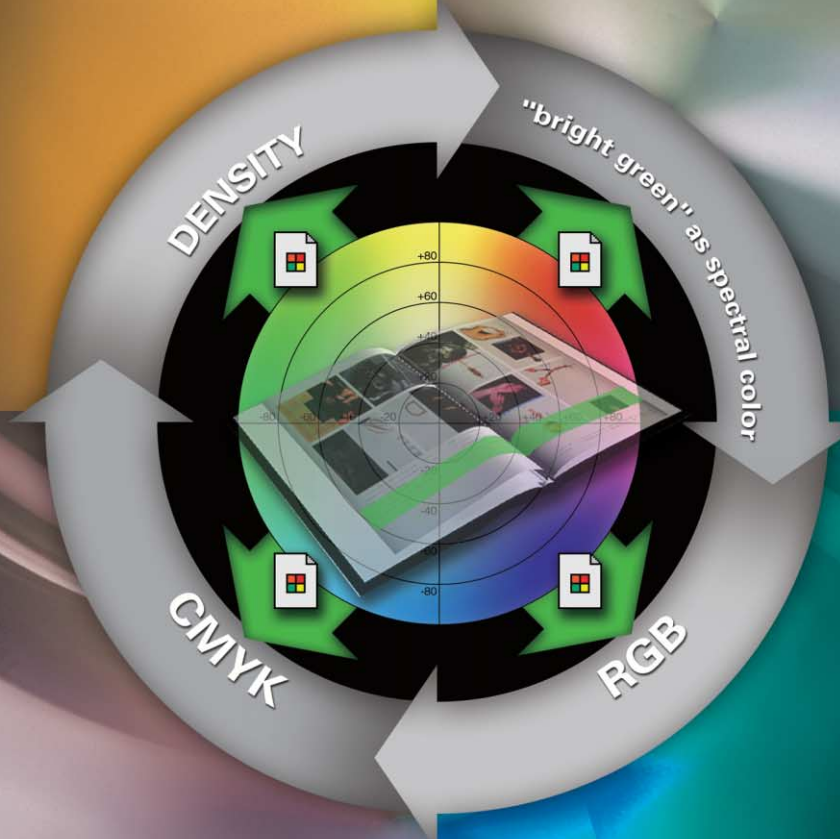


MANAGING COLOR IN A

GLOBAL

PRINT WORKFLOW



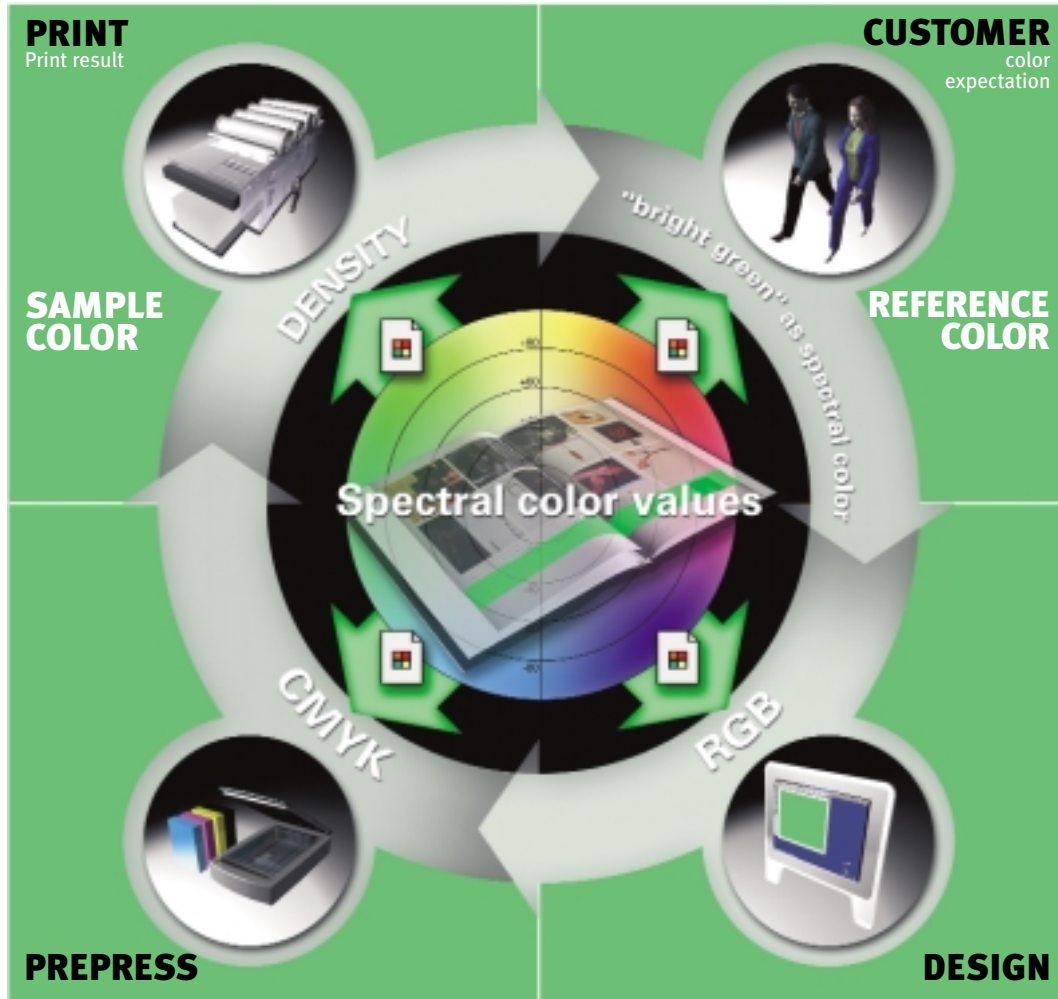
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1. Edition, April 2001

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*Communication on the basis
of spectral color values*



*Color expectation,
defined in spectral
values*

*Documents with spectral
color information*

The workflow in print production should remove: strictly.

C O N T R O L I N W O R K F L O W – A P R E R E Q U I S I T E F O R S U C C E S S

Digital workflow, while considered a pioneering step in the early nineteen-nineties, has today become a prerequisite for forward-looking printing companies aiming to maintain and enhance their competitiveness. Controlling all production relevant data from receipt of an order to delivery of the finished product has become a core challenge. With the advances of PDF-based solutions, color management systems and computer-to-plate technology, the entire flow of digital data has progressed from design to final product. This reduction of information to the binary digit has enabled the highest level of control and consistency throughout the print production process.

The last holdout to this digital revolution remains firmly entrenched where the ink meets the page. Current solutions have created the means to carry digital information far into the pressroom and finishing processes with technology such as digital ink pre-setting. However, the data transferred from plate to substrate still remains in analog form. This analog step remains exposed to the chemical, thermodynamic and mechanical influences inherent to the print process. This breakdown in the digital information exchange has limited the implementation of fully digital controls. Standardized process control procedures are often used in this analog world in an effort to maintain the highest possible consistency and to achieve reproducible printing results. These procedures include monitoring raw materials such as ink, paper, blankets and dampening solution for consistency, monitoring print results through means of densitometry and profiling presses using color management that conforms to ICC standards.

Color in particular has been severely affected by the deficit in digital data communications. Accurate color reproduction and color prediction are areas that can greatly benefit from a digitally controlled workflow, but many workflows today still include analog steps even prior to the pressroom. In theory, process controls can eliminate analog process variation, but in practice adequate process controls are rarely performed in most production operations. As a result, any benefit derived from advanced digital color control in part of the process is rendered invalid due to inconsistent elements elsewhere. Technology such as digital proofing, color management from prepress to press, and spectral color specification can add tremendous value in terms of workflow effectiveness and customer satisfaction, but are rendered useless when the press can not print consistently. It is this aspect of the print process that must be examined in an effort to increase quality assurance. The goal is to devise methods to communicate color clearly and coherently to the customer.

