

COLOR MANAGEMENT IN CONVENTIONAL AND DIGITAL PRINTING PROCESSES

White paper

IN THIS PAPER

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Section 01

COLOR MANAGEMENT IN CONVENTIONAL AND DIGITAL PRINTING PROCESSES

One of the biggest challenges for label and packaging printers is to ensure the color consistency that brand owners demand for their packaging products. Through the years this has become more challenging. As turnaround times get shorter and job lengths vary, one print technology can no longer provide all the answers. Thus multiple print technologies – both digital and conventional, are required, driven by the need of printers to address the demands of the market in the most economical way. This white paper outlines the color management challenges and solutions for conventional and digital printing processes, how to deal with this as a printer and which technologies to consider to simplify this complex matter.

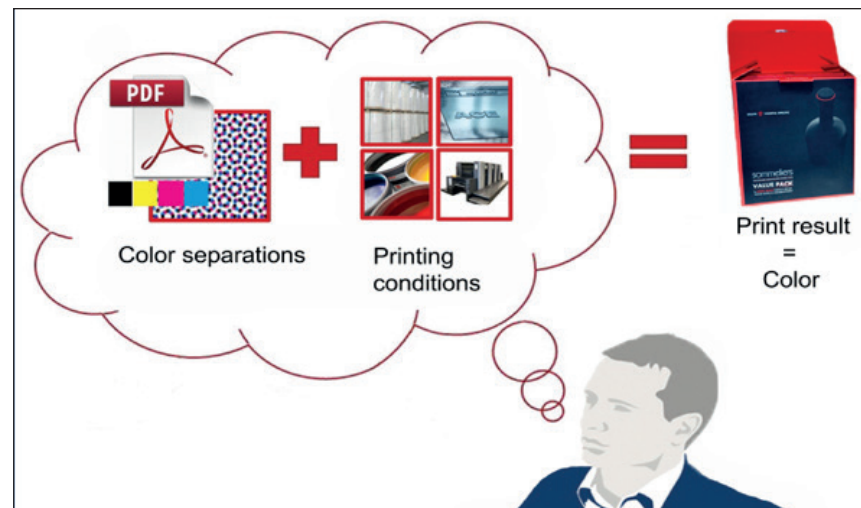
For a long time, only proven experts dared to tackle the subject of color management. Today, you no longer need to be an expert to achieve color-consistent results in print. The fundamentals on which color management is based are easy to follow, and with them it is easy to understand how color management systems work. For the implementation in reality, however, a certain amount of practice and knowhow is necessary in order to exploit the possibilities.

BASIC KNOWLEDGE

Color management initially revolves around the question “What is color?” For a printer this is clear. For him, color in the printing process is composed of the four or more process colors (CMYK+OrangeVioletGreen) as well as spot colors from the Pantone or HKS palettes. These are contained in the color separations in the form of data in a PDF file from which the printing plates for a job are produced. With the printing plates as information carriers, the job is then printed under defined printing conditions. For the printer, the print result is the possible color result = color.

And every printer knows the situation when the color result in print does not match the color expectations of his customer. Hence setting expectations with customers is key, otherwise corrections may have to be made, which is often a time-consuming, waste generating process.

