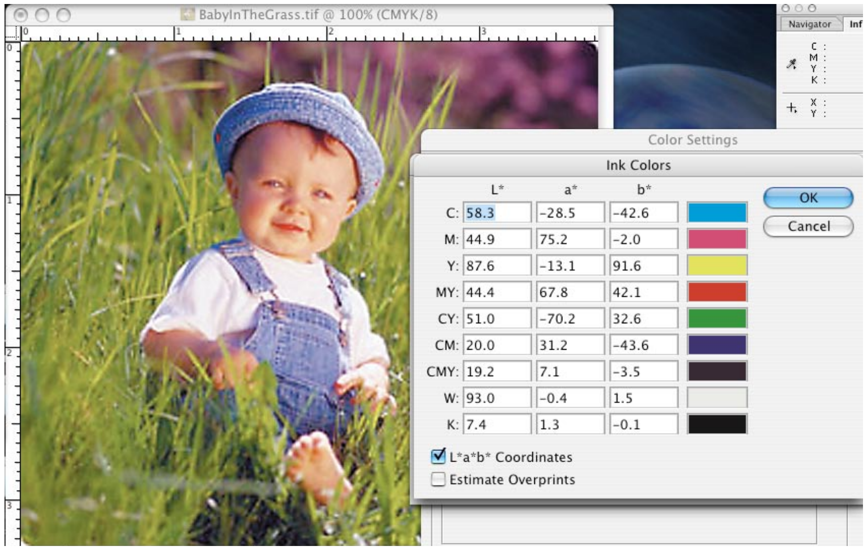
Hybrid Curves©



In real-world color matching in process color, there normally will be one or more of the three color elements that will be out of our complete control.

Introduction:

"Hybrid Curves©." I'm sure you have never heard this term unless one of our Chromatix™ color control experts visited your facility, or you attended the Screen Printing Technical Foundation's four-color process workshop in the last year.

So what you are about to read is a new concept in setting curves for better color matching. It has been field tested and verified for more than two years as a step forward in producing more accurate color on substrates with excessive color in the white point of the substrate. Let's start with a bit of history regarding the development and implementation of "Hybrid Curves."

For many years I have been teaching printers that the "North Star Truth" of matching a color target is achieving the same values on press as those of the color target we are attempting to match. It is a simple concept, but an absolute truth on which you can base all color control implementation with absolutely no chance of failure. It doesn't matter if it is screen printing, litho, flexo or digital printing. The closer to the measurable desired target values we can come, the closer the color match. Don't try to make it harder than this. Just measure it and match it.

With that said, there continues to be a lot of confusion about thinking you can hit correct numbers on press and not match. Printers call me occasionally and say, "I hit the numbers and it didn't match". First of all, let me assure you that it is possible to hit some of the numbers and not match. But if you hit all the numbers, you will match. The reason is because color is simply the ink color (hue and density), substrate color and dot percentage.

That's it. Nothing else. If you match all three of these elements dead on, your color will be dead on. Viewing conditions and substrate textures conducive to metamerism, or colorimetric infusion (colors appearing different than they are because of adjacent colors), can make the color appear wrong. But numerically, the color is right. That is all that can be expected of a printer. (Figure 1, Page 8)

In real-world color matching in process color, there normally will be one or more of the three color elements that will be out of our complete control. The most common is the substrate color. For example, can you make a white baseball white on a blue cast styrene? The answer is no.

But what we can do on the same blue-cast styrene is adjust the tonal values that are higher than 25% to match color regardless of substrate color. We can compensate for color deviation by lowering or raising tonal percentages for color differences. This is the concept of Hybrid Curves. The following paragraphs will explain how to scientifically move tonal areas and densities to achieve the best match possible through implementation of Hybrid Curves.

Two Data Sources Available

There are two data sources available, and they should be evaluated to achieve the best color match to a specified color target, absolute density and tonal percentage (dot area). (Figure 2, Page 8)

If our objective is to just match the intended color target, absolute density is the most accurate because it includes the ink color, dot percentage and substrate color in the data. Dot area or tonal percentage relate better to accurate reproduction of tonal values but ignores substrate and ink color.

Therefore, logic tells us that absolute density will match color better but correct tonal value will match image detail better. But what you may not realize is absolute density and tonal percentage (dot area) can be used together to set curves to match a specific color target.

By Mike Ruff, CTO, Nazdar Consulting

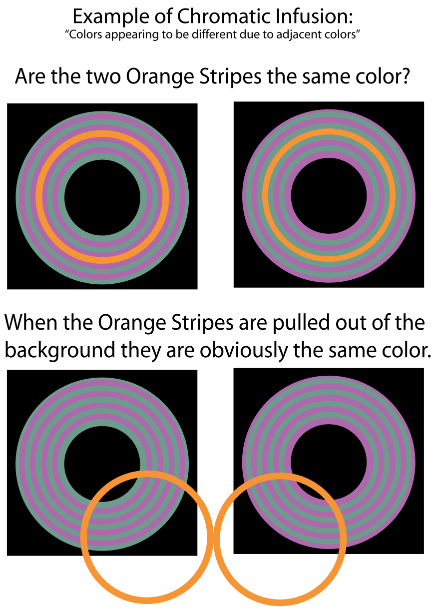


Figure 1: Chromatic Infusion

Typical Absolute Density Values

Assuming the substrate color is close to the anticipated substrate in the "Color Settings" pallette of Photoshop the following values are typical. You will find that analog proofs that are gray balanced and exhibit accurate dot percentages and densities will be close to these values.

