# The Effect of Press Variation on Color Stability with 7-color and 4-color Process Color Tint Builds

Matthew Furr

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Gamut is defined as a subset of colors which can be accurately represented in a given circumstance, such as within a given color space or by a certain output device.

Printing technology has advanced quite rapidly—particularly in packaging. Improved inks, plates, anilox rolls, presses, prepress applications and separations have enabled converters to move from the traditional limitation of 'spot' colors, to a more expanded, advanced, computerized screen and process printing technique using process inks.

This has led printers to consider implementing expanded gamut. Expanded gamut is the use of producing a wider set of colors by adding more than the traditional set of CMYK process inks. The process of expanded gamut is very attractive to printers who, if not constrained by replacing brand color inks after every press run, can speed up makereadies because they do not have to clean ink units on press. More significantly, they can gang jobs together, because ink colors are not created by special inks, but just process builds.

Until recently, particularly with flexo printing, the biggest concern with this practice was the stability of the plates and presses. Could they consistently and predictably hold the dots to assure accurate reproduction within tight tolerances of important colors—like those required by brands and traditional solid Pantone inks? However, improved inks, plates, anilox rolls, presses, prepress applications and separations have enabled converters to move from the traditional limitation of 'spot' colors, to a more expanded, advanced, computerized screen and process printing technique using process inks.

Introducing three more inks into the process, traditionally orange, green and violet, can split the hue components from three to six sections. Rather than relying on yellow and cyan to derive a shade of green, now a printer can rely on mixing yellow

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and green together—or cyan and green. Since they are closer to each other in hue, they can represent more colors, more accurately.

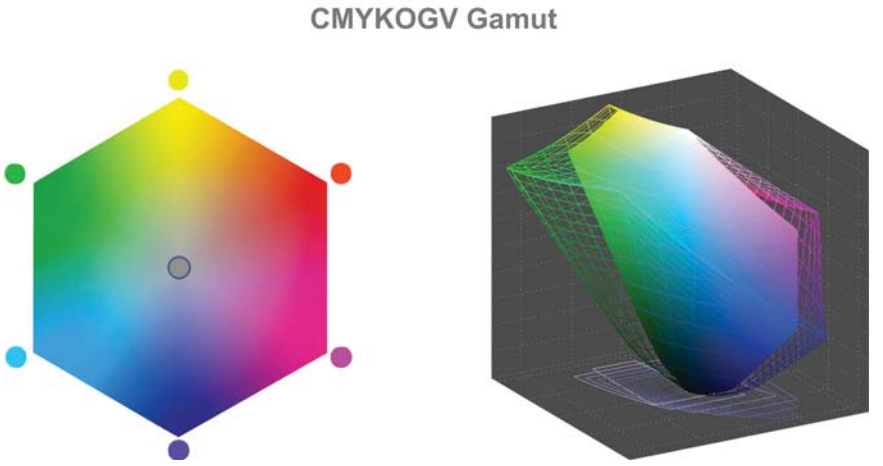



***image 1***

We also know that by implementing GCR (Gray component replacement), shifts in colors on press may not affect results as severely as pure color builds. Our objective was to determine, through press trials, the effect of press variation on color stability with 4-color and 7-color process color tint builds. At the same time, we decided to see how the implementation of GCR affects stability on press.

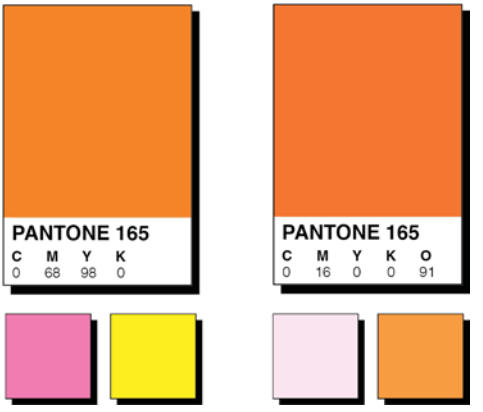



***image 2***

Inks act as levers on the color tint build. However, the more the inks, the shorter the levers are on that build:

*image 3*

*image 4*

This is easy to explain. The differences in hue are further apart with a four-color ink set than a seven-color ink set. In the diagram below, you can see that the difference in hue between cyan and yellow is 140.3°, but only 86.4° between green and yellow.

