A METHOD FOR THE MEASUREMENT AND SPECIFICATION OF COLDSET PROCESS INK TRANSPARENCY

Robert W. Bassemir* and Walter F. Zawacki**

Keywords: Ink, measurement, process, specification, transparency

Abstract: Laboratory proofs of the NAA-COLOR™ AD-LITHO® standard inks were made on black, uncoated paper at a range of ink film thicknesses normally used in coldset lithographic printing. Colorimetric measurements of the unprinted black paper as well as the same area after printing were made with a spectrophotometer and the overall color difference (Delta E*) calculated using the unprinted black paper as a reference. A graph of Delta E* versus ink film thickness was made and the inverse slope of the linear regression line taken as a measure of the transparency of the ink. While based on the method described in our TAGA '94 paper, the black paper was used because a standard opacity chart on newsprint is not available and printed black bars on newsprint were found to give inconsistent results. The practical application of this method was confirmed in conjunction with NAPIM and during the work of ISO/TC130/WG4/TF1 on the proposed ISO 2846-2 standard.

Introduction

ISO/TC 130/WG 4 has been developing a standard for the colorimetry of coldset process inks. One of the important aspects of specifying such inks is some measure of their transparency. The method that was developed for sheetfed and heatset lithographic inks (Bassemir and Zawacki, 1994) used a standard opacity chart on which the inks were proofed. These charts are coated and, therefore, are not suitable for coldset inks which require absorption into the stock for setting. Opacity charts printed on a stock with absorption characteristics similar to newsprint are not commercially available. The initial approach discussed by the WG 4 task force was to print a black bar on the newsprint selected by the committee for the colorimetric characteristics portion of the standard. NAPIM

---

* SunChemical Corporation, 631 Central Avenue, Carlstadt, NJ 07072, 201/933-4500.
** Flint Ink Corporation, P.O. Box 8609, Ann Arbor, MI 48107, 313/995-3100.
Both represent NAPIM/NPIRI on ISO/TC 130/WG 4.

was assigned the task of developing a method for the evaluation of transparency.

Discussion

The customary method for evaluating the transparency of coldset process color inks in the US ink industry is by assessing the light scattering of the colored ink film when printed or drawn down over a printed black bar. Many of the control methods use a comparative visual estimate of the amount of light scattered or "milkiness" of the film over the black bar. Of course, in order to write a specification in the ISO standard, a numerical value is required. In the past, densitometer readings were used by some manufacturers but these measurements are not sufficiently discriminating and can be misleading, especially when different colors are involved. Spectrophotometric measurements, however, can be used to yield colorimetric data as well as an overall color difference value.

One of the objectives of this work was to identify a black substrate that has absorbency and transfer characteristics similar to newsprint. The black needs to be low enough in reflectance so that when it is overprinted with the test ink that there is little, if any, additional absorption. The difference in the resulting spectral curves then becomes a measure of the scattering caused by the less than perfect transparency of the ink being tested.

The following substrates were evaluated to determine the suitability of these materials:

1. Flexo black ink printed on newsprint
2. Flexo black ink printed on offset stock
3. Forms black ink printed on newsprint
4. Forms black ink printed on offset stock
5. Uncoated black paper

The flexo black ink prints were made using a mechanical proofer. Solid black prints, large enough to be cut to an appropriate size for the Prufbau Printability Tester, were made using one, two and three prints of black ink. The prints were allowed to dry between applications. The CIELAB L* values of these prints were 28.6, 25.5 and 22.1 respectively on newsprint and 24.5, 21.3 and 16.6 respectively on the offset stock. (All the spectrophotometric measurements reported in this paper were made using 0/45 geometry with a black backing and the colorimetric values calculated for CIE illuminant D50 and 2° observer.) The Status T optical densities were 1.24, 1.33 and 1.45 respectively on newsprint and 1.37, 1.47 and 1.66 respectively on the offset stock. This bar had the advantage of being dry almost instantly and would not rub off like some black coldset inks.

