Max-Imize Your Color - Oct 09 - Printing with Spot Colors

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Solution Details

Printing with Spot Colors
In this article we will discuss printing with spot colors in Postscript and PDF workflows. First a bit of background is provided followed by a discussion of the mechanisms used by ONYX RIP software for spot color replacement. And finally, some tips and tricks are presented for troubleshooting issues with printing spot colors.

Background
When Postscript was first released in 1984 it only supported black and white (grayscale) printing. Postscript extensions were proposed by different PS Rip implementations that allowed for color printing. When Postscript level 2 was released the ability for a Postscript interpreter to render color output was more clearly defined. With Postscript level 2 there are two modes of specifying color: Direct device colorants can be specified or a color can be defined colorimetrically and converted to device color using a color rendering dictionary. There are several device color modes (DeviceGray, DeviceRGB, DeviceCMYK, and Separation colors) that find their basis in printing using an offset press. (Note: These color modes have logically progressed into PDF workflows as well).

Color printing using an offset press
There are two general methods of getting color output with an offset press – "spot" color printing and "process" color printing. In order to understand these two approaches let's first review some basics of how an offset press works.

A simple model of a five-color press is shown in Figure 1. Paper is conveyed from a paper feed section to a paper take-up section through a series of inking stations. Each inking station only applies a single color of ink to the paper. Having multiple inking stations allows for multiple colors to be printed on a single paper in a single print run. Earlier presses had as few as one inking station. In this case, to get multiple colors on a page, the paper can simply be fed through the press multiple times with different inks in the press for each print run.

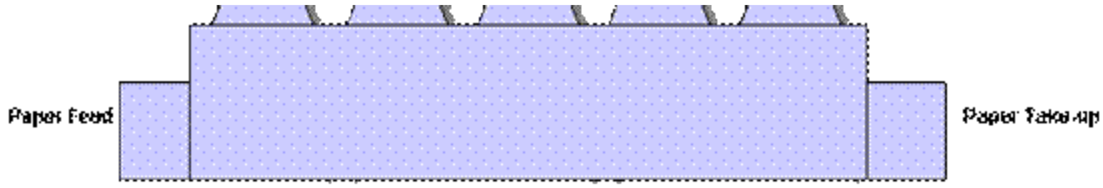

Figure 1 – Basic diagram of a five color offset press

Figure 2 shows a basic overview of a single inking station. A single color of ink is applied to a plate wrapped around a cylinder. The plate represents a single page to a print. Ink is applied to an etched plate in a manner that controls where ink gets placed on the page. The ink is then transferred to an offset cylinder covered with an inking blanket that actually transfers the ink to the paper when the paper is fed between the offset cylinder and the impression cylinder.

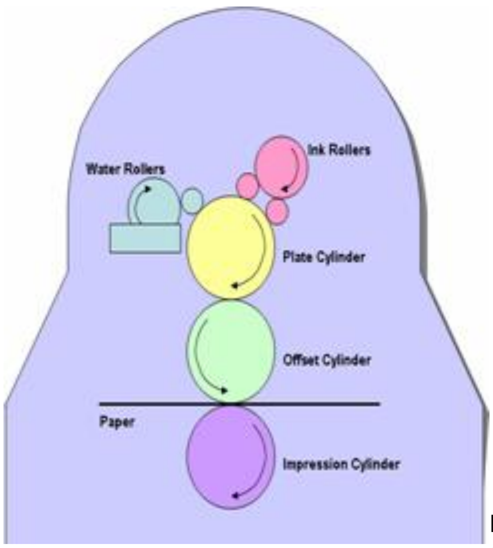

Figure 2 – Essential components of a single inking station in a press

Spot Color Printing
The first method of getting color on a press involves creating separation plates that apply the desired colors of inks to the appropriate "spots" on the paper (hence the term "spot color"). In this case the inks are printed in isolation and are not generally printed at the same location on the page.

For example you may have a two color image where in one spot of the image you want black, and in another spot you want orange. By separating these portions onto printing plates and placing black and orange ink in the press to apply the appropriate color ink at the appropriate spots on the page you get your desired two color output. Any number of "spot" colors can be defined with an appropriate separation and ink formulation for each color.

To get the right color at any spot, you have to put the right color of ink into the press. Mixing colorants to get the right color of ink was generally a big problem until the Pantone Matching System (PMS) was introduced in 1963 as a system for mixing inks for the purpose of spot color printing. The system is based upon combining only 12-basic pigments to achieve all of the colors defined by the system.