The first chapter examines procedures used in practice today and the problems associated with them. Methods of ensuring reliable communication of color from the customer through to the finished printing result are addressed. The often underestimated value of spectrally based color tools in the workflow, such as color management, is described.

The second chapter deals with methods of color measurement. The principle, the spheres of application and the limitations of densitometry are described. Spectrophotometry is presented as a reliable and thus trend-setting measurement method that is suitable for dependable color communication between customers and printers.

The four main fields of application of spectrophotometry are dealt with in the third chapter. These include ink formulation, color management, color monitoring and color control on press.

The fourth chapter explains how the use of spectral color measurement with the relevant color space models is essential in a cross-media future. Color communication on a global scale cannot be accomplished without spectrophotometry.

This is followed by the fifth chapter, which describes the new SpectroMat™ x/y scanning table and iCPrint™ analytical software and its function in the context of global printing workflow.

The sixth and final chapter describes a ten step program for systematic color communication in the context of color management.

1

WORKFLOW IN PRINT
PRODUCTION

7

WORKFLOW IN PRINT PRODUCTION

Workflow describes the individual stages of the overall process leading to the production of printed matter.

Workflow however should not simply describe technical operating procedures, such as the image capture process, digital output, and print production. It must also include information procedures as well. The workflow of information should include all aspects relevant to any given job, such as print quantity, paper grade, imposition, languages, fonts and especially color.

Workflow can thus be divided into two levels: the sequence of sub-processes, and the order-specific information accompanying these processes. On the information level, color is often neglected as an important element in the workflow. This is largely due to the lack of practical methods for communicating color information. Color measurement has largely been constrained to the pressroom using densitometry. While good for process control, densitometry is not suitable for communicating accurate color information. In the absence of solutions, we have devised inaccurate methods based on color swatches and mechanical specifications, or simply ignored color as a specification. Yet, global color communication will become possible only when we learn to specify color information using consistent, visually based spectral tools will global color communication.

The GretagMacbeth automatic measuring system, which combine the SpectroMat™ scanning table and iCPrint™ analytical control software is a trend-setting spectral based solution providing the basis for integrating color information systematically into the digital workflow.



Any print product is only as good as the information accompanying the process. Color communication is critical in the workflow, if the printed result is to match to the customer's expectations.

1 . 1

THE PROBLEMS OF
CLASSICAL WORKFLOW

The traditional method of producing a print job combines several isolated processes to accomplish the final printed product. Each group in the process strives for quality specific to that isolated area of the overall workflow. Often if quality is in question, an isolated area attempts to fix the problem. When the press result does not match the proof, for example, the press operator changes the print conditions in an effort to correct the problem, and then moves on to the next job. This practical approach has proven to achieve high quality print results for many years.



It is the context of the workflow however that the term quality must be re-examined. The goal for quality should not just be focused on the end print result of the workflow. The goal must be to achieve consistent, top-quality results in the most economical manner, resulting in a more effective workflow.

An effective workflow is achieved through successful communication at the information level throughout the process. The isolation of departments in the classic workflow creates major weak points that can seriously obstruct the valuable flow of information. The problem does not always lie in the availability of this information, but in the manner in which it is transmitted and interpreted throughout the process. In an effective workflow, the problem between proof and press is not only identified and corrected for that specific job, but it is also quantified and communicated in a way that allows the entire workflow to identify, respond and correct the source of the problem.

In traditional workflow, the interfaces between the sub-processes are not uniformly defined in many cases. There is no guarantee that important information is transmitted correctly and completely from one sub-process to the next. The customer is thus not assured of a satisfactory outcome in all respects.

C O L O R C O M M U N I C A T I O N T O D A Y

The customer is both the starting and ending point in the print production process. In-between, customer service, graphic design, pre-press, and the pressroom handle the main elements involved in the workflow. These groups are given the assignment of not only performing the production specific processes, but of maintaining the flow of information to ensure the completed job meets the customer's expectations in all respects.

While information on job aspects such as quantity, substrate, imposition, asset management, fonts, etc. are clearly defined and communicated throughout the process, color is a factor that is much more difficult to quantify and therefore is often incorrectly communicated at all stages of the process. Three fundamental problems often lead to these errors:

1. Color is usually assessed too late in the process, namely at the final stage – on the printing press.
2. Despite available color measurement technology, the subjective human eye is often the only gauge used to evaluate color at any stage of the process.
3. Visual evaluation at all stages is often conducted under inconsistent or inaccurate lighting, resulting in variable color judgment.

C O M P R O M I S E A N D U N C E R T A I N T Y

The technological print process has never been capable of exactly reproducing the original idea of the content creator. Technical limitations have always forced the print process to create a compromised approximation of the original. As a result, the color of an image changes by design as it moves from image capture to final print. In addition, most current methods of color communication cannot accurately predict how these compromises will unfold. The workflow of isolated areas, combined with the identified problems in color communication, lead to breakdowns in the reliable transfer of color information as the color is moved from one process to the next.

1 . 2 . 2

**C O M M U N I C A T I O N I N
F O U R - C O L O R R E P R O D U C T I O N**

If the same original is scanned on two separate scanners by a design firm, the RGB data files of the scans will be different. When the two files are transferred to pre-press, the files are processed separately without knowledge of the original image. Without communication, the pre-press has no concept of the original intent. Every process thereafter relies on an educated guess of the customer expectation. This can quickly become a costly process due to the fact that it may take several iterations of proofs to gain the customer's approval.

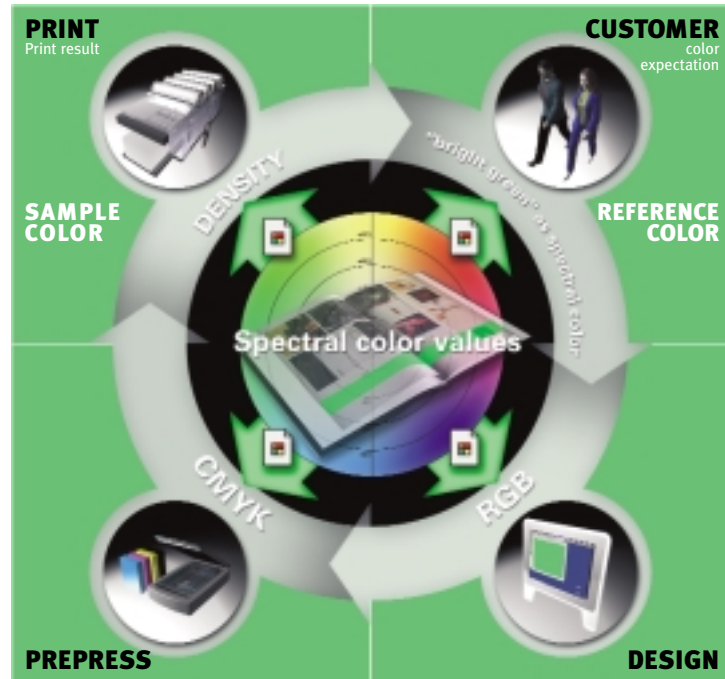
The difficulties resulting from the lack of good color communication methods have been combated by the adoption of print standards. These standards are aimed at using process controls to reduce the variation of color as it moves through the process. In the pressroom this has been accomplished through the use of densitometry. Densitometry, designed for process specific control, provides information on individual aspects of the mechanical process through measurements such as density and dot gain. While optimal for providing consistency on press, densitometry does not describe the visual color result of the process. It is therefore unsuitable for communicating color to the customer who describes color visually.