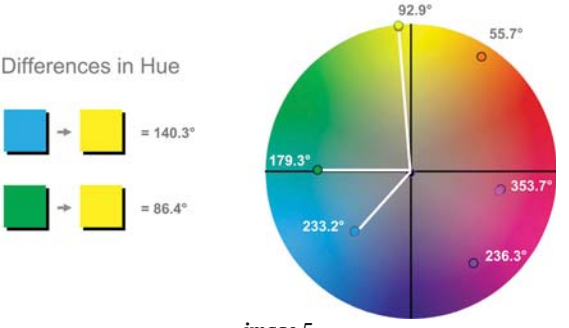



*image 5*

There are also differences in chroma (see image below):

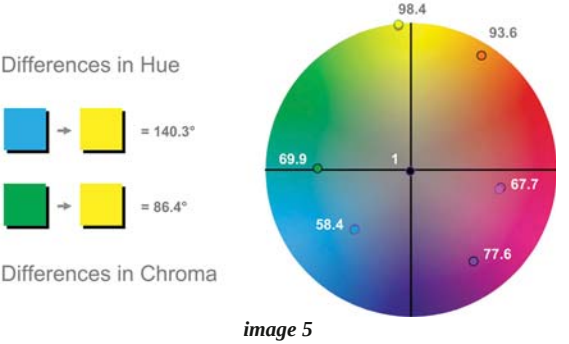



*image 5*

So, our research project attempted to prove three hypotheses. First the maximum GCR results in the least color variation. Second, we believed that color build logic using 7C and Maximum GCR would result in the least color variation. We also felt that a 7C build logic would result in the lowest ink consumption. We selected 300 different ink builds—both 7C and 4C, represented evenly throughout the entire color gamuts.

**(sub) Test methodology**

The methodology was quite direct, although we believe that no one has done this in the past. Following a review of available literature and past studies, we created a simulation of colors and settings into our Color Pilot software and varying ink percentages to see what expected Δ E. Mathematically, it seemed worthwhile to take the test to press. The remaining four portions of the test involved designing the test and setting up the press.

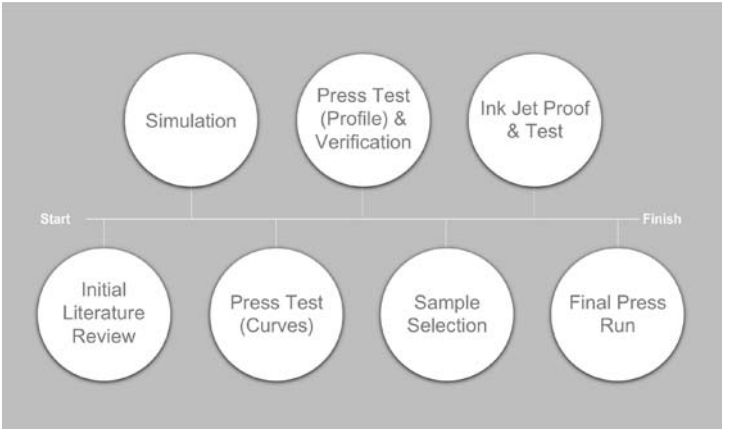
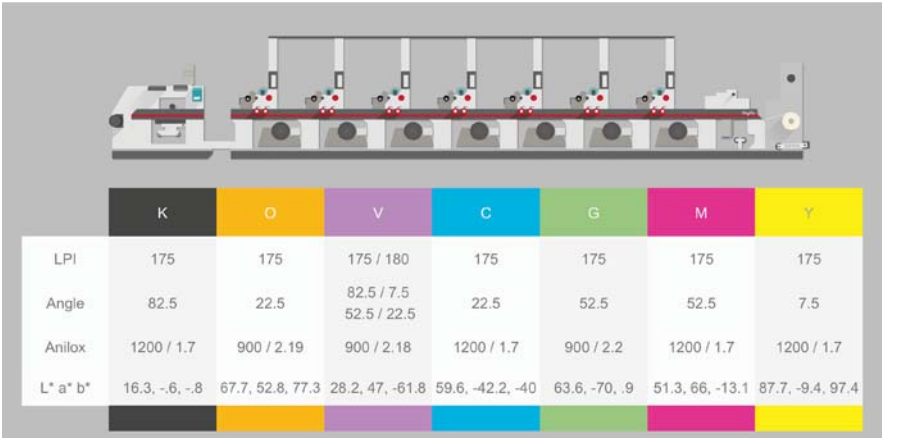



