-bulk chemical products; this materials management practice resulted in a controlled use of chemicals on the press room floor. Ensuring that all chemical containers are kept closed when not in use minimizes the amount of chemical lost through evaporation to the atmosphere. Not only do these simple practices result in less overall chemical usage, thus representing a cost savings, they also result in reduced worker exposure to chemicals and an improved working environment. Table 6-5 lists some of the steps to and benefits of materials management and inventory control.

Selected results from the Workplace Practices Questionnaire reveal that many printers follow a number of these materials management and inventory practices. In one portion of the questionnaire printers were asked to describe their chemical storage practices (how and where), as well as the way(s) in which these products are retrieved for use at a press. The largest percentage of printers, nearly 46 percent, store their chemical products in closed containers or safety cans. Over 35 percent of the respondents use closed drums or pails; safety cans, employed by 10 percent of the responding printers, can further improve the safety and working conditions of the print shop by offering a more improved form of chemical containment. Furthermore, over 50 percent of the printers responding to this portion of the questionnaire pump chemical products from large storage containers to the smaller containers used at the press.

These results also indicate that many printers have opportunities for improving their materials management practices to prevent pollution. Printers who are storing chemicals in open containers can easily improve worker conditions and prevent materials loss by simply using a closed safety container. Investing in a simple hand-held pump can have a rapid pay-back period due to the money saved from preventing the spills that can occur when chemicals are transferred from container to container by hand.

Table 6-4. Benefits of Raising Employee Awareness

Activity to Raise Employee Awareness	Benefits
Prepare a written environmental policy	Establishes environmental management goals; illustrates management commitment to pollution prevention and environmental goals
Prepare written procedures on equipment operation and maintenance, materials handling, and disposal	Better informs employees of the proper procedures for using equipment and disposing of materials; helps prevent accidents
Provide employee training on health and safety issues, materials handling and disposal	Ensures that employees have proper training to understand benefits of proper materials handling and disposal, and potential consequences of improper workplace practices to their health and safety, the environment, and company profitability
Seek employee input on pollution prevention activities	Encourages the persons closest to the process to develop the best, most creative approach to pollution prevention; employee involvement and ownership of the program has been essential to many successful programs
Make employees accountable for waste generation and provide incentives for reduction	Encourages employees to be aware of ways they can prevent pollution; rewards active involvement in pollution prevention activities
Provide feedback to employees on materials handling and disposal, and pollution prevention performance	Re-emphasized management commitment to pollution prevention; encourages employees to continue to improve

Table 6-5. Materials Management and Inventory Practices and Their Benefits

Workplace Practices	Benefits
Manage inventory on a first-in, first-out basis	Reduces materials and disposal costs of expired materials
Minimize the amount of chemicals kept on the process floor at any time	Gives employees an incentive to use less materials
Centralize responsibility for storing and distributing chemicals	Gives employees an incentive to use less materials
Store chemical products in closed, clearly marked containers	Reduces materials loss; increases worker safety; reduces worker exposure; prevents mixing of hazardous and nonhazardous materials
Use a pump to transfer chemical products from large containers to smaller containers that are used at work stations	Reduces potential for accidental spills; reduces worker exposure

Process Improvements

Once the flow of materials within a facility has been documented, the next step is to analyze the process to identify workplace practices that can be adopted to prevent pollution at the source. Process improvements through workplace practices mean reevaluating the day-to-day operation that make up the printing process. Table 6-6 lists some workplace practices, and their benefits, that prevent pollution.

The Workplace Practices Questionnaire also collected specific information on whether printers are using many of these process improvements. According to the results, 62 percent of the surveyed printers use squirt bottles to store chemical blanket washes at the press. In addition, 81 percent of the printers use safety cans, closed containers, and/or safety cabinets for chemical storage beside the press. The use of these materials minimize evaporative losses of chemical products and therefore prevents pollution. Very few respondents (less than 4 percent) identified the use of open containers of any kind beside the press.

In addition to chemical storage practices, many printers reported using good operating procedures to reduce worker exposure to blanket washing chemicals. The use of gloves (nearly 70 percent), eye protection, and aprons protects workers from direct contact with chemical products. The forty-four respondents (22.4 percent) who use no personal protective equipment, however, identify the great potential that exists in a print shop for chemical exposure reduction efforts.

Table 6-6. Process Improvements and Their Benefits

Workplace Practices	Benefits
Use plunger cans or squeeze bottles to deliver controlled quantities of blanket wash	Reduces potential for accidental spills; reduces materials use; reduces worker exposure
Apply a specified amount of chemical products to shop towels rather than an uncontrolled amount directly to blanket	Reduces chemical usage through controlled applications
Reduce the size of the towel or wipe used during clean-up, and use reusable towels or wipes	More efficient use of towels; reduces solvent use; reduces worker exposure
Use reusable towels or wipes, and reuse shop towels for multiple blanket washes	Reduces materials use (shop towels and blanket wash); reduces solid waste generation; reduces worker exposure
Store chemical-laden wipes in closed container between uses	Reduces chemical losses due to evaporation; reduces worker exposure
Evaluate alternative chemicals: water dilution ratios (increase the amount of water)	Reduces chemical usage with no loss of efficiency; reduces worker exposure
Only apply chemicals where necessary	Reduces chemical usage; reduces worker exposure
Avoid delays in cleaning blankets	Simplifies ink removal from blanket
Use appropriate personal protective equipment (gloves, eye protection, etc.)	Reduces worker exposure

The application of cleaning products to shop towels by squirt bottle or safety plunger, identified as standard practice by over 50 percent of the surveyed printers, is another workplace practice that controls the use of chemicals resulting in materials conservation and improved working conditions.

Discussions with printers identified further effective operating procedures and process improvements to minimize waste. One such operating procedure is limiting the number of times the blanket is washed. One respondent to the questionnaire cleans the blanket "only when finished, not every time the position of the plate is changed during a print run". A printer in Tucson, Arizona has changed workplace practices to optimize the number of wipes used. With this current workplace practice, which involves the use of an alternative wash supplemented by the limited use of a strong solvent, wipe use has been reduced by half.

Waste Management Practices

After the blanket is clean, there still exist opportunities for improving the management of waste products generated during normal printing operations. Table 6-7 presents basic workplace practices that can be applied to prevent pollution in the management of wastes. Tables 6-8 and 6-9 present information about printers waste management practices compiled from the Workplace Practices Questionnaire.

The results from the Workplace Practices Questionnaire presented in Table 6-8. After accounting for those printers for which storage of blanket wash chemicals is not applicable (49.8%), over three-fourths of the remaining printers store their blanket wash chemicals in closed containers. The methods of treatment and disposal presented in Table 6-8 reveal that there are a variety of management possibilities available to printers. Recycling of spent-solvents, whether on- or off-site, is preferable to discharging to a sewer system or disposing of the solvent as hazardous or non-hazardous waste.

Table 6-7. Waste Management Workplace Practices and Benefits

Waste Management Practices	Benefits
Maintain accurate logs of chemical and materials stock, chemicals and materials use, and waste generation rates	Understanding materials flow and how it relates to waste generation rates provides insights into pollution prevention opportunities
Segregate waste by waste stream and keep in marked, easily accessible, closed containers	Allows for more effective reuse and recycling of waste materials; prevents nonhazardous waste from becoming contaminated with hazardous waste; minimizes evaporation of chemical waste products; reduces worker exposure
Use gravity-drain, wringing, or centrifugation to collect excess chemical products from used shop towels and wipes	Recovers chemical products for reuse and recycling
Keep used shop towels and collect waste chemicals in closed containers	Minimizes evaporation of chemical waste products; reduces worker exposure

Table 6-8. Waste Management Practices for Waste Blanket Wash

Method of Storage	% Response	Method of Treatment/Disposal	% Response
In a closed container	39.9%	Sent to Recycler	14.8%
In an open container	3.4%	Recycled on-site	1.0%
No specific container	1.5%	Discharged to sewer	2.5%
Other	0.5%	Hazardous Waste	9.9%
No response	4.9%	Nonhazardous Waste	8.4%
Not applicable	49.8%	Other	4.4%
		No Response	9.4%
		Not Applicable	49.8%

Note: Printers were able to specify unique methods under the category "Other". The "Not Applicable" category represents those printers who indicated they do not generate and/or collect liquid waste blanket wash.

Table 6-9 identifies a variety of strategies available for the management of shop towels. As stated in Table 6-6, the use of reusable towels can be an effective pollution prevention practice which conserves natural resources and minimizes waste disposal fees. The cleaning of these reusable towels, however, creates a waste stream from the cleaning facility which must be considered. Collecting used towels in a closed container, a workplace practice employed by nearly 75 percent of the respondents, minimizes chemical losses via evaporation thus improving the work environment. When collected, a pretreatment method (e.g., centrifugation or wringing) to collect any excess chemical remaining on the towels is possible. One respondent to the questionnaire recovers spent blanket wash and reuses it to clean the press rollers. From the results of the survey, however, few printers (less than 10 percent) are taking advantage of such management strategies.

6.1.3 Conclusions

Several pollution prevention opportunities exist to reduce the quantity and toxicity of blanket washing materials used within lithographic printing facilities. Many of these opportunities can be accomplished simply by implementing various improved workplace practices. Written pollution prevention or waste minimization programs, proper materials management, process improvements, and waste management practices represent such workplace practices. A pollution prevention program can establish accepted operating procedures and set waste reduction goals. Proper materials management may offer incentives for printers to use less chemicals and minimize chemical losses through evaporation or inefficient use. It also provides a means to track improvements as well as the resulting cost savings. Safety and health benefits can be achieved with process improvements and proper waste management practices, as well as more efficient use of chemical supplies. These improved workplace practices can be achieved at little to no expense to the print shop; they are cost effective and represent good business practice.

Table 6-9. Waste Management Practices for Reusable Shop Towels

Method of Storage		Method of Pretreatment		Method of Reuse or Disposal	
In a closed container	74.4%	Centrifuge	3.4%	On-site Laundry	0.5%
In an open container	14.3%	Dryer	1.5%	Off-site Laundry	62.6%
No specific container	7.9%	Hand Wringing	3.9%	Hazardous Waste	4.9%
Other	3.4%	Automatic Wringer	0.5%	Nonhazardous Waste	11.3%
		None	70.0%	Other	16.8%
		Other	4.9%	No Response	3.9%
		No Response	15.8%		

Note: Printers were able to specify unique methods under the category "Other".

6.2 RECYCLE OPPORTUNITIES

There are several technologies that may make solvent recovery a viable alternative for printers seeking to reduce their operating costs and waste management expenses. Printers typically use cloth shop towels or leased towels to clean presses and blanket rollers. The spent solvents contained in these wipes may present toxicity and flammability concerns for printers, industrial laundries, and local sewer systems. Printers have adopted several practices for reducing the quantity and toxicity of the solvents left in their press wipes, including the extraction of solvent using a hand-operated wringer or explosion-proof centrifuge. Once extracted, solvents can then be directly reused for imprecise cleaning such as parts washing or can be treated by some form of distillation or filtration for reuse as a blanket cleaner. This section discusses options for extracting solvents from press wipes, as well as options for treating solvents for reuse. Solvent recycling systems used in conjunction with brush-based automatic blanket wash systems are also discussed below.

6.2.1 Solvent Recovery from Press Wipes

Solvent laden press wipes present several environmental concerns for printing facilities, industrial laundries, and local sewer systems that receive the laundry's wastewater. Concerns include volatility, flammability and aquatic toxicity of the effluent discharged by industrial laundries to publicly owned treatment works (POTW). Additionally, some states require that solvent laden press wipes be treated as a hazardous waste. EPA's mixture rule states that a non-hazardous product is rendered hazardous when combined with a hazardous material.[a] Most press wipes would, therefore, be classified as a hazardous waste once contaminated with a hazardous blanket cleaner. Many states, however, have recognized a conditional exemption from the mixture rule for contaminated press wipes. For example, Massachusetts does not consider industrial wipes

[a] *The mixture rule was struck down by a 1991 D.C. Circuit court ruling, but has been temporarily reenacted while EPA conducts a review of the rule. For an update of changes to RCRA, contact the RCRA Hotline at (800)424-9346.*

to be hazardous if they satisfy the following conditions: 1) the wipes are not saturated and are able to pass the Department of Environmental Protection's "one drop test"; and 2) wipes are handled in accordance with state and federal (OSHA) regulations requiring that used wipes be stored in closed containers designed for solvent laden contents. Massachusetts regulations forbid the air-drying of press wipes in order to satisfy the "one drip rule"; however, printers are permitted to extract solvents by hand wringing or mechanical compaction. Several other states recognize an exemption from the mixture rule for contaminated press wipes and industrial wipes in general.[1]

One approach to reducing the quantity and toxicity of solvent being shipped off-site in press wipes is to extract solvents from wipes for reuse or appropriate disposal.[2] This approach has the added benefit of potentially lowering overall solvent costs when solvents are recovered and reused. The following paragraphs discuss two options for extracting solvents from press wipes: hand-operated wringer and explosion-proof centrifuge. The use of these extraction devices may be regulated. Printers should consult with their state and local regulatory authorities before installing such equipment.

Extraction of Solvents from Press Wipes

Two basic methods are available for extracting solvents from press wipes: 1) hand-operated wringers and 2) explosion-proof centrifuges. Hand-operated wringers require the smallest capital investment and may prove to be a viable option for small printing operations that use a limited number of press wipes. When using a hand-operated wringer, printers should verify that the squeeze rollers are resistant to solvents and will not rapidly deteriorate. Squeeze rollers should be made of a rubber material, similar to that used on the blanket cylinder of an off-set printing press. One company manufactures a hand-operated wringer that mounts on the top of a 55-gallon drum. The squeeze rollers are made of nitrite and are resistant to several types of solvents, although printers should investigate the units' compatibility with their specific solvents and determine if any flammability concerns exist as a result of placing their solvents under pressure. The price of the unit is under $600.[3]

A second alternative for solvent recovery is an explosion-proof centrifuge which may be used for extracting cleaning solvents from used press wipes. The centrifuge is most appropriate for large printing facilities that generate significant quantities of shop towels.[b] These centrifuges are manufactured with a self-balancing, perforated basket that retains the rags while liquid solvents are squeezed out and drain through the outer containment shell. Solvents can be extracted from cloth shop towels or disposable wipes. It is estimated that a four-minute cycle can extract between 2.5 and 3.5 gallons of solvent for every load of 225 wipes processed. Centrifuges are available that can process 35, 60, 100, or 130 pounds per load and that cost between $21,000 and $30,000 depending upon the capacity required. The most popular model among printers processes 225 towels per load and costs roughly $25,000. Installation involves bolting the unit in place and connecting it to an appropriate power source and 60 pounds of air supply.[4]

Purchase of a centrifuge unit involves a substantial capital investment and may not be appropriate for all printers. Alternatively, printers may have the option of contracting with a mobile centrifuge service to extract solvents on-site. One such solvent extraction service in Minnesota, operates a van that transports an explosion-proof centrifuge to printing facilities for on-site solvent extraction. Once the solvents have been extracted from the shop towels, it is left to the printing facility to determine how to handle the solvent. Pricing for extraction services are based upon a rate of $65/hour, during which time it is possible to process between 1,500-1,800 towels.

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[b] *Printers should consult with their local regulatory agency to determine if any restrictions exist for operating a centrifuge within their facility. For example, California and Virginia consider the operation of an on-site centrifuge to be a form of hazardous waste treatment and, therefore, subject to local permitting requirements. For a listing of all state environmental agency contacts, refer to the March 1995 issue of Graphic Arts Monthly.*

6.2.2 Methods of Solvent Recycling

Blanket wash solvent recovered from press wipes can not be immediately reused as a replacement for virgin solvents. Typically, solvents are separated by ink color, allowing solid particles to settle out before reuse. This process does not produce virgin quality solvent and is therefore best reused for imprecise cleaning, such as parts washing. Alternatively, used blanket wash can be treated by some form of distillation or filtration before reuse. The most common method of solvent recovery is distillation for both on-site and off-site applications.

Distillation of Blanket Wash

As an option for blanket wash recovery, the distillation process produces near virgin quality blanket wash. Most commercially available distillation units employ the differential distillation process. In this process, the liquid solution is heated to roughly 20 to 30 degrees above the desired solvent's boiling point, causing the more volatile (higher vapor pressure) components to vaporize. The relative boiling points of the solution components are critical for the effective operation of a distillation system. Solvent vapors rise into the condenser where they are cooled and recovered for reuse. Contaminants remain in the distillation tank and are disposed of as a liquid, semi-liquid or solid sludge. Waste residues, referred to as still bottoms, may be designated as hazardous waste if the they were distilled from a listed waste solvent (F-listed wastes). The recovery rate for a distillation unit averages roughly 90 percent.

One manufacturer can provide solvent distillation units with the capacity to handle between eight and 55 gallons of solvent. The largest unit provides the ability to process waste solvents in 20-gallon batches or 55-gallon units of continuous, closed-loop operation. The approximate cost of a 20-gallon unit is $12,000 and increases to $15,000 for the continuous feed option. For printers generating smaller quantities of solvents, a smaller model is available that handles 8-gallons of solvent per batch. The cost of an 8-gallon unit is approximately $3,300.[5] When considering the purchase of a distillation unit, printers should consider the quantities and type of solvent they hope to distill, as well as evaluate capital costs and operating costs for labor, electricity, and parts. Equipment vendors will run tests on a sample of spent solvent to determine whether the system will distill the solvent, and assess the recovery efficiency of the unit. One company charges $100 to test 5-10 gallons of used solvent.[6] In addition, some vendors may have units available for use on a trial basis, allowing printers to better assess whether a distillation unit is appropriate for their individual situation.

Safety concerns, however, are a significant consideration for printers contemplating the purchase of a distillation unit. For example, nitrocellulose, found in inks and paints, is an explosive when dry. Distillation of materials containing nitrocellulose is, therefore, not recommended. The International Fire Code Institute, an organization consisting of state fire marshals, has been investigating whether on-site distillation units constitute an explosion hazard given the flammable nature of the solvents they treat. Changes in the Uniform Fire Code are currently under consideration which may affect the availability of such units. Printers should consult with their local environmental regulatory agency and investigate whether any changes have been made in the Uniform Fire Code before investing in a distillation system.

In many cases on-site distillation will not be cost-effective for printers; instead, a commercial solvent recycling service may prove to be a better alternative. Three basic arrangements are available for off-site, solvent recycling: 1) toll recycling; 2) speculative recycling; and 3) waste brokers. Toll recycling involves off-site processing of solvents by a recycling firm for reuse by the printing facility. Typically large batches are required for such an approach to be cost-effective, although some recyclers will accept small quantities from many producers and combine their waste for batch distillation. Speculative recycling schemes recycle the waste solvents and then sell the product on the market. In this case, recyclers may pay the facility for solvents if the product has a high market value. Waste brokers match the needs the facility seeking to dispose of their solvents with a potential waste user. Such an arrangement can only be considered a recycling scheme if the solvent is bought by a solvent recycler. More commonly, waste brokers will sell the solvent for use as a waste-derived fuel for use in a cement kiln or industrial furnace.[7]

Ultrafiltration of Blanket Wash

Several filtration technologies are available to handle a variety of applications requiring the removal of suspended waste particles from contaminated solutions. The ultrafiltration process operates by passing effluent through a porous material, screening out the largest molecules as the effluent travels through the filter. Through the use of selective pore sizing, solutions can be filtered to varying degrees of quality. Generally, filtration technologies are similar in that the membrane material is made of some type of proprietary polymer-blend. Where the technologies differ is in the substrate material that holds the membrane in its rigid form. Possible substrate materials include ceramics, stainless steel, and nylon.

According to industry sources, filtration technology is not being used in the lithographic printing industry apart from its use in the treatment of fountain solutions and in conjunction with automatic blanket cleaners. The primary barrier for the use of filtration technology is the incompatibility of the membrane materials with the solvents. One company, however, is currently testing a poly-vinyl, spiral wound membrane that is resistant to solvents and, therefore, appropriate for the treatment of many blanket cleaners.[8] The system will operate using cross-flow filtration. Effluent is passed under pressure across a spiral wound membrane. Gaps between the membrane create turbulence in the flow of the effluent, reducing top loading or clogging of molecules by knocking them off of the membrane's surface. The system is currently being tested and is said to have several advantages over ceramic and stainless steel technologies. The spiral membrane is capable of nanofiltration and is expected to be less costly than stainless steel systems.[9]

Conclusions

Solvent recovery from used shop towels may be an economically sound and environmentally improved alternative for printers. The extraction of spent solvent from shop towels, whether via hand-operated wringers or the use of explosion-proof centrifuges has permits the recovered solvent to be reused. For small printers with limited capital, hand-wringers are the least costly option, whereas larger printers with a greater number of towels to be processed may prefer explosion-proof centrifuges. Extraction of the solvent also provides benefits to printers in terms of reduced expenditures for virgin solvent and/or the use of the spent solvent for less precise equipment cleaning. When the recycled blanket wash solvent is to be reused in place of virgin solvent, distillation is the most common method of reclamation, whether conducted on-site by the printer, or off-site by commercial solvent recycling services. Ultrafiltration, although used in some lithographic processes, is not, as yet, a viable method for solvent reclamation.

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Chapter 7
Evaluating Trade-off Issues

Chapter Contents

This chapter serves to summarize much of the information presented throughout the CTSA. Section 7.1 presents a summary of the findings, drawing upon the risk information developed in Chapter 3 and the cost analysis developed in Chapter 4. Section 7.2 presents a benefit/cost analysis of using the baseline blanket wash, VM&P naphtha, compared to the substitute blanket washes. Information on costs, exposures and risks are presented here so that an easy comparison can be made between the substitute blanket washes and the baseline. Section 7.3 provides summary sheets for each blanket wash. These summary sheets contain information on composition, performance, cost, risk, exposure, and regulatory concerns and are intended to provide the reader with a quick reference guide for each blanket wash.

