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Managing Color Across Processes

An expert's advice on measuring color with different devices and applications.

Color — in both analog and digital reproduction — is primarily combinations of cyan, magenta, yellow, and black (CMYK) inks trying to reproduce what is seen by the human eye. Expanded gamut inks (e.g., orange, green, and violet) try and extend the color gamut of a device, whether it is an analog press, a toner-based digital device, or a digital inkjet printer.

A significant consideration for managing color across different processes is how to measure it. For analog presses, this typically means density readings (the thickness of the ink film on the substrate), while in the digital world, a spectrophotometer is used to read spectral data. Different print processes will require certain devices based on the size of their aperture, the type of light used, and the number of light sources. For instance, reading color patches on a textile — which has a lot of surface texture — requires a device with a large aperture for better sampling across the patch, and, if possible, multiple light sources to eliminate or reduce shadows.

The other critical consideration is having a consistent and repeatable process to eliminate variables. Helping to weigh in on color management across processes is Bruce Bayne of SpotOn! As a software expert with many years of experience in the industry, Bayne has worked with various printers and their data to achieve good color from their devices.

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By Ray Weiss, Director of Digital Print Programs, SGIA, with Bruce Bayne, Founder, SpotOn!

SGIA Color Management Boot Camps — held nationwide — provide hands-on training in achieving consistent, repeatable color.

Weiss: Color management requires managing CMYK and red, green, and blue (RGB) data, but what are some of the challenges you see from one process to another?

Bayne: I'm a firm believer in working in RGB with late conversion to CMYK if, and when, necessary. My reasoning is that the RGB color gamut is larger than current CMYK profile color gamuts, so color vibrancy and brilliance is not clipped to a smaller gamut. Unfortunately, we cannot always control what we start with, as some files arrive in CMYK and others in RGB.

When working with raster image processors and using International Color Consortium (ICC) profiles, there must be a source (input) and a destination (output or printer) profile. This is the way ICC color management works. When using RGB source files, we start with a rather large source gamut that will be converted to the output device's color gamut (usually CMYK) and take advantage of the entire printer gamut available with the printing process, ink, and media being used.

The biggest challenge is with CMYK source files. CMYK source profiles available today are almost always based on an offset printing process, which often has a smaller color gamut than the actual printing device we're using. This forces all CMYK input data to align with this smaller gamut, which will often not take full advantage of the printing device's full gamut. This limits the vibrancy of the colors when printed and is particularly noticeable when printing brand spot colors that are created as CMYK colors. The bright spot colors become muted. This is why I prefer to work with RGB source files as opposed to CMYK source files.

RGB source files allow us to take advantage of the full printer gamut whenever necessary (meaning that if the file has bright colors, there is a better chance of reproducing those colors). There are, of course, some "gotchas" regarding color reproduction of original files. The biggest issue is not all printing devices or processes produce large color gamuts. Some are rather small, even smaller than CMYK offset printing. Much of this has to do with the texture of the media's surface the ink is printed on. A smooth, glossy textured media will produce brighter visual colors than a rough textured media. This is due to how the light striking the media's surface is scattered. Smooth, glossy media reflects most of the light, so we see the colors as bright. Rough textured media scatters the light, so we only see a portion of the light (color) being reflected off the surface, causing the visual appearance to be duller, or less bright. This means you cannot get the same gamut, or visual saturation of colors, when printing on a glossy vinyl as on a dull, highly textured media.

How inks are laid down on the media can also affect color gamut. For example, the solvent in solvent inks melt vinyl surfaces, depositing the ink pigments into them. The surface texture of the ink takes on the surface texture of the media. Smooth, glossy media surfaces have smooth, glossy ink, thus more gamut (brighter colors). Conversely, rough media surfaces have rough ink surfaces and more subdued colors (less gamut).

With UV inkjet, the ink always lies on the media's surface and, depending on the UV curing settings, will most often have a rough texture. This is due to the flash curing of the ink before it has a chance to flow into a smooth surface. Think of painting a wall with a paint roller: When first applying the paint, you see the texture of the roller in the paint. As the paint slowly dries, the texture vanishes as the paint will flow into a smooth surface (or at least flow into the texture of the surface it is on). With UV inkjet, the "paint" (ink) does not have a chance to flow out smoothly as it is flash dried instantly with the UV lamps, leaving the ink with the texture of the inkjet-spraying process (like the texture of the paint roller), which is quite rough. Hence, UV inkjet has a much smaller gamut than solvent or aqueous on the same type of media surface. UV ink never takes on the texture of the media.