*image 7*

We decided to use UV inks, an Impression Dot Area & ΔE-P, a flexo Plate DFR .067, Tape Lohmann 5.1+, and a composite Metering MicroTip doctor blade. Line screens angles, the anilox and L*a*b* settings for each ink are shown in the diagram below. We selected Circular AM screens for all the inks, except violet . We used a G7 process to profile the press to generate a neutral grey, set for traditional 4C printing; not for 7C.



| | K | O | V | C | G | M | Y |
|---|---|---|---|---|---|---|---|
| LPI | 175 | 175 | 175 / 180 | 175 | 175 | 175 | 175 |
| Angle | 82.5 | 22.5 | 82.5 / 7.5<br>52.5 / 22.5 | 22.5 | 52.5 | 52.5 | 7.5 |
| Anilox | 1200 / 1.7 | 900 / 2.19 | 900 / 2.18 | 1200 / 1.7 | 900 / 2.2 | 1200 / 1.7 | 1200 / 1.7 |
| L* a* b* | 16.3, -.6, -.8 | 67.7, 52.8, 77.3 | 28.2, 47, -61.8 | 59.6, -42.2, -40 | 63.6, -70, .9 | 51.3, 66, -13.1 | 87.7, -9.4, 97.4 |

*image 8*

In all, 600 Pantone color builds were selected for the comparison. For each gamut slice, 100 colors were chosen, making sure that, for example, the green builds, an equal number of cyan and yellow components were selected. Of the sample, half were built using 2-components and the other half using 3-components.

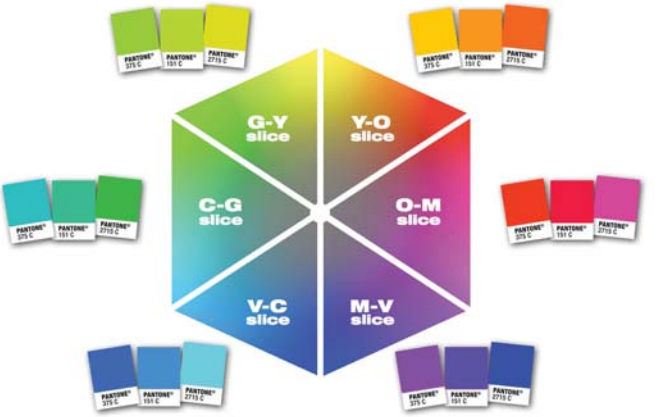



***image 9***

The final press sheet had randomized targets, and comparisons between 4-color builds and 7-color builds were grouped.

