Flexo Quality Consortium

FINAL REPORT

Magenta Conundrum

Peter Pretzer

January 30, 2022

FTA

Introduction

The flexographic industry has, over the past few decades, enjoyed a period of rapid growth. This growth has been accompanied by profound changes in printing technology, both in flexo and other segments of the printing industry. In order to help the industry cope with these technological changes, the Flexo Quality Consortium (FQC) was formed in 1990 to investigate the flexo printing process and gain a better understanding of the factors controlling the quality of the printed image. The FQC's mission statement:

The Flexo Quality Consortium (FQC), acting as a select standing committee of the Foundation of Flexographic Technical Association, Inc. (FFTA), will provide the industry with a better understanding of the factors controlling the quality of a flexographic image. FQC projects investigate selected printing variables in flexographic printing technology.

Currently the Consortium is directed by an Executive Committee that develops and evaluates proposed research projects. Open participation is encouraged by qualified technical representatives from companies in the printing industry on a non-discriminatory basis. A simple philosophy guides all FQC projects in the experimental design and execution:

- The Consortium will use only commercially available materials – no proprietary products or products under development. The goal of the Consortium is to provide process research for the members of the flexographic community, not to do R&D work for the members of the Consortium.
- The Consortium will use industry standard practices throughout – no special procedures to make any component (plate, anilox, ink, etc.) perform better. This avoids biasing the results and further ensures that each company will be able to duplicate and/or apply the results of the experiment to his own equipment.
- The Consortium will use a statistically designed experiment to assure a total systems approach. This type of experimentation yields the highest quality data with the smallest outlay of time and materials.

Projects follow a well-defined sequence of steps; they are ***designed experiments***. Broadly speaking, the experiments are performed under controlled conditions, holding all input variables constant and changing selected input variables according to a statistically designed plan. A process model was developed. (See Figure 1.) Specified output parameters are measured and analyzed, again using statistical techniques.

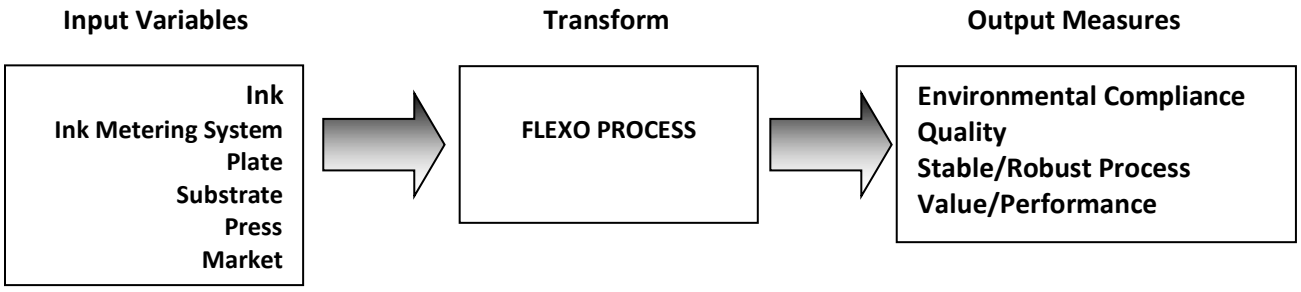

Figure 1 – Process Model

In recent years, another type of experiment has been carried out called a process capability study. These studies still adhere to the process model shown in Figure 1. These types of projects represent an expansion of the original concept of the types of projects undertaken by the FQC and seek to answer specific questions regarding some aspect of flexo printing. These projects are categorized as a capability study.

Each project begins with a proposed charter that follows the approved project charter template and includes:

- Project Title
- Team Members
- Objective
- Scope
- Business Impact
- Duration of Project
- Resource Requirements
- Project Milestones

The Executive Committee reviews the proposed charter and advises the project team on content and technical relevance. Once approved the project team begins to execute the project and brings it to completion. The results are presented to the Executive Committee for final review. Once the Executive Committee supports the results based on the documented data a final report is prepared for the industry. The following report has met the criteria of an FQC project and is considered valid research that examined various factors affecting flexography and can be used by member companies and standards bodies to further the understanding and technology that is flexography.