By Dieter Finna
pack.consult
August 2021



Color in the printing process

Section 02

COLOR IS NOT CMYK, IT IS WHAT WE SEE

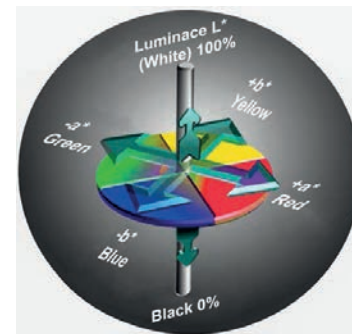
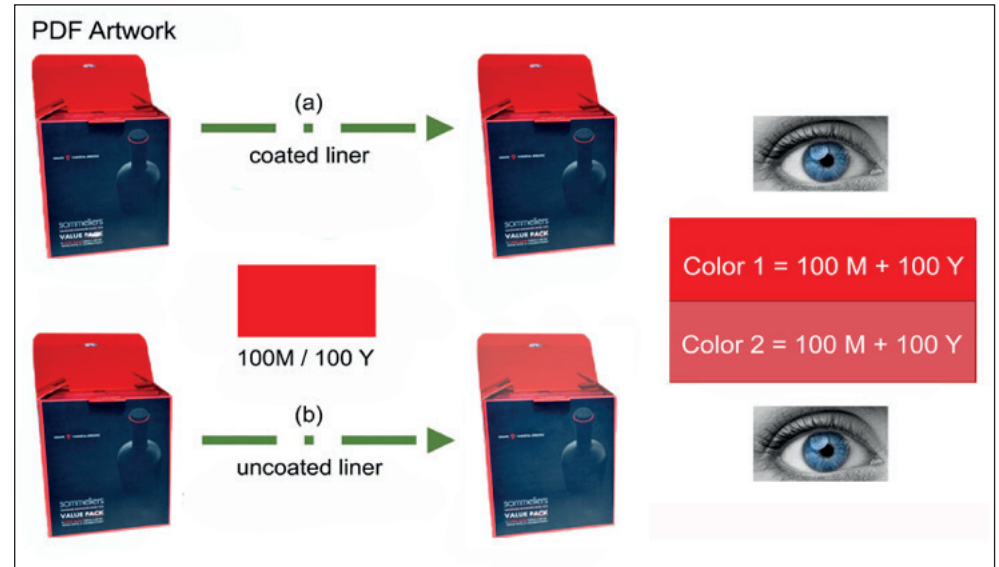
To give an example, when printing, on (a) coated liner and, in a second job (b) on uncoated liner of corrugated cardboard, the results will differ, even with the same ink. This is because of the interaction with the substrate as an uncoated liner looks far less brilliant and causes color results to deviate significantly from the expected color, compared to the coated liner. This is an extreme example but a clear illustration of the impact of the substrate. So color is an interaction between substrate, ink/toner and the printing process. In general, substrates can be clustered in categories which give similar results e.g coated paper, uncoated papers, white Bopp, etc. The process colors CMYK cannot achieve a unique consistent color across different processes or different substrates. That is why color management uses a model that describes the specific color tones of the entire color spectrum and with which color can be communicated.

The $L^*a^*b^*$ color space is such a model and describes the visible colors in a three-dimensional color space, in which the brightness value, L^* , is perpendicular to the color dimensions a^* and b^* . For each color that is visible in the spectrum, there is a finite value called the "Lab" value.

If a color tone is available in printed form, its color coordinate in the Lab color space can be determined with a spectrophotometer. This device measures in a way that is very close to the functioning of the human eye and corresponds to the color perception of our eyes.

In our example, the measurement result for the printed color, 100M + 100Y on the coated liner is L^*50 , a^*76 and b^*61 and on the uncoated liner it's L^*53 , a^*57 and b^*28 . The two results show different values, which reflect how they are perceived by our eyes.

The Lab values can now be used to find out how the desired color shade, in the example above it was 100%M + 100%Y as printed on the offset coated liner, can be reproduced on different substrates. This is done with the help of ICC profiles, which carry out this translation in two steps for a printing process and its inks/toner on a specific substrate.



$L^*a^*b^*$ color space



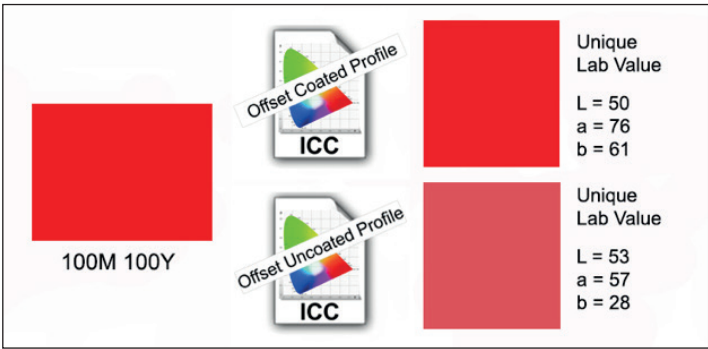
Spectrophotometer for measuring a test chart

THE DUAL NATURE OF AN ICC-PROFILE

An ICC profile is a digital file that contains color information about a printing process on a specific substrate category. In the graphics industry there are some standard profiles such as ISO coated v2. This is a generalised color description of offset printing in Europe, which indicates what color tone designers or print buyers expect in the printing process. An ICC profile works in two directions.

FROM CMYK > LAB

Let's start with the process colors. They are included in the color separation files and indicate how a color will look in the printed result. In the example below it is 100%M + 100%Y as on the offset coated liner. The offset coated or the offset uncoated profiles then give you the color you can expect in a defined process. In relation to our example, that means: With the "Offset Coated" Profile, 100% magenta plus 100% yellow result in an offset red that is clearly identified by the Lab values L*50, a*76, and b*61.



Refer to as: CMYK > Lab

With the "Offset Uncoated" profile table, the result is a shade of red that is specified by the Lab values L*53, a*57 and b*28. It can be seen that printing on different substrates leads to a change in the printed color shade. (If you are interested in how a profile is created, this is shown in detail on page 6).

