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WHITEPAPER
WHAT IS A SPECTRODENSITOMETER

By Bruce Leigh Myers, Ph.D.

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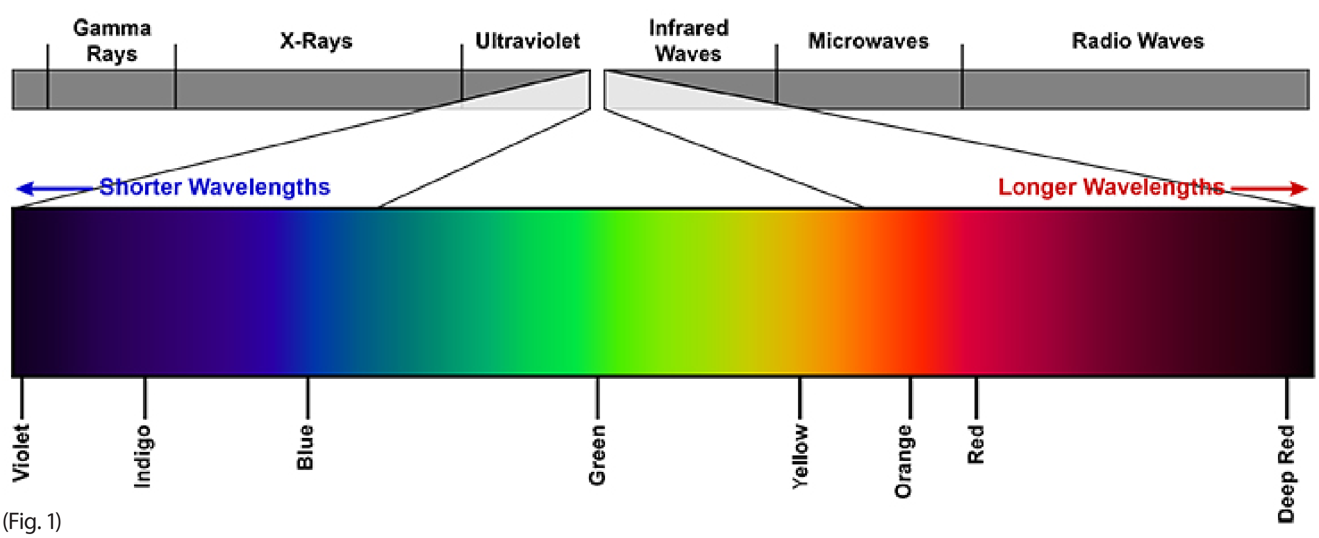
Color reflection densitometers have been used for many years in the graphic communications industry, and are likely the most widely-adopted type of color measurement for process control especially when dealing with four-color process (CMYK) printing. In the 1990's, instruments began to be utilized that, while providing densitometric information, were referred to as "SpectroDensitometers." This has led to confusion by some, and has been regarded as hyperbolic marketing by others. This stems from using the prefix "Spectro," which can be thought to imply "Spectrophotometer." To best understand the differences between the devices, a brief history is provided, along with information about when and how the differences are meaningful.

In its simplest form, a densitometer is comprised of three components designed to measure reflected light, and subsequently monitor colorant on substrate: an illumination component, a light-sensing and measurement component, and a signal processing component. The same can be said for color reflection spectrophotometers. The light-sensing and measurement component, which contains photo-receptors designed to capture reflected light, is what separates densitometers (here, described as "traditional densitometers") from their spectrally-based counterparts.

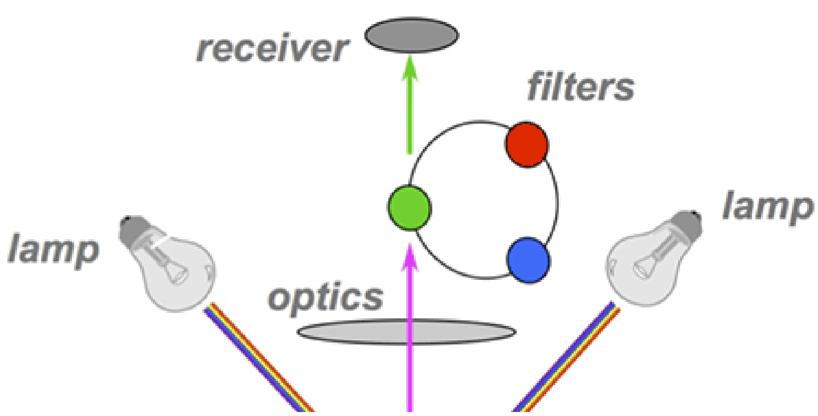
A very brief and admittedly overly-simplified introduction to color theory is provided here, this is sufficient for a rudimentary understanding the concepts discussed. Humans with normal color vision perceive reflected color because objects selectively absorb and reflect the light falling on it; scientists call the illuminant light "incident." If the incident light is white, it contains equal portions of the visible spectrum (frequently thought of as the rainbow.) The wavelength of the light determines its color, the wavelengths of the visible spectrum of light can be measured at essentially 400 nm – 700 nm. The 700 nm wavelengths can be described as red, the 400 nm wavelengths can be described as violet. In between the "R" and "V" many describe the sequential colors as orange (O), yellow (Y), green (G), blue (B), and indigo (I): the famous "ROY G BIV". If the 400 – 700 nm visible spectrum is divided into three equal 100 nm parts, the 400-500nm portion can be called blue, the 500 – 600 nm portion can be called green, and the 600 – 700 nm portion can be called red, the foundation for RGB additive color theory. In this manner, an object illuminated by 400 – 700 nm "white" light which absorbs 400 – 600 nm (the blue and green regions) and reflects the 600 – 700 nm region would be likely described as red…it reflects the red portion of the incident white light. (Fig. 1)



