

Design for the Environment Gravure Partnership



The Effect of Ink Temperature On Solvent Losses and Print Quality



Background—The U.S. Environmental Protection Agency’s (EPA) Design for the Environment (DfE) Program, the University of Tennessee (UT) Center for Clean Products and Clean Technologies, and Western Michigan University (WMU) partnered with the Gravure Association of America (GAA), gravure printers from the packaging and product sectors, and other industry experts to identify 1) common environmental issues for gravure printers, especially small- and medium-sized businesses in the packaging and product sectors; and 2) potential risk reduction and pollution prevention opportunities for addressing key issues.

Packaging and product gravure printers are particularly concerned about solvent losses from ink during press operations—including solvent losses from the ink sump and ink pan areas—which might be reduced by controlling ink temperatures. Smaller gravure printing operations generally use a press-side sump to pump ink to the press, where the ink may

absorb heat from the ambient air or from press operations. Large publication printers generally have in-line heat exchangers and closed-loop ink delivery systems, which are not as subject to solvent losses from elevated ink temperatures. The Gravure Partnership performed a preliminary study of the effect of ink

temperature on solvent losses and print quality, which is summarized below. The results suggest that packaging and product printers could reduce solvent losses, and, in some cases, improve print quality by controlling ink temperatures. Further study by the industry is needed to confirm these results.

Gravure Industry Statistics—The gravure industry comprises three main sectors: publication, packaging, and product printing. Publication gravure plants are generally large operations that tend to be more automated, with more advanced systems for addressing environmental concerns. Packaging and product gravure plants are often small- to medium-sized printing facilities with fewer employees, fewer presses, and more limited resources.

Risk Reduction Opportunities—The partnership began with a scoping phase to identify potential opportunities for packaging and product printers to reduce emissions and risk from printing operations. Project partners consulted with GAA and industry experts to develop a preliminary list of risk reduction opportunities (see box, page 2), which were then verified through site visits to gravure printers in the packaging and product sectors. DfE project leaders chose to study the effect of ink temperature on VOC emissions and printability for the following reasons:

- Ink temperature’s effect on solvent losses and print quality are common problems among various packaging and product printers, in spite of different inks, number of colors, and substrate.
- By controlling ink temperature, printers might gain print quality and cost benefits as well as environmental benefits.

U.S. Gravure Industry Statistics

Sector	# of plants	Avg. presses per plant
Publication*	24	6.3
Packaging	276	2.5
Product	174	2.8
Total	480	2.8
Avg. employees per plant**		<20
Annual sales (\$/yr)**		>\$18 billion

Data from 1987-1993 (GAA Profile Survey of the U.S. Gravure Industry).

* 2000 data from GAA.

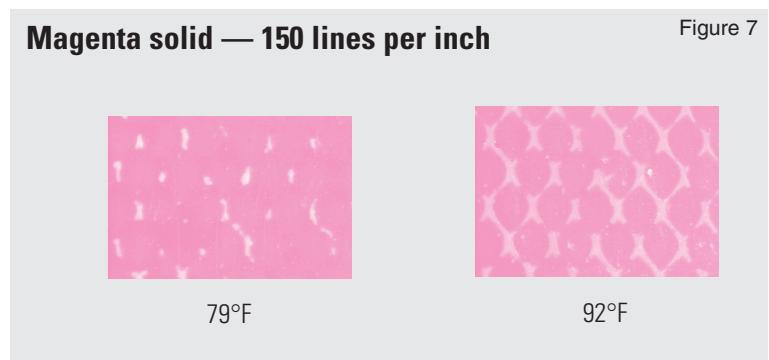
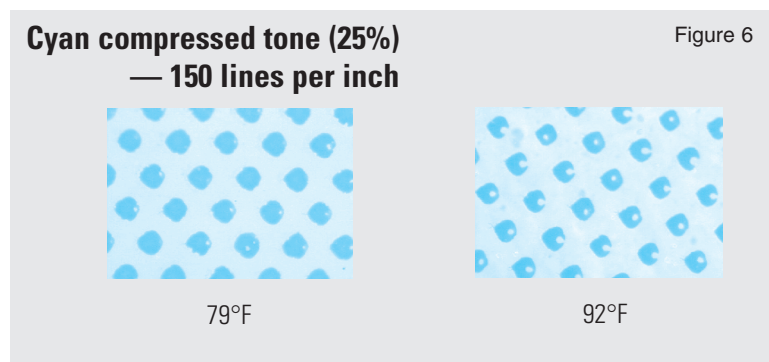
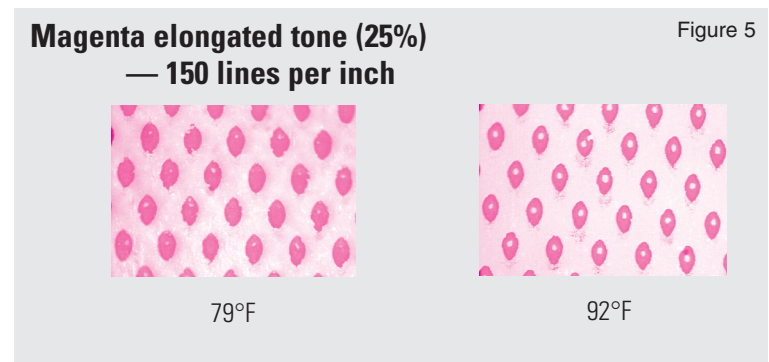
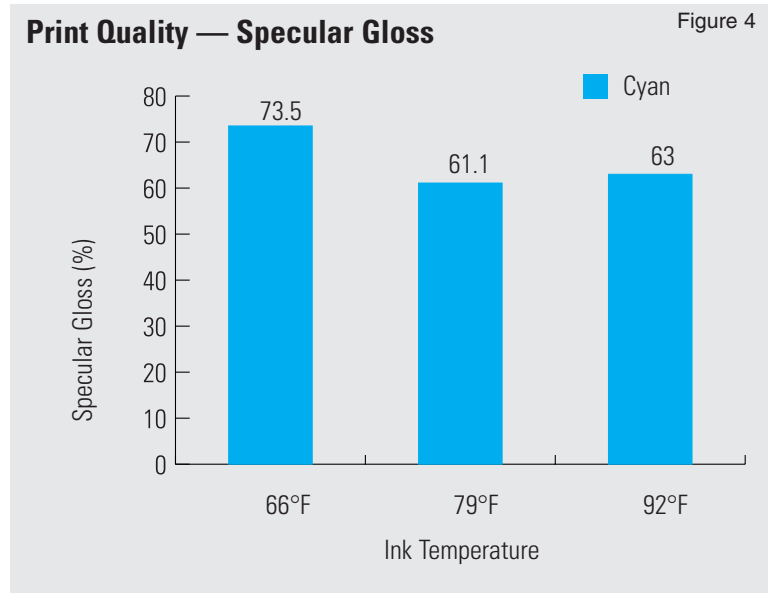
**Data for publication, packaging and product combined.

