# The Printing Problems Created by the Use of Reduced VOC Wash-up Solvents and Their Effect on Press Productivity

by The PIASC Solvent Task Force*

Keywords: Problem, Productivity, Solvent, VOC

Abstract: This paper recounts the problems printers in Southern California have experienced in their mandated use, over a period of one year, of reduced VOC (volatile organic compound) wash-up solvents containing not more than 500 grams per liter of VOCs, and their ongoing tests of very low VOC solvents, i.e., solvents containing not more than 100 grams per liter of VOCs. It also recounts laboratory tests that demonstrate the adverse effect that reduced VOC solvents can have on the lithographic process and which are also being used to screen very low VOC solvents as a prerequisite to on-press testing. Additional information on the behavior of reduced VOC solvents was and is being obtained from three sources: (1) the responses of 74 printers to a survey of their initial experience in using 500 grams/liter solvents, (2) visits to printing plants, and (3) both short term and controlled long term printing tests. The evidence obtained to date from these sources indicates that the most important of the problems experienced by printers are caused by two phenomena: absorption of solvent by the rubber rollers during washups of the inking system rollers, and solvent drips resulting from fugitive solvent hideout during blanket and back cylinder cleaning. Because all of the remedies to the problems that have been developed to date reduce press productivity, a spreadsheet was designed for assessing the effect that a given low VOC solvent has on press productivity. The paper also presents an example of results obtained using this spreadsheet.

## I. Introduction

The information presented here was obtained by an industry task force that was organized by the Printing Industries of Southern California (PIASC), in response to complaints from its members. This paper constitutes a progress report in that the work of the task force is ongoing, and not expected to be completed until the end of 2007. The primary purpose of this paper is to acquaint the industry with the four paramount problems that are created by the use of solvents having VOC

---

* Presented by John MacPhee, Consultant to PIASC

contents of less than 500 grams/liter, based primarily on the experience of printers in the area of Southern California. Three of those problems will be discussed in this paper because the remedies available for solving them have a significant impact on press productivity. The fourth problem, fires in storage bins for used rags, due to spontaneous combustion, will not be discussed because it can be fixed by relatively benign remedies: the enforcement and improvement of existing safety procedures and equipment.

In keeping with this objective, the main body of this paper consists of three sections, each of which is devoted to a description of one of the above three problems, along with various remedies that have been identified and/or tried. The impact of the remedies is also commented on in terms of either cost or press productivity. These three sections are preceded by a section containing background information, and followed by a section containing a summary and conclusions.

## II. Background Information

The acronym in the title, VOC, stands for Volatile Organic Compound, although a more appropriate name might be Volatile and Reactive Compound. Such compounds are important because they are found in many materials widely used by our society, and because they can react with nitrous oxide, which is found in automobile exhaust and in the waste products of many industrial processes. As shown in Figure 1, one product of this reaction is ozone, which at ground level has adverse health effects on humans. Although the hazards of ozone know no

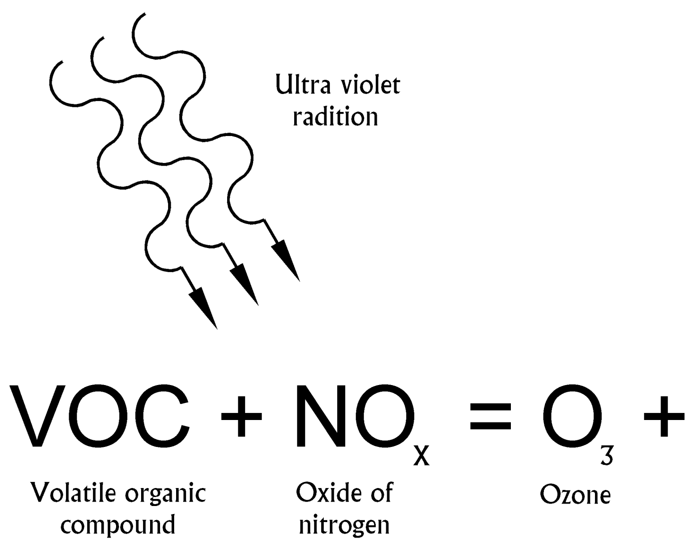


Figure 1 Diagram of the chemical reaction that produces ozone.