FROM LAB > CMYK

This direction describes how a desired color, which is defined by Lab values, is translated into CMYK values for a defined printing process.

The result is a unique CMYK composition when printing on a specific press, in this case a Xeikon CX300 digital press. As you can see in the example, the color tone is no longer composed of 100M and 100Y, but rather there are new values that give the same visual result through my eyes. To get this in print on the Xeikon digital press, it prints the color shade with C1, M99, Y97 and B7 (CMYK). For an observer, this corresponds to the desired color with a Lab value L*50, a*76 and b*61.



Refer to as: Lab > CMYK

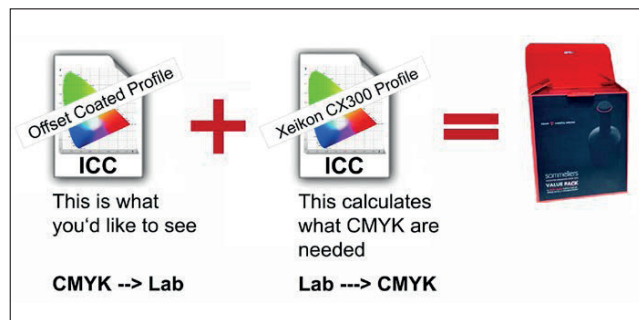
Section 04

COLOR MANAGEMENT WORKFLOW

Every creation of a color workflow is therefore based on conversion processes with two profiles that can be shown in an equation. On the one hand the process that describes “if a CMYK value is specified, which Lab value defines my desired color tone” (CMYK → Lab). In a second step, all Lab values that can be converted in the press are translated back into CMYK values in a kind of backwards calculation (Lab → CMYK).

In simple terms, these two steps can be described as ink to color (CMYK → Lab) and color to ink (Lab → CMYK), and they then result in the desired color tone on the substrate in the printing process.

Ink to color and color to ink = desired color tone



COLOR MANAGEMENT FOR MATCHING DIFFERENT PRINTING PROCESSES TO EACH OTHER

If different printing processes are used in a print shop, for example conventional as well as digital printing, these must be coordinated with each other so that the same printing results are achieved as the end product might end-up on the same shelf alongside each other at a retailer. In this example, the Xeikon CX300 digital press is to be matched to an existing flexo press in order to deliver the same printing results as the flexo press has provided until now.

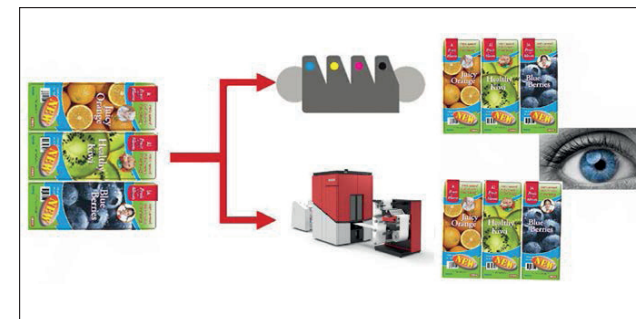
Step 1: For this purpose, a test chart is printed per substrate category on the flexographic press and measured with a spectrophotometer. Then the measurement data is used to calculate the profile that represents for every flexo CMYK color value the related Lab value. This profile describes “color in the flexo process” and is the reference to be matched on the Xeikon CX300 press.

Step 2: A test chart is also printed with the Xeikon CX300 digital press on the same substrate category. It is measured with the spectrophotometer and the Xeikon CX300 profile is calculated. In the Xeikon Color Service

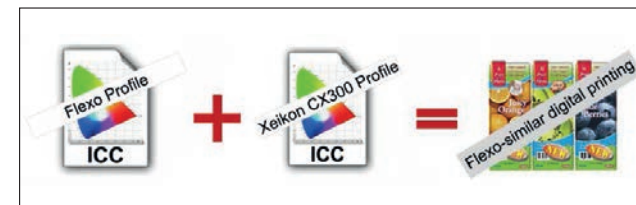
these two profiles are combined to a color transformation to simulate the flexo result on the Xeikon CX300 press. The digital printing machine is the output unit in this process and describes which output values are needed to match the flexo CMYK colors.

The graphic below illustrates, how the corresponding color management workflow looks like.

The best way to show how color profiles are applied in a print shop to achieve the same results on different press systems is to use an example.



Color management for matching different printing processes



Profiles for flexo-similar digital printing

Section 05

EQUIPMENT OF A LABEL PRINT SHOP

A label print shop is particularly well suited for demonstrating different color management solutions, since many different printing processes are used in label printing and the complexity in the workflows is therefore high.

