Max-imize Your Color: **Aug-2010**
Expert Tips from our Color Scientist Max Derhak

Controlling Ink Use

When profiling a print mode in Media Manager, one quickly discovers that the total amount of ink (colorant) can be controlled in several locations. If controlled incorrectly one can significantly damage the color gamut available to the print mode. This article discusses some of the various ways that total ink can be controlled with recommendations on when and how to control ink use to minimize gamut loss.

Controlling Ink in the Processing Workflow

A high level overview of the color processing workflow is shown in Figure 1 with color processing stages indicated in blue. Interestingly, the order in which solid blue stages of the processing pipeline are applied is exactly opposite of the order in which they are configured in Media Manager. This is because each stage has the ability to control the total amount of ink thus redefining how ink is addressed by previous stages.

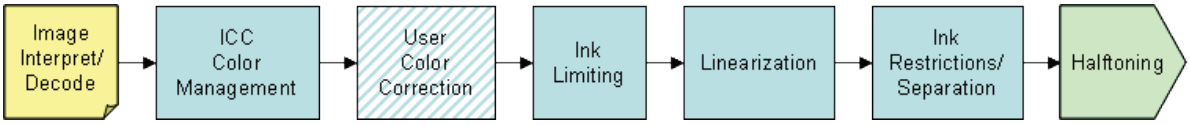

Figure 1 – Color Processing Workflow

Ink Addressing

Every color that can be printed is made up of a combination of values associated with each processing channel. The number of processing channels is determined when a media is defined in Media manager. A single combination of processing channel values can be thought of an address in a printing color space. The printing color space can be represented as an N-dimensional hypercube. The dimensionality of the printing color space is determined by how many process channels are available. The total number of colors (or gamut of colors) that can be printed is determined by the volume of the hypercube. In Figure 2, a CMYK color addressing space is depicted as a four dimensional hypercube.

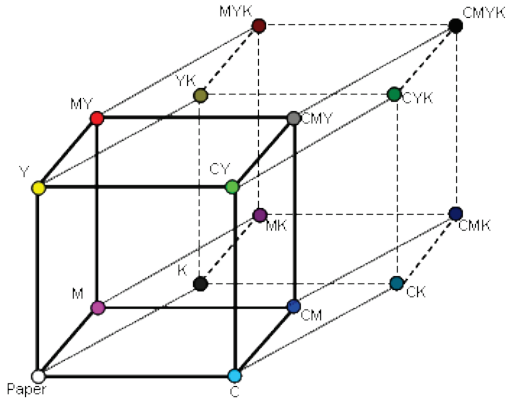

Figure 2 – A four dimensional "cube" representing CMYK ink addressing with each point in the cube representing a single CMYK ink combination

The solid sub-cube represents CMY combinations with no black, and the dashed sub-cube represents CMY combinations with 100% black.

Generally speaking, when ink is limited by any stage in the color processing pipeline the ink addressing is remapped so that the full extent of the addressing range maps onto a smaller subset. The following examples may help to explain this concept.

Ink Scaling

In a one dimensional case we have only one ink (which can be represented as a 1-dimensional hypercube – or a line). Points on this line represent all the possible inking combinations. For this example - we will linearly scale the maximum amount down to 75%. This operation is represented by the graph on the left side of Figure 3 with the corresponding change in Ink Addressing shown on the right.