The Team

- Project Leader: Peter Pretzer, Fujifilm
- FQC Liaison: Steve Smiley, SmileyColor
- FTA Liaison: Bjorn Knutson, FTA
- Team
    - Danny Rich, Sun Chemical
    - Jean Jackson
    - Jason Drake, RRD
    - Kariahlyn Lindsey, Accredo Packaging
    - Johnny Dye, Accredo Packaging
    - Sam Ingram, Clemson University
    - Rob Frimming, SGK
    - Catherine Haynes, APR

Heartfelt thanks to everyone who contributed to the Magenta Conundrum project. Without their diligence, expertise, and insight, this project would not have been possible.

Special thanks also Danny Rich, Steve Smiley, Bjorn Knutson, Kariahlyn Lindsey and the folks at Accredo Packaging, and the FQC Executive Committee members.

Table of Contents

Approaching the Task

The Magenta Conundrum

Brand owners increasingly want their print providers to print to the CRPC6 aims — a characterized reference print condition for a coated neutral material[1] — as a global color target.

CRPC6 has a magenta hue angle of 357 degrees, which correlates to the ISO 12647-6 flexographic printing standard[1]. However, depending on the printing segment — wide or narrow web — magenta can vary from printer to printer. Many flexographic print providers run a magenta with hue angles of 6 to 12 degrees, which is noticeably warmer.

Figure 1 shows the difference between the two hue angles, with 357 degrees measurably bluer, and 12 degrees with a greater component of yellow — more toward a bright red hue.

