G7 Method for Indigo Press Calibration and Proofing

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Abstract

*G7 is a method originally developed for calibrating commercial offset press. Instead of controlling solid ink density (SID) and tone value increase (TVI), the G7 method introduces gray balance control as the key to achieve consistent color reproduction. The gray patches are quantified by CIE L*a*b* values. Inks used in conventional offset printing and Indigo printing are different in ink/toner pigments and ink setting/drying mechanism. Based on gray balance, the G7 method is believed to be valid for calibrating digital printing and other conventional printing processes. This study focused on the quality of color reproduction with the G7 method, and compared to the quality of direct ICC profile method. The results showed that the G7 method could be applied to toner-based printing process. The G7 method could improve gray balance and color gamut.*

Introduction

GRACoL (General Requirement for Applications in Commercial Offset Lithography) has been widely accepted as printing guidelines in the graphic communication industry. This method was developed using the lithographic printing process and on common offset printing substrates. It describes how to approach a consistent color reproduction by printing on standard substrates with standard ink sets. In the previous versions of the guidelines, printing quality was controlled by color density and TVI. The current version of GRACoL results in a closer visual match between the proof and the output on press. Gray balance of 50% gray is determined by combining 50% cyan, 39% or 40% magenta and yellow.

SID (solid ink density) and TVI (tone value increase), used for controlling gray balance, vary from substrate to substrate, because SID and TVI are device dependent parameters. This control requires different SID and TVI aim values for different substrates. In GRACoL7 [1], NPDC (Neutral Print Density Curve), highlight, mid-tone and shadow control points are introduced to simplify the press control and reduce the number of measurement. The gray balance at midtone is determined by reaching a*=0 and b*=-1 on a standard substrate with L*=95, a*=0 and b*=-2 in an CIE L*a*b* color space. NPDC curve is used to replace TVI control. G7™ [2] is based on GRACoL 7 specifications. The "G" refers to calibrating gray values. The "7" refers to the seven primary colors values, which are defined in the ISO 12647-2 [3] printing standard: Cyan, Magenta, Yellow, Black, Red, Green and Blue. The G7 method can be used to calibrate a press and proofer, which eliminates much of the work normally done by ICC color management.

The gray defined in the G7 method combines cyan, magenta and yellow at certain ratio on the substrates and inks defined in ISO 12647-2 [3]. The Indigo press use different ink/toner sets. There is no ISO standard for toner color reproduction. Pigments and drying mechanism for indigo press are different than offset printing. By focusing on gray balance control, G7 is possible to calibrate any printing process including toner-based color reproduction.

This study focused on the validation and efficiency of G7 method in calibrating an Indigo press. By following the guidelines of G7, the quality of gray and color reproduction was evaluated.

Experiments

Test Target

A test target was built following G7 guidelines (Figure 1). This target included a P2P target, an IT8 target, solid patches, highlight, midtone, shadow patches, and color scales.

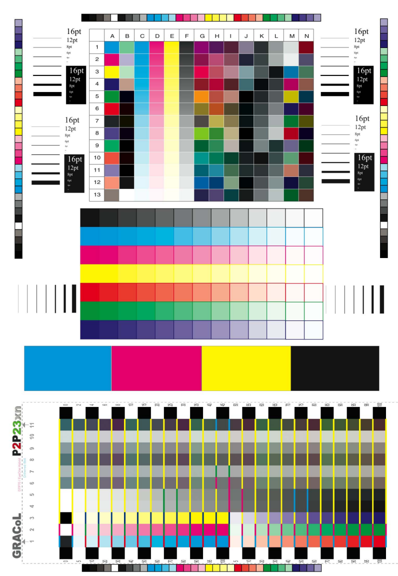

***Figure 1**. Test target for Indigo press*

Materials and Procedures

Mohawk uncoated 100lb book stock was used for the entire study. The colorimetric values of this stock are L* 96.25, a* 0.91, b* -2.70. HP ElectroInk cyan, magenta, yellow, and black inks were used. The colorimetric values of process colors were listed in table 1. HP Indigo 3050 was used to print all samples.