The customer often requests color changes on press based on visual evaluation. The press operator must translate these visual requests into mechanical process changes. The operator is left to accomplish this without the ability to rely on an objective measurement method and therefore must rely on experience and trial and error. It is here that the need for a quantifiable, common color language becomes clearly evident.

1.2.3

COMMUNICATION IN THE CASE OF SPECIAL COLORS

The ability to specify special color inks for use in a print job also suffers from the lack of a good color communication method. Color systems such as Pantone® and HKS provide references in an attempt to work around this problem, but the color reference guides provided are based on specific processes and substrates not common to actual production. The color information provided by these systems is also based on narrow limitations specific to the materials used in the color guide. If you print on a substrate different from that used in the reference guide, the resulting color will often not match the customer's expectation. When this occurs, there is no good method for correcting the problem short of trial and error on press or remixing the special ink.



Ideally, color communication should be based on a standard color space. This color space is a universally valid reference from which process-specific color spaces (RGB, CMYK) can reliably and confidently be derived.

1.3

NEW METHODS OF
COLOR COMMUNICATION

In an effort to solve some of the problems in traditional color communication, new methods have been developed using spectral based color management tools to more accurately specify, control and predict color as it moves through the digital production workflow.



A color management system such as ProfileMaker™ by GretagMacbeth enables maximum color consistency from input to monitor to proof to final print production. The success of color management tools is in part accredited to the standards set forth by the International Color Consortium (ICC). These standards provide the guidelines for color management systems to create ICC device profiles which describe device specific color in terms of a device independent visual color space such as CIE L*a*b*. Color management tools are an indispensable element in a digital workflow. They ensure secure and reliable communication between customers, designers, pre-press and printers.

ProfileMaker™: software for producing ICC profiles for a wide variety of input and output devices.

COLOR MANAGEMENT STARTS IN THE PRINTING PROCESS

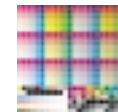
Color management systems yield the most benefit when implemented throughout all production stages from design to print. The value of color management is not only in the ability to successfully communicate color as it moves through the process, but also in its ability to predict color results later in the process. It is this ability to predict color results in advance that enables an effective workflow. For this to take place, color management must start in the pressroom with the final print result and work backward from that point. Creating valid ICC profiles for the press is critical to enabling good color communication.

A valid ICC press profile is created when the press is performing at a known state. This is achieved through process control. By controlling as many variables as possible in this analog system, the print process becomes more consistent, repeatable and therefore, predictable through color management. These process controls can be achieved through the use of good objective measurement tools.

Controlling and predicting the press result in this manner is the key to achieving exceptional print quality and becomes the basis for reliable color communication between the customer, designer and print production. Without establishing these steps in the pressroom, any work toward color communication in preceding processes is futile.

1.3.2 SETTING UP A PROFILE ON THE PRINTING PRESS

Creating a press profile is accomplished by printing a press test target designed for this purpose with a series of known color patches. This press run should be conducted using the strictest of process controls. When completed, the resulting color print is measured, defining the visual color result of the test, using a spectrophotometer, such as the GretagMacbeth SpectroScan™ or SpectroMat™. A color management system such as GretagMacbeth ProfileMaker™ then creates the profile based on a comparison of the measured visual result and the reference data for content of the test target. This profile is now used in preceding processes to optimize color separations for press and to predict press results in advance.



Printed testchart



Measured data LAB



ICC profiles

In order to produce a profile (e.g. for a printing press), the digitally stored reference data from a test chart file and the spectral readings resulting from the scan of the printed test chart are required.

1.3.3 PLATE SCANNING

With computer-to-plate technology, controlling the printing plate process is no longer possible through purely visual assessment of microlines and other exposure tests. A more precise method is required for measuring and analyzing the plate throughout the image area. Good process control is vital to a successful press profile and continued print consistency.

The GretagMacbeth iCPlate™ utilizes a high-resolution video camera to analyze all plate imaging parameters relevant to the printed result. The instrument measures plate resolution, screen resolution, screen angle, dot size and dot shape. With a ring lens system and three different light sources, iCPlate™ is suitable both for positive and negative working plates and for measuring both amplitude modulation (AM line screen) and frequency modulation (FM stochastic) screens.



The iCPlate™ platereader can measure both negative and positive plates, as well as amplitude and frequency modulated screening.

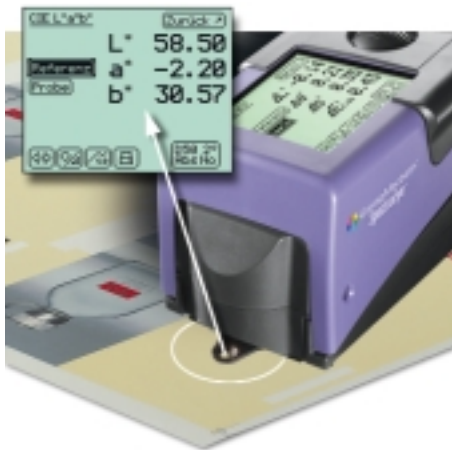
COLOR IS A CLEARLY MEASURABLE QUANTITY

Although color communication through color prediction and color management must start at the last step in the process, successful color communication must also be able to clearly define the customer color expectation at the very beginning of a job. This is accomplished by defining color as early in the process as possible in a visual manner using precise measurable spectral based data. This ensures that color information that defines the exact customer expectation can accompany the job throughout the workflow at the information level.

The ability to spectrally define color early in the process and then control color based on this information throughout the process is dependent on the availability of spectral based tools. In addition, the use of spectral tools requires the proper of expertise. While these tools and concepts are relatively new to the print industry, the technology and expertise is available today to control color throughout the process with precision.

Spectral based color communication can begin as early as the design stage utilizing both ICC press profiles for prediction of color and desktop spectrophotometers such as the GretagMacbeth Spectrolino to establish custom color specifications. The pre-press can continue this process through the use of profiles to enable accurate digital color proofing of both images and the spectrally defined special color specification. In the press-room, spectral based ink formulation can guarantee that the custom colors meet the customer's expectation. Lastly, the combination of the press profile and superb process control procedures based on sound spectral based measurement ensure that the press produces color as predicted.

Color is a measurable, definable and communicable property that can be controlled with precision when utilizing the proper spectral tools and expertise.



*Like other variables describing a print job, color can also be defined accurately and objectively. This requires the use of a spectrophotometer that enables a measured color tone to be assigned to a unique location in the L*a*b* color space.*

2

METHODS OF COLOR
MEASUREMENT

17

METHODS OF COLOR MEASUREMENT

Reliable color communication is based on the ability to predict what will happen to color as it moves through the print process to the final print result. This can only be accomplished through accurate color measurement.

In order to ensure good process control and consistency in the pressroom, printers rely on density measurements to control the print process. Instruments such as the GretagMacbeth D19C™ densitometer can quickly give the press operator information on the specifics of how the press is performing mechanically through the print run. While this information assists the press operator in controlling the consistency of color on press, densitometry is limited in its ability to describe color in a visual manner. It is here that spectral based tools allow for advanced color control. Spectral information is based on the principles of human visual perception. Processing the spectral data into tristimulus values of red, green, and blue as the eye does, spectral tools can describe color as colorimetric values, which closely coincide with the language we as human use to describe color. As such, spectral based information can better describe color in a manner more compatible with the way customers describe color visually. Combining the use of densitometry, spectrophotometry and colorimetry in the pressroom provide precise tools and compatible languages to ensure successful color communication.

