TECHNICAL GUIDE

APPLIED COLOUR MANAGEMENT

M0, 1, 2 AND 3 EXPLAINED

Second Edition

FESPA
profit for purpose

M0, 1, 2 and 3 explained

For a long time the only measuring device used in colour management was a densitometer. While useful in many ways, a densitometer is actually colour blind, and only can measure the amount of ink laid down on the substrate as a single greyscale value.

In modern colour management, a spectrophotometer is used because it can analyse the spectral content of the reflected light from a printed surface, or the emitted light from a monitor or backlit print. A good spectrophotometer can also act as a densitometer. This means that professional spectrophotometers, while very versatile thanks to all the various features they contain, tend to be quite complex and challenging to use correctly.

Different Conditions

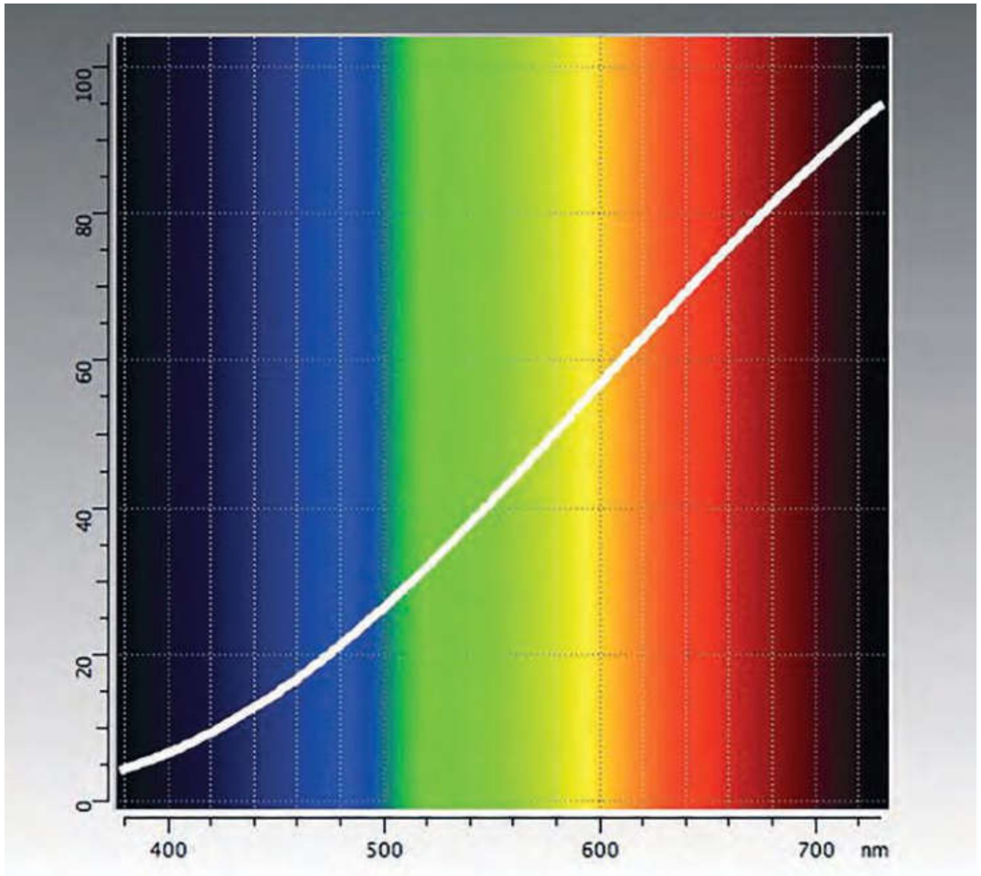
Spectrophotometers are complex because their many features allow them to accommodate different conditions. Even when densitometers were the dominant measuring device, manufacturers had to offer solutions adopted for different types of measuring conditions. One such condition was if the measurement was done on fresh, wet ink, or later after the ink had dried because the results will be different. For wet ink the use of a polarisation filter was recommended to capture the data more accurately, and so offer better measurement data. This is because the polarisation filter reduces the influence of reflections, much like when using polarisation filters in sunglasses.

With the introduction of the spectrophotometer, the possibility to adapt to different light conditions was added, as well as adapting to the characteristics of different substrates. How to correctly calculate the amount of Optical Brightening Agent (OBA) in a paper and adjust the measurements accordingly, has been a big challenge for many years now and will continue to be so. The continuous development of measuring devices led the device manufacturers to introduce four different measurement modes in 2009. This is reflected in the ISO 13655 standard, Spectral measurements and colorimetric computation for graphic arts images, where the term images also refers to printed content. All the four measurement conditions need their own special settings in the spectrophotometer, so that the measurements can be taken, processed and saved correctly. It's called using different measurement Modes, and they are numbered 0-3 (yes, computer geeks like to start with zero when they number things).