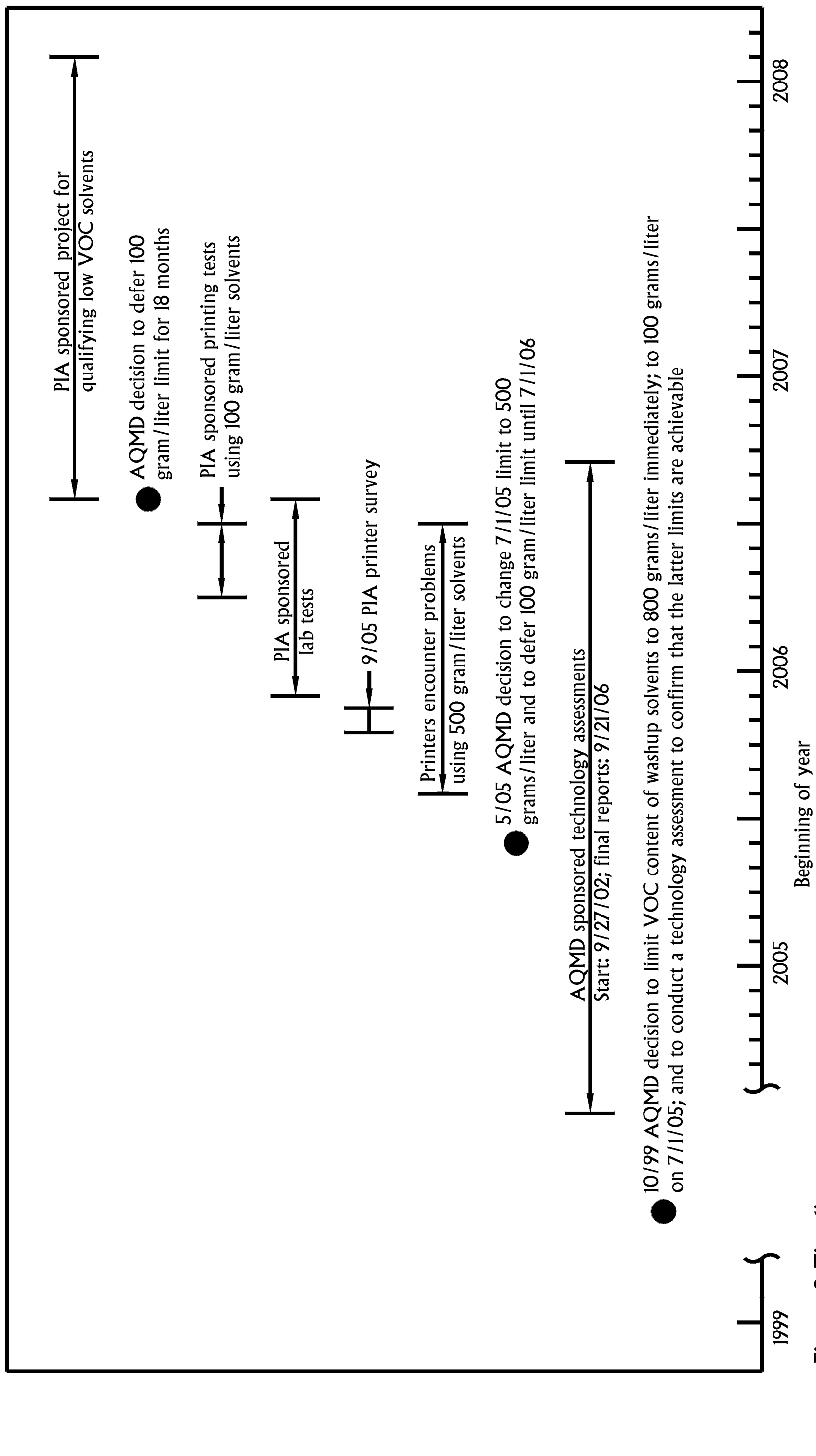


Figure 2 Timeline

geographical boundaries, the area of Southern California, and especially Los Angeles, has been particularly alert to them because of its topography and high population density. It is probably for this reason that the South Coast Air Quality Management District (SCAQMD) has been a leader in promulgating regulations to limit the use of VOCs in industries in the region. Figure 2 is a timeline of the history and current SCAQMD decisions governing the VOC content in wash-up solvents used in the printing industry. A review of this timeline discloses that printers in Southern California were mandated in July 2005 to use solvents with contents not exceeding 500 grams/liter (compared to traditional solvents of 800 grams/liter) and that the limit is scheduled to be reduced to 100 grams/liter on January 1, 2008. Thus, Southern California printers have already had over one year of experience using 500 grams/liter solvents, and face the prospect of having to use 100 grams/liter solvents starting January 1, 2008.