	10%	25%	50%	75%	90%	Solid
Cyan	.15	.27	.50	.84	1.10	1.35
Magenta	.15	.27	.50	.84	1.10	1.40
Yellow	.14	.26	.45	.68	.85	.95
Black	.16	.28.	.52	.86	1.40	1.80

Typical Dot Percentage Values

The following dot percentage values are typical of the "Dot Gain" setting you will fine in the "Color Setting" CMYK Setup in Photoshop. You will find that analog proofs that are gray balanced and exhibit accurate dot percentages and densities will be close to these values.

	10%	25%	50%	75%	90%	Solid
Cyan	18	38	70	88	95	1.35
Magenta	18	38	70	88	95	1.40
Yellow	18	38	68	87	94	.95
Black	18	38	71	88	96	1.80

Figure 2: Typical Data

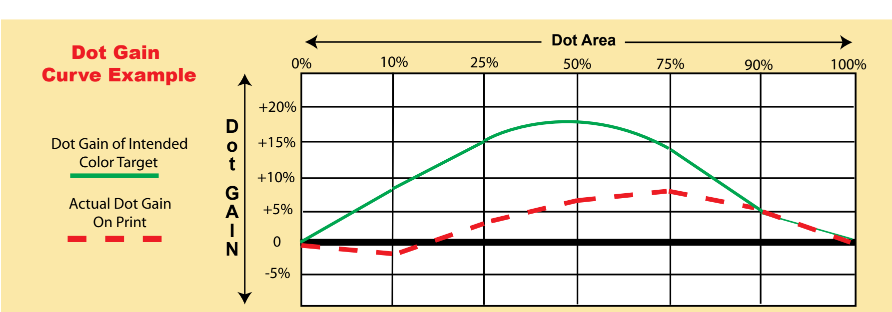


Figure 3: Dot Gain Curve

Color management software does this by using the relative rendering intent. The way this works automatically with color management software is the spectrophotometer looks at the intended color target's white point and solid density. Then, it renders the match as close as possible without loosing the detail in the highlight or shadow while maintaining the relationship between colors. It actually produces correct color in the bulk of the image but it ignores the white point in the lighter tones.

The results normally are good. The image colors — from the quarter-tones through the solids of the image — are very close to a colorimetric match, which is an exact numeric match. But the highlights are allowed to deviate because of the substrate color.

The Advantage of Jointly Using Dot Gain and Density Information

If the substrate and the solid densities of your intended target are the same as those in your print, dot gain curves and Hybrid Curves will yield almost identical numbers. However if the ink or substrate color are dramatically different than the color target (normally an off-press proof), then there is a big advantage in using density and dot percentage data to create a Hybrid Curve for the printing device. This corrects the affect of colored substrate such as styrene, coroplast, gray-cast vinyl and foamcore.

By applying both sets of data we are adjusting the color in the highlights and shadows for better detail with a dot gain curve but adjusting the quarter-tones, mid-tones and three-quarter tones for more accurate color with an absolute density curve. Therefore, if we mix the two different methods of curving our tonal range we can have great detail and more accurate color. We have created a Hybrid Curve.

I began testing the concept of Hybrid Curves a few years ago when I saw a need for higher level of color control on the diverse colored substrates that screen printers and large format digital printers use. One of the biggest productivity drains of press time is changing ink density to hit specific color targets. A press should be used to produce marketable product. A large format press is not a financially feasible proofing device. I noticed that many of these press delays were caused by substrate color differences. Therefore there was a need to move colors closer with better compensation curves than just dealing with solid density and dot gain data. I realized the need to combine dot gain data with absolute density data.

The results were successful; combining the two sets of data to formulate a better and more accurate curve for color matching works beautifully without the complications of using color management software and hardware. The results are much improved color matching without changing ink densities on the printing device. Hybrid Curves can help move your color closer the first time and eliminate many color adjustments at press. In order to explain Hybrid Curves, let's start with explaining a dot gain, or tonal area curve, and a density curve.

Dot Gain or Tonal Area Curve

If we have a color target that has legible color bars, we can read it with a densitometer and document the target density and tonal percentage values in all of the tonal areas, which include highlight, quartertone, mid-tone, three quartertone and shadows. We adjust the printing device's tonal values with a "dot gain curve." It will match the specified color target as long as the desired color target is on a similar colored substrate and the solid density and hue of the ink is close to my color target. (See Figure 3)

Density Curve

A density curve uses the "Absolute Density" setting of a densitometer. Similar to the dot area curve, the intended color target is measured in absolute density in all the tonal areas. I am talking about more than just reading the solids. Read the tonal values on the color bars in absolute density.

The printed result from the printing device is also measured in absolute density. If we "curve" the output to match the intended target successfully, we match. Actually, we match closer than a dot area curve because we are measuring the values of the substrate, ink density and hue, and the tonal percentage all rolled up into one number. (Figure 4)

This seems to be the total solution until you realize you cannot use an absolute density curve on substrates with excessive color in the white. (Figure 5). Compare the print of this little baby in the grass if we set the substrate color to a styrene color. Notice the nice green grass turned a brown cast. (Figure 6).

The density curve could fix this problem in the higher tonal values but we can't fix lighter tones with density correction because we loose detail. Look at what happens to our curve if we attempt to use absolute density when printing on a cool gray styrene. (Figure 7) Notice that the density curve on the intended target asks for .14 density cyan at the 10 percent area. You could pull the color down in your curve to match color, but you would have no detail in the highlight. (Not good.)