7.1 FINDINGS

Earlier sections of the CTSA evaluated the risk and performance of the baseline blanket wash as well as the alternatives. This section presents the findings associated with the analysis of blanket washes. Relevant data include: worker health risks, public health risks, flammability risks, ecological risk, energy and natural resource use, VOC content, and labor, materials, and product costs. Each is discussed in turn below.

<u>Worker Health Risks</u>

The majority of substitute formulations, as well as the baseline, present some concern for dermal exposure, driven primarily by high exposure levels estimated in Chapter 3. The dermal exposure estimates provide an upper-bound estimate which no worker is expected to exceed because the exposure assessment assumes that no gloves or barrier creams are used by workers when cleaning a blanket. Worker inhalation risks are very low for nearly all of the blanket wash products due to low or negligible exposure levels. Only one of the substitute formulations (Blanket Wash 3) triggered inhalation concerns. The components of all other substitute products present low or no concern. The baseline presents low inhalation concern. Table 7-1 presents a summary of worker risks beginning with the baseline product, VM&P naphtha. The risk assessment assumed that components of concern present a greater risk than components of low to moderate concern, and components of low to moderate present a greater risk than components of low concern, and so on (no/low concern < low to moderate concern < concern).

Table 7-1. Summary of Risk Conclusions of Substitute and Baseline Blanket Wash Cleaners

Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
Baseline (28)	Hydrocarbons, petroleum distillates	concern	no/low concern
1	No individual chemicals of concern identified	no/low concern[1]	no/low concern[1]
3	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, aromatic	concern	concern
	Hydrocarbons, aromatic	concern	no/low concern
4	Terpenes	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
5	Hydrocarbons, aromatic	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
	Ethylene glycol ethers	concern	no/low concern
6	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
	Fatty acid derivatives	no/low concern[2]	no/low concern[2]
	Alkyl benzene sulfonates	no/low concern[2]	no/low concern[2]
7	Terpenes	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
8	Propylene glycol ethers	no/low concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
9	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
10	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
11	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
	Alkyl benzene sulfonates	no/low concern[1]	no/low concern[2]
12	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]
14	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
	Propylene glycol ethers	no/low concern[1]	no/low concern[1]
16	Terpenes	concern	no/low concern

Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
17	Glycols	no/low concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
	Alkali/salts	no/low concern	no/low concern[2]
	Fatty acid derivatives	possible concern	no/low concern[2]
18	Hydrocarbons, petroleum distillates	concern	no/low concern
	Dibasic esters	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern[1]	no/low concern[1]
	Esters/lactones	no/low concern[1]	no/low concern[1]
19	Propylene glycol ethers	no/low concern[1]	no/low concern[1]
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
20	Hydrocarbons, petroleum distillates	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern[1]	no/low concern[1]
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[1]
21	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Fatty acid derivatives	no/low concern[1]	no/low concern[1]
22	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
23	Terpenes	possible concern	no/low concern
	Nitrogen heterocyclics	possible concern	no/low concern
24	Alkyl benzene sulfonates	concern	no/low concern[2]
	Terpenes	concern	no/low concern
	Ethylene glycol ethers	possible concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
25	Terpenes	concern	no/low concern
	Esters/lactones	possible concern	no/low concern
26	Esters/lactones	concern	no/low concern[2]
	Esters/lactones	no/low concern	no/low concern[2]
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
27	Terpenes	concern	no/low concern
29	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
30	Hydrocarbons, aromatic	concern	no/low concern
	Propylene glycol ethers	no/low concern[1]	no/low concern[1]
31	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]

Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
32	Hydrocarbons, petroleum distillates	low to moderate concern[1]	low to moderate concern[1]
33	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	no/low concern	no/low concern
34	Terpenes	concern	no/low concern
	Alkoxylated alcohols	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]
35	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]
36	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
	Propylene glycol ethers	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
37	Hydrocarbons, aromatic	possible concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]
	Hydrocarbons, petroleum distillates	low to moderate concern[1]	no/low concern[1]
38	Fatty acid derivatives	no/low concern[1]	no/low concern[2]
	Alkoxylated alcohols	no/low concern[1]	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern	no/low concern[1]
39	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	no/low concern	no/low concern
	Alkanolamines	concern	no/low concern[2]
	Ethylene glycol ethers	possible concerns	no/low concern
40	Hydrocarbons, petroleum distillates	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern[2]
	Hydrocarbons, aromatic	moderate concern[1]	no/low concern[2]
	Fatty acid derivatives	no/low concern[1]	no/low concern[2]

[1] Risks for this chemical in this product could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis of potential hazard.
[2] Risks for this chemical in this product could not be quantified; therefore, the level of concern for this chemical is based upon a low risk call based on estimates of no or extremely low exposure.

Public Health Risk

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Individuals in the general public that are exposed to blanket wash chemicals are potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion due to use of blanket washes under the small shop scenario used here. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.[a] Flammable liquids are defined by OSHA as having a flash point less than 141°F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140°F or less. Table 7-2 presents the flash points of the baseline as well as the alternative blanket washes. Flash points were developed as part of the performance demonstration.

Table 7-2. Relative Flammability Risk of Substitute and Baseline Blanket Washes

Blanket Wash	Flash Point (°F)	Blanket Wash	Flash Point (°F)
Baseline (28)	50	*22*	157+
1	230+	*23*	140
3	114	*24*	100
4	114	*25*	220+
5	139	*26*	230+
6	152	*27*	145
7	165	*29*	230+
8	115	*30*	100+
9	230+	*31*	105
10	230+	*32*	220
11	150	*33*	105
12	125	*34*	138
14	230+	*35*	105
16	145	*36*	175

[a]*Flash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.*

Blanket Wash	Flash Point (°F)	Blanket Wash	Flash Point (°F)
17	220+	*37*	82
18	150	*38*	230+
19	230+	*39*	155
20	170	*40*	155
21	115		

Ecological Risk

The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; in the analysis for this CTSA, only the risks to aquatic species were considered. Evaluation of aquatic risks involved comparing a predicted ambient water concentration to a "concern concentration" for chronic exposures to aquatic species using a hypothetical receiving stream (a relatively small stream at low flow conditions). The concern concentration is expressed in mg/L water. Exposure concentrations below the concern concentration are assumed to present low risk to aquatic species. Exposures that exceed the concern concentration indicate a potential for adverse impact on aquatic species. Two chemicals contained in the blanket wash formulations may present risks to aquatic organisms. The two chemicals were alkyl benzene sulfonates, present in Formulations 3, 4, 6, 8, 11, 18, and 20, and ethoxylated nonylphenols, present in Formulations 4, 5, 7, 8, 9, 17, 24, and 40. Risks to plants (other than aquatic algae) and wildlife were not examined.
Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Use

As described in Chapter 5, the life cycle of any product begins with the extraction of raw materials from the environment, and continues through the manufacture, transportation, use, recycle, and disposal of the product. Decisions at each stage of a product's life will impact its energy and natural resource demand. Section 5.1, Energy and Natural Resource Issues, presents a discussion describing the issues to consider when cleaning the blanket and purchasing blanket washes but does not analyze the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. The issues discussed include: 1) optimization of the washing technique to reduce blanket wash use, press wipe use, and waste print runs; 2) derivation of blanket wash products from non-renewable (petroleum and natural gas) and renewable (plant products) chemical raw materials (it is not clear, however, which raw materials demand the least energy and natural resources without a full life-cycle analysis); 3) lack of differentiation between products in terms of energy consumption during the product formulation process because the same basic processes are used to formulate all blanket wash products; and 4) reduction in packaging requirements and transportation/distribution energy consumption due to the use of concentrated formulations, assuming the products are diluted by the printer. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

Volatile Organic Compound (VOC) Releases

As described in Chapter 4, the volatile organic compound (VOC) content of the alternative and the baseline blanket washes was independently tested by the GATF laboratory in Pittsburgh, Pennsylvania. VOCs are currently regulated under clean air legislation occupational exposure rules and toxics use and release reporting laws; therefore, substitution of high VOC cleaners has the potential to reduce the regulatory burden for printers. Table 7-3 presents a summary of the relative VOC content of the baseline and alternative blanket washes.

Table 7-3. VOC Content of the Substitute and Baseline Blanket Washes

Blanket Wash	VOC Content (lbs/gal;% by weight)	Blanket Wash	VOC Content (lbs/gal;% by weight)
Baseline (28)	6.2; 100%	22	Not measured; 2.17%
1	2.3; 30%	23	0.48; 6%
3	6.4; 91%	24	1.5; 19%
4	6.4; 89%	25	4.1; 55%
5	2.5; 30%	26	1.3; 18%
6	3.5; 47%	27	7.2; 93%
7	3.0; 36%	29	2.1; 30%
8	3.3; 41%	30	0.48; 7%
9	0.11; 10%	31	6.6; 99%
10	0.16; 2%	32	6.5; 99%
11	4.3; 61%	33	3.4; 46%
12	1.3; 20%	34	2.8; 39%
14	0.97; 12%	35	6.7; 99%
16	7.2; 99%	36	3.5; 48%
17	0.051; 0.6%	37	1.0; 14%
18	4.4; 60%	38	4.9; 65%
19	1.8; 22%	39	2.9; 37%
20	2.7; 35%	40	3.8; 52%
21	3.5; 47%		

Performance

The performance of each of the substitute blanket washes as well as the baseline was demonstrated using both laboratory and production run tests. The laboratory tests determined the flash point, VOC content, and pH and demonstrated the blanket swell and wipability of each product. The production run tests, conducted at two facilities for each of the substitute products and at all facilities for the baseline, collected information such as quantity of wash used, time spent to wash the blanket, ink coverage, and the effectiveness of the wash. Summary results are presented in Table 7-4. The widely variable conditions between and within printing facilities and the short duration of the production runs used for the performance demonstrations does not allow the results to be interpreted as definitive performance assessments of the blanket washes.

Table 7-4. Blanket Wash Laboratory Test Results

Form. No.	Flash Point (°F)	VOC Content[1] (lbs/gal; % by weight)	pH	Blanket Swell		Wet Ink Film Strokes	Dry Ink Film Strokes
				1 hr (%)	5 hr (%)		
1	230+	2.3; 30%	7.8*	1.5	3.0	4	6
3	114	6.4; 91%	3.4*	1.5	4.5	4	4
4	114	6.4; 89%	8.7	3.0	5.2	3	2
5	139	2.5; 30%	4.3	6.1	15.4	9	8
6	152	3.5; 47%	5.5	0.7	1.5	8	6
7	165	3.0; 36%	9.3	3.8	6.8	6	8
8	115	3.3; 41%	4.0	7.7	20	7	9
9	230+	0.77; 10%	4.6	1.5	1.5	19	30
10	230+	0.16; 2%	5.7	0.7	0.7	12	13
11	150	4.3; 61%	5.0*	0.0	1.5	4	5
12	125	1.3; 20%	8.2	0.0	1.5	7	11
14	230+	0.97; 12%	5.0	1.5	3.0	8	10
16	145	7.2; 99%	9.8	4.5	10.6	2	2
17	220+	0.051; 0.6%	9.8	1.5	1.5	100	100
18	150	4.4; 60%	5.5	1.5	4.5	8	7
19	230+	1.8; 22%	4.6	1.5	1.5	11	9
20	170	2.7; 35%	7.1	0.0	1.5	5	7
21	115	3.5; 47%	6.2	0.0	1.5	7	6
22	157(a)	NM; 2.17%[2]	7.4(c)	1.5	1.5	13	13
23	140	0.48; 6%	9.2	0.0	1.5	24	100
24	100	1.5; 19%	9.9	1.5	3.0	15	12
25	220+	4.1; 55%	4.3	3.0	4.5	22	32
26	230+	1.3; 18%	7.8*	0.0	0.0	6	14
27	145	7.2; 93%	3.9	3.0	4.5	3	3
28	50	6.2; 100%	6.6	1.5	3.0	3	8
29	230+	2.1; 30%	7.2	1.5	1.5	9	18
30	100(a)	0.48; 7%	7.6(c)	0.7	1.5	5	11

Form. No.	Flash Point (°F)	VOC Content[1] (lbs/gal; % by weight)	pH	Blanket Swell 1 hr (%)	Blanket Swell 5 hr (%)	Wet Ink Film Strokes	Dry Ink Film Strokes
31	105	6.6; 99%	7.6	1.5	3.0	3	3
32	220	6.5; 99%	8.5	0.1	1.5	5	30
33	105	3.4; 46%	7.2*	4.5	7.6	4	4
34	138	2.8; 39%	6.6	1.5	3.0	10	20
35	105	6.7; 99%	6.0	1.5	6.1	3	5
36	175	3.5; 48%	5.7*	0.7	1.5	4	5
37	82	1.0; 14%	3.9	3.0	3.0	5	8
38	230+	4.9; 65%	5.6	0.0	1.5	9	16
39	155	2.9; 37%	9.2	1.5	3.0	7	10
40	155	3.8; 52%	4.8	1.5	3.0	5	10
(a) full strength (c) 25% NC - not calculated NM - not measured * - pH fluctuates wildly							

[1]VOC content in lbs/gal was measured at GATF; % by weight VOC was calculated based on information submitted by the manufacturer.
[2]VOC content in lbs/gal was not measurable; % by weight VOC was submitted by the manufacturer.

Prior to testing the blanket washes in a print shop, the 36 substitute blanket washes were tested in the laboratory for blanket swell potential and wipability. Of the 36 washes, 22 were deemed to be satisfactory for demonstrations at volunteer printing shops (two shops demonstrated each blanket wash). The results of the performance demonstrations were highly variable between the two print shops using a particular blanket wash and among the many blanket washes themselves. Performance varied to a great extent based on the amount of ink coverage. Excluding trials with heavy ink coverage, eleven washes gave good or fair performances at both facilities, seven washes gave good or fair performance at one facility but not the other, and the remaining four washes performed poorly at both facilities.

Labor, Materials, and Product Costs

The costs of using each of the substitute blanket washes as well as the baseline depend on variations in labor costs, product use, and material and equipment use at each facility that participated in the performance demonstrations. Each substitute blanket wash product was tested by two facilities. The baseline product was tested by all facilities. Costs for each product are presented on a per wash basis, a per press basis, and a cost per press/shift/year basis. In comparing the cost data for the substitute and the baseline products, the costs of using the substitute blanket cleaners exceed the cost of using the baseline product in nearly all cases. In some cases smaller quantities of wash or less cleaning time was required, resulting in a cost savings when using the substitute instead of the baseline wash. Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs associated with using the substitute blanket washes range from a low of $1.72 to a high of $8.80 per press.[b] Costs of using the baseline product range from $1.64 to $3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from one percent to 179 percent. Table 7-5 presents a summary of the cost comparisons.

Disposal costs were not considered in this cost comparison because all but one of the printers participating in the performance demonstrations use cloth wipes that are leased from an industrial laundry. Many industrial laundries currently do not distinguish between hazardous and nonhazardous blanket washes when laundering wipes; therefore, it was assumed that there would be no savings in waste handling or processing costs associated with switching to a substitute blanket wash product.

7.2 QUALITATIVE DISCUSSION OF BENEFIT/COST ANALYSIS

7.2.1 Introduction

Social benefit/cost analysis is a tool used by policy makers to systematically evaluate the impacts to all of *society* resulting from individual decisions. The decision evaluated in this analysis is the choice of a blanket wash product. Printers have certain criteria which they use to evaluate the benefits and costs of alternative blanket cleaners such as price, drying time, flexibility of use for rollers and blankets, propensity to cause blanket swell, etc. A printer might ask what impact their choice of blanket washes will have on operating costs, compliance costs, liability costs, and insurance premiums. This business planning process is unlike social benefit/cost analysis, however, because it approaches the comparison from the standpoint of the individual printing firm and not from the standpoint of *society*. A social benefit/cost analysis seeks to compare the benefits and costs of a given action, considering both the private and external costs and benefits.[c] Therefore, the analysis will consider the impact of the alternative blanket cleaners on operating costs, regulatory costs, and insurance premiums, but will also consider the *external* costs and benefits of the alternative blanket cleaners such as reductions in environmental damage and reductions in the risk of illness for the general public. External costs are not borne by the printer, however; they are true costs to society.

Benefits of the substitute blanket cleaners may include private benefits such as increased profits resulting from improved worker productivity, a reduction in employee sickness, or reduced property and health insurance costs and external benefits such as a reduction in pollutants emitted to the environment or reduced use of natural resources. Costs of the substitute blanket cleaners may include private costs such as higher operating expenses resulting from a higher priced blanket wash and external costs such an increase in human health risks and ecological damage. Several of the benefit categories considered in this analysis share elements of both private and external costs and benefits. For example, use of the substitute blanket washes may result in energy and natural resource savings. Such a

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[b] *Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.*

[c] *Private costs include any direct costs incurred by the decision-maker and are typically reflected in the firm's balance sheet. In contrast, external costs are incurred by parties other than the primary participants to the transaction. Economists distinguish between private and external costs because each will affect the decision maker differently. Although external costs are real costs to some members of society, they are not incurred by the decision maker and firms do not normally take them into account when making their decisions. A common example of external costs is the electric utility whose emissions are reducing crop yields for the farmer operating downwind. The external costs incurred by the farmer in the form of reduced crop yields are not considered by the utility when deciding how much electricity to produce. The farmer's losses do not appear on the utility's balance sheet.*

Table 7-5. Summary of Cost Analysis for Blanket Wash Performance Demonstration

Formula Number	Test Facility	Total cost/wash (Baseline)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference[1]
1	Facility 3	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 6	0.46	0.87	1.84	3.48	4,600	8,700	+89
6	Facility 11	0.70	0.82	2.80	3.28	7,000	8,200	+17
	Facility 15	0.50	0.77	2.00	3.08	5,000	7,700	+54
9	Facility 10	0.91	2.08	3.64	8.32	9,100	20,800	+129
	Facility 15	0.50	0.92	2.00	3.68	5,000	9,200	+84
10	Facility 3	0.55	0.57	2.20	2.28	5,500	5,700	+4
	Facility 4	0.85	2.20	3.40	8.80	8,500	22,000	+159
11	Facility 1	0.59	1.29	2.36	5.16	5,900	12,900	+119
	Facility 2	0.53	0.68	2.12	2.72	5,300	6,800	+28
12	Facility 12	0.81	0.99	3.24	3.96	8,100	9,900	+22
	Facility 13	0.80	0.83	3.20	3.32	8,000	8,300	+4
14	Facility 6	0.46	1.07	1.84	4.28	4,600	10,700	+133
	Facility 16	0.66	0.82	2.64	3.28	6,600	8,200	+24
19	Facility 18	0.62	1.66	2.48	6.64	6,200	16,600	+168
	Facility 19	0.53	0.89	2.12	3.56	5,300	8,900	+68
20	Facility 11	0.70	1.13	2.80	4.52	7,000	11,300	+61
	Facility 12	0.81	1.58	3.24	6.32	8,100	15,800	+95

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

Formula Number	Test Facility	Total cost/wash (Base)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference[1]
21	Facility 6	0.46	1.01	1.84	4.04	4,600	10,100	+120
	Facility 17	0.41	0.58	1.64	2.32	4,100	5,800	+41
22	Facility 12	0.81	0.82	3.24	3.28	8,100	8,200	+1
	Facility 13	0.80	1.51	3.20	6.04	8,000	15,100	+89
24	Facility 16	0.66	0.97	2.64	3.88	6,600	9,700	+47
	Facility 17	0.41	0.88	1.64	3.52	4,100	8,800	+115
26	Facility 5	0.55	0.73	2.20	2.92	5,500	7,300	+33
	Facility 15	0.50	0.47	2.00	1.88	5,000	4,700	-6
29	Facility 7	0.57	0.93	2.28	3.72	5,700	9,300	+63
	Facility 8	0.55	0.89	2.20	3.56	5,500	8,900	+62
30	Facility 18	0.62	1.01	2.48	4.04	6,200	10,100	+63
	Facility 19	0.53	0.62	2.12	2.48	5,300	6,200	+17
31	Facility 7	0.57	1.59	2.28	6.36	5,700	15,900	+179
	Facility 8	0.55	0.59	2.20	2.36	5,500	5,900	+7
32	Facility 1	0.59	1.31	2.36	5.24	5,900	13,100	+122
	Facility 5	0.53	0.43	2.12	1.72	5,300	4,300	-19
34	Facility 1	0.59	0.89	2.36	3.56	5,900	8,900	+51
	Facility 19	0.53	0.95	2.12	3.80	5,300	9,500	+79

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

Formula Number	Test Facility	Total cost/wash (Base)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference[1]
37	Facility 3	0.55	0.48	2.20	1.92	5,500	4,800	-13
	Facility 4	0.85	0.79	3.40	3.16	8,500	7,900	-7
38	Facility 2	0.53	1.08	2.12	4.32	5,300	10,800	+104
	Facility 4	0.85	1.11	3.40	4.44	8,500	11,100	+31
39	Facility 5	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 8	0.55	0.80	2.20	3.20	5,500	8,000	+45
40	Facility 1	0.59	0.79	2.36	3.16	5,900	7,900	+34
	Facility 10	0.91	0.87	3.64	3.48	9,100	8,700	-4

[1] A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

The following terms are used throughout the benefit/cost analysis:

Table 7-6. Glossary of Benefit/Cost Analysis Terms

Term	Definition
Exposed Population	The estimated number of people from the general public or a specific population group who are exposed to a chemical through wide dispersion of a chemical in the environment (e.g., DDT). A specific population group could be exposed to a chemical due to its physical proximity to a manufacturing facility (e.g., residents who live near a facility using a chemical), use of the chemical or a product containing a chemical, or through other means.
Exposed Worker Population	The estimated number of employees in an industry exposed to the chemical, process and/or technology under consideration. This number may be based on market share data as well as estimations of the number of facilities and the number of employees in each facility associated with the chemical, process, and/or technology under consideration.
Externality	A cost or benefit that involves a third party who is not a part of a market transaction; "a direct effect on another's profit or welfare arising as an incidental by-product of some other person's or firm's legitimate activity" (Mishan, 1976). The term "externality" is a general term which can refer to either external benefits or external costs.
External Benefits	For example, if an educational program results in behavioral changes which reduce the exposure of a population group to a disease, then an external benefit is experienced by those members of the group who did not participate in the educational program. For the example of nonsmokers exposed to second-hand smoke, an external benefit can be said to result when smokers are removed from situations in which they expose nonsmokers to tobacco smoke.
External Costs	For example, if a steel mill emits waste into a river which poisons the fish in a nearby fishery, the fishery experiences an external cost as a consequence of the steel production. Another example of an external cost is the effect of second-hand smoke on nonsmokers.
Human Health Benefits	Reduced health risks to workers in an industry or business as well as to the general public as a result of switching to less toxic or less hazardous chemicals, processes, and/or technologies. An example would be switching to a less volatile organic compound, lessening worker inhalation exposures as well as decreasing the formation of photochemical smog in the ambient air.
Human Health Costs	The cost of adverse human health effects associated with production, consumption, and disposal of a firm's product. An example is respiratory effects from stack emissions, which can be quantified by analyzing the resulting costs of health care and the reduction in life expectancy, as well as the lost wages as a result of being unable to work.
Illness Costs	A financial term referring to the liability and health care insurance costs a company must pay to protect itself against injury or disability to its workers or other affected individuals. These costs are known as illness benefits to the affected individual.