There are ways to reduce the rough texture of UV inkjet printing. One is to set the UV curing lamps to only cure on the return pass, which gives the ink a bit of time to flow before it is cured. Another is to top-coat with a clear coating that flows over the rough texture of the UV ink, causing it to take on a smooth texture. Both techniques will smooth the ink surface, causing the light to scatter less and provide a larger color gamut.

Ink pigment or dyes also affect color gamut. The best example of this is offset ink vs. almost any inkjet ink. The pigments used in offset ink do not produce a large color gamut. Many, if not most, inkjet inks are more saturated, resulting in a naturally larger gamut than offset inks when printed on the same texture media. Offset inks are particularly low in gamut in the blues and violets because the cyan and magenta inks that combine to print blues are dirty. Cyan is contaminated with yellow and magenta. Magenta is contaminated with yellow. When put together, you get a dirty (gray) blue, and not a pure blue. On the other hand, dye-sublimation (dye-sub) inks can reproduce spectacular blues and purples because the cyan ink is very blue (lots of magenta contamination) and the magenta has less yellow contamination, resulting in very vibrant blues. Unfortunately, the cyan is so contaminated with magenta that you cannot produce aqua colors using dye-sub. This means images of Caribbean turquoise water will always look like there is too much magenta in the color of the water (too blue). While extreme, these are two good examples of how ink pigments affect the color gamut, which is important to know when trying to reproduce colors using different printing processes.

How does density measurement (typical in offset) compare with using spectral data in digital inkjet?

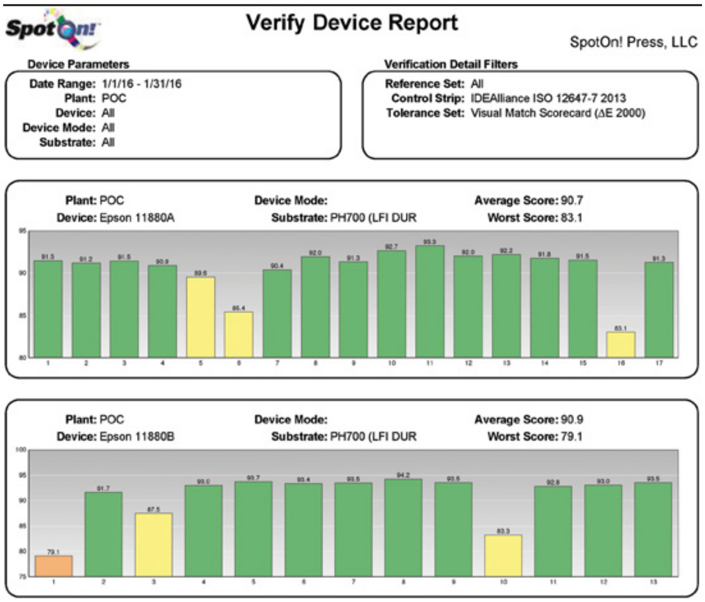
Density is a measurement of reflectance used by offset press operators to measure and control ink film thickness across a press sheet to maintain consistency. Rather than a measurement of color, it is a way to determine how much ink is going on the press sheet (ink film thickness). The industry has some basic starting density values for coated and uncoated press sheets that operators use when setting up a job. From there, they can — and often need to — adjust these starting densities to match a provided proof. Since density is not a measurement of color, there is no way for the operator to determine if a press sheet matches a proof by density. Usually, they visually determine if the press sheet matches the proof. The operator adjusts the amount of ink going on the press sheet for each color to arrive at an acceptable match. Since digital devices do not have ink keys, there is no way for a digital operator to use density as a control metric, as they cannot adjust on the fly as an offset operator can.

Spectral data is an actual color measurement for a given ink or combination of inks. It is often converted into CIELAB data, which can be easier to interpret than spectral data, though spectral data is the basis for CIELAB data. All printing processes can benefit from spectral data, as it defines color value rather than just ink thickness. With spectral CIELAB data, you can assess color appearance and monitor color variation from a standard or proof. You cannot do this with density/ink film thickness.

