# Gravure Press Calibration by G7 Simulation

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**Abstract**

This is a feasibility study that evaluates what it takes to implement the G7 press calibration in a gravure package printing workflow. Since gravure printing is known for its repeatability, the study uses the characterization data from the initial press run (Run 1) and the G7 press adjustment curves to simulate the calibration press run (Run 2). The results show that G7 methodology can be adopted in gravure packaging printing, and gravure printers can continue to use their legacy non-standard inks and non-standard papers to facilitate "shared neutral" appearance between printed jobs.

## Introduction

G7 press calibration methodology was spearheaded by IDEAlliance to promote printing to "shared neutral" appearance. G7 has been adopted with success in offset and digital printing industries.

There are two motivations in conducting this study. The first motivation comes from the industry side, i.e., Packaging Corporation of America (PCA), a gravure package printer in Waco, Texas. PCA is interested in G7 benefits, learning how G7 works and what it takes to calibrate their engraving and gravure printing workflow to G7 conformance. The other motivation in conducting this study comes from the education side, i.e., RIT School of Media Sciences wishes to collaborate with a gravure printer by engaging its faculty and graduate student to build a case study to practice what's taught and learned in the classroom.

Literature Review

G7 press calibration method is specified mathematically in the CGATS TR 015 (2011). Based on a set of specific CMY triplets and an ink-paper-press condition (substrate color, CMY solid, and K solid), TR 015 specifies tone reproduction and gray balance aims for a given printing conditions.

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When G7 adjustment curves are applied in raster image processing prior to platemaking or engraving, different printing conditions will render the pre-defined CMY triplets the same, thus, makes the "shared neutral appearance" of printed jobs possible across multiple substrates and multiple printing conditions.

### *Terminology*

The following terms and definitions are relevant and helpful in understanding the underlying G7 principles.

*Reference Printing Condition (RPC)* – RPC defines the relationship between device CMYK values and color, enables ICC profile construction, and facilitates digital data exchange.

*Simulation* – The use of the A-to-B LUT of an ICC profile to find out the relationship between input (tonal values) and output (CIELAB) of an ink-paper-press printing condition. Simulation is like a virtual press run, we can predict the color measurement of a unprinted test target. Adobe Photoshop offers simulation of printed pictorial color reproduction and ColorThink Pro simulates color measurement of printed test targets, e.g., P2P, IT8.7/4, etc.

*CMY ramp* – Pre-defined CMY dot area combinations, including 50C/40M/40Y/0K, to be rendered as neutral. The CMY ramp in the G7 calibration method is also known as the G7 triplets.

*Tone reproduction* – Tonal relationship from highlight to midtone to shadow of a gray scale or ramp. CGATS TR015 specifies tone reproduction requirements of a CMY ramp and K ramp.

*Gray balance* – There are two definitions of gray balance with very different consequences: (1) gray balance is the outcome of an ink-paper-press condition where some CMY combinations are rendered as neutral. This means that different printing conditions render pre-defined the CMY triplets differently. (2) gray balance is the outcome of any ink-paper-press conditions where G7 triplets are used in the press calibration stage. This means that different printing conditions render the G7 CMY triplet the same when G7 adjustment curves are used in the raster image processing prior to CTP or engraving. This is what makes the "shared neutral appearance" possible across multiple substrates and multiple printing conditions.

### *Objectives*

The objective of this study is to introduce G7 calibration to the Cerutti gravure press at PCA. This involves (1) printing and assessing solid color, tone reproduction, and gray balance conformity of the calibration run (Run_1), (2) generating G7 adjustment curves and simulating engraving and printing (Run_2), and (3) assessing G7 conformity of the simulated press run.

## Methodology

The benefit of a color-managed printing workflow, i.e., the use of ICC profiles in color space exchange, e.g., RGB-to-CMYK, is well known. Using color management principles to simulate a press run, although less known, but extremely valuable, can be explained below:

1. Organize a press run, including test image/form design.

   Figure 1 illustrates the contents in the test form. Two things are of importance: (a) the size of the test form occupies one-half of the printing impression so that the other half of the cylinder can be used for Run_2, and (b) the 25-step P2P target is the target to be measured and adjustment curves generated.


***Figure 1.*** *PCA test form design*

2. Engrave and print to SWOP3 solid color aims (Run_1).

3. Measure the press sheet with a scanning spectrophotometer. If this is already done and there is an Cerutti press ICC profile available, we can extract the measurement data from the simulation procedure listed below:

   a. Open P2P.txt in Chromix CTPro s/w.

   b. Assign the Cerutti ICC profile and choose "Absolute Colorimetric" intent in the worksheet.

   c. Save the "Source & Destination" values from the colorlist.

