



Demystifying Color Standards

G7, GRACoL, and Press Certifications

White Paper Series



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About this Whitepaper

This whitepaper discusses confusion surrounding G7® and General Requirements for Applications in Commercial offset Lithography (GRACoL®). It explores the origin of the G7 methodology, along with a discussion of programs for G7 Master Printer Qualification, GRACoL and Specification for Web Offset Publications (SWOP) proofing system certifications plus the new IDEAlliance Digital Press Certification program. It also discusses best practices for color matching digital printing systems to press reference datasets such as GRACoL and, by extension, G7 neutral print density curves (NPDC).

Fast Facts

- G7 is a methodology for making SWOP or GRACoL separations print well by calibrating a conventional press through its plate-calibration curves.
- A benefit of G7 calibration is that two printing processes that have been G7 calibrated simulate each other's neutral tonality and gray balance in the highlight to midtone range.
- G7 does not help to match saturated colors from one press or process to another.
- There is no G7 certification program for presses, only G7 certification for software tools or contract proofing systems. There is a G7 *qualification* program for printing companies that have calibrated a printing or proofing system at their site to G7 standards.
- GRACoL is a reference print condition for sheetfed offset presses, based on G7 calibration, combined with conformance to ISO 12647-2.
- GRACoL is not an ISO standard. It is based on the TR-006 dataset published by the ANSI Committee for Graphic Arts Technologies Standards (CGATS).
- For conventional presses, it is easy to implement G7 calibration, since platemaking calibration curves are available on prepress front-end systems that drive platesetters.
- Because conventional prepress front-end systems typically do not offer color management, G7 is often the only way to optimize neutral tone reproduction for conventional presses.
- Fiery Driven™ presses offer ICC-based color management. Fiery color settings can be configured to use ICC color management without G7 pre-calibration both to match to G7 and to match a reference print condition such as GRACoL.
- The only certification program for presses in the U.S. is the IDEAlliance Digital Press Certification.

What is G7?

G7 is a reprographic calibration methodology, invented by Don Hutcheson and popularized through IDEAlliance training and certification programs, starting in 2006.

Before G7, conventional print providers moving from film-driven production workflows to computer-to-plate (CtP) plating technologies, faced an onerous task. They had to try to make plate calibration curves match the way they had printed previously with negative working plates. These plates had more tonal value increase (TVI) — or what is historically referred to as dot gain — than positive working CtP plate substrates. If they calibrated CtP plating to a “linear” (input=output) state, as was the practice with the separation films used to image the older negative-working plates, the resulting presswork looked washed out and reddish compared to proofs or pre-CtP press runs of the same CMYK data.

The G7 calibration methodology solved this problem by establishing a manual method, and eventually a digital tool, to calculate plating curves targeted to the average tonality and gray balance of nine different CtP press runs. The GRACoL committee organized these runs in 2004 and 2005, using ISO 12647-2 ink solids and linear plate curves. The averaged target curves they developed were referred to as neutral print density curves or NPDC, and came very close to the legacy NPDC curves of the CGATS TR-001 dataset published by the ANSI CGATS in 1995. Since the default CMYK profile used by Adobe® Photoshop® in the U.S., U.S. Web Coated (SWOP) v2.icc, is based on the TR-001 data, this made it easy to reproduce legacy CMYK files on G7-calibrated presses and contributed to the popularity and success of G7.

The conventional printing industry could have solved this problem another way. They could have used ICC color management to convert from their old color space (Photoshop SWOP v2 profile) to a custom ICC profile of their CtP-based conventional printing system. However, creating a good press profile for conventional presses is neither simple nor cheap, and most prepress systems attached to platesetters lack effective color-management functionality. Although this situation has improved in recent years, users still typically leave color management disabled so they won't change the CMYK dot values already approved by a buyer. Even today, shops rarely color manage CMYK for plating. This makes G7 the only way to partially “color manage” conventional print workflows, at least for neutral grays.