When to Use Hybrid Curves

Here are the Hybrid Curve rules:

- We only need to use hybrid curves when the color of the substrate we are printing on or the ink density is very different from the color target we are attempting to match. (In the large format world, that is about half the time.)
- A dot gain curve does not take into consideration the color that is added by the substrate because we "zero out" the substrate by setting it as "white" and we zero-out the color of the ink because we set it as 100%.
- We are just measuring the dot percentage. If we look at a typical color target and the color of our substrate is different, then we see how we could produce the correct dot percentage and get a color much too dark. (Figure 8, page 9)
- We cannot ignore the substrate color because all of it transfers directly onto our image and challenges our color matching accuracy. In other words, "it makes all the colors too dark." This is why we revert to the density curves in tonal values that are high enough to not lose detail if we adjust them down for correct color. This eliminates the need to "lower the solid density of the ink

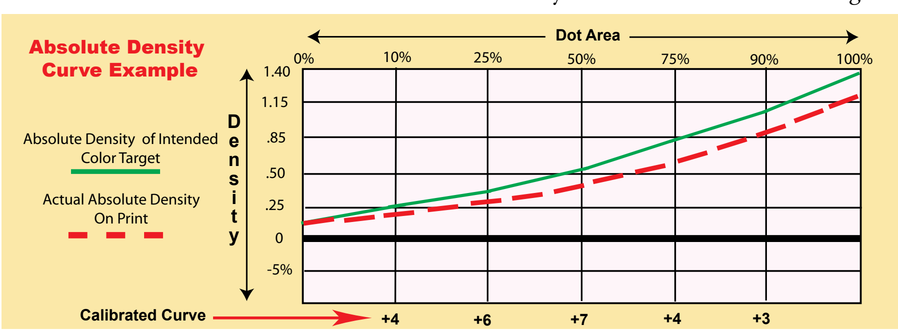


Figure 4: Absolute Density Curve

Figure 5: Standard Substrate Color in Photoshop

Figure 6: Styrene Simulation

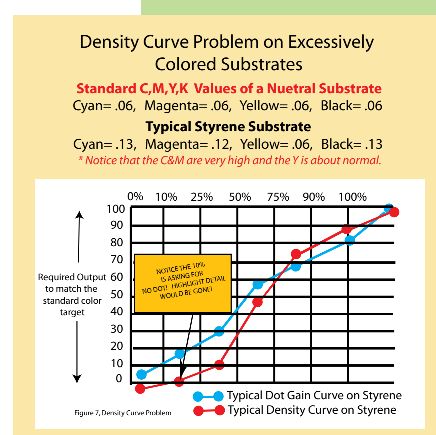


Figure 7: Absolute Density Curve Problem

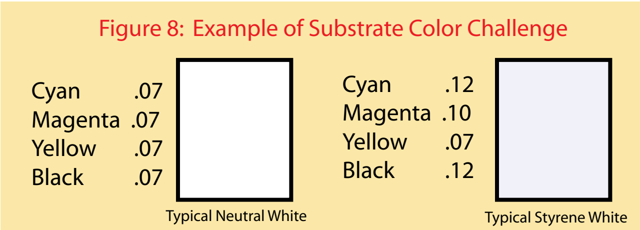
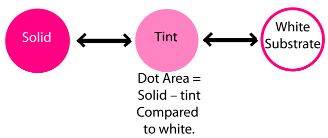


Figure 8: Substrate Color Challenge

Murray-Davies Dot Area Equation

The Murray-Davies formula simply calculates dot by comparing the density of the tint minus paper with the density of the solid minus paper. Most densitometers default to the Murray-Davies equation for dot area or dot gain calculations.



Yule-Nielson Dot Area Equation

The Yule-Nielson equation of dot area measurement allows compensation for the amount of light that is "absorbed" or "trapped" when a dot measurement is taken. In other words, it removes the effect of optical gain by the use of an "N-Factor". Using the Murray-Davies equation, your instrument's N-Factor is simply 1.00. Dot area is just a calculated difference from the solid compared to what is entered as zero or paper. Using the Yule-Nielson formula, the paper and solid densities are divided by an "N-Factor" value that is based on the properties of the substrate material. This will measure true physical gain only if you have the correct N-Factor entered into the instrument.

THE CORRECT N-FACTOR MUST BE USED FOR DIFFERENT SUBSTRATES AND LINE COUNTS.

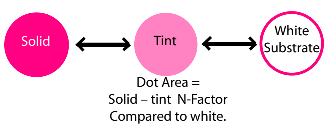


Figure 9: Murray Davies and Yule Neilson

Dot Gain Chart as read using Murrry Davis Equation

Cyan	Density = 1.44	Angle = 82.5	
1 = 3	26 = 41	51 = 69	76 = 86
2 = 6	27 = 43	52 = 69	77 = 87
3 = 8	28 = 44	53 = 71	78 = 87
4 = 9	29 = 45	54 = 71	79 = 88
5 = 11	30 = 46	55 = 72	80 = 89
6 = 13	31 = 48	56 = 72	81 = 89
7 = 14	32 = 49	57 = 73	82 = 90
8 = 16	33 = 50	58 = 73	83 = 90
9 = 18	34 = 51	59 = 74	84 = 91
10 = 19	35 = 52	60 = 76	85 = 91
11 = 21	36 = 53	61 = 76	86 = 92
12 = 23	37 = 55	62 = 77	87 = 93
13 = 24	38 = 55	63 = 77	88 = 94
14 = 25	39 = 57	64 = 78	89 = 94
15 = 26	40 = 58	65 = 79	90 = 95
16 = 28	41 = 59	66 = 79	91 = 95
17 = 30	42 = 61	67 = 80	92 = 96
18 = 30	43 = 61	68 = 81	93 = 97
19 = 32	44 = 62	69 = 81	94 = 97
20 = 33	45 = 63	70 = 82	95 = 98
21 = 34	46 = 64	71 = 83	96 = 98
22 = 36	47 = 65	72 = 83	97 = 99
23 = 37	48 = 66	73 = 84	98 = 99
24 = 39	49 = 67	74 = 85	99 = 100
25 = 39	50 = 68	75 = 85	100 = 100