were influenced by the glossy polyethylene substrate showing through the thinner ink film. The increase in specular gloss seen from 79°F to 92°F may be due to the decreased wettability and increased screening observed at higher temperatures. Screening may have caused more light to be reflected from the polyethylene substrate.

- *Dot structure* (see Figures 5 and 6)—hot inks had deformed dot structure caused by the “donut effect.” As ink fills the engraved cells of a printing cylinder, it forms a concave shape leaving an air bubble to be trapped between the ink and the substrate. The air prevents the ink from being transferred to the middle of the printed dot and forces the ink to be spread outward, creating a “donut.” Warmer, less viscous ink produces a bigger concave meniscus as it lies in the cylinder cells, which results in more air being trapped and a larger donut. As the donut effect increases with temperature, the amount of printed image decreases and the printed dot becomes bigger (Sosa, 1999).

Deformed dots caused by the donut effect also had bigger perimeters. As the dot perimeter increases so do the dot gain and mottle, causing a decrease in print quality. Finally, photographs taken in the solids areas confirmed the reduced wettability of the hotter ink; the white, non-printed areas of the solids rose with increasing ink temperature.

- *Haze*—not a quantifiable variable in the WMU study, but appeared to increase with decreasing temperature. Decreasing efflux time and/or doctor blade pressure may reduce haze.
- *Rub resistance*—no change in rub resistance at different temperatures. A Sutherland ink rub tester was used to rub the printed films against a white surface for a specific amount of time. The reflection density of the white surface was measured before and after the test to determine the amount of ink transferred from the printed film to the surface. The difference in the reflection densities of the hottest temperature and the coldest temperature inks were within the resolution of the densitometer.



Conclusions

The WMU study assessed the effects of three ink temperatures (66°F, 79°F, and 92°F) on solvent consumption and print quality of Type C inks under laboratory-controlled conditions. The study was designed to provide preliminary data on the potential benefits of ink temperature controls to the gravure industry for further technology verification (see box on Study Limitations). The results are promising.

- Small- and medium-sized printers in the product and packaging sector may be able to reduce solvent consumption, improve print quality, and achieve cost reductions by implementing ink temperature controls.
- Decreasing solvent consumption and solvent emissions could also reduce health risks because of reductions in potential exposures to workers or the public.
- The greatest benefits may occur when ink temperature is maintained near a typical room temperature rather than chilled to below typical room temperatures, suggesting less chilling is needed to achieve optimal results.
- Ink temperature controls might also reduce overall ink consumption (up to 20%-30%) without adversely affecting print quality, but these results need to be confirmed on different substrates and in “real world” settings.
- Ink temperature controls can also be expected to reduce solvent use (perhaps up to 50%), especially in the summer months when ambient temperatures are higher.

