CORRECTING PROCESS COLOR IMAGES ON PRESS

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A most challenging aspect of reproducing four-color process images is being able to balance the color on the press. This is one of the most perplexing parts of the process. It is probably this way because of the general lack of color knowledge on the part of press operators and supervisors. In our industry, most pressmen started at the entry level as helpers, rackers, or general production workers. Through experience in the plant they were promoted to the position where they are running the equipment. For general line work and simple fine detail this is not a problem. When we get into a printing system that requires us to overprint colors and control transparent shades, there is difficulty.

Combining the lack of experience in complex color and tone control with a low understanding of four-color process film separations, it is no wonder that press personnel become frustrated. The unpredictable hit-or-miss nature of color correction is what really adds to distress. There are times when the printer doesn't have a clue as to what to do. It seems that no matter what changes are made, the image never comes into balance. There are two common responses. The first is to blame the ink that is being used, and the second is to blame the separations. While it is possible that one or both of these possibilities exist, the challenge almost always lies in understanding the process first.

The two basic causes of color imbalance are printing inks of the wrong hue and strength, and failing to manage dot gain properly. *In the first case, wrong hue and strength, it is imperative that we develop a profile of the process color inks that we will be using. There are no pigments that meet the "ideal" theoretical characteristics as defined by the optical physics of the reproduction process. All of the process color pigments have some contamination and unwanted color absorptions that must be compensated for. These unwanted absorptions affect overprinted colors and neutrals (orange, green violet, brown, grey). Color strength also affects the neutral balance and shades of the resulting overprinted colors.*

Dot gain results in growth of the halftone dot and the final color then appears darker than intended. Dot gain is a fact of life in all printing processes. We cannot get away from it. We can, however, control and compensate for it so that our printed colors end up looking like what we wanted.

Before we get involved with serious ink and press adjustments, an understanding to how separations are made is in order. Without proper balance in the film, it will be impossible to adjust color and dot gain on the press.

All color separations are produced with a set of several basic assumptions. These assumptions relate to color balance and tone values. In the first case, there is an assumption made by the color separator that relatively equal proportions of yellow, magenta, and cyan will produce neutral grey. This is the “grey balance” of the separation. It is very important to realize that the values which the separator uses are based on some known pigment values. They may reflect SWOP standards for web offset. They may be based on Chromalin®, Matchprint®, or Press Match® pigment values. They may represent any one of a number of arbitrary values that the color separator has selected to use.

Since screen printing does not have an established standard for process color inks, there is an excellent likelihood that the grey balance chosen by the separator will not match the grey balance of the process inks that we will be using. No two process color ink sets in this industry are identical. If you are working with a separator that is familiar with our industry, ask if they have established grey balance profiles for the inks that you will be using in your shop. If they don’t, send printed swatches of your process colors to the separator along with your work to be color separated. This will give the separator a chance to adjust the grey values to the inks that you will be using. Even if they do not adjust the values, they will be able to tell you that there will most likely be a shift in a specific direction if you use this ink.

The inks that you use must match colors in the proofing materials that the color separator provides, or the printed piece will show a color shift. There are common shifts in the magenta and cyan process inks that often do not match the proofing materials. These differences affect purity of the overprint colors. Greens, reds, oranges, violets, and blues tend to be greyer and duller.

When a four-layer overlay proof is supplied, the sheets of polyester cause a color shift toward the grey side for all colors. To determine how close your pigment colors are to the proof, print individual process colors and adjust color strength (ink density) to the same value as the overlay material. The value is the relative lightness or darkness of the printed ink film. Use of a color reflection densitometer will give absolute values. If you do not have one of these instruments, visual comparison against the proofing material is acceptable if the lighting is good. It should be a close match. What you are looking for are distinct shifts away from the ideal color (the proof material).

The shifts for the three process colors are:

Ink Color	Shift	Shift	Shift
Magenta:	Yellow	Cyan	Grey (combined Y+C)
Cyan:	Magenta	Yellow	Grey (combined Y+M)
Yellow:	Magenta	Cyan	Grey (combined M+C)

The combination of dominant color shift (hue error) in the ink and the combined color shift (greyness) will determine which direction your printed image will go compared to the proof. For instance, if you have a magenta shift in the cyan and yellow shift in the magenta, the printed neutral grey will be shifted toward the orange. You may also combine this shift with added greyness. This may be all right if you are printing a warm-toned subject such as a model or perfume advertisement. It would be unacceptable if you were working on a piece that has a great deal of green in it. Since the orange is almost opposite green, all of the greens would be shifted toward the brown side, resulting in olive greens instead of clean greens.