The forms black ink prints were made on newsprint using a single-color offset lithographic printing press. A series of prints with a solid bar, large enough to be cut to an appropriate size for the Prufbau Printability Tester, was made using one and two prints of the forms black ink. The prints were allowed to dry between applications. The L* value of the single black on newsprint was 35.4

while two prints of black resulted in a L* value of 25.5. The dry ink densities were 1.05 for one print and 1.33 for two prints on newsprint. On the offset stock, one print of forms black resulted in a L* value of 25.5 and a dry ink density of 1.37 while two prints had a L* value of 17.0 and a density of 1.64. After being printed the second time, the sheets had to be spread out to prevent offsetting and took three days to adequately dry.

An uncoated black substrate with a low reflectance level was also considered since this would provide a consistent black and would not require pre-printing. One stock that meets these requirements is a black paper (#772 Weswrap) that is manufactured for Eastman Kodak to their specifications. This stock has a L* value of 26.0 and a density of 1.32.

Strips of these substrates were cut to the size needed for the Prufbau Printability Tester. The strips were coded and the reflectance of the blacks measured with a 0°/45° geometry spectrophotometer. These measurements were the reference values for black substrate.

To evaluate the transfer characteristics of the various black substrates, the NAA AD-LITHO Cyan was overprinted on multiple strips. The ink volume needed to achieve the normal target wet density of 0.95 was determined using unprinted newsprint. Then, using this same ink volume, multiple prints were made on the various black substrates. The prints were made at a speed of 1 meter/second and a printing pressure of 225 Newtons/centimeter on a Prufbau Printability Tester at Flint Ink. The ink distribution rollers and the printing form were washed up after each print. The actual film weights were determined using the NPIRI standard printing method described by Bassemir and Lavelle (1993). The weight of ink on each print is determined by weighing the printing form before and after printing and using the specific gravity of the ink to calculate the film thickness in micrometers (μm).

After over-printing, the prints were allowed to dry for at least 24 hours and then remeasured. For each print, the CIELAB Delta E* was calculated using the black substrate as the reference.

Substrate evaluation. In evaluating the substrates, several aspects were examined. The spectral curves of the black alone and the cyan over the black were plotted. Theoretically, the black should be low enough in reflectance that when overprinted, the curve of the overprint is at or above that of the black alone. If the curve of the overprint is below that of the black alone then there is additional absorption occurring at those wavelengths. When Delta E* is calculated, it is summing both the negative and positive lobes of the overprint curve and providing a measure of the change in "blackness" as well as the scattering characteristics of the overprinted ink film.

The transfer characteristics were examined by comparing the transfer of the cyan ink onto the various black substrates to the transfer onto unprinted newsprint. The transfer rate was calculated by dividing the weight of the ink transferred to the substrate by the weight of ink on the printing form before printing.

Flexo black. Figure 1 shows the reflectance curve of the cyan ink over two prints of flexo black on newsprint and the curve of the two prints of flexo black before overprinting. The curve of the cyan overprint is mostly below that of the black alone indicating that there is still additional absorption occurring. The curves were similar on the offset stock.

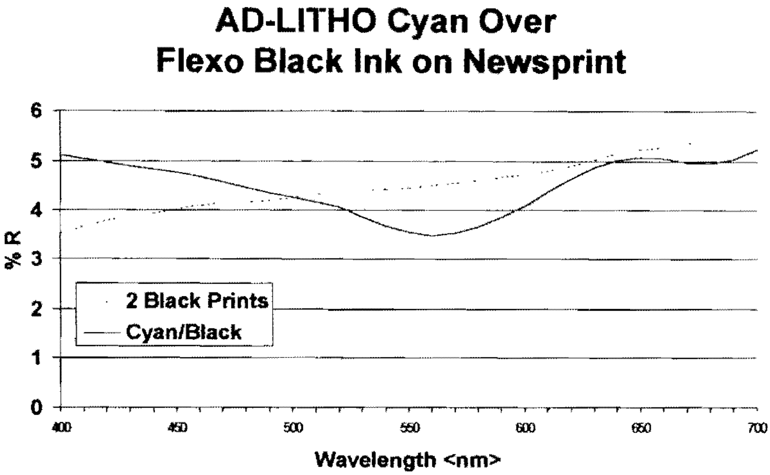

Figure 1. Reflectance curves of flexo black (2 prints) on newsprint and AD-LITHO Cyan ink overprint.