Process Color Printing
The second method of getting color on a press involves printing multiple inks at the same location to get combined colors. By "processing" the image to vary the amount of each ink at the same location a wider range of colors can be achieved than by printing the inks separately. Printing with combinations of Cyan, Magenta, and Yellow inks makes use of the human visual system by attenuating the amount of red, green and blue light. Therefore all possible hues with a wide variety of tints and shades can be reproduced using only three inks. By adding black ink to this mix of process colors less ink can be used (saving money), and a better grayscale as well as a larger print gamut can be achieved. Therefore, with these four colors of ink (CMYK) full color image processing is possible.

However, not every color can always be reproduced using Cyan, Magenta, Yellow, and Black ink, and therefore presses can be set up to print both process colors and spot colors at the same time (as is possible in the press depicted in figure one). When creating an image (using Postscript or PDF) for such a press you want to be able to use spot colors if they are available, but use an appropriate combination of CMYK inks if the press is not set up with your desired spot color. Because of this the Postscript and PDF specifications require that both the spot color name as well as a suitable replacement in terms of device color channels are provided whenever a named spot color is used. One problem is that since the spot color alternate is defined in terms of device color channels there can be great variability in the observed color of the spot color replacement as defined by a Postscript or PDF file. This is because the observed color for each channel of a printing device can vary widely from device to device, or even from print media to print media.

Spot Color Printing in RIPQueue
RIPQueue supports the direct printing of spot colors as spot channels in a printer as well as named spot color replacement that uses color management to perform the color replacement.

If a printer device supports spot colors (or if a media is created in Media Manager with spot channels), then named spot colors in a Postscript or PDF image can be directed to the spot ink channels in the printer. This requires that named spot colors become associated with ink channels in the printer. This relationship is set up using the Postscript Spot Color to Ink Channel Replacement settings in the Spot Channel Replacement dialog. This dialog can be found by pressing the Spot Channel Replacement button in the Output tab of the ICC Profile Setup Dialog (Figure 3).

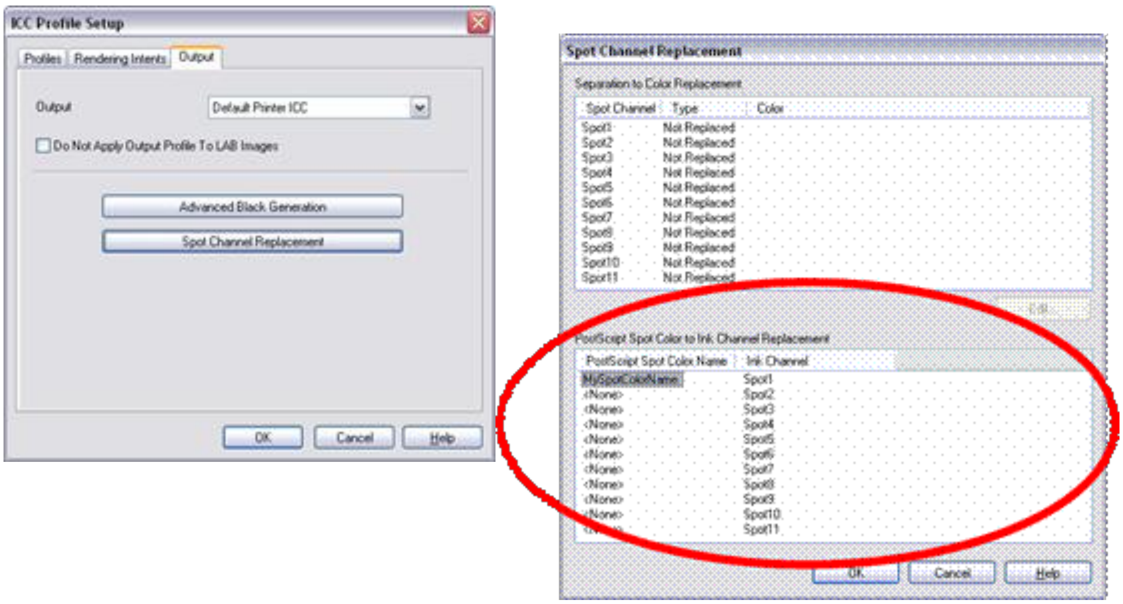

Figure 3 – Setting up Named Spot Color to Ink Channel Replacement

Except for workflows that involve printing with white ink, color formulations for spot colors that can be placed in printers are most likely limited and directly printing spot colors is therefore also of limited value. However many printers have different ink sets as well as printing capabilities that allow for a much larger gamut than can be achieved by offset press printing. As such, the range of spot colors that can be achieved is generally much larger. If the colorimetric value for a spot color is known then color management can be used to find device colorant values that can better reproduce that spot color. When the “Use Color Table” checkbox is set in the Postscript settings for a job (Figure 4) spot color replacement is performed using color management and the system color matching tables.