Magenta	Density = 1.44	Angle = 52.5	
1 = 4	26 = 42	51 = 70	76 = 87
2 = 6	27 = 43	52 = 70	77 = 87
3 = 8	28 = 45	53 = 71	78 = 88
4 = 11	29 = 46	54 = 72	79 = 89
5 = 12	30 = 47	55 = 73	80 = 89
6 = 14	31 = 48	56 = 73	81 = 90
7 = 15	32 = 49	57 = 74	82 = 90
8 = 17	33 = 51	58 = 74	83 = 91
9 = 18	34 = 52	59 = 75	84 = 92
10 = 20	35 = 53	60 = 76	85 = 92
11 = 21	36 = 54	61 = 77	86 = 93
12 = 23	37 = 55	62 = 77	87 = 94
13 = 24	38 = 56	63 = 78	88 = 94
14 = 26	39 = 57	64 = 79	89 = 95
15 = 27	40 = 59	65 = 79	90 = 96
16 = 28	41 = 60	66 = 80	91 = 96
17 = 30	42 = 61	67 = 81	92 = 96
18 = 31	43 = 62	68 = 81	93 = 97
19 = 32	44 = 64	69 = 82	94 = 98
20 = 34	45 = 64	70 = 82	95 = 98
21 = 35	46 = 65	71 = 83	96 = 99
22 = 37	47 = 66	72 = 84	97 = 99
23 = 38	48 = 67	73 = 85	98 = 100
24 = 39	49 = 68	74 = 85	99 = 100
25 = 40	50 = 69	75 = 86	100 = 100

Yellow	Density = 0.98	Angle = 7.5	
1 = 3	26 = 40	51 = 68	76 = 86
2 = 5	27 = 41	52 = 68	77 = 87
3 = 7	28 = 42	53 = 70	78 = 87
4 = 9	29 = 43	54 = 70	79 = 88
5 = 10	30 = 45	55 = 71	80 = 88
6 = 12	31 = 46	56 = 72	81 = 89
7 = 13	32 = 47	57 = 72	82 = 89
8 = 15	33 = 49	58 = 73	83 = 90
9 = 17	34 = 50	59 = 74	84 = 91
10 = 18	35 = 51	60 = 74	85 = 91
11 = 20	36 = 52	61 = 75	86 = 92
12 = 21	37 = 53	62 = 76	87 = 92
13 = 23	38 = 54	63 = 77	88 = 93
14 = 23	39 = 55	64 = 78	89 = 94
15 = 25	40 = 57	65 = 78	90 = 95
16 = 26	41 = 58	66 = 79	91 = 95
17 = 28	42 = 59	67 = 79	92 = 96
18 = 29	43 = 60	68 = 80	93 = 97
19 = 31	44 = 61	69 = 81	94 = 97
20 = 32	45 = 62	70 = 81	95 = 98
21 = 33	46 = 63	71 = 72	96 = 98
22 = 35	47 = 64	72 = 83	97 = 99
23 = 36	48 = 65	73 = 84	98 = 99
24 = 38	49 = 66	74 = 84	99 = 100
25 = 38	50 = 67	75 = 85	100 = 100

Black	Density = 1.83	Angle = 112.5	
1 = 4	26 = 41	51 = 68	76 = 86
2 = 6	27 = 42	52 = 69	77 = 87
3 = 8	28 = 43	53 = 70	78 = 87
4 = 10	29 = 44	54 = 71	79 = 88
5 = 11	30 = 46	55 = 71	80 = 89
6 = 13	31 = 47	56 = 72	81 = 89
7 = 14	32 = 48	57 = 73	82 = 90
8 = 16	33 = 50	58 = 73	83 = 90
9 = 17	34 = 50	59 = 74	84 = 91
10 = 19	35 = 51	60 = 75	85 = 92
11 = 21	36 = 53	61 = 75	86 = 92
12 = 22	37 = 54	62 = 77	87 = 93
13 = 24	38 = 55	63 = 77	88 = 94
14 = 25	39 = 56	64 = 78	89 = 94
15 = 26	40 = 56	65 = 78	90 = 95
16 = 27	41 = 58	66 = 79	91 = 95
17 = 29	42 = 60	67 = 80	92 = 96
18 = 30	43 = 60	68 = 80	93 = 97
19 = 32	44 = 62	69 = 81	94 = 97
20 = 33	45 = 62	70 = 82	95 = 98
21 = 34	46 = 64	71 = 83	96 = 99
22 = 36	47 = 65	72 = 83	97 = 99
23 = 37	48 = 65	73 = 84	98 = 99
24 = 38	49 = 67	74 = 85	99 = 100
25 = 39	50 = 67	75 = 85	100 =100

Imation Matchprint Proof
Low Gain Base
Commercial Color

Dot shape = Elliptical
Resolution = 4000
LPI 62

Figure 10: Complete Tonal Range GAIN Targets for 150 LPI Proofs

because it is too dark". Lowering solid density to get the mid-tone value down because of color added by the substrate only fixes the mid-tone. We do not want to do that because anything dependent on the solid is a problem.

