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REDUCING HEAVY METAL CONTENT IN OFFSET PRINTING INKS

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ABSTRACT

Ecoprint created a commercial offset printing ink using pigments with no heavy metals, thus preventing pollution in three key areas: (1) in the waste ink produced by a printer that must be handled as a hazardous waste; (2) in the printed materials that are landfilled or incinerated; and (3) in the sludge that is created during the de-inking and repulping of waste paper fibers as they are made into recycled paper. The result of the testing throughout the project was the creation of a "palette" of colored inks with a low heavy metal content.

INTRODUCTION

PROJECT DESCRIPTION

Printing is an $80 billion a year industry in the United States and uses large amounts of ink. Colored inks contain many heavy metal-based pigments that are applied to a myriad of printed materials that ultimately end up in the nation's waste stream. This project had five key components:

- Tested the 11 primary colors of printing inks to determine the concentration of 12 key metals
- Identified alternative pigments that were not based on heavy metal compounds
- Formulated new offset printing inks based on these non-heavy metal pigments
- Tested these inks in actual commercial printing conditions
- Created a "palette" of non-heavy metal-based inks in primary mixing colors

Unique Product Features/Advantages

These non-heavy metal-based offset printing inks can be successfully used in most commercial printing applications including the printing of brochures, newsletters, direct mail promotions, letterhead, and many other products. Ecoprint knows of no other sheet-fed lithographic inks on the market that have tested as low for metals content.

APPLICATION

Products Replaced

The result of this project is the creation of inks with greatly lowered heavy metal content, thus preventing pollution in three key areas: (1) in the waste ink produced by a printing company that must be handled as a hazardous waste; (2) in the printed materials that are later landfilled or incinerated; and (3) in the sludge that is created during the de-inking and re-pulping of waste paper fibers on their way to being made into recycled paper.

Waste Prevented

While Ecoprint cannot foresee direct cost savings to the printer (waste ink of all kinds still contains oily compounds, and as such will have to be disposed of as hazardous waste), but there will be savings on a more general, societal level if the use of these new inks becomes commonplace. These savings will come in the form of significantly reduced pollution of air, water, and land. Incineration of waste papers printed with these new inks will produce ash and air emissions that are lower in copper and barium.

Cross Segment Uses

Other sectors of the printing industry also may be able to use these inks, although they would need to be reformulated to be compatible with the different machinery used. Additional applications include flexographic printing, engraving, silkscreening, and other types of offset printing such as web printing (cold and heatset). A wide variety of products -- from packaging materials to magazines -- are printed with these different printing applications.

PROCEDURE

DEMONSTRATION

Ecoprint first selected the metals to be tested by surveying a number of expert sources -- EPA's 33/50 Program, The Chesapeake Bay Foundation, and the National Toxics Campaign Laboratory -- for information on environmental toxins. The 12 target metals selected were:

- Antimony
- Arsenic
- Barium
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc

Ecoprint then arranged for the testing of the 11 primary ink colors (neutral black, transparent white, reflex blue, process blue, green, yellow, warm red, rhodamine red, rubine red, purple, and violet) to determine which inks had problematic heavy metal contents. Samples of the 11 inks were sent to the National Toxics Campaign Laboratory in Boston where the inks were tested for heavy metal content with a Perkin-Elmer Atomic Absorption 5100 spectrophotometer. Certain samples were further tested for barium using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP), when false readings were generated by the presence of calcium.

Ecoprint selected the target ceiling of 100 parts per million (ppm) for a heavy metal content goal. Tests revealed the problem ink colors to be reflex blue (over 200 ppm copper), process blue (3,800 ppm copper), yellow (859 ppm zinc), green (3,300 ppm copper), warm red (122 ppm barium), rubine red (150 ppm zinc), and rhodamine red (181 ppm copper). The other colors tested below the 100 ppm level for the target metals.

