The M Factor…What Does It Mean?

Successful Color Management of Papers with Optical Brighteners

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Many modern printing and proofing papers contain Optical Brightening Agents [OBA]. These agents are added to enhance the brightness of the papers and improve the appearance of the printed product. The presence of these agents in contemporary papers creates challenges for successful color management, so new standards have been defined to help manage and communicate color for papers containing these brightening agents.

Introduction

OBAs operate through the process of fluorescence. They absorb invisible ultraviolet (UV) radiation at wavelengths below 400 nanometers (nm) and, through an electro-physical change, emit light mostly in the blue end of the visible spectrum at about 400 to 450 nm. When this light is emitted from papers using brightening agents, they are perceived as having a color that is "whiter than white," since the observed light from the paper will be the total of the reflected and emitted (due to fluorescence) light when illuminated by a source containing a large UV component. You can often see this effect if you illuminate a paper containing brightening agents with an ultraviolet light source, such as a "black" light.

The perceived color of a piece printed on a substrate containing OBAs will look different, depending whether the light source used to view the print contains UV or not. Older graphic arts measurement standards (except for density standards) specified D50. It was assumed that all substrates would measure the same using a D50 illuminant, and OBA content was not a concern. In practice, colors viewed under real viewing conditions containing UV sometimes were notably mismatched, and failed to meet expectations. These mismatches created serious challenges for people trying to measure and manage color consistency in a variety of workflows.

New Technologies, New Papers and New Standards

New illumination sources, including light emitting diodes [LED], allow handheld color measurement instruments to measure with well-defined and controlled UV illumination components. To ensure consistency, new illumination sources and new substrates require new instrument and measurement standards for defining and measuring the relative UV content, and thus the degree of fluorescence of substrates containing OBAs. Defining and controlling the emitted UV component of the measuring device's illumination is essential to defining standard ways to measure and manage color printed on OBA-enhanced substrates.

X-Rite has always been at the forefront of advocating and helping to design standards for our evolving industry, and has continually advocated the concept of printing to standards. Factors driving this evolution include technology advancements, increasing distribution of information across different media, and the need to improve the efficiency, productivity and profitability of print providers and their supply chain partners.

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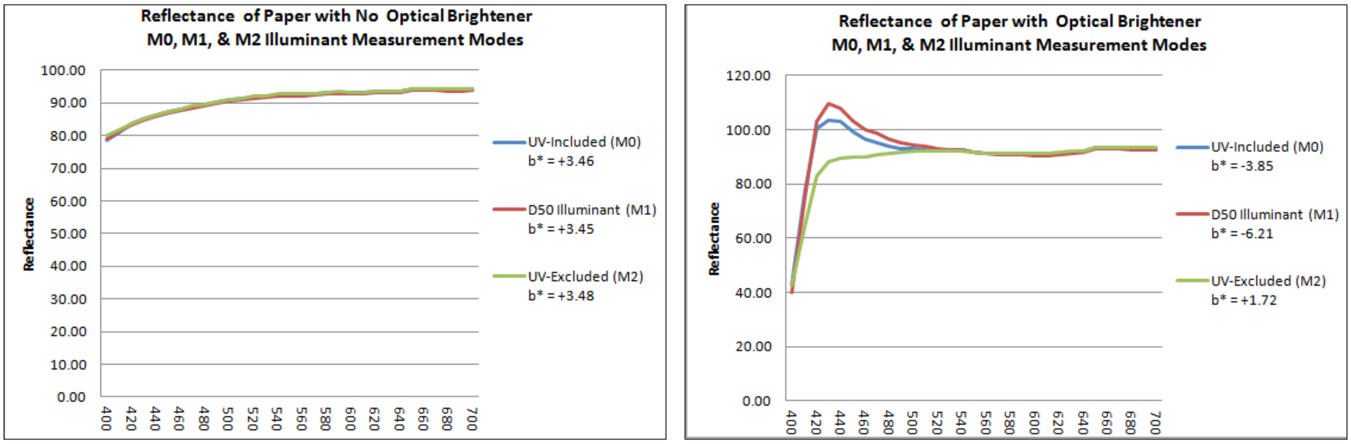
Effects of illumination conditions



This chart clearly demonstrates the effects of three different illumination conditions on the same paper with and without optical brighteners.

A New Series of Measurement Conditions Defined

As part of **ISO 13655-2009: Spectral Measurement and Colorimetric Computation for Graphic Arts Images**, a new measurements standards "M" series of measurement illumination conditions has been defined by the International Organization Standards [ISO] to standardize illumination conditions appropriate for different applications when substrates contain brightening agents. The new M series allows color management of OBA-enhanced substrates to be further refined to a very high degree.

The need for the M series is driven by the color changes seen in materials containing OBAs when viewed with different light sources. The graphs above demonstrate the effects of three different illumination conditions on the same paper with and without optical brighteners. The amount of change between the three illuminants on papers with brightening agents, as shown in the second graph below, would result in an unacceptable match in many workflows and to many clients in the Graphic Arts.