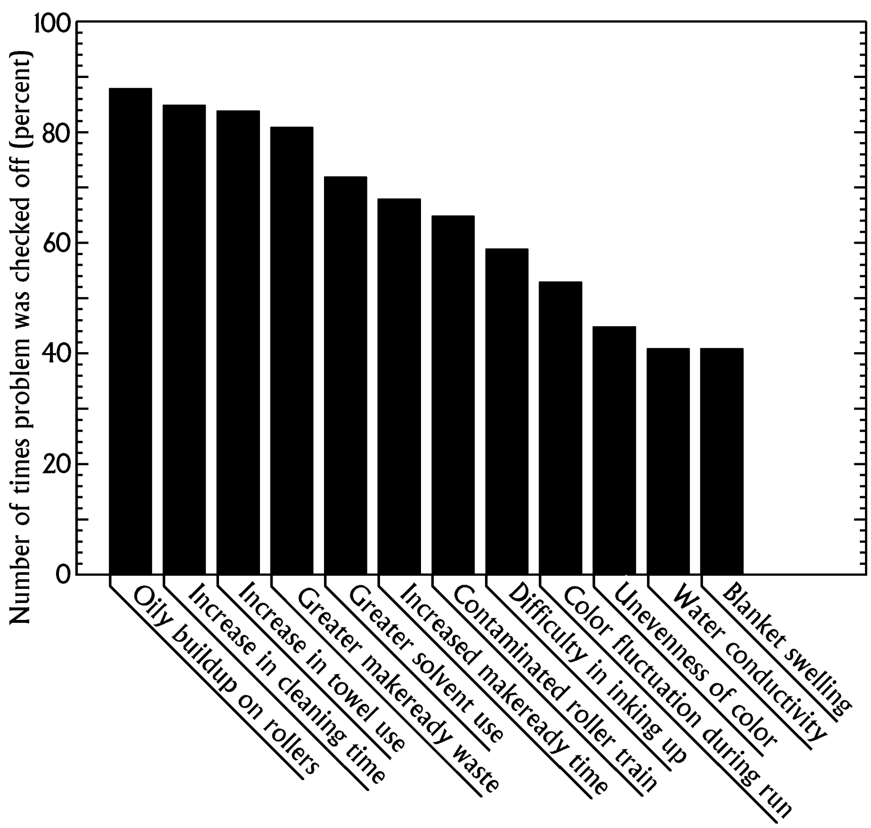


Figure 3 Frequency of problems checked in the 74 responses to the PIASC printer survey conducted in the fourth quarter of 2006.

## III. Print Defects Following Washup of Rollers

A. Description and Cause.

The first problem noted when the switch was made to 500 grams/liter solvents was longer make-ready times following a roller washup. In general, this was caused by the appearance of print defects such as toning and color variations, and the relatively long run time needed for them to go away. In some instances, these problems did not occur right away, but took several weeks to manifest themselves. When the printer would switch to a different brand of solvent, the problems would sometimes go away, only to reappear in another few weeks or so.

Anecdotal evidence that this problem was widespread is provided by the bar chart in Figure 3, which indicates that over 80% of the 74 printers who responded to a PIASC survey in the fourth quarter of 2005 experienced greater make-ready waste, while over 65% experienced longer make-ready times. Additional information is provided by printer's comments given in Appendix A.

