Introduction to the G7 Proofing and Printing System Calibration and Process Control Methodology

A longstanding challenge for printers and print buyers alike has been the inability of the industry at large to consistently match color from proof to press, press to press, and printing facility to printing facility. It has, therefore, been the objective of many in the graphic arts community to construct reliable and consistent methods for matching color between multiple proofing and print output devices. The goal has been to develop systems which allow for common files to be routinely shared between printers with the assurance of achieving similar print quality results, even to the point of reasonable color consistency across multiple print media platforms. An international standard, development of print specifications, and introduction of the G7 proofing/printing system calibration and process control methodology has given the industry viable tools for realizing the goal—not only of color consistency between proof and print, but of close visual matches among a wide variety of print processes.

Before getting into a discussion of G7, let's take a closer look at the International Standard and two printing specifications.

The Standard and Specifications

In an effort to standardize components of the printing process worldwide, the International Organization for Standardization developed ISO 12647-2: *Process Control for the Production of Half-Tone Colour Separations, Proof and Production Prints—Part 2: Offset Lithographic Processes.* ISO 12647-2, the only international print standard, specifies a number of process parameters and reference print target values that are generally agreed to constitute the basis for "good printing." The intent of the International Standard is interpreted, applied, and implemented around the world by detailed print specification data sets and various printing system calibration methodologies. It has long been argued that ISO 12647-2 has certain inherent limitations due to the fact that some of the newer process measurement and control technologies are overlooked; and because the Standard does not specifically define colorimetric gray balance and targets for visual print appearance. The recent update to the Standard (ISO 12647-2:2013) in late 2013 resolved some of those concerns.

In 1996, the International Digital Enterprise Alliance (IDEAlliance) established the GRACoL[1] committee for the purpose of instituting and validating best practices for the graphic arts industry, and to create a reference document (a specification) containing general guidelines, aim points, and tolerance recommendations for color proofing and commercial offset printing. IDEAlliance's GRACoL committee proceeded to develop specification guidelines for high quality sheetfed color printing much as the familiar SWOP[2] specification provides guidelines that have long been the *de facto* print reference targets for publication web offset printing.[3]

GRACoL 2013 is the latest version of the GRACoL specification. GRACoL 2013 is not a standard but rather a *specification* that promotes, implements, and operates within the framework of the internationally recognized ISO 12647-2:2013 standard for offset lithography. GRACoL includes process measurement and control data derived from averaging numerous test press runs across North America and functions as both a reference print condition and a process control tool. GRACoL is a colorimetrically based specification that relies on achieving and maintaining gray balance (both in proofing and on press) as the best practice approach to stabilize color output, to create acceptable press to proof matches, and to meet the intent of the international print standard—ISO 12647-2:2013.

What is G7?

G7 is a calibration and process control *methodology* which utilizes two neutral print density tonal curves, one for black and one for combined CMY gray, to adjust CMYK imaging systems to a common target of near neutral gray balance. With its focus on balanced visual appearance, G7 defines a* and b* target values for each step of the combined three-process-colors gray scale. The GRACoL and SWOP data sets are based on G7 grayscale calibrated press runs. Therefore, G7 defined gray balance is inherently built into the GRACoL 2013 and SWOP 2013/2006 print specifications.

The familiar G7 acronym is derived from the gray balance approach for calibration of proofing and printing systems. The "G" refers to the calibration process that aligns color reproduction devices and processes with established gray values. The number "7" denotes the seven ISO specified process colors and overprints (cyan, magenta, yellow, black, red, green, blue) that are monitored during the calibration procedure.

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[1] GRACoL is an acronym that stands for General Requirements and Applications for Commercial Offset Lithography.

[2] SWOP is an acronym for Specifications for Web Offset Publications. For more information on SWOP 2006 and SWOP 2013 see the Sappi Fine Paper article titled *Frequently Asked Questions Pertaining to GRACoL, G7 and ISO 12647-2.*

[3] GRACoL, SWOP, and G7 are owned by and registered trademarks of IDEAlliance.

Why G7?

In the past, printers calibrated their proofing systems to the print behavior of their press(es). Since printing systems and print conditions consist of literally hundreds of variables, the press is generally the most unstable component of the entire color reproduction workflow! Proof to *specific* printing system calibration is at best a temporary situation. Many printers work hard to maintain their *own* internal proof-to-print calibration but when a customer supplies a common file and contract proofs to multiple (non-G7 calibrated) printers, all bets for a consistent color match are off!

The G7 calibration and process control methodology calls for aiming all devices in the color workflow, not to each other, but to match a common definition/target of near neutral gray balance. G7 offers a rather simple procedure for measuring print appearance and deciding how to control many of the variables inherent to the printing process. When one component in the system starts to drift from target, it can be identified and brought back into calibration. When all systems in a workflow are aimed to a defined gray balance target instead of to the moving targets of particular printing presses/systems, common files can be sent to multiple G7 qualified printing plants with the expectation of a reasonable visual color match.

