Ink Trap: The Moving Target

By

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The purpose of this paper is to discuss the different equations associated with the term "ink trap" and to relate them to physical quantities relevant to the printed page. Here, we look at three such equations which have been promoted in the literature as the appropriate measure of ink trap. By comparing these equations on an equal basis, we should better understand why there is a lack of consensus on the calculation of ink trap.

Before we look at the equations, however, let us think about what we mean by "ink trap." We probably agree that it has something to do with getting ink to move from plate to paper. We also would agree that very often ink will not transfer as readily to a wet ink surface as it will to a clean paper surface. But what should the definition of ink trap be? The contention here is that the graphic arts community has jumped over this very important step and gone directly to the questions of measurement and calculation of ink trap. Thus, when two champions each tout their own trap calculation as "more correct," "better," or "more precise," they often have no common agreement as to how "ink trap" is defined. Dialogue concerning the two methods of computation is doomed unless the definition can be made explicit.

When considering how ink behaves when printed on paper, there are (at least) three physical quantities that might be of interest:

(1) The relative amount of light reflected by the ink.

(2) The relative amount of light absorbed by the ink.

(3) The relative amount of ink transferred to the paper.

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Let us limit our discussion to two cases, viz., ink-on-ink versus ink-on-paper, for solid patches. For simplicity, we shall assume that the paper is a perfect reflector and that there is no additivity failure for the inks. All densities are taken using the complementary filter of the second ink. Then, we define:

D1 = The reflection density of the first ink.

D2 = The reflection density of the second ink.

D21 = The reflection density of the two-color patch.

D2/1 = The additional density contributed by the second ink when printed over the first ink. Thus, we measure D2/1 by computing (D21 - D1).

Since we have assumed that the paper is perfect and densities are additive, we will expect that:

D21 = D2 + D1 and

D2/1 = D2

If ink transfer is NOT ideal, however, what we observe will be something different.

Let us consider case (1) above in which the relevant variable is reflected light. Let us define %TRAP(1) to be 100 times the ratio of the expected reflectance of the two-color patch to the observed reflectance. Notice that we use this ratio instead of its inverse so that under-trapping corresponds to a value less than one. This definition can be expressed algebraically as:

$$\%TRAP(1) = 100 \times \frac{\text{expected reflectance of two-color patch}}{\text{observed reflectance of two-color patch}}$$

Following the well-known relationship between density and reflectance, we may evaluate %TRAP(1) as:

$$\%TRAP(1) = 100 \times \frac{10^{-(D2 + D1)}}{10^{-(D21)}} \qquad \text{or}$$

$$\%TRAP(1) = 100 \times 10^{(D21 - D2 - D1)}$$

This equation expresses the ink-trap formula according to Childers [1].

We now turn to case (2) in which absorbed light is the variable of interest. Let us define %TRAP(2) to be 100 times the ratio of the observed absorption of the two-color patch to the expected absorption. Again we can express this definition algebraically as:

$$\%TRAP(2) = 100 \times \frac{\text{observed absorption of the two-color patch}}{\text{expected absorption of the two-color patch}}$$

Since we take absorption to mean one minus reflectance, we can evaluate %TRAP(2) as:

$$\%TRAP(2) = 100 \times \frac{1 - 10^{-(D21)}}{1 - 10^{-(D2 + D1)}}$$

This equation expresses the ink-trap formula according to Brunner [2].

The similarity between this and the Murray-Davies equation allows us to interpret %TRAP(2) as an effective dot area of the two-color patch. In this context, a two-color patch with under-trapping (say, cyan over yellow) produces the same green patch that would be produced by a %TRAP(2) percent dot of a GREEN INK having a solid density of (D2+D1).

Moving to case (3), we are interested in the amount of ink transferred to the paper. Here, we define %TRAP(3) to be 100 times the ratio of the observed ink-layer thickness of the second ink to the expected ink-layer thickness. Thus, we write:

$$\%TRAP(3) = 100 \times \frac{\text{observed ink-layer thickness of second ink}}{\text{expected ink-layer thickness of second ink}}$$

However, in the absence of additivity failure, ink-layer thickness is directly proportional to ink-layer density. Consequently, it is sufficient to ratio the observed and expected densities of the second ink-layer as follows:

$$\%TRAP(3) = 100 \times \frac{D2/1}{D2}$$

or

$$\%TRAP(3) = 100 \times \frac{D21 - D1}{D2}$$

This equation expresses the trap formula according to Preucil [3]. It is also the GATF ink trap formula [4].