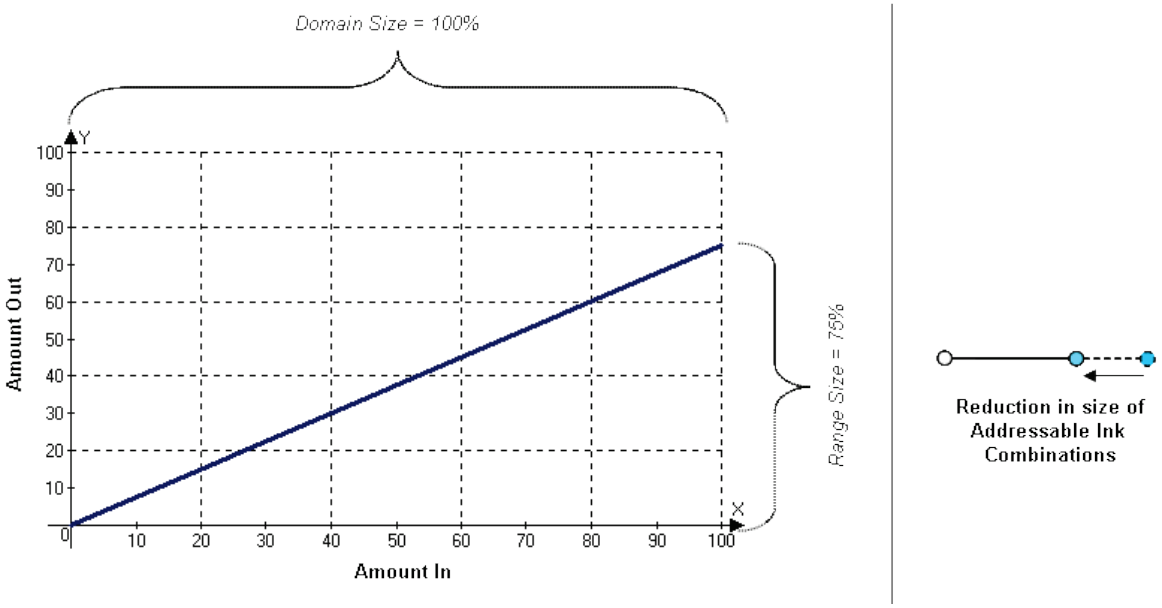

Figure 3 – Ink reduction function (left) and change to Addressable Ink Amounts (right)

As can be seen from the graph on the left, the input domain is the full ink range (or 0% to 100%), and the output range is smaller (only going from 0% to 75%). The scaling of actual Addressable Ink Combinations is depicted on the right side of Figure 3. Notice that the ability to address absolute ink combinations containing more than 75% has been eliminated by this operation Succeeding stages in the color processing pipeline pass the results from one stage to the next resulting in the final values that will be used for halftoning (see Figure 4).

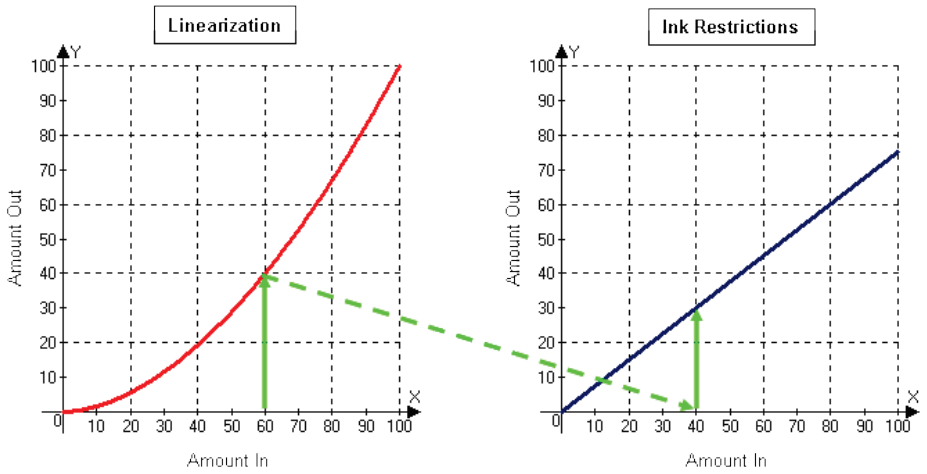

Figure 4 – Ink values are modified by succeeding color processing stages

Ink scaling with multiple inks

If we apply the transform in Figure 3 to the cyan channel when we have CMY print mode then the reduction of Addressable Ink Combinations is applied uniformly to combinations in all dimensions. Figure 5 shows the resulting reduction in Addressable Ink Combinations in this case. Notice that the ink reduction results in a compression of the entire cube surface in the dimension that the ink is reduced, and color combinations that are in the dashed region are no longer addressable. The processing stages before this will have a 0% to 100% addressing to the smaller cube.

