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Expert Tips from our Color Scientist Max Derhak

# Profiling HiFi Print Modes

In this article we will discuss various aspects and caveats of profiling printers that have HiFi ink configurations (i.e. CMYKOG, CMYKRGB, CMYKR, CMYKGB, etc). These ink configurations provide the ability to achieve a larger gamut which result in better reproduction of spot colors, and other highly chromatic RGB colors. However, HiFi printing can potentially complicate the profiling process.

## *Why is HiFi profiling more complicated?*

The basic answer to this question is that there are a lot more possible ink combinations involved. The number of ink combinations is an exponential function of the number of ink channels you have. For example, if you have 4 inks and each ink can print N unique output levels then the total number of ink combinations you can have is N x N x N x N or $N^4$ combinations. If you are using 8-bit processing this equates to about 4 billion possible combinations. If you add one more ink channel, you have $N^5$ combinations which are about 1 trillion 8-bit combinations. With 6 ink channels you have $N^6$ combinations, which are about 256 trillion 8-bit combinations. With each added ink channel you multiply the number of combinations by an additional factor of N.

Another aspect of HiFi printing is even though you have many more ink combinations, you are not necessarily adding a lot of colors that visually appear different from one another. In other words, the additional gamut does not have an exponential increase in size. This means that these print modes generally add a lot of different ways to get the same colors (colors that give the same colorimetric values when measured by a color device). This is especially true for the case of gray and dark colors.

## *Understanding Ink separation*

When building an ICC output profile, you are providing a mechanism to specify how to go from a measured color (defined using a 3-dimensional colorimetric vector for example, L*a*b*) to an ink combination. In order for the final output of color transitions to appear smooth, it is a good idea for nearby colors to be represented by similar combinations of ink.

The process of determining which ink combinations to use for printing similar colors is what defines an ink separation. A simple example is to consider the case of CMYK. For many printers most colors in the printer's output can be achieved printing with only cyan, magenta and yellow inks. With the addition of the black ink channel, some additional colors are made possible, but at the same time there are many colors (near the neutrals)

that can then be accomplished in more than one way. For example: a mid-tone gray color can be achieved by using a combination of CMY, or some amount of K by itself, or some combination of CMY with some additional K. A grayscale separation (defined by black generation settings in the ICC build options) defines how to combine the use of CMY and K inks to achieve any grayscale color. (Note: This also will determine the total available gamut that can be achieved as well).

As mentioned before with HiFi printing, there are many more ink combinations to achieve similar colors. Just like the case of CMY and K, with the addition of red or orange ink to magenta and yellow there are multiple ways to get red and orange colors. With the addition of green ink to cyan and yellow there are multiple ways to get green colors. Similarly, with the addition of blue or purple ink to cyan and magenta there are multiple ways to get blue and purple colors. Also, with these extra inks you are adding multiple ways of getting gray values resulting in a much more complicated grayscale separation.

Each of these "multiple ways" of achieving colors results in a different type of ink separation (for example, a red or orange separation, a green separation, a blue or purple separation, and a gray separation). A proper separation will provide for smooth transitions between nearby colors and try to achieve the maximum printable gamut.

## Profiling HiFi printers with Version X10 Media Manager

The first step in profiling a HiFi print mode in Media Manager is setting up the ink configuration and processing colors for the media, or paper, that will be profiled. For many HiFi printers the ink configurations can be defined as a HiFi ink configuration with specified names or as a CMYK ink configuration with unspecified spot colors. It is recommended that the HiFi ink configurations be used (instead of an ink configuration with spots) so that HiFi colors can be generated even if an ICC profile is not available for the mode. If an ink configuration with spots is selected then the only way that the HiFi colors will be used, is if they are specifically called for by an image (as spot channels) or through the use of an ICC profile that defines and uses the spot colors.

The next important step in HiFi print mode profiling with Version X10 Media Manager is defining ink restrictions. Proper ink restrictions are essential to establishing a good print gamut size. The current recommended preset to use for HiFi print modes is either the "Coated Media Gamut", or the "Extended Gamut" preset as shown in *Figure 1*.

*Please note that the "Reduced HiFi solvent" preset should NOT be used unless you know that you should explicitly use it. Initial research found for a particular printer that the orange and green inks acted similar to light inks by adding a lot more liquid volume which forced greatly reduced ink limits later on in the profiling process. To achieve better results for this printer it was found that using significantly lower restrictions for orange and green ink simplified the ink limiting process. Later experiments performed*