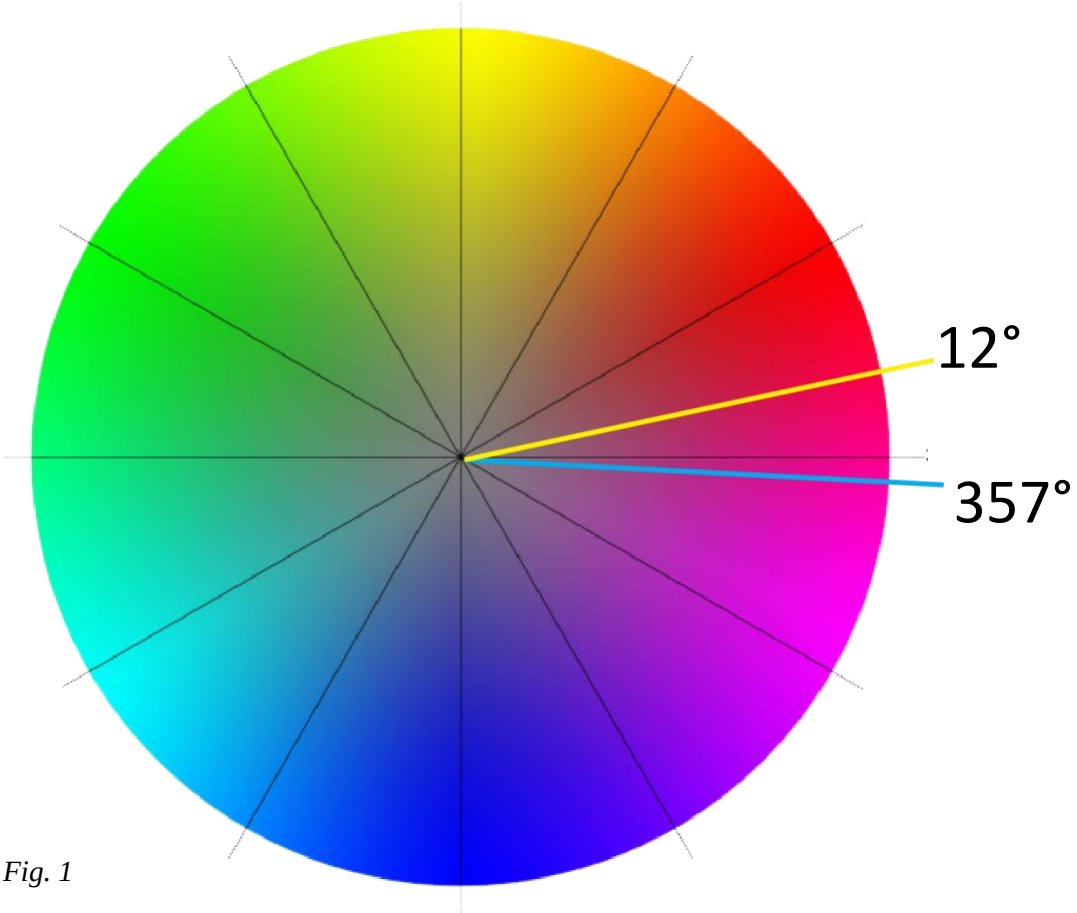

Fig. 1

Pigments: The recommended pigment is PR57:1 (357° hue angle), which is a bluer hue. Many ink makers are using PR52 (12° hue angle), which is yellower. The PR52 magenta also tends to "hook" toward yellow at higher strengths and thicknesses, primarily due to formulation compatibility and print production practices.

Chroma hook:

Chroma means color purity or intensity. Figure 2 shows how when chroma increases, hues can "hook" toward a different angle. In the example below showing the a* and b* axes from the L*a*b* color space, we see the magenta ink hooking to a yellower hue angle as chroma increases.