- Giving up the nice solid density to hit correct mid-tone value is like walking through a barnyard and making a decision on which cow pile to step in. (Not good.)

How to Acquire Dot Percentage Data

There are two distinct ways to measure dot percentage; the Murray Davies and the Yule Neilson. (See Figure 9) Dot percentage needed to set curves should be measured in the Murray Davies formula.

Basically, what happens with the Murray Davies formula is this:

1. We enter the solid value into the densitometer. The densitometer converts this to a value of 100 percent. We then enter the white or "paper" value into the densitometer and it converts this value to 0 percent.
2. After we enter these values, any value less than 100 percent or more than 0 percent will be assigned a percentage number. For example a value exactly halfway between what we set as "white" and what we set as "solid" will have a dot percentage of 50 percent.

Note: In this measurement, the densitometer does not consider a print with the solid ink density that might be extremely low or high. It also does not compensate for substrate color, such as a cool-gray coroplast, cool-gray styrene, yellow foamboard or a bright white decal. The densitometer reads the gray coroplast as white "0" because you set it as white "0." All the data the densitometer records is the dot area values.

After we have set our densitometer up properly, we measure the intended target and the results from linear film printed on a qualified press. Record the dot area data of the print. The dot area curve will be the numbers that correspond to the numbers you are targeting on your intended target. (Figure 10, Typical Dot area of Graphic Arts Industry Standard Proofing.)

How to Acquire Absolute Density Data

Absolute density is the densitometer setting we need for calculating our density curves. Do not subtract out the substrate!

Absolute density is calculated by how much light a substrate or ink on a specific substrate absorbs. It measures what is reflecting back to the densitometer or spectrophotometer. For useful and accurate color data, printers should use "Absolute density" rather than density minus paper because the color that is added by the substrate affects the visual acceptance of the color. Remember the "North Star" includes the substrate, the ink and the tonal percentages. We want all of these elements in our measurement if we want to be accurate.

The way we acquire our data is:

1. Set our densitometer or spectrophotometer to Absolute Density.
2. Measure the key color control tonal values on our color bar and record them in absolute density.
3. Measure the solid density of the ink. Measure the C, M, Y, and K of the solid ink. (All colors)
4. Measure the substrate and record C, M, Y, and K of the substrate.

(Figure 11)

Absolute Density Chart of Dot Area's

Cyan	Density = 1.43	Angle = 82.5	
1 = .06	26 = .23	51 = .49	76 = .81
2 = .06	27 = .24	52 = .51	77 = .82
3 = .06	28 = .25	53 = .52	78 = .84
4 = .08	29 = .26	54 = .53	79 = .86
5 = .08	30 = .27	55 = .54	80 = .87
6 = .09	31 = .28	56 = .56	81 = .88
7 = .10	32 = .29	57 = .56	82 = .90
8 = .10	33 = .30	58 = .57	83 = .92
9 = .11	34 = .31	59 = .59	84 = .94
10 = .12	35 = .32	60 = .60	85 = .95
11 = .12	36 = .33	61 = .61	86 = .98
12 = .13	37 = .34	62 = .62	87 = 1.0
13 = .14	38 = .35	63 = .63	88 = 1.03
14 = .15	39 = .36	64 = .65	89 = 1.05
15 = .16	40 = .37	65 = .66	90 = 1.07
16 = .16	41 = .39	66 = .68	91 = 1.09
17 = .17	42 = .40	67 = .68	92 = 1.13
18 = .17	43 = .41	68 = .70	93 = 1.17
19 = .18	44 = .43	69 = .71	94 = 1.21
20 = .19	45 = .43	70 = .72	95 = 1.27
21 = .20	46 = .44	71 = .74	96 = 1.31
22 = .21	47 = .45	72 = .74	97 = 1.36
23 = .22	48 = .46	73 = .77	98 = 1.37
24 = .22	49 = .48	74 = .78	99 = 1.43
25 = .23	50 = .48	75 = .80	100 = 1.43

Magenta	Density = 1.42	Angle = 52.5	
1 = .07	26 = .25	51 = .51	76 = .82
2 = .08	27 = .25	52 = .53	77 = .84
3 = .08	28 = .27	53 = .54	78 = .86
4 = .09	29 = .28	54 = .54	79 = .88
5 = .10	30 = .29	55 = .56	80 = .90
6 = .10	31 = .30	56 = .56	81 = .91
7 = .10	32 = .31	57 = .58	82 = .93
8 = .11	33 = .32	58 = .59	83 = .94
9 = .12	34 = .33	59 = .61	84 = .96
10 = .13	35 = .35	60 = .62	85 = .98
11 = .13	36 = .36	61 = .63	86 = 1.0
12 = .14	37 = .36	62 = .64	87 = 1.03
13 = .15	38 = .38	63 = .65	88 = 1.04
14 = .15	39 = .39	64 = .66	89 = 1.07
15 = .16	40 = .40	65 = .67	90 = 1.09
16 = .17	41 = .41	66 = .69	91 = 1.13
17 = .18	42 = .42	67 = .70	92 = 1.17
18 = .19	43 = .43	68 = .72	93 = 1.19
19 = .19	44 = .44	69 = .73	94 = 1.24
20 = .20	45 = .45	70 = .74	95 = 1.29
21 = .21	46 = .46	71 = .76	96 = 1.33
22 = .22	47 = .47	72 = .77	97 = 1.38
23 = .22	48 = .49	73 = .79	98 = 1.40
24 = .24	49 = .50	74 = .80	99 = 1.42
25 = .24	50 = .51	75 = .82	100 = 1.42

