M0, M1, M2, M3 modes

Fluorescent effect of optical brighteners

Optical brighteners (or OBA for Optical Brightening Agent) are components added to the print medium to make them appear “whiter than white”. The principle is quite similar to that of bluing additives in detergents. OBAs capture ultra violet (UV), these electromagnetic waves invisible to the human eye because of wavelengths less than 400 nanometers (nm), and transform them into electromagnetic waves barely visible to our eye (of lengths of wave between 400 and 450 nm). This is the principle of fluorescence. These OBAs thus reinforce the shine of the paper, even and above all, when it is not coated.
Optical brighteners also have the effect of modifying the perception of colors printed on the supports which contain them. And since these agents react to UV, the printed colors will not be seen identically when observed, under lights containing or not containing UV, and this even if the two light sources have the same white temperature. This phenomenon is reinforced by the fact that the components of colored pigments used in offset or digital printing can also be subject to the phenomenon of fluorescence.

The image below shows the three combined spectral curves M0, M1 and M2 of the measured color of a support devoid of optical brightener.



measured color of paper without optical brightener

The following image shows the three distinct spectral curves M0, M1 and M2, of the measured color of a support containing optical brighteners.



measured color of a paper with optical brightener

- **the spectral curve M0, in blue, is that of a measurement according to an illuminant containing non-normalized UV;**
- **curve M1 in red that of a measurement according to an illuminant D50 containing UV under control;**
- **the M2 curve in green excludes the fluorescent effects of UV.**

ISO 3664 (which sets the visual examination conditions for graphic arts and photography) has, in its 2009 revision (ISO 3664: 2009), strengthened the UV content of the illuminants used and very precisely targeted the tolerances required. regarding. The standard D50 neon light tubes, delivered today on the market (which equip, for example, illuminated desks at the press outlet) therefore contain enough UV to excite the OBAs possibly contained in the printing supports. From the fluorescence point of view, the appearance at press output of the colors printed on this type of support is therefore now closer to what it will be in natural daylight. (The sun naturally emits UV

rays, sunscreen suppliers know this well!)

A series of standard color measurement condition

ISO 13655: 2009, devoted to spectral measurements and colorimetric calculations relating to images in the graphic arts, has therefore defined four standard conditions for measuring color called M. They run from M0 to M3, knowing that condition M1 is declines according to two measurement methods.

M0 is the standard condition used by most measuring instruments today. This condition is intended to be and to remain compatible with these existing instruments and, as such, is imprecise both in its definition of the measurement conditions and in the UV content of the illuminant used. The many color measuring instruments that use an illuminant close to the CIE A standard (2856 ± 100 K incandescent lamp) therefore target the M0 mode (or vice versa).
M0 thus makes it possible to measure color charts in a “traditional” way without taking into account the action of OBAs or the fluorescence of the inks or pigments used. This is the mode that should be used for any measurement of compliance with ISO 12647-2: 2004.
Since M0 does not define the UV content of the illuminant used, two M0 compatible instruments can however read different values on the same color patch.
It is these sources of measurement inaccuracy that the other “M” modes aim to compensate for.

The M1 standard aims to ensure that the color measurement conditions (in terms of illuminant) correspond to the visual examination conditions in force (defined by ISO 3664: 2009). The illuminant D50 adopted by ISO 3664: 2009 has a UV component which will excite any OBA of the support as well as the fluorescence of inks and toner. The resulting color is thus the combination of the reflection spectrum (reflectance, independent of UV) and that of fluorescence (caused by UV). It is this combined color that needs to be measured.

M1 method 1 . The simplest method (in theory) is to equip the measuring instrument with a D50 light source, targeting the tolerances of ISO 3664: 2009. In practice, this method is difficult to implement mainly because of the necessary miniaturization of the light source. You can't equip a mobile spectrophotometer with a neon tube like you equip a light booth!

M1 method 2. To overcome the difficulties in implementing method 1, ISO 13655: 2009 proposes a second method which aims to differentiate the fluorescence effect of the OBAs present in the support from the reflectance effect. For this, the support is successively illuminated by an energy source containing only UV, then by a light source containing none. We can thus use these values to extrapolate quite precisely the color of the measured object as if it were illuminated according to the prescriptions of ISO 3664: 2009. This second method has the drawback of not taking into account the fluorescence due to the pigments of inks or toners. And its implementation is itself complicated by the fact that it is difficult to build UV energy sources which do not emit any waves falling within the visible spectrum.

The M2 standard is the so-called “UV-Cut” mode. It is designed to measure the color emitted in a UV-free environment or to exchange colorimetric information excluding the action of fluorescence factors. Apart from a few very restrictive applications (such as providing color rendering in a museum for example), this mode is of little use in the press room. M2 compatible spectrophotometers are simply equipped with an anti UV filter to perform their measurements.

Finally, **the M3 standard** is a suitable mode for predicting the printed color in dry ink. In offset, the inks, once dried, exhibit a reduced gloss vis-à-vis the wet ink. M3 compatible spectrophotometers are equipped with polarizing filters which suppress both fluorescent effects and the gloss effects of wet inks.

Undoubtedly of all these modes, the most promising, and which moreover has been retained by ISO 12647-2: 3013, is the M1 mode. However, without even talking about the necessary renewal of the existing machine park, its operation is not a simple snap of the fingers. A phase of testing, evaluation and definition of operational protocols is therefore underway and will still take some time. This also explains why ISO 12647-2: 2013 is not yet used in standardized production.

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