The average transfer rate of the cyan ink to unprinted newsprint was 58%. The transfer rate to the flexo black ink on newsprint was 65% for one print of black and 64% for two and three prints. This was surprising since the transfer rate to a previously printed ink film, even when dry, is normally equal to or slightly less than to the unprinted substrate.

The transfer rate to the flexo black ink on offset stock was 62%, 61% and 57% for one, two and three prints of black respectively. The cyan ink had a 59% transfer rate to the unprinted offset stock.

The need to apply multiple prints of black ink to achieve a sufficiently low reflectance level resulted in inconsistent black bars and a change in the gloss level. Because of the inconsistent results, no additional work was done with the flexo black ink on either newsprint or offset stock.

Forms black. Figure 2 shows the reflectance curve of the cyan ink over two prints of forms black on newsprint and the curve of the two prints of forms black ink. The curve of the cyan overprint is mostly below that of the black alone indicating that there is still additional absorption occurring. The curves were similar on the offset stock.

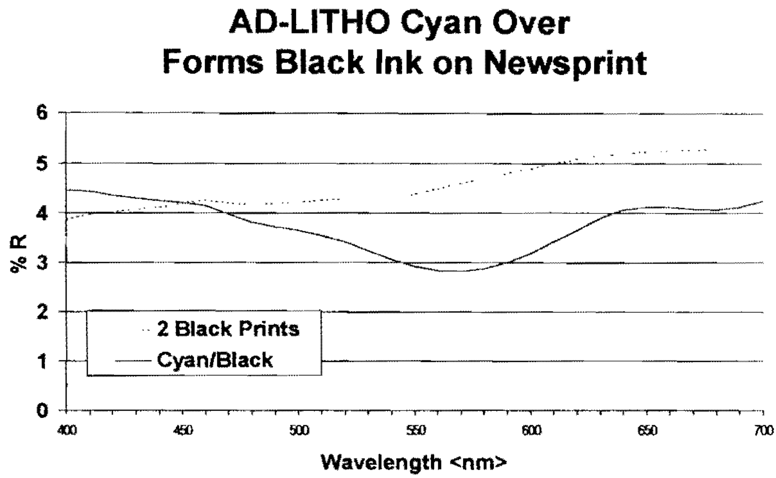

Figure 2. Reflectance curves of forms black ink (2 prints) on newsprint and AD-LITHO Cyan ink overprint.

When the cyan ink was overprinted on a single print of forms black ink on newsprint, the average transfer rate was 54%. When overprinted on two prints of forms black ink, the average transfer rate was 53%. The transfer rates on one and two prints of forms black ink on the offset stock were 55% and 54% respectively.

The black achieved with the forms ink was more consistent than with the flexo ink. The reflectance level was not as low as desired but applying a third print of forms black would likely increase the drying time and would increase the chances of inconsistency. Also, even with two prints of black ink, there was a noticeable increase in the gloss of the black. This stock was chosen for further study and overprinted with various ink film thicknesses of the NAA AD-LITHO process colors.

Black paper. Figure 3 shows the reflectance curve of the cyan ink over the black paper. Unlike the printed blacks, the curve of the cyan overprint is mostly above that of the black alone.

The transfer rate to the black paper was 60%, which was slightly above that to newsprint. The black stock was very consistent and neutral in shade. This stock was also chosen for overprinting with the process color inks.