In this example, the machinery consists of:

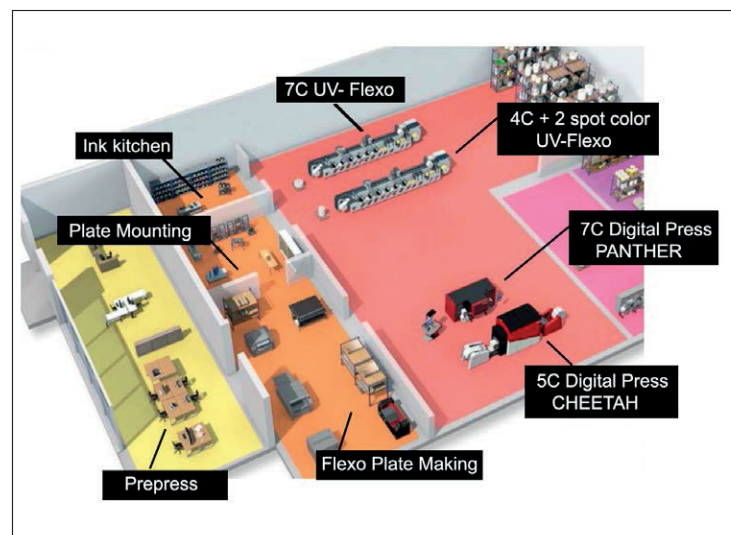
- a. A UV-Flexo press with 7 print stations (fixed pallet of 7 colors)
A fixed pallet helps to avoid setup time of ink change on press even if there is still the setup time for the print cylinders and time needed to process the printing plates.
- b. A UV-Flexo press with six print stations (fixed pallet CMYK + 2 potential spot colors). This conventional press is ideal for print jobs which require specific spot color matching, as certain spot colors can be challenging to match out of a fixed pallet (e.g. pastel tones with light tint of color).
- c. A UV inkjet press with 7 print station (fixed pallet)
This machine addresses the market of durables-, cosmetic-, beer-, chemical-, ..labels. Digital printing with a fixed pallet is not only avoiding ink change over, it also does not require setting up the printing cylinders or making printing.
- d. A Toner digital press with 5 print stations (fixed pallet) addresses the market of food-, pharmaceutical-, wine-, spirits-, .. labels. In addition to the above mentioned advantages of digital print, dry toner offers the flexibility to still use a spot color. The change over to a spot color in dry toner is less cumbersome than changing a (digital) liquid ink.

In addition, the print shop has a pre-press department where the jobs are prepared for the conventional and digital printing processes, as well as its own flexo plate making, plate mounting and an ink kitchen that manages the various ink types and coatings.

The different printing processes in the print shop pose challenges for the operators and production manager. Due to the different systems, not all operators can have the same know-how on the machines and are not equally familiar with questions of color standards in day-to-day business.

The print shop management has therefore decided to apply the possibilities offered by today's color management to all printing processes and to create color profiles. To this end, Xeikon offers a suite of color management tools in the form of Xeikon Color Services XCS Pro 2.0.

The different procedures in color management depend on the existing printing presses and differ in their effort required to run them.

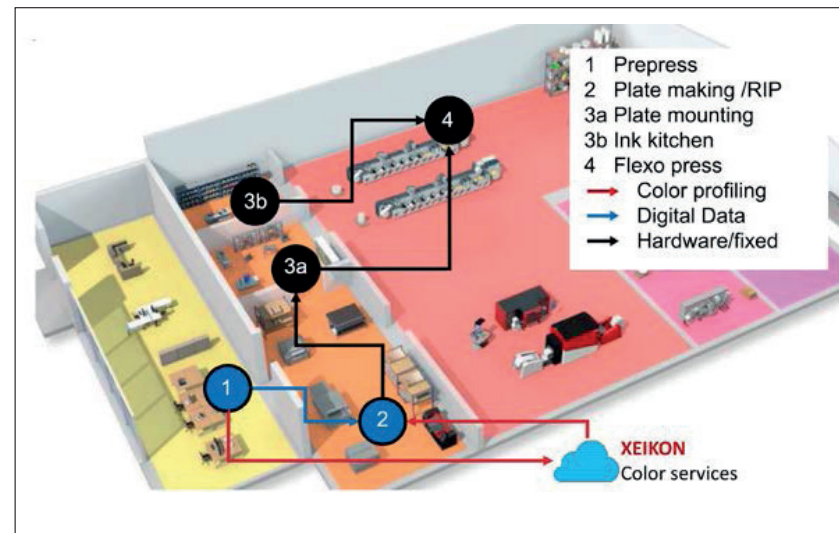


Machinery of the label print shop

Section 06

7 PRINT STATION UV-FLEXO PRINTING WITH 7 COLOR (EXTENDED COLOR PALETTE CMYK + OVG)

The example shows the flow of data in a conventional process on a UV- flexo press with an extended color palette. The job that is transferred from prepress (1) to the RIP of the Computer-To-Plate system (2) is marked in blue. I.e. it is digital data, through which it is possible to process the data, up to this point. In the RIP (2) color profiling intervenes in the job processing, illustrated by the red line.



