TRAP - A STUDY OF TINT OVERPRINTS

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Abstract

With increased use of colour tints it is important to look beyond, the measurement of solid patches for trap. This research paper focuses on the measurement of trap by means of tint overprints. Nine different overprint patches, with variations of solid, 75% tint, and 50% tint were measured. As well, the densities were varied in order to establish the effect on trap.

Our test showed that the solid overprint patch is the most dependable for trap measurement. It was found that the lower the percentage tint, the less dependable the results. However, our data indicates that the 75%/75% tint patch did provide accurate enough results to be used.

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With today's increasing demand for quality colour printing, there is a need to improve or change how we evaluate the printed result.

Currently we have many types of measurement, which we use to guarantee quality. Trapping is one of these measurements. Colour bars incorporate solid trapping patches and there are various computerized systems which monitor trapping on the printed sheet.

The objective of this study is to evaluate the effects of trapping as it relates to overprints of (a) solid over solid, (b) solid over tint, (c) tint over solid, and (d) tint over tint.

We hypothesized that an accurate means of measuring trap, particularly where Under Cover Removal (UCR) and Grey Component Replacement (GCR) are involved, would be through the use of tint overprints. In order to evaluate this theory, it must first be determined if there is a difference between trap values of tint overprints and those of solid overprints. If no differences exist in these values, it can be concluded that trap measurements of tint overprints are as accurate as those of solid overprints.

METHODS OF EVALUATION

Printing magenta over cyan, we produced the following nine overprints:

(1) 100% magenta over 100% cyan,
(2) 100% magenta over 75% cyan,
(3) 100% magenta over 50% cyan,
(4) 75% magenta over 100% cyan,
(5) 75% magenta over 75% cyan,
(6) 75% magenta over 50% cyan,
(7) 50% magenta over 100% cyan,
(8) 50% magenta over 75% cyan,
(9) 50% magenta over 50% cyan.

Six of the above test patches were positioned across the press sheet. The solid densities achieved for both of these colours was approximately 1.40 in order to test the validity of our results, based on ideal printing conditions. We also increased the density of cyan and then magenta to test non-ideal conditions.

The twelve test sheets with the most consistent densities were selected from each of the three test runs. In order to avoid variations, the test patches were positioned at different angles on the press sheet, and readings were taken from alternate patches. Density readings were taken through the use of a wide band densitometer, which represents the most popular means of quality measurement used in the industry today.

A total of 216 readings were taken from each of the 3 press runs. The resulting data were then applied to the trap equations of Childers, Preucil and Brunner for evaluation.

TRAP EQUATIONS USED:

Preucil – Preucil believed that the best way to deal with failure resulting from trapping problems was to put emphasis on monitoring changes in trap rather than trying to achieve the absolute trap. His equation determined trap by subtracting the density of the first colour down, from that of the overprint, divided by the density of the second colour down, and multiplying the result by 100.

$$\text{Percentage apparent ink trap} = \frac{D(op) - D1}{D2} \text{ X } 100$$

Since this equation is based on the relative amount of ink transferred to the paper, it can also be expressed as:

$$\%\text{ trap} = \frac{\text{observed ink-layer thickness of second ink}}{\text{expected ink-layer thickness of second ink}} \text{ X } 100$$

Childers – In 1980, Childers offered a modified version of this equation based on the relative amount of light reflected by the ink, which can be expressed as:

$$\%\text{ trap} = \frac{\text{expected reflectance of two-colour patch}}{\text{observed reflectance of two-colour patch}} \text{ X } 100$$

The relationship between density and reflectance allows us to evaluate percentage trap as:

$$\%\text{ trap} = \frac{10^{-(D2 + D1)}}{10^{-D(op)}} \text{ X } 100 \quad \textit{or} \quad 10^{(D(op)-D1-D2)} \text{ X}100$$

Brunner – In 1984, Brunner suggested a different equation to measure trap.

$$\% \text{ trap} = \frac{1 - 10^{-D(op)}}{1 - 10^{-(D1 + D2)}} \times 100$$

Since this equation is based on the relative amount of light absorbed by the ink, it can also be expressed as:

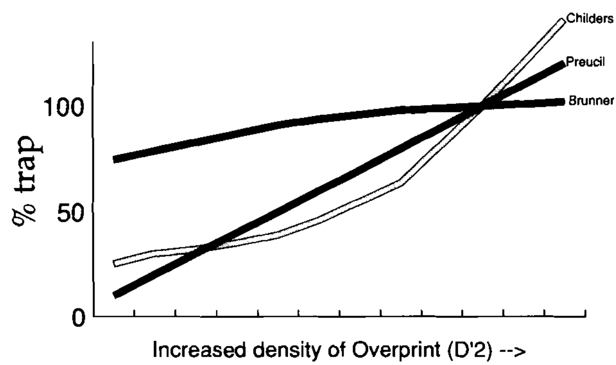
$$\% \text{ trap} = \frac{\text{observed absorption of the two-colour patch}}{\text{expected absorption of the two-colour patch}} \times 100$$

In order to evaluate these equations, Pearson (1983) suggested the use of the following equation which states that density of the overprint is equal to the sum of the density of the first colour down and that of the second.

$$D(op) = D1 + D2$$

In the case where the second colour has perfect trap, D2* would equal D'2**. When the second colour has less than perfect trap, D'2 will differ from D2. Pearson maintains that by keeping D2 constant and by varying D'2 the trapping equations can be evaluated. The following graph presents a comparison of the 3 equations based on Pearson's theory.

Based on the findings of this graph, Preucil's equation produces a linear relation to increasing film thicknesses, which is equal to variations in D'2. This makes it easier to predict the changes in trap, relative to the density of the overprint, since a line can be graphed by plotting only 2 points to predict trap values.



* D2 = Expected density of the second colour down.
** D'2 = Actual density of the second colour down.

According to the graph, Childers overestimates trapping as the percentage trap increases faster then the increase in the density of the overprint. Brunner's equation, on the other hand, underestimates trapping as the percentage trap increases very slowly as the density of the overprint goes up.

TREND ANALYSIS

EVALUATION OF NORMAL TEST SHEETS

Brunner

The Brunner equation is based on the observed and expected light absorption of the two colour overprint. According to Brunner's equation, the higher the amount of light absorbed, the higher the percentage trap. Since we are measuring through the complement filter of the second colour down, the observed absorption should be in direct relationship to the coverage of the second colour. This should result in a higher percentage trap. Therefore, we should expect higher trap with a higher percentage tint of the second colour, rather than with a lower percentage tint. This is reflected by our results which show that the 100 over 50 overprint has the highest percentage trap and the 50 over 50 overprint has the lowest percentage trap.

100/100 vs 75/75 vs 50/50

Trend - The trap values of these overprints decreased as the percentage tints decreased. The range increased as the tint values of the first colour down decreased, which indicates that the 100/100 overprint is more stable to use as a patch for measurement. The 75/75 overprint is reasonably stable and therefore could be used for measurement. The standard deviation increased as the tint values decreased. This would indicate that the 100/100 and 75/75 overprints have acceptable deviations with the 100/100 being the best. The 50/50 overprint varied too much to be considered as a consistent patch for measurement.

	100/100	75/75	50/50
Average	98.07 +/-72	96.63 +/- 1.38	94.48 +/- 8.43
Range	96.66 - 98.58	96.07 - 97.37	93.58 - 97.81
	.92	1.30	4.23
Std. Dev.	.24	.46	2.81
Variance	.06	.21	7.90

* Note, the +/- values presented above with the average represent 3 standard deviations or approximately 95-100% certainty.

100/100 vs 75/100 vs 50/100

Trend - The trap values increased as the percentage tint of the first colour down decreased. The range increased as the tint value of the first colour down decreased. The standard deviation increased as the tint value of the first colour down decreased.

	100/100	75/100	50/100
Average	98.07 +/- .72	98.13 +/- 1.35	98.21 +/- 1.62
Range	97.66 - 98.58	97.13 - 98.79	97.18 - 99.02
	.92	1.66	1.84
Std. Dev.	.24	.45	.54
Variance	.06	.21	.29

100/75 vs 75/75 vs 50/75

Trend - The trap values of these overprints decreased gradually as the tint value of the first colour down decreased.