When using spectrophotometry in the pressroom, the press operator does not have to abandon the familiar values of density and dot gain. iCPrint™ uses the appropriate algorithms to convert spectral information measured with SpectroMat™ into densitometric values. These values are displayed alongside colorimetric readings to allow the highest level of color control and communication.



Today, most printers still mainly use densitometers to monitor and control ink supply during the printing process.

2 . 1

D E N S I T O M E T R Y

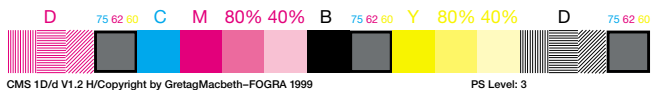
Many print specifications suggest the use of densitometry as a means for controlling print consistency in the pressroom. Of all the densitometric values used in this manner, density of the solid ink and dot gain at the 50% tone are most commonly used to accomplish this task.

2 . 1 . 1

S P H E R E O F A P P L I C A T I O N
O F D E N S I T O M E T R Y

Densitometry is process-related and color tone-dependent. Consequently, this measuring process is suitable only for certain color tones, specifically the four process colors of cyan, magenta, yellow and black.

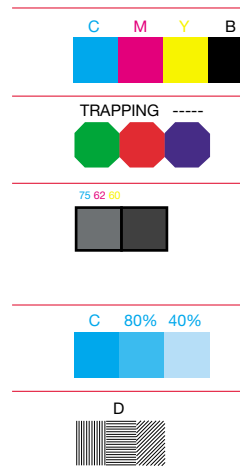
The measurement of optical density is still the most frequently used method for checking and controlling ink transfer in the printing process. Densitometry is especially suitable when producing four-color process images using cyan, magenta, yellow and black ink. Measurement of dot area in a tone scale is designed to check the mechanical ability of a process to reproduce a given dot structure and is therefore used in pre-press to control film and plate dot, as well as in the pressroom to measure the print process. Regardless of whether densities are measured in the film, on the printing plate or in color bars on a printed sheet, the result is always a single value. This value corresponds to the relationship between the light that strikes the sample and the light that is reflected off the sample. In all cases, density measures light fractions as values of gray. Actual color tones cannot be measured by means of densitometry.



Density is usually measured during printing by means of special color control bars on the printed sheet.

To control elements of the mechanical press run, density is measured from specifically designed test areas placed on the printed sheet, usually called color bars. Depending on the design, the color bars feature different elements for measuring the process:

- Solid ink patches for the process inks of cyan, magenta, yellow and black, and for any additional special colors.
- Solid ink patches for the overprint colors of red, green and blue, to check for wet ink trapping.
- Three-color overprint screen tint patches of cyan, magenta, and yellow process inks, along side a black ink screen tint patch to check for gray balance.
- Screen tint patches with different screen percentages for monitoring the dot gain in printing.
- Patches with specific, geometrically arranged microlines for identifying slur, doubling and other visually identifiable effects during the production run.



Different patches provide information during the printing process regarding full-tone density, dot gain, gray balance and problems such as trapping and overprinting.

2 . 1 . 2

LIMITATIONS OF DENSITY MEASUREMENT

Densitometry is an excellent tool for establishing process controls throughout pre-press and the pressroom, enabling consistency and the ability to implement color management. However, densitometry is not a suitable tool for precise color communication. Densitometry is designed to measure solid ink values of cyan, magenta, yellow, and black ink. While dot gain and other densitometric calculations can help the printer determine many characteristics of press performance; densitometry cannot successfully provide information on the final visual color result of the press production. As a result, no direct visual color comparison can be made between the original and the reproduced image. The densitometric value says nothing whatsoever about the actual characteristics of the resulting color and its visual impression, and thus does not allow any conclusions to be drawn regarding the visual differences between the printed sheet and the sample. Successful color communication requires a common language. Customers speak of color in visual terms, while densitometers do not.



The application of densitometry in the printing process is limited strictly to density measurement with the four process colors of cyan, magenta, yellow and black. The measurement of special color tones does not produce conclusive, representative results suitable for color communication.

2 . 1 . 3

P R I N T I N G S P E C I A L C O L O R S

The limitations of densitometry become more apparent when dealing with special ink colors in print jobs. As densitometers are designed to measure solid ink values for cyan, magenta, and yellow ink, special ink colors can be very difficult to control using densitometry.

Nevertheless, from a practical standpoint densitometers can be utilized to help control the consistency of printing special color inks when spectral ink formulation has provided an accurate ink sample at the appropriate density.

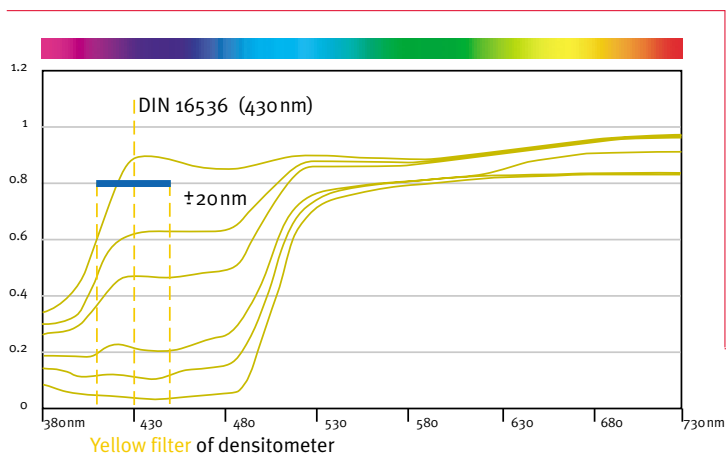
2 . 1 . 4

C O L O R F I L T E R S A N D S P E C I A L C O L O R S

Measuring density of special color inks does present some major weaknesses. As stated above densitometers are designed to measure the process colors of cyan, magenta and yellow. As a result, all measurements made with a densitometer are made in relation to how the instrument measures these three inks. This is accomplished through the use of red, green

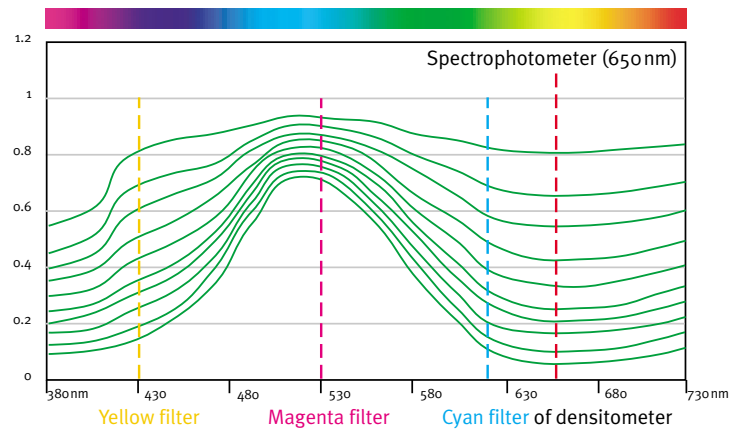
and blue filters in the instrument. The filters of the densitometer focus on a narrow range of color surrounding these three areas. This is designed to focus the sensitivity of the instrument on subtle shifts in ink density of the process inks. Densities that deviate from the target process ink values produce clearly differing results during measurement within this narrow window.

This rule no longer applies if the three filters referred to above (red, green and blue) are to be used to measure special colors with color tones that do not correspond to the three process colors of cyan, magenta and yellow.



The characteristic reflection/absorption curve of yellow printing ink within the range of electromagnetic radiation visible to the human eye. The curves shown trace the reflection behavior of yellow with different ink film thicknesses. The relatively wide gaps enable densities that vary from a target value to be identified quickly and clearly.

