

GRACoL Guidelines for Realistically Applying Color Management

The printer has the toughest job of anyone in the industry and suffers the harshest scrutiny.

BY LARRY WARTER & DON HUTCHESON

Pity the poor printers! They have the toughest job of anyone in our industry and suffer the harshest scrutiny. No matter what happens in prepress, what type of proof is supplied, or what changes the client makes at the last minute, the printer's reputation and financial success ultimately depends on one crucial test—how well and how quickly they can match the proof.

A quality printer is one who can match the proof time after time. A successful printer is one who can match the proof in the shortest time. And it really hasn't gotten any better with time. Why? Because in spite of advancements like digital proofing, CTP and especially color management, there is still no agreed-on standard of what a good commercial proof or press sheet should look like, so the proofs and files a printer is likely to receive continue to require custom adjustments on press. To that end, the GRACoL (General Requirements for Applications in Commercial Offset Lithography) Committee has an ongoing program to help printers take advantage of the color management revolution and make the quality of commercial printing more predictable and consistent for everyone.

Why Have a Print Appearance Standard?

Most printers think color management is just a prepress tool. After all, you can't load an ICC profile into a press. More important, color management is based on the assumption that the output device is stable and repeatable; but if the press prints differently every day, the prepress and proofing operations are aiming at a moving target and a large part of the potential value of color management is lost. So the single most important thing printers can do to improve their own profitability through color man-

agement is to make sure the press prints the same way, day to day, run to run, and sheet to sheet. We're not saying this is easy, but if the press prints the same way every time, then a prepress proof can be adjusted to match that particular press; and the press will, in turn, appear to "match the proof" with a minimum of wasted effort.

Those printers who have adopted color management know that by stabilizing press performance, then creating a custom ICC press profile for this stable condition, they can "force" virtually any proofing system to imitate the press (if necessary via ICC profiles) with amazing accuracy.

This is only likely to happen when proofing and printing happen under the same roof. The question: how can we be sure the press will match the proof when the printer doesn't know where the next proof is coming from? A customer-supplied proof, made a different way—for example with different colorant hues, dot gain, or gray balance—obviously is not going to predict the press, and the printer normally has to resort to the inefficient process of "chasing the proof" in makeready (business as usual). However, if the printer has a profile of the customer's proofing system, then the file can be converted into press-optimized CMYK simply by linking the two profiles together. Although the resulting CMYK values for the printer will be different from the supplied file, the final printed sheet should match the customer-supplied proof very closely, with no change in press operation.

While this conversion of CMYK files via ICC profiles is an almost miraculous way of matching a press to a proof (or vice-versa), it's not always an ideal solution—partly because it requires extra work in prepress and partly because the origin of the supplied proof is



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not always known. Also, the new CMYK values may not preserve special effects, like a black-only drop shadow or a corporate CMYK spot color, and this can be a valid complaint, even though the press sheet matches visually. A better solution would be to adjust everyone's press and proofing system to a constant appearance, so files can be more interchangeable. Such a concept would require some kind of official high quality "print appearance standard" and that's exactly what GRACoL has been preaching.

Although a true print "standard" requires years of careful review and official blessing by an accredited body like CGATS or ISO, the GRACoL program has always been aimed at a prototypical "appearance specification" for commercial printing, which will, at some time in the future, become the basis of a true printing standard (see the article on standards at the end of this article). DTR 004, created two years ago, was the first GRACoL attempt and taught us that there is more to making a commercial print standard than producing one good press sheet. Presently, we are experimenting to find out what good commercial printing should look like in today's color managed world. We expect that, with so many variables and subjective considerations involved, there may be many more changes ahead before we finalize our effort; but the alternative is to continue to waste millions of dollars a year chasing images on press.

Besides technical considerations, GRACoL is faced with the fact that commercial printers tend to reject any effort under the old "you can't standardize art" excuse. Up to a point you can't blame them, but times and technology have changed. So let's look at some typical arguments against standardized printing, (and their accompanying counter-arguments).

