BY MARC LEVINE

New ISO Standard 20654 (SCTV)

Spot Color Tone Value: Clearly Specifying Equity Spot Color Across the Entire Supply Chain

In printing, "tone value" is a term (expressed as a percentage) that is used to indicate the visual weight of a "tint," relative to both the substrate and the solid ink value. The tone value of substrate is always zero (0 = no tone) and the tone value of a solid is always 100 (100 = full tone).

When we think of tone for historical CMYK process, we expect the tone percentage to be higher than the input value. For example, a Cyan 50% might have a tone value (TV) of 72%, or 22% TVI. Intuitively, this make sense as we know that printing dots spread out or "gain" when they are transferred to a substrate. Historically, these measures have been called "dot area" and "dot gain," which are equivalent to tone value (TV) and tone value increase (TVI).

Tone value is useful for setting a printing machine to a specific printing condition. Once the measured tone value at the 50 (and other tints if desired) is established, the printing machine can be measured during production to both gauge the machine stability and also estimate the variability of the printed product.

ISO 12647 parts 1-4 specifies recommended target TVI values that printers should calibrate to when setting up their presses, which are commonly expressed in the form of ISO curves (a curve not only expresses the TVI at the 50, but across the entire range of tints).

Historically, industry specifications for print have been "density based." In other words, those specifications prescribed that solid ink film thickness be run to specific target densities. It makes sense that, historically, density was also used as the basis for calculating tone value. In fact, most tools today use the Murray-Davies equation (introduced in 1936), which produces a tone value based on the density of the solid, substrate and tint.

Use of density for the management of solid ink and tone value has been viable for 4-color process printing, largely because the density filters used to measure print have been built to correspond with standard CMY print colors. However, when it comes to spot colors that fall in between the standard CMY printing colors, density-based strategies are less reliable. This is the reason that print buyers are increasingly specifying equity spot color inks using color (L*a*b*) and not density.

SCTV FORMULA

With the emergence of this new standard, software and hardware manufacturers are expected to implement this new method in their tools. The formula for SCTV is as follows.

$$t = \sqrt{\frac{(f_{x_t} - f_{x_p})^2 + (f_{y_t} - f_{y_p})^2 + (f_{z_t} - f_{z_p})^2}{(f_{x_s} - f_{x_p})^2 + (f_{y_s} - f_{y_p})^2 + (f_{z_s} - f_{z_p})^2}}$$

Where

t is the tone value of the patch measured

s is the solid

p is the paper (substrate)

The particular functions (f) can be calculated either from L*a*b* values

$$f_x = (L+16)/116 + \frac{a}{500}$$

$$f_y = (L+16)/116$$

$$f_z = (L+16)/116 - \frac{b}{200}$$

or tri-stimulus values

$$f_x = f\left(\frac{X}{X_n}\right)$$

$$f_y = f\left(\frac{Y}{Y_n}\right)$$

$$f_z = f\left(\frac{Z}{Z_n}\right)$$

How It Works

While L*a*b* (and more preferably, spectral data) has become popular for specifying and managing spot color solids, there has been no industry-standard color-based approach to tone. This is the foundation of why ISO 20654 was written. ISO 20654 brings the same color-based approach used to specify and manage solid color to tone value.

Spot Color Tone Value (SCTV) is a ratio of the colorimetric difference between the tint, the substrate, and the solid. It works the same way the standard Murray Davies equation does, except that it uses color, versus density.

The key to SCTV is the use of three tri-stimulus functions for XYZ instead of density. These functions are outlined in the section below. The difference in each of the three functions are added together to create a value that represents the colorimetric difference between two measurements. Like Murray Davies, the formula computes the difference between the substrate and tone, and then divides that between the difference between the substrate and the solid. The final output of the formula, like Murray Davies, is a single percentage number that expresses the tone value.

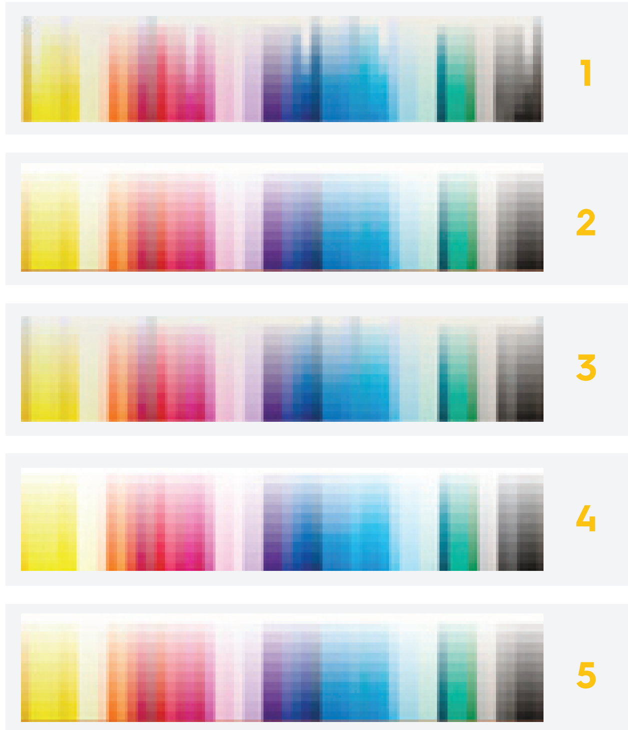
So...what's different?

