What's New in Color and Color Management

Calibration to Appearance: A New Approach to Printing Calibration

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"Calibration to appearance" is a new way to calibrate your printing process. It is much faster and more accurate than traditional methods. It structures your printing to match a predetermined "look." It enables you to choose a "favored" color proof and then setup your printing to visually match that proof, with simple tone curves. It has been demonstrated to shorten makereadies and present an efficient way to visually match an uncommon supplied proof.

Traditional calibration methods use density measurement of individual CMYK tone scales to match printing to proof. Solid ink density (SID), tone value increase (TVI), and print contrast (ratio between 75% tone and SID) are the usual density-based calibration aims. The problem is that calibrating to these traditional aims does not produce a good visual match to the "favored proof." Density measures tone, not color. Matching density aims does not produce a good visual appearance match.

Process color printing is all about overprinting CMYK. Traditional calibration methods only measure individual CMYK scales. This does not account for significant overprinting effects. How these colors interact has a considerable impact on the appearance of the printed image. Density measures, of only individual scales, miss this feature of the printed image. This, too, limits our ability to visually match a "favored proof."

Calibration to appearance uses colorimetry instead of density. Colorimetry is the science of color measurement based on visual appearance. The goal of calibration should be to print a *visual appearance* match to a selected color proof (reference). Colorimetry helps us do that more successfully. In place of individual CMYK scales, calibration to appearance focuses on visually matching a tone scale of equal overprinting CMY (isometric scale). This reveals the overprinting effects that are unique to every printing situation.

Calibration to appearance uses the colorimetry of the isometric scale to calculate new calibration CMYK tone curves. These tone curves are applied in a computer-to-plate (CTP) system. This system produces plates that are optimized to print a visual match to the "favored" reference color proof. The printing is engineered to be a visual match to the reference. These methods have demonstrated visual appearance matches in many color-printing situations. Calibration to appearance matches have been achieved between:

- Different presses
- Stochastic and conventional screening
- Press sheet and digital proof
- Press sheet and print standards (reference printing)
- Different printing companies
- Different paper stocks

Calibration—the Foundation

Precise calibration is an essential foundation of any printing enterprise. Without consistent calibration of the printing process, waste grows to be excessive. The process becomes unpredictable. Calibration delivers a consistent, predictable starting point. Some calibrate to published standards like SWOP (Standards for Web Offset Publication), GRACoL (General Requirements for Application in Commercial Offset Lithography), or ISO 12647-2. SWOP was created for web printing on publication-grade paper. GRACoL is a sheetfed spec for higher-grade papers. ISO 12647-2 is actually an internationally adopted standard for a variety of offset printing conditions. The calibration reference can be just about anything. In a perfect world, that reference would be an internationally accepted ink-on-paper color-printing standard.

Changing your halftone screening system also requires a new calibrated foundation. Stochastic (frequency modulated FM) screening has become a popular printing methodology. FM screening requires a totally different tone reproduction (TR) curve for

platemaking and printing than conventional AM screening. FM screens run with AM curves results in printing that is too dark, full, or "muddy" in appearance. Special calibration is essential when printing with FM screening. The goal is, again, calibration to appearance; engineer the calibration to visually match your "favored proof."

Calibration is also considered the foundation of ICC (International Color Consortium) color management (CM). Most introductions to color management refer to the "three C's"—*calibration, characterization, and conversion.* (Figure 1) *Calibration* is setting up a device or process, so a known input will have a *desired* and *predictable* output. Calibration becomes a well-documented consistent intentional starting point.

Characterization measures the color output of a device or process that results from a known input. ICC profiles are then created. This is a "characterization" of the process. In the profile, the known input values are linked to their measured outputs. Without the foundation of prior calibration, it makes no sense to characterize a process.

Conversion is what happens when colors move through an ICC color managed system. The color values are converted (changed) from one device to another (e.g., RGB to CMYK). Profiles are used to calculate new color values to cause the color to appear the same from all the devices.

Without the foundation of accurate calibration all CM bets are off. No color management system will work. The goal of CM is to keep the visual appearance of color consistent from input (capture) to output (press-sheet). Without an intentional starting point, which can be maintained over time, trying to predict color output from a given input is an impossible goal. This article will concentrate on a new method of calibration based on colorimetry and matching the *visual appearance* of a favored color proof.

Calibrate—to What?

Today, how we calibrate our printing process is open to opinion. CTP systems have given us a new control over our printed output. What do we do with it? We no longer need to follow the linear tone reproduction (TR) constraint we had for film. TR curves can now be applied to plate output. This allows us to achieve just about any TR, TVI, or print contrast we desire. This new CTP tone control can be used to "intentionally" calibrate to appearance.