So, where are we? We have defined three variables which relate to the laydown of ink on paper. Let's work an example to see what's going on. For simplicity, take the same example that Childers presented in his 1980 article. We will be printing cyan over yellow. Because cyan is the second color, we make all our density measurements with a red filter. Now suppose we measure:

D1	=	0.05	(Yellow)
D2	=	1.25	(Cyan)
D21	=	1.20	(Green)

Using the equations just derived, we obtain:

$$\%TRAP(1) = 100 \times 10^{(1.20 - 1.25 - 0.05)} = 79.4\%$$

$$\%TRAP(2) = 100 \times \frac{1 - 10^{-(1.20)}}{1 - 10^{-(1.25 + 0.05)}} = 98.4\%$$

$$\%TRAP(3) = 100 \times \frac{(1.20 - 0.05)}{(1.25)} = 92.0\%$$

What do we conclude from this? Simply that under these printing conditions, when cyan is printed over yellow:

(1) The expected reflectance of the green patch is 79.4 percent of the observed reflectance.

(2) The observed absorption of the green patch is 98.6 percent of the expected absorption.

(3) The observed ink/layer thickness of the overprinted cyan is 92.0 percent of its expected value.

While ALL of these percentages are correctly computed, they CAN'T all be referring to the same definition of "percent ink trap."

We now turn our attention to two special situations. In the first case, suppose that ink trap is IDEAL. That is, the ink transfers just the way we want it to. Under these conditions, we would make the following measurements:

D1	=	0.05	(Yellow)
D2	=	1.25	(Cyan)
D21	=	1.30	(Green)

Using the same equations as before, we obtain:

$$\%TRAP(1) = 100 \times 10^{(1.30 - 1.25 - 0.05)} = 100.0\%$$

$$\%TRAP(2) = 100 \times \frac{1 - 10^{-(1.30)}}{1 - 10^{-(1.25 + 0.05)}} = 100.0\%$$

$$\%TRAP(3) = 100 \times \frac{(1.30 - 0.05)}{(1.25)} = 100.0\%$$

As it turns out, all values agree. This happens because, under ideal conditions, all observations coincide with their expectations regardless of which variables we measure.

The second case, however, is to imagine that NONE of the second ink transfers to the first ink. What value for percent ink trap would you expect to compute? While this case is not likely to occur in practice, it does test the logical limits to which a definition can be pushed.

As before, suppose we measure:

D1 = 0.05 (Yellow)

D2 = 1.25 (Cyan)

But this time, because we are assuming that exactly NONE of the cyan transfers to the yellow, the "two-color" patch is really just the unchanged yellow patch. Consequently, we measure:

D21 = 0.05 ("Green" with no Cyan = Yellow)

Once again, we use our three trap formulas and obtain:

$$\%TRAP(1) = 100 \times 10^{(0.05 - 1.25 - 0.05)} = 5.6\%$$

$$\%TRAP(2) = 100 \times \frac{1 - 10^{-(0.05)}}{1 - 10^{-(1.25 + 0.05)}} = 11.4\%$$

$$\%TRAP(3) = 100 \times \frac{(0.05 - 0.05)}{(1.25)} = 0.0\%$$

This time the values do not agree. The value of %TRAP(1) is positive because the expected and observed reflectances are both positive. The value of %TRAP(2) is positive because the observed and expected absorptions are both positive. However, the value of %TRAP(3) is zero because its numerator, additional density contributed by the second ink, is zero.

Bear in mind, ALL of these percentages are correctly computed. They simply refer to the three different definitions currently in use.

So, what is lacking is a single, commonly accepted definition of ink trap. As a community, we simply have to decide on EXACTLY what we want the words "percent ink trap" to mean, in plain English. Once a definition has been accepted, the dialogue concerning different methods of calculation can continue.

Literature Cited:

[1] Childers, W., "Expert Shows Math Path to Avoid Ink Trap Trap" Graphic Arts Monthly, Dec. 1980, p. 63.

[2] "Cromalin Offset Com Guides/System Brunner," Du Pont Publication, 1984, p. 30.

[3] Preucil, F., "Color and Tone Errors of Multicolor Presses," TAGA Proceedings, 1958, pp. 175-180.

[4] "Control of Color on Press: Overprints," GATF Research Project Report No. 118, 1983, p. 3.