Since the G7 methodology allows calibration with the one-dimensional plate calibration curves available on every prepress system for plating, G7 was instantly available to every conventional print provider in 2006. Therefore, printing companies did not need to invest in new front-end systems or upgrades.

Print providers can calculate G7 correction curves using a manual graphing technique akin to the Jones Diagram method once used to match process cameras and analog scanners to individual printing processes. The G7 “FanGraph” lets the user plot the tonality of each color on the printing system with linear curves loaded, and then reports new target values in units of %dot for each step of the tonal scale and for each color.

Looking at the fan paper is a good way to understand that the G7 process is adaptive in the shadows, where the graph “fans” out. In the highlight to midtone ranges, G7 target aims will be the same for most printing systems. The adaptive nature of the NPDC curves means that devices with low maximum densities will have less contrast in the shadows, and devices with higher maximums will have more contrast in the shadow. See Figure 1.

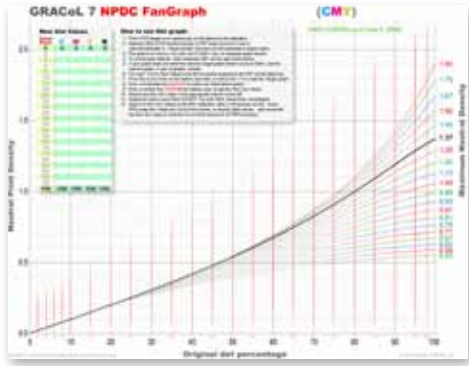


Figure 1: G7 FanGraph paper. Two curves are plotted, one each for CMY and a separate NPDC curve for K. See www.idealliance.org.

Most modern G7 practitioners use a software tool like Curve2™ to create the target calibration curves, rather than the original FanGraph technique.

While G7 is a great methodology for calibrating conventional presses where color management is not available, it primarily focuses on simulating gray tones and gray balance, and is not a true color management system.

So it cannot be used to make different devices deliver precise colorimetric matching to each other. G7-calibrated print systems simulate the appearance of other G7-calibrated processes in the neutral highlight to midtone ranges — where G7 calibration targets are identical for the majority of processes — but not in the three-quarter-tone to shadow areas, where the NPDC targets are adaptive. This means that, for devices using different colorants or with different trapping responses, the primary and secondary overprint colors will not match visually. Refer back to Figure 1 to see how target values fan out, based on the maximum print densities of a given process.

Because G7 does not specify actual ink colors, it is not a reference press condition in the same sense as GRACoL, SWOP or FOGRA39.

GRACoL

In contrast to G7, General Requirements for Applications in Commercial offset Lithography (GRACoL) is a true appearance-matching specification that is based on G7 grayscale calibration in conjunction with targeting the $L^*a^*b^*$ color-appearance values specified in ISO 12647-2 for solids and overprints. It includes a CGATS reference characterization dataset (TR-006) based on real offset press testing and is the first dataset published in the U.S. since CGATS TR-001 in 1995. For convenience, IDEAlliance provides a free ICC profile based on TR-006, GRACoL2006_Coated1v2.icc. Another profile created from the same data, Coated GRACoL 2006 (ISO 12647-2:2004), is included with Photoshop Creative Suite® 4 and later. Both profiles are effectively identical when used as “source” profiles, but each has quite different separation characteristics in gray component replacement (GCR), total area coverage (TAC) and black printer strength. Users can also make their own GRACoL profile from the TR-006 reference dataset.

Because the GRACoL and SWOP 2006 datasets come from G7-calibrated presses, they have G7 built in. If these profiles are used as source profiles for CMYK color management with a precise output profile, users can automatically achieve compliance with G7 tonality and gray balance. See Figure 2 which represents the “perfect” G7 NPDC curves within the GRACoL reference dataset TR-006.