Ecoprint then experimented with alternative, non-heavy metal-based pigments, such as pigments based on calcium compounds or organic pigments. These alternative pigments should match existing colors as closely as possible and should be compatible when mixed with the other components of the ink, such as the resins and oils.

Since these reformulated inks are a proprietary product that will be subsequently marketed, the alternative pigments used cannot be specifically named. However, the pigments are sold by well-known pigment manufacturers, but have not generally been used in printing ink formulations.

The actual mixing of the inks was conducted by Ecoprint's subcontractor, Alden and Ott Inks. Newly formulated inks that contained the alternative pigments were then sampled and sent back to the laboratory to again test for metal content, again with the goal of formulating inks that tested below 100 ppm for each of the 12 metals. Several colors of inks were reformulated in one trial; other ink colors required several trials to obtain the correct formulation. Only two colors, rubine red and rhodamine red, could not be reformulated, as pigments could not be found to match the shade of these colors.

Once achieving the desired test results for metal content, the inks were tested on a printing press to determine their printability. As the inks were used in printing, their performance was monitored in several areas: drying time; absorption onto the paper surface; compatibility with printing plates, fountain solutions, cleaning agents, and solvents; and "holdout" on the sheet after printing to determine if density of color remained strong. Inks were also mixed to see if a sufficient number of different colors could be created to satisfy most commercial requirements.

Approximately 12 press tests were conducted on a Komori Sprint, 1978 model, 2-color press. The machine was retrofitted with an Epic Delta Dampening System, which utilized a separate water form roller with an oscillating bridge roller that contacts the first ink form roller. Other specifics included:

- Running speeds: Between 5,000 to 9,500 sheets per hour
- Blanket: Reeves Vulcan 714 Compressible
- Plates: 3M Viking subtractive
- Fountain Solution: Rosos G-C #1J One-Step concentrate, mixed as follows - 6 ounces concentrate, 2 ounces gum arabic, using water from a reverse-osmosis unit; solution recirculated through Royce refrigeration unit
- Room Temperature: Between 68 and 75 degrees F
- Print Run Length: 1,000 impressions up to 20,000 impressions
- Papers: All uncoated and recycled, but varying in weight from 60 pounds offset to 80 pounds cover
- Ink Coverage: From 5 percent to 50 percent coverage, including solids, screens, and traps, as well as line art

The press was set up as for the "regular" inks, with no change in work habits.

Cost of Demonstration

EPA's contribution to the project through the Pollution Prevention By and For Small Business Grant Program was $25,000; Ecoprint's contribution was $6,749, for a total project cost of $31,749.

While the cost of laboratory analysis was higher than first estimated, it was a vital part of the project. Printing compatibility was much more trouble-free than expected, thus lowering costs in this category. Ecoprint was pleased with the overall results of the project, considering its modest scope and the warning by several industry sources that the goals may be "impossible to achieve."

RESULTS AND DISCUSSION

PERFORMANCE RESULTS

Press Test Results

No difference was detected between the reformulated and the original formulation inks in the following categories:

- Interaction with plate surface: No problem was encountered with plate sensitivity in non-image areas, plate blinding, or premature plate wear.
- Mixability of inks: More study would be desirable to determine if pigment strength poses any problem, particularly with colors mixed with a high proportion of transparent white.

- Performance on press: No stripping on ink rollers was seen; wash-up procedures and interaction with fountain solutions (running alcohol-free posed no problems) were normal; and no tendency of inks to "emulsify" was detected.

- Printing on paper: Good absorption onto sheet surface; good trapping with other colors; drying time averaging the same as original formulation inks. Colors seem to be lightfast indoors (i.e., office lighting) for at least two months (and probably much longer, although long term tests were beyond the scope of this project). No tests were conducted where ultraviolet light (i.e., sunlight) was exposed to the printed material for extended periods of time.

- Folding of printed sheets: While occasional marking (where pullout rollers collect ink and redeposit it onto the sheet as a light mark) was noted, this problem was no worse than with the original formulation inks.