Initially the culprit was thought to be the residue of solvent left on the roller surfaces after a single washup. Tests on an inkometer type instrument led us to conclude that the residue following a single washup was equivalent to a solvent contamination of about 3% in the ink. Subsequently, Terry Walsh, of Kramer Ink, discovered that successive washups of the inkometer had a progressively adverse effect on tack measurements. This suggested that the problem was caused by solvent being reversibly absorbed (meaning capable of being subsequently released) by the rubber, until the amount building up with each successive washup reached a point where the amount of solvent subsequently released to the ink constituted enough contamination of the ink to produce the observed print defects. This thesis is supported by evidence obtained from additional ink tack measurements as given in Figure 4, and described as follows:

1. A comparison of solid curves (a), (b), and (c) shows that the adverse effect of washing up rollers with reduced VOC solvents becomes progressively worse as VOC content is reduced. This is in keeping with the more than one year of experience of printers, who in general, and with some penalty in productivity, have been able to more or less cope with the 500 gram/liter solvents, but not with the <100 gram/liter solvents tried during a short test program sponsored by PIASC in the second quarter of 2006.

2. Dashed curve (d), obtained using ink contaminated with 10% of the <100 gram/liter solvent, is comparable to solid curve (c), obtained after 3 cycles of measurement and roller washup using the <100 gram/liter solvent, i.e., that the solvent released after successive washups produces an ink contamination of about 10%.

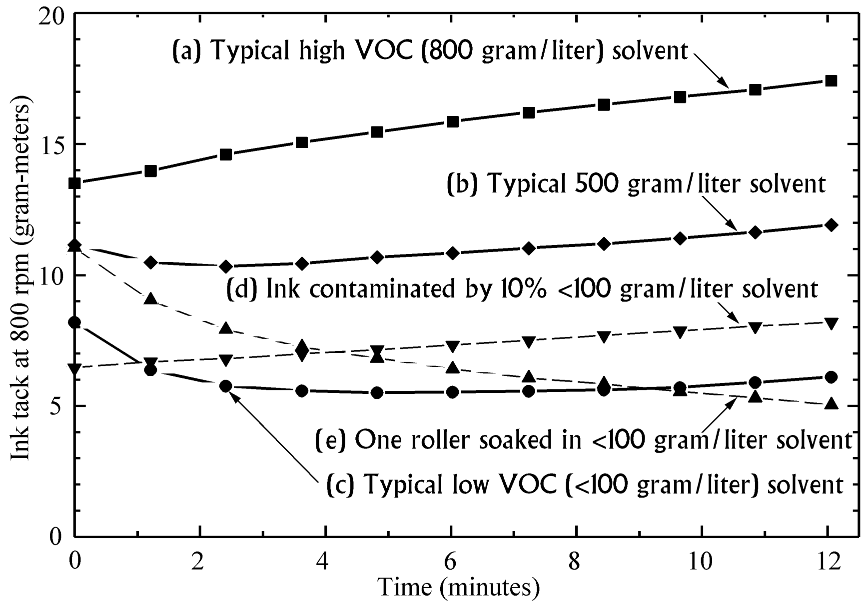

Figure 4 Data on ink tack measurements.

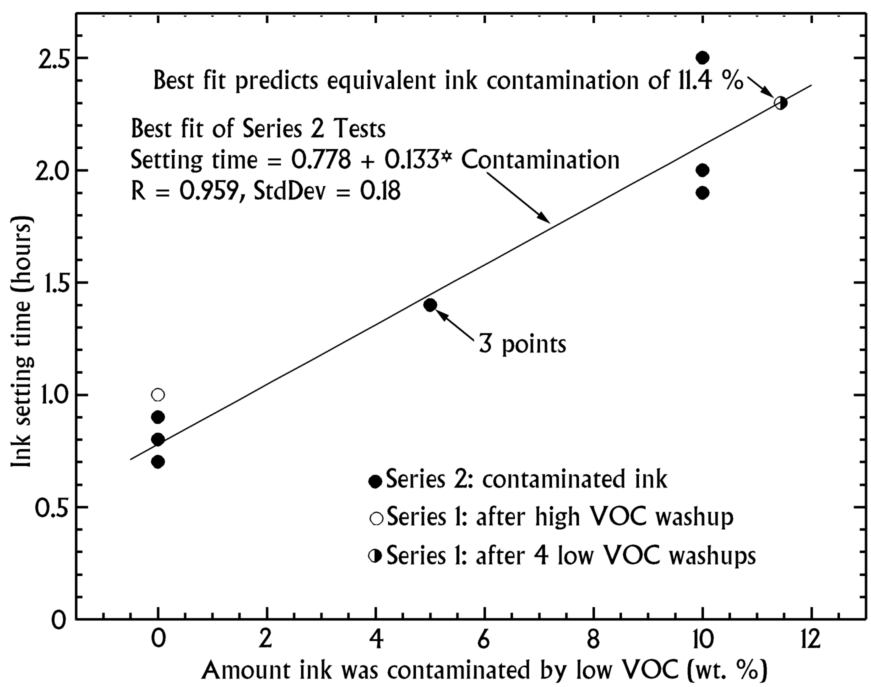

Figure 5 Data on measurements of ink setting time.