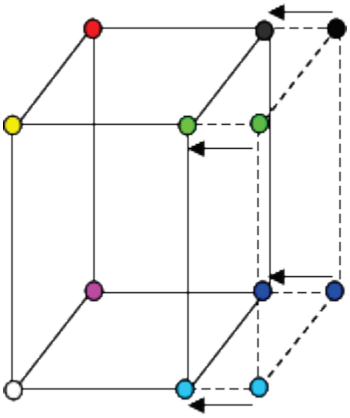

Figure 5 – Independently scaling an ink channel results in compression of a CMY Addressable Ink Combinations cube

Independent Ink Scaling and the Processing Pipeline

Independent ink scaling is important and useful when you want to control the total amount of ink for a channel independent of how it is combined with other inks. This is important if you have too much ink (or wasted ink) in one color combinations. It is also useful for establishing maximum target density for one ink combinations. This type of ink reduction is used for both the Ink Restrictions and Linearization/Calibration processing stages.

Independent ink scaling is not generally the best method to deal with problems in two or more ink combinations. This is because reducing the maximum amounts of single color ink combinations to address problems with more than one ink combination results in a broad loss of addressable ink combinations.

Note: One exception to this general rule is when light inks are used. Since light ink separation is defined by the ink restrictions stage, problems with two process channel combinations involving light ink use can only be resolved by setting the ink restrictions for light inks lower.

Selective Ink Reduction

When you are only having problems with selective inking combinations (example: 2 or more ink combinations) then a more preferable approach to ink reduction would be to use a selective ink reduction strategy. This amounts to individually shifting vertices of the addressable ink combination cube. An example of this can be seen in Figure 6. In this case the two and three color combinations are scaled back while leaving the one color combinations untouched. As in figure 5, colors in the dashed portion of the cube are no longer addressable (thus eliminating potential problems caused by these combinations).

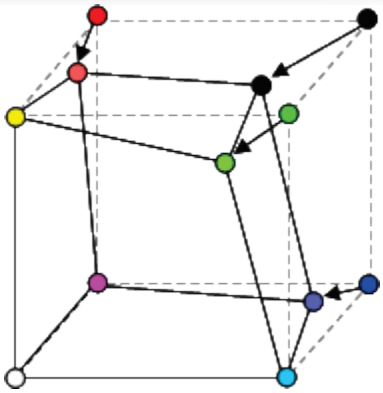

Figure 6 – Selective reduction of ink results in a stretching of the Addressable Ink Combinations cube

Selective ink reduction is used by both the Ink Limit step as well as in ICC profile generation. However, it is not recommended to use ink limiting in ICC profiles if ink limiting is performed in the ink limit step. Also, not setting ink limits in the ICC profiles allows for ink limiting to be applied even when ICC profiles are turned OFF.

The Ink Limit Step in Media Manager

The Ink Limit step in Media Manager is performed after Ink Restrictions and Calibration and therefore the Ink Limit swatch is printed with both of these applied, and the Ink Limiting is performed in terms of ink combinations addressing cube that these later two stages provide (rather than in terms of absolute printer ink amounts). *This is an important concept to keep in mind when setting up ink limits in Media Manager.*

The Ink Limit step uses selective ink reduction by using different ink scaling values for various portions of the ink combination addressing cube. Ink limit values are associated with the various (non-paper) vertices of a CMY cube (with black set at 100%). This is because ink limiting is NOT applied to the black channel (*Also a very important point to remember*). Therefore maximum ink limit values should be considered having a black ink value of 100% (since no scaling of black ink is performed). The CMY cube will be deformed when the total of the ink combination is larger than the ink limit value.

(Note 1: For some printers in X10 ink limiting may not apply to white ink spot channels as well).
(Note 2: If ink limiting is desired for black ink it should be performed in either the Ink Restrictions or Calibration steps).

The limit that is used for the non-vertex inking combinations is a result of an interpolation of the ink limit values between the vertices. This is helpful in understanding why one can set ink limit values for one color combinations above 200% (100% ink + 100% black). This means that intermediate colors will use a combination of the ink limits for the vertex colors.

