Assessment, Development and Demonstration of Low VOC Solvents for Cleaning of Lithographic Printing Ink Application Equipment

Final Report to the

South Coast Air Quality Management District
Contract 03134

By

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ABSTRACT

The objective of the contract, as defined by South Coast Air Quality Management District was to develop low VOC content cleaning solvents for different cleaning categories of offset lithography.

Printing Industries of America/Graphic Arts Technical Foundation (PIA/GATF) were selected to work on the technology assessment of the Rule 1171 2005 target Volatile Organic Compound (VOC) content levels for lithographic printing ink application equipment. The solvent cleaning operations of lithography are a major source of VOC emissions in the South Coast Air Basin. In 1999, Rule 1171 was amended to include lithographic printing. Emission reductions were to be in two steps. The limits for 2001 were 600 grams/liter (g/l) for roller wash step 1 and 800 g/l for roller wash step 2, blanket washing, and the cleaning of other press components. The target for both categories in 2005 to be achieved was 100 g/l.

PIA/GATF identified existing benchmark cleaning solvents already in use by printers in the South Coast Air Basin. The benchmark materials were to be reformulated and new solvents developed to achieve the target VOC content values of the 2005 Rule 1171 technology assessment. The benchmark material VOC content levels ranged from 90 g/l to 811 g/l, dependent on the cleaning application. The result was that two of the initially identified conditions, cold set web offset printing of newsprint and coldset web offset printing on uncoated paper were already at the 2005 target VOC levels. These materials were already being used successfully, indicating that they were already technically and economically feasible.

Heatset web offset and sheetfed offset benchmark materials had a high VOC content level, at or above the interim 2001 limits for Rule 1171, a VOC content level of 600 g/l. Cleaning solvents with progressively deprecated VOC content levels were evaluated for VOC content, swell characteristics, laboratory washability and on-press cleaning performance. Two products with deprecated VOC content levels met the target values of the 2005 Rule 1171 technology assessment, with the target VOC content level of 100 g/l. These solvents were Printers' Service Autowash 1010 and Printers' Service Autowash LV10. The goal of reaching the target VOC content was achieved for all five printing categories of offset lithographic cleaning originally identified.

The performance of the low VOC content solvents in cleaning the blankets and rollers was not as good as the benchmark solvents. The reduction in VOC content level resulted in a slower evaporation rate from the roller surface and there was in several instances a residue left on the blanket surface. It is important that the implications of this residue are investigated as it could result in a deterioration of the transfer characteristics to the substrate, with either additional cleaning required, the press having to condition for greater periods of time between print jobs or significant increases in the make-ready waste.

Table of Contents

List of Figures

List of Tables

List of Appendix Tables

Assessment, Development and Demonstration of Low VOC Solvents for Cleaning of Lithographic Printing Ink Application Equipment

Contract 03134

BACKGROUND

Printing Industries of America/Graphic Arts Technical Foundation (PIA/GATF) were one of three contractors chosen to work on the technology assessment of the Rule 1171 2005 target Volatile Organic Compound (VOC) content levels for lithographic printing ink application equipment. The solvent cleaning operations of lithography are a major source of VOC emissions in the South Coast Air Basin. In 1999, Rule 1171 was amended to include lithographic printing. Emission reductions were to be in two steps. The limits for 2001 were 600 grams/liter (g/l) for roller wash step 1 and 800 g/l for roller wash step 2, blanket washing, and the cleaning of other press components (for example, ink trays). The target for both categories in 2005 to be achieved was 100 g/l. Achieving the 2005 targets are the subject of this technology assessment, contract 03134. If the 2005 VOC limits/targets are not technologically feasible, then the lowest feasible VOC cleaner is to be delivered.

The PIA/GATF task was to begin with cleaning materials that are currently used in the industry in the South Coast Air Basin, and reduce the VOC content in decrements of 50 g/l, where technically feasible, towards achieving the 2005 targets. Anchor-Fuji Hunt, Printers' Service, Varn, Mirachem, and Hurst provided PIA/GATF with reformulated cleaning solvents for performance evaluation.

The PIA/GATF responsibilities, in addition to assisting reformulating the materials used today in the South Coast Air Basin, included performance, cost comparisons, safety comparisons, and environmental impact analysis on the cleaning materials to help determine overall operational feasibility of reducing the VOC contents in these materials.

Solvent cleaning operations in lithography

In lithography, the press components that need to be cleaned are the ink distribution rollers, the printing plates, the blankets, the impression cylinders on sheetfed presses, and the press roller cleaning fixtures/trays. A typical roller configuration on a heatset press is shown in Figure 1. Depending upon the press size and configuration, there may be 18 ink rollers, some metal, and some covered with elastomer. To clean the rollers, a tray with a flexible blade is fastened against one of the rollers after solvent is distributed in the rollers for a few of minutes, the time dependent on the press configuration. The solvent application may be repeated several times until the operator judges that the ink has been removed.

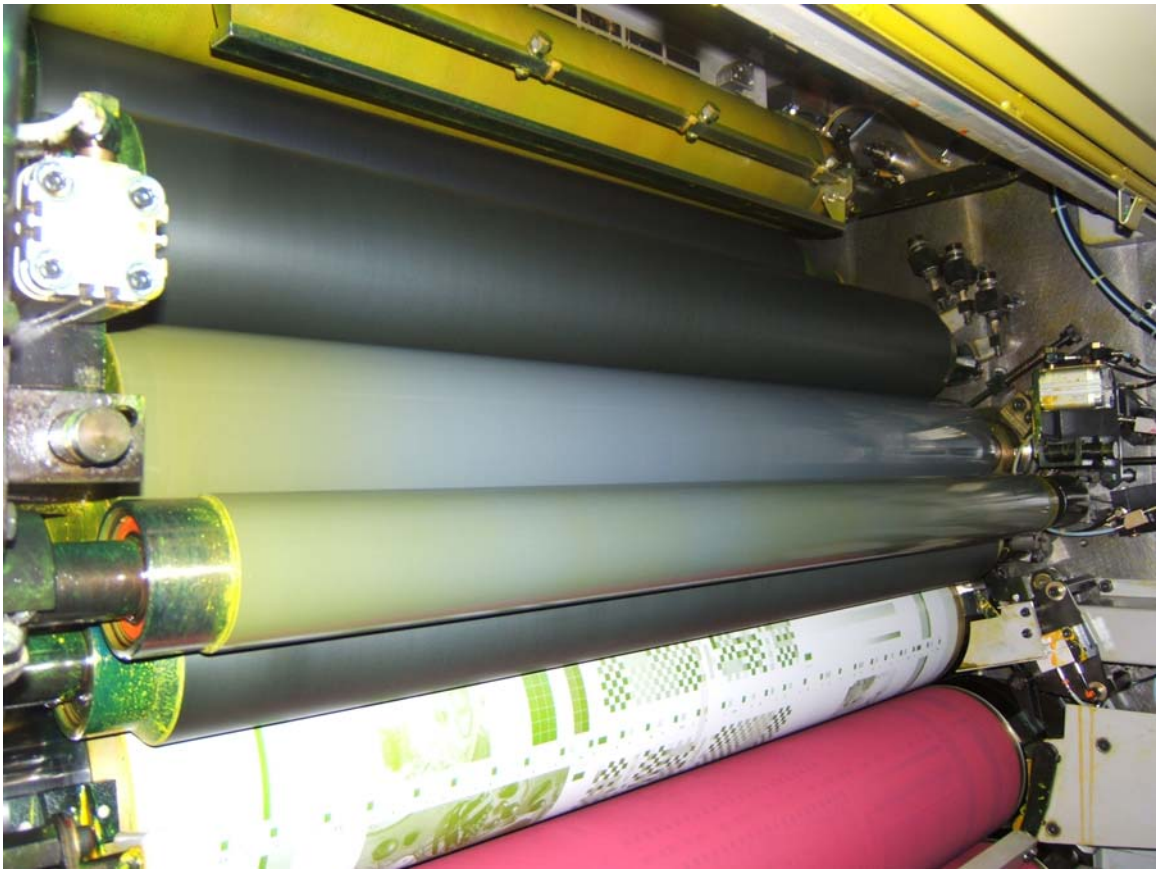

Figure 1.

Roller system on a heatset web press.

The technology assessment refers to a roller wash step 1 and a roller wash step 2. A one-step wash is most common and can be the same material as the blanket wash. A two-step wash will be used maybe once a week, or when a press unit is going to be used to print a different color.

At the end of each roller wash, there is a tray containing a sludge of ink and cleaning solvent. While the liquid can be poured in a barrel for recycling or disposal, the tray requires cleaning with additional rags and solvents.

Blankets are cleaned when they are new and mounted on the press, after every press stop, at the end of each job, whenever the press operator thinks that print quality has deteriorated, and normally after every web splice in web offset. For a lengthy run or during a press makeready, the blankets might need to be washed several times.

Blankets can be washed by hand or with automatic blanket washers. The automatic blanket washers are productivity enhancing accessories on most new press installations. There are times when build-up of debris on the blanket is so great that hand washing is necessary after the automatic cleaning. A press operator cleans a blanket with two rags. One rag is soaked with the solvent and used to remove the build-up on the

blanket. The second rag is dry and is used to wipe the solvent dry on the blanket. In this way, there is minimum contact time of the blanket with the solvent. Excessive exposure to solvent can cause a change in the blanket properties (dimensional, chemical, and release), and this can result in poor print quality and damage to the press components.

Swelling of the blankets and rollers is undesirable because it opens the pores and allows plasticizers, waxes, and anti-oxidants to be leached from the rubber. This process shortens the working life of the blanket and rollers. The automatic blanket washers contain gaskets and rubber bladders and diaphragms that have similar considerations.

For all press types, the cleaning materials require a technology assessment by the press manufacturer or the warranty for the press can be forfeited. A large concern with the press manufacturers is the use of certain materials can give rise to corrosion of the metal components on the press. This can result in costly replacement of the main printing cylinders.

SCOPE OF WORK

This section will outline the tasks of the contract and the methodologies used to complete each of the tasks. The purpose of this work is to develop cleaning materials that will assist the South Coast Air Quality Management District to meet the 2005 targets of Rule 1171. The targets of 2001 and 2005 are shown in Table 1.

Table 1. Technology assessment targets.

Lithographic Printing Cleaning Category	VOC content of formulations to be tested grams/liter		
	Reference VOC Content (2001)	Initial Testing Period	Final Testing Period Target VOC Content (2005)
Roller Wash Step 1	Benchmark VOC Content	Reduce Benchmark VOC Content in 50 g/l decrements	100 g/l
Roller Wash Step 2 blanket wash on press components	Benchmark VOC Content	Reduce Benchmark VOC content in 50 g/l decrements	100 g/l

The project began in the fall of 2002. The lithographic cleaning operations were stratified for the technology assessment according to variety of lithography press and the substrate printed as shown in Table 2.

Table 2. Lithographic printing processes.

Press Type	**Substrate Type**
Coldset Web	Newsprint
Coldset Web	Uncoated Paper
Heatset Web	Coated, Uncoated Paper
Waterless Web	(Any)
Sheetfed (≥ 18" Print Width)	Paperboard, Coated Paper, Uncoated Paper, Metal, Plastic
Sheetfed (≤ 18" Print Width)	Coated Paper, Uncoated Paper, Plastic, Foil

The technology assessment was divided into ten tasks:

1. Develop test protocol
2. Review and comment on compatibility test protocol prepared by University of Tennessee
3. Determination of benchmark solvents
4. Develop and test low-VOC solvents by reformulating benchmark materials
5. Compile and analyze data

6. Cost, emission reduction, safety, and environmental impact analysis
7. Submission of solvents for independent compatibility testing and VOC content determination
8. Conduct performance tests in the South Coast Air Basin for verification by the University of Tennessee
9. Submit draft final report
10. Submit final report

PROJECT METHODOLOGY

An overview of each of the ten tasks, outlined in the scope for the project, will be given in this section.

Task 1: Develop test protocol

PIA/GATF submitted a protocol of methods and methodologies to conduct performance testing of technologically feasible cleaning materials to South Coast Air Quality Management District. The performance tests were designed to assess the technologically feasible materials on actual printing presses, showing how rollers and blankets were not damaged using both measurement and visual assessment, that print production was not adversely affected, and that print quality was not impaired. The protocol outlined laboratory screening tests and cited standards or best practices by which cleaning materials could be judged as feasible or unfeasible.

Task 2: Review and comment on compatibility test protocol prepared by University of Tennessee

The University of Tennessee circulated a draft of documents for measuring blanket swell and roller swell. The documents were a combination of standard ASTM and ISO methods and conversations with manufacturers of blankets and rollers. PIA/GATF provided comments on the protocol and those comments were incorporated in the final procedure.

Task 3: Determination of benchmark solvents

The South Coast Air Quality Management District and the PIA of Southern California provided PIA/GATF with a list of cleaning solvents commercially used in the South Coast Air Basin. The list included product names, VOC content, and contact information. The suppliers were contacted by PIA/GATF and this project was discussed. PIA/GATF chose the lowest VOC material for each category and substrate as the benchmark solvents. The benchmark solvents were approved by the South Coast Air Quality Management District.

Task 4: Develop and test low-VOC solvents by reformulating benchmark materials

PIA/GATF obtained the benchmark cleaning materials. Using the protocol of Task 1, the benchmark materials, with the cooperation of the suppliers, were reformulated to develop the low VOC cleaning solvents. The compatibility and performance testing was repeated on each lower VOC cleaning material.

Task 5: Compile and analyze data

The data on the technologically feasible cleaning materials reformulated in Task 4 were analyzed and organized for each cleaning category and printing press and substrate type.

A detailed discussion with supporting tables is found later in this report.

Task 6: Cost, emission reductions, safety, and environmental impact analysis

PIA/GATF, working with the suppliers of the reformulated technologically feasible cleaning materials, determined the emission reductions, cost and/or economic impacts, and the safety and the environmental impacts. This information was used to assess the overall feasibility of the reformulated low VOC products.

Task 7: Submission of solvents for independent compatibility tests and VOC content determination

Each of the low VOC cleaning materials, as well as the benchmark materials, was submitted to the University of Tennessee for roller and blanket compatibility testing. Each material was sent to the laboratory at the South Coast Air Quality Management District for independent VOC determination.

Task 8: Conduct performance tests in the South Coast Air Basin for verification by the University of Tennessee

PIA/GATF was expected to perform testing of the technologically feasible cleaning materials at selected printers in the South Coast Air Basin if South Coast Air Quality Management District chose to do so. The performance tests were to be observed by the University of Tennessee for an independent evaluation.

Tasks 9 and 10: Submission of draft final report and final report

The report was to be in the format of Section 2 of the Deliverable Section of the Statement of Work.

RESULTS AND DISCUSSION

Task 1: Develop test protocol

The four testing protocols proposed by PIA/GATF were approved November 4, 2002 and are described as follows:

Task 1.1: Total Volatile Organic Content (VOC)

The total volatile organic content was determined according to EPA Method 24. A known weighed amount of the cleaning material, between 0.3 and 0.5 grams, was placed into a tared aluminum weighing dish. The sample was heated in a convection oven for one hour at 105 degrees Celsius. The weight loss was determined and recorded as percentage weight loss. The test was performed in triplicate. In some cases, the material lost upon heating could have been water or an exempt organic solvent, such as acetone. Samples of each cleaning material were sent to the laboratory of the South Coast Air Quality Management District where the water content was determined by the Karl Fisher method and exempt solvents were identified by gas chromatography.

Task 1.2: Degree of swell

The degree of swell is a very important test for blankets. The blanket is soft and porous and washed frequently. The degree of swell is more difficult to determine for rollers. According to best practices, an adverse swelling of a blanket suggests swelling of rollers on the press.

Ten milliliters of cleaning solution were placed in a glass crystallization dish. The blanket caliper was measured with a Cady gauge. A two-inch square piece of blanket was placed over the top of the dish, with the blanket printing face pointing toward the liquid cleaner. The dish and blanket were placed in a clamping device and inverted such that the liquid was in contact with the blanket face. After one hour, the blanket was removed from the cell, the solvent was wiped from the surface, and the caliper of the blanket was measured again. The blanket was returned to contact with the liquid for an additional three hours. After the additional three hours, the blanket was removed from the cell, the solvent was wiped from the surface, and the caliper of the blanket was measured. The percentage swell was calculated according to the following equation:

$$\text{Percentage Swell} = \frac{\text{Final Caliper - Initial Caliper}}{\text{Initial Caliper}} \text{ x } 100$$

According to industry guidelines, the percent swell should be less than 5%.