3. Dotted curve (e), which was obtained using an instrument setup where the vibrating roller had been soaked in the <100 gram/liter solvent for 24 hours, while the other rubber roller had no absorbed solvent, is also comparable to solid curve (c), i.e., the only explanation for the drop in tack observed in both curves is solvent release by the rubber roller(s).

One printer, who specializes in work on non-absorbent stocks, also complained about ink failing to dry. To check on this, ink setting tests were run at PIA/GATF using prints on plastic made on a Little Joe tester using contaminated ink and washed with a high VOC solvent, and using neat ink following successive washups with the low (<100 gram/liter) solvent. The results, shown in Figure 5, are consistent with the ink tack tests, and lend further credence to the finding that release of solvent reversibly absorbed by rubber following successive washups is responsible for the problem, and produces an ink contamination of about 10%.

B. Remedies and Their Impacts.

Two obvious possible remedies are to develop a solvent that is not absorbed by rubber, or to develop a resilient rubber substitute that does not absorb solvent. Whether or not either of these is feasible is academic because either such material would take a long time to prove out. One remedy that has enjoyed some

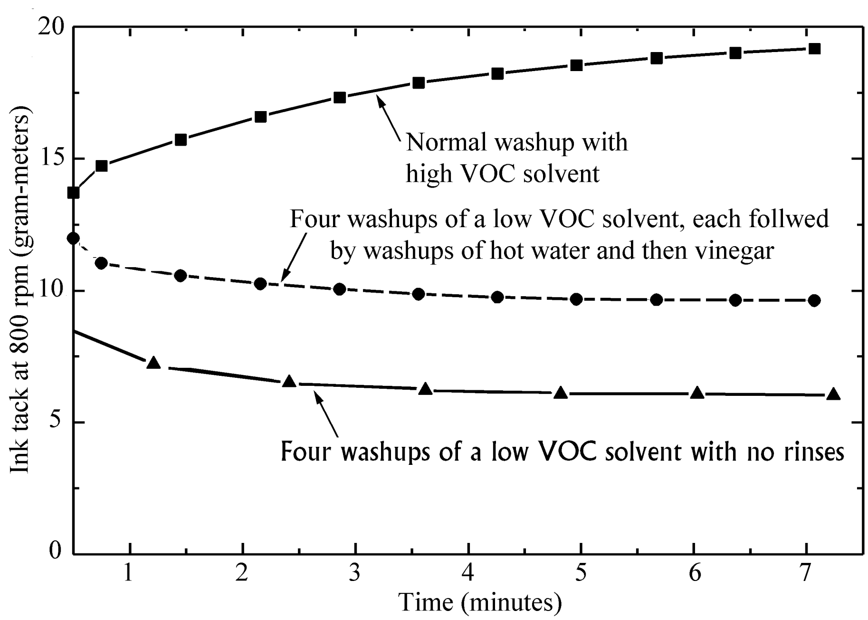


Figure 6 Ink tack data showing an aqueous rinse was not completely effective in restoring tack reduction following washups using a solvent having a VOC content of less than 100 grams/liter.

success with the 500 gram/liter solvents is to follow up the solvent roller wash with multiple rinses using an aqueous based solvent, such as diluted vinegar. However, limited experience and the ink tack measurements shown in Figure 6 do not bode well for its success using solvents having VOC contents below 100 grams/liter. In addition, the rinse cycles currently used with the 500 solvents have a significant adverse effect on press productivity, as is quantified further on.