Furthermore, densitometry is designed to measure solid ink values. When density numbers become significantly higher or lower than expected solid ink values, the sensitivity of the measurements change. As a result, special inks that appear very light or overly dark visually are difficult to control with densitometry. In addition, there are no accepted specifications for measuring the dot gain of non-process ink colors. Densitometry relies on the ability to control both solid ink density and dot gain. With a special ink color, this is not possible.



The characteristic reflection/absorption curve of a green color tone. It is clearly apparent from the diagram that the three filters for the colors of cyan (610 nm) magenta (530 nm) and yellow (430 nm) are unsuitable for measuring the color tone in question, since the gaps between the curves due to differing ink film thicknesses are very narrow, and even small variations from a target value cannot be identified, or only at a very late stage. Spectrophotometric measurement is therefore essential for assessing these color tones.

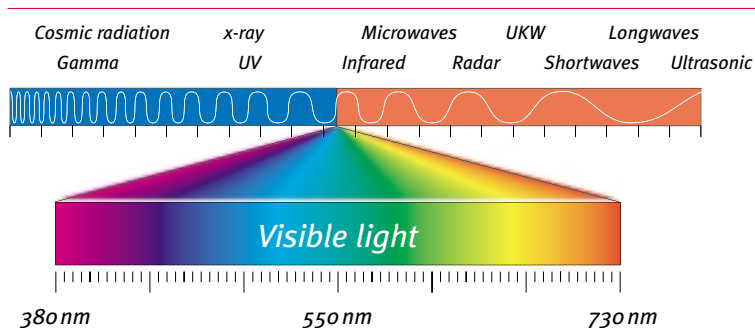
2.2

THE SPECTROPHOTOMETRIC MEASURING METHOD

The spectrophotometric measurement of color (also known as colorimetry) differs fundamentally from densitometry. While densitometry is a measuring method relating purely to the reproduction process, spectrophotometry is an open, process-independent method that provides objective values that can be described visually. Spectrophotometric measurement is used wherever color must be described with absolute precision.

2.2.1

THE VISIBLE SPECTRUM

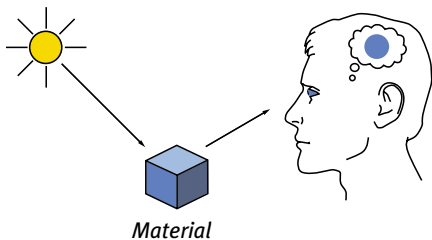


Electromagnetic radiation visible to the human eye exists in an extremely narrow range described in terms of wavelengths approximately between 380 and 730 nanometers (1 nanometer [nm] = 10^{-9} m).

24

Within the wide spectrum of electromagnetic radiation, the phenomenon of human sight is limited to the extremely narrow range between 380 and 730 nm.

Light



The perception of color has a physical, a physiological and a psychological component.

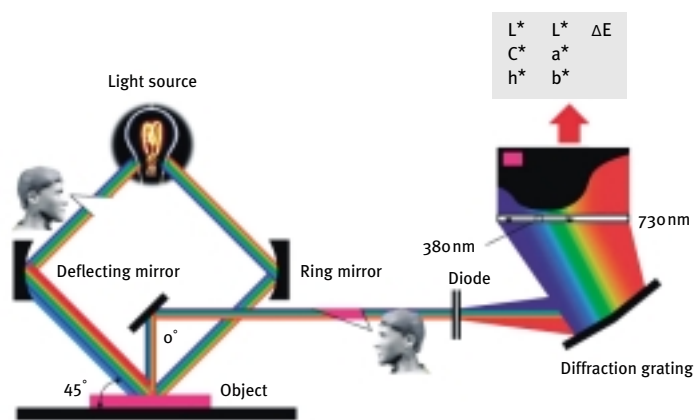
- Visible radiation or light is emitted by a light source or reflected from an illuminated body
 → physical component
- The radiation induces a reaction on the retina of the eye
 → physiological component
- The reaction is interpreted as a color in the brain
 → psychological component

2.2.2

THE USE OF SPECTRAL COLOR MEASUREMENT

As customers have continued to utilize more and more specialized printing inks and increasingly demanded better color accuracy and accountability, the need for practical solutions based on spectral tools in the print process has become a reality. In contrast to current measurement tools based on densitometry, spectral tools allow for the precision measurement, control and communication of color on a visual level. This ability to describe color independent of process specific values enables an international color language.

A spectrophotometer accomplishes this by analyzing how a measured color responds to colored light across the entire visible spectrum, much as the eye does. The SpectroMat™ measuring system is based on this principle of spectral measurement, measuring with a physical resolution of 10 nm. As a result, a measured color is analyzed at 36 different areas across the visual spectrum.

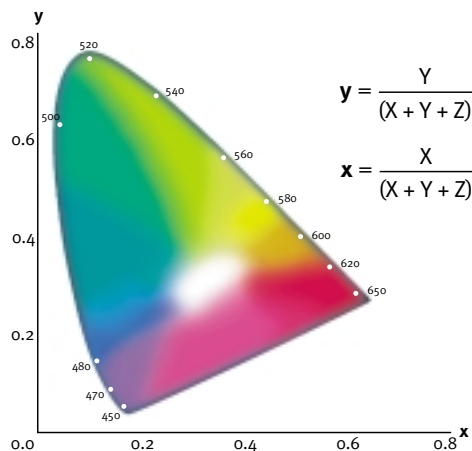


Measuring principle of a spectrophotometer.

2.2.3

LAB: A NEUTRAL COLOR SPACE

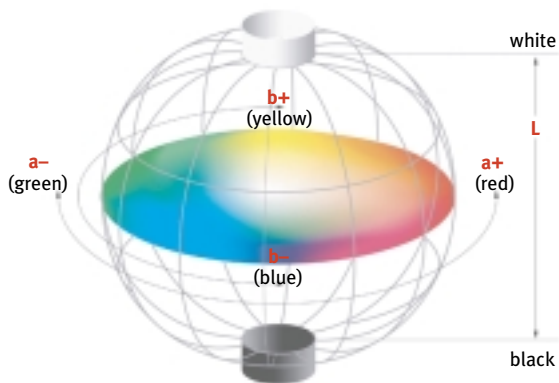
When using spectrophotometry, certain conditions must be met to ensure secure and reliable interpretation and communication of measured values. The Commission Internationale de l'Eclairage (CIE) has established the basis for standardizing color measurement by defining these conditions. In addition, the CIE has also standardized the way that spectral data is communicated in terms of visually based colorimetric methods called color spaces. The CIE XYZ color space is the basis for all colorimetric spaces.



The CIE color diagram describes colors in terms of color tone and saturation on the two axes *x* and *y*, while brightness values are recorded on the vertical *Y* axis.

Using XYZ to describe how the eye perceives color, the CIE developed the xy chromaticity diagram to graphically show all the color we can see. While this system forms the basis of all colorimetry, it is difficult to use practically as it is based on the science of the eye and not how we visually describe color.

(Prof. Dr. K. Schläpfer provides a detailed dissertation of the different color space models in his book entitled «Colormetrics in reproduction and multi-color printing», published by UGRA, St. Gallen).



The CIELAB color system was developed by the Commission Internationale d' Eclairage in 1976 on the basis of the CIEXYZ color system. LAB models were already developed before the deduction of the CIELAB color distance formula. The three coordinates in the CIELAB system are specified *L*a*b** in order to make a clear distinction.