Yellow	Density = 0.99	Angle = 7.5	
1 = .06	26 = .23	51 = .43	76 = .66
2 = .07	27 = .24	52 = .44	77 = .68
3 = .08	28 = .24	53 = .45	78 = .69
4 = .09	29 = .25	54 = .45	79 = .69
5 = .09	30 = .26	55 = .46	80 = .71
6 = .10	31 = .27	56 = .47	81 = .71
7 = .11	32 = .28	57 = .49	82 = .72
8 = .11	33 = .28	58 = .49	83 = .73
9 = .12	34 = .29	59 = .51	84 = .74
10 = .13	35 = .30	60 = .52	85 = .75
11 = .13	36 = .31	61 = .52	86 = .77
12 = .14	37 = .32	62 = .54	87 = .78
13 = .14	38 = .32	63 = .54	88 = .80
14 = .15	39 = .34	64 = .55	89 = .81
15 = .15	40 = .35	65 = .56	90 = .83
16 = .16	41 = .36	66 = .57	91 = .83
17 = .17	42 = .37	67 = .58	92 = .85
18 = .17	43 = .37	68 = .59	93 = .87
19 = .18	44 = .38	69 = .60	94 = .89
20 = .19	45 = .38	70 = .61	95 = .91
21 = .19	46 = .39	71 = .62	96 = .93
22 = .20	47 = .40	72 = .62	97 = .95
23 = .20	48 = .41	73 = .63	98 = .96
24 = .21	49 = .42	74 = .64	99 = .99
25 = .22	50 = .43	75 = .65	100 = .99

Black	Density = 1.83	Angle 112.5	
1 = .07	26 = .23	51 = .50	76 = .84
2 = .08	27 = .24	52 = .52	77 = .87
3 = .09	28 = .24	53 = .53	78 = .89
4 = .10	29 = .25	54 = .53	79 = .91
5 = .10	30 = .27	55 = .54	80 = .93
6 = .11	31 = .28	56 = .56	81 = .96
7 = .11	32 = .29	57 = .57	82 = .97
8 = .12	33 = .30	58 = .57	83 = 1.0
9 = .13	34 = .31	59 = .60	84 = 1.01
10 = .14	35 = .32	60 = .62	85 = 1.03
11 = .12	36 = .33	61 = .63	86 = 1.06
12 = .13	37 = .34	62 = .65	87 = 1.08
13 = .14	38 = .35	63 = .66	88 = 1.12
14 = .14	39 = .36	64 = .67	89 = 1.14
15 = .15	40 = .38	65 = .68	90 = 1.19
16 = .15	41 = .40	66 = .70	91 = 1.22
17 = .16	42 = .40	67 = .71	92 = 1.27
18 = .17	43 = .41	68 = .72	93 = 1.34
19 = .17	44 = .43	69 = .73	94 = 1.39
20 = .18	45 = .43	70 = .75	95 = 1.46
21 = .19	46 = .44	71 = .78	96 = 1.54
22 = .21	47 = .45	72 = .79	97 = 1.63
23 = .21	48 = .46	73 = .81	98 = 1.67
24 = .22	49 = .47	74 = .83	99 = 1.83
25 = .22	50 = .48	75 = .84	100 = 1.83

Imation Matchprint Proof
Low Gain Base
Commercial Color
Xrite 508 Denstimeter Settings: Auto, Absolute, Status T

Dot shape = Elliptical
Resolution = 4000
LPI 150

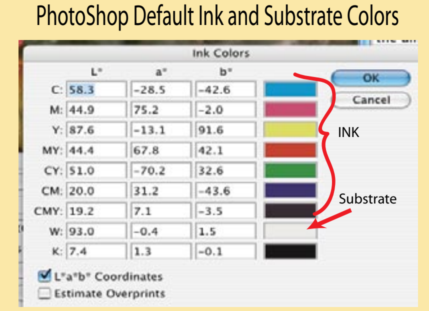
Figure 11: Complete Tonal Range DENSITY Targets for 150 LPI Proofs

Conforming to Graphic Arts Industry Standards

Dot percentage and density are specified in Graphic Arts Industry Standards for analog proofing material. This gives us a benchmark of what is visually standard. It is based on print standards of the most common forms of printing. SNAP standards are for newspaper publications so we really only need to understand GRACol of SWOP to make an intelligent decision about our color target.

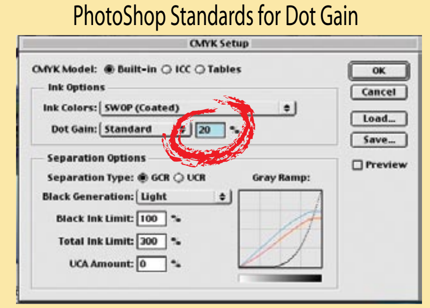
Some graphics consultants say we don't have to conform. This is a very big mistake and will cost you a lot of money in color matching incoming files and proofs. Not conforming is only possible if we don't print for clients that design in Photoshop or have proofing systems calibrated to GRACol or SWOP standards. We also need to pay attention to these standards because the monitors that graphic artists use to develop artwork are visually simulating and transmitting these same densities and dot percentages on the screen. (Figures 12 & 13)

Check it out on your own monitor. If you open and image in Photoshop go to the "colorsetting menu." (Edit>colorsettings>CMYK Setup>Dot Gain) If you have a CMYK image selected, change the dot gain to "0" and see what your image looks like. It will look washed out.



