Technical

Root Cause and Print Analysis in 4-Colour Process

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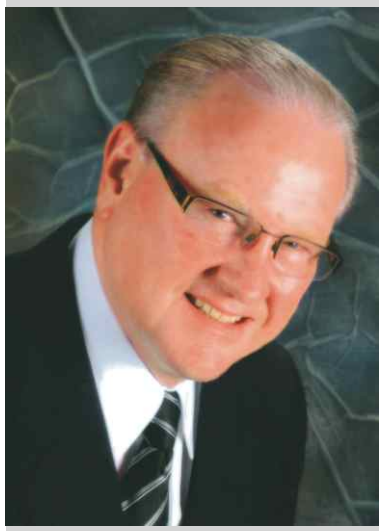

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- Member of the IDEAlliance Print Properties Committee
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Introduction:
In print production of 4-colour process screen printing the most critical time associated with producing a profitable job is in the time it takes to achieve the desired color result. Taking too long to analyze print colour problems are mostly caused by a lack of knowledge and poor methodology for quickly determining the cause of colour matching issues. You must have the correct data and the knowledge of how to use it to quickly make the right move the first time. Not understanding this quickly adds up to hundreds of hours of lost press time every year. It causes the daily schedule to always be lagging behind. It causes overtime that is never added to the customer's bill. Profits (and our family times) are challenged when it causes us to work weekends for free.

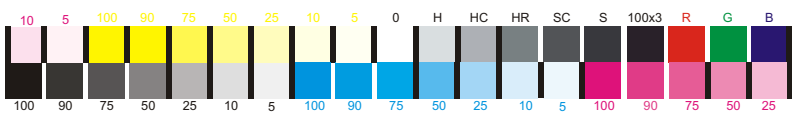
In this short article I will explain **4-colour process root cause and print analysis**. This is a method I developed over time that will save you critical press time, increase your accuracy and improve your productivity. I will explain 3 things.

1. Tools Needed
2. Critical Print Properties of Process Colour
3. How to do print analysis and quickly determine colour moves.

Tools Needed: In 4-colour process screen print analysis there are many tools and software that will eliminate subjective opinion and guessing about colour moves. Your eyes are not the best choice when it comes to analyzing a print. Just because a print is too red or too blue doesn't mean the solid density is wrong. The instruments I will use in this teaching will be a good colourbar, a densitometer, a hand-held spectrophotometer and some data capture software (DCS3) that speeds up the analysis. However, all the values I show can be measured without software by just a standard densitometer or a hand-held spectrophotometer.

Screen PrintColour Bar: (Figure 1)
This powerful screen print colour bar shown in Figure 1is the IDEAlliance12647-5 Screen Print Colour Bar. This simple control strip contains everything you need to do very sophisticated print analysis but it is simple enough not to be confusing. It contains, pure tonal values of the 5%,10%,25%,50%,75%,90% and all the 100% CMYK solids. It reports grey balance of the 10%, 25%, 50%, 75%, 90% as well as the 100x3. (The 100x3 is the solid C,M,Y overprint ink set grey balance.) It has a white patch for the substrate and the Red, Green and Blue overprints. This is all you need for print analysis. This simple but powerful colour bar can also be used in digital print evaluation. Your analysis doesn't have to be from this colour bar but if you want to use it you can download it for free from our website.www.nazdarconsulting.com.

Figure - 1, IDEAlliance 12647-5 Screen Print Colour Bar



The 12647-5 Colour Bar is designed as a complete on-press analysis tool. It provides density, dot area, grey balance information, Red, Green and Blue overprints and 100x3 solid ink balance data.

Densitometer:
(Figure 2) The X-rite 508
This is the most basic instrument required to do print analysis. The two primary functions I will use in my analysis are density and dot area. But with these two functions you can also calculate grey balance and solid ink balance.

Figure 2, Standard Densitometer

Quick and accurate trouble shooting both on and off press can be achieved with a standard densitometer. For calibration and fine tuning our colour matching we would want to add the capability of a full Spectrophotometer but for standard press control this instrument works just fine.

Density: The most basis data a densitometer captures is density. You can subtract the paper value automatically by using the minus paper feature but I recommend using the densitometer in the "absolute mode" and evaluating density with paper included because the final result you see in an image has paper included.

Dot Area / Dot Gain / TVI: All of these terms represent the value of the area that is covered by a dot compared to the nominal value of patch on the file.Paper is subtracted by simply reading the paper and the densitometer automatically knows this is the "zero" point. Therefore to read dot area, dot gain or TVI, you must establish you substrate as "zero" and your solid C,M,Y,K colours as 100%. The densitometer then just reports the value of your colour bar patch compared to the substrate and solid. A colour bar is the only way that you can be sure you are measuring the tonal value you want to control. Dot area, dot gain or TVI are the numbers representing the tonal value of the printed patch.The difference in dot area from dot gain or TVI is that in dot area the densitometer does not subtract the value of the colour patch. An 18% gain reading on a 50% colour patch in dot area will simply be 68% dot area, but in dot gain or TVI it would be 18% gain or 18% Tonal value increase.