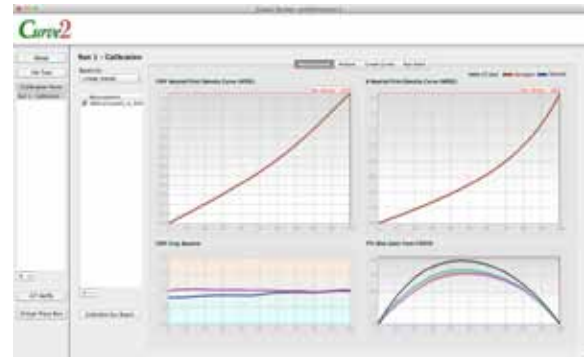


Figure 2: G7 targets in GRACoL reference dataset TR-006.

Qualification and Certification Demystified

To ensure consistent, high-quality adoption of the G7 principles, IDEAlliance has launched several industry programs to qualify G7 practitioners and print shops. There are also certification programs for SWOP and GRACoL proofing systems. Until 2011, there was no G7, GRACoL- or SWOP-based certification available for digital or conventional presses in the U.S. In fact, until 2011, there was never any U.S. press certification program at all.

Historically, the SWOP organization published the only standard for offset printing in the U.S. The original SWOP specification had simple requirements such as the limit for total area coverage in color separations. These specifications allowed color separation houses to deliver films that would run successfully on publication web presses. Over time, the specification collected more detail for the design and production processes. This ultimately led to the creation of the TR-001 dataset with instructions for how to match it on a publication web press. These early specifications did not approximate appearance matching or simulation from press to press since the targets were specified in density units, and the visual appearance of a primary ink color at the SWOP-specified target density could vary from one ink manufacturer to another. Before SWOP merged with IDEAlliance in 2005, the only SWOP certifications available were for contract proofing systems. These early certifications were based on visual evaluation and did not rely on colorimetric measurements.

Since 2006, IDEAlliance has developed a number of programs for qualifying or certifying components of the print manufacturing workflow. These programs have tremendous value to different sectors of the printing industry, but are sometimes confusing to users. Trying to participate and comply with all of them would take too much production time and profit from most modern printing businesses. So it’s important to know what they are and which of them add value to a particular business operation.

G7 Programs

As of March 2013, there are three G7 programs available. Two are professional service certifications and one is a qualification (not a certification) for printing firms. See www.idealliance.com for more details.

G7 Expert Certification

The G7 Expert program is intended for individual practitioners or consultants who want to specialize in G7 calibration. A G7 Expert must complete a rigorous training program that often involves an actual press calibration and pass a challenging examination. G7 Expert qualification lasts for three years. After that, G7 Experts must re-qualify by completing a new exam or taking further training. A G7 Expert is needed to qualify a print business as a G7 Master printer.



G7 Professional Certification

The G7 Professional program is intended for in-house practitioners at a G7 Master location, or individuals who want to receive G7 Expert training without the intention to train others to become G7 Master. A G7 Professional must complete the same rigorous training program and examination as a G7 Expert, but for a lower fee and with a less challenging examination. G7 Professional qualification lasts for three years. Re-qualification requires a new exam or further training.



G7 Master Printer Qualification

G7 Master qualification is awarded to printing, pre-press or proofing companies that have received G7 calibration training from a qualified G7 Expert and submitted press forms or proofs showing their pre- and post- G7 calibration tone curves. The G7 Expert must prepare and submit the qualification application materials. Because this is a qualification, not a certification program, it is valid for a single print shop location for one year after submission. At least one printing or proofing system on the site must be G7 calibrated at the time of submission. To re-qualify, the company must submit new compliance materials annually — again with the assistance of a G7 Expert or an in-house G7 Professional.



In a G7 Master site, at least one printing or proofing system must have been G7 calibrated within the last two years. But the Master status does not imply any level of colorimetric matching to a reference print condition such as GRACoL.