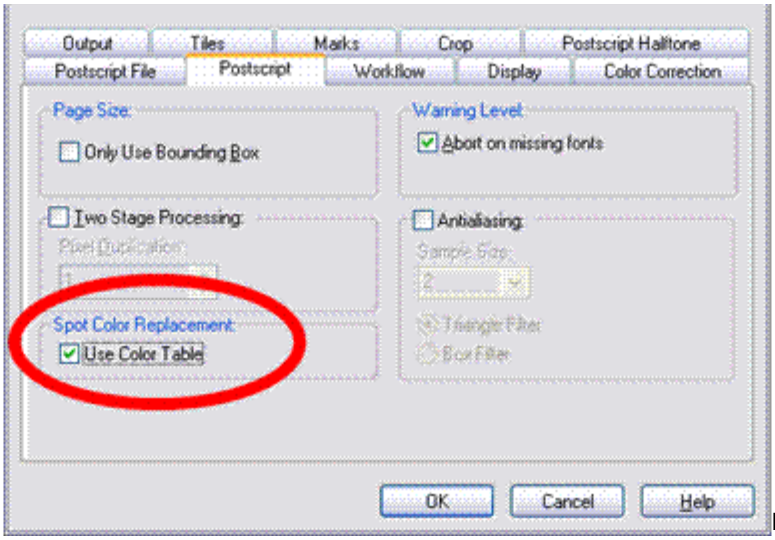

Figure 4 – Setting up Spot Color Replacement for Postscript and PDF files

The spot color management tables are managed using the Color Matching Table dialog (from the Setup->Postscript->Color Matching Table … menu in RIPQueue) which allows one to view all spot color names that can be replaced as well as define additional names and color for the purposes of named spot color replacement (Figure 5).

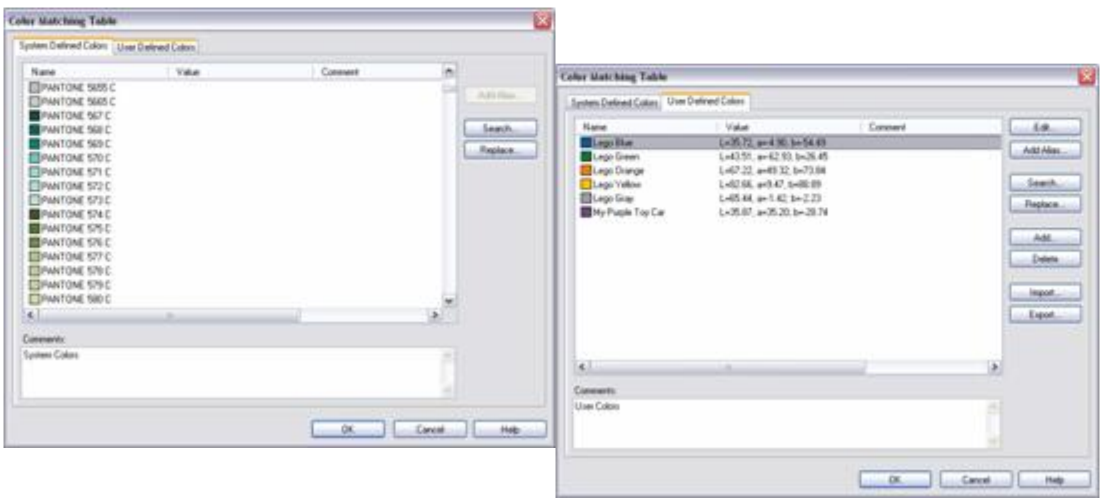

Figure 5 – Managing Spot Color Replacements

Licensing requirements with color systems vendors (like Pantone) require that the actual colorimetric (CIELAB) values for their named colors are not directly displayed. Additional user defined named colors for the purposes of spot color replacement can also be added either by creating an alias to an existing named color, or they can be manually created by specifying the name and CIELAB value. The CIELAB value can be measured directly with a spot measurement device (like an X-rite i1). (TIP: the user defined version for a named color will be used when its name is identical to a system defined color. This allows system defined colors to be re-defined by the user).