Many printers—some might say most—pay little attention to their choice of a calibration reference. They use the basic setup created when their CTP system was installed. Their printing looks good enough to them and they have adjusted a digital proof to agree with it. They've made their own unique "house" calibration reference. This popular proof-to-press calibration strategy has some negative consequences.

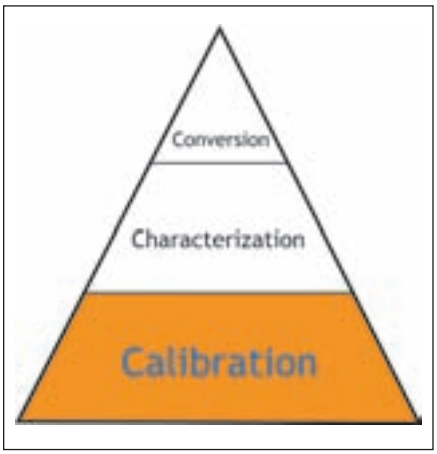

Figure 1. Calibration—The Foundation of Color Management

When calibrating a proof to press, or press to proof, what's the difference? If you're in an environment where you're never required to match anyone else's work or print to a standard (e.g., SWOP), matching a digital proof to existing presswork is the easiest thing to do. If you take this path, the appearance of your printing is *unique.* The look of the printing may be said to be "incidental" and not "intentional," but it matches your proof. With this option, you may have "painted yourself into a corner." You have limited yourself to only matching that unique "house" proof. Most clients use some default Photoshop™ ICC profile (e.g., U.S. Web Coated—SWOP) to convert RGB files to CMYK. If your "incidental" printing doesn't visually match SWOP reference printing, there's a good chance you won't meet your client's color expectations. For more critical color assignments, it is not uncommon for a job to arrive with its own customer-supplied proof. If the supplied proof does not match your unique "house proof," this can lead to costly and wasteful manual color "correction" of the image files.

Limits of Density-Based Calibration Aims

The various groups concerned with printing standards (SWOP, GRACoL, and FOGRA (European Graphic Technology Research Association) have produced reference printing carefully calibrated to their respective specifications. Color targets on these sheets were measured with a spectrophotometer. Colorimetric characterization data from these measures (TR001, TR004, and FOGRA27) was published for each "standard." ICC profiles made from these characterization data sets are included in the latest version of Adobe Photoshop™ (U.S. Web Coated (SWOP) v2, U.S. Sheetfed Coated v2, Europe ISO Coated FOGRA27).

To use these profiles, the idea is this. The printer calibrates their press and proof to a particular "standard" (e.g., SWOP). The client converts their image from RGB to CMYK with the matching U.S. Web Coated (SWOP) v2 profile. The printer prints this image and it matches the proof. This works if your printer has intentionally calibrated the system to *visually* match the SWOP reference printing.

Figure 2. Isometric Tone Scale

To help printers calibrate to these "standards," reference press sheets are available to purchase from the various standards groups. To use the published ICC profiles, you must calibrate your production printing to *visually match* the purchased sheets. A problem with crafting a successful CM workflow is the current calibration aims. The aims provided for calibration are all density-based measures of individual CMYK scales. This is a conundrum. You buy a "standard" reference press sheet and when you print to the published density-based specs of that "standard," you don't get a good visual match to that sheet!

To solve this puzzle, printers must create manually "tweaked" adjustment curves for their CTP system. It usually takes a number of repetitions of this manual-curve adjustment to arrive at an acceptable visual match to the reference sheet. This is a time-consuming and cost-prohibitive process. That is probably why most managers will avoid updating any calibration until a major failure occurs—this is the source of much waste and re-work. Manual adjustment can also lead to plate curves with odd bumps or other anomalies that can compromise overall print quality. When working with any kind of tone reproduction curve, smoother is always better.

When you are trying to calibrate a visual color-match to a standard, traditional calibration aims have some noteworthy limitations. First, they are all based on density measurement. Density is not a color measurement; it's a tonal measure. Density is useful as a process control tool for the press operator to control ink levels during production. But there are more instructive color measures available today for calibration purposes. *Colorimetry* provides much more complete color information for the objectives of calibration to appearance. It is a science based on visual appearance.

A second shortcoming of traditional aims is they are built on density measures of *individual* CMYK tone scales. Color images are composed primarily of *overprinting* values of CMYK. Overprinting inks interact to create hue and tone shifts that are overlooked by assessing only the individual CMYK scales. Measures of individual scales do not account for the considerable overprinting effects that occur in all process color printing. Two processes that have matching midtone TVI, SID, and print contrast commonly won't visually match each other. A good demonstration of this can be seen at the SWOP proofer-certification website (www.swop.org/certification/index.asp). The density-based specs (SID, midtone TVI, and print contrast) are different for each "certified system," but each is judged by SWOP as a "visual match to a SWOP Certified Press Proof." A fine way to achieve this type of visual match is with the methods of calibration to appearance.