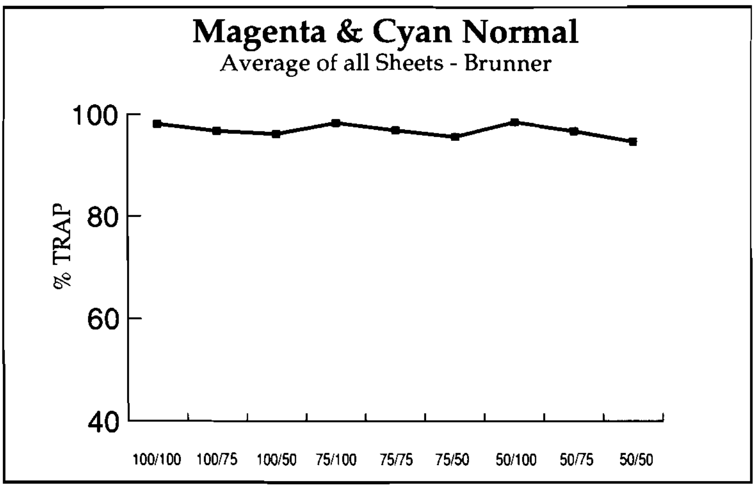
	100/75	75/75	50/75
Average	96.66 +/- 1.29	96.63 +/- 1.38	96.55 +/- 2.34
Range	96.16 - 97.65	96.07 - 97.37	95.20 - 97.69
	1.49	1.30	2.49
Std. Dev.	.43	.46	.78
Variance	.18	.21	.61

100/50 vs 75/50 vs 50/50

Trend - The percentage trap decreased as the tint value of the first colour down decreased.

	100/50	75/50	50/50
Average	96.01 +/- 1.56	95.33 +/- 2.49	94.48 +/- 8.43
Range	95.26 - 96.80	93.82 - 96.59	93.58 - 97.81
	1.54	2.77	4.23
Std. Dev.	.52	.83	2.81
Variance	.27	.70	7.90

According to the graph derived form this data, the highest trap values were obtained when the second colour down was a solid. This is understandable since the best trap is achieved when a solid is printed on a non-image area. A decline in trap values existed from the 100/100 to the 75/75 and again to the 50/50 overprint.



The graph seems to be made up of three levels of trap percentages. The highest being those overprints where the second colour was a solid. The middle range being those overprints where the second colour down was a 75% tint, and the lowest being those overprints that has a second colour of 50%.

Preucil

Preucil's equation is based on the expected and observed thickness of the second ink. Therefore, the higher the tint value of the second colour down and the lower the tint value of the first colour down, the higher the thickness observed. This suggests that the 100 over 50 overprint should have the highest trap percentage and the 50 over 100 overprint should have the lowest trap percentage. Our results support this theory.

100/100 vs. 75/75 vs. 50/50

Trend - The trap percentage of the 75/75 overprint was the highest, followed by that of the 50/50 overprint. The highest readings for the range, standard deviation and variance were found for the 50/50 overprint.

	100/100	75/75	50/50
Average	72.25 +/- 4.89	77.52 +/- 6.84	75.06 +/- 28.32
Range	69.05 - 75.97	75.28 - 81.33	48.48 - 88.89
	6.92	6.05	40.41
Std. Dev.	1.63	2.28	9.44
Variance	2.67	5.18	89.18

100/100 vs. 75/100 vs. 50/100

Trend - The trap percentages increased as the tint value of the first colour down decreased. The lowest range, standard deviation and variance were found for the 100/100 overprint. The highest readings were found for the 75/100 overprint.

