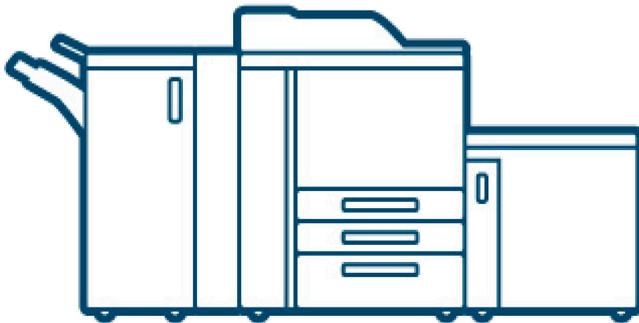


## Color management

The basics simply explained



In this How-to, we explain why color management is necessary and what happens in the background.

The colors in a print job can come from different sources: Images from cameras or scanners, as well as graphics, text and layout from various applications. In each source, color can be defined differently.

Also the output of each printer is a little different. One printer can print many colors, another only a few. Even printers of the same type and manufacturer always print colors a little differently. In addition, the color rendering is influenced by the toner used and the selected paper.

With good color management, it is possible to control the colors in the print job and set up a color-constant printing process. The aim is to achieve a constant color rendering across the various printers and papers according to a predefined standard. If you print a job on different printers with the same paper, you get consistent color rendering. If a customer orders a print job at a later date, they receive an output in the same colors as for the initial order.

A few basics in advance for a better understanding:

## What is a color space

A color space includes all colors that a device or medium can display. The larger a color space is, the more colors can be displayed. Each printer and monitor has its own color space. These color spaces vary in size so that different monitors and printers can display different numbers of colors. A monitor could also display colors that cannot be printed on a printer.

## What is a color model

The colors in the color spaces can be described in different ways.

Various color models are used for this purpose.

---

### RGB color model



The RGB color model is used by devices that generate colors using light, such as monitors, scanners, or cameras. The colors are formed from the basic colors red, green and blue (RGB). The individual color components are described with values from 0 to 255. 0 means no light (no color), 255 means full light (full color). All colors mixed by one hundred percent, make white. Black is where there is no light. RGB (234,28,36) for example produces a warm red. But how this red looks on a device is not defined, because each monitor will show the red a little different.

Well-known RGB color spaces are sRGB or Adobe RGB. sRGB is used by most digital cameras or monitors. The Adobe RGB color space is larger and can display more colors than sRGB. It is mostly used by high-end monitors or high-quality digital cameras.

---

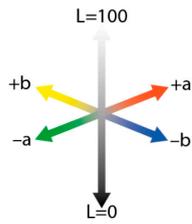
### CMYK color model



The CMYK color model is used in four-color printing. The colors are formed from the primary colors cyan, magenta and yellow (CMY). The individual color components are described with percentages. 0 percent means no color, 100 percent means full color. All colors mixed by one hundred percent result in black. However, since this black is not pure black, black (K) is used as a supplementary color. For example, CMYK (0,100,100,0) produces a warm red. But how this red will look in print is not defined. The rendering of the color depends on the printer used and the type of paper.

Well-known CMYK color spaces are for example PSOcoated\_V3 or PSOuncoated. PSOcoated\_V3 describes the color space that can be achieved with a sheetfed offset press on coated paper and PSOuncoated the color space that can be achieved with a sheetfed offset press on uncoated paper.

## Lab color model

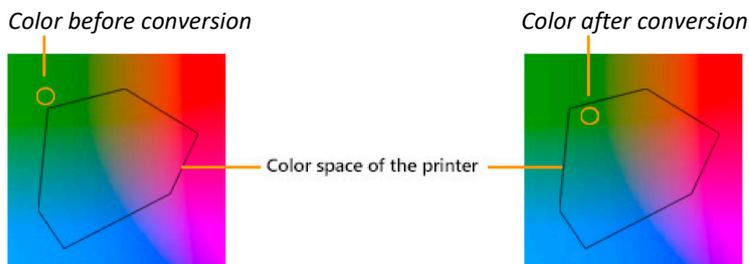


The Lab color model is used as a reference color space when colors need to be converted from one color space to another. The Lab color model is based on the human perception of colors. The colors are described independently of devices and media. With this color model the colors can be defined physically exactly.