Photoshop (and other image manipulation programs) set the default for ink and Substrate.

Figure 12: Default Photoshop Colors.



Photoshop (and other image manipulation programs) set the default for viewing images on the monitor at 20% gain. We cannot ignore this because this is what the people creating the art are seeing on their monitors.

Figure 13: Photoshop default dot gain.

Standard Substrate Color

Again, if we look at the world's most popular image manipulation program (Photoshop), we can see the "default standard" Adobe has set. Look at Figure 12 again. (Edit>colorsettings>CMYK Setup>Custom Ink Colors)

Line count:	87	Substrate: Styrene L*=92.39, A*= - 2.09 B*= - 5.14 C=.11, M= .08, Y=.06, K=.09.			
Tonal area of the file	10%	25%	50%	75%	90%
Dot curve	12	29	55	78	88
Density Curve	7	25	47	71	90
Hybrid Curve	12	25	47	71	88

Table 1: Dot gain curve and Density Curve Combined to make a Hybrid Curve

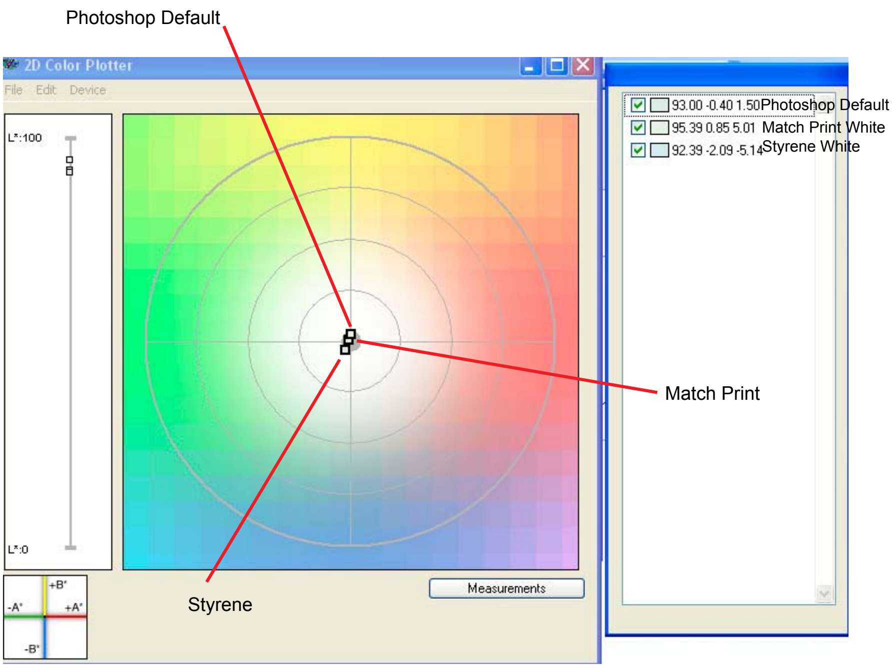


Figure 14: White Point Study

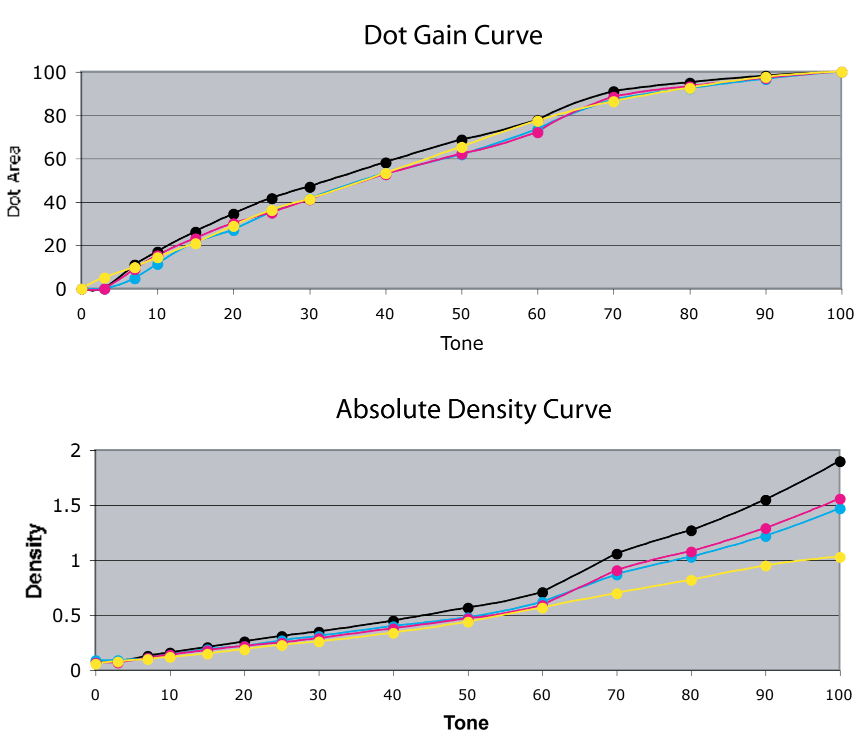


Figure 15: Dot Gain and Density Data

In the ink color palette, it shows the color of the white. (Substrate). It is in L*A*B* color space L*=93.0, A*= - 0.4 and B*= 1.5. Notice that the B axis is a positive number. That means Adobe assumes you are printing on a slightly yellow substrate. (Certainly not a blue substrate.) The Imation Matchprint base is about L*= 95.39, A*= - 0.85 and B*= 5.01.