Calibrating with G7

The G7 methodology calibrates color proofing and printing output systems by using colorimetric data to achieve gray balance in accordance with standardized neutral print density. ISO 10128:2009 includes methods for achieving G7 gray balance. One thing that sets G7 apart from other calibration methods is that G7 continually monitors the colorimetric values of combined 3/color neutral gray tints rather than separate CMY dot gain (TVI) scales. The G7 methodology takes the entire tonal gradient into account keeping all areas, from highlight to shadow, in proper color (gray) balance. RIP/CtP calibration curves are typically constructed to adjust print output to match the G7 target specifications by maintaining exact tonal curve steps for both the 3/color neutral gray scale, and for black-only gray values.[4] Aiming all color rendering systems at near neutral gray balance allows the printer to achieve consistent, reasonable, visual color matches between proofs and press as long as proofing and printing systems are maintained within the established calibration guidelines. It is the job of system operators to ensure that equipment is run to established targets and tolerances. G7 calibrated systems must be closely monitored to ensure that when they drift from target (and they will), steps of corrective action are immediately taken.

Since the core focus of G7 is on universally defined gray scale and tonality *appearance*, the methodology is device, process, and media independent. G7 gray balance calibration can be applied to a variety of printing platforms including commercial and publication web offset, sheetfed offset, flexographic, gravure,

[4] G7's gray tonality formula (the *Neutral Print Density Curve* or NPDC), was derived from the results of multiple offset press runs using ISO standard inks and paper that was within the tolerances for ISO Paper Type 1 (ISO 12647-2:2004) with minimal fluorescence. These press runs represented nominal CtP based printing.

digital, and wide format ink-jet. The same print targets, software, and calibration methodology is used regardless of the print technology, inks, substrate, or type of screening.

It is important to note that G7 calibration creates "paper/substrate relative" gray balance and that the G7 methodology works equally well on all substrates (even non-paper substrates). Therefore, there is no such thing as a "G7 certified" printing paper. The paper choice depends on which print specification/data set the printer wants to align with (e.g., GRACoL, SWOP, custom, etc.). G7 will calibrate the printing system to create paper relative gray balance with any paper by taking optical and physical characteristics of the paper into account (e.g., shade, surface smoothness, ink absorption, etc.). Therefore, with G7 calibration, gray balance will adapt to the print characteristics of the paper and grays will look natural regardless of the paper's shade and surface properties.[5] The same G7 gray balance adaptation principle applies for toners, non-standard inks, and various screening technologies. G7 neutral print density curves can be adapted to all. The underlying prerequisite for G7 calibration is that the CMYK printing system must be controlled by alterable tonal calibration curves or other device calibration utilities.

When calibrating proofing and printing systems to the GRACoL specification (as most commercial printers seek to do), G7 requires the use of printing inks that are defined by ISO 2846-1 so that the dry printed solids measure as close as possible to the CIE L*a*b* values for seven colors – the four primary process colors and three 2/color overprints as specified in ISO12647-2.

It is important to note that while the G7 system calibration methodology is not paper specific, there is, however, a GRACoL 2013 recommendation for paper *characteristics* (e.g., white-point/shade) for proof and press calibration. The GRACoL 2013 specification for paper, taken directly from ISO 12647-2:2013, is as follows: L* = 95, a* = 1, b* = -4 (specified according to the M1 color measurement condition—see ISO 13655:2009). If the paper white-point is more than 3 ΔE 76 from the GRACoL aim, it is considered out of tolerance. In this case the GRACoL data set can be recalculated using substrate correction (i.e., SCCA—Substrate Corrected Colorimetric Aims). The resulting aims and dataset are defined as GRACoL Relative.

G7 Qualification

G7 Master qualification is granted by IDEAlliance to facilities whose equipment and systems are successfully calibrated to G7. G7 Master qualification must be renewed annually and the assistance of a G7 Expert is required to guide the applicant through the qualification process. G7 Experts are certified through the G7 Expert Training program and must pass a comprehensive exam. G7 Experts are recertified every two years.

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[5] Human vision quickly adapts to the shade of paper and gauges printed gray balance in relation to the perceived "neutrality" of the paper (substrate). The G7 gray balance formula takes the shade of the substrate into account, altering the a* and b*values of 3-color gray "balance" to ensure that gray values always appear neutral. Therefore, G7 gray balance is "paper relative."

Summary and Conclusion

G7 is not a color management system but it is a key component of the color managed workflow. Consider the offset print workflow. If proofs are validated to a specification/reference printing condition (e.g., GRACoL/G7), plates are properly imaged according to G7 established CtP curves, and the printing system is operated within the specifications of G7 calibration (including use of proper ink and paper), the process can be predictable and repeatable.[6] All devices and systems are calibrated not to each other but to a measureable near neutral balance of colors throughout the tonal scale. If one component of the system slips out of calibration it can be identified and realigned.

If all proofing systems, printing devices, and color management processes are aimed toward the same gray balance specification (i.e., neutral print density), designers can send common files to various printers with confidence and with an expectation of reasonable color matches. Conversely, printers can receive press ready files and GRACoL or SWOP verified proofs from different sources and expect consistent color matches on press when running according to G7 calibration.

Taking this technology a step further, G7 allows not only for common files to be shared among offset printers but also opens the possibility of the same files being repurposed to a wide variety of CMYK (non-offset) print processes—all aimed at near neutral gray balance targets—with the expectation of reasonable color match.

Sappi North America can recommend specific printing papers that meet the GRACoL 2013 (and SWOP) specifications and are well suited for G7 system calibration in offset and digital printing systems.

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[6] G7 does not compensate for inconsistent materials, unstable print processes, and limited color gamut of printing devices.