Answering the Arguments

"If we all printed the same way, printing would become a commodity." A commodity implies that there is at least a market. Most other crafts are already dead. Printer's don't want to follow.

"If I'm forced to print like my competitors, I'll lose my competitive advantage." Actually, printing to a constant visual appearance, day after day, is one of the toughest challenges a printer can face. Those printers who come closest by measurement to matching that standard will have an automatic competitive advantage and a documented reason to charge a premium.

"A printing standard will just bring everyone's quality down to a lowest common denominator." See the definition of a standard in the attached article.

"We've tried 'printing to the numbers' but it didn't work. If you can't control the proofing process, you still end up chasing the proof." No argument here. We agree completely, but that's exactly why we need a "standard" for all the proofing systems to match.

Developing A Print Appearance Standard

So, if printers tend to reject appearance standards, who is driving the process? Today's publishers, ad agencies and print buyers have been asking for better proofing and printing standards ever since they discovered the almost magical capabilities of ICC color management. These clients are asking why they can't get greater predictability and consistency, even when a print job is widely distributed.

The SWOP Specification has been the answer for the publishing part of the market for more than 20 years. But, commercial printing customers want more than a specification like SWOP can give. Although it's a credit to SWOP (which was never

intended for commercial use) that for years it's been used as a reference point for commercial printing. The reason SWOP has been such a useful stop-gap in the absence of a commercial printing standard is that it is soundly based. "Printing to the numbers" is the right starting point for commercial printing, but tolerances need to be tightened and color gamut needs to be larger, for a commercial printing standard.

Even when printers hit the numbers exactly, there is no guarantee that the press sheet will match the proof closely enough for commercial clients. The problem is that conventional press control is based on densitometry, but densitometry only measures ink quantity (film thickness), not how an ink "appears" to the eye.

Thus, the first thing we have to do is to replace (or at least augment) densitometry with colorimetry, which can measure the appearance of an ink, or proof, in numeric terms referenced to human vision (CIE Lab). But, even fully replacing densitometry with colorimetry is still not enough. There is the bigger question of how many samples to measure, and what values they should be, before a device and the eye agree on a "visual match" between two media. Theoretically, the more points of measurement the better to determine a match, but to avoid slowing down the press control operations, any new colorimetric-based process control system must use the least possible number of measurements that can still be correlated with traditional press variables and visual experience.

So what can we measure that will better control print appearance, without increasing problems in makeready?

That would be where a new process, developed by Don Hutcheson and embraced by GRACoL, comes in. The process, which Hutcheson has been developing for over two decades, begins with conventional press optimization "to the numbers" followed by an initial "press appearance calibration" phase, and introducing some new press control aim-points. Taken all together, they should yield more consistent visual appearance matching than traditional press or proof control methods.

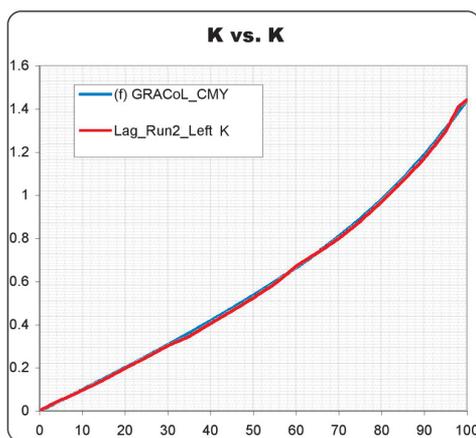
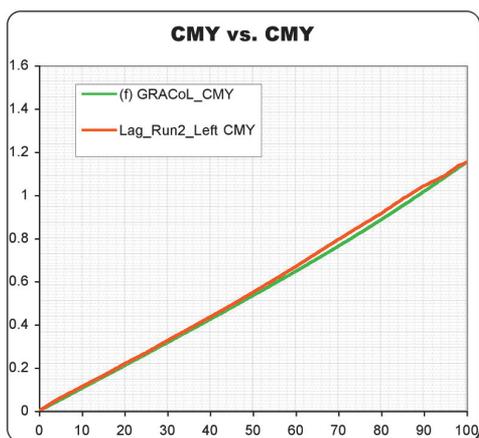
For example, while traditional press control is based on precise solid ink densities and "dot gain" numbers for each individual ink, the new GRACoL method puts less importance on individual ink performance, and focuses more on how the CMY inks behave together. Based on other imaging industries like photography, TV and cinema, Hutcheson's process proposes that