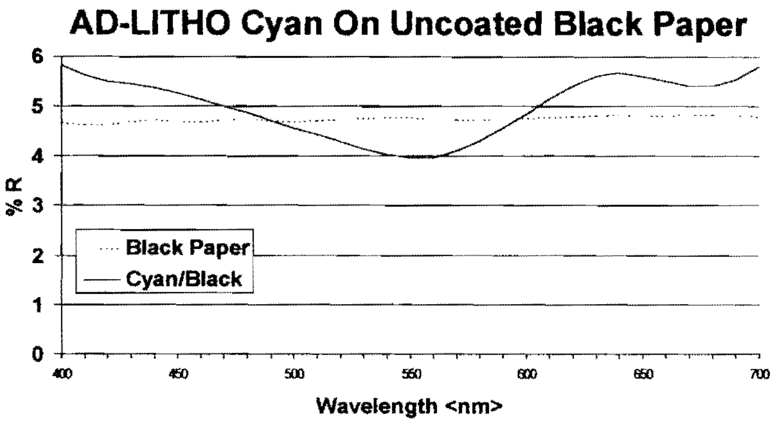

Figure 3. Reflectance curves of black paper and AD-LITHO Cyan ink overprint.

Numerical evaluation of transparency. In our previous work (Bassemir and Zawacki, 1994), it was found that the overall color difference (Delta E*) between the overprinted ink on the black substrate and the unprinted black substrate gave the most reproducible results and generally correlated well with visual estimates of transparency.

We had also found that when Delta E* was plotted against the ink film thickness, the relationship was found to be essentially linear over the practical range of printed ink film thicknesses. The slope of the best regression line through these points was much less variable than absolute values would be, even at a constant film weight. Since the slope decreases for more transparent inks, the inverse slope was chosen as the measure of transparency. The units for this measure of transparency would then be micrometers of ink per unit Delta E*. Thus, a more transparent ink would require a thicker ink film to achieve one unit of Delta E* color difference and the transparency value would be larger than that for a less transparent ink.

The NAA AD-LITHO process color inks were overprinted on strips of the forms black ink (one and two black prints) printed on newsprint and the uncoated black paper at ink film thicknesses varying from approximately 0.6-1.3 µm. The prints were made at a speed of 1 meter/second and printing pressure of 225 Newtons/centimeter on a Prufbau Printability Tester at Flint Ink. Again, the actual film weights were determined by weighing the printing form before and after printing and using the specific gravity of the ink to calculate the film thickness in micrometers (µm).

Transparency plots - Forms black ink on newsprint. Figures 4-6 show the Delta E* vs. ink film thickness graphs of the NAA process colors annotated with the inverse slope transparency (T) values. The results on this black substrate were not very consistent, especially with the cyan and magenta inks. Out of seven different ink film thicknesses, the results for one or two levels were often obviously inconsistent with the other levels.

When a linear fit was calculated with all the levels included, the T values were very high, indicating a high degree of transparency. In some cases, a negative T value was obtained, which would indicate that the ink was so perfectly transparent that film thickness had no effect. In fact, to obtain a negative T value, the color differences would have to be lower at the higher ink film thicknesses. This was not consistent with the visual results. Also, examination of the spectral curves showed lobes that were above the black substrate indicating that the ink was not perfectly transparent. The R^2 values for the linear regression were also very low, especially for the cyan and magenta.

After removing the values for the inconsistent levels and recalculating the slope, the T values were positive but still higher than expected. The R^2 values for the linear regression were higher - 0.876 for cyan, 0.817 for magenta and 0.991 for yellow on the single print of black and 0.778 for cyan, 0.691 for magenta and 0.947 for yellow on two prints of black. The yellow probably gave more consistent results because it is the least transparent of the three inks and therefore, gives larger color differences with changes in ink film thickness.

In summary, the results were inconsistent and the T values obtained did not agree well with the visual evaluation. For this reason, this substrate was determined to be unsuitable for use in a standard test method.

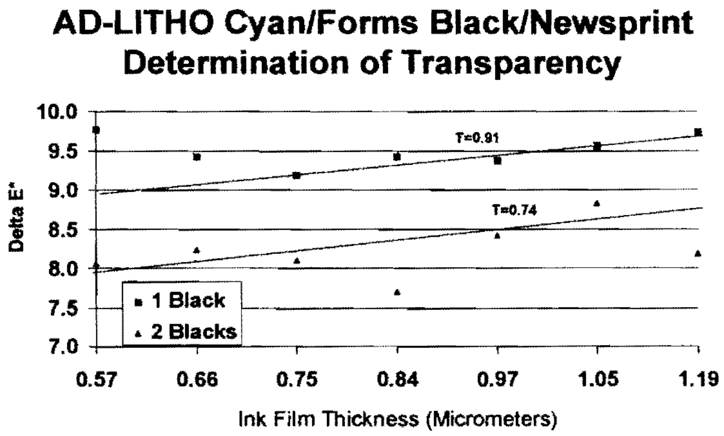

Figure 4. Transparency graph for AD-LITHO Cyan ink over one and two prints of forms black ink on newsprint.