*with other printers have shown that low restrictions are not required (resulting in poor gamut size), and higher ink restrictions (provided by the "Coated" or "Extended" presets) will better achieve maximal gamut size. The "Reduced HiFi solvent" preset will be removed from Media Manager at some time in the future). \*\*Please be aware that the preset names in Version X10.1 do not match this screenshot.*
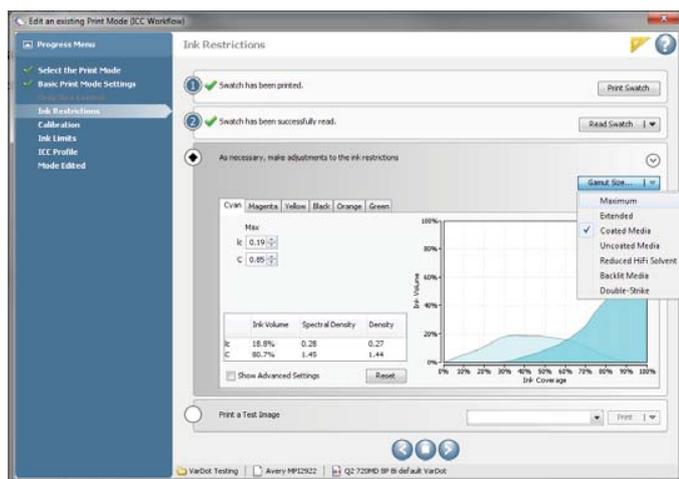


**Figure 1**  *Screenshot showing the Gamut size preset selection.*
*Once ink restrictions are performed, calibration is essentially the same as with CMYK printing.*

The ink limit stage is also basically the same as with CMYK profiling.  The most significant difference is there are more things to look at and consider while defining ink limits (due to the fact that there are more 2, 3, and 4 channel ink combinations). These additional patches labeled "Minimum of A" and "Minimum of B" are set according to the lowest Ink Limit selected for rows A1, 2, 3 and B1, 2, 3

## HiFi Printing without ICC profile

After the ink limits are set, it is strongly recommended to go on to build an ICC profile. However, once the ink limit stage is performed (and before building an ICC profile) a print mode can be used by processing jobs without profiles enabled.  Whenever a job is processed with a HiFi print mode without profiles enabled, the processing algorithms in RIPQueue provide default ink separations for converting RGB or CMYK images to HiFi colors.  Two desirable attributes of such a separation are to provide smooth transitions between hues and to achieve maximum saturation for all hues.  This allows you to achieve more vibrant, saturated colors when printing without profiles enabled (though the hue may not be visually accurate when compared to equivalent RGB or CMYK output).

Currently, the CMYKOG and CMYKRGB ink separations predate the use of true HiFi ICC profiles and the default separations have been recently found to achieve less than complete saturation for some hues.  Therefore, at present it is not recommended to print without profiles using such HiFi Modes to achieve maximum saturation for all hues.

*Please note that the default RGB or CMYK to HiFi separations are being reviewed and revised for a future version of the RIP Software to achieve better printing without the use of profiles.*

When using true HiFi ICC profiles, the ink separation technology is different and significantly improved over the default RGB or CMYK to HiFi color technology. Since the separation used for building HiFi ICC profiles DOES achieve maximum saturation it is currently better to print using HiFi ICC output profiles.

## HiFi Profiling and ICC profile generation

HiFi print modes have a few additional options while printing for, and building ICC profiles. The first critical choice that needs to be considered is which swatch to print and measure to build the ICC profile. Looking at the Swatch dropdown of the Print ICC swatch dialog will show one or more swatch formats for the HiFi mode along with several CMYK swatches as shown in *Figure 2*.
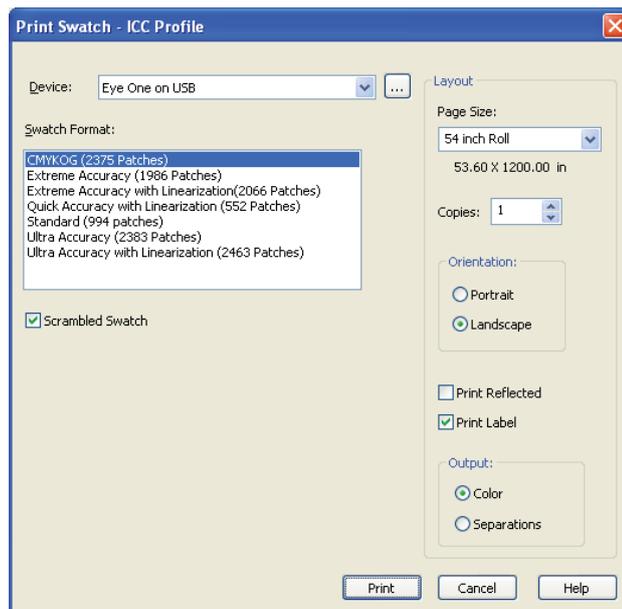


**Figure 2** *Print Swatch dialog for ICC profiles using a CMYKOG HiFi print mode*

If a CMYK swatch is used then only a CMYK profile will be generated. The CMYK values will then be converted to the HiFi ink colors by the default CMYK to HiFi ink separation used when printing without profiles.