The CIE *L*a*b** system was derived from the CIE XYZ color system in 1976. In contrast to the CIE XYZ system, the colors in the CIE *L*a*b** system are arranged based on how we as humans visually describe color. The hue of each color family is arranged around the circumference of the system and the saturation or strength of each varies from the center out to the edge. The gray axis from black to white describes the third dimension, lightness, from bottom to top.

These color spaces, based on how we perceive color, are independent from the specific processes and devices used to reproduce color. It is thus possible to assign precise color values to any given color in a color space with the three coordinates *L*a*b**.

3

3

USING SPECTROPHOTOMETRY
IN PRACTICE

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3 .

USING SPECTROPHOTOMETRY IN PRACTICE

The use of spectrophotometric solutions has become a requirement to establishing modern color communication processes in the printing industry. Four areas for the practical application of these tools are: ink formulation; color management; color monitoring; and color control on the printing press.

3 . 1

INK FORMULATION

Spectral measurement technology is the main foundation for formulating custom ink color based on a customer specification or sample. With its Ink Formulation™ software, GretagMacbeth offers a comprehensive tool for the analysis, communication and accurate mixing of the ink color specified by the customer. With the new Version 4, Ink Formulation™ now enables entire databases and ink formulations to be transmitted worldwide via e-mail between the customers, ink suppliers and printers. Through the spectral measurement of a color, precision color information can be communicated from design to pre-press to ink formulation in the pressroom. Formulating ink based on a digital sample is a reliable method for achieving precise reproducible results regardless of external influences. Once an ink is formulated, the data is stored in a database, creating a reliable digital source for future reference.

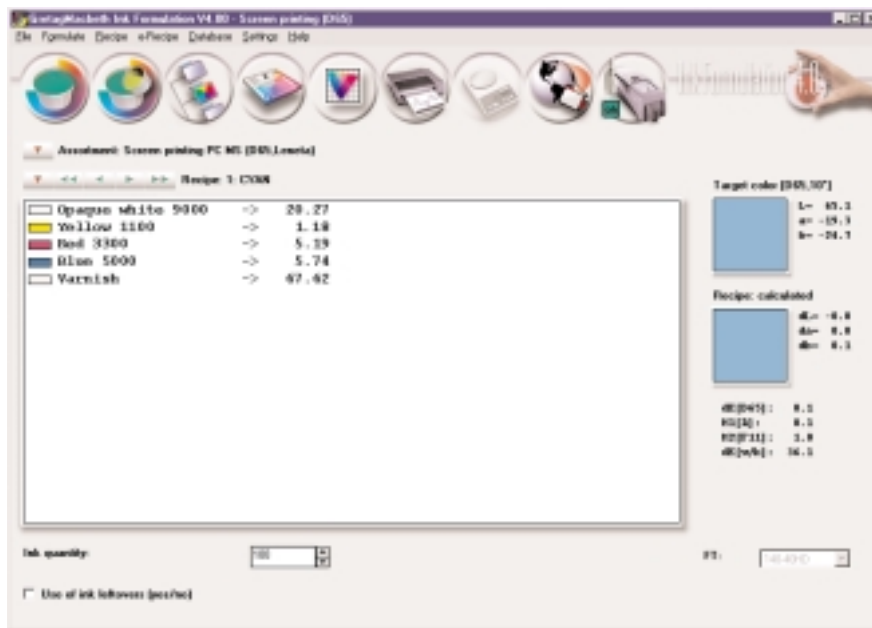
The same data used in Ink Formulation™ can also be read into the iCPrint™ measuring system for use as a valid reference to control the printing process.



Ink formulation systems enable the required color tones to be analyzed, communicated and mixed accurately on the basis of spectrophotometric color measurement.

A fixed number of base ink colors are available to the printer for mixing special ink colors. The spectral composition of each base is stored in the formulation database. A customer color sample is measured spectrally and then simulated from the available base colors by means of mathematical models. The software shows the printer the proportions, by weight, of the base colors that need to be mixed to produce the measured sample color result.

Using Ink Formulation™ to formulate special color inks offers the printer additional financial benefits beyond superior color matching. Mixing custom inks in the exact quantities required to complete a job avoids ink leftovers. At the same time, ink leftovers can be re-used for mixing new special color inks.



After a color tone that is to be mixed has been measured, the Ink Formulation™ program computes an exact ink formulation. The mixing ratio of the individual components required to produce the color tone is displayed on the basis of the colorants available within the formulation system.

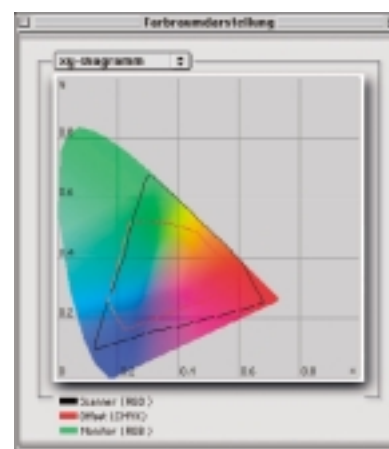
COLOR MANAGEMENT

Color management, a vital component to achieving good color communication in the modern workflow, would be almost impossible without the spectral measurement of colors. Device profiles are the key to the transfer and transformation of color information in a color management system. These device profiles are created using spectrophotometric measurements. Each device in a production workflow has unique, process specific, color differences. The ICC standardized device profiles describe the differences in terms of independent color space and allow for the successful communication and control of color despite those differences.

In order to create a device profile, measuring technology must be used to determine how a specific process reproduces color in a given device color space such as CMYK for an offset press. A test target printed on the press is analyzed spectrophotometrically to define the process specific color in terms of independent visual color space. Combining the GretagMacbeth SpectroScan™ or SpectroMat™ x/y scanning table and ProfileMaker™ profiling software provides a comprehensive solution to meet this goal. This system guarantees accurate and efficient measurement of the profile test target on the printed sheet.



iProfile Bundle, a complete color management system for producing ICC profiles for all types of input and output devices.

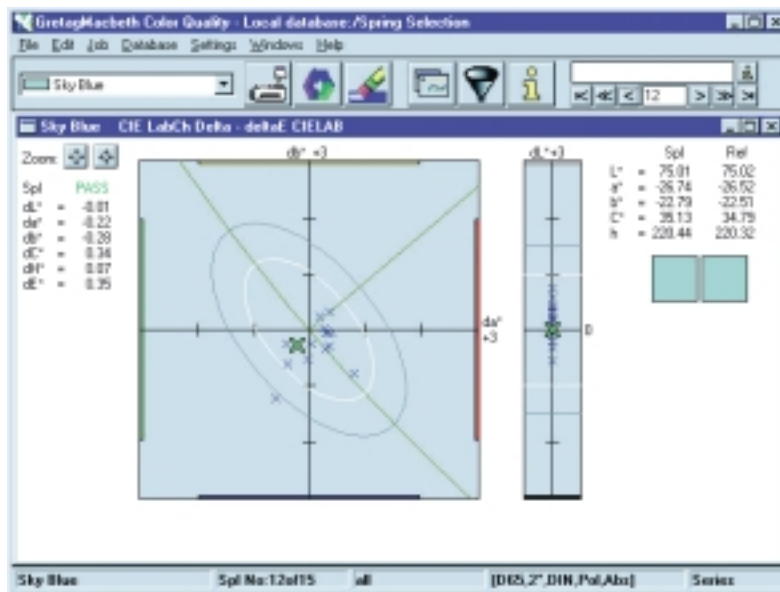


Comparison of output device color spaces in the xyY reference system.