## IV. Roller Swelling

### A. Description and Cause

The effect of absorbed high VOC solvents on rubber rollers is well known to printers—while absorbed, the rubber swells and softens. However, when the solvent is released by the rubber, two changes occur: the rubber shrinks and hardens, because some of the rubber plasticizer is carried away by the high VOC solvent. With many low VOC solvents, however, the result of their absorption by rubber is quite different: some of the absorbed solvent becomes bonded to the rubber producing two opposite effects: the rubber softens and swells. These opposing effects are illustrated by the data in Table I on soaking a typical rubber compound used for sheetfed presses in typical high and low VOC solvents and then baking them in an oven for 24 hours.

Table I Contrasting behavior of the hardness and volume of a given rubber compound when soaked in two different types of solvent.

| Type of solvent | After soaking 24 hours | | After heating 24 hours at 158° F | | Volume solvent bonded to rubber | Volume solvent relesed by rubber |
|---|---|---|---|---|---|---|
| | Change in volume | Change in hardness | Change in volume | Change in hardness | | |
| High VOC | +32.4% | 25 to17 | -38% | 17 to 31 | zero | 32.4% |
| Low VOC | +19.4% | 25 to 20 | +11.3% | 20 to 17 | 11.4% | 8.1% |

The swelling, which takes some time to manifest itself, has caused a host of problems: inability to set the proper stripe, overheating, stalling of the press when inching, and in the extreme, destruction of the roller covering. Although the problem has not yet become common in Southern California, it is well known on web presses elsewhere in the country, especially on web presses where half webs are run frequently. In such cases, uneven roller swelling causes problems when running a full web.

B. Remedies and Their Impacts

The only known practical remedy developed to date is to check solvent compatibility with the rubber compound employed on the press rollers, prior to use. Experience indicates that solvent/rubber combinations exhibiting behavior similar to that in Table I for the low VOC solvent will result in unacceptable swelling over the long term on press. Of course, there are two other remedies possible: develop the ideal solvent to which all rubber compounds are impermeable, or the ideal resilient material that is impermeable to all low VOC solvents. Again, whether or not either of these is feasible is academic because either such material would take a long time to prove out.

V. Drips Onto Paper, Rollers, and Walkways

A. Description and Cause

The third problem to be addressed in this paper, drips, occurs on presses equipped with automatic wash-up systems that apply more solvent than is needed for washing. The excess, or fugitive solvent, hides out on whatever surface it strikes and, when enough has accumulated, drips on whatever is beneath it. Print defects are generated if that surface is the paper being printed, a roller, or a printing cylinder, while a safety hazard is created if the drips fall on a press walkway.

Although unwanted drips are known to have been generated by certain automatic roller wash-up systems, the problem occurs most frequently on presses equipped with automatic blanket cleaners originally designed to be used with high VOC solvents. As long as such systems were used with high VOC solvents, excess solvent was not a problem because it evaporated. However, when the printer was compelled to switch to a low VOC solvent, the excess solvent created the problem of drips.

Table II Solvent usage per unit of a 40 inch wide sheetfed press in three generations of one type of cloth type automatic blanket cleaner that utilizes non-woven cloth rolls.

| Generation and type of system | Solvent type | Total volume of solvent dispensed | Volume of fugitive solvent created |
|---|---|---|---|
| 1. Cloth, spray | High VOC | 90 cc (3.0 oz.) | 85 cc (2.9 oz.) |
| 2. Cloth, spray | Low VOC | 66 cc (2.2 oz.) | 61 cc (2.1 oz.) |
| 3. Presoaked cloth | Low VOC | 5 cc (0.2 oz.) | zero |

The magnitude of this problem is illustrated by the data on solvent usage in Table II for a family of automatic blanket cleaners familiar to one member of the task force (MacPhee). The first generation of this system, listed on Line 1 of the table was developed in the late 1970s and employed dry cloth, onto which a high VOC solvent was sprayed just prior to use. (MacPhee, Gasparrini, and Arnolds, 1982). The data on Line 2 of Table II reveals that when this system was converted to use a low VOC solvent about ten years later, it was found that the volume of solvent could be reduced to 66cc, versus 90cc when using a high VOC solvent. A further reduction in solvent usage to 5cc was realized with the development of the third generation system, in which the cloth was presoaked with a low VOC solvent prior to installing it on the press. If the 5cc is looked upon as the minimum amount needed to clean a 40 inch sheetfed blanket cylinder, then it will be realized that the first and second generation systems of this type were creating 85cc and 61cc of fugitive solvents, respectively, per blanket washup. As an aside, the magnitude of the fugitive solvent was not realized when the first generation system was developed because, since the fugitive solvent evaporated, it did not produce drips. However, the problem of drips soon became apparent with the switch to low VOC solvents in the early 1990s, which is one of the factors that led to the development of the generation 3 system.