Indirect Medical Costs	Indirect medical costs associated with a disease or medical condition resulting from exposure to a chemical or product. Examples would be the decreased productivity of patients suffering a disability or death and the value of pain and suffering borne by the afflicted individual and/or family and friends.
Private (Internalized) Costs	The direct costs incurred by industry or consumers in the marketplace. Examples include a firm's cost of raw materials and labor, a firm's costs of complying with environmental regulations, or the cost to a consumer of purchasing a product.
Social Cost	The total cost of an activity that is imposed on society. Social costs are the sum of the private costs and the external costs. Therefore, in the example of the steel mill, social costs of steel production are the sum of all private costs (e.g., raw material and labor costs) and the sum of all external costs (e.g., the costs associated with the poisoned fish).
Social Benefit	The total benefit of an activity that society receives, i.e., the sum of the private benefits and the external benefits. For example, if a new product yields pollution prevention opportunities (e.g., reduced waste in production or consumption of the product), then the total benefit to society of the new product is the sum of the private benefit (value of the product that is reflected in the marketplace) and the external benefit (benefit society receives from reduced waste).
Willingness-to-pay	Estimates used in benefits valuation intended to encompass the full value of avoiding a health or environmental effect. For human health effects, the components of willingness-to-pay include the value of avoiding pain and suffering, impacts on the quality of life, costs of medical treatment, loss of income, and, in the case of mortality, the value of a life.

benefit may result in private benefits in the form of reduced product usage and waste print runs as well as external benefits in the form of reduced consumption of non-renewable resources.

7.2.2 Benefit/Cost Methodology

The methodology for conducting a social benefit/cost assessment can be broken down into four general steps: 1) obtain information on the relative performance, human and environmental risk, process safety hazards, and energy and natural resource requirements of the baseline and the alternatives; 2) construct matrices of the data collected; 3) when possible, monetize the values presented within the matrices; and 4) compare the data generated for the alternative and the baseline in order to produce an estimate of net social benefits. Section 7.1 presents the results of the first task by summarizing the performance data, risk data, and energy and natural resource information for the baseline and the alternative blanket washes. In Table 7.5 the data required to make a determination of the relative costs and benefits of switching to an alternative blanket wash are organized according to formulation number, beginning with the baseline. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products, allowing identification of the substitute product whose use results in the largest net social benefits. However, because of data limitations and production facility variations, the analysis presents instead a qualitative description of the risks associated with each substitute product compared to the baseline. Benefits derived from a reduction in risk are described and discussed, but not quantified; the information provided can be very useful in the decision making process. A few examples are provided to quantitatively illustrate some of the benefit considerations. Personnel in each individual facility will have to examine the information presented, weigh each piece according to facility and community characteristics, and develop an independent choice.

The analysis is further developed in the following sections, beginning in Section 7.2.3 with summaries of the potential risks of the substitute and baseline blanket washes. Section 7.2.4 provides a summary of the financial costs of the baseline and the alternative blanket washes, Section 7.2.5 compares the benefits and costs of using the substitute blanket wash products instead of the baseline wash, and Section 7.2.6 provides an indication of the minimum benefits per affected person that would accrue to society if switching to substitute blanket wash products reduced cases of certain adverse health effects.

Table 7-7. Costs and Benefits of Baseline and Substitute Blanket Washes

Formula Number	Private Costs[1]		Private Benefits			External Benefits
	Average Cost/Press	**% Change**	**Worker Risk Trade-offs**	**Flamma-bility Risk[2]**	**% VOC**	**Environ-mental Risk**
Baseline (28)			Low to moderate concern for dermal and inhalation exposure.[4]	High risk	99%	No estimated risk
1	Alternative: 2.76 Baseline: 2.20	+25	Overall concern is low for dermal and inhalation exposure.[4]	Low risk	30%	No estimated risk
	Alternative: 3.48 Baseline: 1.84	+89				
3	Not tested		Concern for dermal exposure and inhalation exposure.	Moderate Risk	91%	Aquatic species risk
4	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	89%	Aquatic species risk
5	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	30%	Aquatic species risk
6	Alternative: 3.28 Baseline: 2.80	+17	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	47%	Aquatic species risk
	Alternative: 3.08 Baseline: 2.00	+54				
7	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Low Risk	36%	Aquatic species risk
8	Not tested		Low concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	41%	Aquatic species risk

Formula Number	Private Costs[1]		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk[2]	% VOC	Environmental Risk
9	Alternative: 8.32 Baseline: 3.64	+129	Very low concern for dermal exposure and no concern for inhalation exposure.[4]	Low risk	10%	Aquatic species risk
	Alternative: 3.68 Baseline: 2.00	+84				
10	Alternative: 2.28 Baseline: 2.20	+4	Very low concern for dermal exposure[3] and no concern for inhalation exposure.[4]	Low risk	2%	No estimated risk
	Alternative: 8.80 Baseline: 3.40	+159				
11	Alternative: 5.16 Baseline: 2.36	+119	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	61%	Aquatic species risk
	Alternative: 2.72 Baseline: 2.12	+28				
12	Alternative: 3.96 Baseline: 3.24	+22	Concern for dermal exposure and low concern for inhalation exposure.[3]	Moderate risk	20%	No estimated risk
	Alternative: 3.32 Baseline: 3.20	+4				
14	Alternative: 4.28 Baseline: 1.84	+133	Low concern for dermal and inhalation exposure.[3]	Low risk	12%	No estimated risk
	Alternative: 3.28 Baseline: 2.64	+24				
16	Not tested		Concern for dermal	Moderate	99%	No estimated
17	Not tested		Possible concern for dermal	Low Risk	0.6%	Aquatic
19	Alternative: 6.64 Baseline: 2.48	+168	Low concern for dermal and inhalation exposure.[3]	Low risk	22%	No estimated risk
	Alternative: 3.56 Baseline: 2.12	+68				
20	Alternative: 4.52 Baseline: 2.80	+61	Concern for dermal exposure and low concern for inhalation exposure.[3]	Low risk	35%	Aquatic species risk
	Alternative: 6.32 Baseline: 3.24	+95				
21	Alternative: 4.04 Baseline: 1.84	+120	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	47%	No estimated risk
	Alternative: 2.32 Baseline: 1.64	+41				
22	Alternative: 3.28 Baseline: 3.24	+1	Moderate concern for dermal exposure[3] and low concern for inhalation exposure.[4]	Low risk	17%	No estimated risk
	Alternative: 6.04 Baseline: 3.20	+89				

Formula Number	Private Costs[1]		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flamma-bility Risk[2]	% VOC	Environ-mental Risk
23	Not tested		Possible concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	6%	No estimated risk
24	Alternative: 3.88 Baseline: 2.64	+47	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	19%	No estimated risk
	Alternative: 3.52 Baseline: 1.64	+115				
25	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	55%	No estimated risk
26	Alternative: 2.92 Baseline: 2.20	+33	Concern for dermal exposure and no concern for inhalation exposure.[4]	Low risk	18%	No estimated risk
	Alternative: 1.88 Baseline: 2.00	-6				
27	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	93%	No estimated risk
29	Alternative: 3.72 Baseline: 2.28	+63	Low concern for dermal exposure[3] and no concern for inhalation exposure.[4]	Low risk	30%	No estimated risk
	Alternative: 3.56 Baseline: 2.20	+62				
30	Alternative: 4.04 Baseline: 2.48	+63	Concern for dermal exposure and low concern for inhalation exposure.[3]	Moderate risk	7%	No estimated risk
	Alternative: 2.48 Baseline: 2.12	+17				
31	Alternative: 6.36 Baseline: 2.28	+179	Concern for dermal exposure and low concern for inhalation exposure.[3]	Moderate risk	99%	No estimated risk
	Alternative: 2.36 Baseline: 2.20	+7				
32	Alternative: 5.24 Baseline: 2.36	+122	Low to moderate concern for dermal and inhalation exposure.[3]	Low risk	99%	No estimated risk
	Alternative: 1.72 Baseline: 2.12	-19				
33	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	46%	No estimated risk
34	Alternative: 3.56 Baseline: 2.36	+51	Concern for dermal exposure and low concern for inhalation exposure.[3]	Moderate risk	39%	No estimated risk
	Alternative: 3.80 Baseline: 2.12	+79				

Formula Number	Private Costs[1]		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk[2]	% VOC	Environmental Risk
35	Not tested		Concern for dermal exposure and low concern for inhalation exposure.	Moderate risk	99%	No estimated risk
36	Not tested		Concern for dermal exposure and low concern for inhalation exposure.[3]	Low risk	48%	No estimated risk
37	Alternative: 1.92 Baseline: 2.20	-13	Low to moderate concern for dermal exposure and low concern for inhalation exposure.[3]	High risk	14%	No estimated risk
	Alternative: 3.16 Baseline: 3.40	-7				
38	Alternative: 4.32 Baseline: 2.12	+104	Low to moderate concern for dermal exposure and low concern for inhalation exposure.[3]	Low risk	65%	No estimated risk
	Alternative: 4.44 Baseline: 3.40	+31				
39	Alternative: 2.76 Baseline: 2.20	+25	Low concern for dermal exposure and very low concern for inhalation exposure.	Low risk	52%	No estimated risk
	Alternative: 3.20 Baseline: 2.20	+45				
40	Alternative: 3.16 Baseline: 2.36	+34	Concern for dermal exposure and low concern for inhalation exposure.[4]	Low risk	52%	Aquatic species risk
	Alternative: 3.48 Baseline: 3.64	-4				

[1] Cost analysis based upon product performance as determined by the performance demonstration at various testing facilities and pricing submitted by the product supplier. See Chapter 4 for a more in-depth description of the cost analysis and descriptions of the testing facilities.
[2] Flammability risks are defined as follows: 1) High Risk: products with a flash point less than 100°F; 2) Moderate Risk: products with a flash point greater than 100°F but less than 150°F; and Low Risk: products with a flash point greater than 150°F.
[3] Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis.
[4] Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based solely upon estimated exposure levels.

7.2.3 Potential Benefits

The potential social benefits associated with the use of a substitute blanket cleaner versus the baseline wash include: reduced health risks for workers and the general public, reduced risk of fire and explosion due to lower flammability, reduced ecological risks, reduced use of energy and natural resources, and reduced VOC emissions. In order to assess the risk to workers, the EPA risk assessment combines hazard and exposure data for individual chemical components of the substitute as well as the baseline products into a single qualitative expression of risk. This qualitative expression of risk provides the basis for comparing the relative worker exposure risks associated with the use of the substitute blanket wash products as compared with the baseline. While members of the general public are also potentially at risk from blanket wash chemicals that are released to air and water, the EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion. Due to data limitations, the exposure assessment does not estimate cumulative exposures from landfill releases or septic system releases. The relative risks of fire and explosion are determined by comparing the flash point of each blanket wash, using the OSHA definition of a flammable liquid as well as EPA's definition of an ignitable waste as a benchmark. In addition to the risks faced by workers and the general public, the risk assessment considers the potential ecological risks of using each of the alternative products and the baseline blanket wash. Several of the substitute formulations were found to present a risk to aquatic species. The energy and natural resource requirements of the substitute and the baseline blanket wash vary and a full life-cycle assessment, which was beyond the scope of this CTSA, would be needed to determine the requirements. The risks associated with volatile organic compound (VOC) releases were not examined within the risk assessment; however, the relative VOC contents of the substitute formulations are discussed below since VOC releases are the primary driving factor behind current regulations affecting printers.

Reduced Worker Health Risks

Reduced risks to workers can be considered both a private and an external benefit. Private worker benefits include reductions in worker sick days and reductions in health insurance costs to the printer. External worker benefits include reductions in medical costs to workers as well as reductions in pain and suffering associated with work related illnesses. The EPA risk assessment considers two paths of worker exposure: inhalation and dermal. Inhalation exposure results from the volatilization of blanket wash chemicals from the blanket during washing and from the rags used to wipe down the blanket. Dermal exposure results from direct contact with the blanket wash chemicals during blanket cleaning. Worker dermal exposure to all products can be easily minimized by using proper protective equipment such as gloves or barrier creams during blanket cleaning. Worker health risks associated with the use of any blanket wash product are a function of both the product's toxicity as well as the degree of worker exposure which occurs during blanket cleaning. For example, the worker health risks associated with the use of a more toxic blanket wash may be reduced by the product's low volatility (i.e., reduced inhalation exposure) or workplace practices such as the use of automatic blanket cleaning technology (i.e., reduced dermal exposure). The exposure assessment (Chapter 3) estimates worker exposure (dermal and inhalation) for each of the blanket wash products. The risk assessment (Chapter 3) evaluates the toxicity of the individual blanket wash components for the substitute and baseline products and integrates the hazard and exposure information into a single qualitative expression of risk. The risk assessment does not provide a single measure of risk for the products overall, making it difficult in some cases to determine the relative risk from one product to another. For example, blanket wash 22 contains heavy aromatic solvent naphtha and fatty acid esters which were determined to posses moderate dermal concern and low dermal concern, respectively.

Reduced Public Health Risk

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Such releases impose an external cost on society that is typically not considered by printing facilities in selecting their blanket wash. For example, people may breath blanket wash vapors that have been released from a printing facility or people may drink water containing blanket wash residues discharged by a facility. Individuals in the general public that are exposed to blanket wash chemicals are therefore potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Reduced Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility (Table 7-3). Reduced flammability risk may result in both private and external benefits. Private benefits may accrue to the printer in the form of lower risk of fire damage to the print shop. The population surrounding the print shop may experience external benefits in the form of lower risks of fire damage to their homes. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.[d] Flammable liquids are defined by OSHA as having a flash point less than 141°F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140°F or less. The baseline product has a flash point of 50°F, well below OSHA and EPA standards. Several of the substitute blanket washes have flash points below the OSHA and EPA thresholds: blanket washes 3, 4, 5, 8, 12, 21, 23, 24, 30, 31, 33, 34, 35,and 37.

Reduced Ecological Risk

Blanket wash formulations are potentially damaging to terrestrial and aquatic ecosystems, resulting in external costs borne by society. The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; however, only the risks to aquatic species were considered. Reductions in aquatic species risks may create external benefits by increasing the catch per unit effort for commercial fishers as well as by increasing catch and participation rates of recreational fishers. The following formulations were found to pose a risk to aquatic species: blanket washes 3, 5, 6, 8, 11, 18, and 20. All the chemicals of concern are amine salts of an alkylbenzene sulfonate. Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Conservation

Benefits may accrue to society (external) as well as the printer (private) in the form of energy and natural resource savings if substitute blanket washes are substituted for the baseline wash. For example, blanket wash 34 was found to require fewer impressions to get back to acceptable print quality than with the baseline wash, thereby consuming less paper and energy. A similar situation may occur with press wipes. By switching to the substitute blanket wash, the printer might experience lower energy and resource costs. At the same time, society would also benefit from the printer's reduction in energy and natural resource use. As discussed in Section 7.1, the analysis did not estimate the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

Reduced Volatile Organic Compound (VOC) Releases

The reduction of volatile organic compounds (VOCs) within the pressroom can potentially result in private benefits including lower compliance costs and savings on insurance premiums, as well as external benefits including a safer work environment and reduced health effects outside

[d] *Flash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.*

of the facility.[e] VOCs are currently regulated under clean air legislation as well as toxics use and release reporting laws and, therefore, were not re-evaluated as part of the risk assessment. Because there are several sources of VOCs within any given print shop, no attempt was made to quantify the benefits associated with an incremental reduction in the release of blanket wash VOCs. However, case studies are available documenting the potential benefits of VOC reduction throughout the pressroom. For example, the Commonwealth of Massachusetts Office of Technical Assistance found that Hampden Papers of Holyoke, Massachusetts experienced savings by reducing VOCs (97 percent reduction over a ten year period).[f] Hampden Papers, by adopting a source reduction strategy, has avoided the need to purchase VOC collection and control equipment or explosion-proof mixers for inks and coatings containing VOCs. In addition, they have incurred significant savings in fire insurance premiums, and reduced their liability under Superfund, air regulations, OSHA, RCRA, and other laws (OTA, no date). VOC content of the baseline as well as the alternative formulations, as measured by the GATF laboratory, are presented in Table 7-4. VOC content ranges from a low of 2 percent to a high of 99 percent. The baseline product and blanket wash 31 have the highest VOC content (99%).

7.2.4 Associated Costs

In comparing the cost data for the alternative and the baseline products, the costs of using the alternative blanket cleaners exceed the cost of using the baseline product in nearly all cases. Some cases required smaller quantities of wash or less cleaning time, resulting in a cost savings when using the substitute instead of the baseline wash. Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs of the using the substitute blanket washes range from a low of $1.72 to a high of $8.80 per press.[g] Costs of using the baseline product range from $1.64 to $3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from one percent to 179 percent.

7.2.5 Costs and Benefits by Formulation

The objective of a social benefit/cost assessment is to identify those products or decisions that maximize net benefits. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products in terms of a single comparable unit (i.e., dollars) and calculate the net benefits of using the substitute instead of the baseline product. Due to data limitations, however, the analysis presents a qualitative description of the risks associated with each product compared to the baseline. Table 7-8 compares the relative risks and costs of each substitute blanket wash to the baseline. While this table presents a comparison between the blanket washes and the substitutes, it is important to keep in mind that not all of the risk assessments are based on risk (comprised of both exposure and hazard), but that some of the assessments are based solely on a hazard call based upon a structure-activity analysis. A frowning face (☹) indicates an increase in cost, worker health risks, flammability, risk to aquatic species,

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[e] *A successful VOC reduction strategy can not be limited to blanket washes. All sources of VOC releases (i.e., inks, coatings, etc.) within the print shop must be evaluated in order to design and implement an efficient emissions control plan.*

[f] *For a copy or further information about this case study, contact: Office of Technical Assistance (OTA), Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, Massachusetts 02202, or phone OTA at (617) 727-3260.*

[g] *Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.*

or VOC content when using the substitute blanket wash instead of the baseline product. A smiling face (☺) indicates a reduction in cost, worker risk, flammability, aquatic species risk, or VOC content when using the substitute instead of the baseline product. A zero (○) indicates that the risk assessment identified no difference in relative risks when using the substitute blanket cleaner instead of the baseline. Because the risk assessment evaluated individual blanket wash components, the relative worker health risks are based upon the component that poses the highest degree of concern. For example, components of Blanket Wash 32 were determined to pose no or low concern (propylene glycol ethers) and concern (aromatic and petroleum distillate hydrocarbons); therefore, the overall dermal risk of Blanket Wash 32 is one of concern. Blanket Wash 32 is shown to have similar relative dermal risks to workers when compared to the baseline because the baseline product's component of highest concern poses concern (i.e., petroleum distillate hydrocarbons).[h]

In nearly every case the substitute product costs more to use than the baseline. There were several products whose use was determined to decrease dermal worker health risks; these were Blanket Washes 1, 9, 10, 14, 17, 19, 22, 23, 29, 37 and 38. Formulation 10 was found to increase costs by less than 10 percent for one of the facilities. The few products that did show evidence of reduced costs, had mixed results in terms of their relative health risks. For example, Blanket Wash 37, which was found to be less expensive to use than the baseline, was found to reduce worker dermal risks but was neutral in terms of relative inhalation risk. Blanket Washes 26 and 40 showed evidence of reduced costs; in addition, the risk assessment found that worker dermal risks were similar for both products over the baseline. In addition, while Blanket Wash 32 was less expensive than the baseline at one facility, it was found to present increased dermal and inhalation risks over the baseline. All of the substitute products had lower flash points and, therefore, reduced flammability risk when compared to the baseline. Finally, three blanket washes (6, 11, and 20) had higher aquatic risks than the baseline.