	100/100	75/100	50/100
Average	72.25 +/- 4.89	76.93 +/- 18.15	79.79 +/- 9.36
Range	69.05 - 75.97	69.92 - 83.09	74.58 - 84.67
	6.92	13.17	10.09
Std. Dev.	1.63	3.47	3.12
Variance	2.67	12.03	9.72

100/75 vs. 75/75 vs. 50/75

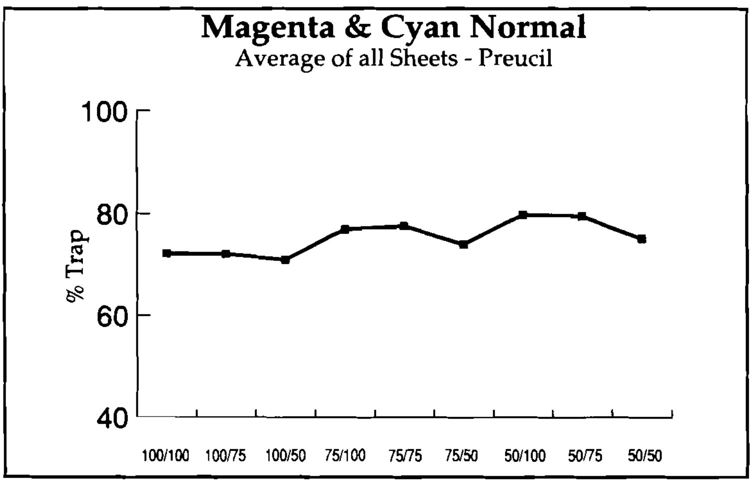
Trend - The trap percentages increased as the tint value of the first colour down decreased. The highest readings for the range, standard deviation and variance were found for the 100/75 overprint. While the 75/75 overprint had the lowest.

	100/75	75/75	50/75
Average	72.09 +/- 10.59	77.52 +/- 6.84	79.38 +/- 9.84
Range	67.12 - 79.49	75.28 - 81.33	73.33 - 84.81
	12.37	6.05	11.48
Std. Dev.	3.53	2.28	3.28
Variance	12.45	5.18	10.74

100/50 vs. 75/50 vs. 50/50

Trend - The trap percentages increased as the tint value of the first colour down decreased. The range, standard deviation and variance increased as the percent tint of the first colour down decreased.

	100/50	75/50	50/50
Average	70.95 +/- 10.98	73.99 +/- 14.01	75.06 +/- 28.32
Range	65.08 - 77.78	65.52 - 79.69	48.48 - 88.89
	12.70	14.17	40.41
Std. Dev.	3.66	4.67	9.44
Variance	13.44	21.85	89.18



The graph derived from Preucil's equation, followed a similar pattern as that of Brunner with respect to trap variations, with the exception of the higher trap percentage of the 75/75 overprint. However, considering the wider range and greater standard deviation of these results, Preucil's equation seems to present a more sensitive means of measuring trap. Unlike, the declining trap percentages of the overprints of common tint values for the Brunner equation (100/100, 75/75, 50/50), Preucil's equation showed the 75/75 overprint as having the greatest trap and the 100/100 as having the lowest.

According to these results, trapping is greatest as the dot percentage of the first colour down decreases according to this equation. This is not surprising, considering that the best trapping results are achieved when a solid is printed on plain stock.

Childers

Childers has based his equation on the expected and observed reflectance of the overprint. Therefore, the smaller the dot percentage of both the first and second down inks, the greater the percentage trap. Our results reflect this anticipated trend, as the 50 over 50 overprint has the highest percentage trap and the solid over solid has the lowest.

100/100 vs. 75/75 vs. 50/50

Trend - The trap percentages increased as the tint values decreased. The range, standard deviation and variance all increased as the tint values decreased.

	100/100	75/75	50/50
Average	41.78 +/- 8.37	65.42 +/- 11.49	71.21 +/- 27.42
Range	36.31 - 45.71	60.26 - 72.44	45.71 - 78.10
	9.4	12.18	32.39
Std. Dev.	2.79	3.83	9.14
Variance	7.79	14.66	83.45

100/100 vs. 75/100 vs. 50/100

Trend - The trap percentage increased as the tint value of the first colour down decreased. The highest range, standard deviation and variance figures were found for the 75/100 overprint and the lowest figures were found for the 100/100 overprint.

	100/100	75/100	50/100
Average	41.78 +/- 8.37	49.26 +/- 13.05	53.80 +/- 9.69
Range	36.31 - 45.71	41.69 - 58.88	46.98 - 58.88
	9.40	17.19	9.90
Std. Dev.	2.79	4.35	3.23
Variance	7.79	18.90	10.45

100/75 vs. 75/75 vs. 50/75

Trend - The trap percentages increased as the tint value of the first colour down decreased. The 100/75 overprint showed the greatest range.