Table 1. Colorimetric values of HP ElectroInk

ElectroInk Color	L*	a*	b*
Cyan	63.06	-35.13	-42.41
Magenta	57.08	68.36	-5.94
Yellow	92.23	-4.85	81.15
Black	32.98	0.18	1.35

The test target was first printed with no RIP adjustment. The original printed P2P target and the IT8 target were measured by GretagMacbeth SpectroScan. The spectral data of P2P target was input to IDEALink™ software to analyze gray balance. The dot gain, gray balance, and optical density were evaluated. The software output adjustment curve for adjusting the RIP. The spectral data of IT8 target was used to build profile for further testing.

The test target was printed with profile embedded before the RIP was adjusted. Then the RIP curve was adjusted based on the suggested curved generated by IDEALink™ software. The test target was printed again with no profile. The P2P and the IT8 targets were measured again by SpectroScan, and used to compare with the original print, which had no RIP adjustment and no profile embedded.

Profile was created by ProfileMaker 5.0. All measured data was input to ColorThink Pro for color space comparison.

Results and Discussion

HP ElectroInks are different from commercial offset printing inks. The first print was made on an Indigo 3050 with no RIP adjustment. There are limited adjustments in adjusting solid ink densities on the Indigo press. The solid ink density of cyan, magenta, yellow, and black on the test target were kept the same after the Indigo press was started. The colorimetric values of process colors are different from the inks defined in ISO 12647-2 [3]. The color differences were listed in table 2. Color difference ΔE is calculated by the following equation.

$$\Delta E=((L_1^*-L_2^*)^2+(a_1^*-a_2^*)^2+(b_1^*-b_2^*)^2)^{1/2} \quad (1)$$

where, L_1^*, a_1^* and b_1^* are the colorimetric values of one color. L_2^*, a_2^* and b_2^* are the colorimetric values of another color.

Table2. Color difference of process colors between HP ElectroInk and commercial offset ink

ElectroInk Offset Ink	L*	a*	b*	ΔE
Cyan	63.06	-35.13	-42.41	11.24
	54	-36	-49	
Magenta	57.08	68.36	-5.94	11.70
	46	72	-5	
Yellow	92.23	-4.85	81.15	9.88
	88	-6	90	
Black	32.98	0.18	1.35	17.03
	16	0	0	

As shown in table 2, the color difference ΔE values are higher than what are specified in the G7 method. The G7 method requires that the printed solid ink density of process color is controlled to be less than 5 when compare to ISO 12647-2 standards. This brought up the question, whether the difference in process color affects the efficiency of the G7 method.

The printed P2P target was measured by SpectoScan and input to IDEALink™ software for building RIP adjusting curve. The results were shown in the following two figures.

Figure2*. Ideal (in green) and measured (in red) NPDC curves of cyan, magenta, yellow (left), and black (right)*

Figure 3. *Adjusting curves generated by IDEALink™*

The measured data showed that the neutral densities of cyan, magenta, yellow, and black at different steps, which were printed by the Indigo ElectroInks, were lower than the ideal numbers, which were determined for commercial offset printing. Then the IDEALink™ software generated a set of RIP adjusting curves to increase neutral densities of the four process colors.

The IT8 target was measured by SpectroScan and input to the ProfileMaker5.0 for making profile. The profile was embedded to the test target for the second time print. Then the RIP adjusting curve was applied, and the test target with no profile was printed again. On the P2P target, the black only grayscale and cyan, magenta, yellow combined grayscale were measured. The colorimetric values of gray balance scale were recorded to compare with the reference values suggested by the G7 method. The suggested values are shown in figure 4.

The first printed grayscale (with no RIP adjustment, no profile), the curved gray scale (with RIP adjustment, no profile), and the profile gray scale (no RIP adjustment, with profile) were compared to the G7 specifications. The results were shown in figure 5. In figure 5, the x-axis represents the steps of grayscale, which are listed in figure 4; the y-axis represents the delta E values of comparing printed grayscale to the G7 suggested values.