Task 1.3: Laboratory washability-wiping test

The Laboratory Washability-Wiping Test places a piece of an offset printing blanket into a Gardner Scrubbing Apparatus. A known volume of ink was spread out with

a brayer on the metal plate on a Quick Peek Color Proofing device. The ink was then transferred with the brayer onto the blanket surface. An absorbent rag was attached to a sled, and a constant amount of cleaning solvent (5 cc) was applied to the rag. The sled and solvent are placed in contact with the ink on the blanket with a known force. A motor dragged the sled back and forth over the printed surface in a cleaning motion. The operator records the number of cycles required to clean the blanket.

Task 1.4: On-press testing

The final protocol was testing on the offset presses at PIA/GATF. This test was only performed if the swell test was acceptable. The on-press testing was subjective, but it was performed by experienced press operators who have their own expectations of what cleans acceptably.

This test was performed on the MAN Roland heatset web offset press and on the Heidelberg SM102 40-inch sheetfed press. The press fountain was filled with black ink and the ink was distributed over all the rollers. The blanket and plate were put on impression, resulting in ink being transferred to the blanket from the plate. The press was then stopped, and the blanket or rollers were cleaned. The press operator compared each candidate-decrement-reformulated product to the approved benchmark solvents. Solvent was applied to the rollers or blanket cleaning rag in measured amounts. The operator commented on how well the material cleaned the rollers or blanket, how long it took, and whether more solvent than the benchmark solvent was required.

Task 2: Review and comment on compatibility test protocol prepared by the University of Tennessee

PIA/GATF did not have many comments on the University of Tennessee compatibility test protocol. The blanket swell protocol was similar to that already approved by the South Coast Air Quality Management District for PIA/GATF. There were differences in the amount of time the blankets were allowed to air dry before measurements were made. In the PIA/GATF method, the blanket was wiped dry and the caliper was measured immediately. In the University of Tennessee's protocol, the blanket was allowed to air dry for 72 hours before caliper measurement. Allowing additional time for drying would result in the blanket having time to recover its original condition. In practice on a printing press, the blankets and rollers would be cleaned and the press would then be used immediately.

Task 3: Determination of benchmark solvents

This task began with a list of all cleaning solvent suppliers that operated in the South Coast Air Basin. This list was collated by PIA of Southern California. The list contained the following suppliers:

- Anchor Fuji Hunt
- Mirachem
- Printers' Service
- A.G. Layne
- Hurst Chemical
- Varn International
- Litho Chem, Inc.

These suppliers represented a large number of the potential benchmark materials that are listed in Appendix B. The first approach was to select two solvents for each of the press and cleaning categories. Following consultations with the suppliers and their technical specialists, the merits of the distinct press categories that the solvents were grouped in were reaffirmed, with respect to the different cleaning requirements.

These printing operations of = coldset web offset printing and newspaper printing are more concerned with removing "piling" or paper residue on the blankets than they are concerned about deep cleaning of the blanket. This market will take an existing product and dilute it by 20% to 200%. Including dilution, these materials are at or near the 2005 target already. Heatset web offset print operations and sheetfed offset print operations tend to use a fast, higher-VOC solvent for a deeper cleaning effect. Solvent based cleaning systems carry or dissolve more ink than aqueous systems. The emulsion cleaners require additional surfactants. A solvent based system is a candidate for solvent recovery and recycling. The solvent that is recovered is not a VOC emission. The aqueous emulsion is difficult to recycle or recover and represents a greater disposal cost.

The statement of work required that the list of available products as outlined in Appendix B be consulted, and those products closest to the 2005 VOC content target that are sold in the South Coast Air Basin should be chosen as the benchmark solvents. The following materials were selected, Figure 2.

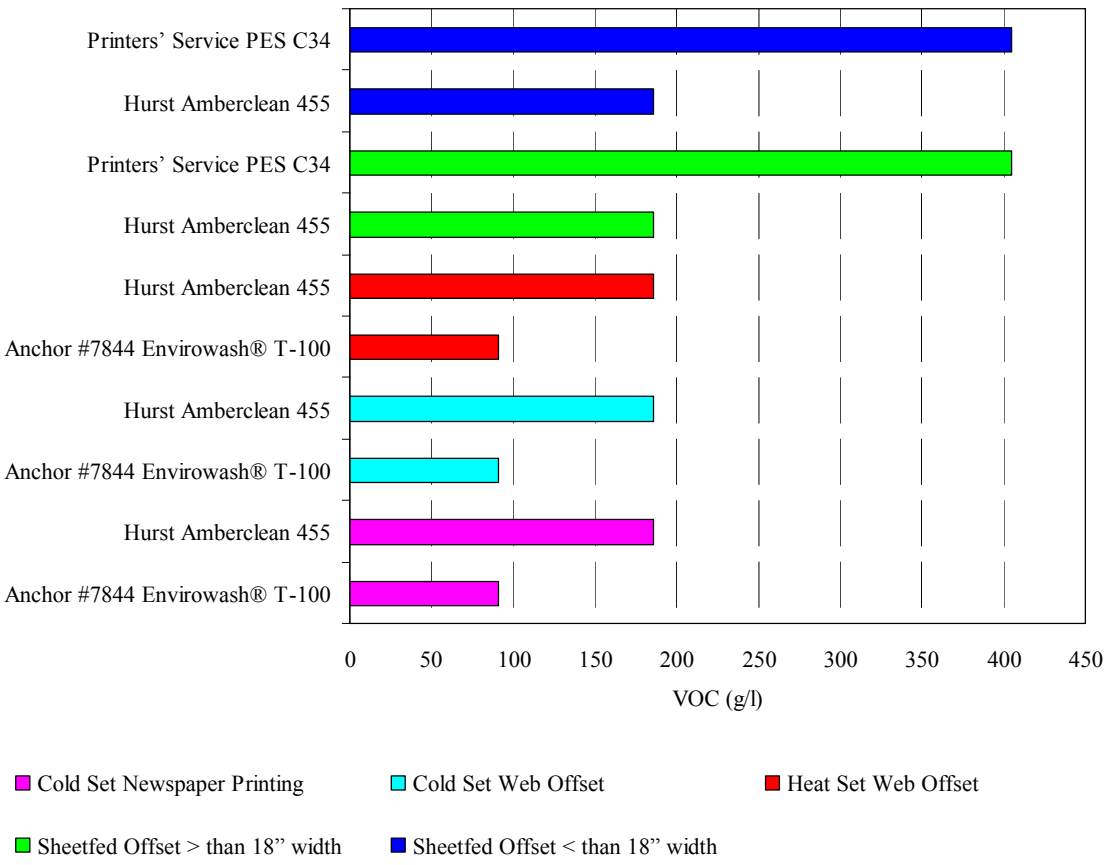

Figure 2. VOC content of the initial benchmark solvents selected based on lowest VOC content products, according to EPA Method 24.

The list of available cleaning products, as shown in Figure 2, contained materials that suggested that the 2005 VOC targets had already been attained in some cases. This was the case in newspaper printing, heatset web offset printing, and coldset web offset printing.

The material choices, as indicated in Figure 2, were reviewed with the suppliers on the South Coast Air Quality Management District technical advisory group. It was their recommendation that benchmark solvents should be those materials used in significant quantities, not those solvents with the lowest VOC content that have no market penetration. The benchmark solvents were selected a second time using the following rationalization process.

In coldset web offset and newspaper printing operations, low VOC materials already exist and are in common use. The cleaning operations are not stringent, and the ink never dries hard on any of the surfaces to be cleaned. With this requirement, detergents or surfactant based products work well. Mirachem and Printers' Service PESC34 were the two products selected as benchmark solvents.

Coldset web offset inks are more difficult to clean when compared to the coldset web offset newspaper inks. The cleaners may require a higher VOC content. In order to ensure full participation in the project, different suppliers were identified in this category. Hurst Amberclean 455 and Anchor #7844 Envirowash® T-100 were the two products selected as benchmark solvents.

Heatset web offset benchmark solvents represented press cleaning requirements focused primarily on productivity and print quality. Anchor #7274 A-240 Wash and Varn Wash A-230 were the two products selected as benchmark solvents. These are at the upper limits of the 2001 Rule 1171 targets, above the 600 g/l target for a roller wash step one and below the 800 g/l for a roller wash step two. Along with one or two other products, these were the cleaning solutions used predominantly in the South Coast Air Basin. They were miscible with water and were used for all aspects of press cleaning, blankets, rollers, and cleaning accessories. They were also compatible with automatic blanket and roller washing systems.

Similar cleaning requirements existed for sheetfed printing as for heatset web offset, whether the printing presses were greater than 18 inches wide or less than 18 inches wide. Printers' Service Autowash 6000 and Varn Wash V-120 were the two products selected as benchmarks solvents for both the presses greater than 18 inches wide and less than 18 inches wide. As was the case with the heatset web offset benchmark solvents, these benchmark solvents were at or above the 2001 Rule 1171 guideline targets (600 g/l target for a roller wash step one and 800 g/l target for a roller wash step two). The benchmark solvents selected and their VOC content are shown in Figure 3.

One important requirement of the benchmark solvent suppliers for this project was that they all had research and development projects underway that promised to help PIA/GATF and South Coast Air Quality Management District move toward the 2005 Rule 1171 goals (100 g/l target for a roller wash step one and 100 g/l target for a roller wash step two). The statement of work under the contract required that PIA/GATF would work with the suppliers to reformulate existing cleaning products. The suppliers of these products were in a position to greatly assist with the project and central to its successful completion.

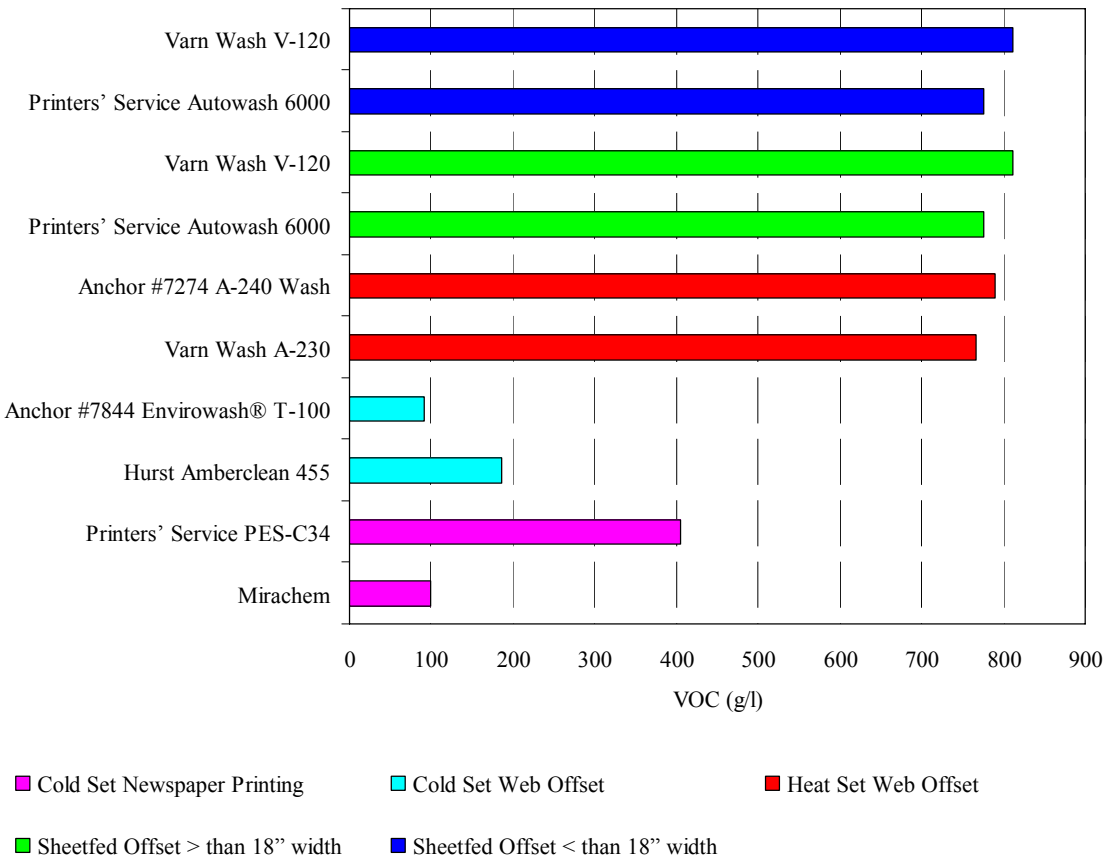

Figure 3. VOC content of the final benchmark solvents selected, according to EPA Method 24.

Task 4: Develop and test low-VOC solvents by reformulating benchmark solvent materials

This task contains the main results from the investigation and has been separated into several sections. The benchmark materials with respect to their VOC content and swell characteristics will be presented initially. This will be followed by a discussion of the results from the VOC content reductions for each of the appropriate solvent classes that were evaluated, as outlined in Task 1.1. The swell characteristics of these solvents were also measured, as outlined in Task 1.2. This is followed by the laboratory washability wiping testing results, as outlined in Task 1.3. The results and discussion section is completed with the results of the on press evaluation, carried out for both rollers and blankets on the web and sheetfed presses at PIA/GATF, as outlined in Task 1.4.

The benchmark solvent materials, as identified during Task 3 of the project, were approved by the South Coast Air Quality Management District in April of 2003. The protocols, determined during Task 1 of the project, were used to measure VOC content, as determined according to EPA Method 24, and the degree of swell on an offset blanket. The results for the VOC content were presented in the previous section of the report, Figure 3, with the swell testing results for the benchmark solvents shown in Figure 4. These findings were shared with South Coast Air Quality Management District.

The benchmark materials for coldset newspaper printing and coldset web offset printing were so close or below the technology assessment 2005 Rule 1171 goals (100 g/l target for a roller wash step one and 100 g/l target for a roller wash step two) that reformulation was determined not to be necessary for these product categories as part of Task 4; for VOC content refer to Figure 3. This course of action was approved following discussion with South Coast Air Quality Management District.

In the experience of the PIA/GATF laboratories, any swell percentage less than 5% is acceptable for the 4-hour swell. This value is approached by two of the benchmark cleaning solvents, the Varn Wash V-120 (sheetfed offset) and Anchor #7274 A-240 Wash (heatset web offset). It is important to note that this guideline of 5% is only exceeded upon 4 hours of contact with the blanket. This length of contact would never occur in practice, and is an extreme case of screening exposure.

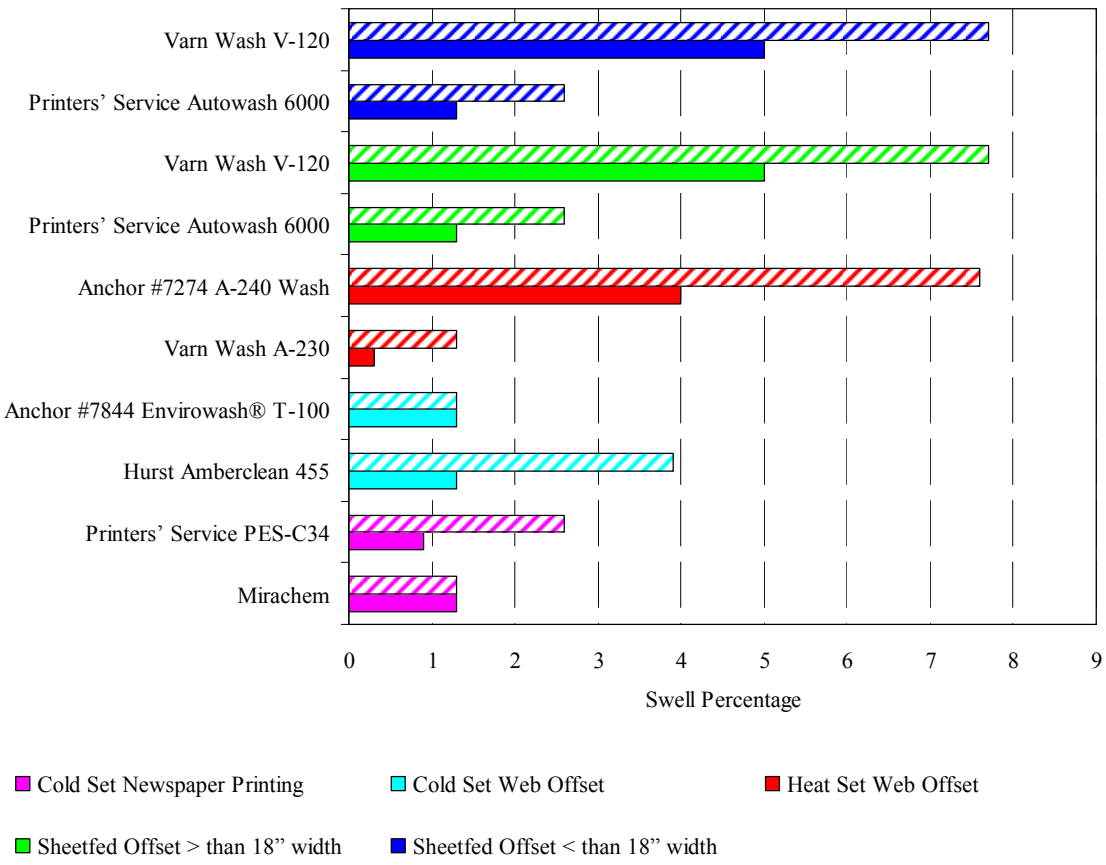

Figure 4. Swell characteristics of the final benchmark solvents selected.