TABULATION OF DATA

The metal contents of the five ink colors that were reformulated are shown in Table 1.

TABLE 1. Metal Content in Inks before and after Reformulation (Parts per Million)

	Reflex Blue		Green		Warm Red		Yellow		Process Blue	
Metal	Before	After	Before	After	Before	After	Before	After	Before	After
Antimony	* <10	<2.5	<10.0	42.00	7.00	<5.0	* <10	<2.0	<10	19.0
Arsenic	6.30	<0.1	<10.0	2.00	17.00	<3.6	4.20	12.00	<0.3	11.0
Barium	8.80	55.6†	76.00	<36.0	122.00	4.50	11.40	<22.0	6.60	29.0
Cadmium	0.35	1.14	0.86	0.50	0.52	3.04	<0.04	<0.1	0.33	0.20
Chromium	<0.2	1.00	8.60	15.90	3.80	12.40	<0.4	<0.07	3.30	11.9
Copper	205.0	1.60	3300.0	10.60	1.22	2.50	2.39	<0.07	3800	9.40
Lead	1.50	1.00	<0.1	<2.0	<0.3	6.90	<0.5	3.60	0.70	<1.0
Mercury	<0.1	<.05	5.10	22.00	0.09	<0.2	1.10	0.73	<0.1	20.0
Nickel	5.28	1.40	4.66	6.60	5.51	1.96	6.08	<0.1	6.53	5.30
Selenium	<10	<0.1	<10.0	<36.0	<10.0	<9.0	<10.0	<22.0	<10	<11
Silver	<0.2	<.05	<0.4	1.20	<0.2	<3.6	<0.2	0.40	<0.2	0.30
Zinc	4.30	10.1	59.00	3.70	26.00	63.20	859.00	9.00	6.20	12.2

* <X indicates that concentration is lower than the limits of detection
† a second test indicated less than 6 ppm

In reflex blue, copper was nearly eliminated, dropping from 205 ppm to less than 2 ppm. Barium did increase to 55 ppm in the first analytical test, but stayed at less than 6 ppm in a second test.

In reformulating yellow, the first analytical test resulted in a reading of 859 ppm for zinc. While the pigment was not changed, Ecoprint suspected that yellow was

being mixed in the presence of another contaminant. A more careful mixing of the yellow did result in the near elimination of the zinc to 9 ppm.

The metals content of the inks that did not require reformulation (as all metals were below 100 ppm) is shown in Table 2.

TABLE 2. Metals Content of Inks not Requiring Reformulation

Metal	Trans. White	Neutral Black	Purple	Violet
Antimony	15.00	<10	<10	<10
Arsenic	17.00	15.00	<7	4.10
Barium	* <0.5	<0.5	6.60	12.00
Cadmium	0.99	0.67	0.20	0.43
Chromium	2.10	1.10	46.00	2.30
Copper	1.09	4.59	1.40	79.90
Lead	2.10	<0.6	1.30	3.50
Mercury	<0.1	0.50	2.60	<0.1
Nickel	3.80	4.98	4.00	5.16
Selenium	<10	<10	<10	12.00
Silver	<0.3	<0.3	<0.3	<0.2
Zinc	3.10	8.30	8.70	5.10

* <X indicates that concentration is lower than the limits of detection

The metals content of the two inks that could not be reformulated (as alternative pigments could not be found) is shown in Table 3.

TABLE 3. Metals Content of Inks that Could not be Reformulated

Metal	Rubine Red	Rhodamine Red
Antimony	* <10	6.00
Arsenic	0.60	4.10
Barium	90.00	4.30
Cadmium	0.81	0.50
Chromium	4.50	43.00

Copper	2.16	181.00
Lead	3.00	1.30
Mercury	0.01	<0.04
Nickel	6.82	5.78
Selenium	<10	<10
Silver	<0.2	0.07
Zinc	150.00	9.10

* <X indicates that concentration is lower than the limits of detection

COST/BENEFIT ANALYSIS

The reformulated inks are not likely to save printers or their customers money in the printing costs. The inks are likely to be from 20 to 200 percent more expensive per pound in the near term (being produced in small batches). Likewise, there is no cost savings to the printer in waste disposal.