G7 Compliance Levels

There are three levels of G7 compliance. The most basic level, G7 Grayscale, involves successful calibration to the G7 NPDC and gray balance specification, without using standard inks. While the original G7 how-to document recommends press colorants conform to ISO 12647-2 to meet colorimetric aims of primary and overprint colors, these requirements are not normative for G7 Grayscale. Therefore, compliance with these ISO specifications is not strictly required for a plant to become G7 Master Printer Qualified.

Two higher levels of G7 compliance involve more stringent requirements. These are G7 Targeted and G7 Colorspace.

G7 Targeted compliance requires meeting the published $L^*a^*b^*$ target values within $5\Delta E$ of ISO 12647-2 primary and two-color overprint solid standards, in addition to basic G7 Grayscale compliance. Matching G7 Targeted with plate curve calibration alone is not much more challenging than G7 Grayscale

compliance provided ISO-compliant substrate and inks are used, and is regarded as the optimum realistic G7 compliance level for offset printers.

G7 Colorspace compliance includes all the requirements of G7 Targeted and also requires a colorimetric match to a reference print condition such as GRACoL or SWOP. This match must be within tolerances defined by the IDEAlliance Print Properties and Colorimetric Council. G7 Colorspace compliance requires maintaining tight tolerances over the full gamut of the reference dataset.

G7 System Certification

The G7 System Certification program is for software tools that calculate two-dimensional G7 correction curves. To date, three products have been certified including Chromix/Hutchcolor Curve2™, Fuji Colorpath Sync™ and Heidelberg Prinect Tool Box.



SWOP and GRACoL Certification Programs

IDEAlliance offers GRACoL and SWOP certification programs for contract proofing system manufacturers. This includes digital inkjet and conventional hard-copy systems and onscreen softproofing systems. One identifier of a certification, as opposed to a qualification, is the presence of normative colorimetric matching requirements — typically expressed in ΔE . For instance, achieving SWOP or GRACoL proofing system certification requires matching the press reference within an average ΔE_{76} of 1.5 for the IT8.7/4 1617 color patch set. Over 60 such hard-copy proofing systems have been certified since the inception of the program in 2006 including several systems using EFI Fiery XF.



The softproofing certification program uses the IDEAlliance media wedge and requires an average ΔE_{00} of 1.5 maximum for the 54 color samples, along with more stringent requirements for matching neutral colors. Over 20 such systems have been certified at present.

IDEAlliance Digital Press Certification

Digital Press Certification (DPC), from IDEAlliance, is a true certification program with published colorimetric targets and tolerances for compliance, specified in ΔE_{00} metrics — depending on the test. The IDEAlliance Digital Press Certification program was launched in May of 2011. To attain IDEAlliance Digital Press Certification, the print system (Digital Front End [DFE]+ print engine + substrate) must meet exacting requirements for print consistency, print stability over time and colorimetric matching to the GRACoL press reference as measured using the IT8.7/4 1617 patch color target. Systems that have attained IDEAlliance Digital Press Certification can rightly claim that they match GRACoL within an average of less than or equal to $2.5 \Delta E_{00}$, less than or equal to $4.0 \Delta E_{00}$ for the 95th percentile of all patches, and an average of less than or equal to $3.0 \Delta E_{00}$ with a maximum of less than or equal to $5.0 \Delta E_{00}$ for the 226 outer gamut patches of the IT8.7/4 target. Because of this exacting requirement for colorimetric matching, these systems will also match G7 Grayscale and, in most cases, the more challenging G7 Colorspace parameters.



These systems go beyond color matching to the GRACoL reference. They must also pass challenging print-quality metric tests including consistency within the page, from page to page, over a run of 1000 sheets and over a 24-hour period. When evaluating digital press systems, a certified solution ensures customers purchase a print system capable of precise colorimetric matching to the GRACoL reference and, by extension, compliance with the G7 specification on which GRACoL is based. It also confirms that the print system can maintain color consistency within a print run and over time, for the purposes of reprints and pickups.