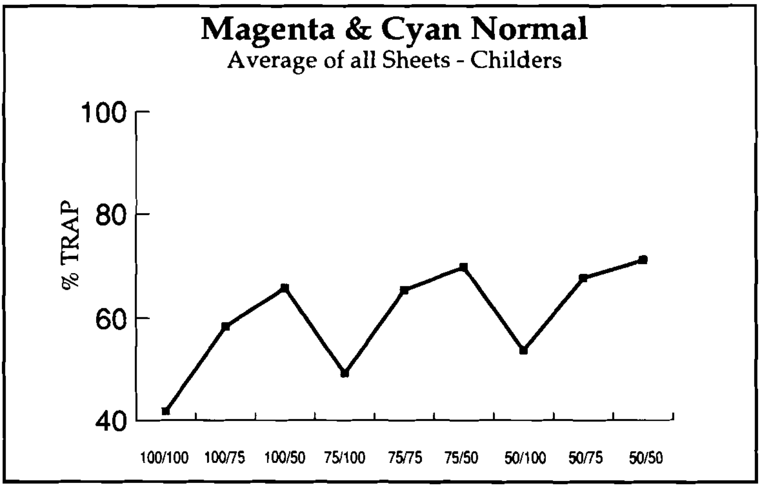
	100/75	75/75	50/75
Average	58.36 +/- 12.78	65.42 +/- 11.49	67.60 +/- 10.65
Range	51.29 - 69.18	60.26 - 72.44	63.10 - 75.86
	17.89	12.18	12.76
Std. Dev.	4.26	3.83	3.55
Variance	18.19	14.66	12.58

100/50 vs. 75/50 vs. 50/50

Trend - The trap percentages increased as the tint value of the first colour down decreased. The highest figures for the range, standard deviation and variance were found for the 50/50 overprint. The lowest figures were found for the 75/50 overprint.

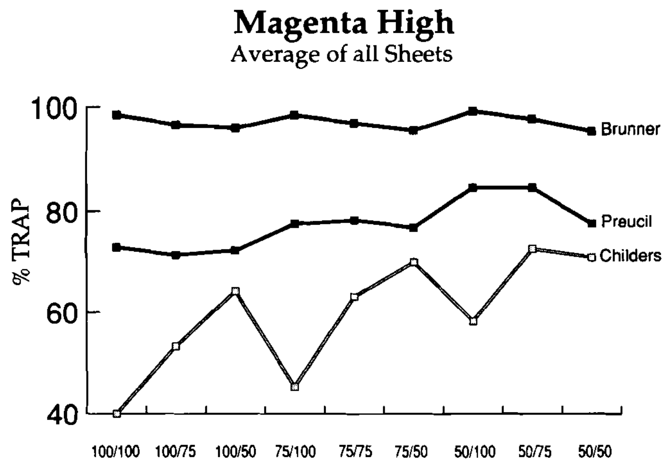
	100/50	75/50	50/50
Average	65.81 +/- 12.12	69.82 +/- 11.31	71.21 +/- 27.4[illegible]
Range	60.26 - 72.44	63.10 - 74.13	45.71 - 78.10
	12.18	11.03	32.39
Std. Dev.	4.04	3.77	9.14
Variance	16.32	14.23	83.45

There is a trend towards higher trap percentages as the percentage tin of the second colour down decreases. As well, higher trap percentages we recorded as the percentage tint of the first down decreases. The graph showing the average of all sheets demonstrates this trend "M" like curve. Our results indicate that the standard deviation and therefore, the amount of variance, is lowest in the 100/100 overprint. This indicates that any readings taken on this overprint will have the best stability. This supports the current method of measurement for trapping as being the most dependable. However, other overprints, such as the 75/75, demonstrate an acceptable low level of deviation which indicates that it is an area which could be used for measurement. The 50/50 overprint demonstrated an extremely high level of variance which would make it unsuitable as a patch for measurement. The reason why the 50/50 patch shows such instability is that it is very hard to match the same amount of coverage throughout.