7.2.6 Potential Benefit of Avoiding Illness Linked to Exposure to Chemicals Commonly Used in Blanket Washing

As mentioned above, the risk assessment did not link exposures of concern to adverse health outcomes. Data do exist, however, on the cost of avoiding or mitigating certain illnesses that are linked to exposures to blanket wash chemicals. Such cost estimates indicate potential benefits associated with switching to less toxic products. Health endpoints potentially associated with blanket wash chemicals include: eye irritation, headaches, nausea, and asthma attacks. The following discussion presents estimates of the economic costs associated with each illness. To the extent that blanket wash chemicals are not the only factor contributing toward the illnesses described, individual costs may overestimate the potential benefits to society from substituting alternative blanket cleaners; also, this is not a comprehensive list of the potential health effects of exposure to blanket washes. For instance, inks and other pressroom chemicals may also contribute toward adverse worker health effects. The following discussion focuses on the external benefits of reductions in illness: reductions in worker medical costs as well as reductions in pain and suffering related to worker illness. However, private benefits, accrued by the decision-maker, may be incurred through increased worker productivity and a reduction in liability and health care insurance costs. While reductions in insurance premiums as a result of pollution prevention are not currently widespread, the opportunity exists for changes in the future.

Often adverse health effects are experienced when working with chemicals. For example, press operators at facility 12 experienced nausea and dizziness when using blanket wash 20, a petroleum based blanket wash containing petroleum distillates and aromatic hydrocarbons. In

[h] *The risk classification scheme should be interpreted as follows: no/low concern < low to moderate concern < concern.*

Table 7-8. Relative Benefits and Costs of Substitute Versus Baseline Blanket Wash [1]

Formula Number	Cost/Press		Worker Health Risk		Flammability Risk	Risk to Aquatic Species	VOC Content[2]
	Facility #1	Facility #2	Dermal	Inhalation			
1	☹	☹	☺[3]	○[3]	☺	○	☺
3	Not tested		○	☹	☺	☹	☺
4	Not tested		○	○	☺	☹	☺
5	Not tested		○	○	☺	☹	☺
6	☹	☹	○	○	☺	☹	☺
7	Not tested		○	○	☺	☹	☺
8	Not tested		○	○	☺	☹	☺
9	☹	☹	☺	○	☺	☹	☺
10	☹	☹	☺[3]	○	☺	○	☺
11	☹	☹	○	○	☺	☹	☺
12	☹	☹	○	○	☺	○	☺
14	☹	☹	☺[3]	○	☺	○	☺
16	Not tested		○	○	☺	○	○
17	Not tested		☺	○	☺	☹	☺
18	Not tested		○	○	☺	☹	☺
19	☹	☹	☺[3]	○	☺	○	☺
20	☹	☹	○	○	☺	☹	☺
21	☹	☹	○	○	☺	○	☺
22	☹	☹	☺[3]	○	☺	○	NM
23	Not tested		☺	○	☺	○	☺
24	☹	☹	○	○	☺	☹	☺
25	Not tested		○	○	☺	○	☺
26	☹	☺	○	○	☺	○	☺
27	Not tested		○	○	☺	○	○
29	☹	☹	☺	○	☺	○	☺
30	☹	☹	○	○	☺	○	☺
31	☹	☹	○	○	☺	○	○

Formula Number	Cost/Press		Worker Health Risk		Flammability Risk	Risk to Aquatic Species	VOC Content[2]
	Facility #1	Facility #2	Dermal	Inhalation			
32	☹	☺	☹	☹	☺	○	○
33	Not tested		○	○	☺	○	☺
34	☹	☹	○	○	☺	○	☺
35	Not tested		○	○	☺	○	○
36	Not tested		○	○	☺	○	☺
37	☺	☺	○	○	☺	○	☺
38	☹	☹	☺	○	☺	○	☺
39	☹	☹	☺	○	☺	○	☺
40	☹	☺	○	○	☺	☹	☺

[1] Baseline Blanket Wash is Formulation 28, VM&P naphtha. Information used to develop this table varies in the level of confidence. Please refer to earlier tables and to the development of each type of information for additional information.
[2] "NM" indicates that VOC content was not measured.
[3] Level of concern for this substitute blanket wash based upon a structure-activity analysis of potential hazard.

addition, blanket wash 20 aggravated a previously existing respiratory condition in one press operator. The economic literature provides estimates of the costs associated with eye irritation, headaches, nausea, and asthma attacks, each of which may result from exposure to blanket wash chemicals. An analysis summarizing the existing literature on the costs of illness estimates individual willingness-to-pay to avoid certain acute effects for one symptom day (Unsworth and Neumann, 1993). The estimates for eye irritation, headaches, nausea, and asthma attacks are all based upon a survey approach designed to illicit estimates of individual willingness-to-pay to avoid a given illness. Such surveys, when properly designed, should capture direct treatment costs, indirect costs, and costs associated with pain and suffering.[i] As eye irritation, headaches, nausea, and asthma attacks typically occur as short-term, discrete incidents, cost estimates represent an individual's willingness-to-pay to avoid a single incidence and not the average lifetime cost of treating a disease. Table 7-6 presents a summary of the low, mid-range, and high estimates of individual willingness-to-pay to avoid each of these health endpoints. These estimates provide an indication of the benefit per affected individual that would accrue to society if switching to a substitute blanket wash product reduced the incidence of eye irritation, headaches, nausea, and asthma attacks.

[i] *Several approaches are available for estimating the costs of illness. Appendix E provides a brief description of each.*

Table 7-9. Estimated Willingness-to-pay to Avoid Morbidity Effects for One Symptom Day (1995 dollars)

Health Endpoint	Low ($)	Mid-Range ($)	High ($)
Eye Irritation[1]	20.79	20.79	46.14
Headache[2]	1.67	13.23	66.72
Nausea[1]	29.11	29.11	83.66
Asthma Attack[3]	15.62	42.96	71.16

Sources:

[1] Tolley, G.S., et al. 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. University of Chicago. Final Report for the U.S. EPA. January. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.
[2] Dickie, M., et al. 1987. *Improving Accuracy and Reducing Costs of Environmental Benefit Assessments*. U.S. EPA, Washington, DC, September, and Tolley, G.S., et al. 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. University of Chicago. Final Report for the U.S. EPA. January. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.
[3] Rowe, R.D. and L.G. Chestnut. 1986. *Oxidants and Asthmatics in Los Angeles: A Benefit Analysis*. Energy and Resource Consultants, Inc. Report to U.S. EPA, Office of Policy Analysis, EPA-230-07-85-010. Washington, DC March 1985. Addendum March 1986. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

7.3 OVERVIEW OF RISK, COST AND PERFORMANCE

This section gives an overview of the substitute blanket washes including information regarding performance, cost, risk and exposure, and regulatory concerns. Since these evaluation factors are unique to each formulation, an individual profile was developed for each of the substitute blanket washes. The results of the process safety and general population risk analyses are similar for all formulations (see Sections 3.5 and 3.4.4, respectively). The profile summarizes information from various sections of the CTSA as described below.

Chemical Information

The generic chemical composition of each substitute blanket wash is provided. The categorization of blanket wash chemicals used to genericize the formulations was described in detail in Section 2.1. Also included in each profile are the flash point, VOC content, and pH of each substitute wash, which were determined during laboratory testing by the Graphic Arts Technical Foundation (GATF) (see also Table 4-1).

Performance

The performance section of the profile summarizes information collected during laboratory and production run performance demonstrations with each substitute blanket wash. The data on wipability and blanket swell were determined in laboratory evaluations conducted by the GATF (see also Table 4-1).

Wipability is based on the number of strokes required to remove a standard volume of either wet or dry ink from the test blanket using a measured volume of the substitute blanket wash. Washes for which more than 100 strokes were required to clean the blanket were eliminated from field testing. The blanket swelling potential of each substitute wash was determined by measuring the thickness of the test blanket before and after exposure to the substitute blanket wash for one and five hours. Washes for which the blanket swell exceeded 3 percent after 5 hours were eliminated from field testing.

Based on the laboratory test results, 22 products qualified for further evaluation through field demonstrations. Each of the 22 substitutes was demonstrated at two facilities, and performance was compared to a standard baseline wash (VM&P naphtha). Qualitative performance evaluations were made by DfE observers and printers at the test facilities (see also Table 4-2).

Cost

A cost analysis was conducted for the 22 field-tested substitute blanket washes and the baseline wash. The primary source of information for the cost estimates was the performance demonstrations. The specific assumptions and methodology used in the analysis are discussed in detail in Section 4.2. In general, the data for cost per wash were based on estimates for labor, blanket wash, and material costs. The cost per press was calculated by multiplying the cost per wash by the estimated number of blankets per press. The annual cost was calculated by multiplying the total cost per press by the number of washes per shift, the number of shifts per week, and the number of weeks worked per year. The percent change refers to the percent increase or decrease that the facility would incur if it switched from using the baseline (VM&P naphtha) to using the substitute blanket wash. These data were extracted from Table 4-3. The number of times the blanket wash was used by the printing facility provides the number of data points, i.e., the sample size.

Risk and Exposure

This section of the profile addresses the risks that may result from the substitute blanket washes under typical conditions of use. The risk characterization integrates hazard and exposure information into quantitative and qualitative expressions of risk. The specific assumptions and methodology used to estimate occupational exposure are described in detail in Section 3.2. The risk characterization methodology is discussed in detail in Section 3.4.1 and 3.4.3.

Separate risk estimates are presented for dermal and inhalation exposure. Most of the formulations (27 of the 37 formulations including the baseline) present at least some concern for dermal exposures to workers primarily due to relatively high potential exposure levels. In contrast, worker inhalation risks are very low for almost all of the formulations, reflective of the generally low exposure levels.

Flammability risks are defined as follows: 1) High Risk: products with a flash point less than 100°F; 2) Moderate Risk: products with a flash point greater than 100°F but less than 150°F; and Low Risk: products with a flash point greater than 150°F.

Environmental risks are also presented. Only those formulations containing alkyl benzene sulfonates or ethoxylated nonylphenols presented a possible risk to aquatic species. The methodology and specific results can be found in Section 3.4.2.

Regulatory Concerns

This section identifies the substitute blanket washes that may trigger federal environmental regulations. Discharges of blanket wash chemicals may be restricted by air, water, and solid waste regulations; in addition, facilities may be required to report releases of some blanket wash products. It is important to note that this analysis is based on the generic chemical composition. Specific blanket wash chemicals that trigger federal environmental regulations (and one occupational health regulation) are given in Table 2-6. They are:

- Clean Water Act (CWA)
- Clean Air Act (CAA), Section 112B - Hazardous Air Pollutants
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Superfund Amendments and Reauthorization Act (SARA), Section 313
- Superfund Amendments and Reauthorization Act (SARA), Section 104
- Resource Conservation and Recovery Act (RCRA)
- Occupational Safety and Health Act (OSHA)

The generic category for these chemicals (based on Table 2-1) was compared to the generic compositions of the substitute blanket washes.

Blanket Wash Formulation 1

Composition:
Fatty acid derivatives
Alkoxylated alcohols

VOC Content: 30%; 2.3 lbs/gal
Flashpoint: 230+°F
pH: 7.8 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes; dry ink- 6 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 1 was demonstrated at two facilities. Facility 3 based their performance evaluation on a sample size of ten blanket washes and printed with conventional inks. This facility found that the wash yielded good performance for light or medium ink coverage but poor performance for heavy ink coverage. The extra time and effort required for heavy ink coverage were unacceptable. The wash also left a slight residue that was removed with a dry rag.

Facility 6 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash yielded poor performance, and resulted in print quality problems. The image of the previous job was still showing. Facility 6 did not use alternative product 1 for the full week-long demonstration, discontinuing use after experiencing print quality problems believed to have been attributable to use of the alternative product.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 1 instead of the baseline product at both facilities 3 and 6. Performance results indicate a 25 percent increase and a 70 percent increase in cleaning times at facilities 3 and 6, respectively. The costs associated with product use (i.e., volume x price) are also significantly higher for Blanket Wash 1 when compared to the baseline, driven primarily by the product's high price. The manufacturer's price for product 1 is $20/gallon versus $5.88/gallon for the baseline product. Costs associated with product use increased roughly 220 percent and 160 percent for facilities 3 and 6, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
3	$0.69	$2.76	$6,900.00	$5,500.00	+25
6	$0.87	$3.48	$8,700.00	$4,600.00	+89

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 1. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. However, overall concern is low because of low inhalation exposure levels, poor dermal absorption, and low to moderate toxicologic concern based on structure-activity analysis.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 3

Composition:
Hydrocarbons, petroleum distillates
Fatty acid derivatives
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 91%; 6.4 lbs/gal
Flashpoint: 114°F
pH: 3.4 (fluctuates wildly)

Performance

Wipability:	wet ink- 4 strokes	Blanket swell:	1 hr.- 1.5%
	dry ink- 4 strokes		5 hrs.- 4.5%

The performance of Blanket Wash 3 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 3 were not developed.

Risk and Exposure

Dermal Exposure: Hazard quotient calculations indicate a concern for exposure to some aromatic hydrocarbons and very low concern for exposure to other aromatic hydrocarbons. However, the hazard values are based upon oral or inhalation studies. Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons. However, the hazard values are based upon inhalation studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Inhalation Exposure: Hazard quotient calculations indicate very low concern for exposure to aromatic hydrocarbons. However, the hazard value for one of these aromatic hydrocarbons is based upon an oral study. The RfD used to calculate the risk estimate is classified as "low confidence" by IRIS (Integrated Risk Information System). Margin of exposure calculations indicate concern for exposure to certain aromatic hydrocarbons, but very low concern for exposure to others. Due to negligible inhalation exposure, the alkyl benzene sulfonates and fatty acid derivatives used in this formulation present no concern. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 4

Composition:
Terpenes
Ethoxylated nonylphenol

VOC Content: 89%; 6.4 lbs/gal
Flashpoint: 114°F
pH: 8.7

Performance

Wipability:	wet ink- 3 strokes	Blanket swell: 1 hr.- 3.0%
	dry ink- 2 strokes	5 hrs.- 5.2%

The performance of Blanket Wash 4 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 4 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and low concern for exposure to ethoxylated nonylphenols. However, the hazard value for terpenes is based upon an oral study.

Inhalation Exposure: Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, no concern exists for exposure to the ethoxylated nonylphenols.

Flammability: Moderate risk

Environmental: Aquatic species risk due to presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 5

Composition:
Water
Hydrocarbons, aromatic
Ethylene glycol ethers
Ethoxylated nonylphenol
Alkyl benzene sulfonates
Alkoxylated alcohols
Alkali/salts

VOC Content: 30%; 2.5 lbs/gal
Flashpoint: 139°F
pH: 4.3

Performance

Wipability:	wet ink- 9 strokes	Blanket swell:	1 hr.- 6.1%
	dry ink- 8 strokes		5 hrs.- 15.4%

The performance of Blanket Wash 5 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 5 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons and ethylene glycol ethers, and very low concern for exposure to ethoxylated nonylphenols. However, the hazard value for aromatic hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons and ethylene glycol ethers. Due to negligible exposure, no concern exists for the other chemicals in this formulation.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates and ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Ethylene glycol ethers		X		X		
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 6

Composition:
Fatty acid derivatives
Hydrocarbons, petroleum distillates
Solvent naphtha (petroleum), heavy aromatic
Alkyl benzene sulfonates

VOC Content: 47%; 3.5 lbs/gal
Flashpoint: 152°F
pH: 5.5

Performance

Wipability: wet ink- 8 strokes; dry ink- 6 strokes
Blanket swell: 1 hr.- 0.7%; 5 hrs.- 1.5%

The performance of Blanket Wash 6 was demonstrated at two facilities. Facility 11 based their performance evaluation on a sample size of 11 blanket washes and printed with conventional and vegetable-based inks. This facility found that the wash left an oily residue that interfered with print quality. Due to its thick consistency, the wash did not readily absorb into rags creating delays. In addition, this facility found that more effort was required with heavy ink coverage. This facility felt that Blanket Wash 6 yielded fair performance results overall.

Facility 15 based their performance evaluation on a sample size of 23 blanket washes and printed with conventional inks. This facility also noted that the blanket wash did not readily absorb into rags due to its thick consistency. This created delays in cleaning, and prompted this facility to rate the cleaning effort as "high." However, this facility felt that Blanket Wash 6 cut the ink well and did not leave a residue on the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 6 instead of the baseline. Costs for facilities 11 and 15 increased roughly 20 percent and 50 percent respectively when using Blanket Wash 6 instead of the baseline. Performance results indicate an 11 percent increase and a 69 percent increase in cleaning times at facilities 11 and 15, respectively. Despite a 30 percent decrease in the average quantity of blanket wash used, facility 15 experienced a 60 percent increase in costs associated with blanket wash use (i.e., volume x price) due to a product cost of more than twice the baseline cost ($12.35/gallon for product 6 compared to $5.88/gallon for the baseline product). Facility 11 experienced a 20 percent increase in product use, with a subsequent increase of 170 percent in costs associated with product use.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
11	$0.82	$3.28	$8,200	$7,000	+17
15	$0.77	$3.08	$7,700	$5,000	+54

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 6. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margins of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon inhalation studies. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The fatty acid derivatives and alkyl benzene sulfonates are of low concern due to their expected low rate of dermal absorption and low to moderate hazard.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, the petroleum distillate hydrocarbons, alkyl benzene sulfonates, and fatty acid derivatives used in this formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 7

Composition:
Terpenes
Ethoxylated nonylphenol
Alkoxylated alcohols

VOC Content: 36%; 3.0 lbs/gal
Flashpoint: 165°F
pH: 9.3

Performance

Wipability:	wet ink- 6 strokes	Blanket swell:	1 hr.- 3.8%
	dry ink- 8 strokes		5 hrs.- 6.8%

The performance of Blanket Wash 7 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 7 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and very low concern for exposure to ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values, although none of the chemicals present more than a low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 8

Composition:
- Water
- Hydrocarbons, aromatic
- Propylene glycol ethers
- Alkyl benzene sulfonates
- Ethoxylated nonylphenol
- Alkoxylated alcohols
- Alkali/salts

VOC Content: 41%; 3.3 lbs/gal
Flashpoint: 115°F
pH: 4.0

Performance

Wipability:	wet ink- 7 strokes	Blanket swell: 1 hr.- 7.7%
	dry ink- 9 strokes	5 hrs.- 20%

The performance of Blanket Wash 8 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 8 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for propylene glycol ethers and very low concern for ethoxylated nonylphenol. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicated a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The other compounds in the formulation present low to moderate hazard concerns.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon a subacute oral study. Due to low or negligible inhalation exposure, other chemicals in the formulation present little or no concern.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates and ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkali/salts	X		X			
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 9

Composition:
Fatty acid derivatives
Water
Ethoxylated nonylphenol

VOC Content: 10%; 0.77 lbs/gal
Flashpoint: 230+°F
pH: 4.6

Performance

Wipability: wet ink- 19 strokes; dry ink- 30 strokes
Blanket swell: 1 hr.- 1.5%; 5 hrs.- 1.5%

The performance of Blanket Wash 9 was demonstrated at two facilities. Facility 10 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash yielded poor performance overall. The wash did not cut ink well, required excessive effort for cleaning, and did not soak into the rag. For these reasons, this facility discontinued using Blanket Wash 9 after four washes.

Facility 15 based their performance evaluation on a sample size of 21 blanket washes and printed with conventional inks. This facility also found that the wash yielded poor performance and that the wash did not soak into the rag. This facility felt that using Blanket Wash 9 required much more effort than using the baseline.

Cost

Blanket washing costs increase significantly when using Blanket Wash 9 as compared to the baseline product at facilities 10 and 15. Costs increased 129 percent and 84 percent at facilities 10 and 15 respectively when compared to the baseline. Performance data indicate that increased cleaning times are the driving force behind the cost increases experienced by both facilities. Cleaning times increase 175 percent and 129 percent when compared to the baseline at facilities 10 and 15, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
10	$2.08	$8.32	$20,800	$9,100	+129
15	$0.92	$3.68	$9,200	$5,000	+84

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 9. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate a very low concern for ethoxylated nonylphenol. Risks for the fatty acid derivative could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption.

Inhalation Exposure: Due to negligible inhalation exposure, the chemicals used in this formulation present no concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 10

Composition:
Fatty acid derivatives
Water

VOC Content: 2%; 0.16 lbs/gal
Flashpoint: 230+°F
pH: 5.7

Performance

Wipability: wet ink- 12 strokes; dry ink- 13 strokes

Blanket swell: 1 hr.- 0.7%; 5 hrs.- 0.7%

The performance of Blanket Wash 10 was demonstrated at two facilities. Both facilities 3 and 4 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. Both facilities declined to further test the blanket wash due to the level of effort required to clean the blankets. Blanket Wash 10 did not absorb well into the rags and did not cut ink well at either facility.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 10. Blanket washing costs increased 4 percent at facility 3 and 160 percent at facility 4 when Blanket Wash 10 is used rather than the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
3	$0.57	$2.28	$5,700	$5,500	+4
4	$2.20	$8.80	$22,000	$8,500	+159

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 10. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risk for this formulation could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption of the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 11

Composition:
Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 61%; 4.3 lbs/gal
Flashpoint: 150°F
pH: 5.0 (fluctuates wildly)

Performance

Wipability:	wet ink- 4 strokes	Blanket swell:	1 hr.- 0.0%
	dry ink- 5 strokes		5 hrs.- 1.5%

The performance of Blanket Wash 11 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of 26 blanket washes and printed with vegetable-based inks. This facility found that the blanket wash yielded good performance results from light to medium ink coverage, but poor performance results for heavy ink coverage due to the extra time and effort required. This facility found that the blanket wash left a slight, oily residue on the blanket, although this did not affect the print quality.