*In order to produce a profile of an output device – in this case a printing press – a test form is produced on the relevant output device. The patches on the test form are scanned. Next the measured L*a*b* values are compared with the L*a*b* values of the reference file. This comparison is used to generate a profile that accurately characterizes the output device.*

As explained in Chapter 2.1.2 Limitations of density measurement, color cannot be monitored objectively with density values. A reliable basis for communicating color can only be provided by a measuring method that utilizes the principles of visual color perception. A spectral measuring tool, such as SpectroMat™ with the accompanying Color Quality software from GretagMacbeth, analyzes color visually like the human eye. Measurable and quantifiable results can be provided, demonstrating the visual success of meeting the color expectations of the customer. In the application of these tools, all variables from ink to end product remain precise and controllable on the basis of objective values. Thus quality is ensured through the entire production process. Customers and printers can communicate in a common language with reference to a clear color definition based on the spectrally derived L*a*b* coordinates.



Quality control software for analyzing, visualizing and recording color data.

COLOR CONTROL ON THE PRINTING PRESS

When a job reaches the printing press, the first goal is to meet the process control specifications and maintain consistency throughout the production run. Ideally, measurements for this purpose are performed not only on a color control bar printed in the non-image area, but also in measurable points specified at various locations within the printable area. Ultimately measuring within the printed area offers many benefits. It is the product itself, not a control bar that the customer and printer are most concerned about in terms of color accuracy. Eliminating the need to print color control bars in non-image areas and removing them from the final product at a later finishing stage can also achieve substantial paper savings. While beneficial, measurement technologies of the past have not provided the rapid, automatic and precise measurement of color within the image area to make this process practical.

With the increased in use of special colors, densitometry continues to fall short in its ability to fully control special color inks. Printers are increasingly receiving colorimetric specifications from customers with required Delta-E tolerancing. Densitometric color control systems cannot fulfill the requirements to satisfy these customer demands. Spectral based x/y scanning technology such as the GretagMacbeth SpectroMat™ and iCPrint™ software provide modern measurements solutions capable of the rapid, automatic and precise measurement of color within the image area combined with the colorimetric technology to determine exact color results, which are tied directly to special color ink formulation. Spectral based tools are essential to successful color communication in an efficient color workflow.



iCPrint™ color monitoring and control software from GretagMacbeth.

4

THE BENEFITS OF
SPECTROPHOTOMETRY

THE BENEFITS OF SPECTROPHOTOMETRY

Essentially, four fundamental characteristics or application-specific advantages make spectrophotometry the favorite when it comes to future methods of communicating and controlling color in the printing process:

- Only spectrophotometry makes global color communication possible between customers, graphic designers, prepress operations and printers. Spectrophotometric color measurement uses measuring technology to simulate the mode of operation of the human eye and its color perception. In contrast to the abstract density values provided by densitometric measurement, the colorimetrically measured color in the CIE $L^*a^*b^*$ color space can be clearly described with the three values - $L^*a^*b^*$. Each measurement provides easily understandable information about the color hue, saturation and lightness of a color. This correspondence between the spectrophotometric measuring process and visual assessment as performed by the human eye makes the colorimetric principle a useful and practical tool for global color communication.
- Spectrophotometry is a process-independent, open measuring principle. Based on colorimetric values, its range of application extends over the entire production process for printed information. The spectrophotometric method enables a color to be described in the CIE $L^*a^*b^*$ color space regardless of equipment or process and therefore describes color independent of media, substrate, screening or any other technology to be invented



The spectrophotometric measuring method provides the basis for global color communication between different media.

in the years to come. As color braves new medias and applications, the ability to describe color independently will become invaluable.

- While the measurement of color density is confined to the process colors, spectrophotometry can be used for all colors. Only spectral measurement can reliably ensure color accuracy of the special color inks used daily in the packaging print industry. These custom color inks continue to find increased use across all print production processes. This need for spectral measurement becomes even more profound when a printing plant is mixing these special color inks internally using a formulation system. The need to communicate custom color directly to the printer as an $L^*a^*b^*$ value will become more critical as customer color expectations increase.
- A spectrophotometer enables colors not only to be verified exactly with respect to color location in the CIE $L^*a^*b^*$ system, but also enables the ink film thickness to be verified on the basis of the densities known to the printer. The versatility of spectral measurements allows the printers to check all aspects of color including color metamerism. At the same time, spectral measurements can be translated into familiar process control terms such as density and dot gain.

5

A NEW, TREND-SETTING
MEASURING SYSTEM

5 .

A NEW, TREND-SETTING MEASURING SYSTEM

GretagMacbeth has been studying spectrophotometric color measurement for many years. This Swiss company has developed this superior measuring method into an indispensable tool for the printing industry as it progresses toward comprehensive effective workflow solutions and universally reliable quality management.

Against the backdrop of multimedia publishing, only a media-independent, universal color system can satisfy the increasingly high standards required for reliable communication and objective color assessment between customers and suppliers in modern printing production. The successful introduction of quality management systems in printing plants requires a platform that will remain valid over the long term. This must enable sub-processes to be interlinked while making understandable information available globally for use in communication both in-house and externally.



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5 . 1

SPECTROMAT AND ICPRINT BY GRETAGMACBETH

Our comments up to this point have shown the central importance of spectrophotometric measurement for reliable and generally understandable color communication. However, all efforts to conform to these objective principles are futile if the appropriate means are not available on the printing press so that the specified values can be worked with, monitored reliably during the production run and maintained through systematic action.

The new measuring system from GretagMacbeth with the SpectroMat™ x/y scanning table and iCPrint™ analytical software can be used on offset presses of all makes with any number of printing units up to a maximum format of 1040 x 750 mm.

5.1.1

X / Y S C A N N I N G T A B L E U P T O M E D I U M - S I Z E F O R M A T

The new GretagMacbeth measuring system consists essentially of the SpectroMat™ scanning table with a measuring head that can be moved in the x and y axis, plus iCPrint™ analytical software. An intuitive user interface is provided with simple menu-based functions. The measuring system can be used on offset presses of any make with any number of print units up to a maximum sheet format of 1040 x 750 mm. The x/y traverse enables the scanning process to be performed on both a control bar and on individual measurements anywhere within the printed sheet. The time to complete the scanning process on a color control bar is 30 seconds on the maximum format of 1040 mm.

5.1.2

A S P E C T R A L M E A S U R I N G S Y S T E M W I T H O P T I O N S

The SpectroMat™ measuring system with iCPrint™ is based on the spectrophotometric principle. The measuring process immediately provides information on conformance to shop standards along with recommended corrections. Though spectrally based, the software also computes density and dot gain from the spectral data. The combination of colorimetric values and densitometric values allows for precise and practical control of four-color process and special color inks. Printers are thus able to monitor the process colors as usual on the basis of density values, while the special colors are monitored and controlled on the basis of colorimetric Delta-E values.