IDEAlliance Digital Press Certification is the first and only U.S.-based certification available for any type of press. The IDEAlliance Digital Press Certification program is as challenging as the highly respected FOGRA Certification (FograCert) in the realm of digital presses. FograCert, a popular standard in Europe, also includes colorimetric tests but only for a control bar, not the full IT8.7/4 dataset. It also uses the less stringent ΔE_{76} standard rather than ΔE_{00} which is used for the IDEAlliance program. FograCert for digital presses does not have a normative requirement for rub resistance, and does not test for run uniformity or repeatability over time as the IDEAlliance program does. FograCert is still highly respected, and unlike the IDEAlliance program, requires that officials from the FOGRA organization be on-site to verify that test prints are produced as specified.

The outcome of the IDEAlliance Digital Press Certification process is an application data sheet (ADS), available in the certification section of the IDEAlliance [Web site](#). This ADS specifies the exact procedures used to pass the certification.

PSA Certification

The Printing Standards AuditSM (PSA) certification program from the Printing Applications Laboratory at Rochester Institute of Technology (RIT) provides conformance assessment to nationally and internationally recognized standards such as ISO and CGATS. The process involves the definition of workflows and their requirements, calibration methodologies and substrate-corrected aim values plus compliance tolerance with these aims. PSA offers two levels of certification: PSA Certified and PSA Certified with Honors.



PSA is similar in some aspects to the Process Standard Offset (PSO) program developed by FOGRA (Germany) and the BVDM (Germany) and other certifications throughout Europe by organizations such as UGRA (Switzerland), UNIC (France), SCGM (Netherlands) and BPIF (UK).

However, while PSA can certify conformance to a variety of standards, it is unique in offering assessment of conformance to datasets as described in CGATS/TR016:2012. G7 Master Printers who achieve PSA Certification to dataset will be eligible for IDEAlliance recognition as G7 GRACoL or G7 SWOP Certified printers when the program is announced. More details can be found at the [PSA Web page](#).

Best Practices for Digital and Hybrid Workflow

It is extremely important to understand that using a DPC digital press system does not ensure that it will match the press reference in any production environment. It is essential to have strict practices in place for calibration, precision monitoring and color profiling to conform to the standards. The ADS for each certified system provides details about all the tools an organization needs and the exact procedures, engine settings and parameters for calibration and color profiling tools to use.

The first step is to get the ADS for the press, and assemble the tools and materials used for the certification. Without these tools and strict process-control implementation, matching the stringent colorimetric requirements of the DPC program may be impossible at a production site. Regardless of whether the company performs G7 pre-calibration, they will need to create an ICC output profile for the digital press/substrate/print settings with a tool like Fiery[®] Color Profiler Suite to simulate the GRACoL and G7 aims within acceptable tolerances.

Companies need to have these tools on-site to maintain the match, along with the knowledge and standard operating procedures to use the tools to achieve the desired ongoing system conformance. For this reason, certification organizations highly recommend hiring a certified G7 Expert to assess requirements, make custom profiles and pre-calibrate the digital print system to G7 if necessary.

Be certain that the engagement includes:

- Reporting of ΔE conformance to the GRACoL print specification during the delivery and implementation of the print system.
- Standard procedures for re-calibration, re-profiling and monitoring of color conformance using a tool such as Color Verifier Assistant, a component of Fiery Color Profiler Suite.

How to Match a Colorimetric Print Specification on Fiery Servers

Since Fiery servers have full ICC color-management functionality, the first step to matching a colorimetric specification like GRACoL is to calibrate the Fiery server with an ES-2000/ES-1000 spectrophotometer. Before calibrating, follow the recommended steps for internal print engine calibration and adjustment.