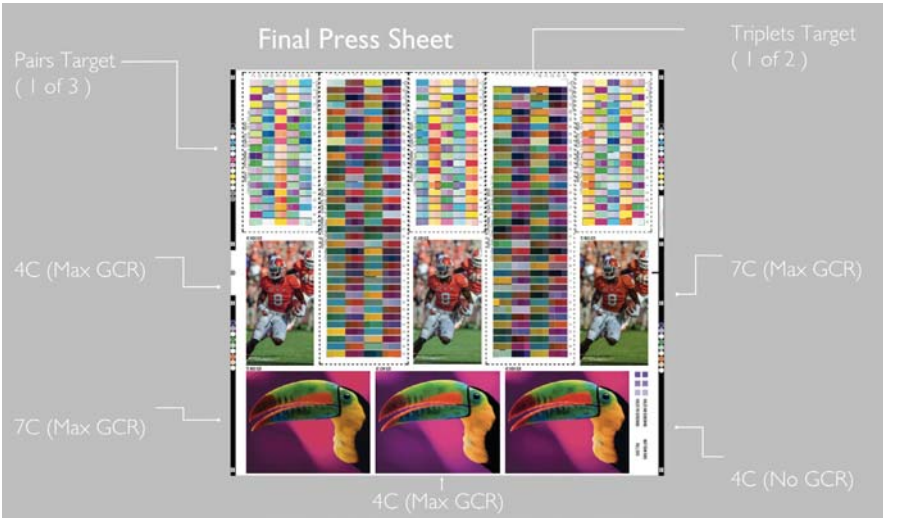



***image 10***

Our test involved over-impression of printing plates. However, to control the results, only one ink was varied at a time. So, in all, there were twenty-one runs, providing an over-impression of each ink three different times. About 5,000 feet of substrate was produced for each run, to make sure that there would be no problem with any set. The order was randomized.

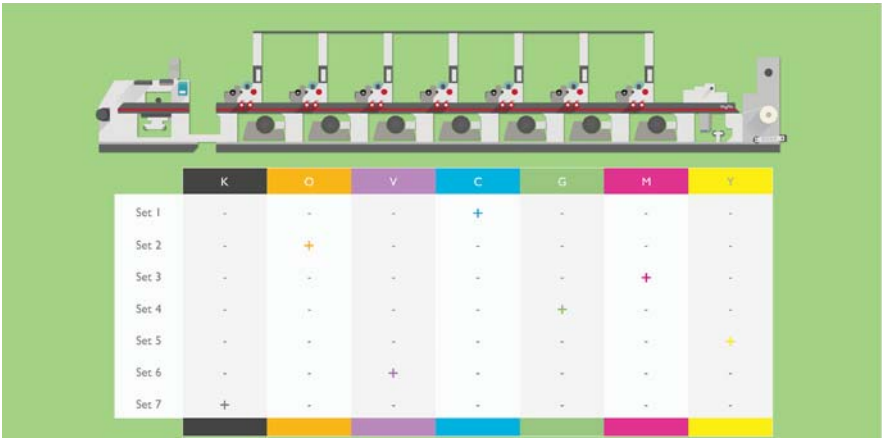



*image 11*

**(sub) Data reporting**

Color difference (ΔE) was measured using both CIE 1976 as well as ΔE 2000, which takes into account what humans see as a color shift—more of saturation to hue.

How much of stability is related to the grey component? We first compared 4C, no GCR to 4C max GCR results, to see how much stability can be increased by working with GCR,