The 100/100 is presumably the standard which we would want to achieve and maintain. In this case we are assuming that 41.78 is an acceptable percent trapping. Of these three patches, the 100/100 has the lowest average trap percentage and the smallest amount of variance. The 75/75 patch has a higher percent trap and variance. This indicates that it is not as stable a source for measurement as the 100/100 patch, however, since it has a small range. Although slightly higher than the 100/100 patch range, it does indicate a certain degree of stability. The 50/50 patch shows a high degree of variance. Therefore, it would not be suitable as a source for measurement.

EVALUATION OF MAGENTA HIGH TEST SHEETS



Brunner

The trend of the trap percentages derived from the Brunner equation appeared to be the same for the higher magenta densities as they were for those sheets tested under ideal densities. However, there is an overall increase in the trap percentages by about 0.5%. This supports the dependence of the Brunner equation on the second colour down. As stated above, the higher the percent tint or increased density of the second colour down, the higher the percentage trap.

Preucil

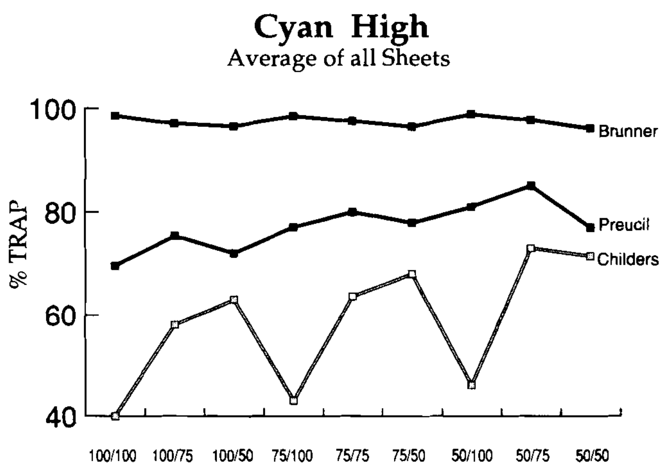
Preucil's equation is based on the thickness of the second ink down. For this reason, the test sheets of the higher magenta densities indicated an overall increase in trap percentages by approximately 2%. As was the case for the results of the Brunner equation, the trend remained basically the same. However, there seemed to be more stability shown by a lower standard deviation and variance.

Childers

Once again, the trend remained unchanged. However, there was an overall decrease in trap percentages from .5% to 4.5%. This decrease in trap is explained by the emphasis placed by Childers on the reflectance of the overprint, which equates to higher trap percentages with lower percentage dots or densities.

As these results indicate the same trend as the cyan magenta normal test sheets, we felt that it was not essential to present the same level of detail as that of our previous findings.

EVALUATION OF CYAN HIGH TEST SHEETS



Brunner

There is an increase in the percentage trap, however it is not an overall increase. The patches with lower percentage tints of cyan had higher percentage trap. This is explained by the fact that there was more dot gain in the 50% tint. Therefore, the emphasis placed in the first colour down by the Brunner equation tends to support these results. There was less deviation and variation with the higher cyan density.

Preucil

The trap percentages decreased with the 50 over 50 patch. The decrease in trap percentage with this patch, is explained by the fact that the higher the percentage tint the lower the percentage trap, according to the Preucil equation.