Task 4.1 Total Volatile Organic Content

Printers' Service, Anchor Fuji Hunt, and Varn were contacted and cleaning materials with lower VOC were solicited for testing by the protocols of Task 1. The objective, outlined in the trial protocol (see Task 1) was to take the benchmark solvents and reduce the VOC content at 50 g/l intervals. During these discussions it was determined that a number of solvents were a developed by the manufacturers with the objective of obtaining the reduced 2005 Rule 1171 goals (100 g/l target for a roller wash step one and 100 g/l target for a roller wash step two). There was a large distribution of VOC content within these new solvents from the benchmark VOC levels through to the target levels. It was recommended that these new solvents should be used in place of the 50 g/l reductions. Discussions were held with South Coast Air Quality Management District regarding this approach, and approval was obtained from them to deviate from the initial agreed trial protocol outlined in Task 1 and use the new solvents.

The VOC content, as determined according to EPA Method 24, for the materials supplied by the manufacturers are shown in Figure 5 for heatset web offset, Figure 6 for sheetfed web offset (greater than 18 inches width) and Figure 7 for sheetfed web offset (less than 18 inches width). These all show a reduction in the VOC content of the solvents. They cover a wide range, from the benchmark solvents with high VOC levels to

low VOC solvents that meet the requirements of the 2005 Rule 1171 target values for VOC content level.

The evaluation of the solvents showed in all cases a progressive reduction in the VOC content of the benchmark solvents (at 700 g/l to 800 g/l) down to the requirements of the 2005 Rule 1171 target values for VOC content level at 100 g/l. The solvents selected following discussion with the vendors and South Coast Air Quality Management District resulted in the same solvents being used for the sheetfed printing presses that were greater than 18 inches wide or less than 18 inches wide. There had been the suggestions in the planning stages that different solvents would be used for the press configurations. Based on the same solvents being used for both of these press applications, the results in the following sections are presented for sheetfed press solvents as a single entity.

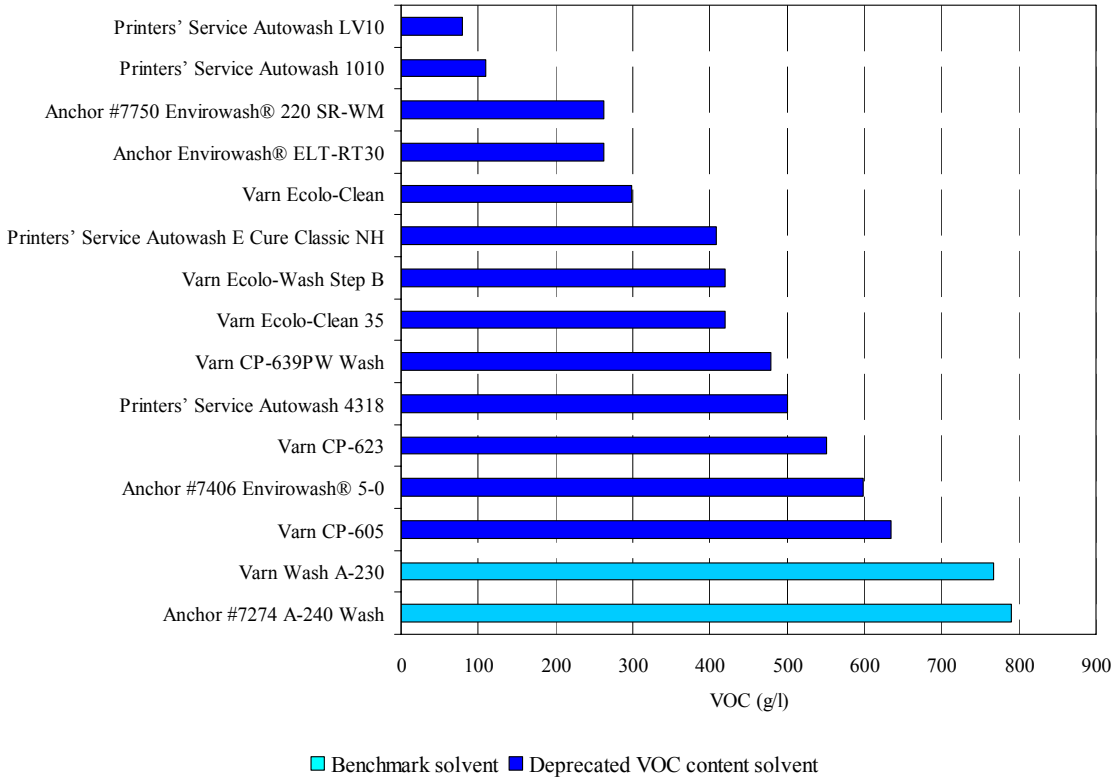

Figure 5. VOC content of solvents according to EPA Method 24, evaluated for heatset web offset.

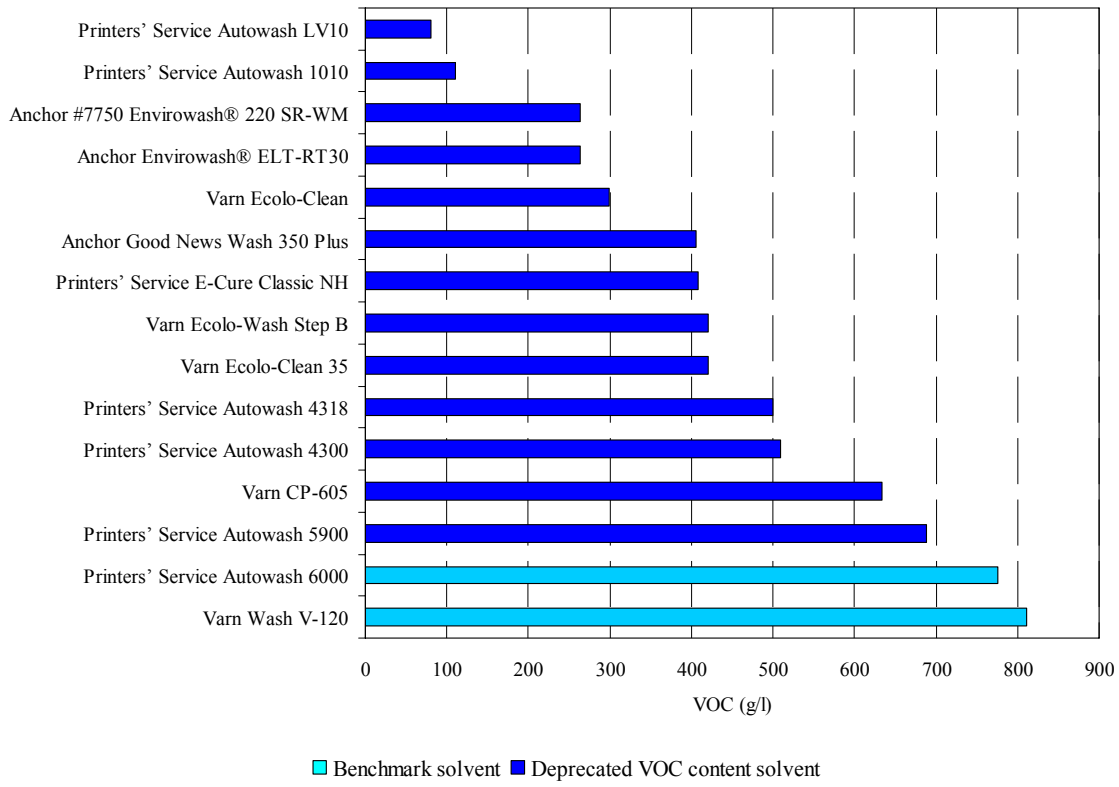

Figure 6. VOC content of solvents according to EPA Method 24, evaluated for sheetfed offset greater than 18 inches in width.

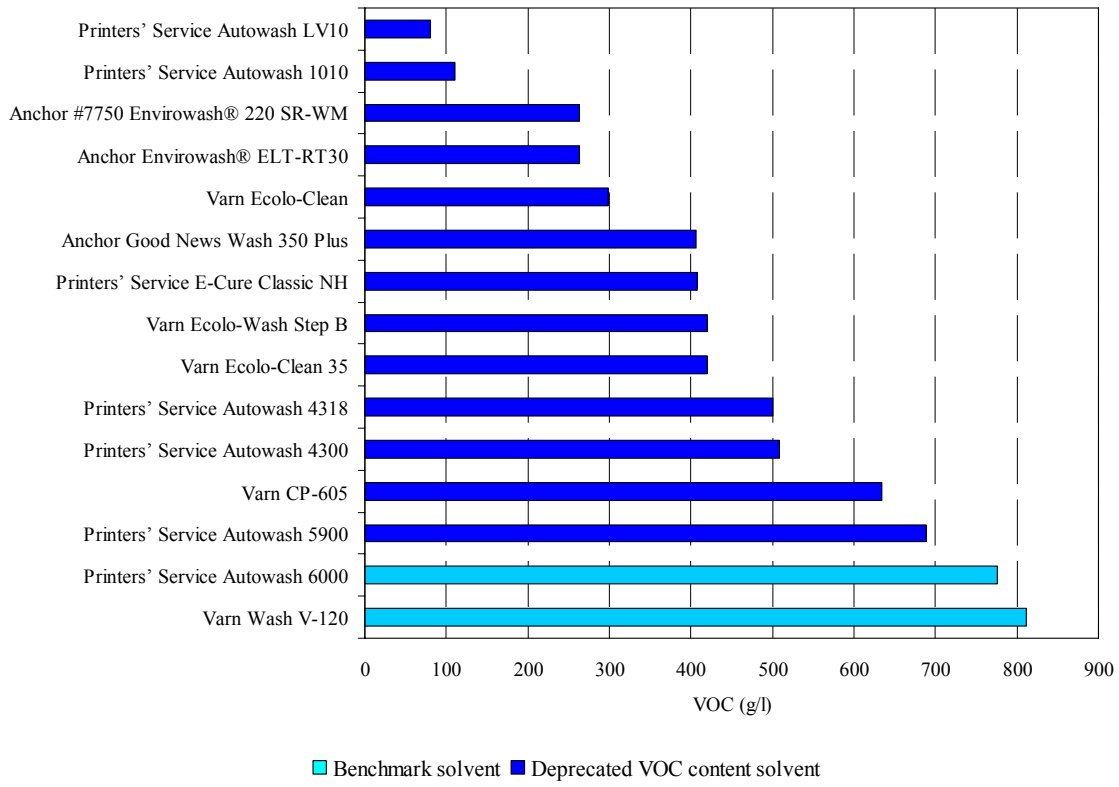

Figure 7. VOC content of solvents according to EPA Method 24, evaluated for sheetfed offset smaller than 18 inches in width.

Task 4.2: Degree of swell

The percentage swell has been calculated from the experimental data derived from the degree of swell test, as defined in Task 1.2. The results are shown in Figure 8 for heatset web offset and in Figure 9 for sheetfed web offset. In the experience of the PIA/GATF laboratories, any swell percentage less than 5% is acceptable for the four hour swell. The one hour swell is checked to give indications of very poor swell characteristics for solvents. This 5% swell value is only exceeded by the benchmark solvents after the four hour period. All of the reduced VOC content solvents had swell percentages less than 5%, and would be commercially acceptable with respect to the swell characteristics.

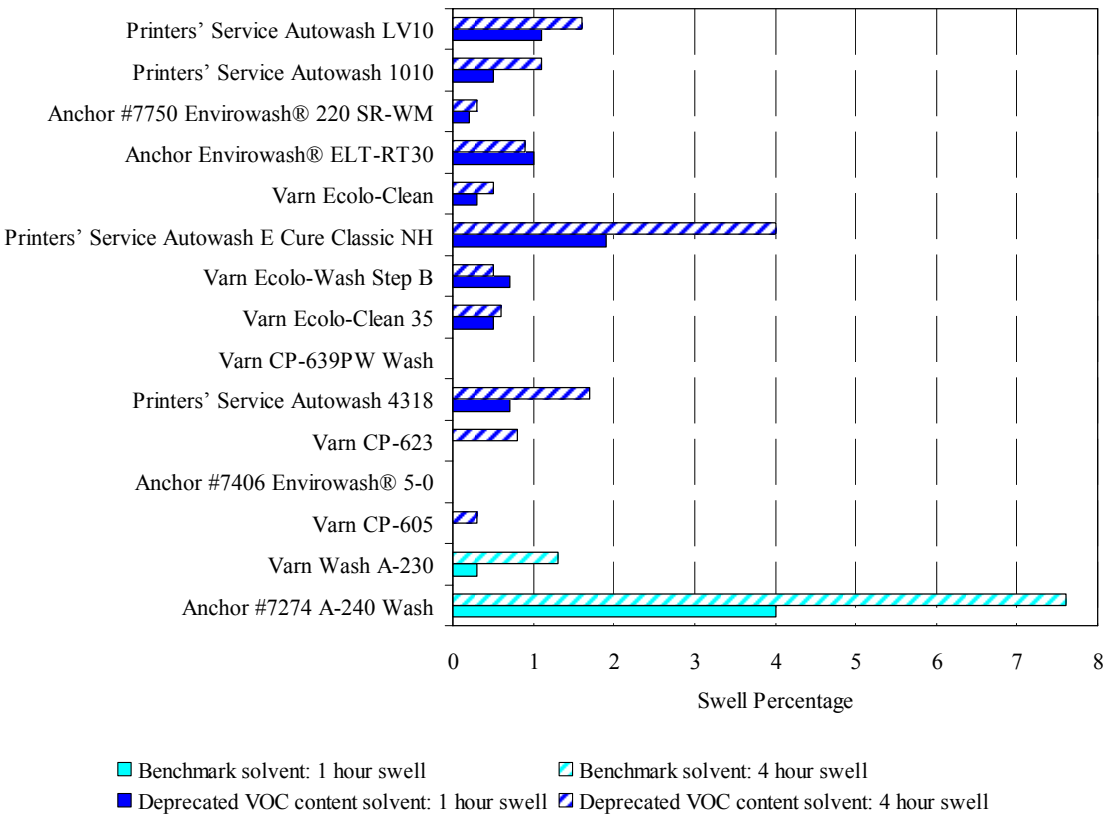

Figure 8. Blanket swell performance, evaluated for heatset web offset.