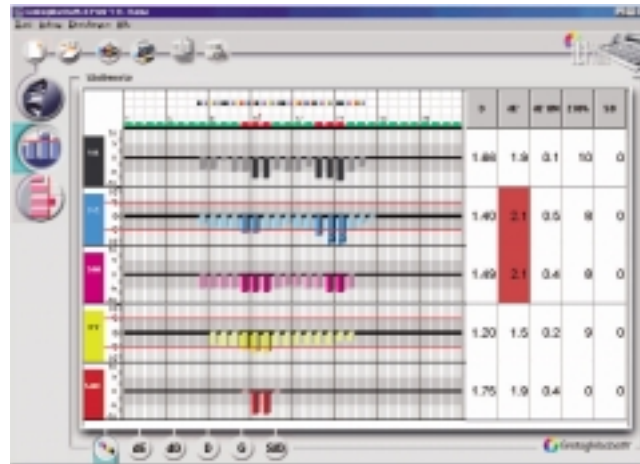
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5.1.3

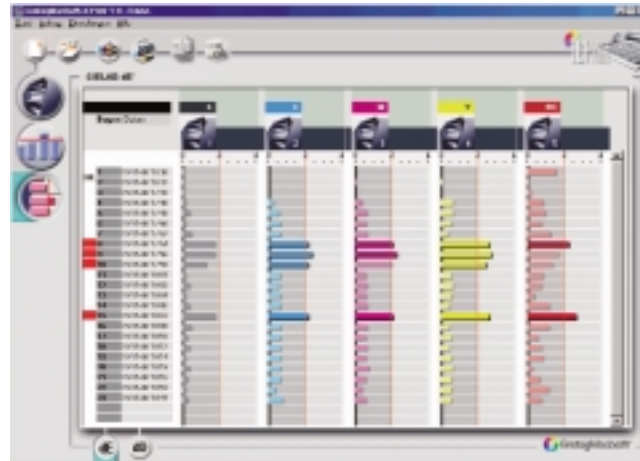
T H E F A S T R O U T E T O S U C C E S S

The SpectroMat™ measuring system with iCPrint™ guarantees that standard target values are achieved as quickly as possible during the make-ready process and ensures that those standards are maintained within close tolerances during the printing process. The print job is defined by means of the iCPrint software with respect to color character (spectral composition), substrate and the number of print units required. The target values for the colors are either based on previously measured color samples, stored as standard data in a database, or measured with the SpectroMat™. Stop guides are positioned to ensure accurate placement of the measurements on each sheet. Measurement points are then determined for the job and stored into the system.

The operator can quickly observe print conditions in relation to specifications via the actual and target values displayed for the various print zones on the monitor. If a specific sheet is approved for color, this sheet can be entered as a new reference. The system archives all measured data during the production run. This provides a documented record of the entire printing process and serves as a seal of quality for the printer to the customer. A trend display provides information on deviations from the target values during the production run and ensures that the printer can take timely and appropriate action. This quality control process, performed automatically, quickly and precisely by the SpectroMat™ system with iCPrint™ enables consistency to be maintained within the set tolerances throughout the print run.



Zone-by-zone display of actual and target values on the monitor, along with the relevant standard recommendations, quickly guide printers to the required specifications.



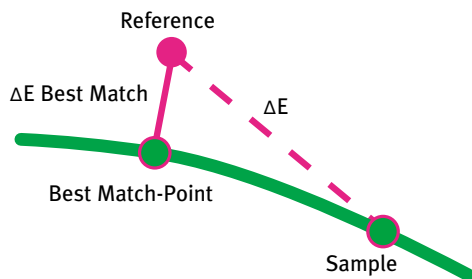
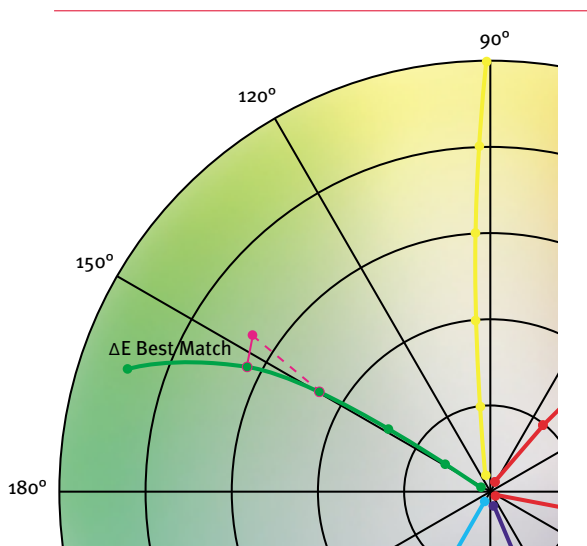
A trend display provides information on variations from the target value during the production run and ensures that the printer is able to take timely action. This ensures that ink supply can be maintained within the set tolerances throughout the print run.

5.1.4

BEST MATCH FOR PRINTING WITH SPECIAL COLORS

A given color tone can only be measured qualitatively using the spectrophotometric method. The analysis of color with regard to its spectral composition is required for detecting color shifts from a color sample during the production run and making valid decisions about how to correct any problem. The objective assessment of special colors in particular requires clearly defined color reference values in order to determine reliable color matching on the printing press.

This fact was taken into account during the development of the SpectroMat™ measuring system with iCPrint™. The Best Match method included in the analytical software provides the printer—via a single measurement—with clear information regarding the physical limit up to which a target color can be achieved. In this way a printer can determine whether a color is achievable on press or whether the color difference is too wide and it cannot be achieved purely through press adjustments. This gives the operator a clear understanding of when custom color ink will have to be re-mixed.



The green curve describes the shift in color tone resulting from a change in ink film thickness. The line drawn vertically from the reference point to the curve corresponds to the closest approximation to the target tone value. With ΔE Best Match the printer can see at a glance how close he can get to the target value with the printing ink as currently mixed, and whether he will be within the set tolerances.

COLOR RELIABILITY IN THE OFFSET PROCESS

The SpectroMat™/iCPrint™ color measuring system represents a significant step toward achieving reliable color communication based on objective values and dependable quality control in the production run. The system speeds up the make-ready procedure from the first sheet to the start of the production run and ensures stable ink supply. In the process, precise reference values provide the trustworthy basis for communication between everyone involved in the printed product, regardless of whether process colors are being printed according to standard values or special colors are being used.

6

TEN IMPORTANT ASPECTS
OF COLOR WORKFLOW

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TEN IMPORTANT ASPECTS OF COLOR WORKFLOW

Reliable and traceable workflows in printing production require good process controls and color communication throughout the workflow. GretagMacbeth provides powerful hardware and software tools for achieving this goal. These tools can be applied to the process in a 10 step program:



D19C™

iCPlate™

SpectroInno™

SpectroEye™

SpectroMat™

iCPrint™

Color Quality™

InkFormulation™

ProfileMaker™

iQueue 1.0

**WORKFLOW WITH
PROCESS COLORS**

- 1 Calibration of imagesetters and CTP systems
- 2 Quality assurance of plate process
- 3 Profiling the printing press
 - a printing the profile test chart to standard process control values
 - b measuring the printed profile test chart
 - c building the ICC profiles for the printing press
- 4 Implementing color management (ICC profiles) in the prepress workflow
- 5 Running the printing press to standard process control values for process inks
- 6 Monitoring and documenting print quality (in the image and on the control bar)

**WORKFLOW WITH
SPECIAL COLORS**

- 7 Spectral definition of the special colors, i.e. use of spectral model from a database
- 8 Formulating special color inks
- 9 Regulating special colors according to the Best Match method
- 10 Checking and documenting print quality (in the image and on the control bar)

	D19C™	iCPlate™	SpectroInno™	SpectroEye™	SpectroMat™	iCPrint™	Color Quality™	InkFormulation™	ProfileMaker™	iQueue 1.0
1 Calibration of imagesetters and CTP systems	●	●		●						
2 Quality assurance of plate process		●								
3 Profiling the printing press										
a printing the profile test chart to standard process control values					●	●				
b measuring the printed profile test chart					●				●	
c building the ICC profiles for the printing press									●	
4 Implementing color management (ICC profiles) in the prepress workflow									●	●
5 Running the printing press to standard process control values for process inks					●	●				
6 Monitoring and documenting print quality (in the image and on the control bar)					●	●				
7 Spectral definition of the special colors, i.e. use of spectral model from a database			●	●			●			
8 Formulating special color inks								●		
9 Regulating special colors according to the Best Match method					●	●				
10 Checking and documenting print quality (in the image and on the control bar)					●	●				



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