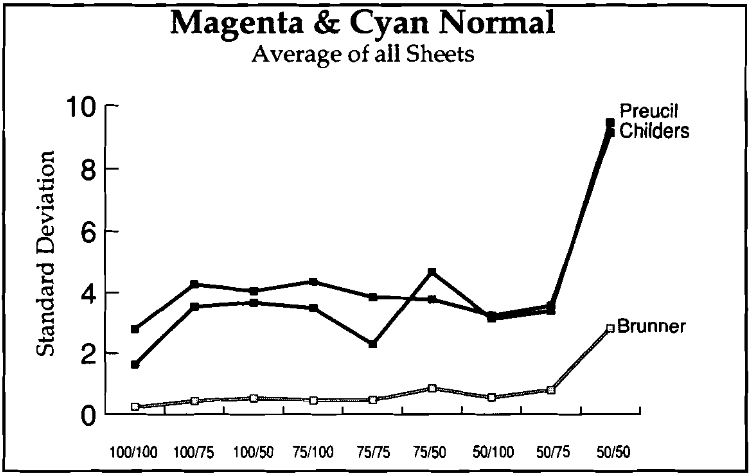
Childers

There was a noticeable decrease in the percentage trap of the 100 over 100 patch and less so in the 75 over 75 patch. This supports Childers' equation which equates lower percentage trap with greater coverage of the first down ink. The trends of the graph provide further support of this since it has about the same shape as the graph for regular coverage with slightly lower trap percentages where the first colour is solid.

The data derived from these tests of higher densities supports the analysis and conclusions made from the data derived from the normal densities. The trend towards greater stability of trap percentages with higher densities would suggest that higher densities would be better. However, this is not always practical as it may interfere with the quality of the reproduction. For example, a poster with large type and heavy ink coverage, without halftones, would be a good candidate for this sort of adjustment. However, a finely detailed reproduction of an artist's painting would suffer in print quality.

CONCLUSIONS

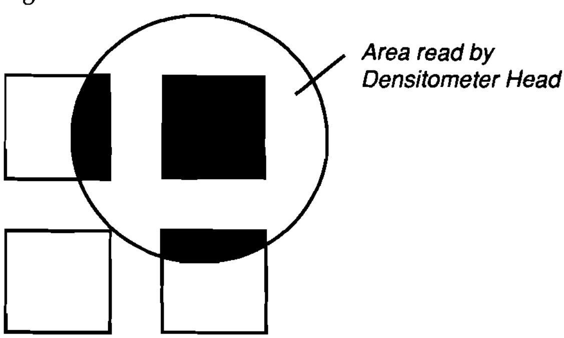
Of the nine patches, the ones we focused on were the 100/100, the 75/75, and the 50/50 patches. Looking particularly at the difference or variation between the numbers. As you can see by this graph, which shows the standard deviation of each group. The results showed that variation did exist in our readings of the nine overprints. This variation is due to the dots not printing perfectly on top of each other. The most consistent results were on the solid overprint patch. However, as you can see by this graph the 75/75 patch does appear to be almost as stable as the solid overprint patch. Due to the extreme amount of deviation, the 50/50 patch can not be used for accurately evaluating trap.



The 50/50 overprints show a large amount of deviation, variance and range. Due to this instability, this patch can not be used for evaluating trap. The reason for this instability is the unpredictability of the amount of overprint when tints are involved.

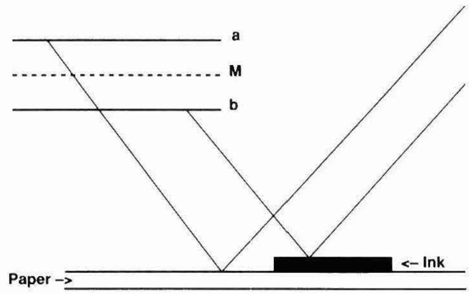
As shown in diagram A, the densitometer takes readings of reflection of the light from the paper surface through its aperture. Since this aperture is not exactly one light beam in width, the densitometer takes an average of this spot, being image and non-image areas, and derives a density from that.

Diagram A:



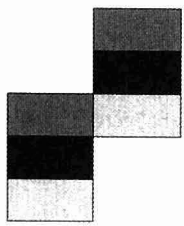
As shown in Diagram B, there is two parallel beams of light. One beam strikes a solid patch of ink (Some of the light is absorbed by the ink) and then reflects back from the surface (represented by line "b"). A second beam strikes the paper directly, then reflects back more powerfully from the paper surface (represented by line "a"). As one can see (Diagram B), the intensity of the reflectance of these two beams differs. Therefore, the densitometer would average the two, represented by line M on the diagram. Due to this averaging, any measurement of areas of tint will result in different percentage trap readings depending on the percentage of the second dot overlapping on the first dot.