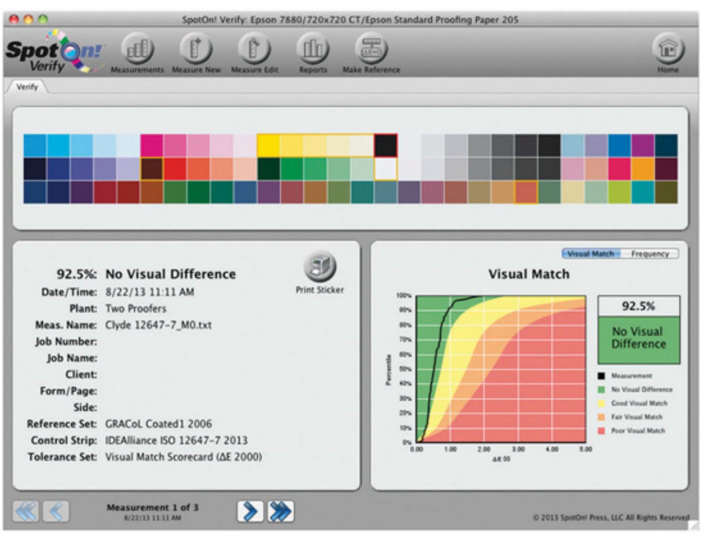
Using spectral data in any printing process, you can determine when the process is in or out of control (matching a proof or standard), but you cannot make adjustments, or really know what to adjust. In digital printing, when the process is not matching, you can recalibrate, reprofile — or both — or adjust the original file. This is where density becomes a control metric for offset operators. If the operator notes each ink's density when the job color is correct, he/she can maintain those densities throughout the press run by monitoring them and making ink key adjustments.

What are some of the differences between digital inkjet and toner-based devices?

My experience with toner-based printing devices is that they tend to be a bit more temperature- and humidity-sensitive, meaning color consistency is affected more by temperature and humidity. This doesn't mean inkjet devices aren't affected by temperature and humidity, but they aren't as sensitive as toner-based devices. The gamut of toner-based devices on similar-surfaced medias is a bit smaller than inkjet in general, especially in the darkest neutral tones. The advantage of toner-based devices is speed. They are faster than inkjet, but that gap is slowly vanishing. I would say the future is in inkjet and as its speed increases, toner-based devices will begin to lose what seems to be their only advantage. Inkjet generally has a wider gamut and more color stability — speed is the only missing component. ▸



A Verify Device Report for multiple devices. Courtesy of SpotOn!



Visual matching. Courtesy of SpotOn!

Analyzing primaries. Courtesy of SpotOn!

What "rule of thumb" would you share when considering managing color across different print processes?

The first thing that comes to mind is measurement data accuracy. We are using a spectrophotometer to gather color data, and the No. 1 goal of good measurement is that it is accurate (i.e., it represents how we see the color as best as possible). This means we must trick a fixed-focus, limited-aperture, limited-illumination (45º) data-gathering device to "see" color the way we do.

I often use M3 (polarized) measurements for all ink-jet devices with the widest aperture possible. Using wide apertures captures data by averaging a reasonably large area of color as opposed to a very small area that can often be inconsistent. Our eyes average a large area unless we are forced to look at a pinpoint of color, so why not mimic what our eyes are doing? The accuracy is more closely aligned to how we see. Polarization can compensate for the spectrophotometer lighting being fixed at 45º. Nature lighting is more diffuse than the lighting in a spectrophotometer, so texture is less pronounced. A spectrophotometer's lighting will accentuate the texture and capture data that is inconsistent with how we see that color. A polarization filter will reduce the glare from the high points in the texture, allowing for better shadow detail, which modifies the data capture to better simulate how we see the color in natural lighting.

Everything during and after data capture is about consistency — being aware of each step and doing it the same way every time. For great color across different print processes, having a process that is predictable and repeatable will put you on the right path. ■

Having joined SGIA in 2014, Ray Weiss provides solutions and technical information on digital printing, equipment, materials, and vendor referrals. An SGIA Color Management Boot Camp instructor, Ray oversees several workshops, SGIA's digital equipment evaluation program, and both the PDAA and Digital Color Professional Certification programs. Ray regularly contributes to the SGIA Journal and won the 2016 Swormstedt Award for Best in Class writing in Digital Printing. His 25-plus years in the graphics industry have spanned owning his own prepress and offset business to digital wide-format sales, training, support, and service. Ray has also worked closely with the Smithsonian Institution to implement a color managed workflow in their Exhibits department.

Bruce Bayne is an industry-recognized expert in color management, press calibration, and production workflow. He is certified to train G7 MasterPrinters as a G7 Expert and G7 Process Control Expert and serves as a vice chair of the Print Properties and Colorimetric Committee at Idealliance. There, he helps shape standards for the industry, keeping him at the forefront of print trends and color technologies. After moving from print production to consulting, Bayne began developing process control tools to address gaps in color management. These prototypes matured into the award-winning SpotOn! software suite.