Because SCTV is based on L*a*b* best derived from spectral data, it works equally well on all colorants, substrates, and print processes. That means, when working with spot colors on a variety of substrates, SCTV produces a consistent result. When calibrating different spot colors across a variety of hues, substrates, and print processes, SCTV reliably produces a visual result where the 50% tint of the color approximates the expected 50% appearance.

Clarification

SCTV is a method for calculating tone value. Using a set of target values, SCTV can be used to measure the current behavior of the print process, create a correction curve, and then determine if the corrected process has achieved the target or intended behavior. SCTV is not a predictive algorithm that estimates what the target L*a*b* of an ink should be at a given percentage. SCTV is not a strategy for making the 50% tint of one printing machine match the 50% tint of another printing machine. Like Murray-Davies, it's a formula that calculates tone value. It just works much better for spot colors than density-based formulas.

SPECTRUMS



What's the target?

Historically, specifications have offered target numbers for tone value based on print process and substrate type. ISO 12647-2:2015 prescribes 16% TVI when printing on a #1 coated sheet using standard CMYK inks. The same standard prescribes 22% when printing CMYK on uncoated materials. Generally speaking, specifying TVI depends on the process, the ink, and the substrate.

SCTV is different. The recommended target for SCTV is always the same as the tint value. A 50% tint should have a measured tone value of "50." A 75% tint should have a target of "75" and a 2% should be a "2." Although these targets are recommended for use with SCTV, ISO 20654 does not explicitly prescribe a specification target. ISO 20654 provides a formula, which can be used effectively to calibrate and manage the printed tone behavior of printed spot colors. However, it is up to the appropriate print specification documents to officially prescribe use of SCTV, including the targets for use with the SCTV method. This is a communication between all parties in the supply chain and a calibration between the design intent, graphic target (proof), and the print reproduction.

Why it's better for spot colors.

In a nutshell, SCTV is better for spot-color tone because it is visually consistent and uniform, where density-based approaches are not.

SCTV in practice (vs Spectral Density)

Spectrum 1 is an image of 54 color ramps. This visual was created by collecting color ramp data across several different pressruns, spanning multiple print processes, substrates, and colors. The spectral data, in 10% increments, was then corrected so that the 50% tint would produce a 50% tone value, using spectral density. Spectral density is based on the highest-absorption wavelength, so it is essentially a customized density measure for each color. It should have worked. However, it is easy to see how inconsistent the corrected data is. Even in the black colors, behaviors are very different. This is a clear indicator that density measurement does not provide a reliable, consistent correction.

Spectrum 2 is what designers would see in Adobe Creative Suite if they defined these same exact spot color solids and then reduced the coverage by 10% increments using their application tools. It's easy to see that, no matter what the color, the ramps are smooth and consistent.

Spectrum 3 is the same data used for the top example (correction using spectral density), but corrected using the SCTV formula. Note that all the ramps develop evenly from top to bottom, just like the ramps that the prepress/design user would see. Note, too, that these 54 color ramps have 54 different white points whereas the prepress image is normalized to a "white." As a result, you can see differences in the top row, which is a function of the substrate differences and not the SCTV calculation.

By normalizing each color strip to white, versus the measured color of the substrate, you can see exceptional correlation between the SCTV result and the Photoshop color preview underneath it (Spectrums 4 and 5).

Long story short, calibrating a press with SCTV, making the 50% tone a "50," produces a printing behavior that better mirrors the expected printing behavior… no matter what the process, substrate, or ink hue.

Can SCTV be used for CMYK colors, too?

SCTV has clear benefits for use with spot colors. From a technical perspective, it is possible to use this method for calibration and management of CMYK colors. However, because the industry has already adopted many different specifications related to CMYK printing, which include both use of single-ink calibration and near-neutral calibration (CMY composited), the proposed scope of ISO 20654 is spot colors only.

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