Grey Balance: (Figure 3, Grey Balance).You also can read a process colour gray patch and determine grey balance using absolute density. You can also check it in

Figure - 3, Midtone Grey Balance

This C,M&Y grey patch in the photograph is almost perfectly balanced. This is the fastest method for analyzing a print on press. The tonal value of the file in the midtone grey patch should be C=50%, M=40%, Y=40%. But after overprinting it should produce a balanced absolute density of about C=.58, M=.58, Y=.58 with a .04 maximum spread tolerance.

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L*a*b* but absolute density is easier for a pressman to use because they are normally using a densitometer on press, not a spectrophotometer.If the densities of the solids are right and the TVI is correct, the 3-color grey reading will quickly indicate the colour that is high or low. Figure 3 shows the density values of a C,M&Y grey patch almost perfectly balanced. This is the fastest way to analyze a print on press. The tonal value of the file in the midtone grey patch should be C=49.1%, M=40%, Y=40%. But after overprinting the C,M,Y it should produce a balanced absolute density at about C=.58, M=.58, Y=.58 with a .04 maximum spread tolerance. If the substrate is adding a cast, this simply means you should adjust the curve of the offending color to bring it into a neutral compliance.

Figure 4, Solid Ink Balance

A very useful tool of a modern densitometer is the ability to calibrate and monitor "solid ink balance". This is also sampled using absolute density. The 100% C,M&Y should be within .05 of the same density when you read the 100% of the three colours as they overprint. This means your solid inks are balanced and as the inks overprint in the image they do not add a colour cast to the print.

100x3 Ink Balance: (Figure 4, Solid Ink Balance). The densitometer will also report your balance of your ink set in absolute density. This is critical to good grey balance because if your C,M,Y overprint is not neutral, you are throwing a colour cast into the print throughout the entire image.

Critical Print Properties of Process Colour:

Critical Print Properties for On-Press Analysis are only 3 things that represent a comparison between the colour target and the print. They are:

1. Absolute Density:
2. Grey Balance Density values.
3. L*a*b* values compared to my target data set.

Print analysis and determining color moves.

On the analysis below I am just using a low costXrite i1. This instrument is handy because the software converts the spectral data that I scan to what ever I need. (Density, TVI or L*a*b*) The software I'm using is called DCS3. We created this for analyzing screen print and digital print results. You can read more about it at www.nazdarconsulting.com. The software is simple, fast and easy to see what is happening on a print.

Order of Analysis:

Your focus on trouble shooting while on press must be speed. We must get the press running as quickly as possible producing an acceptable product. Therefore we need to have an order of evaluation with the most valuable information for trouble shooting first. If I solve the problem with the first thing I look at, I am not going to continue with analysis exercises that do not matter on the specific print I am analyzing. When the job is completed, I will then use the other data for tracking potential curve, density or ink adjustments I may need to do for future jobs. But my goal while on press is to solve the colour issue and then continue printing with the right solutions as quickly as possible. This is the order I suggest looking at a scan of a colour bar.

Figure - 5, Grey Balance Assessment

Gray Bars	Target				Job			
	V	C	M	Y	V	C	M	Y
Substrate	0.06	0.06	0.05	0.05	0.07	0.07	0.06	0.06
HC	0.31	0.30	0.30	0.30	0.38	0.38	0.34	0.33
HR	0.59	0.58	0.58	0.58	0.71	0.73	0.61	0.59
SC	0.96	0.94	0.94	0.94	1.03	1.00	0.94	0.90
100X3	1.42	1.40	1.40	1.40	1.27	1.11	1.32	1.35

1. Grey Balance Assessment:

Just one quick measurement of the grey balance results of the IDEAlliance12647-5 Screen Print colour bar and compare it to the desired grey balance in absolute density.

The numbers on the left are the "Target". The numbers on the right are the print I am comparing to the ideal values on the left.

Notice that the HR (Midtone grey balance) shows a cyan of .73 absolute density. With magenta at .61 and yellow at .59 this is a blue cast. I have to adjust the density of the cyan down or reduce the dot gain. But which one is the correct move? The grey balance is only is an indication of the colour cast and strong and weak colours. But to correct the colour I need to investigate the solid density before I can make that determination. If the solid density is correct, then the dot gain is too high in the cyan. If the solid density is not too high, then it is a dot gain issue. It could be both. If I am looking at just the grey balance I might assume that the density is too high in the cyan but it might the dot gain or the solid density of the cyan could even be too low.