*Procedure with a
7-color UV Flexo
press with extended
color palette*

Section 07

BUILDING A PRINTER PROFILE FOR A FLEXO PRESS

We will now take a detailed look at the time required to create the necessary color profile.

To create a color profile, a test chart must first be printed on the 7-color UV flexo press. Often a test chart with 2,000 up to 3,000 patches is used to produce the profile. From this

- the color profile is calculated and in addition
- a look-up table with the colorimetric data of the Pantone or HKS colors is obtained.

These colorimetric data indicate how the spot colors are converted to achieve the desired color in the printing process. The color profile and the Pantone/HKS values are loaded onto the RIP of the CTP system. The color profiling process takes a total of 45 minutes. No production is possible during this time.

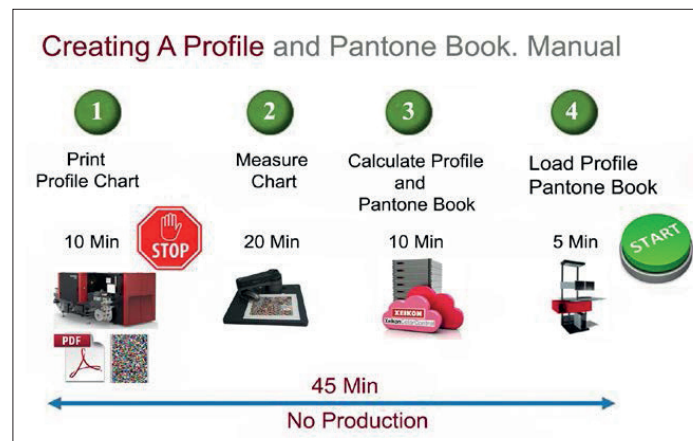
QUALITY CHECK CONVENTIONAL PRINTING

Once a color profile has been created, the stability of the flexo process needs to be monitored. This is done by measuring print control elements at the edge of the web during the production jobs. Periodic quality checks with test charts need to be done e.g. when inks or plate types are changed or print buyers ask for color quality protocols.

QUALITY CHECK DIGITAL PRINTING

The test chart is printed again and measured to check the results in quality control. This verifies whether the color values are really within the printer's color standard. This process takes about 16 minutes. If the result is not satisfactory, the process must be repeated to create a color profile from the beginning. It is recommended to perform the QC every now and then on the defined substrates.

In order to ensure color consistency, however, it is essential to carry out these steps and thus create a color standard in a print shop. At the same time, one gains insight into the limits and possibilities of the individual printing systems and creates a basis for decision-making on which to assess whether a job can be switched from a conventional to a digital press, for example, or vice versa. Knowing the possible variations is necessary know-how for day-to-day business.



Time required for a color profile in digital printing. In conventional printing approx. 30 minutes have to be added for job change and set-up.



Let's now take a look at a color management process on a conventional press that uses spot colors.

6 PRINT STATION UV FLEXTON PRINTING (CMYK WITH 2 OPTIONAL SPOT COLORS)

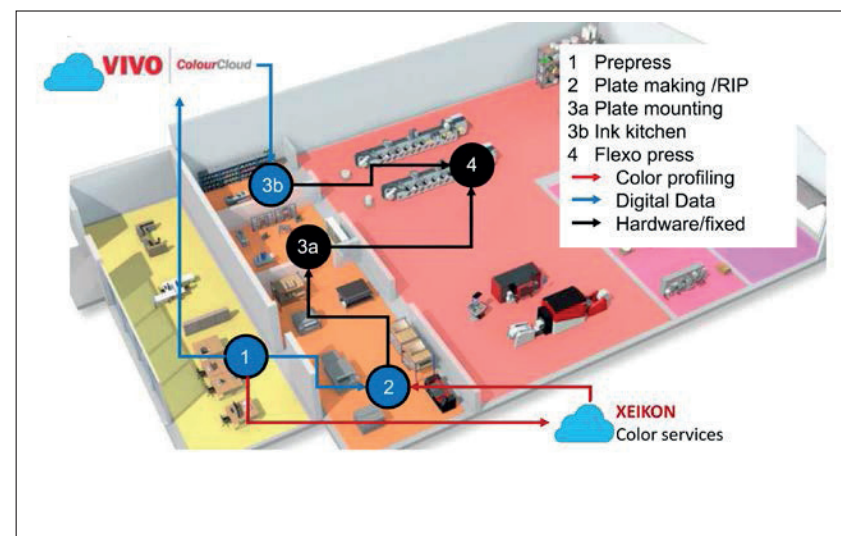
This is the second option for producing the job on a conventional press. On the six print station press the spot colors can be printed on printing units five and six. The color profiling process of the spot colors is carried out as described in the paragraph "Building a Printer Profile". For the spot colors, it is possible to work with the VIVO Colour Cloud.