(Fig. 1)

For the chromatic process colors (C, M and Y), a traditional densitometer included at least one set of three differently colored filters which were selected to transmit only certain portions of the visible spectrum to the photo-receptors. These filters were selected based on their ability to divide the visible spectrum into essentially three regions, the aforementioned red, green, and blue. These filters have an interesting effect; for example, a yellow object illuminated by white light and viewed through a blue filter is perceived as near-black. This is because the blue filter largely blocks the green and red portions of the incident spectrum, which is the portion that the yellow object would normally reflect. As the yellow object absorbs the blue light, it appears near-black.

This means that small changes in the yellow object would be more easily perceived by the photo-receptors of the densitometer when viewed through the blue filter. The same is true for the green filter, which magenta objects would perceive as near-black, and the red filter, which cyan objects perceive as near-black. These red, green and blue filters can be thought of as “bands” or “pass-bands”, or even “channels.” This provides the foundation for chromatic process color reflection density: again, traditional densitometers would contain red, green and blue filters designed for measuring cyan, magenta and yellow ink films[1]. The specific characteristics of the red, green and blue filters are part of the densitometer’s “status,” that is, the standard to which the densitometer is based.



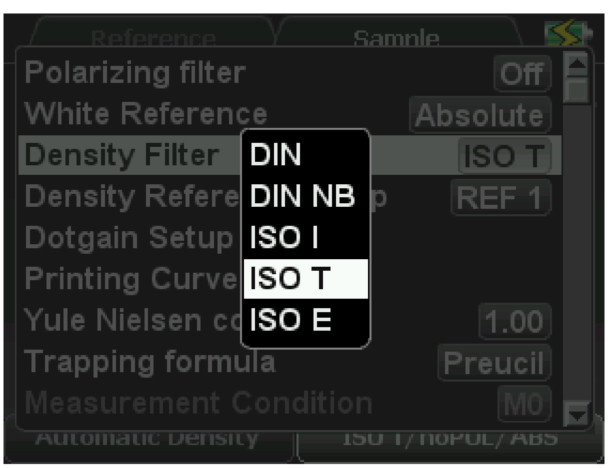
(Fig. 2)

Spectrophotometers, on the other hand, are designed to measure across the entire visible spectrum. For example, a "10 nm abridged spectrophotometer" would obtain a reading of the reflectance of an object at 400 nm, 410 nm, 420 nm and so on, up to 700 nm. These 31 data points could be connected to build a 'spectral curve,' which is a very complete description of the reflective properties of an object. Some refer to the spectral curve as the DNA of the color of an object; this is because with the spectral values it is possible to calculate many different metrics, including colorimetry (e.g.: CIELAB, Delta-E), specialized indices (e.g.: paper brightness) and even status densitometry. As the densitometry status is based on known, standardized filter responses, it is simply a matter of having the correct math and the spectral values to accurately calculate status density.

The so-called spectrodensitometer is just that, an instrument that can calculate density readings from spectral values. While there are very real benefits for this methodology, which are subsequently reviewed, some are taken aback that not all spectrodensitometers can also display colorimetric readings. The situation is akin to that of pocket calculators; an office supply store sells very basic inexpensive versions and scientific calculators with a myriad of capabilities, albeit for more money. All are comprised of a power supply, circuitry and a display, but it is the programmed capabilities that largely determine the cost differences. In this same manner, spectrodensitometers take spectral readings and have the on-board ability to calculate density. This does not necessarily mean that they can calculate and display colorimetric values or other indices that can be based on spectral values.