These steps are described in detail in section four (4) of the ADS for your print system if it has passed IDEAlliance Digital Press Certification. The certified systems page on the IDEAlliance DPC [Web site](#) has the ADS for all certified systems. In general, the ADS for Fiery systems that have achieved IDEAlliance Digital Press Certification are as follows:

1. Calibrate with ES-2000/ES-1000 or similar spectrophotometer.
2. Create a custom output profile using Color Profiler Suite and the ES-2000/ES-1000. Use at least 928 patches to create the profile.
3. Set source CMYK profile in Color Settings to the GRACoL2006 Coated profile. See Figure 3.
4. Set CMYK processing to Full (Output GCR). See Figure 3. In Figure 3 the output profile is shown as "Fiery De..."



Figure 3: Fiery CMYK processing settings.

Note that, when using plain paper or low-quality coated paper, users may not be able to match the reference print condition due to insufficient press gamut. This is because the output profile color gamut may be smaller than that of the reference print condition. Use the Color Profiler Suite Inspector module to compare the output profile created for the paper with the GRACoL reference profile. If part of the reference gamut “sticks out” of the paper profile (where the gamut of the output profile is larger), try setting a different reference profile that can be matched in the gamut of the printing system with that paper. This could mean choosing the “SWOP2006_Coated” CMYK source instead of GRACoL, for example. See Figure 4 which shows an example comparing the GRACoL reference gamut (in red) with the paper profile for the print system (in green). Because the GRACoL gamut exceeds the gamut of the output device, precise color matching for all of the GRACoL gamut is not possible with the profile for this paper and print system combination. When in doubt, try using the paper defined in the ADS and following the detailed instructions the ADS contains.

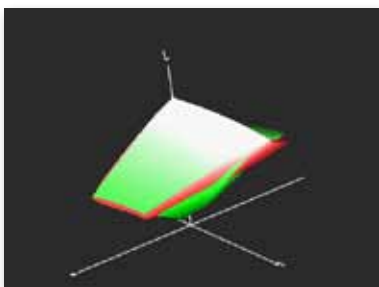


Figure 4: Fiery Profile Inspector.

For a quick analysis of ΔE compliance with the GRACoL reference condition, use the Color Verifier Assistant in Fiery Command WorkStation® on a job configured with GRACoL as the CMYK source and the preferred output profile set in Job Properties. To run this test, right-click on the job from a system running Command WorkStation and a licensed version of Color Profiler Suite. Choose Color Verification from the right-click popup menu, as shown in Figure 5.

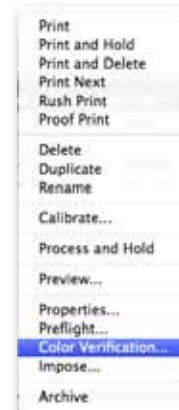


Figure 5: Launching Fiery Color Verification Assistant.

Follow the wizard steps to print, and measure color test pages with the ES-2000/ES-1000. Refer to the CMYK section of the Color Verification Assistant report to check compliance with the GRACoL press reference as shown in Figure 6.



Figure 6: Fiery Color Verification Assistant CMYK report.

For a more accurate match using a Device Link Profile, use Color Profiler Suite 3.1 or above Device Linker and the “match to a standard” functionality. Fiery Device Linker will report ΔE precision as users optimize the device link with additional patch measurements. See Figure 7.

After completing these steps, users can also print, measure and evaluate a G7 Proof2Print target with IDEAlliance Curve2 software. Since GRACoL, SWOP3 and SWOP5 profiles are all based on G7 calibration, users should be able to verify that the tone curves of the press output match G7 NPDC aims when choosing any of these profiles as the source CMYK on the Fiery server. More important, the print will also match the colorimetric press condition, including the ISO 12647-2 CIE Lab aims for solids and overprints as verified in Curve2 software.

There are various arguments in the technical community about whether it is acceptable to match G7 through color management alone. There are two primary arguments against this approach. The first is that, for a non-linear imaging system, bringing it into compliance with G7 before creating ICC output profiles will make the profiling process give better results.



Figure 7: Fiery Device Linker iteration status.