If a job contains spot colors, the prepress department (1) can send the Lab values of the spot colors to the VIVO Colour Cloud, together with the information about the substrate. This information is translated in the VIVO Colour Cloud into an individual ink recipe for the spot color, which can be obtained as a recipe for a Flint Group concentrate system, as a CxF file in color interchange format or as data for digital printing of a color chart (DigiSwatch). The recipe provided is based on a typical transfer volume of an anilox roller of 6cm³/m² in narrow web printing. This transfer vol-

ume needs to be adjusted to the anilox rollers used in the print shop, by means of an anilox worked out in advance.

The adjusted recipe is transferred to the ink dispenser (3b) in the ink kitchen. There, the spot colors are mixed from the basic color system of the ink dispenser. As a rule, color

accuracy is achieved straightaway and no further corrections are required. Printers who use the VIVO system report significant time savings of up to several hours a day by using VIVO formulations compared to 'normal spot color mixing'.



Procedure for a 6-color UV flexographic printing press

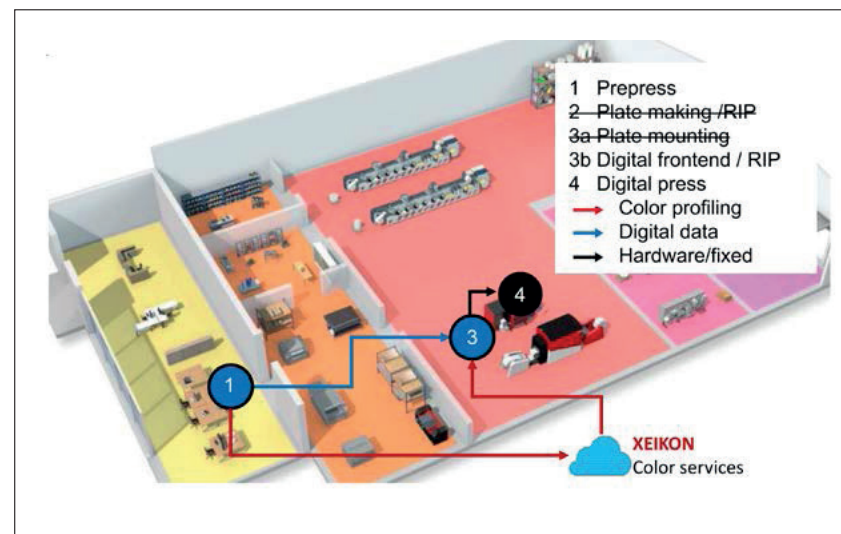
Section 08

COLOR PROFILING IN INKJET PRINTING

The Xeikon PX30000 inkjet digital printing system is equipped with 8 print stations (CMYK + OV + 2x White) and prints in the extended color space. White is available in the 1st and the 2nd printing station. Digital printing also requires color profiling, which is carried out in the same way as with conventional presses, again via Xeikon Color Services.

In contrast to the processes on the conventional presses, the job data from prepress (1) is sent directly to the RIP (3) on the front end of the inkjet system, which controls the digital printing system (4). This data is marked here with a black line, indicating that it is “hardcoded”, which means even if it’s a digital file the data can no longer be changed at this stage of the production process. For color profiling, this means that they must already be exactly right. It must be determined in advance what the color expectation is; what color accuracy is to be achieved, i.e. how large the delta E of a spot color may be. If this does not meet expectations, the job data must be edited or a new color profile must be created altogether. This takes time and causes additional costs.

This becomes much easier, when technology allows, if the color profiling is done automatically. This can be seen in the next example.



Procedure for a 7-color digital press with extended color gamut

Section 09

COLOR PROFILING WITH ANY CHEETAH DRY TONER DIGITAL PRINTING SYSTEM

The digital press is equipped with 5 colors CMYK + white, whereby the fifth printing station can also be used for gamut extension. In the outlined sequence, the color profiling has already been carried out.