C%	M%	Y%	ND	L*	a*	b*	X	Y	Z
0	0	0	0.06	95	0	-2	84.48	87.62	74.59
1.96	1.18	1.18	0.08	93.4	0	-1.96	80.88	83.88	71.4
3.92	2.75	2.75	0.1	91.81	0	-1.91	77.41	80.28	68.31
5.88	4.31	4.31	0.11	90.55	0	-1.87	74.72	77.5	65.93
7.84	5.49	5.49	0.13	88.99	0	-1.82	71.49	74.14	63.06
10.2	7.45	7.45	0.15	87.13	0	-1.78	67.76	70.27	59.75
14.9	10.98	10.98	0.2	83.16	0	-1.67	60.23	62.46	53.07
20	14.9	14.9	0.26	79.27	0	-1.56	53.42	55.4	47.03
25.1	18.82	18.82	0.31	75.74	0	-1.46	47.7	49.47	41.96
30.2	23.14	23.14	0.36	71.97	0	-1.36	42.05	43.61	36.97
34.9	27.06	27.06	0.42	68.24	0	-1.26	36.93	38.3	32.43
40	31.37	31.37	0.48	64.56	0	-1.15	32.3	33.5	28.33
45.1	35.69	35.69	0.53	61.18	0	-1.05	28.4	29.45	24.89
49.8	40	40	0.59	57.53	0	-0.96	24.56	25.47	21.5
54.9	45.1	45.1	0.66	53.89	0	-0.86	21.09	21.87	18.44
60	50.2	50.2	0.73	50.23	0	-0.76	17.95	18.61	15.67
65.1	55.29	55.29	0.8	46.85	0	-0.65	15.34	15.91	13.37
69.8	60.39	60.39	0.88	43.17	0	-0.56	12.8	13.27	11.13
74.9	65.88	65.88	0.96	39.47	0	-0.46	10.54	10.93	9.15
80	71.76	71.76	1.05	35.79	0	-0.36	8.58	8.9	7.43
85.1	78.04	78.04	1.14	32.43	0	-0.25	7.02	7.28	6.06
89.8	84.31	84.31	1.24	28.93	0	-0.16	5.6	5.81	4.82
94.9	92.16	92.16	1.33	25.7	0	-0.07	4.48	4.65	3.84
98.04	96.86	96.86	1.38	24.16	0	-0.03	4	4.15	3.43
100	100	100	1.42	23.01	0	0	3.67	3.8	3.14

Figure 4. *Grayscale of cyan, magenta and yellow combinations, the suggested colorimetric values of each step by the G7 method [4]*

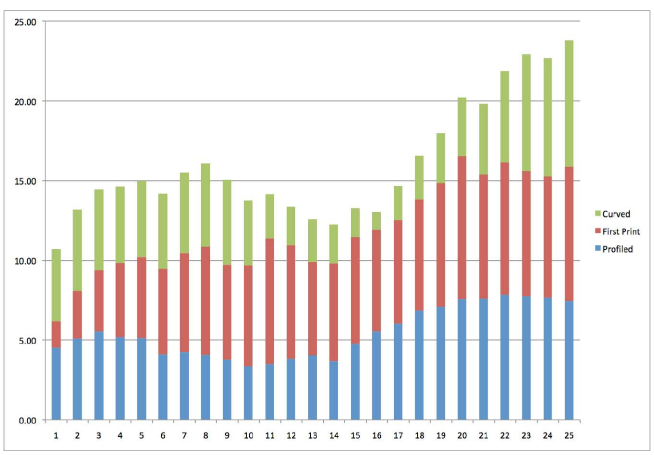

Figure 5. *Delta Es of cyan, magenta, and yellow combined grayscale and the G7 suggested values. The green data is from the print with RIP adjustment; blue data is from the print with profile embedded; the red data is from the print with no RIP adjustment and no profile embedded*

In figure 5, it showed that when the test target was printed with no RIP adjustment and profile, the deltas Es are less than 5 when the gray patches are 10% or less. The highest delta E is 8.97 at 75% gray. The average delta E of the first printed grayscale is 6.35. After the RIP was adjusted, the steps of delta E less than 5 on the grayscale are in 30% - 85% range. The highest delta E is 7.92 at 100% black. The average delta E of the RIP adjusted grayscale is 4.26. After the profile was applied, the steps of delta E less than 5 on the grayscale are in 10% - 55% range. The highest delta E is 7.85 at 90% gray. The average delta E of profile adjusted grayscale is 5.45. The results showed that the gray balance was improved by either RIP curve adjustment or embedding profile. The grayscale printed with RIP adjustment curved showed better result in neutral color reproduction.

The IT8 targets were measured and the ColorThink Pro was used to evaluate color gamut of all three prints. The results were shown in the following figures. It showed that after applied either RIP adjustment curve or profile, the printed images showed improvement in color gamut. Profile improves color gamut slightly better than RIP curve adjustment.