Diagram B:



Variation on the tint overprint patches is due to the percentage of the second dot overlapping on the first printed dot. As illustrated by diagram C, the first colour down is cyan, and the second colour down is magenta. Magenta is half overprinting onto the cyan and half overprinting onto the paper. Hypothetically, the half of magenta which is overprinting onto the paper would have a 100% trap. However, suppose the magenta half that overprints on the cyan is only trapping 80%. This would then produce an average trap of 90%.

Diagram C:

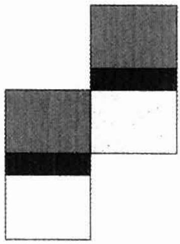


% trap	x	%coverage	=	contribution
100%	x	50%	=	50%
80%	x	50%	=	40%
				90% trap reading of area

However, if the dots do not align due to different screen alignment or misregistration on the press, the results could easily change.

For example, in diagram D the magenta is only overprinting onto the cyan by 20% and is overprinting on the paper by 80%. Therefore, this would average out as a 96% trap.

Diagram D:



% trap	x	%coverage	=	contribution
100%	x	80%	=	80%
80%	x	20%	=	16%
				96% trap reading of area

In theory, the trapping we were obtaining on the overprint was 80%, yet due to different dot alignment or misregistration on the press we were getting variation in the percentage overprint of the second colour down on top of the first colour down. This resulted, in our example, of trapping percentages of 90% and 96%. The only way we could have determined this in practice would be to measure the exact amount of area of the second colour overprint on top of the first. If, in our example, the solid overprint had indicated 85% trapping, and we did not know the amount of coverage in the overprint of the tints (dot alignment), we could not have realized that there was a different trapping occurring in halftone areas than in solid. The only way to calculate this would have been to blow up each overprint to access the percentage coverage of each dot combination. To do this we would have needed sophisticated microscopes, which were not at our disposal, and perhaps further research into other areas of study.

A particular area of investigation would be the study of different screen angles to be used in the tint overprints. By aligning the dots one on top of each other, less variation would exist. Therefore, more stable results could be obtained. The advantages of this would be two-fold; the readings would be more consistent and the trap of tints could be more accurately compared to that of solids.

However, all the accuracy in the photomechanical stages would be all for naught, if we could not guarantee accurate register on the press. As mentioned we did three test runs, varying the densities of the two colours. The results were analyzed using three different trapping equations to see if any trends existed. Particular attention was paid to the effect of the varying densities on the variance of the readings.

The Brunner equation places more emphasis on the first colour down, Therefore we found a higher density of the first colour down results in greater variation in the trapping percentage with tint overprints, then a higher density of the second colour down would show.

The Preucil equation is based on the thickness of the second ink down, Therefore, a higher density of the second colour down resulted in greater variation in trapping with tint overprints, then a higher density of the first colour down would show.

The Childers equation reacts similar to the Brunner equation in that: A higher density of the first colour down resulted in, noticeably more variation in trapping with tint overprints, then a higher density of the second colour down would produce.

We started with the hypothesis that accurate and more relevant trap readings could be obtained through the use of tint overprint patches, because the overprinting of tints is more dominant on the press sheets today then the overprinting of solids. Through the analysis of our test results, we conclude that a 75 over 75 patch does provide accurate trap measurement. Even though our test results indicated that there was greater variance for this patch, it was only slight. For example with the results obtained using the Preucil formula. It was found that the percentage trap reading for the 75% overprint was +/- 6.84%. On the solid overprint patch the results were +/- 4.89%. A difference of just 2%, leading us to believe the 75% overprint could be used with the following considerations:

- Modification of plant standards to reflect the trapping results obtained using a tint overprint patch. Each equation will react differently to the change from a solid overprint for measurement to a tint overprint for measurement. For example, if using the Preucil equation, one might have a plant standard of 72.25 +/- 4.89 for solid overprints. However, a new standard of 77.52 +/- 6.84 would be required for a 75% overprint.

- Give proper consideration for optimal screen alignment and the effect of registration on the press. Either of which will cause variation in trap readings.

- Consider the effect that higher densities have on the trap results which vary from formula to formula. Any shift in density will affect how the formulae evaluate trap, particularly when using tint overprint patches

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This paper has been submitted by Derek Seaton to the 1991 TAGA Student Papers competition.

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April 23, 1991