Calibrating to Appearance

Color-printing calibration needs to be faster, more accurate, and less costly. If it were, more attention would be paid to this very important part of the production workflow. Calibration to appearance offers three improvements to enable efficient calibration. First, its aims are established through *colorimetry,* an appearance-based color measure. Next, these aims originate from measures of an *isometric tone scale* (overprinting equal values of CMY) (Figure 2). Finally, aims are matched through ordinary *CMYK tone curves* that are easily employed in platemaking by the CTP system.

Anyone who has tried to match printing to a color proof with density-based SID, midtone TVI, and print contrast knows it's inefficient. You are always repeating and fine-tuning color controls to zero in on a good visual match. The lack of "real" color information hinders this approach. The knowledge of colorimetry appreciably aids computing an appearance match.

Calibration to appearance begins with colorimetry. You measure the *color output* of the printing or proofing process from an "isometric" scale. The brownish scale is measured with a spectrophotometer.

The color and tonality of the printed isometric scale is the end result of all of the complex variables (ink/color/optical) and interactions of overprinting process inks on a particular paper. These colorimetric measures help define the appearance of any given printing process. Printing that is calibrated to a visual (colorimetric) match of the isometric scale renders images that are a good visual match to the reference proof. Printing that matches a proof visually normally doesn't have matching density specs. Overprinting differences account for much of this difference. If two printers print to the same density-based CMYK specs, chances are very good that their color won't match (see swop.org proofer certification site).

Colorimetric "characterization" data of the isometric tone scale can be used to compute a visual match between two processes. CMYK tone curves can be calculated from this data to calibrate printing to visually match a favored proof. Matching the isometric scale will govern the calculation of the TR curves. These curves produce calibrated plates that are optimized to print a visual match to the color reference

standard proof. Calibration to appearance with simple CMYK CTP tone curves works. Figure 3 demonstrates the procedure. The printing in 'A' ('Press Uncalib.') does not match the "reference proof." CMYK tone curves were computed to colorimetrically match the isometric scale of the 'reference.' These curves were applied to Printing 'A'. The result is Printing 'B,' calibrated to *match the appearance* of the reference. These calibration curves were computed using colorimetric measures of the isometric scale from *real* printing data. In actual practice, this demonstration requires two different press runs.

This procedure is economical to use because it's employed as a normal part of the CTP plate-making process. This really streamlines a CM workflow. The first two (Calibration and Characterization) happen jointly during calibration. The third C (Conversion) isn't required when the CMYK images are prepared with the profile of the calibration reference.

Managers are normally loath to recalibrate their printing process. It usually takes some catastrophe before they attempt it. Previously, it was an expensive, time-consuming, repetitive procedure. This cheaper and more-accurate calibration method should help to increase the practice of calibration. This would hopefully lead to printing calibration being verified and updated more often. This in turn would lead to faster makereadies and color OKs, less waste, and needless color "correction" of image files.

Using Calibration to Appearance

The methods of calibration to appearance have recently been tested in sheetfed commercial applications with conventional and stochastic screening. They have allowed users to calibrate their printing to optimize a visual appearance match to reference proofs. Users were able to visually match their own "favored proof." Some matched published "standards," like ISO, SWOP, GRACoL, or others. They