Facility 2 based their performance evaluation on a sample size of 31 blanket washes and printed with conventional and vegetable-based inks. This facility found that the blanket wash yielded good to fair performance results for light to medium ink coverage but poor performance for heavy ink coverage due to the extra product, time and effort required. This facility also found that the blanket wash left a slight, oily residue on the blanket which did not affect the print quality.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 11 instead of the baseline. Overall costs per wash at facilities 1 and 2 increased roughly 120 percent and 30 percent respectively when using Blanket Wash 11 instead of the baseline. Costs associated with product use (i.e., volume x price) are driven by the higher price of Blanket Wash 11 as compared to the baseline. Blanket Wash 11 is priced at $12.15/gallon compared to $5.88/gallon for the baseline product. Material costs (i.e., press wipes) increased by roughly 210 percent and 140 percent at facility 1 and 2, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
1	$1.29	$5.16	$12,900	$5,900	+119
2	$0.68	$2.72	$6,800	$5,300	+28

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 11. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to the petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The alkyl benzene sulfonates are of low concern due to their expected low rate of dermal absorption and low to moderate hazard.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 12

Composition:
Hydrocarbons, petroleum distillates
Water

VOC Content: 20%; 1.3 lbs/gal
Flashpoint: 125°F
pH: 8.2

Performance

Wipability: wet ink- 7 strokes; dry ink- 11 strokes

Blanket swell: 1 hr.- 0.0%; 5 hrs.- 1.5%

The performance of Blanket Wash 12 was demonstrated at two facilities. Facility 12 based their performance evaluation on a sample size of 16 blanket washes and printed with conventional inks. The wash was diluted 50% with water. This facility noted that the wash caused potential print quality problems. This facility also found that the wash had difficulty cutting paper residue and discontinued use of the wash on paper residue coated blankets. Nevertheless, the wash was considered equal to baseline in overall performance.

Facility 13 based their performance evaluation on a sample size of 19 blanket washes and printed with conventional inks. This facility considered the overall performance of the wash to be fair across ink coverages and dilutions. When not diluted with water, performance surpassed baseline and standard washes. The wash required slightly less effort than the baseline wash when averaged over all dilution levels.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 12 instead of the baseline. Average costs per wash increased roughly 20 percent and 5 percent at facilities 12 and 13, respectively. At a cost of $16.40/gallon, however, Blanket Wash 12 would not be economically competitive with the baseline ($5.88/gallon) unless the average quantity used was significantly lower.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
12	$0.99	$3.96	$9,900	$8,100	+22
13	$0.83	$3.32	$8,300	$8,000	+4

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 12. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risk could not be quantified, but structure-activity analysis indicates a low to moderate hazard concern.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risk could not be quantified but is expected to be low due to low exposure and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 14

Composition:
Fatty acid derivatives
Propylene glycol ethers
Water

VOC Content: 12%; 0.97 lbs/gal
Flashpoint: 230+°F
pH: 5.0

Performance

Wipability: wet ink- 8 strokes; dry ink- 10 strokes
Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 14 was demonstrated at two facilities. Facility 6 based their performance evaluation on a sample size of 15 blanket washes and printed with conventional inks. This facility found that the wash cut ink well, and the performance was good. The facility noted that extra effort was required to remove the oily residue that the wash left on the blanket.

Facility 16 based their performance evaluation on a sample size of 34 blanket washes and printed with conventional inks and printed with conventional inks. This facility found that the substitute wash did not cut ink as well as the baseline wash. Black inks and heavy ink build up were especially difficult to clean. In addition, the thick consistency of the wash made it difficult to soak into the rag.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 14 instead of the baseline product at both facilities 6 and 16. Compared to the baseline, total costs per wash increased 133 percent at facility 6 and 24 percent at facility 16. The average cleaning time increased significantly at facility 6 compared to the baseline, requiring an additional minute per wash. Despite a decrease in the average cleaning time, overall costs per wash at facility 16 increase, driven primarily by the product's higher price. Blanket Wash 14 is priced at $9.55/gallon compared to $5.88/gallon for the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
6	$1.07	$4.28	$10,700	$4,600	+133
16	$0.82	$3.28	$8,200	$6,600	+24

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 14. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified but are expected to be low based on structure-activity predictions of low toxicity for both the fatty acid derivatives and the propylene glycol ethers. Also, the fatty acid derivatives are expected to be poorly absorbed.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern. Risks for the propylene glycol ether are also expected to be low due to low exposure and its predicted low toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 16

Composition:
Terpenes

VOC Content: 99%; 7.2 lbs/gal
Flashpoint: 145°F
pH: 9.8

Performance

Wipability:	wet ink- 2 strokes	Blanket swell:	1 hr.- 4.5%
	dry ink- 2 strokes		5 hrs.- 10.6%

The performance of Blanket Wash 16 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 16 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analyses of these compounds indicate low to moderate hazard concerns.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value for terpenes is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low due to low exposures and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 17

Composition:
Ethoxylated nonylphenol
Glycols
Fatty acid derivatives
Alkali/salts
Water

VOC Content: 0.6%; 0.051 lbs/gal
Flashpoint: 220+°F
pH: 9.8

Performance

Wipability:	wet ink- 100 strokes	Blanket swell:	1 hr.- 1.5%
	dry ink- 100 strokes		5 hrs.- 1.5%

The performance of Blanket Wash 17 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 17 were not developed.

Risk and Exposure

Dermal Exposure: Hazard quotient calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon an oral study. Margin of exposure calculations indicate very low concern for ethoxylated nonylphenols and alkali/salts. However, the hazard value for alkali/salts is based upon oral values. The alkanolamine component of the fatty acid derivative/alkanolamine salt presents a possible concern. However, dermal absorption of the alkanolamine salt is likely to be lower than that of free alkanolamine.

Inhalation Exposure: Hazard quotient calculations indicate no concern for glycols. However, the hazard value is based upon an oral study. Due to negligible inhalation exposure, ethoxylated nonylphenol, fatty acid derivatives and alkali/salts present very low concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Alkali/salts	X		X			

Blanket Wash Formulation 18

Composition:
- Fatty acid derivatives
- Hydrocarbons, petroleum distillates
- Hydrocarbons, aromatic
- Dibasic esters
- Esters/lactones
- Alkyl benzene sulfonates

VOC Content: 60%; 4.4 lbs/gal
Flashpoint: 150°F
pH: 5.5

Performance

Wipability:	wet ink- 8 strokes	Blanket swell:	1 hr.- 1.5%
	dry ink- 7 strokes		5 hrs.- 4.5%

The performance of Blanket Wash 18 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 18 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and dibasic esters. However, the hazard values are based on inhalation studies. Risk from the alkyl benzene sulfonates could not be quantified but is expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Risk from esters/lactones is also expected to be low based on structure-activity predictions of low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and dibasic esters. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Flammability: Not available

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 19

Composition:
Fatty acid derivatives
Propylene glycol ethers
Water

VOC Content: 22%; 1.8 lbs/gal
Flashpoint: 230+°F
pH: 4.6

Performance

Wipability: wet ink- 11 strokes; dry ink- 9 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 1.5%

The performance of Blanket Wash 19 was demonstrated at two facilities. Facility 18 based their performance evaluation on a sample size of 5 blanket washes and printed with soy oil-based inks. This facility noted that the thick consistency of the wash made it difficult to soak into the rag, which resulted in uneven application. Large quantities were required to cut ink.

Facility 19 based their performance evaluation on a sample size of 8 blanket washes and printed with soy oil-based inks. This facility noted that the thick consistency of the wash was messy and difficult to use. The demonstration was cut short due to the extra effort and time required to clean the blanket.

Cost

The results of the performance data indicate an increased financial cost when using Blanket Wash 19 instead of the baseline at both facilities 18 and 19. Overall costs per wash increased roughly 170 percent and 70 percent at facilities 18 and 19, respectively. This increase in cost was due in large part to an increase in cleaning and drying times. Press operators commented that cleaning and drying times were excessive, as reflected in the performance data; performance results indicate a 150 percent increase and a 60 percent increase in cleaning times at facilities 18 and 19, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
18	$1.66	$6.64	$16,600	$6,200	+168
19	$0.89	$3.56	$8,900	$5,300	+68

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 19. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be calculated due to the unavailability of hazard values. However, risks are expected to be low based on structure-activity predictions of low toxicity of propylene glycol ethers and poor absorption and low to moderate toxicity of the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives present no concern. Risks for propylene glycol ethers are expected to be low due to low exposure and low hazard concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 20

Composition:
- Water
- Hydrocarbons, petroleum distillates
- Hydrocarbons, aromatic
- Alkyl benzene sulfonates

VOC Content: 35%; 2.7 lbs/gal
Flashpoint: 170°F
pH: 7.1

Performance

Wipability:	wet ink- 5 strokes	Blanket swell:	1 hr.- 0.0%
	dry ink- 7 strokes		5 hrs.- 1.5%

The performance of Blanket Wash 20 was demonstrated at two facilities. Facility 11 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional and vegetable-based inks. This facility considered the performance of the wash to be fair, but worse than facility and baseline washes. The wash left an oily residue on the blanket that required additional rotations to remove. The wash also was hard to apply to rags due to its thick consistency.

Facility 12 based their performance evaluation on a sample size of one blanket wash and printed with conventional inks. The product induced nausea in press operators, and the facility discontinued the test.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 20 instead of the baseline. Average costs per wash increased roughly 60 percent and 95 percent at facilities 11 and 12, respectively. For facility 11, this increase is due in large part to an increase in cleaning times. Cleaning times at facility 11 increased from an average of 60 seconds for the baseline to an average of 100 seconds for Blanket Wash 20. The contribution of labor to the product cost for Facility 12 is based on only one observation.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
11	$1.13	$4.52	$11,300	$7,000	+61
12	$1.58	$6.32	$15,800	$8,100	+95

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 20. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard value. Risk from the alkyl benzene sulfonates is expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 21

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates
Fatty acid derivatives

VOC Content: 47%; 3.5 lbs/gal
Flashpoint: 115°F
pH: 6.2

Performance

Wipability: wet ink- 7 strokes; dry ink- 6 strokes

Blanket swell: 1 hr.- 0.0%; 5 hrs.- 1.5%

The performance of Blanket Wash 21 was demonstrated at two facilities. Facility 6 based their performance evaluation on a sample size of 6 blanket washes and printed with conventional inks. This facility considered the performance of the wash to be fair. The wash cut ink well, but the oily residue was difficult to remove and began to affect subsequent runs. Extra waste sheets were required to get back up to color due to the residue.

Facility 17 based their performance evaluation on a sample size of 25 blanket washes and printed with conventional inks. This facility also considered the performance of the wash to be fair. This facility also found that the wash cut the ink well. The oily residue caused print problems if it was not completely removed. In addition, the wash did not absorb into the rag easily.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 21 instead of the baseline. Costs per wash increase roughly 120 percent at facility 6 and 40 percent at facility 17 when compared to the baseline. Extra wiping was required to clear the blanket as reflected in the performance data --- when compared to the baseline, average cleaning times increased roughly 110 percent for facility 6 and 50 percent for facility 17.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
6	$1.01	$4.04	$10,100	$4,600	+120
17	$0.58	$2.32	$5,800	$4,100	+41

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 21. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. However, the hazard values are based upon inhalation studies. Risk for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. Due to negligible exposure and predicted low toxicity and absorption, fatty acid derivatives present no concern.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 22

Composition:
Fatty acids derivatives
Hydrocarbons,aromatic
Water

VOC Content: Not measured
Flashpoint: 157°F (full strength)
pH: 7.4 (25%)

Performance

Wipability: wet ink- 13 strokes; dry ink- 13 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 1.5%

The performance of Blanket Wash 22 was demonstrated at two facilities. Facility 12 based their performance evaluation on a sample size of 5 blanket washes and printed with conventional inks. This facility considered the wash to be a fair performer overall. The substitute wash cut ink as well as the baseline, but it did not readily soak into the rag, creating delays.

Facility 13 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional inks. This facility also considered the wash to be a fair performer. The facility found that the wash was difficult to apply to the rag due to its thick consistency. In addition, the wash left the blanket slightly streaked and wet. As a result, extra drying time was required to prevent quality problems. The facility also found that the wash cut ink as well as baseline wash, but it required greater effort.

Cost

Performance data indicate mixed results for Blanket Wash 22. Total costs per wash increased 89 percent for facility 13, but increased only 1 percent for facility 12. Despite a 34 percent decrease in the average quantity used, costs associated with product use (i.e., volume x price) increased 50 percent for facility 12. Blanket Wash 22 is priced at $13.15/gallon compared to a price of $5.88/gallon for the baseline product. Average cleaning time increased 67 percent at facility 13 compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
12	$0.82	$3.28	$8,200	$8,100	+1
13	$1.51	$6.04	$15,100	$8,000	+89

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 22. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be calculated due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds.

Risks from the fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Inhalation Exposure: Risks could not be quantified but are expected to be low due to low or negligible exposures.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 23

Composition: Terpenes Nitrogen heterocyclics Alkoxylated alcohols Water VOC Content: 6%; 0.48 lbs/gal Flashpoint: 140°F pH: 9.2

Performance

Wipability:	wet ink- 24 strokes	Blanket swell:	1 hr.- 0.0%
	dry ink- 100 strokes		5 hrs.- 1.5%

The performance of Blanket Wash 23 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 23 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate possible concerns for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on low exposure and structure-activity predictions of poor absorption and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 24

Composition:
Terpenes
Ethylene glycol ethers
Ethoxylated nonylphenol
Alkyl benzene sulfonates
Alkali/salts
Water

VOC Content: 19%; 1.5 lbs/gal
Flashpoint: 100°F
pH: 9.9

Performance

Wipability:	wet ink- 15 strokes	Blanket swell:	1 hr.- 1.5%
	dry ink- 12 strokes		5 hrs.- 3.0%

The performance of Blanket Wash 24 was demonstrated at two facilities. Facility 16 based their performance evaluation on a sample size of 28 blanket washes and printed with conventional inks. This facility found that the wash cut ink well. However, the wash left an oily residue, which required some extra effort to wipe off. In addition, the oily residue significantly increased the number of copies required to return to print quality.

Facility 17 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility also found that the wash cut ink well. Again, extra effort was required to wipe off the oily residue. In addition, the thick consistency of the wash caused the operator to curtail use. The operator felt that the citrus odor of the wash was very strong.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 24 instead of the baseline. Costs per wash increased roughly 50 percent at facility 16 and 110 percent at facility 17, when compared to the baseline. When compared to the baseline, average cleaning times increased 18 percent and 160 percent for facilities 16 and 17, respectively. Despite the fact that facility 17 used a smaller average quantity of Blanket Wash 24 compared to the baseline, the costs associated with blanket wash use (i.e., volume x price) increased due to a much higher price per gallon. The manufacturers price for product 24 is $17.85/gallon versus $5.88/gallon for the baseline product. Costs associated with product use (i.e., volume x price) increased roughly 220 percent and 160 percent for facilities 16 and 17, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
16	$0.97	$3.88	$9,700	$6,600	+47
17	$0.88	$3.52	$8,800	$4,100	+115

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 24. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for alkyl benzene sulfonates and terpenes, possible concern for ethylene glycol ethers, and very low concern for ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for alkali/salts could not be quantified but are expected to be very low based on structure-activity predictions of no absorption and low to moderate toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes and ethylene glycol ethers. However, the hazard value for terpenes is based upon an oral study. Due to negligible exposure, the other chemicals in this formulation present no concern.

Flammability: Moderate risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Ethylene glycol ethers		X		X		
Alkali/salts	X		X			
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 25

Composition:
Terpenes
Esters/lactones

VOC Content: 55%; 4.1 lbs/gal
Flashpoint: 220+°F
pH: 4.3

Performance

Wipability:	wet ink- 22 strokes	Blanket swell:	1 hr.- 3.0%
	dry ink- 32 strokes		5 hrs.- 4.5%

The performance of Blanket Wash 25 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 25 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and possible concern for exposure to esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes and esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 26

Composition:
Fatty acids derivatives
Esters/lactones

VOC Content: 18%; 1.3 lbs/gal
Flashpoint: 230+°F
pH: 7.8 (fluctuates wildly)

Performance

Wipability:	wet ink- 6 strokes	Blanket swell:	1 hr.- 0.0%
	dry ink- 14 strokes		5 hrs.- 0.0%

The performance of Blanket Wash 26 was demonstrated at two facilities. Facility 5 based their performance evaluation on a sample size of 14 blanket washes and printed with conventional inks. This facility considered the performance to be good after every wash. The wash performed as well as both the standard facility wash and the baseline wash. However, a slight oily residue caused print quality problems when the wash was used for roller clean-up.

Facility 15 based their performance evaluation on a sample size of 22 blanket washes and printed with conventional inks. This facility also considered the performance to be good after every wash. Again, the wash performed as well as both the standard facility wash and the baseline wash.

Cost

Performance data indicate mixed results for Blanket Wash 26. Total costs per wash increased roughly 30 percent for facility 5, but decreased 6 percent at facility 15. Despite the fact that Blanket Wash 26 is priced higher than the baseline wash, differences in costs associated with product use (i.e., volume x price) did not contribute to the higher overall cost per wash at facility 5. Blanket Wash 26 is priced at $12.24/gallon compared to a price of $5.88/gallon for the baseline. Performance data indicate that the average quantity of blanket wash used at both facilities decreased by roughly 40 percent compared to the baseline. The savings experienced by facility 26 result from a 14 percent decrease in cleaning time compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
5	$0.73	$2.92	$7,300	$5,500	+33
15	$0.47	$1.88	$4,700	$5,000	-6

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 26. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for esters/lactones and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Due to negligible exposure, the chemicals used in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 27

Composition:
Terpenes

VOC Content: 93%; 7.2 lbs/gal
Flashpoint: 145°F
pH: 3.9

Performance

Wipability:	wet ink- 3 strokes	Blanket swell:	1 hr.- 3.0%
	dry ink- 3 strokes		5 hrs.- 4.5%

The performance of Blanket Wash 27 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 27 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 28

Composition:
Hydrocarbons, petroleum distillates

VOC Content: 100%; 6.2 lbs/gal
Flashpoint: 50°F
pH: 6.6

Performance

Wipability:	wet ink- 3 strokes	Blanket swell:	1 hr.- 1.5%
	dry ink- 8 strokes		5 hrs.- 3.0%

The performance of Blanket Wash 28 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 28 were not developed.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a low to moderate concern for petroleum distillate hydrocarbons.

Flammability: Not available

Environmental: Not available

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 29

Composition:
Fatty acid derivatives

VOC Content: 30%; 2.1 lbs/gal
Flashpoint: 230+°F
pH: 7.2

Performance

Wipability: wet ink- 9 strokes; dry ink- 18 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 1.5%

The performance of Blanket Wash 29 was demonstrated at two facilities. Facility 7 based their performance evaluation on a sample size of three blanket washes and printed with conventional inks. This facility considered the performance of the wash to be good. The wash cut ink well; however, extra effort was required to dry the blanket.

Facility 8 based their performance evaluation on a sample size of 36 blanket washes and printed with conventional inks. This facility noted that the wash did not cut ink as well as the baseline wash and did not cut paper dust or powder. In addition, a slightly oily film remained on the blanket, which required more effort to remove.

Cost

Using Blanket Wash 29 rather than the baseline, costs per press increased roughly 60 percent at both facilities 7 and 8. Blanket Wash 29 is priced three-times higher than the baseline, contributing significantly to the higher overall costs associated with its use. Costs associated with product use (i.e., volume x price) increase 300 percent and 230 percent at facilities 7 and 8 respectively due primarily to the products higher price. Blanket Wash 29 is priced at $18.00/gallon compared to a price of $5.88/gallon for the baseline. In addition, average cleaning times are higher for Blanket Wash 29 compared to the baseline for both facilities. Cleaning times increased 22 percent for facility 7 and 64 percent for facility 8.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
7	$0.93	$3.72	$9,300	$5,700	+63
8	$0.89	$3.56	$8,900	$5,500	+62

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 29. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity for the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the chemicals in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 30

Composition:
Hydrocarbons, aromatic
Propylene glycol ethers
Water

VOC Content: 7%; 0.48 lbs/gal
Flashpoint: 100°F (full strength)
pH: 7.6 (25%)

Performance

Wipability: wet ink- 5 strokes; dry ink- 11 strokes

Blanket swell: 1 hr.- 0.7%; 5 hrs.- 1.5%

The performance of Blanket Wash 30 was demonstrated at two facilities. Facility 18 based their performance evaluation on a sample size of three blanket washes and printed with soy oil-based inks. This facility considered the performance of the wash to be good. This facility noted that the wash cut ink well and worked best when not diluted with water.

Facility 19 based their performance evaluation on a sample size of eight blanket washes and printed with soy oil-based inks. This facility also noted that the wash cut ink well. However, the wash left an oily film on the blanket, which required extra effort to dry. In addition, the thick consistency of the wash was difficult to use, and extra effort was required due to its resistance to the surface of the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 30 instead of the baseline. Compared to the baseline, costs per wash increased roughly 60 percent at facility 18 and 20 percent at facility 19. Increased cleaning time was the primary contributor to the higher cost per wash for both facilities. According to the performance data, cleaning times at facility 18 increased from an average of 48 seconds for the baseline to an average of 82 seconds for Blanket Wash 30; however, this alternative was only tested under heavy ink coverage conditions and the baseline wash was observed under light and medium coverage conditions. The press operator at facility 19 commented that Blanket Wash 30 evaporated slowly; cleaning times for the alternative increased by roughly 30 percent, compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
18	$1.01	$4.04	$10,100	$6,200	+63
19	$0.62	$2.48	$6,200	$5,300	+17

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 30. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for propylene glycol ethers could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low hazard concern for propylene glycol ethers.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for propylene glycol ethers could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 31

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.6 lbs/gal
Flashpoint: 105°F
pH: 7.6

Performance

Wipability: wet ink- 3 strokes; dry ink- 3 strokes
Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 31 was demonstrated at two facilities. Facility 7 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash cut ink well. However, the wash left an oily residue on the blanket, which required slightly more effort to remove. In addition, the oily residue slightly increased the number of copies required to return to print quality. The facility noted that the smell was not as strong as the facility's standard wash or the baseline wash.