When your contamination is complementary to the color that you are printing, the image will tend to lose color saturation. If the color shift is adjacent to the color that you are printing, the result is a dominant cast in the direction of the contaminated color. For instance, a marine blue ocean would shift toward jade if the cyan ink contains too much yellow. For more information and discussion on this, see "Hue Error and Greyness in Process Color Inks," Screen Printing Magazine (Aug 1991).

The second major factor that is built into process color separations is the tone range. This is the difference between the light and the dark. When you order a set of separations with a range of 15% – 85%, you are telling the separator to give you film with no dots smaller than 15% and no more solid than 85%. In order for the printed piece to accurately reproduce values on the film, color strength of the ink must be at the correct level.

If the ink is too weak, values in the shadow portion of the image will not be dark enough. If the ink is too strong, the lighter tones will be too dark. By adjusting the ink density to match the values that are on the proof, you should be fairly close to the ideal.

Print the sequence that you will be using during the run and overlay all three of the process colors on each other. If the balance is correct, you should achieve a color very close to neutral black. It will most likely be cast to the brown side owing to the high level of yellow contamination in all magenta inks. This is why we add black to the printing sequence.

If the resulting three-color black is lighter than the desired target, you must increase the color strength. There are two ways to adjust it. The first method is to add pigment toners available from your supplier. These highly concentrated colors are mixed into inks to increase the color load.

The second method is to increase the ink film thickness. If possible, avoid this solution. The ink film thickness is adjusted by using a thicker stencil or a coarser mesh. You do not want to do this because it can cause problems with dot gain and moiré. It is much better to print a thin ink film with high color concentration than to increase the ink film thickness. If you do not have access to the necessary toners, this may be the solution of last resort.

To summarize so far, all separations are produced with a normal grey balance that is established for the proofing material that the separator uses. We must compare our ink colors against the proof material colors to make sure that no color shifts are occurring. If possible, we should have the separator adjust the grey balance to reflect our choice of inks. The grey balance is based on printing the three primary process colors at a specific color strength. To evaluate our printed image accurately, our printed ink film must be of equal value to the color strength of the proofing material. With these two major factors as our foundation, we can begin to analyze our printed image on the press.

The very basis for process color is that transparent inks are overprinted to form secondary and tertiary colors. The efficiency with which the colors overlay and the purity of the resulting overprint are referred to as trapping. This is not to be confused with the spreading of an image to aid in registration. If the inks are not perfectly transparent (and they never are), the resulting overprint colors will be less than ideal. It is our job to determine how efficient overprinting will be. The test overprint colors will be red, green, blue, brown, and grey. The first three are the secondary colors and the last two are the tertiary colors. Because of the failure of pigments in our inks to be ideal, red usually prints as an orange, and blue prints as a violet or purple. Green is relatively pure. By evaluating the printed order we can choose the best sequence that will yield the best possible range of overprinted colors.

There are two methods for printing process color images. The first is dry trapping. In this method, each process color is printed and dried before the next color is applied. This is the most commonly used method for graphics printers. The wet trapping method is used by textile printers and uses wet-on-wet applications of the process color. The resulting overprint colors are dependent on the transparency of the pigments and the amount of "touch-off" when printing wet-on-wet. The differences between the two trapping methods can be quite dramatic.

To evaluate an image on the press it helps to have a grey scale and color bar. The grey scale shows the progressive tonal steps from white to black and is based on the neutral grey generated by the three primary process colors. The color bar shows the solid ink values for the three primary process colors and the resulting overprints of red, green, blue, brown, and three-color black (grey).

Our first step is to print the solid ink values of the three primay colors and match them to the printed proof. We can now evaluate the trapping efficiencies of the overprinted colors. With colors that are not transparent, there will be a definite shift toward the last color down. In the color sequence Y+M+C, the reds will be more orange, the greens will be darker, and the blue will be cast to the purple shade. If the sequence is changed to Y+C+M, the red will be dominant and the green weaker. Blue will be cast to the violet shade.

Changing the sequence to M+C+Y, the greens will be lighter and cast to the yellow shade. The blue will be more neutral, and the red will be much more orange. The challenge is that yellow is the least transparent of the process colors. In fact, it is translucent. This has the effect of casting everything toward the yellow shade and results in a predominant yellow cast. It is possible to obtain a transparent yellow, but the pigment is considerably more expensive.

If you are printing wet-on-wet, the yellow must be printed at the beginning of the sequence. The reason is simple. Yellow is the dominant color in the separations. It has the most area. If it is printed last, or later in the sequence, the first down colors will contaminate the purity of the yellow. If printed after the magenta, it will become orange. If printed after the cyan, it will go green. If printed last, it will be shaded to brown. Because yellow is the lightest color, any contamination is very apparent.