The M Series

The first generations of spectrophotometers typically used one or several halogen (Tungsten) lamps for the light source. The problem is that this type of lamp doesn't create a full spectrum of light. This means that it cannot replicate real daylight or D50, the standard daylight reference used in ISO standards dealing with printed colour management. Halogen lamps conform only to CIE Illuminant A which is supposed to represent typical tungsten filament lighting. However Illuminant A has a limited spectral power distribution (see illustration 1.) Another problem was that for a long time the emitted light from halogen lamps wasn't specified or standardised, so it could be pretty random. And older halogen lamps might not even conform to Illuminant A. Fortunately there are several other standardised illuminations, and of particular interest for print and publishing processes are the ones that simulate daylight. These are the CIE D50, D55, D65 and D75 standard illuminants.

1. Illuminant A spectrum.jpg



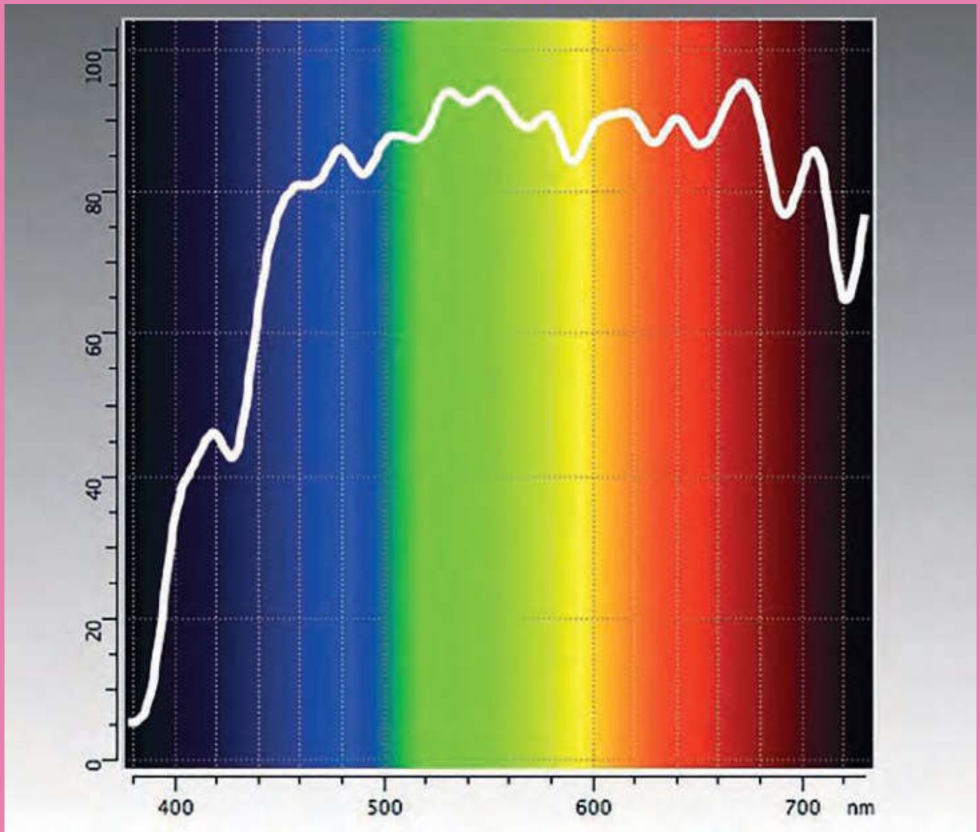
The Standard Illuminant A, typically produced by using a halogen lamp, has a limited spectral power distributions, with almost no UV-light.

Today's spectrophotometer lamps should conform to CIE illuminant D50. Most of the ISO standards for graphic arts production normally reference the D50 standard. This uses a white point of 5000 K, which is a slightly warm white and a kind of compromise. It balances average indoor lighting at around 4000 K with D65 a colder, more blue outdoor daylight standard which has a reference whitepoint of 6500 K. What is also important is that the spectral composition of a light source is specified, and particularly that there are no gaps in the spectrum. If there are gaps in the spectrum, we can't detect the colours that depend on those wavelengths.

The D50 standard is also the primary reference for virtually every viewing booth on the market. Viewing booths are crucial if you want to be able to evaluate both proofs and prints correctly. A spectrophotometer with no other light source than a halogen lamp, and with no special filters applied, can only produce measurements according to M0 mode. Since this mode uses Illuminant A and the viewing booths generally use Illuminant D50, you can see there is high likelihood of conflict in how the colours will be evaluated and this could be expensive, if the errors end up on the prints.

M1 for OBAs

It is for these reasons that an additional mode was developed. The M1 mode requires the spectrophotometer to have some other additional light source, either replacing a halogen lamp, or complementing it to ensure a complete spectrum of light. The light source must be able to emit ultra-violet (UV) light because the M1 mode assumes that there is UV light in the light source. This ensures that the complete spectrum of a D50 compliant illuminant can be simulated. The UV part of the spectrum is important when you know, or suspect, that the paper contains OBAs. The chemical components of the OBAs respond to UV light, and create fluorescence. If the light source emits no, or very little, UV light, the OBAs in the paper will not respond and fluoresce. It is the fluorescing chemicals in the paper that make it look whiter to the human eye. Without a UV component to the illuminant's spectrum the spectrophotometric measurements cannot correctly capture the true appearance of the colours, or the paper whiteness.