Wow! It's a lot more yellow. Now let's compare this to a typical styrene substrate color. (L*=92.39, A*= - 2.09 and B*= - 5.14) Notice the minus sign on the B axis. It has moved to the blue side. Also, the A axis is now on green side instead of the red side. If I convert this to the CMYK absolute densities of the styrene, it is C=.11, M= .08, Y=.06 and K=.09. (Figure 14)

You can see the blue gray cast but you probably didn't realize that the substrate was adding so much magenta and that the yellow was almost the same as the Photoshop default. This understanding can take you to new exciting places.

The Affects of Non-Standard Substrates

You might ask, "Is it worth it to adjust for the excessively colored substrates?" Think about this. If we were always printing on very neutral and white substrates, it would be like driving in Western Kansas, with no curves, hills or bumps in the road. But as Dorothy in the Wizard of Oz said, "We're not in Kansas, Toto."

We are not printing on standard and neutral white substrates most of the time. Standard specification charts tell us what the standards are for density and dot percentage. This works well as long as we are printing on a substrate exactly the same color as the substrate, which is the same as the Graphic Arts Industry Standard.

When the substrate is different, the affect of this will be a very strong color shift toward the substrate color because the colors we use for process color printing CMYK are very translucent. This means we will have to adjust for the color added by the substrate.

The Correspondence of Dot Gain and Density Data

In Figure 15, you see the dot percentage data gathered by a densitometer in the Murray Davies formula compared with the absolute density data from the same Graphic Arts Industry Standard analog proof. This gives you a good perception of how dot percentage relates to absolute densities.

Developing hybrid curves.

We have discussed how to create a dot gain curve and a density curve. To determine if color would be better with a Hybrid curve just simply look at the data and compare it. (Table 1)

If the density curve is very low in the highlight area and would require moving tonal values below 10% dot percentage in the 10%, use a dot area curve for the highlight. If the mid-tone shows the density curve lower in the mid-tone than the dot area curve, use the density curve in the mid-tone to correct the color. This will overcome the weaknesses of the dot area curve and the weakness of the density curve. We will affectively be combining the best attributes of both. The results will be an acceptable alternative that will get us closer to the intended color target without sacrificing detail; The "Hybrid Curve". (Figure 16)

The following is a review of the steps we have described here.

Step one: Determine the color target. (Make sure it has readable color bars in all tonal areas.)

Step two: Measure the color target.

Step three: Print a linear tonal ramp on the printing device on the substrate you are setting the curve for.

Step four: Document the dot area data of the print required to achieve a match to the color target.

Step five: Document the absolute density area of the print that is required to match the color target.

Step six: Evaluate the data side-by-side.

Step Seven: Set a Hybrid curve using the follow criteria.

a. Use the dot gain curve if the density curve requires moving the 10% dot area lower than 10%. (This protects the detail but sacrifices an exact color match in the highlight.)

b. Use the density curve in the mid-tones to correct the color to match the target.

c. Use the dot gain curve in the shadow to ensure detail above the 90% area. This sacrifices very little color because shadow colors are not dramatically affected by dot area. (There is not much dot area there.)

Controlling the Hybrid Curve on Press.

After you have set your Hybrid Curve you need to train the printers to first print a clean dot in register then check 50% dot area in absolute density. The value should be the same as your intended target. Absolute density numbers in the mid-tone truly identify correct color compared to the intended color target. If the number is exact, your color will probably be very close. You will immediately see that the excessive colored substrates that you struggle with will look a lot closer to your color target than prints that use no curve at all or use just a dot gain curve. Remember that a Hybrid Curve also has its weakness. It will not match the color target in the highlights unless the color target is simulating the color of the substrate. You will still notice that the lighter tones will still be cast toward the substrate color. This is normal and acceptable deviation from the target if the color target does not simulate the color of the substrate.

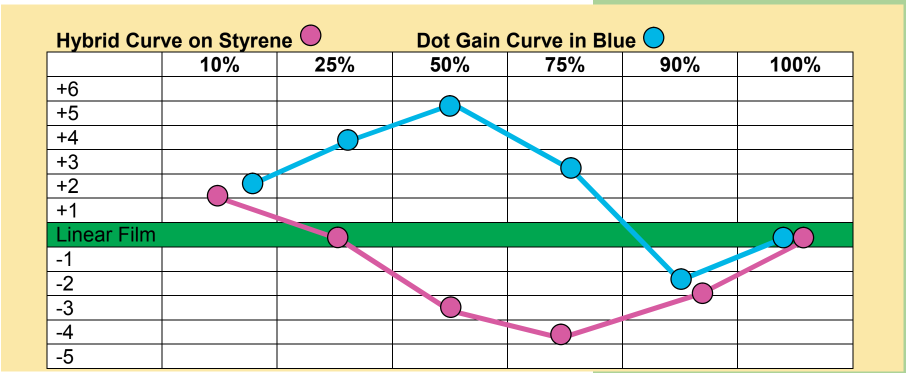


Figure 16: Hybrid Curve vs. Dot Gain Curve on an Excessively Colored Substrate

Conclusion:

I close with this thought. Countless hours of screen press and digital press time is wasted in print facilities each year by not understanding and adjusting the tonal values and absolute densities to the best match possible to a qualified color target. I hope this helps you in understanding the objectives, understanding the target and understanding the data needed to adjust for the best color match possible. If Hybrid Curves saves you only 1 hour a day, on an in-line screen press or a large format digital device this would save you 260 hours per year. At a billing rate or $500 per hour for these devices that would be $130,000 per year per press. A nice bonus for just a little work in developing "Hybrid Curves".