For job processing, the pre-press department (1) sends the print data to the digital front end (3) where the data is ripped. The data path from the front end to the press is marked in blue, indicating that the data can still be processed before imaging.

It is an extremely innovative technology that Xeikon is using for the first time in its dry toner systems. In future, this technology can also become available for inkjet printing systems. The innovative part is that with the X800 7.0 digital frontend, Color Services 2.0 and the built-in spectrophotometer in the CHEETAH Press, the color gamut can be measured during the printing process (4) and at the same time, the color profile can be verified via a cloud connection in the Xeikon Color Services Cloud and, should it be required, the profile can be adjusted again in the front end (3). This

process is marked with green arrows in the diagram and is a continuous process during printing. This means that the previously manual process of color profiling and QC has developed into an **automatic process for color profiling and QC**, which starts with every production of a new job.

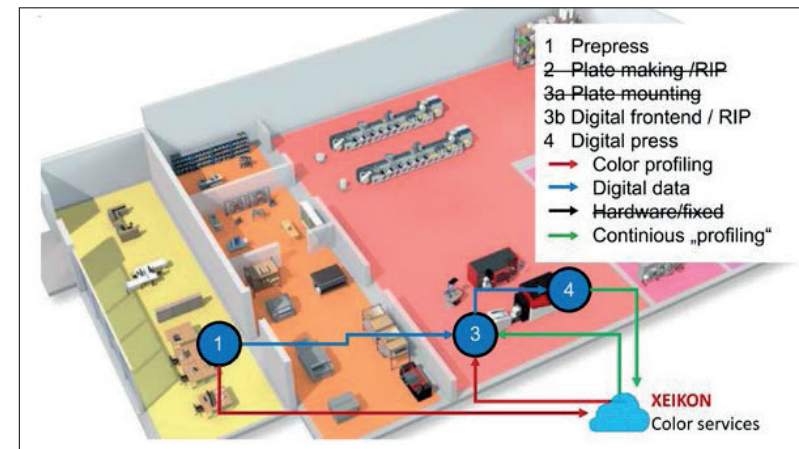
The entire procedure of measuring the color profile, generating a color profile via the Xeikon Color Services Cloud and then installing the color profile on the front end of the digital press takes approximately eight minutes, while the press is printing at a speed of 30 meters/minute. Once the color profiling is complete, quality control can be started while production is running. This process, again running parallel to production, takes about two minutes.

When this is completed, there are then several options:

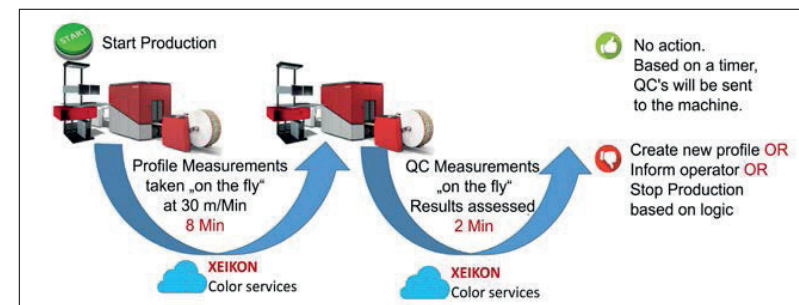
- a If the color profile is within the quality framework, no further action is necessary.
- b In case of deviations
 - b1 the press can automatically re-profile.
 - b2 Should this fail, the operator is alerted and can decide to undertake specific maintenance actions
- b3 Should this not resolve the situation the production manager and/or Xeikon service can be alerted.

In the process, the procedures for achieving the color tone specification are digitalised. The operator no longer has to decide whether or not to continue printing while the press is running. Through automation, this decision takes place on a neutral basis, which makes the process flow easier and safer.

In order for the color profiling to work automatically, a 1cm wide color strip is required, which is positioned at the edge of the web next to the print motif. With this, the CHEETAH press continuously measures the color values and corrects the color profile if necessary, without any operator intervention.



Procedure with a 5-color dry toner press



Automatic color profiling

Section 10

UNIFORM SOLUTION IN THE PRODUCTION



Control strip at the edge of the web

With Xeikon Color Services all printing systems in a print shop can be integrated into one color management system, both digital and conventional. The cloud-based solution XCS Pro 2.0 is available around the clock and ensures that the print shop is always running with the latest software updates.

It can be used to implement color standards even at different company sites, thus enabling identical color results regardless of location. This is an important quality criterion when supplying brand owners.