In order to minimize this measurement variability, and to provide a way to communicate the illumination source used for measurement, a new notation of measurement illumination conditions was developed for inclusion in ISO 13655. It defines four distinct measurement illumination conditions. This notation also addresses other measurement parameters such as polarization. The "M" standards, as they have been named, are designed to take into consideration the conditions listed below.

Measurement condition M0

The vast majority of the world's population of spectrophotometers and densitometers used in graphic arts have incandescent lamps with spectra close to Commission Internationale de l'Eclariage [CIE] Standard Illuminant A, with a color temperature of 2856 K, ± 100 K. This is the expected illumination condition for M0. M0 is limited in its definition and does not fully define either the measurement illuminant condition or the UV content of the source. This is because M0 is also meant as a broad definition to include historical instruments of all types that do not fit into any of the other M conditions. For example, X-Rite and the former GretagMacbeth instruments have historically had tight agreement of the illuminant color temperature between instrument product lines, and have closely maintained this agreement to that of Illuminant A.

Measurement illumination condition M0 does not define UV content. Thus, ISO 13655 specifies that M0 is not recommended for use when measured sheets exhibit fluorescence and there is a need to exchange measurement data between facilities. The standard notes that when instruments meeting M1 are not available, and relative data are sufficient for process control or other data exchange applications, M0 instruments of like manufacturer and model provide a viable alternative. This provision helps ensure that the existing population of instruments is not immediately called into question, and can continue to be used in many workflows. Use of M0 is the most common practice today.

Measurement Illumination Condition M1

Measurement illumination condition M1 was defined to reduce variations in measurement results between instruments due to fluorescence, either by optical brighteners in paper or fluorescence of the imaging colorants or proofing colorants. M1 (Part One) specifies that the spectral power distribution of the light source used to measure the specimen should match CIE Illuminant D50. M1 also defines a second, (Part Two) method for achieving M1 compliance that is only valid for measuring optically brightened papers but not for measuring inks or toners that fluoresce. This is due to the historical complexity of delivering a true D50 illumination in handheld instruments. This second definition only requires that a compensation method is used with a controlled adjustment of the amount of UV component (spectral region below 400 nm) used to measure. This is to provide correlation to the D50 illumination conditions as defined in ISO 3664:2009 viewing standard. This second method must be tied to a viewing condition compliant to ISO 3664:2009, so caution in using it must be exercised, and testing for agreement is advised.

Measurement Illumination Condition M2

For the first time, an ISO standard defines what UV exclusion (variously known as UV-cut, No UV, or UV-filtered) should be in a measurement tool. M2 also provides a test to ensure compliance to the standard. Instrument manufacturers now have a defined way to provide agreement when customers require an instrument that does not contain UV. We will be able to measure papers containing optical brightening agents and communicate color data with greater precision and consistency. X-Rite, as part of its XRGA efforts, has made sure that all new UV-cut products meet this definition.

Measurement Illumination Condition M3

M3 defines the effect of polarization. In essence, M3 requires the UV-restricted properties of M2 and adds a definition of polarization. Polarization is used in certain measuring instruments to remove or minimize reflections. Polarization is usually accomplished by choosing a polarization function or adding an optional manufacturer-specific polarizing filter. X-Rite, as part of its XRGA efforts (see below), has insured that its instruments offering M3 mode (polarization filter) provide a UV level that is compliant with the new standard.

Applications and use of M0, M1, M2, and M3

In theory, the cases where each of these measurement illumination conditions are used are relatively clear:

- M0 is for any use where neither substrate nor imaging colorants fluoresce.
- M1, part 1, is intended for use when either substrate or imaging colorants, or both may fluoresce.
- M1, part 2, is designed for use when a substrate may fluoresce, the fluorescing characteristic needs to be captured, and the user is confident that the imaging colorants do not fluoresce. (When in doubt, consulting with the ink manufacturer is recommended.)
- M2 is for use when the paper fluoresces, but there is a desire to eliminate this effect from affecting the data.
- M3 is for special use cases where first surface reflections should be minimized, including the use of polarization to do so.

	M0	$M1_1$	$M1_2$	M2	M3
Measure effect of OBAs		✓	✓		
Measure ink fluorescence		✓			
Measure non-OBA stock	✓	✓	✓	✓	
Cut the effect of OBAs				✓	✓
Cut first surface reflections					✓
Agree on M standard for use in exchanging data prior to measurement	**When using any M standard to exchange data, it is essential to agree on a particular M standard before measuring data.**				

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In practical terms, the use cases are less clear. Today, all industry standard print conditions have been established with M0 instrumentation. There is a movement in ISO to examine this issue in light of the continued use of brightened substrates and imaging colorants, but currently M0 is the de facto standard measurement illumination condition for graphic arts.