B. Possible Remedies and Their Impacts

One obvious remedy to this problem is to upgrade or replace those automatic systems that result in the problem of drips. However, with some types of automatic blanket cleaners, this remedy will be very costly.

A second remedy, which many printers have used, is to follow up an automatic wash with a manual rag wipe of those areas on the press, e.g., blanket cylinder gaps, where solvent is known to accumulate. The impact of this remedy is that it has a significant adverse effect on press productivity. In order to quantify this impact, the spreadsheet shown in Table III was designed. The groups of data, labeled Press Information and Wash-up Information, are supplied for a given press by the printer. The spreadsheet then calculates the corresponding group of data labeled Productivity Information. Table III contains actual data from a typical printer for a 6-color 40-inch sheetfed press, operating on two shifts, when using a 800 gram/liter and when using a 500 gram/liter solvent. The calculated results show that the impact of the remedies used to solve the first and third problems described above was a reduction in productive hours of almost 10%, which is significant.

## VI. Summary and Conclusions

This paper has identified the three most important problems posed to printers by the use of low VOC solvents—the print defects caused by the release of solvent absorbed by rubber rollers, the swelling of rubber rollers caused by their absorption of solvent, and drips of fugitive solvent produced by certain

Table III Spreadsheet used to access press productivity.

| Press Information | Reference (high VOC) | 500 gram/liter solvent |
|---|---|---|
| 1. Number of weeks run per year | 48 | 48 |
| 2. Number of days run per week | 5 | 5 |
| 3. Number of shifts per day | 2 | 2 |
| 4.Length of each shift, hours | 8 | 8 |
| 5. Average job size, sheets | 5000 | 5000 |
| 6. Average makeready time, hours* | 1 | 1 |
| 7. Typical printing speed, iph | 12,000 | 12,000 |
| 8. Percentage of single sided jobs | 25 | 25 |
| (a) Number blanket washes/job | 3 | 3 |
| 9. Percentage of double sided jobs | 75 | 75 |
| (a) Percentage requiring 2 makereadies | 25 | 25 |
| (b) Number blanket washes/job | 7 | 7 |
| Washup Information | | |
| 10. Wash all blankets | | |
| (a) Time required in minutes | 1.16 | 2.58 |
| 11. Clean ink fountains/wash rollers | | |
| (a) Time required in minutes | 6.8 | 12.42 |
| (b) Frequency per day | 3 | 3 |
| 12. Clean back cylinders | | |
| (a) Time required in minutes | 10 | 17 |
| (b) Frequency per day | 2 | 2 |

* Does not include time to wash rollers and clean ink fountains (separate entry).

| Productivity Information | | |
|---|---|---|
| 13. Total number of jobs run per year | 1810 | 1635 |
| 14. Number one-sided jobs run per year | 452 | 409 |
| 15. Number two-sided jobs run per year | 1357 | 1226 |
| 16. Productive hours per year | | |
| (a) Doing makereadies | 2149 | 1941 |
| (b) Printing | 1320 | 1192 |
| (c) Total productive hours | 3468 | 3133 |
| 17. Non-productive hours per year | | |
| (a) Washing Blankets | 210 | 422 |
| (b) Washing rollers/cleaning fountains | 82 | 149 |
| (c) Washing back cylinders | 80 | 136 |
| (d) Total non-productive hours | 372 | 707 |
| 18. Change in productive hours | Reference | -9.70% |

automatic wash-up systems. Thus, the problems encompass solvents, materials (rubber) and equipment (wash-up systems), so the best fix for the problems may lie beyond developing an acceptable solvent.

However, PIASC's activities in the future will be focused on identifying compatible solvents and rinses in that its commitment to the SCAQMD is to conduct a series of laboratory and press tests with the objective of identifying at least three solvents that satisfy both SCAQMD's objective of limiting solvents to a VOC content under 100 grams/liter and its printer members' objective of remaining competitive.