Another important aspect should be mentioned. Color management contributes significantly to material savings in a print shop through shorter make ready times and less waste. This has an impact on OEE (Overall Equipment Effectiveness) and improves press availability.

All the solutions presented here offer

- a significant savings potential
- b limitation of human interaction
- c a reduced need for color experts which is most effective with the automated option.

Section 11

ADVANTAGES IN SALES AND MARKET PRESENCE OF THE PRINT SHOP

Finally, let's take a look at how color management affects the workflow in a print shop, especially the possibilities that the sales department can use to their advantage.

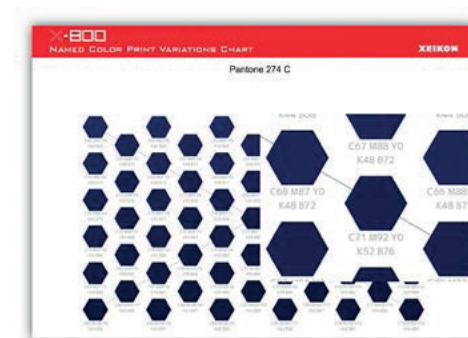
Because run lengths for customer enquiries vary greatly, the question for the sales department is which print technology should be used for which print motif and run length? Should the job be produced on a conventional or a digital system? What color expectations does the customer have and what influence does this have on the calculation? Often the sales department needs scale prices for different order sizes.

Xeikon Color Services contains a tool for the sales department to show the design variants on the different machine systems. The prerequisite for this is that the different printing systems of a print shop are profiled in Color Services. Then the sales or prepress department can load the PDF files with the artwork into a tool called "Color Forecast".

With the specification of the jobs, the desired substrates, the different run lengths and the design variants, the sales department can see in Color Forecast which print system can most closely achieve the targeted color result. The color result depends on the customer's requirements, for example they could be satisfied with a Delta E of 2 or even higher. In the color forecast, the sales department can already see how the jobs would be executed in

the different printing processes and how big the color deviation will be in each case. There is also the option of printing color cards on original print run material. These samples can help to avoid color discussions later on during the print approval process and the customer has a binding color sample when placing the order, which can also be achieved in print. The sales department can prepare a price quotation for different versions, designed to meet the customer's color accuracy requirements, specifying the Delta E deviation and the pricing for this.

This means that the sales department is well prepared and can present all variants to the customer. The discussion then revolves around the quality and the expected print result with the sales department providing a sound basis for the customer's decision. This consultation is elevated to a different level than just talking prices.



Color card Pantone 274 C

Section 12

SMART FACTORY WITH IMPROVED SERVICE

For a long time, color management was a matter for specialists to achieve good results. With the move to automation, color management has become an interactive process that fits into the production environment.

From a manual profiling process with corresponding time requirements, a system has evolved that draws its data from the ongoing process. Through the continuous exchange of data and the connection to a cloud-based system, color management in a smart factory regulates itself and supports the operator by suggesting actions.

However, color management not only supports production, but the advantages can also be used in sales to communicate color with customers in a binding manner. For example, through the aforementioned color cards on original printing stock, which are made available to the sales department for customer consultation. With them, the customer can specify which exact color tone he wants, and this can be accurately achieved in the subsequent production run. Color cards are quite easy to produce in digital printing and can also be done in conventional flexo printing, but the effort is very high and hard to justify economically. With these new possibilities, it is now up to production and sales to agree on the best way for the print shop to use these tools in discussions with print buyers.



Order discussion about design variants

The Xeikon logo consists of the word "XEIKON" in a bold, white, sans-serif font, centered within a red rectangular box.

ABOUT XEIKON

Xeikon is an innovator in digital printing technology. The company designs, develops and delivers web-fed digital color presses for label and packaging applications, document printing, as well as commercial printing. These presses utilize LED-array-based dry toner electrophotography, open workflow software and application-specific toners. Xeikon also manufactures basysPrint computer-to-plate (CtP) solutions for the commercial printing market. These proven CtP systems combine the latest exposure techniques with cost-efficient UV plate technology, high imaging quality and flexibility. For the flexographic market, Xeikon offers digital platemaking systems under the

ThermoFlexX brand name. ThermoFlexX systems provide high resolution plate exposure including screening, color management, as well as workflow management. All the Xeikon solutions are designed with the overarching principles of profitability, quality, flexibility and sustainability in mind. With these guiding principles and a deep, intimate knowledge of its customers, Xeikon continues to be one of the industry's leading innovators of products and solutions.

For more information,
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XEIKON MANUFACTURING N.V.

T. +32 (0)3 443 13 11
Duwijkstraat 17 - 2500 Lier - Belgium
www.xeikon.com - info@xeikon.com

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