Color strength is most important. Without this baseline, we will not be able to make the necessary adjustments. Ink color strength determines the contrast in the image and the point at which balance adjustments are made. Contrast is purity of the whites and darkness of the solids. If the ink is too weak, the strength of the solid color will look washed out. Instead of dark cyan blue, it will look like medium cyan. This also has an effect on the black shadow areas. If the color strength is too weak, you will not be able to attain good black values. This is one of the most common problems that I see with screen printers. They tend to "base back" or extend their process colors too much.

The basing back–or extending–of color is the result of color shift on the press caused by dot gain. This is the film dot increasing in size on the printed substrate. The effect is that the printed image looks dark and muddy. As the dot increases in size, the contrast of the printed image decreases. The dot in the highlight area gets bigger, and the point at which the tone goes solid decreases. This is called tonal compression and is the reason that most printed separations look muddy.

A very typical mistaken correction for this is to decrease the color strength in order to lighten the image. This has the effect of further reducing the contrast of the image. The resulting print is flat, lacks contrast, and is muddy. High ink color strength is the key to achieving a good tonal range. If you have to resort to lightening the ink value, you have too much dot gain. To reduce the amount of dot gain, try reducing your ink thickness by using :

- less squeegee and flood bar pressure
- higher mesh tension
- a finer thread diameter
- thinner stencil
- harder squeegee
- lower off contact distance
- or all of these options.

If you are not successful in controlling the gain, the only correction is to have the separations adjusted.

One of the easiest ways to tell if your color strength is too weak is to look at the grey scale. Our eye does not see color strength or density on a linear basis. This means that we see small differences in color much more easily in lighter areas than in darker ones. It is very easy to see a 1% difference in the highlights while it is difficult to notice a 5% difference in the shadow areas.

In viewing a printed grey scale where ink is too weak, the highlight will be cast in one direction, the shadow grey in the complementary color. For instance, a weak magenta will have highlights that look too magenta and shadows that are green. The reason for this is that dot gain will increase faster visually in the highlights while you attempt to obtain neutral grey in the shadows. This gain in the highlight shifts the neutral grey to magenta. In the shadow areas, it is not possible to increase dot size to compensate for weakness of ink color. The grey scale stays green because of this.

Go for the correct neutral grey in the shadow area first. Establishing this grey balance is crucial. If all of your colors are too weak, you will never be able to get the darkest grey as shown on your color proof. If you are able to get the darkest grey, but the lighter greys are too dark, you know that you have a dot gain problem that will need to be dealt with in the separations.

When it comes to strengthening or diluting colors, there are a few tips that may make it easier for you. Never assume that the ink you receive from your vendor is of the same color strength as your last batch. While I wish this were the case, my experience has shown that there is indeed variation. Start with a draw down on sample material through the same mesh at the same tension. For instance, use 355 PW at 25 N/cm with 1/32" off contact and a 75 durometer squeegee. Use this set-up each time you check an incoming batch of ink. Pull three or four samples on the same proofing material and compare the printed color against the prior batch. If it is different, you will need to adjust it up or down to match. The comparison can be as simple as a visual check or, more accurately, you may use a densitometer or colorimeter. The densitometer measures color strength; the colorimeter plots the actual color for a match according to the CIE color space.

Adjustment is accomplished through the use of concentrated color or halftone extender base. These are obtained from your supplier and are balanced for the specific ink that you are using. Start with a given quantity of the incoming ink that needs adjustment–either by volume or weight. Add concentrate or extender until you can match the previous sample. Use the same unit of measurement when adding the concentrate or extender. Your color should be within ±.05 density units if you are using a densitometer.

Once we have achieved grey balance and tone balance, we can start the run. All the work that done up to this point is useless if we cannot control the consistency of color and tone during the run. Here are a few tips that will help to maintain your consistency.

If you are running wet-on-wet, as in textile production, tape approved printed samples at the unloading station of the press and at the end of the dryer. This way, each printed piece can be compared to the approved sample. Very small shifts in color and tone can be easily noticed and corrected.

If you are printing and drying each color, it will be necessary to sample your sheets on a periodic basis. During your proofing phase, pull off progressive color samples at the correct color strength and dot percentage. Use these in the same fashion as the approved sample above. Compare every 50th to 100th sheet against the control. This is where a densitometer is very handy. By measuring and recording every 50th sheet, you will develop a dot gain profile throughout the run. Strive for ±.05 density unit shift as your control range. Also try to turn your sheets in the finished stack so that they are face down. This will keep your sheets in the same printed order for each color and makes a big difference in maintaining consistency when other colors are printed.

Determining color and tone balance is one of the most difficult aspects of process color reproduction. Maintaining it on the press is one of the true keys toward mastering this type of printing. As you and your printers become more accustomed to viewing and analyzing color, the mystery will slowly dissolve. As I have said in the past, there are no secret tricks to successful process color reproduction–only serious attention to the many details that are required.