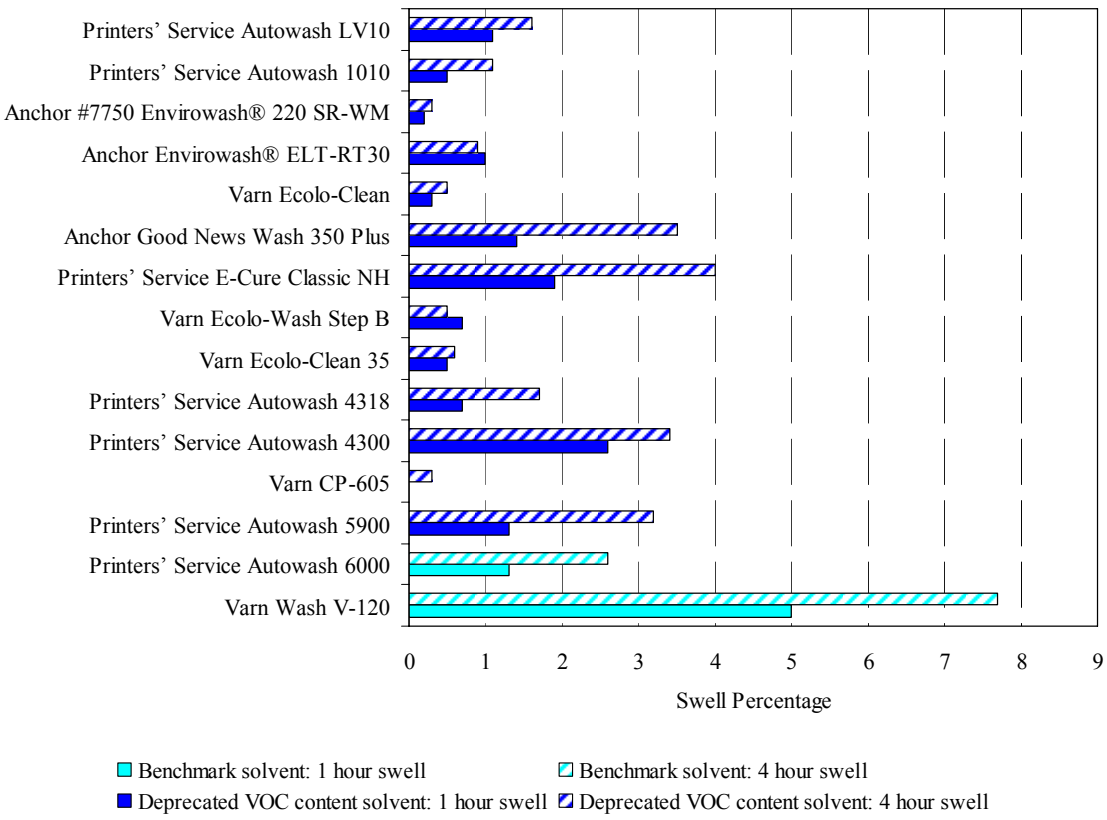

Figure 9. Blanket swell performance, evaluated for sheetfed offset.

Task 4.3: Laboratory washability-wiping test

The number of cycles required to clean the surface of the blanket for each of the solvents has been assessed experimentally in the laboratory, as defined in Task 1.3. The results are shown in Figure 10 for heatset web offset and in Figure 11 for sheetfed web offset. There was no appreciable difference between the results obtained from the heatset solvents, with the blanket being clean within three cycles. There is an increase in the number of cycles required to clean the sheetfed inks, with more cycles being needed as the VOC content is reduced. This would indicate these reduced VOC content do not clean as effectively.

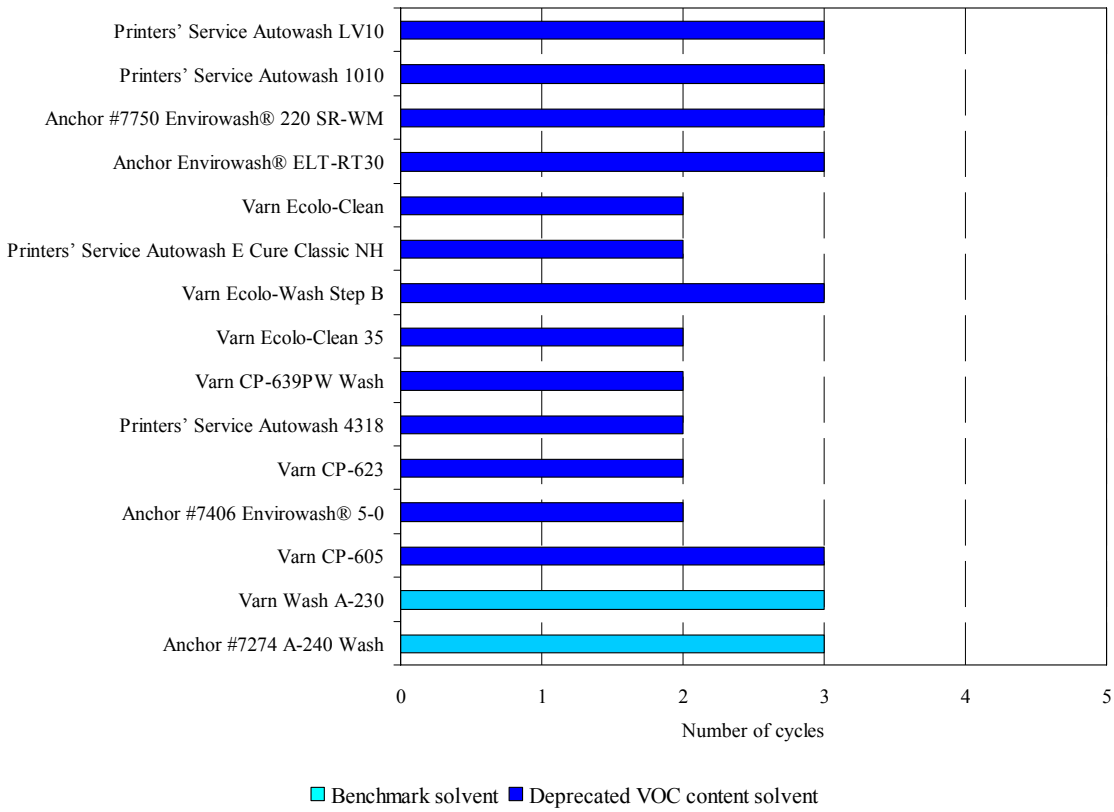

Figure 10. Washability performance for heatset offset.

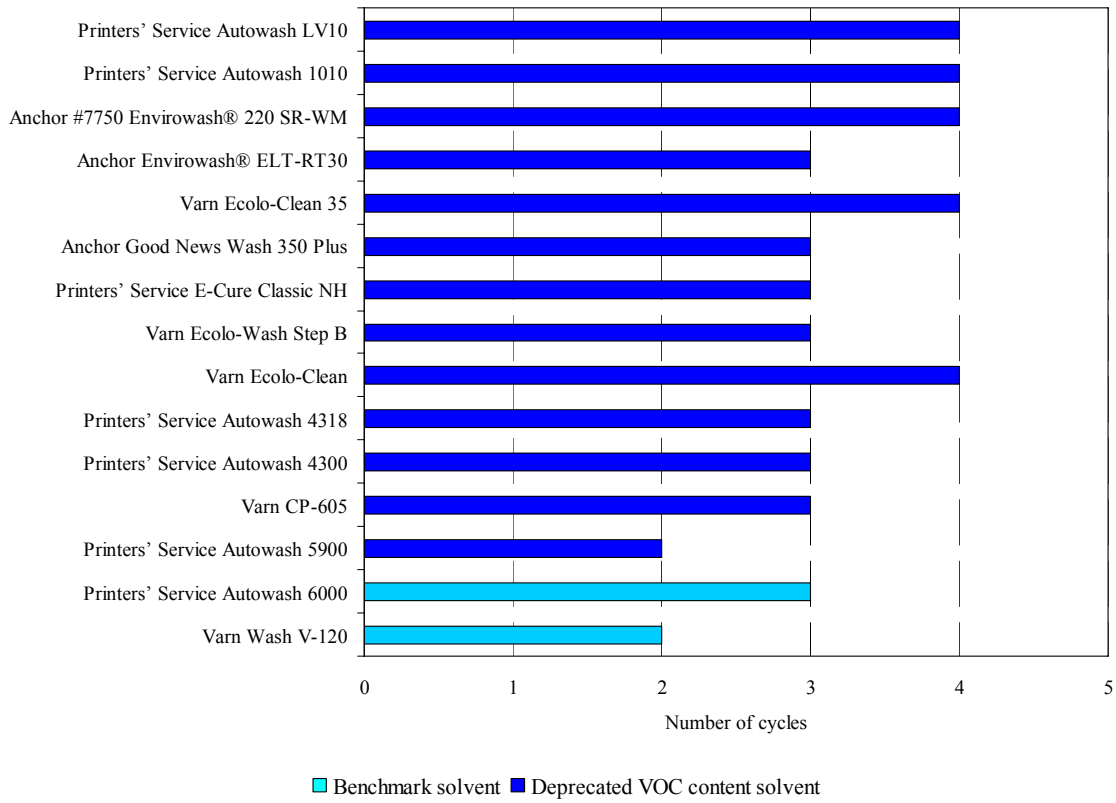

Figure 11. Washability performance for sheetfed offset.

Task 4.4: On press testing

The on press testing has been divided into four sections. The results from the heatset web offset solvents are presented first, for the blanket cleaning and then for the roller cleaning performance. This is followed by the findings from the cleaning performance of sheetfed solvents for both the blankets and rollers on the press. The protocol for the evaluation was outlined in Task 1.4.

Task 4.4.1 Blanket cleaning performance of heatset web offset solvents

The blanket washing results show the VOC content levels being reduced from the benchmark levels of 750 g/l through 11 decrements (13 solvents evaluated) to a VOC content level consistent with the 2005 Rule 1171 target of 100 g/l, Figure 5. The benchmark and decrement solvents were systematically evaluated by press operators for cleaning feasibility on blankets and rollers using printing equipment at PIA/GATF. A research technician assisted the press operators by recording their comments, how much liquid was required to remove the ink, and the time required to remove the ink.

The cleaning was performed on a 2003 MAN Roland Rotoman N 38 inch heatset web offset press located at PIA/GATF. A compressible Kinyo DYC SX7620 blanket was mounted on the press for the duration of the evaluation.

The blanket cleaning procedure on the MAN Roland was performed on the black unit. The ink and water keys were both set at 30, which represents a typical charge of ink on the rollers. The rollers distributed the ink for 30 seconds. The blanket and plate were put on impression, resulting in ink being transferred to the blanket from the plate. The press was then stopped and the blanket or rollers were cleaned. The operator placed a hundred milliliters of each solvent on a cotton shop rag. The blanket was cleaned with the solvent and then the wet blanket was wiped with a dry cotton shop rag. The comments from the operators are listed below and are summarized in Figure 12.

Benchmark solvents

- Varn Wash A-230 removed the ink well, and left no film on the blanket after it dried.
- Anchor #7274 A-240 Wash required a little more effort to dissolve the ink, but it dried quickly and there was no film on the surface after it dried.

Deprecated VOC content solvents

- Varn CP-605 removed the ink pretty well, but there were a lot of streaks and there appeared to be a film when it dried. It didn't dry very fast.
- Anchor #7406 Envirowash® 5-0 did not dissolve the ink well and required more effort to loosen the ink (rate poor in the table). It dried pretty fast and left no film on the blanket.
- Varn CP-623 removed the ink well and left no film on the blanket when it dried. The evaporation rate was pretty fast.
- Printers' Service Autowash 4318 dissolved the ink, but had some drag on the rag in the wiping action. Evaporation was slow, and there were streaks remaining on the blanket.
- Varn CP-639PW Wash left a lot of streaks on the blanket and just seemed to move the ink around. This received a poor rating in the cleaning table.
- Varn Ecolo-Clean 35 dissolved the ink well and left no streaks. Evaporation rate was good.
- Varn Ecolo-Wash Step B removed the ink well. There was a small amount of streaking but not residue. The evaporation rate was good.
- Printers' Service E-Cure Classic dissolved the ink well, with slight streaking and good evaporation.
- Varn Ecolo-Clean dissolved the ink well and demonstrated good evaporation rate. There was no residue and very slight streaking.
- Anchor Envirowash® ELT-RT30 dissolved the ink well, evaporated well, and produced some streaking.
- Anchor #7750 Envirowash® 220 SR-WM performed the same as the ELT-RT30.
- Printers' Service Autowash 1010 appeared to dissolve the ink and seemed to produce some drag or resistance on the rag. This product left some residue and some streaking. This product did not evaporate as fast as the operator would have liked, even after wiping with the dry rag.
- Printers' Service Autowash LV10 dissolved the ink well, left an oil residue on the blanket, and evaporated slow after wiping.

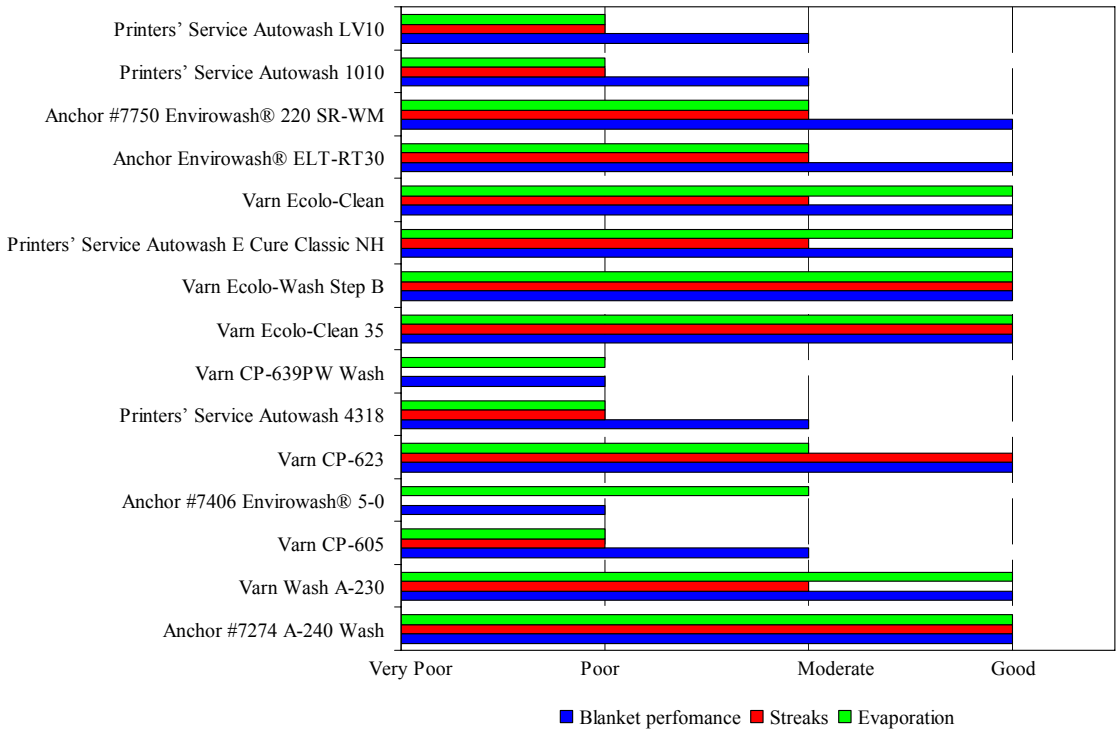

Figure 12. On-press heatset web offset blanket cleaning performance.[1]

Task 4.4.2 Roller cleaning performance of heatset web offset solvents

The solvents were evaluated for roller washing technical feasibility on the MAN Roland heatset web offset press. The ink and water keys were both set at 30, which represents a typical charge of ink on the rollers. The rollers distributed the ink for 30 seconds. One hundred milliliters of each solvent was put in a squeeze bottle and squirted into the rollers every few seconds for a period of 15 minutes. The press cleaning blade was engaged during this time and the operator commented on the amount of solvent required and the cleaning efficiency relative to the benchmark materials and his press operator experience. The comments from the operators are listed below and are summarized in Figure 13 for the performance. The quantity of material used is shown in Figure 14.

[1] *The following provides an overview of the descriptors used in the analysis.*
Blanket performance: *Good: the solvents effectively cut the ink and during the cleaning the cleaning rag was not dragging. Moderate: There solvent either did not effectively cut the ink or caused the rag to drag. Poor: The solvent did not remove the ink and may also have been difficult to move with the rag.*
Streaks: *Good: There were no streaks on the blanket after cleaning. Moderate: There was some small evidence of streaks once the blanket was cleaned. Poor: There were significant streaks after the cleaning and this would defiantly require another round of cleaning and/or drying.*
Evaporation: *Good: There was a fast evaporation and limited drying was required. Moderate: The evaporation rate was acceptable once the blanket had been dried. Poor: There was a slow evaporation that required several rags to be applied to the blanket surface with extra blanket revolutions.*

Benchmark solvents

- Varn Wash A-230 cleaned the rollers well but also required the most volume by the press operator. This could be a physical solvency phenomenon, or due to the fact that the operator started out with this familiar material.
- Anchor #7274 A-240 Wash required the most volume of cleaner, but the operator took the time to comment that rollers "felt" good after cleaning. This was interpreted as the deep cleaning and lack of residue following use of this product.