gray balance should be the most important single variable in 4-color printing, because print is just an extension of photography. Yet, gray balance is virtually unmentioned in traditional press control methods because it would be wrong to legislate two control points like density/dot gain and gray balance which are potentially contradictory. Hence, a crucial aspect of the new GRACoL method is the precise definition and control of gray balance, not density and dot gain, as the preferred process control method for printing.

Another new concept in this process is the use of CTP calibration curves to adjust visual contrast and density, rather than dot gain. The new procedure specifies an exact tone shape all the way from highlight to shadow for both a 3-color neutral gray scale, and a black-only gray scale. These curves are smoothed so that adjustments on press produce uniform results across the scale. Furthermore, the relative density of a mid-tone (mid-tone density minus paper density) is fixed, regardless of the device's available contrast range. This effectively de-couples highlight contrast from device-specific shadow density variations and ensures that pastel highlight tones and flesh-tones will look very similar, no matter the device on which they are printed.

By comparison, dot gain numbers do not control highlight contrast very well, because dot gain is dependent on density. Also, because the new approach defines image contrast throughout the whole tonal range, it also matches shadow detail response better from device to device. Solid ink density (SID) is still an essential guide in press setup, but the actual SID values of C, M and Y should be permitted wider runtime tolerances, if necessary, to maintain accurate mid-tone gray balance and density.

To test these somewhat radical theories, this year GRACoL will complete a series of experimental press runs based on gray balance, curve shape and mid-tones (without proofs as guides). Results from the first runs already show the process really does produce a much closer visual match between press sheets from widely different sites than could be expected with traditional methods—simply by: 1) Using ISO-standard inks and "grade one" papers, 2) Adjusting the press to a pre-defined gray balance, and 3) Adjusting the print density response (via CTP curves) to a pre-defined smoothed curve shape. Multiple presses have already produced an amazingly good subjective visual match even though traditional measurements like ink density and dot gain may not be exactly "in spec."



Example of Hutcheson's spreadsheet showing gray scale density curves for GRACoL CMY (green), measured CMY (orange), GRACoL black (blue) and measured black (red).

GRACoL 7 (due out by the end of the year) will detail parameters and procedures of this new process, with cross-references where necessary, to legacy metrics like SID and dot gain. If you can't wait that long, here's a brief overview of the new GRACoL calibration process.

It all starts with the assumption that the press is in optimal working order mechanically and the printing process is under control. This is no small assumption, and we are searching for a simple way to qualify that at makeready, but for now let's just assume:

- ▶ Inks and paper color conform to ISO 2846-2,
- ▶ The press is within normal GRACoL tolerances for solid ink density,

- ▶ Dot gain of all four inks are similar to each other,
- ▶ There are no obvious anomalies in any of the dot gain curves.

If the latter two conditions are met, the ink is probably transferring normally, and the press is probably inside its safe operating window. We could also define other "optimization" variables like trap, sequence, and opacity, but just how many variables GRACoL should try to define is another discussion.

Next the printer makes a *calibration run* using a linear CTP plate curve for all plates. By linear, we mean no attempt to adjust the plate curve except to ensure a 50 percent file value produces a 50 percent dot on plate. (Obviously, the CTP system, including laser intensity, focus, plate development, etc., should itself be optimized according to manufacturer specifications.)