However, while these inks are more expensive, the ink price in relation to the total cost of the printing job must be considered. Inks contribute from 1 to at most 10 percent of a print job's selling price, with most jobs averaging approximately 2 percent. Even a tripling of ink costs would only increase the cost of the average job by approximately 4 percent. In the short term, costs would be slightly higher, particularly because the printer will not be using these inks on all jobs and will order them in small quantities. Like any new product, lower costs can be expected once the product is produced and used in larger quantities.

The cost per pound of traditional inks is compared to the reformulated inks in Table 4.

TABLE 4. Estimated Differnece in Cost per Pound between "Regular" Imks and Non-Heavy Metal-Based Inks (Based on the Purchase of 10 Pound Quantities)

Color	Regular Inks ($ per pound)	New Inks ($ per pound)
Reflex Blue	5.85	18.55
Process Blue	5.10	16.15
Warm Red	5.25	11.60
Green	7.15	14.75
Yellow	7.90	9.35

The cost breakdown of a sample print job is outlined in Table 5: an 8 page newsletter, 70 pound opaque recycled paper, 50,000 copies, prints black and one color ink, folded to mail. (These figures are taken from cost breakdowns provided by the Printing Industries of America 1988 "Financial Ratio Study.")

Considering all types of commercial print jobs, ink constitutes, on average, 1.62 percent of the total price of the job. A three-fold increase in ink price would increase the cost of the job by slightly less than 3.4 percent. Small jobs would probably increase by a higher percentage as would jobs using a large amount of ink coverage.

TABLE 5. Cost Breakdown of Sample Print Job

Cost Factor	Price	Percent of Total Cost
Total Sales Price	$5,000	100.00%
Total materials, including paper, outsider services, but excluding ink	$1,782	35.64%
Factory payroll	$1,283	25.66%
Factory expenses	$664	13.27%
Administration, interest, and selling expenses	$1,039	20.78%
Profit before taxes	$151	3.03%
INK	$81	1.62%

CONCLUSIONS

POLLUTION PREVENTION ASSESSMENT

Incentives

The reformulated inks are now available for use in sheetfed offset printing, and can easily be mixed in larger quantities by Alden & Ott. Since there are many variables in printing and before making wide guarantees of press performance to customers, Ecoprint is conducting even more press tests.

Any sheetfed commercial printing establishment should be able to use these inks. Even web printers (cold-set) should be able to test these inks with some minor modifications in their formulation.

Barriers

Not every color in the Pantone Matching System (PMS) color book can be mixed, as Ecoprint does not yet have substitutes for two primary mixing colors, rubine red (high in barium and zinc) and rhodamine red (high in copper). PMS is the most widely accepted color matching system in the industry, and some customers will need colors that cannot be mixed using non-heavy metal inks.

One solution to the PMS matching dilemma is to continue the research to find substitutes for rhodamine red and rubine red. Should this not be possible, customers can choose from the PMS colors that can be mixed with the 9 colors that all passed the 100 ppm metals test; this still provides a significant palette of colors with which to work.

The cost of some alternate pigments may always be slightly higher, but if these inks were to be adopted by the industry, the price of the pigment may drop due to large-scale production. Print buyers may need to be educated to use less ink coverage on the sheet to control ink costs. For example, one simple way to accomplish this is to discourage designs that cover an area with 100 percent ink and then "reverse out" a headline so that the letters appear in white. Lighter ink coverage has the additional advantage of being "more environmentally sound," as less ink on a sheet makes it more easily recycled.