Since digital presses are pre-calibrated from the Fiery server, they often already approximate G7 tonality. So the difference in profiling a G7-calibrated versus a standard-calibrated digital press may not represent a significant improvement. Use EFI Color Verifier or Color Verification Assistant to compare a system set up each way — taking into account the extra time it will take an operator to do the additional G7 calibration step each time.

The second argument is that G7 calibration is essential for a press since it allows operators to focus on density and neutrality metrics as they adjust press console controls during the course of a run, rather than using older, more complex monitoring techniques including TVI, print contrast and trap. Using G7 characteristics of press monitoring does not benefit the digital press operator, however, because digital presses do not have controls to adjust print variables while the press is running. If the press loses calibration during a run, the only solution is to stop the press, re-calibrate it, then resume the run.

Conclusions

Matching industry-standard press conditions, such as SWOP, has been a goal of publication print providers since the 1990s. Early attempts to establish a standard for sheetfed commercial printing were hampered because even the existing SWOP specification did not deliver appearance matching from one press to another unless shops used the same inks. They certainly did nothing to help match one printing process to another. The primary value was in establishing requirements for the media supply chain so that files and color separations would reproduce successfully in the target production environment. This began to change when TR-001 was published and when the vast majority of color separation work migrated to Adobe Photoshop.

G7 revolutionized commercial offset and other printing processes by defining a simple methodology by which conventional presses or non-conventional printing systems could simulate a consistent, universal tonality and gray balance condition. The fact that the target condition closely approximated the TR-001 dataset meant that a G7-calibrated print system could deliver excellent-quality color appearance from legacy CMYK files or separations, without the need for ICC color management, which is rarely available or employed on front-end systems for conventional printing presses.

The definition of GRACoL, SWOP3 and SWOP5 reference print conditions in 2006 — with the publication of the G7 methodology — represented a further evolution of the process by which printing has been standardized in the U.S. It established an ISO appearance-matching standard for sheetfed offset presses, and a new definition for web-coated and web-supercalendared publication printing.

Digital Press Certification from IDEAlliance is the only certification program available for digital presses in the U.S. Certified presses are verified to be capable of simulating GRACoL within tight colorimetric tolerances. Because the GRACoL reference is based on G7, Digital Press Certification conformance naturally ensures that the printing system also conforms to G7 appearance aims. Implementing a Digital Press Certified system does not guarantee it will comply with the tolerances at a given location. Variables, including substrate and environmental conditions at the production location, will cause fluctuations in digital press behavior, as is the case with all conventional printing presses and processes. This means that closely simulating GRACoL or another reference print condition using ICC color-managed workflows will be most successful if companies retain a G7 Expert for the initial implementation. Proper training for shop personnel, along with access to the tools and procedures required to update calibrations and output profiles, will also help to monitor compliance on a daily or shift-by-shift basis.

RIT's PSA offers PSO equivalent certification, and takes G7 to the next level by embedding it in a quality system and enabling assessment of conformance to datasets (product color) in addition to conformance to process aims (press control).

About the author

Lou Prestia joined EFI in 2009 and serves as a product line manager in the Fiery division. He has more than 20 years of industry experience. In 2006, Prestia became a Certified G7 Expert and has worked with numerous customers to achieve and maintain their G7 certification. Prior to joining EFI, he worked for eight years as a color consultant calibrating conventional print systems, wide- and grand-format production and proofing systems, and photo operations. He has worked on early desktop scanning and color separation technologies at both Barneyscan and Pixelcraft. Prestia also worked at Adobe Systems where he served in technical marketing roles, managed the Adobe in-plant graphic arts lab responsible for all Adobe prepress operations, and worked as Adobe's color evangelist. Prestia further developed his in-depth knowledge of digital print production by characterizing early digital engines from Xerox and Canon while at Pixelcraft and later through in his role at Nimblefish as color workflow architect. He graduated from RIT in 1990. Prestia maintains an active presence on the EFI Color Forums and encourages questions and feedback from the professional print community on the forums or at lou.prestia@efi.com.

About EFI

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