In this color model, all colors are defined by three components: "L" describes the brightness with values from 0 to 100, L=0 means very dark/black, L=100 means very bright/white. The color is defined with "a" and "b". "a" indicates a color value that lies on an axis that goes from red to green and ranges from +127 to -128. The closer the value approaches zero, the more the color loses saturation and approaches a gray tone. Positive "a" values are reddish; negative "a" values are greenish. "b" indicates a color value on an axis from yellow to blue. Positive "b" values are yellowish, negative "b" values are bluish. Lab (51, 73, 53) produces a warm red, for example.

## Color conversion between the color spaces

The colors in a document can be defined by different color models in different color spaces. The colors are converted into the color space of the printer for printing. Colors that lie outside the color space of the printer must be converted into colors that are as similar as possible and that lie within the color space of the printer and can be printed.



ICC profiles are used for this purpose. ICC profiles are standardized value tables that contain information about the color space used, color adjustments or even the paper whiteness. With the help of a profile, the colors of the document can be converted into the color space of the printer via a device-independent reference color space (e.g. Lab).

The following profiles are required for printing:

- **RGB source profile**

This profile describes the color space in which the RGB colors were created in the document. Each RGB color value is linked to a Lab color value. This allows the RGB color values to be converted into the CMYK color values that are within the printer's color space.

- **CMYK target profile** (*also known as simulation profile*)

This profile defines the standard for printing. It sets the desired color space of the printer. It also defines how the CMYK colors of the document are to be interpreted.

- **Printer profile** (*also known as output profile*)

The printer profile describes the special properties of the printer and the paper used. The printer profile determines how the calculated CMYK color values are to be adapted to the output on the current printer with the selected paper. Since each printer prints a little differently and each paper takes up the colors differently, profiles should be created for each printer and each type of paper with which you want to produce correct colors.

## Ensuring correct color output at the printer

To ensure that the output is always clean and correct, the following steps are necessary:

### Printer linearization

When linearizing, you are adjusting your printer to print technically clean colors. *A small comparison: Imagine you have a yellow and a blue highlighter. The highlighters have dirty tips that you need to clean in advance to draw a clean yellow and clean blue. That would be linearization.*

When linearizing, a color wedge is printed that contains a large number of color fields for each of the printer's color channels. Each color field is assigned a color value in uniform tonal value gradations between 0 and 100 percent. The printed color fields are measured with a spectrophotometer and compared with the color values assigned to them. Color values that deviate from the setpoint are corrected. This resets the printer to a standard and ensures that the colors are printed consistently and in consistently good quality.



Before linearization



After linearization

**An example:**

*The color gradations in the dark areas of the color wedge are incorrect, so that the color differences are not reproduced properly in the dark areas of the image. Linearization restores the color gradations so that all color nuances in the image can be printed.*

However, if the printer prints technically clean colors, it does not mean that it is printing the right colors. For true color output, the printer must be profiled.

### Printer profiling

Profiling checks whether the printer mixes the right colors from the basic colors and how the mixed colors are reproduced on the different papers. Color deviations can be corrected here. *Another comparison: You have a clean yellow and a clean blue highlighter. Now you want to draw a green tone with it. To do this, you need to specify how much yellow and how much blue you put on the paper to achieve the desired color tone: Maybe a little more yellow or a little more blue. That would be profiling.*

During profiling, a test chart is printed on the desired paper and printer. The test diagram contains color fields in different colors. Each color field is assigned a color value in a device-independent color space (e.g. Lab). The printed color fields are measured with a spectrophotometer and compared with the stored color values. Color values that deviate from the setpoint are written to a correction table and saved as a profile on the printer. The profile ensures that the color deviations are automatically corrected during printing.



Before profiling



After profiling

**An example:**

*The mixed colors are not printed correctly; the printing result has a color cast. When the printer is profiled, the colors are converted so that the colors are printed correctly and without color cast.*



Constant conditions are important for constant behavior. Changed environmental conditions, such as a change in temperature and humidity in the print room or mechanical errors, affect the production process and can lead to changes in color behavior.