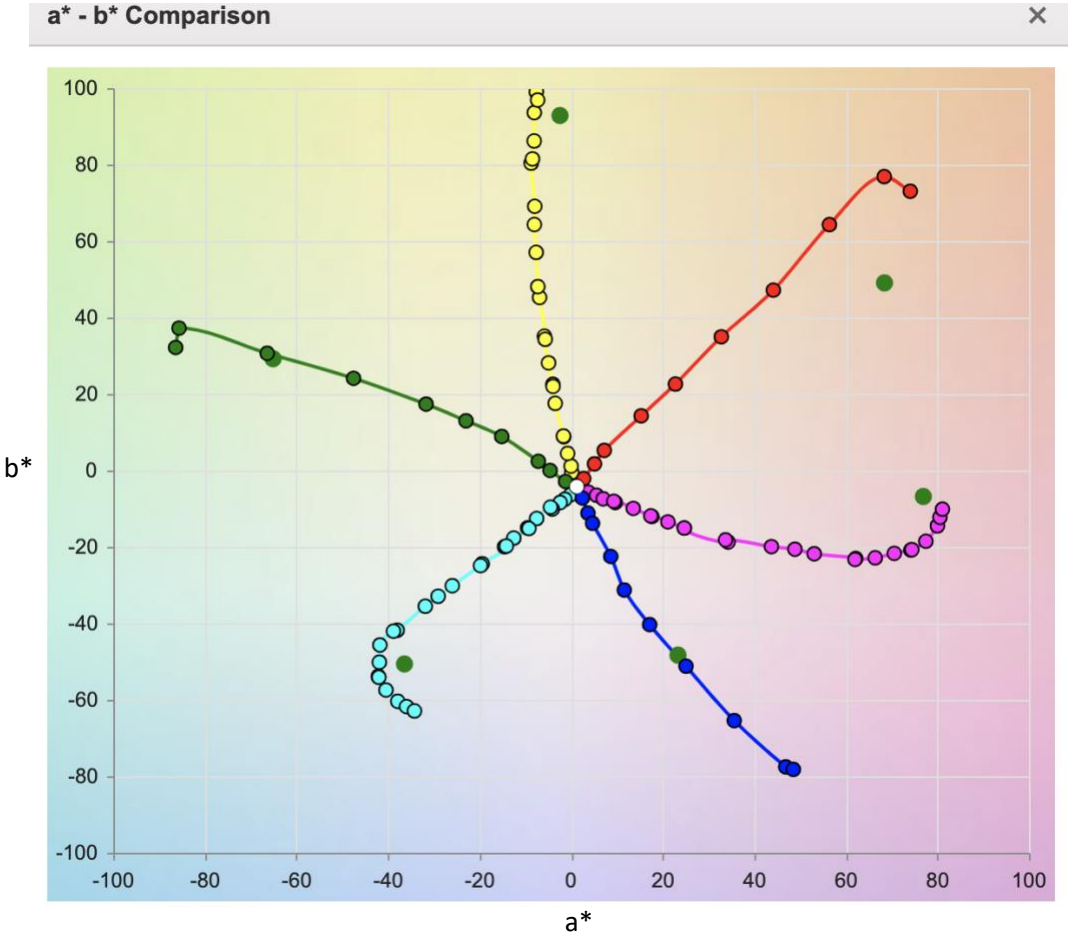

Fig. 2

Why is all this a conundrum? Ink suppliers no longer manufacture magenta ink with the warmer PR52 pigment. With the brighter red pigments no longer being used, questions include the following:

1. How will the bluer-hued magenta inks affect printers who were previously running the redder-hued inks, and
2. What can they do about the differences?

Phase 1 — The Experiment

This project's objective is to print, measure, and document how the overall printed color gamut and print quality change based on magenta pigment selection. The recommended pigment is pigment red 57:1, which has a bluer hue. Pigment red 52 is the yellower hue, and this ink also causes chroma to hook toward yellow at higher ink thicknesses. Part of our objective was to observe and compare the characteristics of the two inks specifically regarding hue angle and hooking, both measurably and visibly.

Methodology

Determine Usage: We looked at industry polls for which segments (wide and narrow) were using which inks. We found, as we suspected, that usage was evenly split conversely between the wide and narrow segments:

- Narrow Web 80% PR57:1 Hue angle 357°
- Wide Web 80% PR52 Hue angle 7.5°

Predict differences: We then built synthetic datasets that would compare colors spaces of the two different magentas with the CRPC6 data set.

Practical confirmation: For practical confirmation, we would perform banded anilox runs for both segments for both water and solvent-based inks.

Once we confirmed the banded runs, we'd then perform runs for using both magenta inks for 4-color and 7-color (if possible), and measure and record the actual data sets for further comparison.

- In early meetings we learned of several manufacturers of pigments had stopped producing PR52, leaving only one supplier. This supplier stated that they were "moving all magenta process inks to Pigment Red 57:1 based on the global availability of pigment, with no change in properties."
- As we tried to compare water and solvent inks, we learned there were no more ink suppliers for water-based PR52 pigmented inks.

Material Selection

Inks: Inks supplied by Flint Group and Accredo. L*a*b* values of draw-downs for each shown below:

	L*	a*	b*	h°
CRPC6	48	75	-4	357°
R52 (Accredo)	44	76	10	7°
R57 (Accredo)	44	75	1	1

Substrates: Paper and film to be determined by team.

Comparison of the Two Inks: Spectral Reflectance Curves of Inks at Normal Strength

It's also possible to reduce the amount of pigment. Note hue angles and spectral differences indicating the PR52 ink being redder and yellower:

- PR52: 7°
- PR57: 357°

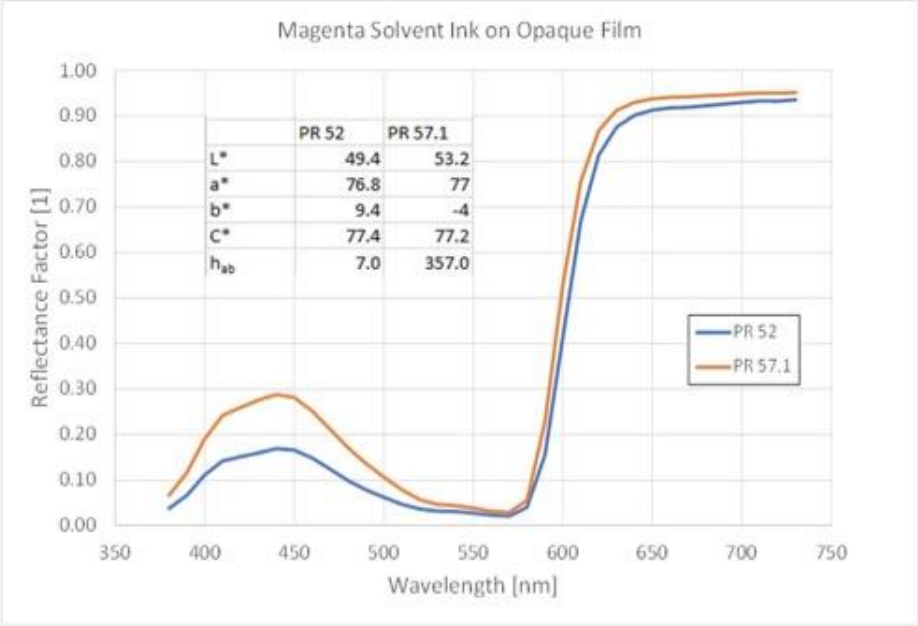

Fig. 3

Fig. 4: Spectral Reflectance Curves of Inks with PR52 Ink Pigment Amount Reduced Until Hue Angle Is 357°

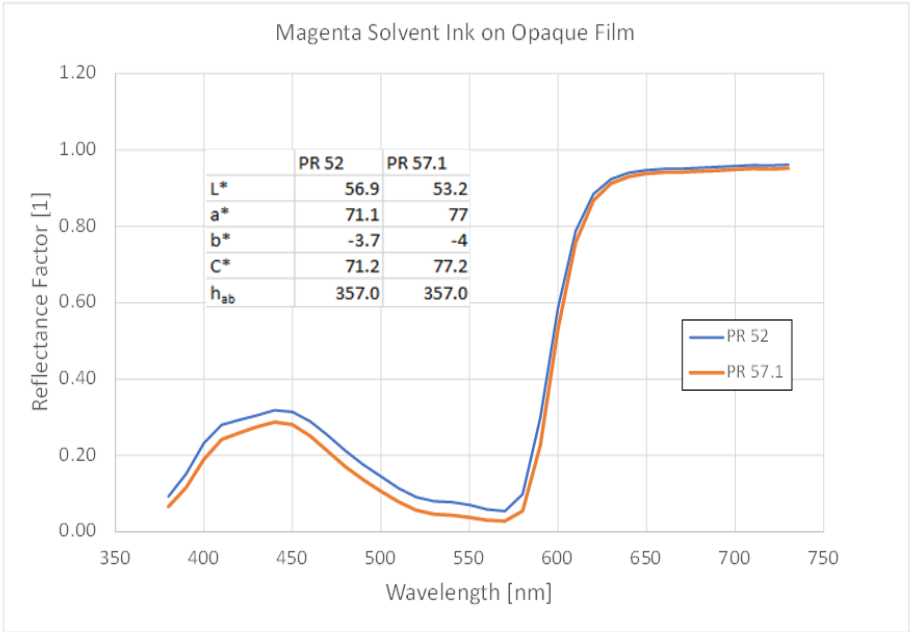

Fig. 4

Note that the two inks now more closely bracket the colorimetric values of CRPC6 magenta. We learned that it's possible to change the hue angle by reducing the amount of pigment in PR52 inks.