Facility 8 based their performance evaluation on a sample size of 61 blanket washes and printed with conventional inks. This facility also found that the wash cut ink well. The wash performed as well as the standard wash, and the facility considered the performance to be good. Slightly more effort was required due to the resistance of the wash to the surface of the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 31 instead of the baseline. Compared to the baseline, costs per wash increased roughly 180 percent at facility 7 and 7 percent at facility 8. The press operator at facility 7 observed that drying times for Blanket Wash 31 were greater than the baseline; cleaning times averaged 140 seconds for Blanket Wash 31, compared to 45 seconds for the baseline product. The press operator at facility 8 experienced a decrease in cleaning time, but an increase in the quantity of blanket wash used. According to the performance data, cleaning times at facility 8 decreased by 4 percent compared to the baseline. The average quantity of blanket wash used, however, increases roughly 60 percent, off-setting the gains in labor savings.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
7	$1.59	$6.36	$15,900	$5,700	+179
8	$0.59	$2.36	$5,900	$5,500	+7

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 31. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 32

Composition:
Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.5 lbs/gal
Flashpoint: 220°F
pH: 8.5

Performance

Wipability: wet ink- 5 strokes
dry ink- 30 strokes

Blanket swell: 1 hr.- 0.1%
5 hrs.- 1.5%

The performance of Blanket Wash 32 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of four blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. However, the substitute wash required slightly higher effort to remove excess wash than the standard wash. The substitute wash left an oily-residue on the blanket affecting subsequent print quality.

Facility 5 based their performance evaluation on a sample size of 12 blanket washes and printed with conventional inks. This facility also considered the performance of the wash to be good. The substitute wash left a slight, oily residue that was removed with dry rags; the residue did not affect print quality.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 32. Total costs per wash increased roughly 120 percent at facility 1, but decreased 20 percent at facility 5. Material costs (i.e., press wipes) contributed significantly to the higher costs per wash observed at facility 1. Costs associated with material use increased roughly 160 percent compared to the baseline. Facility 5 reported lower cleaning times and reduced blanket wash use for Blanket Wash 32, compared to the baseline. Performance results indicate a 15 percent decrease in cleaning time and a 60 percent decrease in the quantity of blanket wash used for facility 5.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
1	$1.31	$5.24	$13,100	$5,900	+122
5	$0.43	$1.72	$4,300	$5,300	-19

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 32. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 33

Composition:
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Propylene glycol ethers
Water

VOC Content: 46%; 3.4 lbs/gal
Flashpoint: 105°F
pH: 7.2 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes
dry ink- 4 strokes

Blanket swell: 1 hr.- 4.5%
5 hrs.- 7.6%

The performance of Blanket Wash 33 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 33 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and aromatic hydrocarbons and very low concern for propylene glycol ethers. However, the hazard values for petroleum distillate hydrocarbons and aromatic hydrocarbons are based upon an inhalation study.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, aromatic hydrocarbons, and propylene glycol ethers.

Flammability: Not available

Environmental: Not available

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 34

Composition:
Water
Terpenes
Hydrocarbons, petroleum distillates
Alkoxylated alcohols
Fatty acid derivatives

VOC Content: 39%; 2.8 lbs/gal
Flashpoint: 138°F
pH: 6.6

Performance

Wipability: wet ink- 10 strokes; dry ink- 20 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 34 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of 37 blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. The wash cut the ink well with the same effort as with the standard wash for light/medium ink coverage. For heavy ink coverage, slightly more effort was required, but the level of effort was acceptable.

Facility 19 based their performance evaluation on a sample size of 13 blanket washes and printed with soy-oil based inks. This facility considered the performance of the wash to be fair/poor. Again, the wash cut the ink well. However, it did not soak into the rag. In addition, the wash left an oily residue, which required extra effort to remove.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 34 instead of the baseline; average costs per wash increased roughly 50 percent and 80 percent at facilities 1 and 19, respectively. Performance data indicate that costs associated with product use (i.e., volume x price) at facility 1 increased roughly 160 percent. This increase is completely attributable to the alternative product's higher price. Blanket Wash 34 is priced at $15/gallon compared to a price of $5.88/gallon for the baseline. At facility 19, increased cleaning time is the single largest contributor to the higher average cost per wash of Blanket Wash 34; cleaning times averaged 67 seconds for Blanket Wash 31, compared to 41 seconds for the baseline product.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
1	$0.89	$3.56	$8,900	$5,900	+51
19	$0.95	$3.80	$9,500	$5,300	+79

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 34. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for terpenes and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Risks for petroleum distillate hydrocarbons could not be quantified. Structure-activity analysis indicates low to moderate hazard concern for these chemicals.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate hazard concern.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 35

Composition:
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic

VOC Content: 99%; 6.7 lbs/gal
Flashpoint: 105°F
pH: 6.0

Performance

Wipability: wet ink- 3 strokes; dry ink- 5 strokes

Blanket swell: 1 hr.- 1.5%; 5 hrs.- 6.1%

The performance of Blanket Wash 35 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 35 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 36

Composition:
Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Propylene glycol ethers

VOC Content: 48%; 3.5 lbs/gal
Flashpoint: 175°F
pH: 5.7 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes; dry ink- 5 strokes
Blanket swell: 1 hr.- 0.7%; 5 hrs.- 1.5%

The performance of Blanket Wash 36 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 36 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and propylene glycol ethers. Due to negligible exposure, the fatty acid derivatives present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low due to low exposure.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 37

Composition:
Water
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic

VOC Content: 14%; 1.0 lbs/gal
Flashpoint: 82°F
pH: 3.9

Performance

Wipability: wet ink- 5 strokes; dry ink- 8 strokes

Blanket swell: 1 hr.- 3.0%; 5 hrs.- 3.0%

The performance of Blanket Wash 37 was demonstrated at two facilities. Facility 3 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional inks. This facility noted that longer drying time was required with the substitute wash than with the baseline and standard facility washes. The performance was rated as good and fair on light and medium coverages, respectively. The press operators had no problems with the substitute wash.

Facility 4 based their performance evaluation on a sample size of six blanket washes and printed with conventional inks. This facility found that the substitute wash worked well initially but caused paper breakup due to blanket tackiness. Use of the substitute wash was discontinued.

Cost

Performance data indicate a reduced financial cost when using Blanket Wash 37 instead of the baseline. Average costs per wash decreased roughly 13 percent and 7 percent at facilities 3 and 4, respectively. Overall costs per wash decreased due to reduced cleaning time and material use (i.e., press wipes). Compared to the baseline, cleaning times decreased roughly 20 percent at both facilities 3 and 4.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
3	$0.48	$1.92	$4,800	$5,500	+13
4	$0.79	$3.16	$7,900	$8,500	-7

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 37. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate possible concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The petroleum distillate hydrocarbons present low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate hazard.

Flammability: High risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 38

Composition:
Hydrocarbons, petroleum distillates
Alkoxylated alcohols
Fatty acid derivatives

VOC Content: 65%; 4.9 lbs/gal
Flashpoint: 230+°F
pH: 5.6

Performance

Wipability: wet ink- 9 strokes; dry ink- 16 strokes
Blanket swell: 1 hr.- 0.0%; 5 hrs.- 1.5%

The performance of Blanket Wash 38 was demonstrated at two facilities. Facility 2 based their performance evaluation on a sample size of nine blanket washes and printed with conventional and vegetable-based inks. This facility found that the wash left an oily residue, which caused print quality problems. Use of the substitute wash was discontinued due to poor performance and print quality problems.

Facility 4 based their performance evaluation on a sample size of six blanket washes and printed with conventional inks. This facility found that the wash cut ink satisfactorily. However, use of the substitute wash was discontinued due to print quality problems associated with the oily residue.

Cost

Performance data indicate an increased financial cost when using Blanket Wash 38 instead of the baseline. Average costs per wash increased roughly 100 percent at facility 2 and 30 percent at facility 4. Costs associated with product use (i.e., volume x price) contributed significantly to the higher overall costs of using Blanket Wash 38. Specifically, compared to the baseline, costs associated with blanket wash use increased 400 percent at facility 2 and roughly 260 percent at facility 4 due primarily to Blanket Wash 38's high price. Blanket Wash 38 is priced at $19.00/gallon compared to $5.88/gallon for the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
2	$1.08	$4.32	$10,800	$5,300	+104
4	$1.11	$4.44	$11,100	$8,500	+31

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 38. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified due to the unavailability of hazard values. The fatty acid derivatives and alkoxylated alcohols are expected to present low risk based on structure-activity predictions of poor absorption and low or low to moderate toxicity. Petroleum distillate hydrocarbons present low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 39

Composition:
Water
Hydrocarbons, petroleum distillates
Propylene glycol ethers
Alkanolamines
Ethylene glycol ethers

VOC Content: 37%; 2.9 lbs/gal
Flashpoint: 155°F
pH: 9.2

Performance

Wipability: wet ink- 7 strokes; dry ink- 10 strokes
Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 39 was demonstrated at two facilities. Facility 5 based their performance evaluation on a sample size of 32 blanket washes and printed with conventional inks. This facility found that the wash cut ink well and rated its performance as good overall. However, the substitute wash did not dry as quickly as the baseline wash and left an oily residue on the blanket. In addition, the product did not work well on rollers.

Facility 8 based their performance evaluation on a sample size of five blanket washes and printed with conventional inks. This facility noted that the wash did not cut ink well and, thus, required extra time and effort to clean the blankets. In addition, it was difficult to get the wash to soak into rags, and the wash left an oily residue on the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 39 instead of the baseline. Costs at facilities 5 and 8 increased roughly 25 percent and 45 percent respectively when using Blanket Wash 39 instead of the baseline. Performance results indicated roughly a 40 percent increase in cleaning time at both facilities 5 and 8. Despite a 30 percent decrease in the average quantity of blanket wash used, the costs associated with product use (i.e., volume x price) did not vary between Blanket Wash 39 and the baseline. The manufacturer’s price for product 39 is $12.35/gallon compared to $5.88/gallon for the baseline product.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
5	$0.69	$2.76	$6,900	$5,500	+25
8	$0.80	$3.20	$8,000	$5,500	+45

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 39. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons, propylene glycol ethers, and alkanolamines as well as possible concern for other propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based on an inhalation study.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, propylene glycol ethers, and ethylene glycol ethers. However, the hazard value used for propylene glycol ethers is based on an oral study. Due to negligible exposure, alkanolamines present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Alkanolamines		X	X	X		X
Ethylene glycol ethers		X		X		

Blanket Wash Formulation 40

Composition:
Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates
Fatty acid derivatives
Ethoxylated nonylphenol

VOC Content: 52%; 3.8 lbs/gal
Flashpoint: 155°F
pH: 4.8

Performance

Wipability: wet ink- 5 strokes; dry ink- 10 strokes
Blanket swell: 1 hr.- 1.5%; 5 hrs.- 3.0%

The performance of Blanket Wash 40 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of six blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. The facility noted that when the wash was diluted with water, it left a residue. There was no residue when the wash was used full strength.

Facility 10 based their performance evaluation on a sample size of 20 blanket washes and printed with conventional inks. This facility found that the wash cut ink well and rated its performance good. The facility noted that the wash required slightly more effort when coverage was heavy.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 40. Compared to the baseline, average costs increased roughly 35 percent at facility 1 but decreased 4 percent at facility 10. The higher cost experienced by facility 1 is attributable to Blanket Wash 40's higher price as well as an increase in the average number of press wipes used. The average quantity of blanket wash used by facility 1 is 2.5 ounces for both the alternative as well as the baseline; however, costs associated with blanket wash use (i.e., volume x price) increased roughly 80 percent due to Blanket Wash 40's higher price. The reduced costs experienced by facility 10 are attributable to a reduction in the average quantity of blanket wash used. Costs associated with product use decreased roughly 30 percent for facility 10.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
1	$0.79	$3.16	$7,900	$5,900	+34
10	$0.87	$3.48	$8,700	$9,100	-4

* These costs refer to the cost/press/shift/year
** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 40. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for ethoxylated nonylphenol. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Due to negligible exposure, fatty acid derivatives and ethoxylated nonylphenol present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low due to low exposure.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

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APPENDIX A
ENVIRONMENTAL HAZARD ASSESSMENT METHODOLOGY

A.1 HAZARD PROFILE

The environmental hazard assessment of chemicals consists of the identification of the effects that a chemical may have on organisms in the environment. An overview of this assessment process has been reported by Zeeman and Gilford (1993a). The effects are expressed in terms of the toxicity of a chemical on the organisms and are generally given as the effective concentration (EC) that describe the type and seriousness of the effect for a known concentration of a chemical. When the effective concentrations for a range of species for a chemical is tabulated, the tabulation is called a Hazard Profile or Toxicity Profile. A more detailed discussion of a comprehensive Hazard Profile has been presented by Nabholz, 1991. The most frequently used Hazard Profile for the aquatic environment consists of six effective concentrations as reported by Nabholz, et al., (1993a). These are:

- Fish acute value (usually a fish 96-hour LC_{50} value)
- Aquatic invertebrate acute value (usually a daphnid 48-hour LC_{50} value)
- Green algal toxicity value (usually an algal 96-hour EC_{50} value)
- Fish chronic value (usually a fish 28-day chronic value (ChV))
- Aquatic invertebrate chronic value (usually a daphnid 21-day ChV value)
- Algal chronic value (usually an algal 96-hour NEC value for biomass)

For the acute values, the LC_{50} (mortality) (EC_{50}) (effects) refers to the concentration that results in 50 percent of the test organisms affected at the end of the specified exposure period. The chronic values represent the concentration of the chemical that results in no statistically significant effects on the test organism following a chronic exposure.

The Hazard Profile can be constructed using effective concentrations based on toxicity test data (measured) or estimated toxicity values based on Structure Activity Relationships (SARs). The measured values are preferred, but in the absence of test data SAR estimates, if available for the chemical class, can be used. Thus the Hazard Profile may consist of only measured data, only predicted values, or a combination of both. Also, the amount of data in the hazard profile may range from a minimum of one acute or chronic value to the full compliment of three acute values and three chronic values.

In the absence of measured toxicity values, estimates of these values can be made using Structure Activity Relationships (SARs). SAR methods include Quantitative Structure Activity Relationships (QSARs), qualitative SARs or use of the best analog. The use of SARs by OPPT has been described (Clements, 1988; Clements, et al., 1994 in press). The use and application of QSARs for the hazard assessment of new chemicals has been presented (Clements, et al., 1993a). The development, validation and application of SARs in OPPT have been presented by OPPT staff (Zeeman, et al., 1993b; Boethling, 1993; Clements, et al., 1993b; Nabholz, et al., 1993b; Newsome, et al., 1993 and Lipnick, 1993).

The predictive equations (QSARs) are used in lieu of test data to estimate a toxicity value for aquatic organisms within a specific chemical class. Although the equations are derived from correlation and linear regression analysis based on measured data, the confidence interval associated with the equation are not used to provide a range of toxicity values. Even with measured test data, the use of the confidence limits to determine the range of values is not used.

A.2 DETERMINATION OF CONCERN CONCENTRATION

Upon completion of a hazard profile, a concern concentration (CC) is determined. A concern concentration is that concentration of a chemical in the aquatic environment which, if exceeded, may cause a significant risk. Conversely, if the CC is not exceeded, the assumption is made that probability of a significant risk occurring is low and no regulatory action is required. The CC for each chemical is determined by applying Assessment Factors (AsF) (USEPA 1984) to the effect concentrations in the hazard profile.

Assessment Factors incorporate the concept of the uncertainty associated with (1) toxicity data; laboratory tests versus field test and measured versus estimated data and (2) species sensitivity. For example, if only a single LC_{50} value for a single species, is available, there several uncertainties to consider. First, how good is the value itself? If the test were to be done again by the same laboratory or a different laboratory, would the value differ? Second, there are differences in sensity (toxicity) among and between species that have to be considered. Is the species tested the most or the least sensitive? In general, if only a single toxicity value is available, there is a large uncertainty about the applicability of this value to other organisms in the environment and large assessment factor, i.e., 1000, is applied to cover the breadth of sensitivity known to exist among and between organisms in the environment. Conversely, the more information that is available results in more certainty concerning the toxicity values and requires the use of a smaller assessment factor. For example, if toxicity values are derived from field tests, then an assessment factor on 1 is used.

Four AsFs are used by OPPT to set a CC for chronic risk: 1, 10, 100, and 1000. The AsF used is dependent on the amount and type of toxicity data contained in the hazard profile and reflects the amount of uncertainty about the potential effects associated with a toxicity value. In general, the more complete the hazard profile and the greater the quality of the toxicity data, a smaller factor is used. The following discussion describes the use and application of the assessment factors:

1. If the hazard profile only contains one or two acute toxicity values, the concern concentration is set at 1/1000 of the acute value.

2. If the hazard profile contains three acute values (base set), the concern concentration is set at 1/100 of the lowest acute value.

3. If the hazard profile contains one chronic value, the concern concentration is set at 1/10 of the chronic value if the value is for the most sensitive species. Otherwise, it is 1/100 of the acute value for the most sensitive species.

4. If the hazard profile contains three chronic values, the concern concentration is set at 1/10 of the lowest chronic value.

5. If the hazard profile contains a measured chronic value from a field study, then an assessment factor of 1 is used.

A.3 HAZARD RANKING

Chemicals can be also be ranked according to hazard concern levels for the aquatic environment. This ranking can be based upon the acute toxicity values expressed in milligrams per liter (mg/L). The generally accepted scoring is as follows (Wagner, et al. 1995):

High Concern (H)	≤ 1
Moderate Concern (M)	> 1 and < 100
Low Concern (L)	> 100

This ranking can also be expressed in terms of chronic values as follows:

High Concern (H)	≤ 0.1
Moderate Concern (M)	> 0.1 and < 10.0
Low Concern (L)	≥ 10.0

Chronic toxicity ranking takes precedent over the acute ranking.