Potential Cost Savings—Potential savings were estimated for two scenarios using the assumptions of the model facility (see box at right) and the solvent and ink consumption results from the WMU study. Scenario 1 assumes a small printer operates at 92°F for three months and 79°F for nine months a year. Scenario 2 assumes the printer implements temperature controls to maintain a constant temperature of 79°F all year.

Conditions will vary greatly by facility; many other factors may also affect these estimates. Nonetheless, they provide a starting point for companies to estimate their

Study Limitations

- The WMU laboratory study was designed to evaluate the potential risk, performance, and cost benefits of ink temperature controls for gravure printers. The study does not establish a definitive relationship between ink temperature, solvent emissions, and print quality.
- The study evaluated the effects of ink temperature on Type C inks only. Results may differ with other ink types.
- The range of test temperatures (66°F to 92°F) was selected to represent the extreme of printing conditions that might be encountered in the industry. Smaller printers may have ink temperatures approaching the upper limit in the summer months, but these higher temperatures are not typical of year-round operating practices.
- Many ink and solvent systems used in packaging and product gravure have an affinity for pressroom air moisture, particularly at low temperatures. Moisture pickup due to low ink temperature can cause blushing and ink kick-out. The study did not directly assess the moisture pickup of the colder inks, but no blushing and ink kick-out effects were seen.

Potential Cost Savings

Parameter	Scenario 1	Scenario 2	Reductions or savings
Solvent emissions (lb/yr)	113,400	86,400	27,000
Ink consumption (lb/yr)	97,200	86,400	10,800
Annual solvent costs	\$56,700	\$43,200	\$13,500
Annual ink costs	\$388,800	\$345,600	\$43,200
Solvent & ink costs	\$445,500	\$388,800	\$56,700

Example Model Facility

Press size:	23" wide
Printing units:	3
Annual operation time:	7200 hr/yr
Press speed:	300 ft/min
Solvent use rate:	9 lb/hr at 92°F
(per color):	4 lb/hr at 79°F
Ink use rate:	6 lb/hr at 92°F
(per color):	4 lb/hr at 79°F
Solvent cost:	\$0.50/lb
Ink cost:	\$4.00/lb

own potential savings. Although these estimates do not account for the cost of cooling, any cooling solution and associated energy requirements that cost less than the estimated savings above could result in payback after the first year.

Industry Challenge—The results of the DfE Gravure Partnership suggest ink temperature controls may present

gravure printers with an excellent opportunity to prevent pollution at the source, while improving print quality and reducing costs. Small- and medium-sized printers that experience printing inefficiencies due to fluctuations in ink temperatures may benefit most from ink temperature controls, but no clear or commonly implemented solutions for addressing these inefficiencies yet exist. The DfE Gravure Partnership challenges the industry to confirm project findings to optimize printing operations. To meet this challenge, gravure printers could:

- Independently evaluate the effects of ink temperature on solvent and ink consumption, print quality and cost.
- Assess and/or optimize current ink temperature control options, including
 - Submerged copper coils in the ink sump, including the cost and pollution implications of frequent cleaning.
 - In-line heat exchangers on the supply line.
 - Room temperature control (air conditioning).
- Adapt a temperature control option from another industry.
- Develop a new, innovative method for controlling ink temperatures.

Questions to consider when evaluating the use of temperature control in a printing facility include:

- How will less solvent consumption affect treatment systems such as oxidizers and recovery systems?
- What is the cost of adding temperature controls on press and providing cooling water?
- How do different colors and ink types behave, noting that in this study the two Type C inks behaved differently?

References

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- GAA (1991). *Tone Reproduction*. Gravure, Rochester, NY.
- Sosa, Rodrigo (1999). *Effects of Temperature Control on Gravure Packaging Ink: A Thesis Submitted to the Faculty of the Graduate College in partial fulfillment of the requirements for the Degree of Paper and Imaging Science*, Western Michigan University, Kalamazoo, MI.

What is EPA's Design for the Environment Program?

EPA's Design for the Environment (DfE) Program partners with stakeholders to help businesses help the environment. DfE projects help businesses design products, processes, and management systems that are cost-effective, cleaner, and safer for workers and the public. The DfE goals are to:

- Encourage businesses to incorporate environmental information into their decision criteria.
- Effect behavior change to facilitate continuous environmental improvement.

To accomplish these goals, DfE and its partners use several approaches including cleaner technology and life-cycle assessments, environmental management systems, formulation improvement, best practices, and green supply chain initiatives.

To date, the DfE Program has brought environmental leadership to over 2 million workers at over 170,000 facilities. Small- and medium-sized businesses recognize DfE as a unique source of reliable environmental (as well as performance and cost) information that allows them to make better decisions.

How Can I Get More Information?

To learn more about EPA's DfE Program or the Gravure Partnership, contact:

EPA's DfE Program

Phone: 202-260-1678

Web site: www.epa.gov/dfe

The Gravure Association of America

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