Fig. 5: Banded Anilox Form

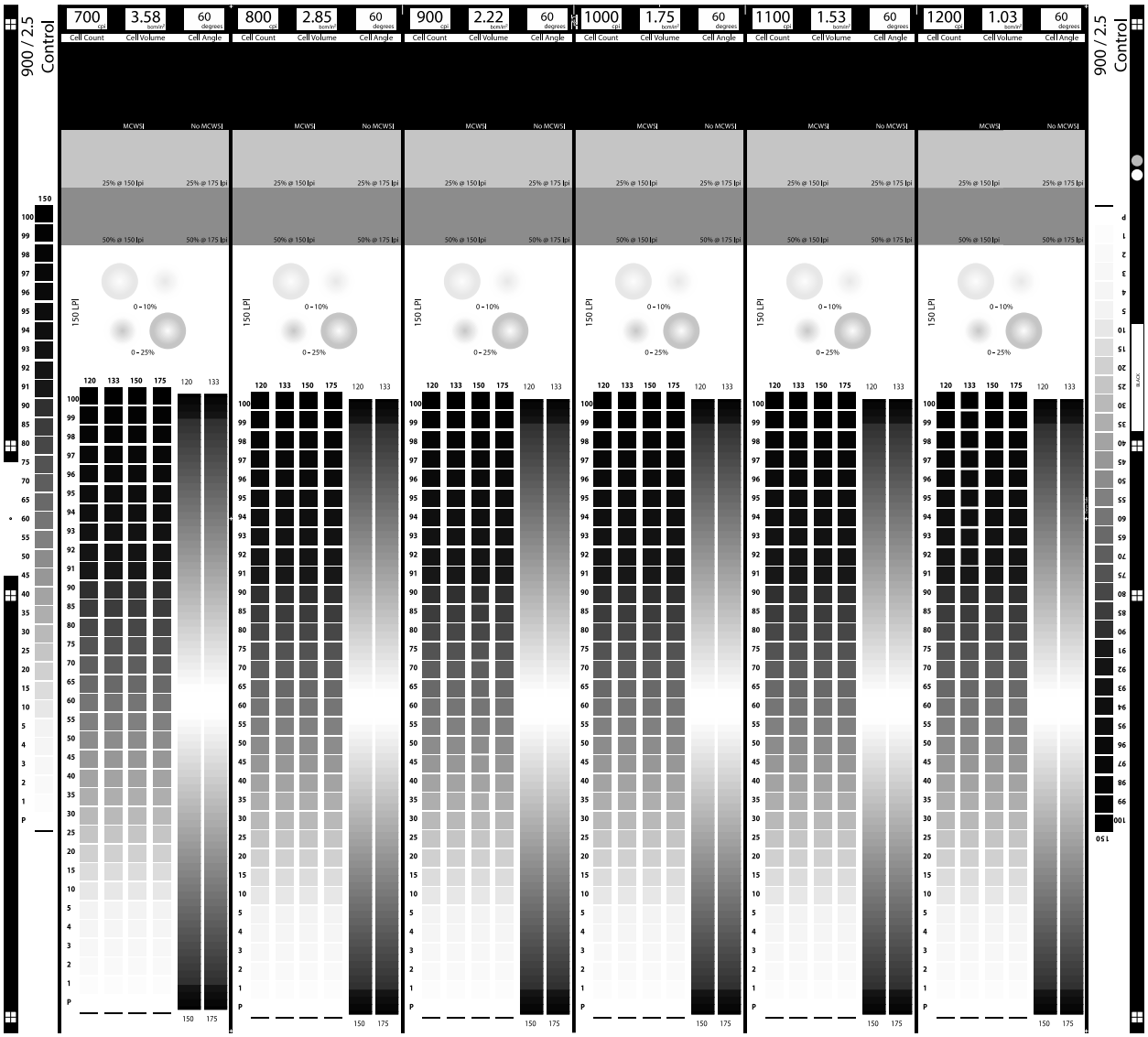

Fig. 5

Layout For Banded Anilox Press Run

Results of Banded Anilox Runs at Accredo

The data below show the results of the banded anilox measurements for each ink.

Comparing PR52 to PR57 Flint Inks

PR52	Accredo Cyan	2.5 bcm/sq. in. Magenta	150lpi Yellow	Black	Lightness	Chroma	Hue
0%	0.1097	0.1083	0.1295	0.1088	90.6971	-1.0716	2.6156
10%	0.1482	0.2243	0.2274	0.1954	83.1841	7.9424	2.6584
20%	0.1849	0.3456	0.3257	0.2803	76.2195	16.8101	2.7067
30%	0.1992	0.4403	0.3928	0.3367	71.6515	24.6619	2.4523
40%	0.2261	0.5542	0.4819	0.4042	66.5051	32.1859	3.2299
50%	0.2481	0.6885	0.5674	0.4731	61.4162	40.756	3.0063
60%	0.2545	0.8405	0.6369	0.531	57.0891	50.5724	1.9591
70%	0.266	0.9825	0.7107	0.5781	53.6828	57.6133	2.6326
80%	0.2779	1.1488	0.7902	0.6228	50.5284	64.011	3.834
90%	0.2874	1.3176	0.8556	0.6574	48.1235	69.024	4.8264
95%	0.3009	1.4728	0.919	0.6861	46.2414	72.1073	6.3917
100%	0.3188	**1.45**	0.9356	0.6991	45.8672	71.236	6.3977