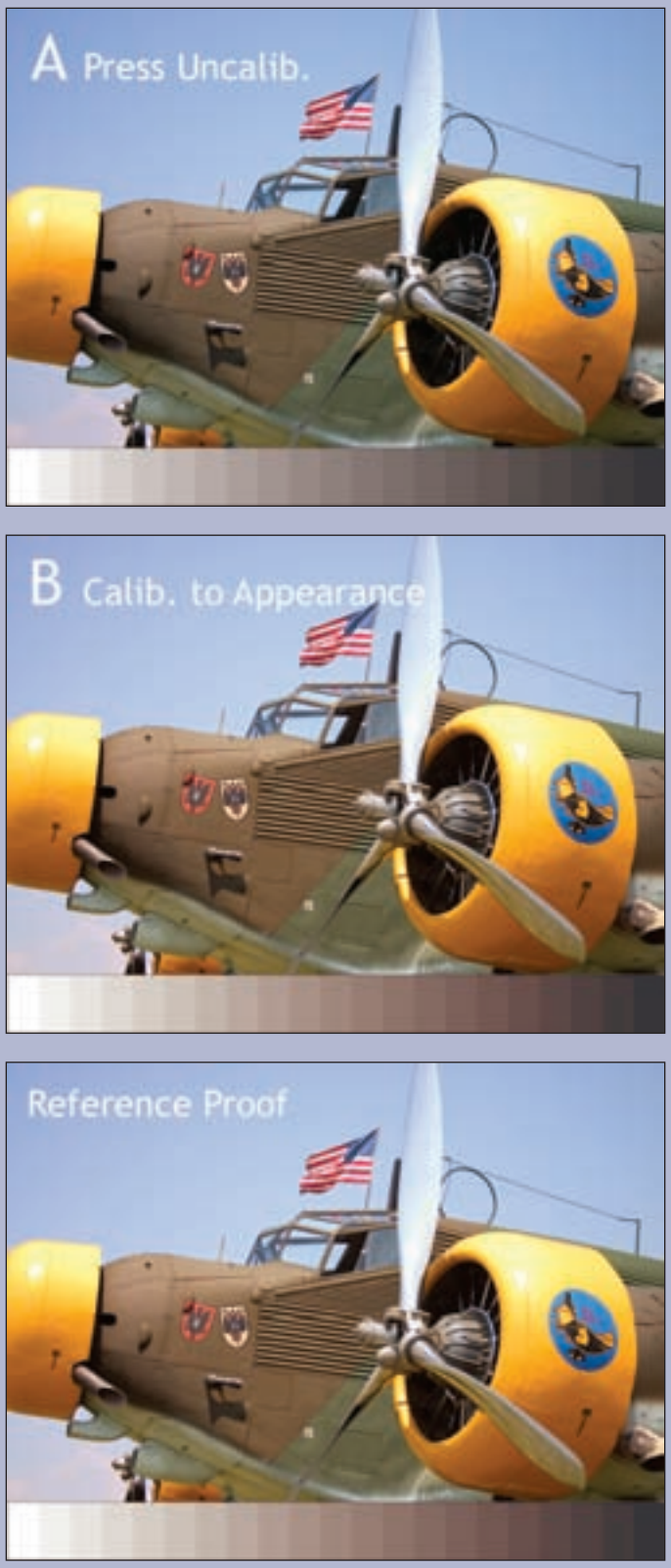

Figure 3—After Calibration, Printing "B" Matches the Proof

also created new CTP curves to visually match proofs supplied by customers. The system even achieved superb matches of 20-micron stochastic printing to pre-approved digital halftone proofs.

Calibration to appearance harmonizes printing to visually match a "favored" or customer approved proof. There are six steps to the process:

1.) Create a "favored" target color proof that includes images and an isometric tone scale.
2.) Plate the above target form with linear CTP or no curves applied.
3.) Print the linear plates to "normal" stabilized solid ink densities on common house stock.
4.) Measure the isometric scales on the target proof and linear plate printing with a spectrophotometer.
5.) Calculate individual CMYK TR curves to optimize the TR and visual color match of the target isometric scale.
6.) Apply these curves to the test form or production plates in the CTP system. Print these to confirm the accuracy of the visual match of printing to proof.

Only a single six-step cycle is required to achieve a high-quality printing visual match to a favored reference proof. Repeating the cycle to manually "zero in" on a visual match is not necessary. The resulting calibration is efficient and cost-effective. It's quick enough to be used on a regular basis to insure timely and accurate calibration for whatever printing/proof reference needs to be matched. The ability to print to "standards" consistently or reliably match a client's supplied color proof would be marketing advantages.

Your printing process will inevitably change. New inks, blankets, fountain solution, presses, or unusual paper types are just some of the many things that can alter output. Recalibrating to visually match the new printing conditions to your standard proof will be just six steps away.

Summary

Color calibration is important for accurate color and efficient printing. Timely and precise calibration reduces waste and the necessity of "color correcting" image files to match a proof. Calibrating to traditional density-based aims (SID, TVI, etc.) of individual CMYK tone scales will not achieve a visual match to the reference proof. Accurate calibration is also essential to an ICC color-managed (CM) workflow. For a successful CM workflow, printing calibration must be a *visual match* to the profiled reference proof / printing.

Calibration to appearance produces printing with a *visual match* to the reference color proof. It is faster and more accurate than using density-based measures. Calibration to appearance is based on the *colorimetry* of an "isometric" (equal CMY) overprinting tone scale. The calibration and matching is achieved through simple CMYK tone curves. These curves are calculated from colorimetric data from the isometric scale. They're applied in CTP platemaking. This procedure has demonstrated excellent results in calibrating printing to visually match a published standard reference (FOGRA 27) and unique "house standards." Calibration to appearance has also been used to visually match stochastic screening to customer-supplied color proofs. Because it is fast and cost-effective, it can be used on a regular schedule to insure consistent appearance matching of printing to reference/proof.

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