Important Factors to Consider

If you are trying to hit standardized values, "print to the numbers," or to meet customer supplied values, it's essential to understand the source of the values. Density values are less affected by illuminant conditions, but differences will result when measuring paper and other non-solid ink colors. Changes will be significant for different Status (T, E) responses and/or when a polarizer (M3) is added. When exchanging data, it will be just as important to note the measurement illumination condition (M0, M1, M2, M3) and the colorimetric computation method (e.g. D50/2, D65/10) as the density status.

X-Rite is working with the ISO to define a more complete method to exchange measurement data using the Color Exchange Format [CxF] format (see below). Our customers can be assured that X-Rite will provide a path to bring them from legacy instruments to XRGA devices. This includes all measurement illumination requirements and conditions as specified in ISO 13655. However, before we embarked on that endeavor, X-Rite decided to help our customers better manage color data originating from our mix of product families. Some recent efforts of this commitment can be found in XRGA and CxF. These technologies are designed to help minimize X-Rite device portfolio variability as well as standardize the file format used to communicate digital color data. The products that we have delivered that embody these technologies will help you better utilize measurements made using the new ISO measurement illumination conditions (M0–M3).

X-Rite Graphic Arts Standards [XRGA]

X-Rite and the former GretagMacbeth have taken great care over their histories to provide tools that meet their customer's requirements and conform to ISO standards. Since the merger between X-Rite and GretagMacbeth we (the new X-Rite, Inc.) have been aware that there are differences in the calibration standards used in the legacy product lines of each of the previous individual companies. Traditionally each company maintained their own traceable calibration standards and processes. We are aware that these differences represent an issue for our customers, especially for those that use multiple measurement instruments, or who need to exchange data.

XRGA is the new corporate X-Rite factory calibration standard for graphic arts instruments. It includes new advances in color technology and changes required to meet ISO-13655. It is the goal of X-Rite to ensure that our portfolio is optimized so that all of our customers – regardless of their legacy affiliation – can enjoy high quality data exchange in workflows that use different instrumentation.

The X-Rite Standard for Graphic Arts [XRGA] :

- Incorporates best in class methods for calibration
- Maintains traceability to the American National Institute of Standards and Technology (NIST)
- Is compatible with respect to existing standard ISO 13655
- Improves inter-model agreement for existing instruments
- Preserves agreement among former X-Rite instruments and former GretagMacbeth instruments
- Provides a single standard for all future graphic arts instruments to be delivered by X-Rite

New graphic arts instruments from X-Rite ship in compliance with XRGA, and existing graphic arts instruments will be compliant with XRGA as soon as they have been returned to X-Rite for the recommended annual recertification.

For more information on XRGA: http://www.xrite.com/product_overview.aspx?ID=1336

L7-462 XRGA Whitepaper: http://www.xrite.com/documents/literature/en/L7-462_XRGA_Whitepaper_FINAL_en.pdf

CxF3

CxF3 provides an XML– (eXtensible Markup Language) based color specification mechanism that is comprehensive, flexible and applicable to any industry where faithful communication of color and appearance data is critical. CxF takes advantage of the openness and universal acceptance of XML and therefore can be seamlessly integrated into any workflow. Through the use of XML, CxF presents self-identifying color data and enables a flexible communication mechanism. CxF is able to integrate data seamlessly from other color communication methods, including ICC color profiles, Density, CIE-Lab, XYZ, RGB, CMYK, PANTONE, RAL, NCS, Toyo, HKS, etc. CxF is currently an object of the ISO standards development process under the collective title: ISO 17972 Graphic Technology — Colour Data Exchange Format (CxF/X).

Conclusion

X-Rite continues to support new standards for our industry as they are defined and evolve. In so doing, we help our customers and the industry rise to new levels of quality and prosperity. We are privileged to work with great people in many workflows, and we look forward to continuing to support them in the Graphic Arts industries with the best measurement tools on the planet.

About the Authors

Ray Cheydleur has worked with X-Rite for more than a decade and in the Photo, Printing and Process control areas for more than 30 years. Ray is chairman of the Committee for Graphic Arts Technologies Standards (CGATS) accredited by ANSI, as well as chair of CGATS SC3, Metrology and Process Control. Ray also participates in the US delegation to the ISO on Graphic Arts and Photographic Standards.

Kevin O'Connor has wrestled with color for decades as a photographer, designer, product manager, speaker and educator. He brings his Irish wit and love of language to his passion—communicating complex color concepts in ways that can be understood.

Acronym List:

CGATS: Graphic Arts Technologies Standards

CxF: Color Exchange Format

D50: Daylight 5000 Kelvin

ISO: International Organization Standards

LED: Light emitting diodes

M: Measurement Mode

nm: Nanometers

UV: Ultraviolet

XML: eXtensible Markup Language

XRGA: X-Rite Graphic Arts Standards

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