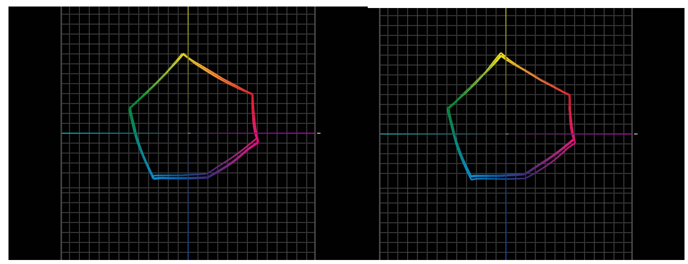

Figure 6. *Color space comparison. The left one is the comparison of the first print (no RIP adjustment, no profile) and the one printed with RIP adjustment. The right one is the comparison of the first print (no RIP adjustment, no profile) and the one printed with profile embedded.*

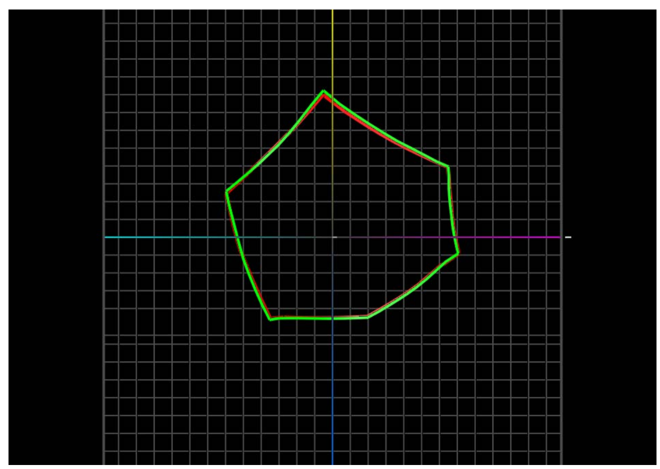

Figure 7. *Color gamut comparison. The green line represents color gamut of test target printed with profile embedded. The red line represents color gamut of test target printed with RIP curve adjustment*

Conclusions

The G7 method uses colorimetric concepts for press calibration and control. Instead of controlling solid ink density (SID) and tone value increase (TVI), this method controls the press by colorimetric values of gray to achieve a better visual match. Theoretically, it can be applied to any color reproduction regardless of printing methods. With the results from the Indigo press calibration, the G7 method demonstrated its ability in calibrating a printing press other than offset printing. The improvement in gray balance proved that colorimetric control could achieve a better visual match.

The test target printed with RIP curve adjustment showed better result in gray balance control, but the color gamut of the target printed by this method was smaller than the one printed with profile embedded.

The G7 method was developed from offset printing using standard inks and paper defined in ISO 12647-2 (1997). Compared to commercial offset printing, the difference in ink colorants resulted in different densities at different tone values and different densities of solid process colors when printed with HP ElectroInks. Using the curved created by offset data, the calibration may not be as precise as for offset printing. At the same time, there is less control on digital press in adjusting solid ink density during printing, which means control the press by colorimetric value alone may not be sufficient. It affects the accuracy of using gray balance control in controlling press calibration and proofing.

This study was done on the substrate different to the one defined in the G7 method. The results showed that the concept of gray balance control is valid for different ink and substrates combination. In order to study the efficiency of the G7 method, more tests need to be done to printing processes with different ink colorants other than those for offset inks, and substrates other than the ones defined in the G7 method.

References

[1] IDEAlliance® GRACoL® Specifications 2007 (GRACoL 7), (2007).

[2] IDEAlliance® G7™ Proof-to-Press Process, (2006).

[3] ISO 12647-2:2004(E) Graphic technology – Process control for the production of half-tone colour separations , proof and production prints, Part 2: Offset lithographic processes. (2004).

[4] IDEAlliance® Calibrating, Printing, and Proofing by the G7TM Method, pg. 46. (2006).

Author Biography

Xiaoying Rong received her BE in Graphic Arts Technology from Beijing Institute of Graphic Communication and her PhD in Paper Engineering, Chemical Engineering and Imaging from Western Michigan University. She is an Assistant Professor in Graphic Communication Department of California Polytechnic State University (Cal Poly). Her work focuses on the printability study of digital and conventional printing, color management, and ink formulation.