For example: Both the ink limit setting for C as well as the ink limit setting for CMY will determine how ink limiting is performed as ink transitions from CK to CMYK. When looking at an ink limit swatch notice that the one color lines ultimately transition from the one color values plus black to CMYK (Figure 7). The CMYK patches actually correspond to a different color addressing vertex which is controlled by the 3 color combinations ink limit value.

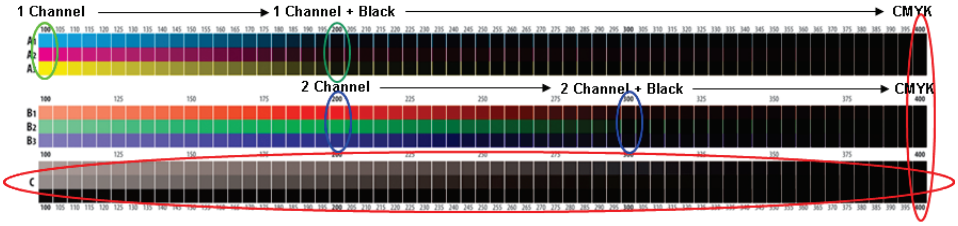

Figure 7 – Basic Ink limit swatch color usage

Figure 8 shows a graph of ink limit boundaries for colors going from CK to CMYK. The total ink used will be the minimum of the total ink and the ink limit boundary. (Note: When the boundary is less than the ink, the ink will be scaled to the boundary). This example shows how having different ink limit values for C result in a different ink limit boundary being defined.

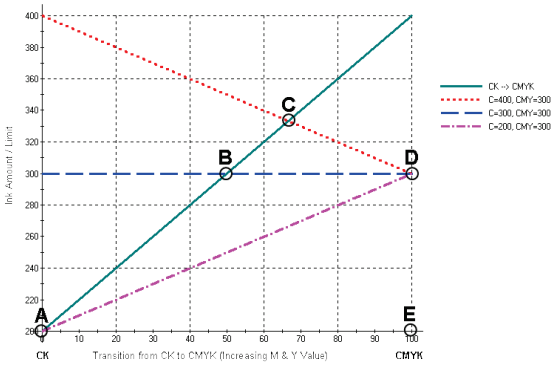

Figure 8 – Various Ink limit boundaries from CK to CMYK

The dark cyan line shows the total ink as we transition from CK to CMYK. The red dotted line shows the ink limit boundary going from an ink limit of 400 for C and 300 for CMY with the boundary going from point A to C to D to E. The blue dotted line shows the ink limit boundary going from an ink limit of 300 for C and 300 for CMY with the boundary going from point A to B to D to E. The magenta dash-dot line shows the ink limit boundary going from an ink limit of 200 for C and 300 for CMY with the boundary going from point A to D to E.

Because ink limiting is performed relative to the ink addressing provided by ink restrictions and linearization, the actual physical ink amounts are not easily determined from looking at values in the ink limit swatch (IE the values are relative). Also, because linearization was applied, the physical ink values going from 0% to 100% may have been adjusted to achieve the tone mapping criteria set during the calibration step.

Advanced Ink Limiting

When using advanced ink limiting, the Black ink compensation and Chromatic ink compensation values are used to compensate for the assumed amount of black or grey component inks being used. Larger values of black ink compensation result in an assumption of less black ink being used in black highlights and midtones. This assumption of less black ink results in the ability to use more of the other inks (since black ink is not limited). Similarly, larger values of chromatic ink compensation also result in the assumption of less ink being used in the gray component highlights and midtones – also resulting in allowing more ink to be placed in these regions. These controls can be used to improve dingy shadow colors caused when lower ink limits are used.

Conclusions

Ink reduction can be performed in a variety of ways in the profiling process in Media Manager. Ink reductions applied in one stage result in the inability to address ink combinations in earlier stages. It is important to use good judgment where ink reduction is performed. Using the Ink Limit tool allows for ink reduction to be selectively performed. Additionally, it is important to realize that combinations of ink limit values are used to define the ink limit boundaries for "in between" colors. Hopefully, with a better understanding of how ink limiting works you can better "fine tune" your results.

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