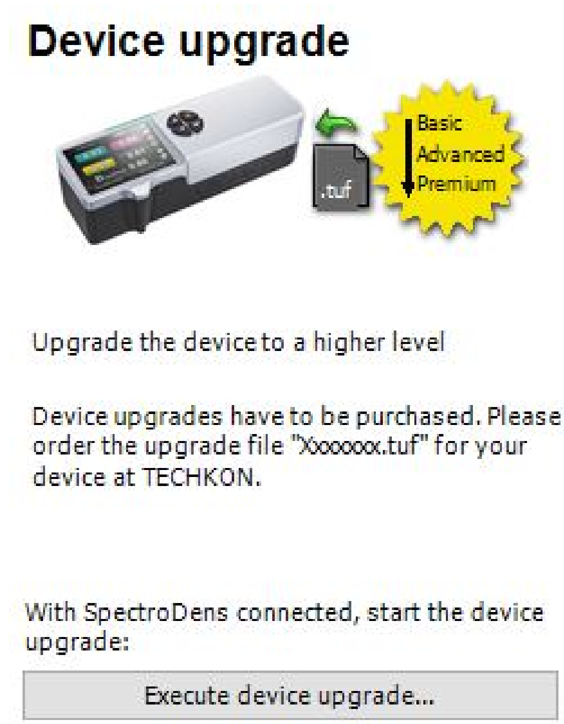
Multiple Density Statuses

The ability to read multiple density statuses. Traditional densitometers are typically "either/or" regarding status, they can either read Status-T (most popular in the U.S.) OR Status-E (most popular in Europe). Spectrodensitometers can normally read both of these most popular graphic arts color reflection standards; the user selects that which is desired.



Upgradeability

While many spectrodensitometers do not display colorimetric values, often they could. This means that a basic spectrodensitometer with the ability to display only densitometric attributes purchased today can likely be upgraded to the ability to read colorimetric values and other indices as needs increase. Such upgrades are generally not possible with traditional densitometers. This allows users to purchase an instrument for their current needs, with an eye toward having the ability to upgrade should future requirements call for colorimetric values, for example.

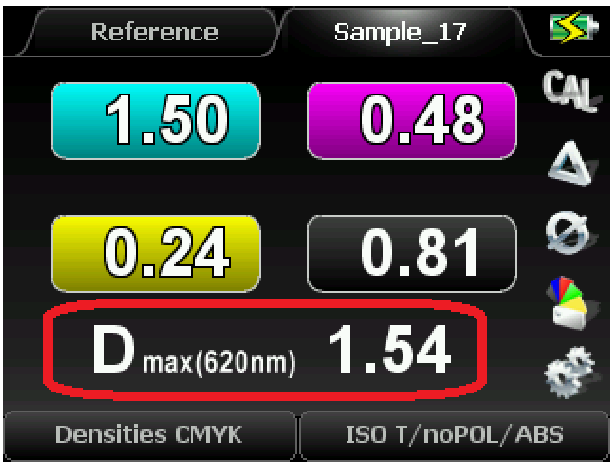


Accuracy

Spectrodensitometers may be more accurate and repeatable than traditional color reflection densitometers. In some cases, they are also simpler to calibrate.In addition, Spectrodensitometers often take advantage of the spectral values with attributes that were not possible with traditional densitometers. These attributes are especially useful for printers working with spot colors and expanded-gamut process color projects, and include spectral density and density optimization based on spectral values.

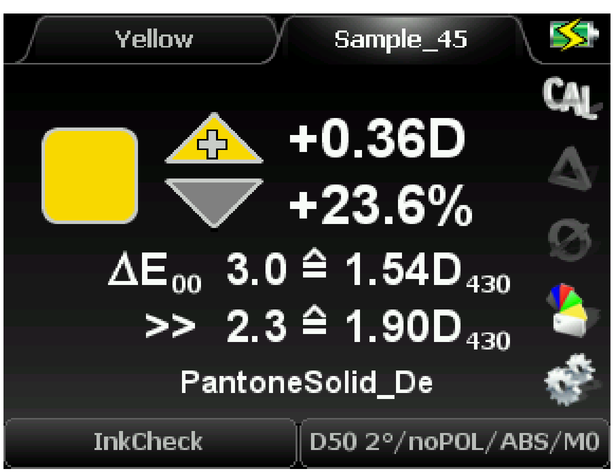
Spectral Density (sometimes called Density-by-Wavelength or Lambda Density)

Filter-based traditional densitometers are optimized to read process colors. While a user will obtain a number when non-process spot colors are read, they are not designed for this purpose. Spectrodensitometers often have the ability to choose an optimum wavelength with which to calculate density. While this is not "status density," for process control purposes such as optimizing and adjusting ink film thicknesses for non-process colors, spectral density is more useful than status density. Spectral density is also important for more precise process control of expanded gamut process color printing, as well..



Density Optimization Based on Spectral Values)

Known as InkCheck with Techkon SpectroDens instruments, InkCheck answers the question "What density will minimize Delta-E for this sample?" With this feature, users can make informed decisions on press about optimizing Delta-E through the adjustment of density. This will often indicate whether an ink needs to be re-mixed, or if a simple density adjustment will sufficiently match the standard.



Summary

To summarize, while traditional densitometers still have their place in process color printing operations, it is important to remember that they are best utilized for process control of CMYK printing. The enhanced capabilities possible with the spectrodensitometer are critical for those printing brand colors, expanded gamut, or who desire more advanced controls. The increased importance for colorimetric information is also noteworthy: such data are required for many industry standardization initiatives and are invaluable for other often overlooked applications such as the incoming materials inspection of paper and ink.

[1] Today, many traditional densitometers do not utilize filters but take advantage of advances in LED technology to achieve Status density, however the principle remains the same.

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