How it works

To perform spot color replacement when processing a Postscript or PDF file the file itself will specify for a color to render a named separation, a tint value (percentage of spot ink to use), and a replacement function to convert to device color if the spot color output plate is not available. When the spot color replacement setting for the associated job is turned ON, the RIP checks the following tables to find a color relationship for each spot color name used (recursively looking up aliased colors as needed):

1. Mode based named color replacement table (only used by HP Professional Pantone Emulation). (Note: This can be disabled by setting the PSRIP setting USENAMEDCOLORTABLE to OFF).
2. User defined color table
3. System defined color table

If the spot color name is found in a mode based color replacement then the actual device values for a solid (100%) fill of the color defined in the table are used.

Otherwise, the named color is defined as CIELAB combination by either the user defined table or system defined table. The CIELAB combination is then processed through the output side of the print mode's default ICC profile. When processing the CIELAB values through the output ICC profile the SPOTRENDERINTENT Postscript setting defines the rendering intent to use (0=Perceptual, 1=Absolute Colorimetric, 2=Relative Colorimetric, 3=Saturation, where not defined=Absolute Colorimetric). The output ICC profile provides the actual device color values to use for a solid fill (100%) of the spot color. (Note: the output ICC profile is used for spot color replacement regardless of what ICC profile settings are defined in the ICC Profile Setup for the associated print job).

The tint value is then applied to the device values associated with a 100% fill of the spot color, and the resulting device values are then used for rendering purposes.

Tips and Tricks
As can be deduced from the previous section, named spot color replacement relies heavily on color management provided by the output ICC profile for the print mode to determine device values to use for reproducing spot colors. (Note: In this case, colors are not guaranteed to match unless the Absolute Rendering intent for spot color replacement is used).

There could be several reasons why a replaced spot color in a Postscript/PDF file may not appear to match the corresponding color found in a published swatch book. These are as follows:

1. The colorimetric value of the color is outside the gamut reproducible by the printer. Since the output profile is used to find the device values used to print the color, if the color is outside the printers gamut, gamut mapping will be used to find an alternate color that is inside the gamut.

(TIPS) The gamut report for a print mode (obtained in Media Manager->Reports and Tools->Gamut Report) will display an estimate of how well all of the system table and user table colors can be reproduced by the print mode (Figure 6).