4. Generate G7 adjustment curves in the Chromix Curve2 software.

    a. Select "SWOP2006_Grade_3" as the reference target.

    b. Go to the "Calibrate" tab and load Run_1 file.

    c. Verify G7 conformance of Run_1 to SWOP3.

    d. Create and save the curve adjustment file.

    e. Generate a Run_1 report.

5. Apply G7 adjustment curves in engraving. In simulation mode, the adjustment curves are applied to test images in Adobe Photoshop.

    a. Open the P2P target in Photoshop and go to Edit/Assign Profile, select Run_1 ICC profile. The effect of tone reproduction and gray balance of the initial printing condition should be visible in Column 4 and 5 of the P2P target.

    b. Apply the curve adjustment by going to Image/Adjustment/Curves. If the adjustment is done correctly and the printing is repeatable, Column 5 (CMY ramp) will visually match Column (Column 4) in tonality and gray balance closely.

    c. Save the adjusted tiff image, P2P_curved.tif, as an embedded file.

6. Simulate press Run_2 in ColorThink Pro 3.0.3.

    a. Open the adjusted TIFF image, P2P_curved.tif in the s/w.

    b. Use the custom marquee (12 x 25) to select target values. This result is a colorlist.

    c. Select the absolute colorimetric intent from the embedded ICC profile and save the colorlist.

    d. Open the above text file in Excel, and replace the curved CMYK input values by the original P2P CMYK input values, and rename the file.

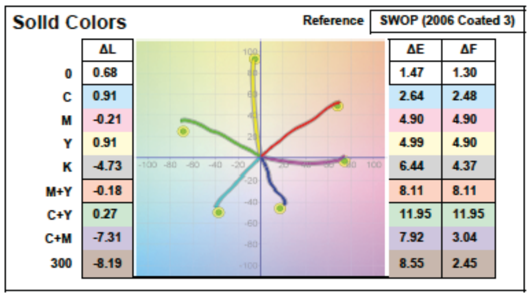
    Note: This is equivalent to repeating the Run_1 printing condition and measuring the curved P2P target colorimetrically.

7. Verify Run_2 for G7 conformance.

## Results

*1. Run_1 assessment*

Solid color conformity – Figure 2 illustrates the a*b* plot of the single color (C, M, Y) and two-two overprint (R, G, B) and ΔEs between the measurements and the SWOP3 aims. Colorimetric tolerances for single color solids is 5 ΔE*ab (G7 Pass/Fail, 2012). Run_1 results indicate that magenta, yellow, and black solids are either marginally conform or out of conformance.




| | ΔL | ΔE | ΔF |
|---|---|---|---|
| 0 | 0.68 | 1.47 | 1.30 |
| C | 0.91 | 2.64 | 2.48 |
| M | -0.21 | 4.90 | 4.90 |
| Y | 0.91 | 4.99 | 4.90 |
| K | -4.73 | 6.44 | 4.37 |
| M+Y | -0.18 | 8.11 | 8.11 |
| C+Y | 0.27 | 11.95 | 11.95 |
| C+M | -7.31 | 7.92 | 3.04 |
| 300 | -8.19 | 8.55 | 2.45 |

***Figure 2.*** *Run_1 solid color conformity*

Figure 3 shows the result of average and maximum values of tone reproduction and gray balance for CMY triplets and K-only tints of Run_1. In Figure 3 (top), the ΔL* for cmy is color-coded in orange and the ΔL* for k is color-coded in gray.

In Figure 3 (bottom), the Δa* for cmy is color-coded in red; Δb* for cmy triplets is color-coded in blue; and the ΔCh is color-coded in green.

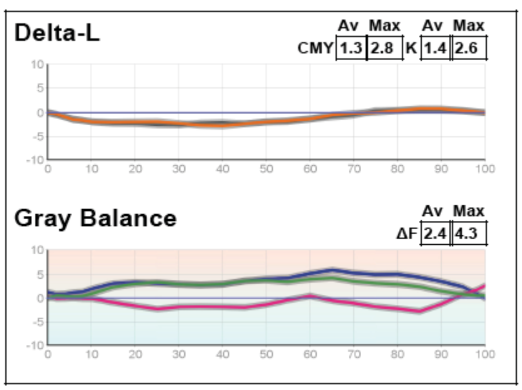



***Figure 3.*** *Tone reproduction (ΔL*) and gray balance (ΔCh) result of Run_1*

Tone reproduction conformity -- The average Delta-L for CMY and K ramps are 1.3 and 1.4 respectively. The maximum Delta-L for CMY was 2.8 and 2.6 for K-only. According to the G7 Pass/Fail Requirements, the average weighted

Delta-L equals to 1.5 and the maximum Delta-L equals to 3.0. Therefore, tone reproduction of K and CMY ramps conform to G7 requirements.