Because of this, and the concern that not enough resources, especially of technologies outside the industry, will be marshaled to pursue other avenues to find an acceptable resolution, it behooves all branches of our industry to help in whatever way they can to resolve this dilemma.

## VII References

MacPhee, J., Gasparrini, C. R., and Arnolds, C.
1983, "Development of a System for Automatically Cleaning the Blankets of a Web Offset Press", 1982 TAGA Proceedings, pp 378-401.

## VIII Acknowledgements

The information contained in this paper was generated by an industry task force organized by Gerry Bonetto of the Printing Industries of Southern California, with the aid of funding provided by the Printing Industries of America. The task force is made up of a large group of both printers and suppliers. Individuals who made direct contributions to this paper include Larry Lester of Lester Lithograph who was always available to provide the printer's view of the subject, Terry Walsh of Kramer Ink who provided the data contained in Figures 4 and 6, Len Kruizenga of RotaDyne Corporation who provided the data contained in Table I, and Shaun Kilfoyle of Baldwin Technology who gave his permission to publish the data contained in Table II.

## Appendix A Selected Comments by Printers Who Responded to the PIASC Survey

1. Cleans well but remains oily—which creates safety concerns as well as continuous drips onto the product. The drips led to significant product quality concerns and customer complaints.

2. Breakdown of blankets has occurred.

3. Must flush with water to get oil out of roller train.

4. How is it working? Not very well. Even our (well known) press manufacturer cannot give us a better suggestion,

5. All formulations less than 500 G/L are too oily. Don’t dry—leaves deposits on press brackets/side frames that drips onto rollers—stripping ink and ruining production.

6. Changing over to the new wash was a costly process for us. We spoiled a couple of high dollar jobs because the low VOC wreaked havoc.

7. Downtime has increased. Operators have to scrub blankets much more. Cleanup is not as thorough on UV.

8. How is it working? Average at best. We are at the point that we need something stronger and less oily. If they make it weaker, waste will go through the roof.

9. How is it working? Dries too fast/will take image off plate (80–90% acetone)

10. Requires more solvent, doesn’t break down paper dust buildup on blankets, must clean blankets with water and wipe dry. We are not happy with any of the blanket and roller washes we have tested. Good products are not available.

11. Safety issue problem with slip and fall—solvent never dries.

Wash builds up in blanket gaps and spits. Increases chances of customer quality complaints and safety issue.

12. Slow and costly transition. Still looking for products that truly work.

13. Oily buildup on the grippers is the main problem.

14. How is it working? Very well. (This is on a duplicator.)

15. Has made our solvent recycling system useless because the boiling point is too high to cook off impurities.

16. Not great. Still oily and won’t clean back cylinder properly.

17. How is it working? Not very well at all. Basically we do not use our automatic wash systems and wash by hand.

18. Changing over to the new wash was a costly process for us. We spoiled a couple of high dollar jobs because the low VOC solvent wreaked havoc.

19. These solvents are not much better than salad dressing. They do not emulsify or clean well. Also leave an oily bi-product on the rollers that will not evaporate without using another solvent.

20. How is it working? Very poorly. Pressmen complain that the cleaners do not work—very difficult to produce jobs in a timely manner and in the quality our customers expect.

21. At the current formulations, it is extremely difficult to work with the cleanup products—any lower and we won't be able to clean our press at all!

22. Help!

23. Leaves oily residue. Rinse many times with water trying to get oil off rollers. Thank God we have sold this (waterless) press. It would be miserable trying to run each day using these new solvents!

24. Doesn't clean very good at all! Going to a lighter color must wash several times. Too much oily buildup. Oil marking all the time. Constantly wiping with dry rag.

25. Products are "thinned down" using water or oil to decrease VOCs. The added water is promoting rust and the oil prohibits ink from adhering to rollers and blanket. Towel usage is increased from 5 towels per day to 6 towels because of oily buildup on rollers and blanket.

26. It's impossible to produce a good product with this limit. If it goes down even more my company might have to shut down and move to another state.

27. Acetone products are legal but carry a heavy smell and takes a toll on blankets.

28. We cannot use any automatic systems which OSHA prefers we use, due to the inability of the solvents to work properly with these systems