The main point of this calibration run is to test the "native" print characteristic curve, i.e., the relationship between digital dot percentage and printed density, or lightness (L^*) of the press. The calibration run should aim for nominal GRACoL solid densities; but, if necessary, these densities (and/or other press variables) should be adjusted until a gray patch of 50c, 40m, 40y

measures as close as possible to a CIELab value of 0.0 a^* and 0.0 b^* . (Of course, you'll need a spectrophotometer or spectrodensitometer to measure this.)

Once a good calibration sheet is obtained, two gray scales are measured—one printed in black-only, and another in CMY, balanced to neutral gray.

Measurements are made using simple visual density, and should include about 20 points from 0 percent to 100 percent. The results are plotted on a Hutcheson custom spreadsheet/graph and compared to an "ideal" curve, which is part of the new GRACoL specification. Correction values necessary to match the GRACoL curve are then entered into the CTP system, and another set of plates is made through the new curves.

A second press run is required to confirm that the calibration was successful. When the resultant same two gray scales are measured and plotted again, they should perfectly overlay the "idealized" GRACoL curves, assuming the press is operating exactly the same way. This run may (optionally) also include a characterization target from which a custom ICC profile can later be built for that particular press, but this should be less necessary in the future because one of the main points of all these GRACoL press runs is to derive an improved characterization data set to replace the DTR 004 data set issued by GRACoL in 2003. ICC profiles built from the new data should represent any press calibrated to the same specifications, and reduce the need for press-specific profiles.

That's the process. In summary, the target print density curves are perhaps the single most important aspect of the new GRACoL method, because they define the overall lightness or darkness and local contrast characteristics so crucial to the eye's evaluation of pictorial "appearance." But they also invite

controversy, because no matter what curve we pick, it will inevitably NOT match the way all presses print today. So at least some of the industry will have to change their press or proofer characteristics, at least slightly, if they want to match the GRACoL curve. This is an unavoidable by-product of our standardization efforts; but we feel that once the transition period is passed, the effort will lead to more uniform printing and proofing, and more accurate and fool-proof interchangeability of image files.

In deriving target neutral density curves for the new GRACoL commercial print specifications, five requirements were considered;

① The curves should be similar to what a good commercial press would print today with “linear” CTP plates to minimize the impact on all printers and maximize compatibility with existing files. This also would ensure that printers who do not create custom CTP curves can still print reasonably close to the GRACoL curve.

② The curves should be very smooth—with no ripples, sharp angles, or bumps—to maximize ICC profile accuracy, especially in digital proofing.

③ The curves should have a constant highlight slope or contrast regardless of dynamic range so different printing types would share at least the same highlight appearance with each other. Curve compression or expansion, for example to allow for higher or lower densities, would then be restricted to darker tones, where the eye is less sensitive to small differences.

④ A black 50 percent patch should be printed at the same density as the 50c, 40m, 40y middle tone gray patch.

⑤ The curves should ideally be acceptable to both U.S. and foreign printers, to form a basis for international print appearance standardization.

After some study, most of these characteristics were found in the widely-used TR 001 (SWOP) characterization data set after applying a slight smoothing function. It turns out that a typical commercial press with linear CTP plates closely approximates a neutral density curve that is very similar in shape to that of TR 001. The extra dynamic range (shadow contrast) of commercial printing is preserved automatically by the adaptive nature of the GRACoL curve function, with the result that a well-calibrated GRACoL press sheet displays similar highlight contrast and mid-tone density compared to a TR 001 sheet, but whiter whites, cleaner colors, and richer blacks. This means the new

GRACoL specification should be visually compatible with SWOP, while still offering all the color gamut advantages of commercial printing. It also means that, in a pinch, the same separation file can be used on both SWOP and GRACoL presses with no serious side effects. Neutral gray tones should look visually the same, and colors won't be far off, because both SWOP and GRACoL use the same ink set! At first blush, the GRACoL curves also seem quite similar to typical European print density curves. We know a few big ad agencies and other print buyers who'd love to see that.