2. Absolute Solid Density Assessment:

Inspection of the solid densities compared to the colour target is very interesting. Notice that the cyan on the job is only .98 and the target is 1.45. But the grey balance shows that the print is way too blue. This proves that printers that see blue and automatically run to the ink room for the base to lower the density on the cyan are making a mistake. The density is already too low. It is the dot gain of the cyan that is the problem. The print is over all weak in density with the cyan being the worst. The grey balance issue is gain, not density.

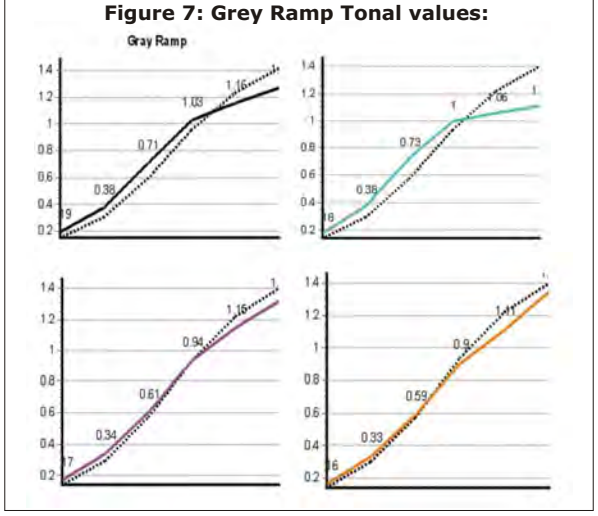
Figure 6: Absolute Density Assessment

	Density	Target	Job		Density	Target	Job
CYAN	100%	1.45	0.98	MAGENTA	100%	1.45	1.23
	75%	0.90	0.78		75%	0.90	0.80
	50%	0.53	0.39		50%	0.53	0.45
	25%	0.28	0.25		25%	0.28	0.26
YELLOW	100%	1.00	0.84	BLACK	100%	1.70	1.61
	75%	0.73	0.62		75%	0.96	0.84
	50%	0.45	0.30		50%	0.56	0.42
	25%	0.25	0.18		25%	0.30	0.25

3. Grey Ramp Tonal values:

The CMY&K Grey Ramp tonal values map a standard line that tonal values should follow to achieve a neutral grey print. A neutral grey print will allow all the colours within the process image to be represented accurately because the press is not adding a colour cast to the image. You can see by the tone value grey ramp here that, just as the grey bar indicated, the cyan is too high in from the SC (3/4 quartertone,75% area and down.) But notice the solid of the cyan. It's somewhere South of New Zealand. Someone has lowered the solid density to try to fix the excessive cyan dot gain. It didn't work. The problem is the dot gain from the ¾-tone down. The density is actually too low in the cyan.

Figure 7: Grey Ramp Tonal values:



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The "K" in the grey tone ramp is not really the pure black tonal percentage in this graph. It is the result of the C,M and Y blending to make a black. So the high cyan is pushing the line up. The pure black is monitored in the pure colour bars. All the colours are a little weak in the solids. But the magenta and yellow are close to correct from the SC (3/4 tone down.) Looking at the tonal values in a gray ramp rather than the pure colours is much more accurate because the inks here are blending together to create the image.

4. Ink Set Balance: (100x3)

Figure 8: Ink Set Balance: (100x3)

Ink Set Balance: (100x3)

Gray Bars	Target				Job			
	V	C	M	Y	V	C	M	Y
100X3	1.42	1.40	1.40	1.40	1.27	1.11	1.32	1.35

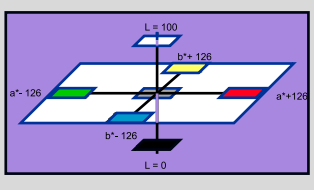
At the bottom of the grey balance analysis there is a line that shows the 100x3. The numbers on the right are the print. The numbers on the left are the balanced ideal target for the ink balance. The balance of the C,M,Y is what is important here. The 100x3 reading is the absolute value of the density reading of the 100% CMY overprint. Notice that the cyan is low on the solid. This means the low cyan density is adding a "red" cast to the upper tonal area. A high cyan dot gain and a touch of "red" from the ink cast causes blue cast but above the ¾ tone there is actually a red cast. This may be why the dot gain of the cyan is up because a pressman was attempting to correct the red cast from the ink and the cyan solid density was the real problem. This is a case of someone correcting the wrong thing and causing an unexpected adverse result in another part of a balanced process colour image. This ink set should be balanced and then the tonal values should be adjusted to produce neutral grey.