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APPENDIX B
EXPOSURE ASSESSMENT CALCULATIONS

This appendix presents the following model input data used for developing the exposure information presented in Chapter 3:

B.1 Sample Formulation Calculations for Modeling for 4 Chemicals
B.2 ISCLT Input File Example
B.3 BOXMOD Model Run For Sample Formulations for 2 Chemicals

B.1 SAMPLE FORMULATION CALCULATIONS FOR MODELING

B.1.1. Solvent Naphtha, heavy aromatic:

<u>ISCLT Parameters:</u>

Half-life in air: 2.5 days (from Fate Summary)
x 24 hours/day x 60 minutes/hour x 60 seconds/minute = 216,000 seconds

Release Rate for Single Facility:
0.02429 g/sec ÷ 100 m^2 = 0.0002429 = 2.4 x 10^{-4} g/sec/m^2

Model Result: 4.3 µg/m^3

<u>Exposure calculations:</u>

mg per year:
4.3 µg/m^3 x 20 m^3/day x 250 days/year ÷ 1000 = 21.5 mg/year ≈ 20 mg/year

Lifetime Average Daily Dose (LADD)
4.3 µg/m^3 x 20 m^3/day x 0.001 ÷ 70 kg = 1.2 x 10^{-3} mg/kg/day ≈ 1 x 10^{-3} mg/kg/day

<u>BOXMOD Parameters:</u>

DECAY = 0.693 ÷ 216000 = 3.21 x 10^{-6}

Time Constant= 1 ÷ DECAY = 216000 ÷ 0.693 = *311688*

Molecular Weight = 128

Release Rate for Denver:
0.02429 kg/site/day x 235 sites = 5.7 kg/day
5.7 kg/day ÷ 277130000 m^2 (277.13 km^2) = 2.1 x 10^{-8} g/sec/m^2

Model Result: 0.68 µg/m^3

<u>Air Potential Dose calculations:</u>

mg per year:
0.68 x 20 m^3/day x 250 days/year ÷ 1000 µg/mg = 3 mg/year

Lifetime Average Daily Dose (LADD)
0.68 x 20 m^3/day x .001 ÷ 70 kg = 1.9 x 10^{-4} mg/kg/day ≈ 2 x 10^{-4} mg/kg/day

B.1.2. Propylene glycol monobutyl ether

ISCLT Parameters:

Half-life in air: *14 hours*

14 hours x 60 minutes/hour x 60 seconds/minute = *50400 seconds*

Release Rate for Single Facility:

0.03815 g/sec ÷ 100 m^2 = 0.0003815 g/sec/m^2

Model Result: 4.7 µg/m^3

Exposure calculations:

mg per year:

4.7 µg/m^3 x 20 m^3/day x 250 days/year ÷ 1000 = 23.5 mg/year ≈ 20 mg/year

Lifetime Average Daily Dose (LADD)

4.7 µg/m^3 x 20 m^3/day x 0.001 ÷ 70 kg = 1.3 x 10^{-3} mg/kg/day ≈ 1 x 10^{-3} mg/kg/day

BOXMOD Parameters:

DECAY = 0.693 ÷ *50400* = *1.38 x 10^{-5}*

Time Constant = 1 ÷ DECAY = *50400*/0.693 = *72728*

Molecular Weight = 132

Release Rate for Denver:

0.03815 kg/site/day x 235 sites = 9.0 kg/day

9.0 kg/day ÷ 277130000 m^2 (277.13 km^2) = 3.2 x 10^{-8} g/sec/m^2

Model Result: 1.0 µg/m^3

Exposure calculations:

mg per year:

1.0 µg/m^3 x 20 m^3/day x 250 days/year ÷ 1000 = 5 mg/year

Lifetime Average Daily Dose (LADD)

1.0 µg/m^3 x 20 m^3/day x 0.001 ÷ 70 kg = 2.9 x 10^{-4} mg/kg/day ≈ 3 x 10^{-4}mg/kg/day

B.1.3 Fatty Acids, C_{16}-C_{18}, Methyl Esters

Water Release of 225.3 kg/site/year
Estimate of 94% removal during wastewater treatment

Daily Release:
225.3 kg/site/year ÷ 250 days/year = 0.9 kg/site/day

Daily Release after treatment:
0.9 kg/site/day x (1-0.94) = 0.05 kg/site/day

50th percentile mean flow of 499 million liters per day
0.05 kg/site/day x 1000 ÷ 499 million liters per day = 0.1 µg/L

Human Potential Dose via drinking water in mg/year:
0.1 µg/L x 2 L/day x 250 days/year ÷ 1000 = 5 x 10^{-2} mg/year

Human Potential Dose via fish ingestion:
Log BCF = 5.65; BCF = $10^{5.65}$ = 446,683
0.1 ug/L x 250 days/year x 16.9 g/day x 446,683 ÷ 1,000,000 = 189 mg/year
≈ 2 x 10^2 mg/year

10th percentile mean flow of 66 million liters per day
0.05 kg/site/day x 1000 ÷ 66 million liters per day = 0.8 µg/L

Human Potential Dose via drinking water in mg/year
0.8 µg/L x 2 L/day x 250 days/year ÷ 1000 = 0.4 mg/year

Human Potential Dose via fish ingestion:
Log BCF = 5.65; BCF = $10^{5.65}$ = 446,683
0.8 µg/L x 250 days/year x 16.9 g/day x 446,683 ÷ 1,000,000 = 1510 mg/year
≈ 2 x 10^3 mg/year

10th percentile low flow of 1 million liters per day
0.05 kg/site/day x 1000 ÷ 1 million liters per day = 50 µg/L

Denver Release Daily Release Amount:
225.3 kg/site/day x 235 sites ÷ 250 days/year = 212 kg/day

Denver Daily Release After Treatment:
212 kg/day x (1-0.94) = 12.71 kg/day

South Platte River Mean flow Stream Concentration:
12.71 kg/day x 1000 ÷ 875 million liters per day = 15 µg/L

Human Potential Drinking Water Ingestion in mg/year:
15 µg/L x 2 L/day x 250 days/year ÷ 1000 = 7.5 mg/year

Human Potential Fish Ingestion in mg/year:
15 µg/L x 16.9 g/day x 446,683 x 250 days/year ÷ 1,000,000 = 2.8 x 10^4 mg/year
≈ 3 x 10^4 mg/year

South Platte River Low flow Stream Concentration:
12.71 kg/day x 1000 ÷ 590 million liters per day = 22 µg/L

B.1.4 Tetrapotassium pyrophosphate

Water Release of 25.2 kg/site/year

Estimate of 0% removal during wastewater treatment

Daily Release:
25.2 kg/site/year ÷ 250 days/year = 0.1 kg/site/day

Stream Concentrations:
50th percentile mean flow of 499 million liters per day
0.1 kg/site/day x 1000 ÷ 499 million liters per day = 0.2 µg/L

Human Potential Dose via drinking water in mg/year:
0.2 µg/L x 2 L/day x 250 days/year ÷ 1000 = 0.1 mg/year

10th percentile mean flow of 66 million liters per day
0.1 kg/site/day x 1000 ÷ 66 million liters per day = 1.5 µg/L

Human Potential Dose via drinking water in mg/year
1.5 µg/L x 2 L/day x 250 days/year ÷ 1000 = 0.8 mg/year

10th percentile low flow of 1 million liters per day
0.1 kg/site/day x 1000 ÷ 1 million liters per day = 1 x 10^{2} µg/L

Denver Release Daily Release Amount:
25.2 kg/site/day x 235 sites ÷ 250 days/year = 23.7 kg/day

Denver Daily Release After Treatment:
23.7 kg/day x (1-0.94) = 1.4 kg/day

South Platte River Mean flow Stream Concentration:
1.4 kg/day x 1000 ÷ 875 million liters per day = 1.6 µg/L ≈ 2 µg/L

Human Potential Drinking Water Ingestion in mg/year:
1.6 µg/L x 2 L/day x 250 days/year ÷ 1000 = 0.8 mg/year

Human Potential Fish Ingestion in mg/year:
1.6 µg/L x 16.9 g/day x 446,683 x 250 days/year ÷ 1,000,000 = 3.0 x 10^{3} mg/year

South Platte River Low flow Stream Concentration:
1.4 kg/day x 1000 ÷ 590 million liters per day = 2.4 µg/L

B.2 ISCLT INPUT FILE EXAMPLE

```
SITE 001 - SANBERN - Sample Formulation Single Facility in San Bernardino
 1 2 2 0 0 3 2 3 4 2 0 0-7-8-9 0 0 1 0 1 0 0 1 1 0
   1   0  30  16   0   1   6   5  16   0

    33.33     66.67    100.00    133.33    166.67    200.00    233.33    266.67
   300.00    333.33    366.67    400.00    433.33    466.67    500.00    533.33
   566.67    600.00    633.33    666.67    700.00    733.33    766.67    800.00
   833.33    866.67    900.00    933.33    966.67   1000.00
       0.     22.50
(7X,6F7.5)
  N     0.001580.000200.000000.000000.000000.00000
NNE     0.000730.000000.000000.000000.000000.00000
 NE     0.000210.000000.000000.000000.000000.00000
ENE     0.000080.000000.000000.000000.000000.00000
  E     0.000180.000000.000000.000000.000000.00000
ESE     0.000150.000000.000000.000000.000000.00000
 SE     0.000210.000000.000000.000000.000000.00000
SSE     0.000290.000000.000000.000000.000000.00000
  S     0.000550.000000.000000.000000.000000.00000
SSW     0.001150.000300.000000.000000.000000.00000
 SW     0.003930.001000.000000.000000.000000.00000
WSW     0.005670.001800.000000.000000.000000.00000
  W     0.014280.004600.000000.000000.000000.00000
WNW     0.010100.003400.000000.000000.000000.00000
 NW     0.005820.001600.000000.000000.000000.00000
NNW     0.002300.000400.000000.000000.000000.00000
  N     0.003510.000400.000100.000000.000000.00000
NNE     0.003190.000300.000000.000000.000000.00000
 NE     0.002430.000100.000000.000000.000000.00000
ENE     0.002590.000200.000000.000000.000000.00000
  E     0.004070.000200.000000.000000.000000.00000
ESE     0.002480.000200.000000.000000.000000.00000
 SE     0.002020.000100.000000.000000.000000.00000
SSE     0.001300.000200.000000.000000.000000.00000
  S     0.002390.000600.000000.000000.000000.00000
SSW     0.003180.000800.000300.000000.000000.00000
 SW      0.007580.003400.001600.000000.000000.00000
WSW     0.009880.005800.003200.000000.000000.00000
  W     0.022150.012400.007300.000000.000000.00000
WNW     0.012960.006100.002400.000000.000000.00000
 NW     0.006630.002500.000600.000000.000000.00000
NNW     0.002220.000600.000100.000000.000000.00000
  N     0.001070.000500.000900.000200.000100.00000
NNE     0.001460.000400.000400.000000.000000.00000
 NE     0.001990.000400.000100.000000.000000.00000
ENE     0.001920.000500.000000.000000.000000.00000
  E     0.003130.000700.000000.000000.000000.00000
ESE     0.001730.000300.000100.000000.000000.00000
 SE     0.001780.000500.000200.000000.000000.00000
SSE     0.001190.000500.000200.000000.000000.00000
  S     0.000970.000500.000400.000000.000000.00000
```

```
SSW    0.001160.000600.000600.000000.000000.00000
 SW    0.002960.002200.002900.000100.000000.00000
WSW    0.004290.003900.008400.000400.000000.00000
 W     0.007670.006400.020900.000900.000000.00000
WNW    0.002830.002300.004000.000300.000000.00000
 NW    0.001280.000700.000900.000000.000000.00000
NNW    0.001100.000800.000500.000000.000000.00000
 N     0.002800.001200.001300.004800.002400.00060
NNE    0.001900.000900.000700.003200.001500.00080
 NE    0.001940.001200.000300.000700.000200.00010
ENE    0.003070.001900.000400.000100.000000.00000
 E     0.009610.003800.001300.000200.000000.00000
ESE    0.007900.002900.001600.000100.000000.00000
 SE    0.006660.002500.001800.000400.000000.00000
SSE    0.003620.001400.000800.000400.000000.00000
 S     0.003350.001500.001000.000200.000000.00000
SSW    0.003580.001300.001000.000300.000000.00000
 SW    0.009760.004200.003600.001300.000000.00000
WSW    0.016040.007400.008000.003900.000100.00000
 W     0.026460.013000.018300.010100.000100.00000
WNW    0.007520.003700.002500.000800.000000.00000
 NW    0.003720.001600.000900.000800.000000.00000
NNW    0.002300.001100.000700.001400.000200.00000
 N     0.003700.001200.001700.000000.000000.00000
NNE    0.009260.002500.001500.000000.000000.00000
 NE    0.028130.009000.000600.000000.000000.00000
ENE    0.036010.010100.000600.000000.000000.00000
 E     0.057860.011300.000500.000000.000000.00000
ESE    0.036440.005100.000000.000000.000000.00000
 SE    0.024540.002800.000000.000000.000000.00000
SSE    0.008130.001500.000000.000000.000000.00000
 S     0.006850.001200.000100.000000.000000.00000
SSW    0.003970.000700.000100.000000.000000.00000
 SW    0.013900.004000.000800.000000.000000.00000
WSW    0.037200.014100.004000.000000.000000.00000
 W     0.062430.023800.009400.000000.000000.00000
WNW    0.008390.002400.000700.000000.000000.00000
 NW    0.002870.000800.000100.000000.000000.00000
NNW    0.002090.000900.000500.000000.000000.00000
   294.10    294.10    294.10    291.00    287.90    287.90
  1728.00
  1152.00
  1152.00
   843.00
   534.00
     0.00
     0.00
     0.00
     0.00
     0.02
     0.00      0.00      0.00      9.800.00000321
     1.5       2.5       4.3       6.8       9.5       12.5
     0.00     22.50     45.00     67.50     90.00    112.50    135.00    157.50
   180.00    202.50    225.00    247.50    270.00    292.50    315.00    337.50
```

0.15000001						
0.15000001						
0.2						
0.25						
0.30000001						
01011020	0.00	0.00	3.00	10.00	0	0.0002429

B.3 BOXMOD MODEL RUN FOR SAMPLE FORMULATION

B.3.1 Solvent Naphtha

* * * * GAUSSIAN BOX MODEL INPUT * * * *

Latitude 39.49.30. Longitude 104.57. 0.
Area Width (km) = 1.66E+01
Emission Rate (g/m**2/s) = 2.10E-08
Time Constant (s) = 3.12E+05
Precipitation Rate (mm/hr) = 1.22E+00
Precipitation Frequency = 4.30E-02
STAR station 0618 - DENVER/STAPLETON CO
Molecular Weight = 1.28E+02

* * * * GAUSSIAN BOX MODEL RESULTS * * *

Scavenging Coeff (1/s) = 6.01E-05
Deposition Speed (m/s) = 7.00E-03
Concentration (ug/m**3) = 6.77E-01

B.3.2 Propylene Glycol

* * * * GAUSSIAN BOX MODEL INPUT * * * *

Latitude 39.49.30. Longitude 104.57. 0.
Area Width (km) = 1.66E+01
Emission Rate (g/m**2/s) = 3.20E-08
Time Constant (s) = 7.27E+04
Precipitation Rate (mm/hr) = 1.22E+00
Precipitation Frequency = 4.30E-02
STAR station 0618 - DENVER/STAPLETON CO
Molecular Weight = 1.32E+02

* * * * GAUSSIAN BOX MODEL RESULTS * * *

Scavenging Coeff (1/s) = 5.92E-05
Deposition Speed (m/s) = 7.00E-03
Concentration (ug/m**3) = 9.99E-01

APPENDIX C
LITHOGRAPHIC PERFORMANCE DEMONSTRATION METHODOLOGY

This chapter presents information on the methods that were used to gather the performance demonstration data at the print shops and in the laboratory, as presented in Chapters 4 and 7. Specifically, this appendix includes:

C.1 Characteristics to be Reported Out of the Performance Demonstration
C.2 Demonstration Methodology
C.3 Blanket Swell Test (laboratory test)
C.4 Washability/wipe Test (laboratory test)

C.1 CHARACTERISTICS TO BE REPORTED OUT OF THE PERFORMANCE DEMONSTRATION

C.1.1 Cost of Each Product as Utilized

Product Cost

Interested product suppliers should include the manufacturer's suggested retail price (to the end user) of their products ($ per 5 gallon drum) upon submission of samples for demonstration so that the cost per volume used in a cleaning cycle can be determined and reported.

Disposal/Spoilage Costs

Suppliers should provide specific recommendations for the disposal or treatment of wastes associated with using their products. Based upon these recommendations and the wastes determined in the field tests, disposal or treatment costs will be estimated.

Labor/Down-time Costs

This information will be based on the time required to wash a standard 19" X 26" blanket (based on two measures: button-push to completion of wash excluding time for other activities, such as refilling paper; and, after washing, zero the counter and count the number of sheets to get back to salable printing), a standard press operator wage, and standard press time costs. The costs of time and paper losses while returning to salable printing following the wash should be included here as well as any costs that may be associated with changes in or destruction of the blanket or other printing system components. The standard press operator wage information will be obtained from the wage and hourly survey developed by the National Association of Printers and Lithographers.

Storage Costs

These costs will include any special storage required due to hazardous components present in the blanket wash materials.

C.1.2 Product Constraints

The blanket wash supplier should provide information about product compatibility with specific inks (e.g. petroleum or vegetable oil based, UV water based), if known. If the supplier does not provide information regarding product incompatibilities, it will be assumed that there are none.

C.1.3 Special Safety Storage Requirements

Suppliers should provide information about the flammability (as measured by flash point) of the product. This will be confirmed by the laboratory test in the pre-screening procedure.

C.1.4 Ease of Use

The physical effort required to effectively clean the blanket using the test product will be evaluated and reported. This is a subjective judgement based on the experience of the press operator.

C.1.5 Duration of the Cleaning Cycle

The measured time will be the entire cleaning cycle from press shut down to completion of the cleaning process (this excludes any activity unrelated to blanket cleaning). This information when correlated with labor and press-time costs will attempt to measure the total costs associated with the use of the product.

C.1.6 Effectiveness of the Blanket Wash Solution

This will be the subjective judgement of the press operator. The basic criteria will be whether the blanket is sufficiently clean to resume printing based on the judgement of the operator. VM&P Naphtha will be used as the baseline blanket wash to measure a test solution's efficacy, and the operator should also compare against what is normally used on the press.

C.1.7 Printing Equipment and Ink

Information will include the manufacturer, type and age of the press, the blanket and the ink, and the length of press run prior to blanket wash.. This is basically descriptive information that may assist in discovering and reporting incompatibilities between the blanket washes and equipment or inks. Additionally, the type of printing job, type of fountain solution, paper size relative to press size, paper type, brief description of blanket condition (Note: the blanket used should be runable with no smashes or repairs) along with a general description (light, medium, and heavy) of ink coverage will also be reported.

C.2 DEMONSTRATION METHODOLOGY

C.2.1 Product Pre-Screening and Masking

The project will demonstrate alternative blanket washes. Products, product information and Material Safety Data Sheets (MSDS) will be submitted by suppliers in properly labeled generic commercial containers to an independent laboratory (e.g. Graphic Arts Technical Foundation (GATF) or university). The independent laboratory will test the flash point and volatile organic chemical (VOC) content of the alternative blanket washes. The vapor pressure of the product will be submitted by the supplier (the supplier will note whether the vapor pressure is based on a calculation or test data.) The pH of the product will be provided by the supplier and will be verified by the laboratory. Suppliers wishing to participate in the performance demonstration will have to make direct arrangements with the independent laboratory.

The laboratory will mask all products by removing the trade names and manufacturer from the containers and assign each sample a random ID number. Suppliers will provide a masked MSDS in addition to the standard MSDS sent for shipping. They will also give directions for use of the product without any identifying names, labels or characteristics.

The laboratory will perform a standard test for blanket swelling potential of each product. They will also perform a washability/wipe test for cleaning effectiveness on all of the products submitted. The blanket swell test and the washability/wipe test proposed methodologies are attached. The directions for each specific product will be used as much as possible, including the manufacturer's directions for dilution or mixing. Any deviation from the manufacturers directions will be noted along with the reasons for the deviation. Only products that pass this functional demonstration stage will be used in the field demonstration portion of the project.

Based on the results of the product pre-screening, products will be grouped into categories based on their formulation and/or chemical parameters. These categories should be consistent with the categories used in the EPA risk assessment. One or more products successfully completing the screening will be chosen to "represent" each of the categories; these representatives (one or two per category) will be from the average of the class. The selection of masked products will be sent to volunteer printers for field demonstration. The selection of printers will take into account the type of inks being used as well as the sizes and types of blankets. The variety of inks and blankets used for the demonstration will depend on the number of demonstration sites. Each printer will test a limited number of products. This number will be determined when the number of volunteer printers is established. Although contingent upon the number of categories, the number of volunteer printers, and available resources, each representative blanket wash will be field demonstrated by at least two.

C.2.2 Documentation of Existing Conditions at Volunteer Facility

Once the products have been shipped to the volunteer printing facilities, an observer[a] will record the type, color, and manufacturer of the ink currently being used on the press. The observer will also document the type, model, and condition of the press and blanket being used for the demonstration and the type of paper being run on the press. The observer will also briefly describe the experience of the press operators participating in the test and will document any past experiences that the printer has had with the demonstration of blanket washes; the observer will note any potential biases. The current waste and wipe disposal practices and costs will be documented by the observer. **NOTE:** Presence of observer should be cleared with insurance carrier if necessary, and the purpose of the observer should be carefully explained to the personnel in the pressroom.

The observer will record the product name and cleaning procedure for the blanket wash currently used by the company. The observer will record the cost of the current blanket wash solution. The observer will also record how the product is being stored (in bulk and at the press) and disposed of as waste.

The observer will document the current practices by observing the clean up of a blanket, utilizing the company's current product. This will include any pre-application dilution of the product. The observer will measure the quantity used for the cleaning with the company's current

[a] *A contract is currently being prepared by EPA to staff this function. This observer will not provide technical assistance to the printers. The observer will serve to document the demonstration and record the operators observations. The observer will ensure the operator performs the demonstration according to the final approved methodology. The observer will additionally serve as the press operators conduit to the technical assistance personnel. This conduit is necessary so as to clearly document the direction given and the actions taken.*

blanket wash solution and record the time required for the cleanup. The pressman will use a clean rag to clean the blanket, and the observer will record the size and weight of the rags used for cleaning before and after the cleaning. This will provide an estimate of the retention factor of the product.

The observer will describe the density of the image currently being printed and will record information on the relative frequency of blanket cleaning. The observer will document the number of images required to obtain an acceptable print.

C.2.3 Establishing Evaluation Baseline at Volunteer Facility

The blanket will be cleaned by the press operator using the baseline solution (VM&P Naphtha). This initial cleaning will serve to familiarize the press operator with the baseline product performance. The printer will compare the baseline solution with the blanket wash that is typically used. It has been suggested that this initial cleaning should not be used for comparative purposes, but the information noted below in Section B.2.4 should be noted for reference in any case.

C.2.4 Demonstration

The press will then be restarted for printing and then stopped for cleaning according to the company's standard procedures. The observer will measure the time of cleaning from button push to completion of wash excluding time for other activities, such as refilling paper, and will ask the press operator to zero the counter in order to count the number of sheets to get back to salable printing. The observer will document the volume of baseline solution used and describe the procedure used to ensure the directions were adhered to by the operator. This procedure will be followed for three complete cleaning cycles.

C.2.5 Press Operator Evaluation

At the completion of these cycles the press operator will subjectively evaluate the condition of the blanket, i.e., scaling, picking, etc. Additionally, the operator will evaluate the ease of use and performance of the baseline solution. The observer will describe the density of the image currently being printed. The observer will document the number of images required to obtain an acceptable print image for each of the cleaning cycles.

C.2.6 Resetting the Blanket

The blanket will be cleaned by the press operator using the test blanket wash solution. This initial cleaning will serve to familiarize the press operator with the product and to avoid complications with the previously used solutions. The press operator should measure the volume after each cleaning (the volume used in the initial cleaning may not be used for comparative purposes).

C.2.7 Demonstration

The press will be restarted for normal operation and then be stopped for cleaning according to the company's standard practice. The observer will measure the time of cleaning from button push to completion of wash excluding time for other activities, such as refilling paper, and will ask the press operator to zero the counter in order to count the number of sheets to get back to salable printing. The observer will document the volume of solution used and describe the procedure used to ensure the directions were adhered to by the operator. This procedure will be followed for five complete cleaning cycles.