Deprecated VOC content solvents

- Varn CP-623 cleaned better than the benchmark solvents, in the operator's opinion, and used less material.
- Printers' Service Autowash 4318 used a very small amount of liquid to clean the roller train. The rollers cleaned well, but evaporation was slow and there was a greasy film remaining.
- Varn Ecolo-Clean 35 cleaned as well as the benchmark solvents, in the opinion of the operator.
- Varn Ecolo-Wash Step B cleaned as well as the benchmark solvents.
- Printers' Service E-Cure Classic produced immediate cleaning of ink on the rollers. After cleaning, the rollers had an oily appearance.
- Varn Ecolo-Clean cleaned the rollers well, using less volume than the other emulsion based "white" solvents.
- Anchor Envirowash® ELT-RT30produced rapid cleaning results, faster than the "white" solvents. After cleaning, the rollers had an oiled appearance.
- Anchor #7750 Envirowash® 220 SR-WM cleaned in a rapid manner, and there was an oily film remaining on the rollers.
- Printers' Service Autowash 1010 produced fast cleaning results, and there was a slight film remaining on the rollers after cleaning.
- Printers' Service Autowash LV10 removed ink from the rollers faster than previous materials, almost as soon as the ink cleaning blade was engaged. The evaporation rate was slow, and a slight greasy film was left behind.

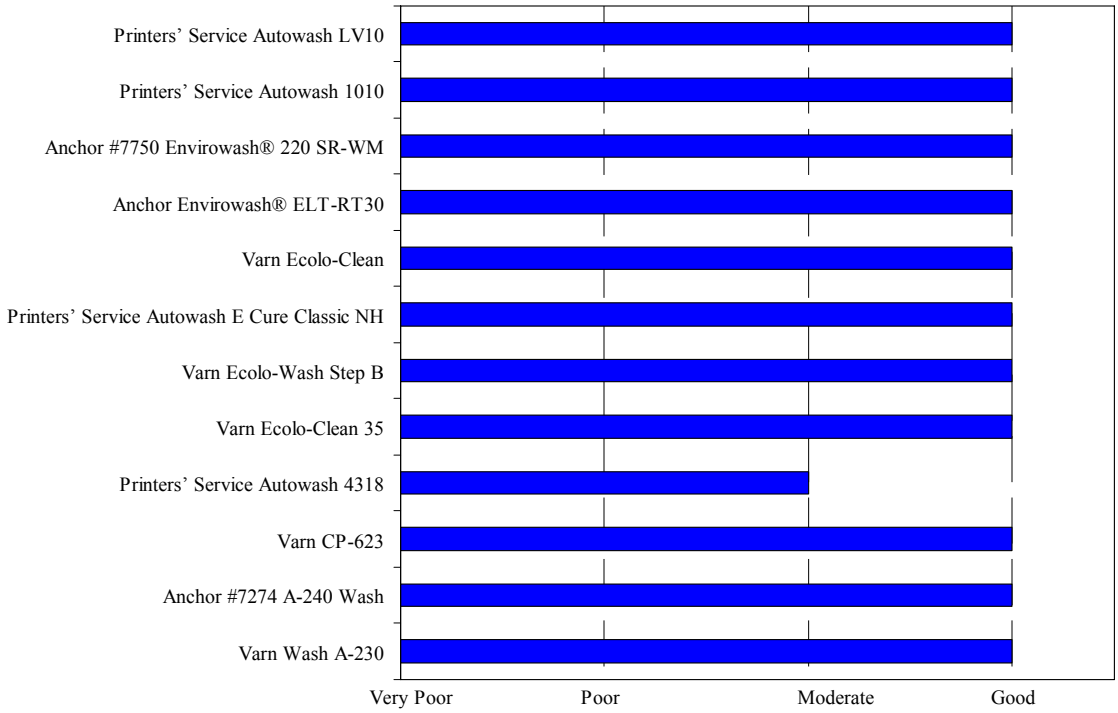

Figure 13. On-press heatset web offset roller cleaning performance.[2]

[2] *The following provides an overview of the descriptors used in the analysis.*
Roller cleaning: *Good: the solvents effectively cleaned the rollers in five minutes or under. Moderate: the time taken to clean the rollers was one minute longer, and more solvent may have been required. Poor: the time taken to clean the rollers was at least two minutes longer and significantly more solvent was required.*

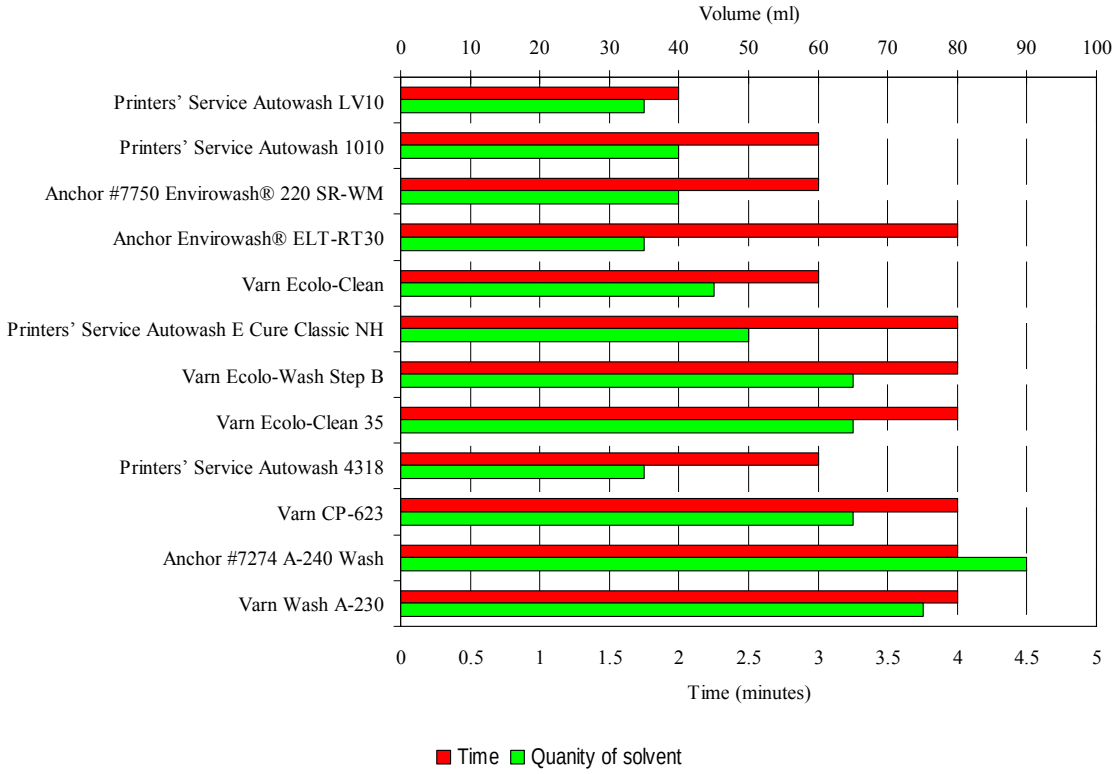

Figure 14. On-press heatset web offset roller cleaning time and material required.

The performance of all the solvents was considered good with the exception of Printers' Service Autowash 4318. The operator observed that the emulsion based "white" solvents would clean first on the outside ends of the rollers and then clean toward the center of the press. The single-phase solvents cleaned the entire roller surface simultaneously. The operator preferred the last four solvents listed: Anchor Envirowash ELT-RT30, Anchor #7750 Envirowash® 220 SR-WM, Printers' Service Autowash 1010, and Printers' Service Autowash LV10. There was no appreciable difference between the solvents. These four were the lowest VOC content solvents.

Task 4.4.3 Blanket cleaning performance of sheetfed offset solvents

The solvents identified for sheetfed offset, greater than 18 inches width and for sheetfed web offset less than 18 inches width are the same. This was the case for the benchmark solvents and the deprecated VOC content solvents. As a result of this, the solvents were both evaluated on a single press.

The sheetfed cleaning evaluation was performed on a 2001 Heidelberg Speedmaster SM102, which is commonly referred to as a 40-inch press. The blanket cleaning protocol for sheetfed was the same as the heatset web offset press. The operator was different, but the number of years of experience was similar, greater than 20 years. The rollers were covered with black ink at an ink key setting of 20% blade opening. The press was set for 20 automatic rotations. The blanket and plate were put on impression,

resulting in ink being transferred to the blanket from the plate. The press was then stopped and the blanket or rollers were cleaned. The operator placed a hundred milliliters of each solvent on a cotton shop rag. The blanket was cleaned with the solvent and then the wet blanket was wiped with a dry cotton shop rag. The comments from the operators are listed below and are summarized in Figure 15.

Benchmark solvents

- Varn Wash V-120 dissolved the ink well, dried fast, and left a slight oily residue after cleaning.
- Printers' Service Autowash 6000, dissolved the ink well, dried fast, and the blanket was not tacky after use.

Deprecated VOC content solvents

- Printers' Service Autowash 4300 dissolved the ink well, evaporated a little slow compared to the benchmarks, and left a residue on the blanket.
- Printers' Service Autowash 4318 dissolved the ink well, but required a lot of effort to dry the blanket afterwards.
- Varn Ecolo-Clean 35 dissolved the ink well, evaporated slow, and left no residue or tackiness to the blanket.
- Varn Ecolo-Wash Step B dissolved the ink well, but required a little more volume to clean the whole blanket. Evaporation was slow. While the surface was not tacky it was a little oily.
- Printers' Service E-Cure Classic NH, despite a disagreeable odor, dissolved the ink with ease. A slight residue remained and there was no apparent rate of evaporation.
- Anchor Good News Wash 350 Plus dissolved the ink well, evaporated slowly, and left an oil-like film on the blanket.
- Varn Ecolo-Clean dissolved the ink well, evaporated slowly, and left an oil-like residue on the blanket.
- Anchor Envirowash® ELT-RT30 dissolved the ink well, required effort to dry, and left an oil-like residue on the blanket.
- Anchor #7750 Envirowash® 220 SR-WM dissolved the ink well, but required several dry rag passes to dry the blanket. There was a slight oil-like residue on the blanket.
- Printers' Service Autowash 1010 dissolved the ink well, but several drying passes were required with the dry shop towel. The dried blanket was free of oil-like residue, and it was not tacky.
- Printers' Service Autowash LV10 dissolved the ink well. The blanket had an oil-like sheen after drying. Drying the blanket took extra passes with the dry shop rag.

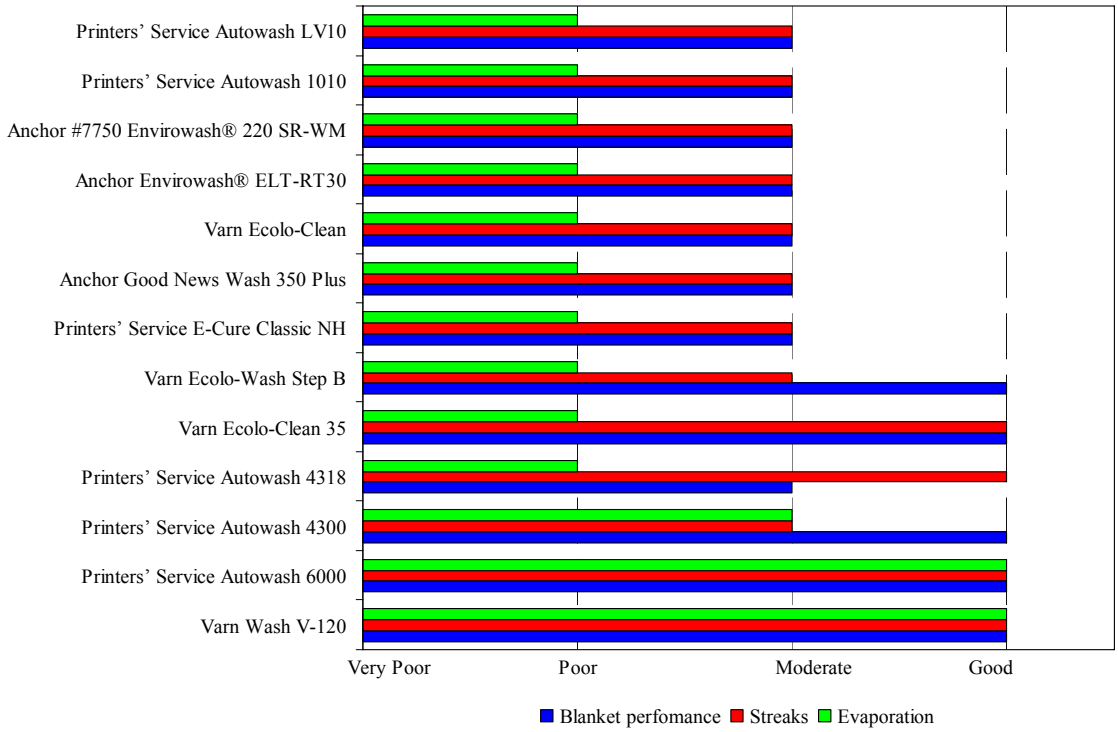

Figure 15. On-press sheetfed offset blanket cleaning performance.[3]

Task 4.4.4 Roller cleaning performance of sheetfed offset solvents

The solvents were evaluated for roller washing technical feasibility on the Heidelberg Speedmaster SM102. The rollers were covered with black ink at an ink key setting of 20% blade opening. The press was set for 20 automatic rotations before each solvent was evaluated. The operator began with 100 ml of solvent in a squeeze bottle. The time required for cleaning and the amount of solvent consumed were recorded as well as any subjective observations. The comments from the operators are listed below and are summarized in Figure 16 for the performance. The quantity of material used is shown in Figure 17.

[3] *The following provides an overview of the descriptors used in the analysis.*
Blanket performance: *Good: the solvents effectively cut the ink and during the cleaning the cleaning rag was not dragging. Moderate: There solvent either did not effectively cut the ink or caused the rag to drag. Poor: The solvent did not remove the ink and may also have been difficult to move with the rag.*
Streaks: *Good: There were no streaks on the blanket after cleaning. Moderate: There was some small evidence of streaks once the blanket was cleaned. Poor: There were significant streaks after the cleaning and this would defiantly require another round of cleaning and/or drying.*
Evaporation: *Good: There was a fast evaporation and limited drying was required. Moderate: The evaporation rate was acceptable once the blanket had been dried. Poor: There was a slow evaporation that required several rags to be applied to the blanket surface with extra blanket revolutions.*

Benchmark solvents

- Varn Wash V-120 required 50 millimeters of solvent and 4 minutes to clean the rollers.
- Printers' Service Autowash 6000 required 5 minutes and 50 milliliters to clean the ink rollers.

Deprecated VOC content solvents

- Printers' Service Autowash 4300 cleaned the rollers in five minutes with 30 milliliters of solvent.
- Printers' Service Autowash 4318 cleaned the rollers with 35 milliliters of solvent in 5 minutes. The press operator commented on the strong odor of the product.
- Varn Ecolo-Clean 35 cleaned the rollers more slowly with 55 milliliters of solvent in 6 minutes. The rollers had an oil-covered appearance when the cleaning was done.
- Varn Ecolo-Wash Step B took some time to see any results, but after 7 minutes and 70 milliliters, the rollers were clean.
- Printers' Service E-Cure Classic NH did a good job of cleaning in 4 minutes with 55 milliliters of solvent. The press operator found the odor of this cleaner very objectionable.
- Anchor Good News Wash 350 Plus appeared to not clean at first, but after 6 minutes and 75 milliliters of solvent the rollers were clean.
- Varn Ecolo-Clean produced cleaning results more rapidly than other "white" or emulsion based materials. Cleaning was accomplished with 70 milliliters of material in 7 minutes.
- Anchor Envirowash® ELT-RT30 produced cleaning results right way with 40 milliliters of material in 4 minutes.
- Anchor #7750 Envirowash® 220 SR-WM also produced cleaning results right away with 50 milliliters in 5 minutes.
- Printers' Service Autowash 1010 rapidly dissolved the ink and cleaned the rollers with 30 milliliters of material in 4 minutes.
- Printers' Service Autowash LV10 cleaned like Autowash 1010, with 50 milliliters of solvent and 4 minutes duration.