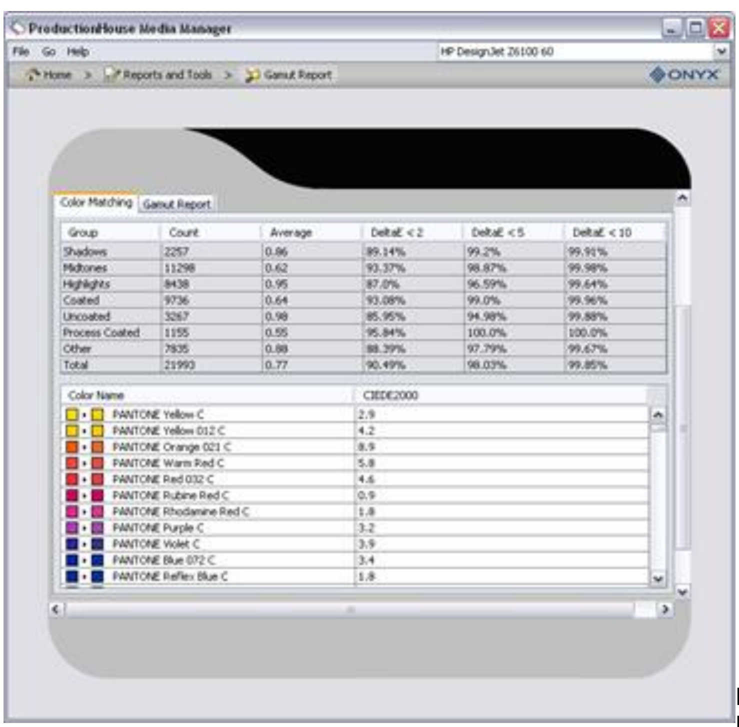

Figure 6 – Example Gamut Report Results

To calculate these estimates the CIELAB value (colorimetry) of each color is applied through both the output and input tables of the profile associated with the print mode. This first calculates device values for the color and then finds out the colorimetry (CIELAB value) of the resulting device values. This resulting colorimetric value is then compared to the original colorimetric value to get an estimation of what the profile would estimate the color difference between the original color and the color of the printed output. If the particular color difference is large (CIEDE2000 greater than 2.0) then significant apparent color differences should be noticeable, and this is possibly a good indication that the color is outside of the gamut achievable by the print mode. In order to get better results a larger print gamut may be needed. In some cases choices made during ink restrictions, ink limiting, or ICC profile generation may be reducing the available gamut.   In other cases this may not be possible and a different media, print mode may be required to get better results.

2. The colorimetry for the sample in the printed swatch book color does not match the colorimetry defined in the system defined color table used by RIPQueue.
For each of the standardized color matching systems (Pantone, HKS, RAL) ONYX Graphics has received from each vendor the officially recommended colorimetric values for each of the color names in their respective color matching systems. It is quite possible that these values can differ from the actual color measurement from any particular swatch for a number of reasons. One is that since the production of swatch books is a physical process there are tolerances and variability that can occur in the reproduction of each color patch. The second is that once a swatch book is printed the color can change over time. (It is for this reason that Pantone recommends that swatch books be replaced on a regular basis).

(TIPS) One thing that makes evaluating this possibility difficult is that the colorimetry for each of the system defined colors is not readily available (due to licensing considerations). One way to check to see if there is a possible a mismatch between a reproduction through RIPQueue and a known swatch book color would be to create a user defined color using an actual measurement of the swatch book color and then try to reproduce the color using the user defined color. If the user defined color when printed is closer to the measured color this might be an indication of a difference between the “standard” color measurement (as provided by the vendor) and the “actual” color measurement of a particular swatch book color.

3. The reproduced color is a metamer to the actual color. Two physical colors are metamers if they appear the same under one viewing condition, but appear different under a different viewing condition. When this happens this is known as metamerism. The viewing condition involves both the viewer as well as the light source. Differences in either light sources and/or viewers can result in whether two metameric colors appear the same.

The meaning of CIELAB colors includes both the concept of a viewer (observer) as well as a light source used to view the color. Because of this a print mode’s ICC profile only attempts to match colors under a single light source (usually CIE D50) for a “standard” observer. In some cases the optimized light source can be decided when building an ICC profile with the ONYX ICC Profile Generation Engine. If spectral reflectance measurements are used then the user has the ability to pick a single reference light source when the profile is generated. Otherwise, if colorimetric measurements are used then a D50 illuminant is always used.

(Caution: The standardized CIE D50 illuminant is theoretical and will generally not correspond to an actual measurement of daylight. Additionally, “daylight” light sources in light booths may have a correlated color temperature of 5000K (thus matching theoretical appearance of CIE D50 for a non-selective white or gray), but the spectral distributions of the light sources most likely will differ thus resulting in the possibility of a metameric mismatch of spectrally different surface colors).

(TIPS) To test if metamerism is an issue one can define a spot color in the user color table with a known CIELAB D50 value. (Note: this assumes that the print mode’s ICC profile was built for the CIE D50 illuminant). Create a Postscript or PDF document that uses this spot color and print the document with color replacement and then measure the CIELAB D50 for the reproduced color with a color device. If the measurements are the same then either observer or light source metamerism is most likely occurring.

One way to improve spot color matching of some gray colors (that differ due to metamerism) is to build the profile using black generation that results in a more stable grayscale. (See the previous Thrive article “Metamerism and Color Inconstancy” for tips on generating ICC profiles that have less color inconstancy).

4. The ICC profile associated with the print mode does not accurately characterize how the printer is actually printing.
If the gamut report shows that a desired color should be reproducible with a small color difference, but the measured output appears to have a large color difference then it is most likely that the print mode’s ICC profile doesn’t correspond well with how the printer is currently printing. This is because the print mode’s ICC output profile is used to convert from colorimetry to device values. Without an accurate profile one cannot really expect the spot color matching to be accurate.