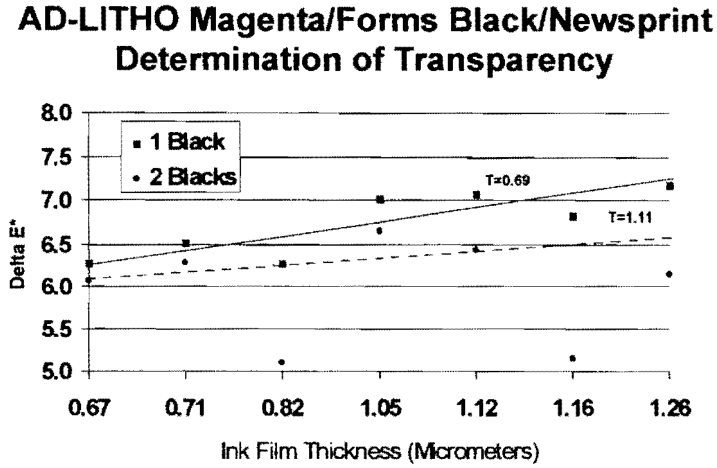

Figure 5. Transparency graph for AD-LITHO Magenta ink over one and two prints of forms black ink on newsprint.

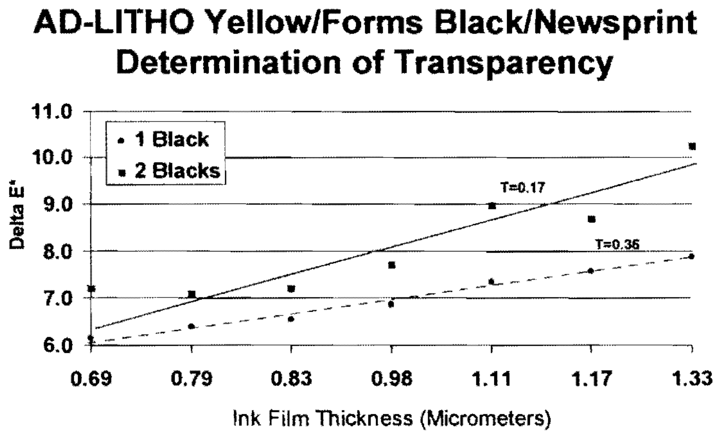

Figure 6. Transparency graph for AD-LITHO Yellow ink over one and two prints of forms black ink on newsprint.

Transparency plots - Uncoated black paper. Figure 7 shows the Delta E* vs. ink film thickness graph of the AD-LITHO process colors annotated with the inverse slope transparency (T) values. The results were very consistent on this substrate. All of the ink film thickness levels that were prepared were used in the calculation of the slopes for each color. The results were also consistent with the visual assessment of transparency. The R^2 values for the linear regression were 0.925 for the cyan, 0.986 for the magenta and 0.992 for the yellow.

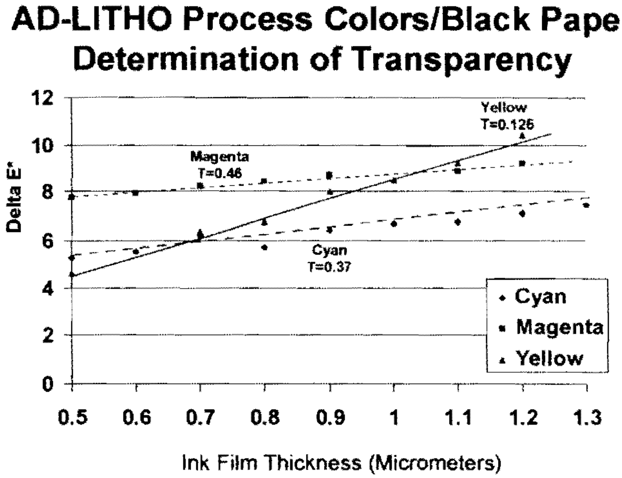

Figure 7. Relative transparency of the AD-LITHO process colors on black paper.