*Please note that since the default CMYK to CMYKOG/CMYKRGB separation has been shown to not always achieve maximum saturation the gamut will be sub-optimal if a CMYK based HiFi profile is performed. It is therefore recommended that one of the HiFi swatches is used to print, measure, and build the ICC profile. At some future point when*

*the default separation is improved then generating a CMYK profile may prove to have some advantages including: smaller number of patches, quicker profile build times, and reduced sensitivity to measurement error. One disadvantage of using a CMYK ICC profile with a CMYKOG print mode is the reduced ability to predict (proof) the color for any possible HiFi ink combination.*

After selecting and printing a HiFi swatch it is important to take care that the swatch is accurately measured. It has been found that artifacts introduced by touching or scratching the swatch or other measurement errors can significantly affect the output quality of a HiFi ICC profile in areas of gamut not affected by the inaccurate measurements. This is due to the difference in how the device colors are modeled in HiFi printing versus how they are modeled in CMYK printing.

*Please note that with HiFi printing, the total possible number of ink combinations greatly increases and the relative number of patches contained in the swatch (compared to total number of combinations) actually decreases (when compared to a CMYK swatch). Therefore much more is accomplished by a HiFi color model which has a reduced sampling of the possible ink combinations. This reduced sampling results in greater sensitivity to measurement error.*

Once the measurements are accurately taken, it is recommended to use the default settings, as shown in *Figure 3*, and build the profile. Alternately, you can change the build options to suit a particular need, especially selecting the appropriate ink separation settings. For HiFi modes, the profile build options will include the additional option to "Dynamically Generate Ink Separations". If this option is not selected then a default separation will be applied. This default separation is currently different than the separation used when printing without profiles and it does achieve a maximum saturation and implements a smooth transition of ink use between hues, but it may not always achieve the maximum gamut. If the ink separation is dynamically generated then a maximum gamut will be attempted, with the possibility that the ink transitions between hues might be not as smooth.

*Please note that if a CMYK with spots ink configuration is used to generate an ICC swatch, then the separation will ALWAYS be dynamically determined meaning this option will be selected and grayed out.*
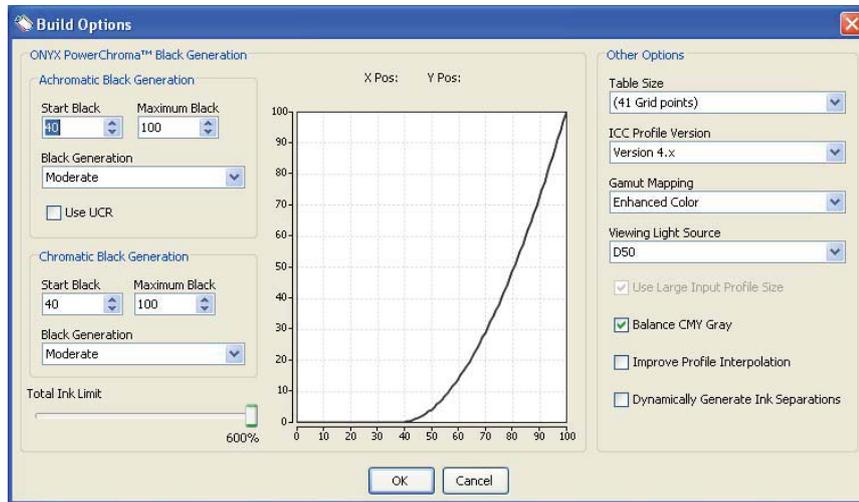
***Figure 3.*** *ICC profile build options dialog for a HiFi print mode*

## Review of HiFi mode ink separations

Let us review in this section different ways that the ink separation to HiFi colors can occur:

1. When printing without ICC profiles, a default ink separation is used to convert from RGB/CMYK to HiFi Inks.
2. When printing with CMYK ICC profiles, the same default ink separation from above, is used to convert from CMYK to HiFi inks.
3. When printing with HiFi ICC profiles, the ICC profile already has the ink separation built into it. There are two ways to build this separation into the ICC profile.
   a. Use the default ICC Profile generation separation (currently different than the separation used in point 1 above) by NOT selecting "Dynamically Generate Ink Separation" option from the build options dialog as shown in ***Figure 3***.
   b. Selecting "Dynamically Generate Ink Separation" will attempt to build a separation optimized for the particular print mode. This option is selected by default when a CMYK with spots ink configuration is used.

## Review of HiFi mode profiling recommendations

In conclusion the following are recommendations when profiling HiFi print modes:

1. Use the appropriate HiFi ink configuration (rather than CMYK with spots) when defining the media.
2. Use either "Coated Media Gamut" or "Extended Gamut" as the Gamut Size preset in the ink restrictions step.
3. Select a HiFi swatch when printing the ICC profile swatch.
4. Be careful to measure the swatch accurately without damaging the swatches.

5. Check the option "Dynamically Generate Ink Separations" only if you are willing to sacrifice transition smoothness for a potential increase in gamut.

*Please note that recent ICC build option recommendations for HiFi Profiling that have been found to be useful include NOT selecting "Improved profile interpolation" and turning OFF the "Balance CMY Gray" option.*