(TIPS) There are multiple reasons that an ICC profile may not accurately characterize a print mode. These can include:

a. Using the wrong profile or print mode. When a new media or new ink set is used that hasn't been properly profiled, just trying different media and print modes to find one that "works" may result in images generally appearing ok, but for color critical applications like spot color matching it is a good idea to have a profile that has been generated using color measurements of actual printed output.

b. The print mode is out of calibration. In this case the printer may need maintenance, or a recalibration may be in order. (See the previous Thrive article "Understanding calibration").

c. The measurement data used to build the profile is inadequate to properly characterize the print mode. This can happen either if the number of patches used is insufficient, or if there are problems with the color measurement data.

It should be recognized that ICC profile generation is a labor intensive task. Consumables are expended and time is needed to print and measure color swatches used to characterize a print mode. If fewer patches are measured then it is very possible that the profile will be less accurate. Building a profile with more patches provides more information to detect and correct for idiosyncrasies in the printed output. Going back and generating a new profile with more patches in the swatch is a possible way of getting better profile accuracy. Additionally, the black generation settings can also affect profile accuracy. Since fewer patches are printed when more black ink is present, using more black ink can possibly result in a less accurate characterization.

Color measurement problems can also lead to inaccurate profiles. A poorly calibrated color measurement device or the physical characteristics of the media and ink can lead to measurement difficulties. Additionally, if there is fluorescence in either the media or the ink then there are usually assumptions that are made by the color measurement device that generally result in measurement values that do not reflect the color appearance. (Note: UV cutoff filters in the device may help, but not including light in the measurement processes does not help to achieve an accurate representation of color appearance when UV light is actually present when viewing the print).

Printing at lower resolutions, gloss and surface texture can result in inconsistent measurements. For these cases measuring patches multiple times, or measuring multiple copies of the same color for each patch and averaging can help to overcome measurement inconsistencies.

d. The internal characterization model in the profile generation engine is inadequate. Since only a small sampling of possible device value combinations are printed and measured, the colors that are not printed are approximated. If the means of approximation is inconsistent with how the printer prints then inaccuracies in the profile are a result. Different ICC profile generation engines will use different models for defining the approximations. There is not much a user can do to affect this internal behavior. Things that affect characterization models include the number of colorants being characterized, the number of patches in the swatch, and the algorithms used. Having more colorants generally complicates characterization. More patches generally result in less work by the algorithms. Internal algorithms generally can not be directly changed by customers aside from using a different profile generation engine. Since this is such an important aspect of color management, creating accurate characterization models is constantly an active area of research and development by ONYX Graphics.

When all else fails…
What do you do in those cases when you have determined that the color is in gamut, but the print mode is unable to exactly reproduce a spot color with a known CIELAB value after exhausting all attempts to improve accuracy found in the above Tips and Tricks? An analogy of using a paint gun that is out of alignment with its targeting scope might be appropriate (Figure 7). If you aim for the center (c) and you actually hit low and to the right (a) then aiming hi and to the left (x) gives you a better chance of hitting the center.

Figure 7- Adjusting aim to hit center

This can be applied to spot color matching in a similar fashion. For a printed reproduction of a user spot color with a known CIELAB value, measure the resulting color with a color measuring device (using the color measurement tool available when in spot color setup), calculate the difference between the desired color and the actual color, and modify the target CIELAB value by the difference.

Example: You are trying to reproduce a pinkish gray with a CIELAB value of L*=73, a*=8, b*=-2, and you get a lighter and slightly more colorful result which measures with a CIELAB value of L*=76, a*=13, b*=-3. The difference between the target and the measured is ΔL*=3, Δa*=5, b*=-1. Subtracting the difference from the target would give a new target of L*=70, a*=3, b*=-1. (Note: If this doesn't get the color exactly you may have to revise the target more than once. In this case, an understanding of how color appearance changes as CIELAB values change will help to get the color to look better).

There are two caveats to this approach:

1. User defined spot colors are globally defined. Putting in corrections to account for a problem in a specific print modes may provide more incorrect results if a different Printer, Media, or Mode is used.

2. The desired color has to be in the gamut of the print mode's output profile. No amount of correction will result in getting the right color since the gamut boundary places a limit on the colors that can be achieved.

Figure 8 – Gamut boundary prevents the ability to correct for out of gamut colors

(Note: Since black generation and ink separation settings used when an ICC profile is built can determine the gamut size achievable by the print mode, a color that may be thought to be achievable when printing without profiles may not be achievable when using the output profile). If you try to adjust the color multiple times and do not seem to be getting closer to the desired color it may be that the color you are trying to achieve is simply outside the gamut of the print mode's output profile.