A series of prints with various ink film thicknesses were also made with a different yellow ink to check the agreement of the numerical evaluation of transparency with the visual evaluation. As seen in Figure 8, this yellow, which was very close in transparency to the AD-LITHO yellow, had a similar slope and a negligibly higher T value. This agreed very well with the visual evaluation of the transparency.

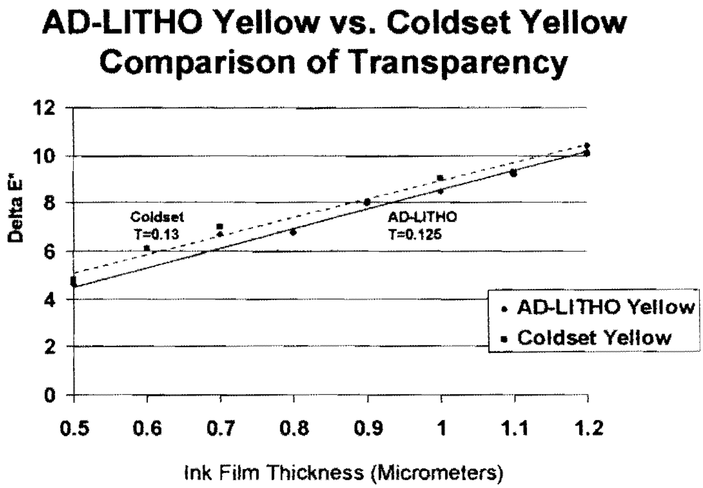

Figure 8. Graph comparing transparency results for two yellows.

Based on these results, the transparency test method using the uncoated black paper was recommended for use in ISO 2846-2.

Conclusions

A laboratory method for determining a numerical value for the transparency of coldset process inks has been developed during the course of the work on proposed standard ISO 2846-2. The method requires the preparation of a series of prints of known ink film thicknesses on a black stock using a printability tester.

An uncoated black paper that is manufactured for Eastman Kodak to their specifications was identified as a suitable black substrate for this method. Other black papers with absorbency characteristics similar to newsprint and with a L* value equal to or less than 26.0 may also be suitable.

A spectrophotometer capable of excluding the specular component is necessary for making the color difference measurements for transparency determination. A spectrophotometer with directional geometry (0/45 or 45/0) is preferred. A sphere (d/8) spectrophotometer with specular component excluded geometry will give different values of "T", but rank them in the same order and relative spacing.

The use of the inverse slope of the Delta E* vs. ink film thickness plot provides a numerical value which correlates well with visual assessment of transparency.

Examination of the reflectance curves of the black substrate and the overprint on it can provide valuable insight into changes which occur during overprinting.

Acknowledgments

The authors want to acknowledge the special efforts of two people. Susan Bartman, formerly of Flint Ink, made a large number of Prufbau prints on the various substrates. Richard Peters, Flint Ink, coordinated the flexo and litho pre-printing of the substrates and made a large number of spectrophotometer measurements.

References

Bassemir, R. W. and Lavelle, J. S.
1993 "Colorimetric Parameters of Lithographic Prints at Various Film Thicknesses", TAGA Proceedings.

Bassemir, R. W. and Zawacki, W. F.
1994 "A Method for the Measurement and Specification of Process Ink Transparency", TAGA Proceedings.

ISO 2846-2 *Graphic technology - Specification for colour and transparency of printing ink sets - Part 2: Inks for coldset offset lithographic printing*
Copy of current draft can be obtained from NPES, 1899 Preston White Drive, Reston, VA 20191-4367, Telephone: 703/264-7200, Fax: 703/620-0994.