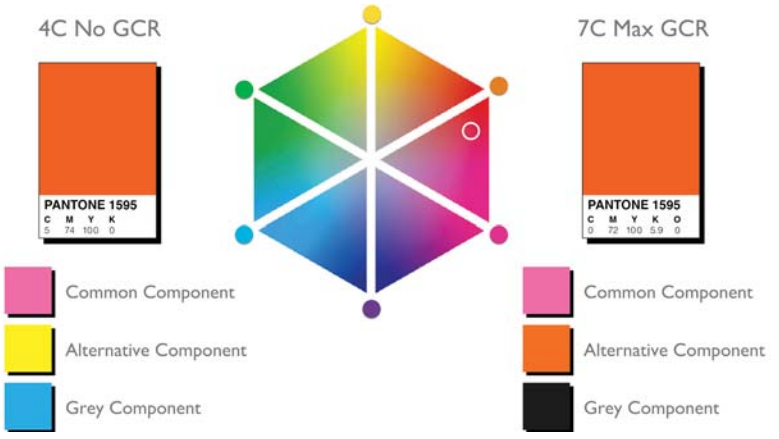



*image 12*

Looking at the results for colors in each quadrant, we can see that the ΔE 2000 is greater with no GCR than with Max GCR. In fact variation, if you print with black, is reduced by 36%. To a good degree there is insignificant difference in results between either four- or seven- color printing with max GCR.

ΔE 2000 in Grey Component Variation

| | 4C No GCR | 4C Max GCR | 7C Max GCR |
|---|---|---|---|
| Y-O | 3.10 | 0.72 | 0.87 |
| M-O | 2.81 | 0.60 | 0.72 |
| M-V | 1.49 | 0.62 | 0.61 |
| C-V | 1.36 | 0.80 | 0.58 |
| C-G | 3.04 | 1.59 | 1.94 |
| Y-G | 3.24 | 1.76 | 2.13 |

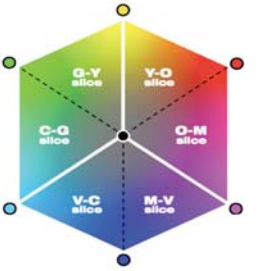



*image 13*

**How much of the stability is related to the use of expanded gamut printing?** We conducted a number of two- and three- component builds, looking to see how variations in the common components and alternative components would affect ΔE.

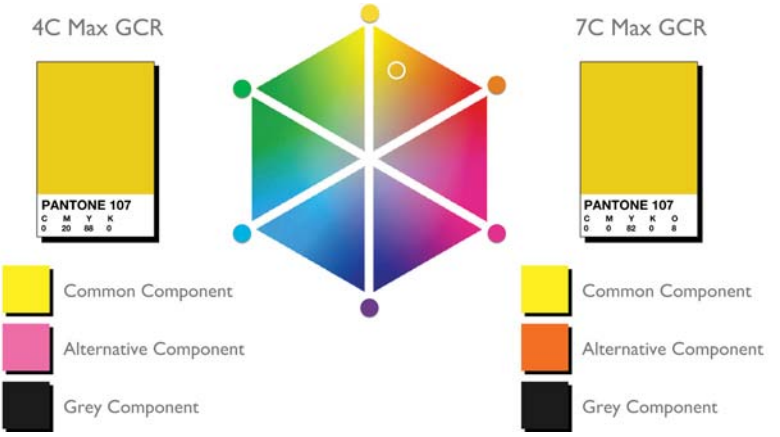



*image 14*

No matter whether a color was built with two or three components, or within a 4C Max GCR or 7C Max GCR, the seven-color build was always more stable when a color varied on press. In fact, in general we determined that variation in ΔE was reduced by 28% by printing with a seven-color model:

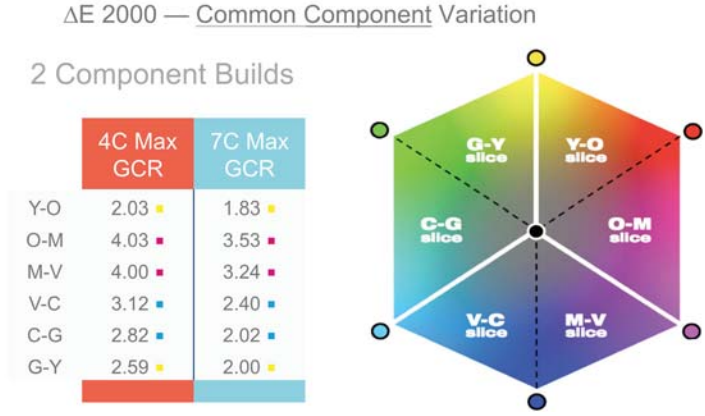



*image 15*

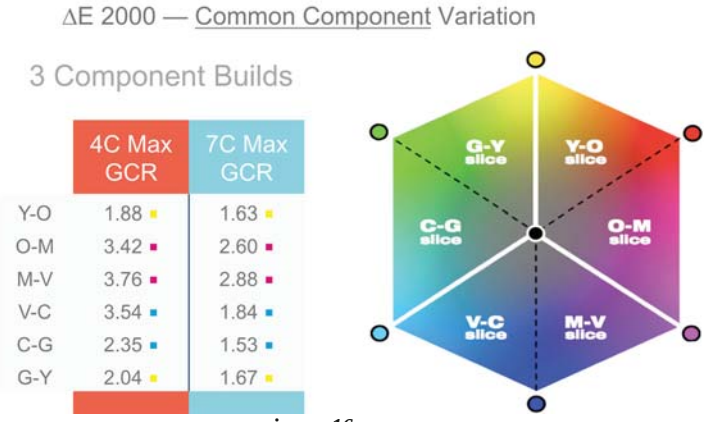



*image 16*

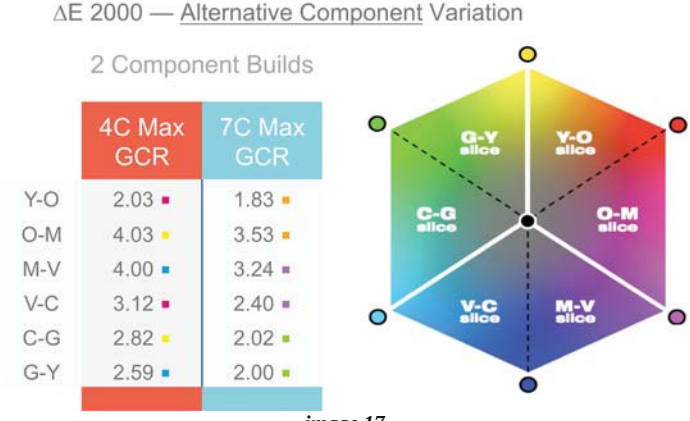



*image 17*

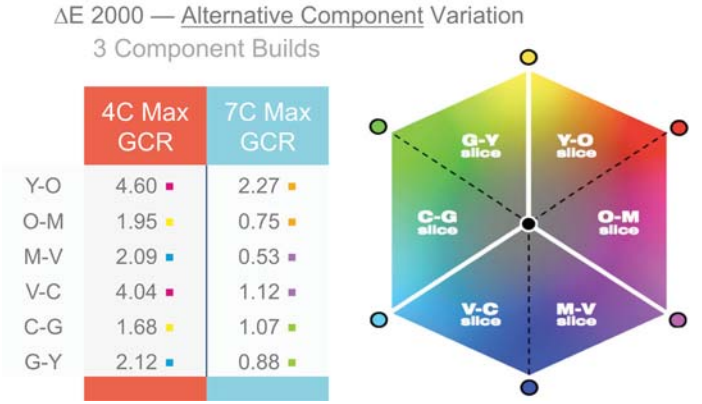



***image 18***

As well, there was an 18.8% difference in total area coverage with two component builds, and a 12.2% difference in three component builds. With extended color printing, it is possible to use less ink to get to final color.

**(sub) Summary of Findings**

In summary are five conclusions we can reach from our research.

- You should print maximum GCR: There is less variation in color when black is added.
- A 7C Max GCR resulted in lower Common Component variation when compared to 4C Max GCR: This and conclusion three both indicate that extended gamut printing provides more stable color builds.
- A 7C Max GCR resulted in significantly lower Alternative Component Variation when compared to 4C Max GCR
- 18.8% difference in TAC in builds with 2 components: This, and item five suggest that extended gamut printing, besides being more stable, also saves on ink costs.
- 12.2% difference in TAC in builds with 3 components