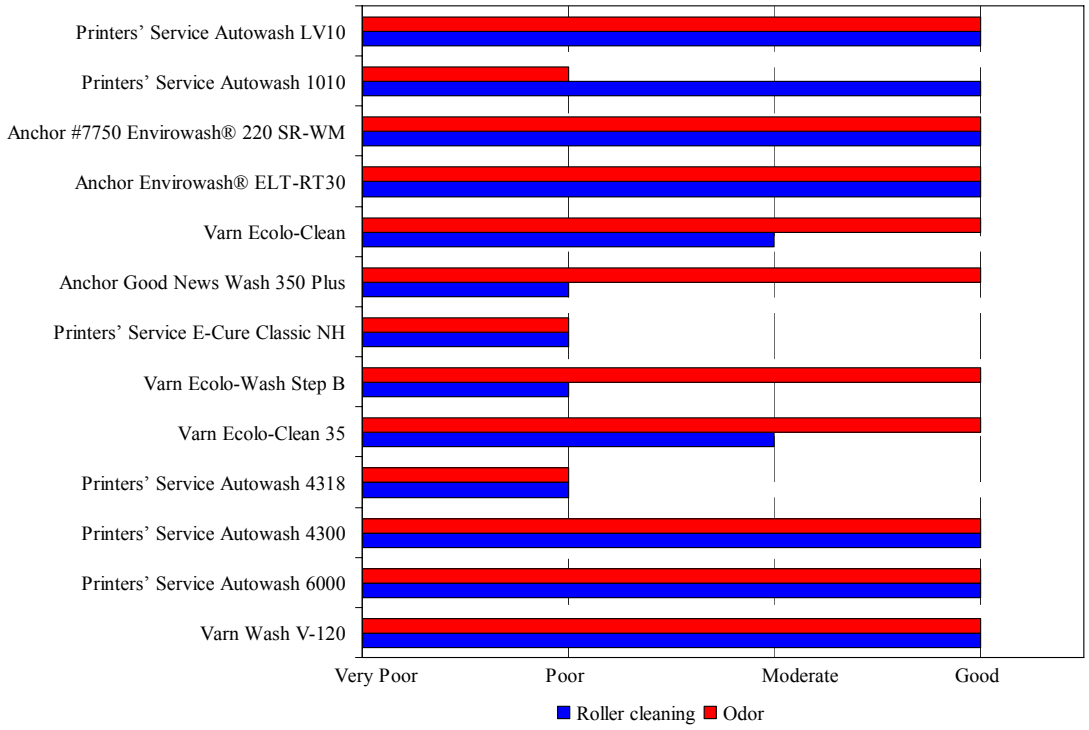

Figure 16. On-press sheetfed offset roller cleaning performance.[4]

[4] *The following provides an overview of the descriptors used in the analysis.*
Roller cleaning: *Good: the solvents effectively cleaned the rollers in five minutes or under. Moderate: the time taken to clean the rollers was one minute longer, and more solvent may have been required. Poor: the time taken to clean the rollers was at least two minutes longer and significantly more solvent was required.*
Odor: *Good: there was no unacceptable odor. Moderate: a slight odor was detected by the operators, though this was minimal. Poor: Strong unacceptable level of odor.*

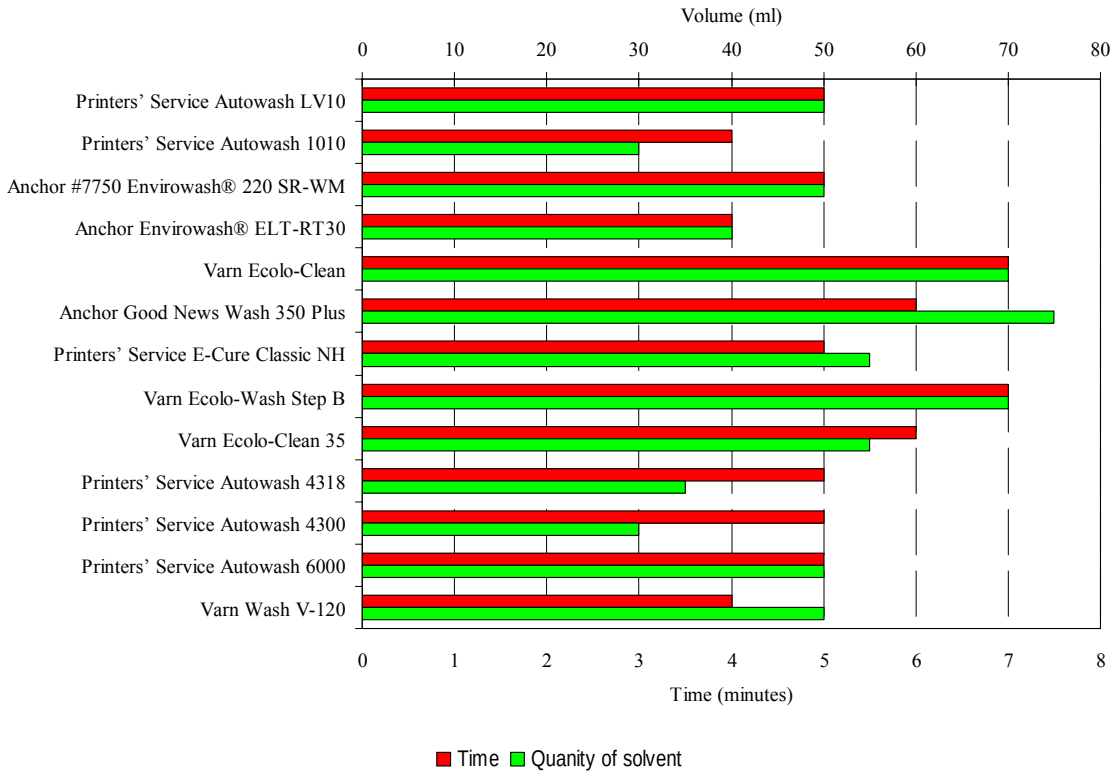

Figure 17. On-press sheetfed offset roller cleaning time and material required.

Considering the VOC content, the solvents were successfully reformulated or formulated that were technologically feasible to clean lithographic press components. These materials were at or below the Rule 1171 2005 VOC content targets for this technology assessment. The solvents with the reduced VOC content performed significantly better than the benchmark solvents with respect to the amount of swell measured on the blankets, Task 1.2. During the on press roller cleaning for both the sheetfed and heatset solvents, the reduced VOC content formulations performed in a similar manner to the benchmark solvents in the majority cases. The odor from three of the sheetfed reduced VOC content formulations was considered unacceptable by the press operators. The blankets were more difficult to clean and the largest difference between the solvents was identified in this testing. The blanket cleaning performance of reduced VOC content formulations were, in general, worse than those of the benchmark solvents. In addition, many of these solvents were slow to evaporate, resulting in longer press make-readies, and they also left a residue on the blanket surface. This residue is concerning as the compatibility of this residue with the inks can give rise to significant print problems. The cleaning of blankets and subsequent print runs at PIA/GATF have shown that if there is an incompatibility this can give rise to serious print quality issues, including a complete lack of solid ink transfer.

Task 5: Compile and Analyze Data

The results of Tasks 1 to 4 are summarized in this section.

Coldset web newsprint printing

The benchmark solvent from Mirachem met the goals of Rule 1171 2005 VOC content targets of 100 g/l. In normal operations, these solvent materials diluted further. Mirachem is 84% water. The cleaning requirements for this category were not as stringent; the cleaner is used for removing paper fiber from the blankets. Since the news inks do not dry by oxidation or evaporation, roller washing is a rare occurrence.

Coldset web offset on uncoated paper

The benchmark materials selected, Anchor #7844 Envirowash® T-100 and Hurst Amberclean 455, met the technologically feasible criterion of Rule 1171 2005 VOC content targets of 100 g/l, especially with dilution. The Anchor #7844 Envirowash® T-100 is 86% water while Hurst Amberclean 455 contains little or no water. The Material Safety Data Sheet for Hurst Amberclean 455 contained no declarable materials. Anchor #7844 Envirowash® T-100 contains derivatives of sulfonic acid and alkoxyalkanol surfactants for dissolving ink.

Heatset web offset on coated and uncoated paper

The benchmark solvents both had high VOC content for both blanket and roller washing (700 g/l to 800 g/l). The benchmark solvents were Anchor #7274 A-240 Wash and Varn Wash A-230. The VOC content was reduced through ten decrements to achieve a selection of low VOC materials. Two of the reformulated products, Printers' Service Autowash 1010 and Printers' Service Autowash LV10 are at the technology assessment targets for Rule 1171 for VOC content, 100 g/l. These materials did not clean the blankets as well as the benchmark solvents. Assuming that these materials are commercially viable as well as technologically acceptable, these materials represent, on average, an 88% reduction in VOC for the South Coast Air Basin in this one cleaning operation. The same materials are proposed for both roller washing and blanket cleaning.

Sheetfed printing width greater than 18 inches on paperboard, coated paper, uncoated paper, metal, and plastic

The benchmark solvents were Printers' Service Autowash 6000 and Varn Wash V-120, and they both had high VOC content for both blanket and roller washing (700 g/l to 800 g/l). The VOC content was reduced through ten decrements to achieve a selection of low VOC content materials. Two of the reformulated products, Printers' Service Autowash 1010 and Printers' Service Autowash LV10 are at the technology assessment targets for Rule 1171 for VOC content, 100 g/l. Assuming that these materials are commercially viable as well as technologically acceptable, these materials represent, on

average, an 88% reduction in VOC for the South Coast Air Basin in this one cleaning operation. The same materials are put forth as both blanket and roller washes.

Sheetfed printing width less than 18 inches, on coated paper, uncoated paper, plastic, and foil

The same solvents were used in this category as in those for the sheetfed printing greater than 18 inch width. The cleaning materials are the same for rollers and blankets, even if the printer changes the substrate being printed.

Task 6: Cost, emission reduction, safety, and environmental impact analysis

Cost estimation began with discussions with PIA/GATF printer members to determine the quantity of cleaning solvent (gallons) a printer will use in a year, and to obtain an estimation of the costs the printer pays for a gallon of cleaning solvent. This data would represent the benchmark cost for cleaning solvent.

The suppliers were asked for a cost per gallon of their materials. This was a quantity dependent number, the larger the volume obtained, the greater the discounts offered. Two suppliers provided cost data for their products. Printers' Service provided the following cost list, Table 3, for the products contributed to this technology assessment. These costs are on a per gallon basis, when they are purchased by the 55-gallon drum. Discounts are available for purchases of 10-, 20-, or 30-drum increments. Bulk storage tanks at some printers can result in a lower price.

Table 3. Cost of select solvents provided by Printers' Service.

	$/gallon (55 gal. Drum)
Printers' Service Autowash 4318	$10.70
Printers' Service Autowash 1010	$14.00
Printers' Service Autowash 4300	$ 9.00
Printers' Service Autowash 5900	$ 7.40
Printers' Service Autowash 6000	$ 6.60
Printers' Service Autowash LV10	$16.00
Printers' Service Autowash E Cure Classic NH	$16.40
Printers' Service Autowash PES-C34	$10.20

Mirachem reported that their product cost $8.50/galllon, when purchased by the 55-gallon drum. The product is diluted for use anywhere from 2:1 to 115:1 such that the final cost for the printer is $1.00 to $3.00 per gallon.

A survey of printers was carried out to determine data regarding the volume, use, and price of their cleaning solvents. The gallons per unit data collected will depend to some degree on the run length and the number of make readies. The results obtained are summarized below.

Printer A owns fourteen 40-inch press units and six 29-inch press units, all of the presses are sheetfed. This printer used 3575 gallons of blanket and roller wash per year and paid an average price of $4.83 per gallon. That amounts to 178 gallons of cleaning solvent per press unit per year, combining 40-inch and 29-inch usage.

Printer B has 48 units of heatset web offset press capacity (counting upper and lower units as 2 units), 46 units of sheetfed capacity, and 38 units of coldset web offset capacity. They consumed 5100 gallons per year of press wash and 5500 gallons per year of blanket wash, for a total of 10,600 gallons, and they paid $3.75/gallon. This corresponds to 80 gallons per unit per year.

Printer C has nineteen 40-inch sheetfed printing units and uses 2860 gallons of solvent per year. This corresponds to 150 gallons per unit per year.

Printer D has 82 units of heatset web offset capacity and consumed 30,679 gallons of solvent per year. This corresponds to 274 gallons per unit per year.

The data shows that here is a large distribution of the quantity of solvent used in each of the different facilities. As previously stated, this will be affected by the number of makereadies, the type of production and also the quality expectations of the printers customers.

To estimate the economic impact, we can propose that Printers' Service Autowash LV10 was substituted at the current cost of $16/gallon by the drum. For the calculation a 30% discount for quantity has been assumed. This discount is based upon Printers' Service quoted price for Autowash 6000 as $6.60/gallon, while Printer A is paying $4.83/gallon with a purchase of 65 55-gallon drums. The results are shown in Table 4, and all show that there would be a significant increase of at least 200% for the printers, in some instance there is a 300% increase. The high cost of the low VOC solvents will reduce as the volume use increases. However, it is not possible to predict how fast the price will drop due to market forces.

Table 4. Potential cost increases for printers in use of discovered low VOC cleaners.

	Yearly Gallons	Cost @ $4.83/gal	Cost @ $11.20/gal	% Increase
Printer A	3,575	$17,267.00	$40,040.00	230
Printer B	10,600	$39,750.00	$118,720.00	300
Printer C	2,869	$13,813.00	$32,032.00	230
Printer D	20,679	$115,046.00	$343,604.00	300

The economics can also be considered by assessing the material recycling implications. Materials with high VOC content and low water content are candidates for solvent recovery and solvent reuse. If a printer is paying only $3.47 per gallon, the incentive isn't there to recycle. If the price is $11.00 to $16.00 per gallon, there is incentive to recycle material. This lowers the VOC content use in the process. Recycling and reuse is possible for the four lowest VOC content materials, Table 5, in the technology assessment:

Table 5. Water and VOC content of the four lowest VOC content solvents assessed.

	% water	VOC g/l
Anchor Envirowash® ELT-RT30	0.1	263
Anchor #7750 Envirowash® 220 SR-WM	0.1	263
Printers' Service Autowash 1010	0.1	110
Printers' Service Autowash LV10	0.1	80

Emission Reduction

There is a significant emission reduction achieved during the project. Considering the initial statement of work, the contractor, and PIA/GATF were to reformulate existing cleaning materials and illustrate the technological feasibility of achieving cleaning materials with 100 g/l VOC content, the technology assessment targets for Rule 1171. The greatest emission reduction was possible with the sheetfed offset and heatset web offset cleaners and this is shown in Figure 18 and Figure 19. In these instances there is 85% to 90% reduction in the VOC content.

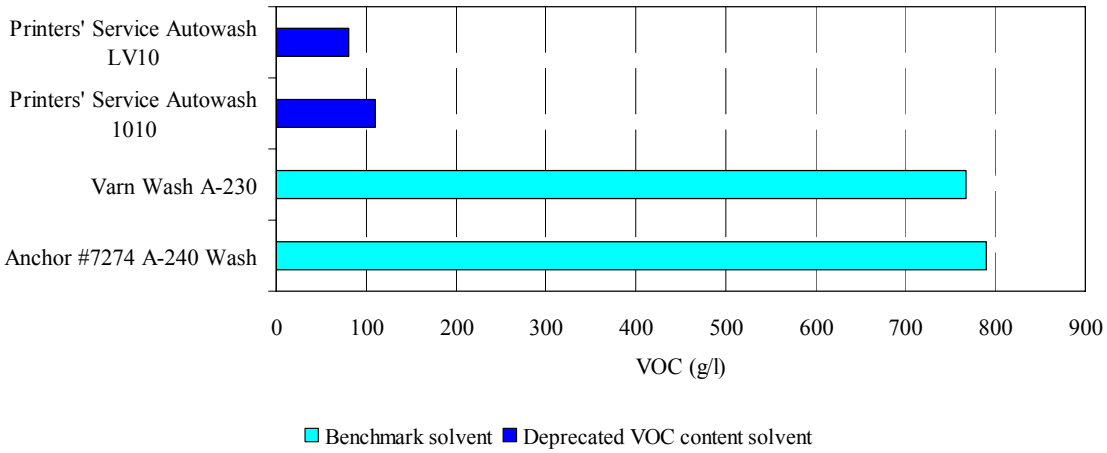

Figure 18. Emission reduction from benchmark to low VOC content solvents for heatset web offset presses.