We have had four press tests to date: **Sandy Alexander** in New Jersey, **Integrity Graphics** in Connecticut, **Man Roland** in Chicago and **LGraphico** in Los Angeles. Results have been exciting. In all cases we printed the job (IT8.7/4, SCID images and Hutch targets) using only the new process as a guide, and we only visually compared results after the printing was done. Despite the fact that the ink varied somewhat and the Grade 1 paper varied a lot in color, the initial impression, looking at the sheets, was that they were all very acceptable matches to each other even by commercial printing standards. True, closer examination revealed differences in saturation, trap and stock color, but these didn't leap off the page from normal viewing distances. We go into the final printings at Heidelberg, Komori, and possibly one or two more commercial printers, with great confidence.

There is still a lot of work to be done before *GRACoL 7* is ready to publish; and when it is, we'll have much more work on our hands: getting ink and proofing vendors on board, training pressrooms and prepress users to use the new processes, getting profiles based on new GRACoL data into applications like Adobe Photoshop, and working on the extras like stochastic and high-saturation inks. But in spite of this additional effort, we think this is a win-win situation for everyone because it leads to a future of printing based both on optimized classical control methods and new visual-based printing goals, linked by color management. Neither is sufficient on its own, but together they represent a major step toward greater consistency, lower costs, and better quality for everyone. One thing's for sure, the future of printing as we know it will never be the same.

To find out more about GRACoL's recent press testing program, go to www.gracol.org. Full details of the new specifications and press control methodology will be included in the *GRACoL 7* edition, which is targeted for publication by the end of 2005. 

Standards, Specifications and Guidelines Defined

Standards, specifications & guidelines are standardizing options; but they have slightly different definitions.

BY LARRY WARTER & DICK PRESLEY

There is still a lot of confusion about the differences between the terms *standards*, *specifications* and even *guidelines*. They are all standardizing options, but they have slightly different definitions and intents. While there is no officially accepted distinction (no formal standard for standards), they are not interchangeable and users should keep in mind the relevant differences.

Standards are defined in the dictionary as either 1. *reference conditions by which all other applications are judged*; or 2. *usual or known practices*.

Accredited standards like CGATS or ISO, as we know them in the graphic arts, are really a combination of the two definitions. In essence, they are codified “best practices” which should apply to everyone in the industry and which have been formally recorded by an official (accredited) organization. There are only two differences that formal accreditation brings to the standards process. First, when the standards are written, they must be open to input from everyone and the standards writing groups must formally publish their deliberations and formally respond to any input from anyone before the standard can be published.

Second, each standard must be reviewed on a periodic basis (usually every five years), and it must be re-authorized or it will expire. That is all there is to accredited standards. They have no authority over any practitioners except the tacit acceptance that they should be acknowledged by everyone as the formal best practice for the industry. People who believe standards are required or have the power to limit users don't understand the process.

Specifications are defined as contractual requirements or conditional agreements. That is how they

are used in specific market segments in our industry. They are process control specifications jointly developed by printers and their customers that define what the customers, as a group, expect from their printer suppliers. They also have no formal jurisdiction over our industry; but, since they are developed by customers, they are usually incorporated directly into contractual arrangements with the printers.

While there is no officially accepted distinction between standards, specifications and guidelines, they are not interchangeable.

Guidelines are defined as optional process directions. In our industry they are used to give orientation to users in various marketplaces. They are never binding in any way.

An example of the differences between the three as they apply to the GRACoL efforts would be:

- ▶ Setting the press up to the best printing conditions would be guidelines;
- ▶ Printing to a prescribed set of density and dot gain (or gray balance and highlight contrast) conditions would be the specification. These could easily be sufficient as a requirement for the printer's customers to specify in contracts in the future; and
- ▶ The resulting printing process and related “print appearance model” would be formalized in a standard that would serve as a unified basis for color management for the industry that all would be free to use or ignore. 