C.2.8 Press Operator Evaluation

At the completion of these cycles the press operator will subjectively evaluate the condition of the blanket, i.e., scaling, picking etc. Additionally, the press operator will document the density of the last printed image. The press operator will document the number of images required to obtain an acceptable print image for each of the cleaning cycles. The press operator will compare the relative performance of the test solution as compared to the baseline solution.

C.2.9 Long Term Test

After completion of the above demonstration, a longer term test will be performed by the printer. This test will consist of continued use of the supplied product for a period of one week. The blanket will not be cleaned with any other solutions until the observer returns. The press operator will record the total number of copies printed, the number and relative frequency of blanket washes performed, the volume of product used for each blanket wash, the total amount of product used, and the number of images required to obtain an acceptable print quality for each cleaning cycle.

At the completion of this phase, the observer will return to the shop and will record the press operator's data. The observer will then document the procedures used in a final cleaning of the blanket by the press operator. This will indicate whether there has been any deviation from the initial cleaning procedure by the press operator. If there has been a deviation the observer shall record the reasons for the deviation.

The press operator will then evaluate the condition of the blanket and describe the density of the product currently being printed.

If at any time during this phase of the demonstration there is problem with the solution or the press, the press operator or company point of contact will document the problem as specifically as possible and call the technical assistance provider[b] for guidance. Any corrective action will be documented by both the technical assistance provider and the press operator. The observer will record the actions documented by the press operator.

C.2.10 Trouble Shooting

If problems arise during the field demonstration of the blanket solutions, the following procedures will be followed. If the observer is present, the problem will be documented and the observer will call the technical assistance provider for guidance. If the observer is not present the press operator will document the problem and contact the technical assistance provider.

The technical assistance provider will first review the procedures used by the press operator to ensure they are in compliance with the instructions provided with the product. If the procedures are correct then the technical assistance provider will contact one of the printers currently using a product in that category for assistance. Names of these support printers will be provided by the suppliers of the products. The technical assistance provider will relay and filter the recommendation of the support printer to the press operator. The technical assistance provider will ensure the confidentiality of the products is maintained during this period. The identity of the product in the field will remain masked, and the identity of the specific product being used by the support printer providing guidance will not be asked or provided by the printer.

[b] *A contract will be prepared by EPA to staff this function. The technical assistance provider (i.e., GATF, university, etc.) will be available to trouble-shoot during the field demonstration portion of the project.*

The observer and/or the technical assistance provider will document all actions recommended and taken.

If the recommendations provided by the technical assistance provider are unsuccessful, the press operator will then attempt to solve the problem. The observer and/or the technical assistance provider will document the actions taken by the press operator and the success or failure of the actions.

The above procedures will be repeated for each product tested at the printer test site.

C.2.11 Results and Final Report

Final results will be assembled from the test sites and provided to a contractor to develop into a final report. The report will be developed so that the blanket wash products submitted for testing are grouped according to their formulations/chemical parameters (e.g., VOC content, vapor pressure). The results from similar products in a grouping will be reported in ranges so that the scope of performance from each group can be reported in the information provided to printers. The parameters delineating the grouping will be clearly defined so that both printer and supplier can determine the grouping for any particular blanket wash of interest. Special attention will be paid to the report-out of information on water-miscible products so that printers realize that the category characteristics are based on the use of proper amounts of water. [Note: No results will be provided for individual/named products, but blanket washes participating in the study will be listed in the report, along with their grouping.] Results from the field demonstration will be evaluated and assembled so that for any particular group the "average" experience with the products in the group is presented, along with the extreme reactions.

The report will thus have two parts. One part that presents the independent laboratory's screening and other information founded in essentially concrete or quantitative data and a second part that gives experiential anecdotes derived from the subjective evaluations of the demonstration site personnel. Both types of information can be used to develop a second type of information product: case studies of individual demonstration locations that discuss specific actions, changes in techniques, attitude adjustments or other factors that could be significant to a printer that is contemplating product substitution. The products would continue to be masked in the case study. It may be possible to combine several sites with similar experiences into a single report focussing on a single group of products.

C.3 BLANKET SWELL TEST

The purpose of this test is to determine the effect of blanket washes on lithographic blankets by measuring any change in thickness by the use of a micrometer.

Equipment:

Crystallization Dish
Cady Gauge (gauge +/- 0.0005 inch)
Swell Test Clamp
2 x 2 inch squares compressible blankets
VM&P Naphtha, Varnish Makers' and Painters' Naphtha; petroleum fractions meeting ASTM specifications. (Distillation range, at 760mm Hg 5% at 130°C; greater than 90% at 145°C)
Various Blanket Washes

Experimental Procedure:

This procedure involves measuring and adding 10 ml of the blanket wash to a crystallization dish using a graduated cylinder. An initial caliper measurement is taken of the 2 x 2 inch blanket sample and then it is placed over the mouth of the dish. The dish and blanket are placed into the swell clamp where the blanket is tightened down onto the mouth of the dish until a leak proof seal is formed. The various washes are kept in contact with the blanket for one hour. Caliper readings are taken and the percent swell is calculated. The blanket is re-tightened, exposed for an additional five hours, and the caliper is measured again. This same procedure will be repeated for each blanket wash. The VM&P Naphtha will be used as a control.

$$\text{Percent Swell} = \frac{\text{Final Caliper} - \text{Initial Caliper}}{\text{Initial Caliper}} \times 100$$

Sample	% Caliper Change After 1 Hour	% Caliper Change After 6 Hours
1. Control (VM&P Naphtha)		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

Temperature ____________________________

Relative Humidity ______________________

Blanket Type ____________________________

C.4 WASHABILITY/WIPE TEST

Equipment:

Ink - Sheetfed Process Black
Blanket - Compressible Blanket Cut Into Squares
Quickpeek Brayer Apparatus
Gardner Scrubber Apparatus
Graduated Cylinder
Control Blanket Wash - VM&P Naphtha
Playtex® Panty Shield
Status T Reflective Densitometer
Standard 1200-1500 Watt Blow Dryer
Various Candidate Blanket Washes

Experimental Procedure:

The procedure involves an initial evaluation by using both a dry and wet ink film drawn down on separate pieces of blanket using a quickpeek brayer apparatus. The ink stripes will measure 2 inches wide and five inches in length. The amount of ink applied will be determined by using one small or large hole on the Quickpeek apparatus. The blanket will be new and cleaned with the standard prior to applying the ink films. One of the ink films will be dried with a standard blow dryer.

The piece of blanket will then be placed into the holder of the Gardener Scrubber Apparatus. A measured volume of standard and candidate washes will be evaluated. The number of strokes necessary to clean the blanket with the standard will be determined. Once the area has been cleaned with the standard, the densitometer will be used to evaluate the cleanliness of the blanket. Each candidate wash will be placed onto a clean Playtex® Panty Shield and the cleanliness of the blanket will be measured after the same number of strokes found necessary by the standard. if the blanket is not clean, the number of strokes necessary to clean the blanket will be noted. Any residue or other unusual conditions will be indicated.

One of the wet ink films will be dried for 20 minutes with the blow dryer. The same volume of standard and blanket wash as used for the wet ink will be use. The above procedure will be repeated.

The following represents a more detailed review of the step-by step procedure for the Gardner Scrubber Apparatus:

1. A piece of blanket is cut to fit into the holder of the Gardener Scrubber apparatus and the section to be scrubbed is drawn on the blanket. A measured quantity of ink is spread evenly onto the surface of the blanket, insuring that the thickness of the ink is uniform in the area to be scrubbed. Inking should be done on a counter or other level surface - inking in the holder will result in an uneven surface.

2. The wooden block is used to hold the sample collector, in this case a Playtex® Panty Shield. A new, dry shield should be weighed, without the coated paper that protects the adhesive. Solvent will be placed on the shield, not on the inked surface. The initial weight of the shield should be noted and the shield placed on the wooden block. Affix the shield on the side of the block not marked "top" block using the shield's adhesive, and place the block in its holder. Make sure the shield ends are inside the metal holder. They can be

forced in by hand or held with thumbtacks. Use the side screw to insure the block is held securely.

3. Prepare a pipet with 0.4 mL of standard solvent. Insure that the Scrubber counter is reset and that the holder is in a position where it can be stopped after the test. The far right hand side of the tray is suggested.

4. Place the inked blanket into the tray. Hold the wooden block with the panty shield up and away from the inked surface so that no ink gets on the panty shield. Pipet the wash onto the pad using a swirling motion to evenly distribute the solvent over the surface.

5. Turn the pad over and start the scrubber. It should be allowed to go back and forth 20 times. At the completion of the last cycle, lift the pad off the blanket surface.

6. Lift the tray and blanket out of the apparatus.

7. Remove the block holder and remove the panty shield. Place in a 110 C forced draft oven for 2 hours to drive off the solvent. Weigh the dried panty shield and note the weight.

8. Clean the piece of blanket and re-ink to perform more tests.

9. Complete the tests for the blanket wash materials being tested with 2 replications each. Repeat the test using the standard solvent upon completion of the test series.

Note: A modified method may need to be developed for aqueous cleaners.

APPENDIX D
PERFORMANCE DEMONSTRATION OBSERVER SHEETS

The following four forms (shown on the following pages) were used by the observers and printers to record information for the performance demonstrations:

D.1 Observer's Evaluation Sheet
D.2 Observer's Performance Evaluation Sheet
D.3 Printer's Evaluation Sheet
D.4 End-of-Week Follow-up Questionnaire

D.1 OBSERVER'S EVALUATION SHEET

FACILITY NAME: ____ **DATE:** ___________

Ask each participating printer in the substitute blanket wash performance demonstrations, to answer these questions when you call to schedule your visit to their facility. Once on-site, verify the answers.

1. Printing process

Approximately what percentage of your business (based on annual sales) is in the following segments? Please check all boxes that apply.

	<50%	**50 - 95%**	**95 - 100%**
Lithography/Offset	☐	☐	☐
Gravure	☐	☐	☐
Flexography	☐	☐	☐
Screen printing	☐	☐	☐
Letterpress	☐	☐	☐
Other (specify)	☐	☐	☐

2. Products

What percentage of your *lithography* business (based on annual sales) is in the following products? Please check all boxes that apply.

	<50%	**50 - 95%**	**95 - 100%**
Commercial Printing	☐	☐	☐
Direct-mail Products	☐	☐	☐
Business Forms	☐	☐	☐
Publications (other than news)	☐	☐	☐
Packaging	☐	☐	☐
News	☐	☐	☐
Other (specify)	☐	☐	☐

3. General Facility Information

How many employees are at this location? __________

How many employees work in the press room? __________

How many shifts does your facility run per day? __________

4. Press Type(s)

Describe the press(es) that will be used for the performance demonstrations. The required press size is in the 19" x 26" class.

1. **Press size:** __________ *(in. x in.)* **# of print units:** ___________ **Print speed:** __________ *(# impressions/hour)*

2. **Press size:** __________ *(in. x in.)* **# of print units:** ___________ **Print speed:** __________ *(# impressions/hour)*

5. Blanket information

On the press(es) that will be used for the demonstration, what is the average number of times a blanket is washed per shift? ________________

What type of blanket do you use on the press(es) that will be used for the demo:

- Manufacturer: _____________________________

- Type (e.g., 3-ply compressible, etc.) _________________________________

- Number of impressions on this blanket prior to the demonstrations:
  1 week or less...☐ 1 week to 3 months...☐ 3 months or more...☐

- Do you have any automatic blanket washers in your facility? ____________

6. Blanket Washes

Press Used in Demo.	**Trade Name of Blanket Wash/Manufacturer**	**Cost ($/gallon)**	**Dilution Ratio (wash:water)**	**Ink Type(s)**
				conventional ☐ vegetable oil-based ☐ UV ☐ waterless ☐ other___________ ☐
				conventional ☐ vegetable oil-based ☐ UV ☐ waterless ☐ other___________ ☐

7. Experience with Substitute Blanket Washes

a. Have you tried any substitute blanket washes for environmental or worker health and safety reasons?

- Did the substitute wash work better, the same, or worse than your old wash? Why?

b. Besides substitute washes, have you changed any equipment, procedures or work practices that reduced your use of blanket wash solution or reduced the time required to wash the blanket?
Yes.....☐ No.....☐ - If yes, please describe:

8a. Cleaning Procedure - CURRENT PRODUCT
Record blanket cleaning procedure using the chart below and the space at the bottom of the page for additional comments. In each column, check all that apply.

Method for Applying Blanket Wash	Type of Wipe Used to Clean the Blanket	Avg. No. of Wipes Used/Cleaning (cleaning+excess)	Method for Removing Excess Wash from Blanket	Wipes Management
Use squirt bottle to spray directly on blanket ☐	**Disposable** ☐ Size:________	1-2 ☐	Clean dry rag ☐	Send off-site for laundering ☐
Use squirt bottle to spray on wipe and apply wipe to blanket ☐	Wet ☐ Dry ☐	2-4 ☐	Clean wet rag ☐	Launder on-site ☐
Dip wipe in blanket wash and apply to blanket ☐	**Reusable** ☐	4-6 ☐	Allow to evaporate ☐	Dispose of as hazardous waste
Use safety plunger can ☐	Size:_________ Wet ☐ Dry ☐	6-8 ☐	No excess ☐	Dispose of as non-hazardous waste ☐
None Used ☐		8-10 ☐	Other (specify) ☐	
Other (specify) ☐	**Other** (specify) ☐	Other (specify) ☐		Other (specify) ☐

• Was the rotation of the blanket during washing *(circle one):* **manual** or **automatic**?

• Note any other steps taken in washing the blanket:

• For the current blanket wash product, ask the press operator if there are ever any variations in the cleaning procedure, and if so, under what circumstances?

8b. Cleaning Procedure - BASELINE PRODUCT
Clean the blanket using the baseline product, Naphtha, recording the required information on the observer's evaluation sheet for each cleaning.

• Note the condition of the blanket **before** cleaning:

• Weigh the Naphtha container before use. Record weight: ___________

• Pour Naphtha onto a clean, dry wipe.

• Weigh the Naphtha container again. Record weight: ____________

• Record the difference in weight on the evaluation sheet.

• Clean the blanket.

• Was the rotation of the blanket during washing *(circle one):* **manual** or **automatic**?

• Note any other steps taken in washing the blanket:

8c. Cleaning Procedure - SUBSTITUTE PRODUCT # _________
Clean the blanket using the substitute blanket wash. Follow the manufacturers instructions and record the required information on the observer's evaluation sheet for each cleaning.

• Note the condition of the blanket **before** cleaning:

• Describe the cleaning procedure:

• Was the rotation of the blanket during washing *(circle one):* **manual** or **automatic**?

D.2 OBSERVER'S PERFORMANCE EVALUATION SHEET

Facility Name____Date____________

Demo Type: *(Check one and enter wash #)*

Current Wash ______ Baseline Wash ______ Substitute Wash ______ (enter code # ______)

Wash # ______ (1 - 3) Wash # ______ (1 - 5)

Ink used before wash-up	Specify ink color, type, and manufacturer: conventional ....☐ vegetable oil-based....☐ other (specify) _________________
Run length	Record length of run (# impressions) ________________
Ink coverage *(obtain a sample sheet for each level of coverage)*	*(check one)*: Heavy______ Medium______ Light______
Substrate	*Record substrate printed:*
Drying time	Time from end of press run to start of blanket wash: ____________ minutes
Dilution	_____________ *(enter wash:water ratio* or *"none" if used at full strength)*
Quantity of wash used	_____________ ounces *(pour wash on wipe; record volume of wash poured)*
Cleaning time	______________ minutes *(time for blanket cleaning only)* ______________ rotations *(corresponding number of blanket rotations)*
Ease of cleaning	*(check one for each question):* • Compared to your standard wash, was the effort needed: Lower______ Same______ Higher______ • Compared to the baseline wash, was the effort needed: Lower______ Same______ Higher______ • Did the wash cut the ink: Well____ Satisfactorily____ Unsatisfactorily____
Excess wash	Did you have to remove excess wash? *(check one)* Yes _______ No_______ If "Yes", how was it removed? *(check all that apply)*: Wet wipe____ Dry wipe____ Allow to evaporate____
Wipes used	Enter the total number of fresh wipes used for blanket washing *(includes both wipes used for washing and for removing excess wash)*: __________

Odor	*(check one):* Odor not noticed______ Odor detected______ Strong odor______
Printer's opinion of the wash performance?	The wash **performance** was *(check one):* Good______ Fair______ Poor______
Examine the blanket	Evaluate the blanket appearance after the wash:
Printing after the wash	Specify the ink color and type used after the wash: How many impressions were run to get back to acceptable quality? ____________ Does the printer think the wash caused problems with the print quality? Yes *or* No If yes, explain:

D.3 PRINTER'S EVALUATION SHEET

Facility name: ____ Date: _________

Press Operator's Initials: ________

Answer these questions for the BLANKET WASH ONLY (do not include the roller cleaning)	
Ink used before wash-up	Specify ink color: ______________ Specify ink type: conventional...........☐ other____________________ vegetable oil-based...☐
Run length	Record length of run: *# impressions =* ________________
Ink coverage	*circle one*: Estimate the image coverage: Heavy Medium Light
Quantity of wash used for this cleaning	_________ # of ounces from Portion Aid dispenser provided
Cleaning rotations	______________ rotations *(record the number of blanket rotations completed during the blanket cleaning)*
Ease of cleaning	*circle one*: The effort needed to clean the blanket was: Low Medium High
Wipes used	Number of fresh wipes used for blanket washing: __________
What is your opinion of this blanket wash?	*circle one*: The wash performance was: Good Fair Poor
Examine the blanket condition after the wash	Is there any residue, debris, etc. on the blanket? Yes.....☐ No.....☐ If yes, please explain:
Printing after the wash	How many impressions were run to get back to acceptable print quality? Did the blanket wash cause problems with the print quality? Yes...☐ No...☐ If yes, please explain:
Comments or suggestions - Use the back of this sheet or the space below for any comments:	

D.4 END-OF-WEEK FOLLOW-UP QUESTIONNAIRE

End of Week Follow-Up to Lithographers

At the end of the week-long demonstration, contact the press operator who used the blanket wash either in-person or by phone. Interview the operator to determine if there were any problems, changes, or concerns since your visit. If you are contacting them by phone, remind them to send in the completed forms immediately.

Facility Name ________________________________ **Substitute Wash #** ________

1. In your opinion, was the performance of the substitute wash better, worse, or about the same as your standard wash? Why?

2. Did you find any conditions where the wash did not work? (e.g., a certain ink type, ink color, or especially heavy coverage). If so, describe the condition(s).

3. Have you changed the appliation procedure in any way?
   - Do you use more wash?
   - Have you changed the dilution?
   - Have you changed the method for removing excess wash?

4. Do you think the number of impressions required to get back to acceptable print quality is greater, the same, or less than were required using your standard blanket wash? Why?

5. Did you use any other blanket washes during the week on this blanket? Why?

6. Note the condition of the blanket

7. Do you have any other comments, concerns or problems regarding the substitute blanket wash?

APPENDIX E
CATEGORIZATION FOR LITHOGRAPHIC BLANKET WASHES

Table E-1. presents the following categories and classsification of formulations that were developed by the DfE Lithography Project Core Group and reviewed by the blanket wash suppliers. The categorization was developed to assist with the development of the Performance Demonstrations.

Table E-1. Categories and Classifications of Formulations

Category	Mix	Washes	
		All	Pass[1] to Demo
1.	Vegetable fatty ester	1 26 29	1 26 29
1a.	Vegetable fatty ester (+glycol)	14 19	14 19
2.	Ester/Petroleum	3 21 36 38	21 36 38
2a.	Ester/Petroleum (+surfactant)	6 11 18 40	6 11 40
3.	Ester/Water	9 10	9 10
4.	Petroleum	31 32 35	31 32
5.	Petroleu/Terpene	13 15	13
6.	Petroleum/Water	5 8 20 37 39	20 37 39
6a.	Petroleum/Water (diluted for use)	12 30 33	30 12
7.	Water/Petroleum/Ester	22 34	22 34
8.	Terpene	16 24 27	24
8a.	Terpene (+ additives)	4 7 23 25	
9.	Detergent	17	

[1] indicates formulations passed blanket swell test ($\leq$3.0%) and basic washability

APPENDIX F
COST OF ILLNESS VALUATION METHODS

Several approaches are available to estimate the economic benefits of reduced morbidity effects associated with pollution releases, including: contingent valuation, averting behavior, hedonic valuation, and cost of illness approaches. Table F-1 provides a brief summary of each.

Table F-1. Cost of Illness Valuation Methods

Valuation Method	Description
Contingent Valuation Approach	The contingent valuation approach uses a survey to illicit estimates of individual willingness-to-pay to avoid a given illness. The contingent valuation technique, when properly designed, should capture direct treatment costs, indirect costs, and costs associated with pain and suffering.
Cost of Illness Approach	The cost of illness approach estimates the direct medical costs associated with an illness and will sometimes include the cost to society resulting from lost earnings. Cost of illness studies do not account for pain and suffering, the value of lost leisure time, or the costs and benefits of preventive measures.
Hedonic Valuation Approach	Hedonic valuation studies use regression analysis to estimate the relationship between environmental improvement or reduced worker risk and other independent variables. For example, a hedonic wage study may attempt to describe the relationship between wage rates and job related risks (i.e, what is the premium required to compensate workers for the added risk they incur from their occupation). The weakness of the hedonic approach is based upon the difficulty in separating illness effects from other independent variables.
Averting Behavior Approach	The averting behavior method examines preventive measures undertaken to avoid exposure or mitigate the effects of illness. Investments made in preventive measures are then used as a proxy for individual willingness-to-pay to avoid a particular illness.
Source: Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.	