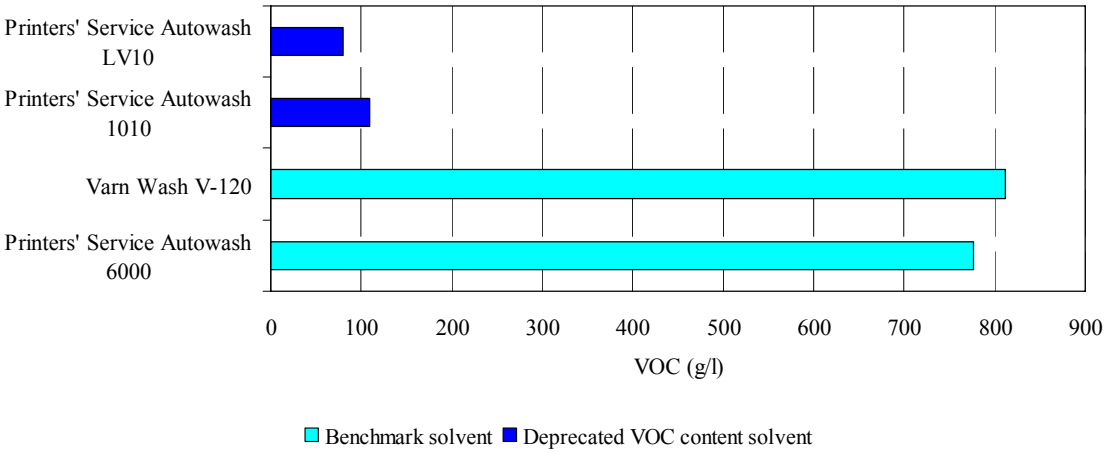

Figure 19. Emission reduction from benchmark to low VOC content solvents for sheetfed offset presses.

The screening tests on printing equipment at PIA/GATF headquarters suggested that in several instances the technologically feasible low VOC content materials cleaned the rollers or blankets with a smaller amount (fewer ounces) of cleaner.

Safety and Environmental Impact

The scientists at the South Coast Air Quality Management District raised the following questions all with the same objective

- As the VOC content was reduced from the benchmark solvents, what was put into the formula in their place?
- Was the "cure" worse than the "disease"?
- Were the materials in the new formulas more harmful than the petroleum hydrocarbons that were typically replaced?

Working with the current suppliers of cleaning materials, and confirmed by laboratory testing by the South Coast Air Quality Management District, it is safe to say that the replacement materials were not exempt solvents.

One benchmark solvents, Printers' Service Autowash 6000 with a VOC content level of 776 g/l, will be used to compare toxicity and hazardous waste properties to the proposed technologically feasible products. Printers' Service Autowash 6000 is a combustible liquid with a flash point of 105°F and it is photoreactive. The empty containers are an explosion hazard, requiring certified firms for reconditioning and disposal. The formulation contains reportable quantities of 1, 2, 4 – trimethylbenzene, cumene, and xylenes, which are on the HAP SARA Title III Section 313 list. Overexposure to these chemicals will produce headaches, dizziness, and skin irritation. Sheetfed printers use this product every day.

The Printers' Service Autowash 6000 will be compared to Printers' Service Autowash LV10 with a VOC content level of 80g/l VOC. Printers' Service Autowash LV10 is not considered a combustible liquid, having a flash point greater than 212°F. There are no materials that are reportable HAP SARA Title III Section 313 list. Skin contact can lead to irritation or dermatitis. The other low VOC content solvent, Printers' Service Autowash 1010 contains dipropylene glycol monomethyl ether, and has a flash point of 244°F. There are no materials that are reportable HAP SARA Title III Section 313 list.

The technologically feasible low VOC cleaning products, at first screening, appear to be safer for the press room, the press operators, and the environment.

Task 7: Submission of solvents for independent compatibility tests and VOC determination

Throughout the durations of the project, samples of each benchmark and decrement solvent were forwarded to both the South Coast Air Quality Management District laboratory and to the University of Tennessee. The South Coast Air Quality Management District laboratory reported back water contents, shown in Appendix A. The University of Tennessee performed blanket and roller swell tests that were reported on in quarterly meetings and their final report.

Report Conclusions

In the fall of 2002, PIA/GATF was contracted by South Coast Air Quality Management District to develop low VOC content cleaning solvents for different cleaning categories of offset lithography. PIA/GATF began with existing benchmark cleaning solvents already in use in the South Coast Air Basin. The benchmark materials were to be reformulated to achieve the target VOC content values of the 2005 Rule 1171 technology assessment, with the target VOC content level of 100 g/l or less. The benchmark material VOC content levels ranged from 90 g/l to 811 g/l, dependent on the cleaning application. This range was based on defining the benchmark materials as those cleaners that are currently used by printers. The result was that two of the initially identified conditions, cold set web offset printing of newsprint and coldset web offset printing on uncoated paper were already at the 2005 target VOC levels. These materials were already being used successfully indicating that they were already technically and economically feasible. The reason for low VOC content materials existing already is explained by the less stringent definition of clean for these printing processes (affecting print quality), the non-drying nature of the ink, and the low ink viscosity.

Heatset web offset and sheetfed offset benchmark materials had a high VOC content level, at or above the interim 2001 limits for Rule 1171, a VOC content level of 600 g/l. Cleaning solvents with progressively deprecated VOC content levels were evaluated for VOC content, swell characteristics, laboratory washability and on-press cleaning performance. The lowest VOC content levels were achieved by Printers' Service Autowash LV10 and Printers' Service Autowash 1010. Both of these products met the target VOC content values of the 2005 Rule 1171 technology assessment, with the target VOC content level of 100 g/l. The goal of reaching the target VOC content was achieved for all five printing categories of offset lithographic cleaning originally identified.

Several of the products from Printers' Service were recommended as technologically feasible cleaning solutions for rollers and blankets for both sheetfed and heatset web offset. It is clearly possible that a single material is suitable for these two conditions. The ink chemistry is similar, and the roller and blanket formulations are very similar. Given time, and the success of these products, the selection of low VOC content solvents from multiple suppliers will multiply due to market forces. The same market forces and environmental awareness will move the price down. The price of the low VOC content alternative is an obstacle to further use of these products.

The performance of the low VOC content solvents in cleaning the blankets and rollers was not as good as the benchmark solvents. The reduction in VOC content level resulted in a slower evaporation rate from the roller surface and there was in several instances a residue left on the blanket surface. It is important that the implications of this residue are investigated as it could result in a deterioration of the transfer characteristics to the substrate, with either additional cleaning required, the press having to condition for greater periods of time between print jobs or significant increases in the make-ready waste.

The suppliers were very cooperative in suggesting new and developing products to get closer to and eventually reach the Rule 1171 target VOC content levels.

In the case of Printers' Service Autowash LV10, the product was in select customer evaluation sites. It is a new product that is in beta testing. There are two products by Anchor, at 263 g/l VOC content, that show similar promise. While not at the 2005 target, the VOC content levels represent at least 60% emission reduction.

Appendix A

Appendix Table 1. The VOC of Benchmark solvents according to EPA Method 24.

Product	Category	Non Volatile %	VOC + H2O%	% H_2O	VOC g/l
Printers' Service Autowash 6000	Sheetfed	2.7	97.3	0.1	776
Varn Wash V-120	Sheetfed	1.8	98.2	0.2	811
Varn Wash A-230	Heatset Web Offset	2.0	98.0	0.1	767
Printers'Service PES-C34	Newsprint	32.2	67.8	0.1	405
Hurst Amberclean 455	Coldset	77.8	22.2	0.7	186
Mirachem	Newsprint	6.0	94.0	84	100
Anchor #7844 Envirowash® T-100	Coldset	4.0	96.0	86	91
Anchor #7274 A-240 Wash	Heatset Web Offset	4.7	95.3	0.2	790

Appendix Table 2. The VOC content according to EPA Method 24, solvents evaluated for heatset web offset. Benchmark solvents were Varn Wash A-230 and Anchor #7274 A-240 Wash.

Product	Non Volatile %	VOC + H2O%	% H_2O	VOC g/l
Varn Wash A-230	2.0	98	0.1	767
Anchor #7274 A-240 Wash	4.7	95.3	0.2	790
Varn CP-623	9.0	90.8	26.7	551
Varn CP-605	16.7	83.3	0.2	634
Varn CP-639PW Wash	36.2	63.8	0.1	479
Anchor #7406 Envirowash® 5-0	21.0	79.0		599
Printers' Service Autowash 4318	84	16	0.03	500
Varn Ecolo-Clean 35	7	93	45	420
Varn Ecolo-Wash Step B	7	93	48.3	420
Printers' Service Autowash E Cure Classic NH	86	14	0.07	408
Varn Ecoloclean	9	91	41.2	299
Anchor Envirowash® ELT-RT30	62	38	0.1	263
Anchor #7750 Envirowash® 220 SR-WM	59	41	0.1	263
Printers' Service Autowash 1010	66	34	0.09	110
Printers' Service Autowash LV10	63	37	0.05	80

Note 1: Printers' Service, Anchor Fuji Hunt, and Varn were contacted and cleaning materials with lower VOC were solicited for testing by the protocols of Task 1. The objective, outlined in the trial protocol (see Task 1) was to take the benchmark solvents and reduce the VOC content at 50 g/l intervals. During these discussions it was determined that a number of solvents were a developed by the manufacturers with the objective of obtaining the reduced 2005 Rule 1171 goals (100 g/l target for a roller wash step one and 100 g/l target for a roller wash step two). There was a large distribution of VOC content within these new solvents from the benchmark VOC levels through to the target levels. It was recommended that these new solvents should be used in place of the 50 g/l reductions. Discussions were held with South Coast Air Quality Management District regarding this approach, and approval was obtained from them to deviate from the initial agreed trial protocol outlined in Task 1 and use the new solvents. The solvents that were developed could all be classed as belonging to a similar solvent family, though the formulations were altered for different cleaning characteristics, additives and VOC content according to EPA Method 24.

Appendix Table 3.

The VOC content according to EPA Method 24, solvents evaluated for sheetfed presses greater than 18 inches in width. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

Product	Non Volatile %	VOC + H2O%	% H_2O	VOC g/l
Varn Wash V-120	1.8	98.2	0.2	811
Printers' Service Autowash 6000	2.7	97.3	0.1	776
Printers' Service Autowash 5900	1	99	0.1	688
Varn CP-605	16.7	83.3	0.2	634
Printers' Service Autowash 4300	10.6	89.4	0.2	509
Printers' Service Autowash 4318	84	16	0.3	500
Varn Ecolo-Clean 35	7	93	45	420
Varn Ecolo-Wash Step B	7	93	48.3	420
Printers' Service E-Cure Classic NH	86	14	0.07	408
Anchor Good News Wash 350 Plus	6.5	93.5		406
Varn Ecoloclean	9	91	41.2	299
Anchor Envirowash® ELT-RT30	62	38	0.1	263
Anchor #7750 Envirowash® 220 SR-WM	59	41	0.1	263
Printers' Service Autowash 1010	66	34	0.09	110
Printers' Service Autowash LV10	63	37	0.05	80

See Note 1.

Appendix Table 4. The VOC content according to EPA Method 24, solvents evaluated for sheetfed presses less than 18 inches in width. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

Product	Non Volatile %	VOC + H2O%	% H_2O	VOC g/l
Varn Wash V-120	1.8	98.2	0.2	811
Printers' Service Autowash 6000	2.7	97.3	0.1	776
Printers' Service Autowash 5900	1	99	0.1	688
Varn CP-605	16.7	83.3	0.2	634
Printers' Service Autowash 4300	10.6	89.4	0.2	509
Printers' Service Autowash 4318	84	16	0.3	500
Varn Ecolo-Clean 35	7	93	45	420
Varn Ecolo-Wash Step B	7	93	48.3	420
Printers' Service E-Cure Classic NH	86	14	0.07	408
Anchor Good News Wash 350 Plus	6.5	93.5		406
Varn Ecoloclean	9	91	41.2	299
Anchor Envirowash® ELT-RT30	62	38	0.1	263
Anchor #7750 Envirowash® 220 SR-WM	59	41	0.1	263
Printers' Service Autowash 1010	66	34	0.09	110
Printers' Service Autowash LV10	63	37	0.05	80

Appendix Table 5. Benchmark solvents based on lowest VOC content according to EPA Method 24 products available for use in the South Coast Air Basin.

Cold Set Newspaper Printing	Anchor #7844 Envirowash® T-100	91 g/l
	Hurst Amberclean 455	186 g/l
Cold Set Web Offset	Anchor #7844 Envirowash® T-100	91 g/l
	Hurst Amberclean 455	186 g/l
Heat Set Web Offset	Anchor #7844 Envirowash® T-100	91 g/l
	Hurst Amberclean 455	186 g/l
Sheetfed Offset > than 18" width	Hurst Amberclean 455	186 g/l
	Printers' Service PES C34	405 g/l
Sheetfed Offset < than 18" width	Hurst Amberclean 455	186 g/l
	Printers' Service PES C34	405 g/l

Appendix Table 6. VOC content according to EPA Method 24 of selected benchmark solvents by press and process category.

Cold Set Newspaper Printing	Mirachem	100 g/l
	Printers' Service PESC34	405 g/l
Cold Set Web Offset Printing	Hurst Amerclean 455	186 g/l
	Anchor #7844 Envirowash® T-100	91 g/l
Heat Set Web Offset	Varn Wash A-230	767 g/l
	Anchor #7274 A-240 Wash	790 g/l
Sheetfed Offset > than 18" width	Printers' Service Autowash 6000	776 g/l
	Varn Wash V-120	811 g/l
Sheetfed Offset > than 18" width	Printers' Service Autowash 6000	776 g/l
	Varn Wash V-120	811 g/l

Appendix Table 7.

Blanket swell performance of benchmark solvents.

Product	Application	VOC g/l	1 hour swell %	4 hour swell %
Printers' Service Autowash 6000	Sheetfed	776	1.3	2.6
Varn Wash V-120	Sheetfed	811	5.0	7.7
Varn Wash A-230	Heatset Web Offset	767	0.3	1.3
Printers' Service PES-C34	Newsprint	405	0.9	2.6
Hurst Amberclean 455	Coldset	186	1.3	3.9
Mirachem	Newsprint	100	1.3	1.3
Anchor #7844 Envirowash® T-100	Coldset	91	1.3	1.3
Anchor #7274 A-240 Wash	Heatset Web Offset	790	4.0	7.6

Appendix Table 8. Blanket swell performance of heatset web offset benchmark solvents and decrement solvents. Benchmark solvents were Varn Wash A-230 and Anchor #7274 A-240 Wash.

Product	VOC g/l	1 hour swell %	4 hour swell %
Varn Wash A-230	767	0.3	1.3
Anchor #7274 A-240 Wash	790	4.0	7.6
Varn CP-623	551	0	0.8
Varn CP-605	634	0	0.3
Varn CP-639PW Wash	479	0	0
Anchor #7406 Envirowash® 5-0	599	0	0
Printers' Service Autowash 4318	500	0.7	1.7
Varn Ecolo-Clean 35	420	0.5	0.6
Varn Ecolo-Wash Step B	420	0.7	0.5
Printers' Service Autowash E Cure Classic NH	403	1.9	4
Varn Ecoloclean	299	0.3	0.5
Anchor Envirowash® ELT-RT30	263	1.0	0.9
Anchor #7750 Envirowash® 220 SR-WM	263	0.2	0.3
Printers' Service Autowash 1010	110	0.5	1.1
Printers' Service Autowash LV10	80	1.1	1.6

Appendix Table 9. Blanket swell performance of sheetfed offset benchmark solvents and decrement solvents, for press widths greater than 18 inches. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

Product	VOC g/l	1 hour swell %	4 hour swell %
Varn Wash V-120	811	5.0	7.7
Printers' Service Autowash 6000	776	1.3	2.6
Printers' Service Autowash 5900	688	1.3	3.2
Varn CP-605	634	0	0.3
Printers' Service Autowash 4300	509	2.6	3.4
Printers' Service Autowash 4318	500	0.7	1.7
Varn Ecolo-Clean 35	420	0.5	0.6
Varn Ecolo-Wash Step B	420	0.7	0.5
Printers' Service E-Cure Classic NH	403	1.9	4.0
Anchor Good News Wash 350 Plus	419	1.4	3.5
Varn Ecoloclean	299	0.3	0.5
Anchor Envirowash® ELT-RT30	263	1.0	0.9
Anchor #7750 Envirowash® 220 SR-WM	263	0.2	0.3
Printers' Service Autowash 1010	110	0.5	1.1
Printers' Service Autowash LV10	80	1.1	1.6

Appendix Table 10. Blanket swell performance of sheetfed offset benchmark solvents and decrement solvents, for press widths less than 18 inches. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

Product	VOC g/l	1 hour swell %	4 hour swell %
Varn Wash V-120	811	5.0	7.7
Printers' Service Autowash 6000	776	1.3	2.6
Printers' Service Autowash 5900	688	1.3	3.2
Varn CP-605	634	0	0.3
Printers' Service Autowash 4300	509	2.6	3.4
Printers' Service Autowash 4318	500	0.7	1.7
Varn Ecolo-Clean 35	420	0.5	0.6
Varn Ecolo-Wash Step B	420	0.7	0.5
Printers' Service E-Cure Classic NH	403	1.9	4.0
Anchor Good News Wash 350 Plus	419	1.4	3.5
Varn Ecoloclean	299	0.3	0.5
Anchor Envirowash® ELT-RT30	263	1.0	0.9
Anchor #7750 Envirowash® 220 SR-WM	263	0.2	0.3
Printers' Service Autowash 1010	110	0.5	1.1
Printers' Service Autowash LV10	80	1.1	1.6

Appendix Table 11. On-press heatset web offset blanket cleaning results of benchmark solvents and decrement solvents. Benchmark solvents were Varn Wash A-230 and Anchor #7274 A-240 Wash.