Gray balance conformity -- The average ΔCh (ΔF in the figure) for gray balance was 2.4 and the maximum was 4.3. According to the "G7 Pass/Fail Requirements", the average weighted ΔCh tolerance for the CMY ramp is 1.5 and the maximum weighted ΔCh tolerance for the CMY ramp is 3.0. Therefore, both gray balance metrics, weighted average ΔCh and weighted maximum ΔCh, are out of the tolerance.

The G7 adjustments are derived so that the Deltas are accounted for in the four (CMYK) 1-D adjustment curves. For example, when the b* value (the blue line in the bottom of Figure 3) of the triplet in the midtone is positive, less yellow tints are called for in the adjustment.


***Figure 4.*** *G7 adjustment curves*

2. *Run_2 assessment by simulation*

Solid color conformity – G7 method only adjusts tints and has no effect on the solid colorimetrically. Thus, Run_2 results are identical as Run_1 regarding magenta, yellow, and black solids conformance.

Figure 5 shows the result of average and maximum values of CMY and K-only of Run_2. Notice that the Deltas in tone reproduction and gray balance are smaller in comparison to Run_1.

Tone reproduction conformity -- According to the G7 Pass/Fail Requirements, the average weighted Delta-L tolerance is 1.5 and the maximum weighted Delta-L tolerance is 3.0. Run_2 indicates that tone reproduction of K ramp (0.1 and 0.7) and CMY ramps (0.5 and 1.1) both conform to G7 requirements.

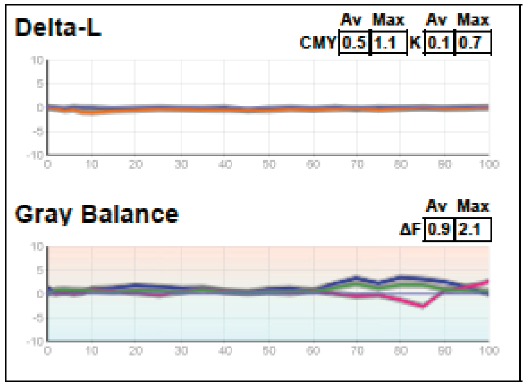



***Figure 5.*** *Tone reproduction (ΔL*) and gray balance (ΔCh) result of Run_2*

Gray balance conformity -- The weighted average and weighted maximum ΔCh for gray balance are 0.9 and 2.1 respectively. Run_2 simulation also conforms to G7 requirements.

## Discussions

This case study describes how to use color management tools, ICC profiles, and test targets to calibrate a gravure press to G7 conformity. The results show that a G7 calibrated press, improves gray balance as well as tone reproduction in a simulated press run.

The TVI curves in Run_1, plotted using 'P2P_sim1.txt' Figure 6a, are higher and equal (greater than 20%). The TVI curves in Run_2, plotted using 'P2P_sim2b.txt' in Figure 6b, are lowered and unequal because TVI gave precedence to tone reproduction and gray balance. This indicates that (1) similar TVI curves (Run_1) do not yield gray balance when nonconforming SWOP inks are used, and (2) gray balance (Run_2) can be achieved using non-standard inks or substrates by the G7 press calibration method.

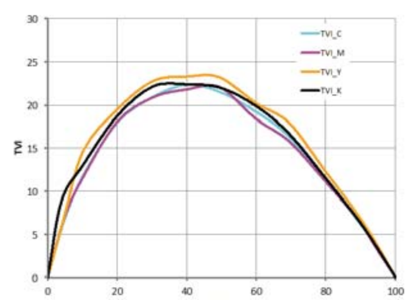



***Figure 6a.*** *TVIs in Run_1*

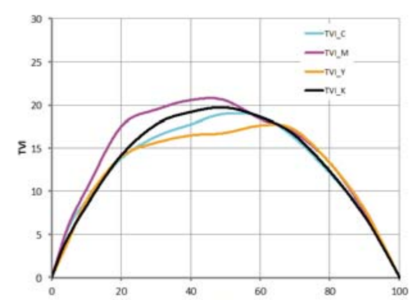



***Figure 6b.*** *TVIs in Run_2*

## Conclusions

G7 press calibration benefit gravure printers because (1) gravure printing is inherently stable, (2) they can continue to use their legacy non-standard inks and non-standard papers because G7 recognizes the color of the substrate and manages its gray balance based on paper color. Gravure printer can print to a larger color gamut if needed. There is still a challenge, i.e., to streamline the G7 adjustment curves with the RIP/engraving operations.

On a different note, this project started as collaboration between RIT and PCA. RIT graduate student and co-author of this paper, Jing Sheng, worked on the project as a co-op student. PCA management was pleased with the project outcome and hired Jing as a full-time employee. PCA plans to implement the G7 gravure press calibration and to seek G7 Master qualification status in the future.

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## References

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