5. L*a*b* Comparisons(See the L*a*b* Illustration)

The first thing to look at on press after you have at least 15 to 20 cycles of the squeegee and are printing clean dot and the print is in register is "grey balance". If the print is in grey balance and the print looks good, print it. But if you are struggling to match colour and it is a chronic problem, then take a look at the L*a*b* comparisons of the print properties of your target compared to your print. I will go through them here to show you that they also indicate the same problems we noted with the densitometer but add some insight on the correct corrective action.

L*a*b* Comparisons (See the L*a*b* Illustration)

	Target			CIE1976	Job		
	L*	a*	b*	Δ E	L*	a*	b*
1. Cyan	55.00	-37.00	-50.00	13.16	64.06	-35.25	-40.62
2. Magenta	48.00	74.00	-3.00	8.54	51.37	69.66	-9.54
3. Yellow	89.00	-5.00	93.00	8.92	90.28	-9.43	85.36
4. Black	16.00	0.00	0.00	1.96	17.52	0.24	1.21
5. Substrate	95.00	0.00	-2.00	1.82	93.85	-0.64	-0.75
6. HC	75.74	0.00	-1.46	6.75	70.90	-4.01	-3.93
7. HR	57.53	0.00	-0.96	12.61	52.05	-8.60	-8.38
8. SC	39.47	0.00	-0.46	7.82	37.35	-3.97	-6.86
9. Red	47.00	68.00	48.00	8.51	51.38	60.72	48.46
10. Green	50.00	-68.00	25.00	13.29	58.90	-63.44	33.76
11. Blue	24.00	17.00	-46.00	12.41	29.13	28.30	-45.66



The L*a*b* Color Model

Cyan Solid L*a*b* Analysis:

The cyan has already been identified as too low in density and too high in gain. The solid cyan here shows a 13.16 delta E from my target value. The L* on the cyan indicates that most of the problem is being too light. The L* is 9 points higher. A higher value is lighter on the L* axis. We already know it's lighter from the density reading. The low density is also affecting the b*. The –b* should be -50 toward the blue. It is only -40.62. This is also a density problem. The cyan is weak. The densitometer told us that as well but it didn't tell us how much it was weak.

The Substrate L*a*b* Analysis:

The substrate is a little warm. I don't have to see the substrate to tell you that it will appear as very yellow. It should be -2b* but it is only .75b*. This also is enhancing my weak cyan problem.

Solid Magenta L*a*b* Analysis:

Magenta is a little weak and green cast.

Solid Yellow L*a*b* Analysis:

Yellow is not weak but has a very green cast with and a* at -9.43.

Red, Green and Blue Overprint L*a*b* Analysis:

All these deviations of the solid colours are negatively affecting the red, green and blue. The green is normally the worst overprint if the solids are not correct or if the print sequence has not been calibrated with the 100x3.

Midtone Grey Balance (HR) L*a*b* Analysis:

Now notice the grey balance of the HR (midtone grey). This is the first thing we measured with the densitometer while on press. It is 12.51 delta E out with an -8 delta E on both the a*and b*. The L* indicates it is too dark. With the solids all being weak it tells me the gain is too much too high. The a* is -8.60 too green and the b* is -8.38 too blue. (Mostly caused by the cyan.)

Conclusion of the Root Cause and Print Analysis:

You may have noticed here that in this article I did not show you the print or the colour target. My objective was to demonstrate that you don't really need to see the print to analyze what it looks like in comparison to an accurate, grey balanced colour target or an accurate computer monitor. Without seeing the print you should be able to confidently know that the print has a strong blue cast in photographs and the solid colors like reds, greens and blues are weak. The tones below the 10% area will have a cast toward the yellow substrate. I also can confidently state that the correction here is the following adjustments:

1. Raise the density of the cyan to normal.
2. Raise the density of the magenta and yellow to normal.
3. Balance the 100x3 inks at full the new full density.
4. Lower the dot gain of the cyan.
5. Adjust the tonal curves until the greys are balanced in the 25%, 50% and 75% tonal areas.

If these corrections are made, our print will look very much like an accurate colour target or a properly calibrated computer monitor.

I hope this article helped you with understanding of how to quickly and accurately do print analysis without looking at the print. Of coarse, I am not advocating not looking at the print, but looking at the print is the worst way to evaluate colour moves or press adjustments. I suggest that you first capture the data and evaluate the numbers before you make a knee jerk colour correction move. When the greys are balanced and the tonality is on the line, you will look at the print and see that it looks like your accurate grey balanced colour target.

If you would like to evaluate and test the DCS3 software that I used in this print analysis you may request a free 30 day trial at www.nazdarconsulting.com. Be sure and mention this article when you request the free trial. You will need a PC and an i1 or Xrite 528 in order to use the software.

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