The Standard Illuminant D50, commonly used in print production, has a spectral power distribution which includes UV (the wavelengths at about 400 nm and below).

The introduction of OBAs into papers came with the uncoated papers typically used in office laser copiers and printers. Gradually, over the years, OBAs have come to be used in more and more types of paper stocks, and this has caused considerable problems in applied colour management. The spectrophotometer simply doesn't "see" the colours in the same way as the human eye. The most common problem with this is that a digital proof looks too yellowish, compared to the final print. This is because a spectrophotometer working in the classical M0 mode, doesn't stimulate the OBAs in the same way as happens when the print is viewed in proper D50 light, as in a light booth. The CIE Lab values of the whitepoint will suggest a blue-purplish tint to the paper, and if not adjusted for, the colour management system will try and compensate for this by adding more yellow in the proofing process. Another effect is that if you use an ICC profile created when printing on a paper with no OBA, the colours won't match fully, if you are printing on a paper that contains a high amount of OBA.

3. ColorChecker PROOF.jpg

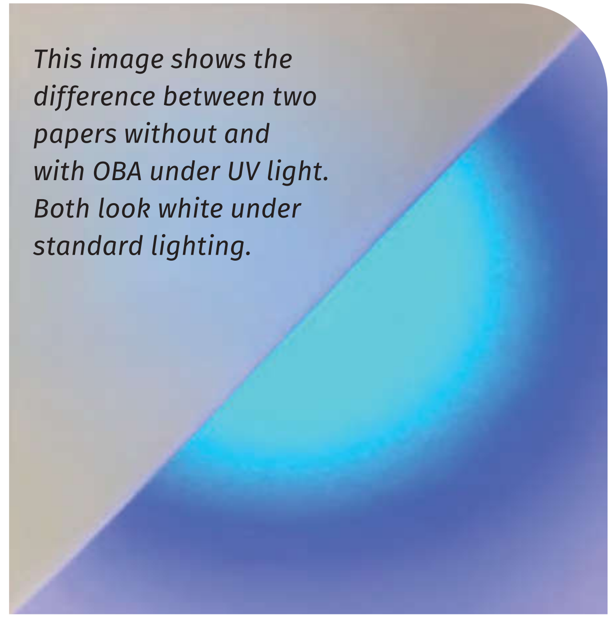
If OBA is suspected in the printing or proofing paper, the appearance can be determined with the help of the X-Rite ColorChecker PROOF reference.

We can conclude that when using print- and proofing papers which don't contain any OBA, the M0 mode works fine, at least if we are measuring dry prints. If we use paper containing a high degree of OBA, we need to use a modern spectrophotometer that supports measurements in M1 mode. In general the M1 mode better reflects the D50 illuminant, so today it has more or less replaced the older M0 mode.

Rarely used M2 mode

While the M0 and M1 modes are the most commonly used in print production, there is a special mode, M2. This mode is used in the rare cases when the viewing light doesn't contain any UV light. One of the few places where this might occur is for example in a museum where UV light is excluded in order to protect the paintings and drawings and other exhibits from its damaging effects. The UV mode is sometimes called UV cut, since the spectrophotometer is either equipped with a physical filter or a digital function in the software, to omit the UV part of the measurement data. This means cutting off the spectral information near the wavelengths of UV light, which is in the span from about 100 nm to 400 nm. Visible light is normally regarded to be the wavelengths between 380-720 nm, so there is a little overlap between the wavelengths of UV light and visible light. The M2 mode is rarely relevant for use in a print production workflow, but you may come across it.

M3 of interest for printers


This image shows the difference between two papers without and with OBA under UV light. Both look white under standard lighting.

The last measurement mode of interest in print production is M3. M3 mode will give accurate readings of newly printed wet sheets. This is because it uses one or more polarisation filters when conducting measurements. This is mainly of interest for conventional printing technologies such as litho offset, but it is also relevant in other printing technologies, where the ink isn't instantly dry such as screen printing.

In conclusion the relatively new M1 measurement mode should be used in applied colour management scenarios, especially for digital proofing and printing. All modern spectrophotometers should support this mode, whereas older spectrophotometers cannot.

Another factor to keep in mind is the need to make sure your spectrophotometer is serviced at the recommended intervals, normally once per year, or possibly every second year.

Published by FESPA Limited
Holmbury
The Dorking Business Park
Station Road
Dorking
RH4 1HJ

t +44 1737 240788
f +44 1737 233734
e info@fespa.com
www.fespa.com

FESPA
profit for purpose