Product	VOC g/l	Blankets	Streaks	Evaporation
Varn Wash A-230	767	Good	Slight	Fast
Anchor #7274 A-240 Wash	790	Good	None	Fast
Varn CP-623	551	Good	None	Medium
Varn CP-605	634	Fair	Moderate	Slow
Varn CP-639PW Wash	479	Poor	A lot	Slow
Anchor #7406 Envirowash® 5-0	599	Poor	A lot	Medium
Printers' Service Autowash 4318	500	Fair	Moderate	Slow
Varn Ecolo-Clean 35	420	Good	None	Fast
Varn Ecolo-Wash Step B	420	Good	None	Fast
Printers' Service Autowash E Cure Classic NH	403	Good	Slight	Fast
Varn Ecoloclean	299	Good	Slight	Fast
Anchor Envirowash® ELT-RT30	263	Good	Slight	Moderate
Anchor #7750 Envirowash® 220 SR-WM	263	Good	Slight	Moderate
Printers' Service Autowash 1010	110	Fair	Moderate	Slow
Printers' Service Autowash LV10	80	Fair	Moderate	Slow

Appendix Table 12. On-press heatset web offset roller washing results of benchmark solvents and decrement solvents. Benchmark solvents were Varn Wash A-230 and Anchor #7274 A-240 Wash.

Product	VOC g/l	Roller Cleaning	Time, Min.	Solvent Amount ml.
Varn Wash A-230	767	Good	4	75
Anchor #7274 A-240 Wash	790	Good	4	90
Varn CP-623	551	Good	4	65
Printers' Service Autowash 4318	500	Fair	3	35
Varn Ecolo-Clean 35	420	Good	4	65
Varn Ecolo-Wash Step B	420	Good	4	65
Printers' Service Autowash E Cure Classic NH	403	Good	4	50
Varn Ecoloclean	299	Good	3	45
Anchor Envirowash® ELT-RT30	263	Good	4	35
Anchor #7750 Envirowash® 220 SR-WM	263	Good	3	40
Printers' Service Autowash 1010	110	Good	3	40
Printers' Service Autowash LV10	80	Good	2	35

Appendix Table 13. On-press sheetfed offset presses blanket cleaning results of benchmark solvents and decrement solvents. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

Product	VOC g/l	Blanket Cleaning	Streaks	Evaporation Rate	Odor
Varn Wash V-120 (*)	811	Good	None	Fast	
Printers' Service Autowash 6000 (*)	776	Good	None	Fast	
Printers' Service Autowash 4300	509	Good	Residue	Moderate	
Printers' Service Autowash 4318	500	Fair	None	Slow	Yes
Varn Ecolo-Clean 35	420	Good	None	Slow	
Varn Ecolo-Wash Step B	420	Good	Residue	Slow	
Printers' Service E-Cure Classic NH	408	Fair	Residue	Slow	Yes
Anchor Good News Wash 350 Plus	406	Fair	Residue	Slow	
Varn Ecoloclean	299	Fair	Residue	Slow	
Anchor Envirowash ELT-RT30	263	Fair	Residue	Slow	
Anchor #7750 Envirowash® 220 SR-WM	263	Fair	Residue	Slow	
Printers' Service Autowash 1010	110	Fair	Residue	Slow	Yes
Printers' Service Autowash LV10	80	Fair	Residue	Slow	

Appendix Table 14. On-press sheetfed offset presses roller washing results of benchmark solvents and decrement solvents. Benchmark solvents were Varn Wash V-120 and Printers' Service Autowash 6000.

	VOC g/l	Roller Cleaning	Clean Time, Min.	Solvent Amt. ml.
Varn Wash V-120	811	Good	4	50
Printers' Service Autowash 6000	776	Good	5	50
Printers' Service Autowash 4300	509	Good	5	30
Printers' Service Autowash 4318	500	Poor	5	35
Varn Ecolo-Clean 35	420	Fair	6	55
Varn Ecolo-Wash Step B	420	Poor	7	70
Printers' Service E-Cure Classic NH	403	Poor	5	55
Anchor Good News Wash 350 Plus	419	Poor	6	75
Varn Ecoloclean	299	Fair	7	70
Anchor Envirowash® ELT-RT30	263	Good	4	40
Anchor #7750 Envirowash® 220 SR-WM	263	Good	5	50
Printers' Service Autowash 1010	110	Good	4	30
Printers' Service Autowash LV10	80	Good	5	50

Appendix Table 15. Potential VOC content emission reductions of technologically feasible materials developed / identified during the project compared to the benchmark materials for heatset web offset.

	Initial	Final	% Reduction
Anchor #7274 A-240 Wash	790		
Varn Wash A-230	767		
Printers' Service Autowash 1010		110	86%
Printers' Service Autowash LV10		80	89%

Appendix Table 16. Potential VOC content emission reductions of technologically feasible materials developed / identified during the project compared to the benchmark materials for sheetfed offset.

	Initial	Final	% Reduction
Printers' Service Autowash 6000	776		
Varn Wash V-120	811		
Printers' Service Autowash 1010		110	86%
Printers' Service Autowash LV10		80	91%

Appendix B

Potential benchmark materials that meet the requirements of the statement of work.
Cleaning materials are arranged according to press type.

Coldset Web

	VOC, #/gal	VOC, g/l	
Anchor Enviro 100	1	119	
Anchor Enviro 160	1.6	192	veg. Oil based, aromatics
Anchor Enviro 220	2.2	264	
Anchor #7406 Envirowash® 5-0	5	600	
Anchor Good News Wash 350 Plus	3.5	420	emulsion
Varn Ecoloclean	2.5	300	
Varn Ecolo-Clean 35	3.5	420	
Varn CP-605 80% VOC Wash	5.25	630	
Varn Response 4420	2.2	262	
Varn Response 4425	3.4	405	
Varn Response 4415	3.5	420	
Varn Mercury Ecolo-Wash 325	2.2	260	
Varn Mercury Ecolo-Wash 330	3.3	400	
Varn CP-639 60% VOC Wash	4.1	486	
Varn CP-623 70% VOC	4.6	552	
Homogenized Wash			
Mirachem			emulsion
Hurst Amberclean 455	1.5		emulsion
A.G. Layne #1 Roller Wash	5	598	
A.G. Layne #2 Roller Wash	6.6	790	
A.G. Layne 1200 Custom Blend	6.7	798	
A.G. Layne Hydroclean	6.6	795	
A.G. Layne Meter Roll Cleaner	2.7	324	
Printers Service			
Wonder Wash 35	3.53	423	
SuperClean 2C	6.67	800	
SuperClean 1IC	5.04	605	
Autowash 6000	6.48	777	
Autowash 9000 CA	6.6	792	
PowerKlene WM Special	6.69	802	
PowerKlene VC Special	6.69	802	
MRC	2.76	331	
MRC-F	3.54	425	

Heatset Web Offset

Anchor Enviro 100	1	119	
Anchor Enviro 160	1.6	192	veg. Oil based, aromatics
Anchor Enviro 220	2.2	264	
Anchor #7406 Envirowash® 5-0	5	600	
Anchor Good News Wash 350 Plus	3.5	420	emulsion
Varn Ecoloclean	2.5	300	
Varn Ecolo-Clean 35	3.5	420	
Varn CP-605 80% VOC Wash	5.25	630	
Varn Response 4420	2.2	262	
Varn Response 4425	3.4	405	
Varn Response 4415	3.5	420	
Varn Mercury Ecolo-Wash 325	2.2	260	
Varn Mercury Ecolo-Wash 330	3.3	400	
Varn CP-639 60% VOC Wash	4.1	486	
Varn CP-623 70% VOC	4.6	552	

	Homogenized Wash		
Mirachem			emulsion
Hurst Amberclean 455	1.5	180	emulsion
A.G. Layne #1 Roller Wash	5	598	
A.G. Layne #2 Roller Wash	6.6	790	
A.G. Layne 1200 Custom Blend	6.7	798	
A.G. Layne Hydroclean	6.6	795	
A.G. Layne Meter Roll Cleaner	2.7	324	
Printers Service			
Wonder Wash 35	3.53	423	
SuperClean 2C	6.67	800	
SuperClean 1IC	5.04	605	
Autowash 6000	6.48	777	
Autowash 9000 CA	6.6	792	
PowerKlene WM Special	6.69	802	
PowerKlene VC Special	6.69	802	
MRC	2.76	331	
MRC-F	3.54	425	

Waterless Web Offset Same as coldset and heatset web

Sheetfed Presses greater than 18 inches in width

Anchor			
Enviro 160	1.6	192	
Anchor #7406 Envirowash® 5-0	5	600	
Anchor Good News Wash 350 Plus	3.5	420	emulsion
Varn Ecoloclean	2.5	300	
Varn Ecolo-Clean 35	3.5	420	
Varn CP-605 80% VOC Wash	5.25	630	
Varn Response 4420	2.2	262	
Varn Response 4425	3.4	405	
Varn Response 4415	3.5	420	
Varn Mercury Ecolo-Wash 325	2.2	260	
Varn Mercury Ecolo-Wash 330	3.3	400	
Varn CP-639 60% VOC Wash	4.1	486	
Varn CP-623 70% VOC	4.6	552	
Homogenized Wash			
Varn Ecolo-Wash Step A	0.8	95	
Varn Ecolo-Wash Step B	3.5	420	
Mirachem			emulsion
Hurst Amberclean 455	1.5	180	emulsion
A.G.Layne #204 Blanket Wash	6.4	770	
A.G.Layne 204C Blanket Wash	4.4	528	
A.G.Layne 1.68 Blanket Wash	1.68	201	
A.G.Layne 2.68 Blanket Wash	2.68	321	
Printers Service			
Wonder Wash 35	3.53	423	
SuperClean 2C	6.67	800	
SuperClean 1IC	5.04	605	
Autowash 6000	6.48	777	
Autowash 9000 CA	6.6	792	
PowerKlene WM Special	6.69	802	
PowerKlene VC Special	6.69	802	
MRC	2.76	331	
MRC-F	3.54	425	
PES 115	1.5	180	
PES 153	5.3	636	
PES 320	1.8	216	
PES 353	5.2	624	
PES ABW-1	2.16	259	

Sheetfed presses less than 18 inches wide

Enviro 160	1.6	192	
Anchor #7406 Envirowash® 5-0	5	600	
Anchor Good News Wash 350 Plus	3.5	420	emulsion
Varn Ecolo-Clean QD	3.5	420	
Mirachem			emulsion
Hurst Amberclean 455	1.5	180	emulsion
A.G.Layne #204 Blanket Wash	6.4	770	
A.G.Layne 204C Blanket Wash	4.4	528	
A.G.Layne 1.68 Blanket Wash	1.68	201	
A.G.Layne 2.68 Blanket Wash	2.68	321	
Printers Service			
Wonder Wash 35	3.53	423	
SuperClean 2C	6.67	800	
SuperClean 1IC	5.04	605	
Autowash 6000	6.48	777	
Autowash 9000 CA	6.6	792	
PowerKlene WM Special	6.69	802	
PowerKlene VC Special	6.69	802	
MRC	2.76	331	
MRC-F	3.54	425	
PES 115	1.5	180	
PES 153	5.3	636	
PES 320	1.8	216	
PES 353	5.2	624	
PES ABW-1	2.16	259	
Speedy	2.91	349	

Appendix C

Cleaning materials, active ingredients, according to MSDS sheets

	VOC,g/l		
Mirachem	**100**		
Anchor	**91**	alkoxyalkanol	5-10%
#7844 Envirowash® T-100		alkylaryl sulfonic acid derivative	1-5%
		aryl sulfonate	0.5-1.5%
		water	80-100%
Printers Service	**405**	tetradecanoic acid, methyl ester	50-60%
PES-C34		aliphatic petroleum distillate	30-40%
		aromatic petroleum distillate	1-10%
		dipropylene glycol methyl ether	1-10%
Hurst	**186**	no hazardous materials to list	
Amberclean 455			
Anchor #7274 A-240 Wash	**790**	aliphatic petroleum distillate	30-50%
		aromatic hydrocarbons	30-50%
		cumene	1-5%
		dipropylene glycol monomethyl ether	3-7%
		misc. glycol ethers	0.5-1.5%
		nonylphenol ethoxylates	0.5-1.5%
		nonylphenol ethoxylates	1-5%
		xylene, mixed isomers	1-5%
		1,2,4-trimethylbenzene	15-30%
Varn Wash A-230	**767**	petroleum naphtha	90%
		petroleum naphtha	5%
		1,2,4-trimethylbenzene	2%
Printers Service	**776**	aliphatic petroleum distillate	70-80%
Autowash 6000		aromatic petro distillate	20-30%
		nonylphenoxy(ethyleneoxy) ethanol	1-10%
Varn Wash V-120	**811**	petroleum naphtha	43%
		petroleum naphtha	32%
		1,2,4-trimethylbenzene	12%
		dipropylene glycol monomethyl ether	6%
		p-mentha-1,8-diene	2%
		xylene, mixed isomers	1%
Varn CP-605	**634**	petroleum naphtha	67%
		petroleum naphtha	6%
Varn CP-623 70%	**551**	petroleum naphtha	55%
VOC homogenized		petroleum naphtha	8%
wash			
Varn CP-639 60%	**479**	petroleum naphtha	46%
VOC wash		petroleum naphtha	7%

Anchor #7406 Envirowash® 5-0	**599** VOC,g/l	aliphatic hydrocarbon	20-40%
		aliphatic hydrocarbon	30-50%
		aromatic hydrocarbon	3-7%
		cumene	.1-1%
		fatty acid ester	15-30%
		xylene, mixed isomers	0.1-1%
		1,2,4-trimethylbenzene	1-5%
Anchor Good News Wash 350 Plus	**406**	aliphatic hydrocarbon	7-15%
		aliphatic hydrocarbon	5-10%
		aromatic hydrocarbon	20-40%
		fatty acid ester	3-7%
		water	40-60%
Printers Service Autowash 5900	**688**	aliphatic hydrocarbon	50-60%
		aromatic hydrocarbon	20-30%
		fatty acid ester	10-20%
		nonylphenoxypoly(ethyleneoxy) ethanol	1-10%
Printers Service Autowash 4300	**509**	fatty acid ester	40-50%
		aliphatic hydrocarbon	30-40%
		aromatic hydrocarbon	20-30%
Varn Ecolo-Clean 35	**420**	petroleum naphtha	40%
		petroleum naphtha	6%
Varn Ecoloclean	**299**	petroleum naphtha	25%
		petroleum naphtha	6%
Varn Ecolowash Step A	**94**	petroleum naphtha	5%
Varn Ecolowash Step B	**420**	petroleum naphtha	40%
		petroleum naphtha	6%
Anchor **Envirowash 7750**	**263**	aliphatic hydrocarbon	10-20%
		aromatic hydrocarbon	5-10%
		dibasic esters	7-15%
		carboxylic acid esters	30-50%
		butanedioic acid esters	10-20%
		dipropylene glycol mono-methyl ether	1-5%
Anchor Envirowash 7895	**263**	aliphatic hydrocarbon	10-20%
		alkylphenol	0.5-1.5%
		aromatic hydrocarbon	5-10%
		dipropylene glycol mono-methyl ether	1-5%
		fatty acid ester	60-80%
Printers Service E-cure Classic NH	**403**	propylene glycol propyl ether	30-50%
		fatty acid ester	40-60%
Printers Service Autowash 1010	**110**	propylene glycol propyl ether	2.5-5%

Printers Service	**500**	aliphatic petroleum distillate	30-40%
Autowash 4318		solvent naphtha	10-20%
	VOC,g/l		
		1,2,4-trimethylbenzene	5-10%
		xylene	<2.5%
		cumene	<2.5%
Printers Service	**80**	octadec-1-ene	70-80%
Autowash LV10			