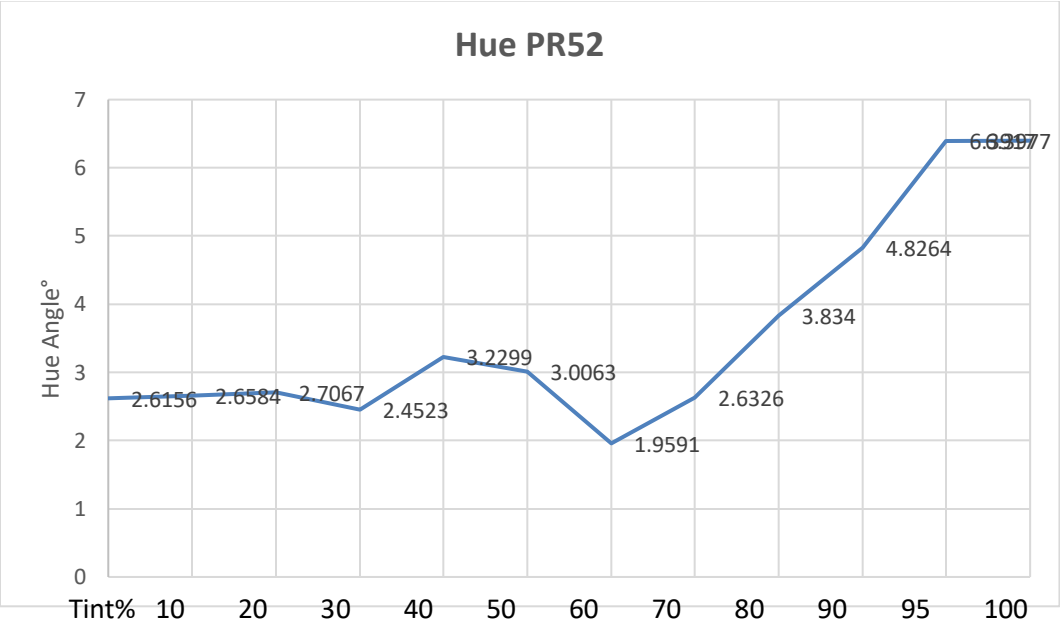

Fig. 6

Note increased “hooking” with PR52 in 2.6 to 6.4 range compared with PR57 below.

PR57	Accredo	2.5 bcm/sq. in.	150lpi				
	Cyan	Magenta	Yellow	Black	Lightness	Chroma	Hue
0%	0.1097	0.1083	0.1295	0.1088	90.6971	-1.0716	2.6156
10%	0.1476	0.2125	0.2177	0.1877	83.8503	6.943	2.566
20%	0.1816	0.3108	0.2969	0.2585	78.0033	14.1759	2.3107
30%	0.2083	0.4248	0.379	0.332	72.1275	23.0039	1.6934
40%	0.2364	0.5302	0.4617	0.3965	67.205	30.0971	2.2445
50%	0.2642	0.6845	0.5604	0.478	61.1865	40.1961	1.8349
60%	0.2759	0.8545	0.6349	0.5464	56.1924	50.9702	0.0955
70%	0.2927	0.9799	0.7012	0.5931	52.9676	56.6973	0.46
80%	0.305	1.1621	0.7776	0.6421	49.5289	64.1291	0.9117
90%	0.305	1.1621	0.7776	0.6421	49.5289	64.1291	0.9117
95%	0.3128	1.3565	0.8406	0.6785	46.9654	70.1543	1.443
100%	0.357	**1.56**	0.9534	0.7353	43.7151	71.9747	4.4683

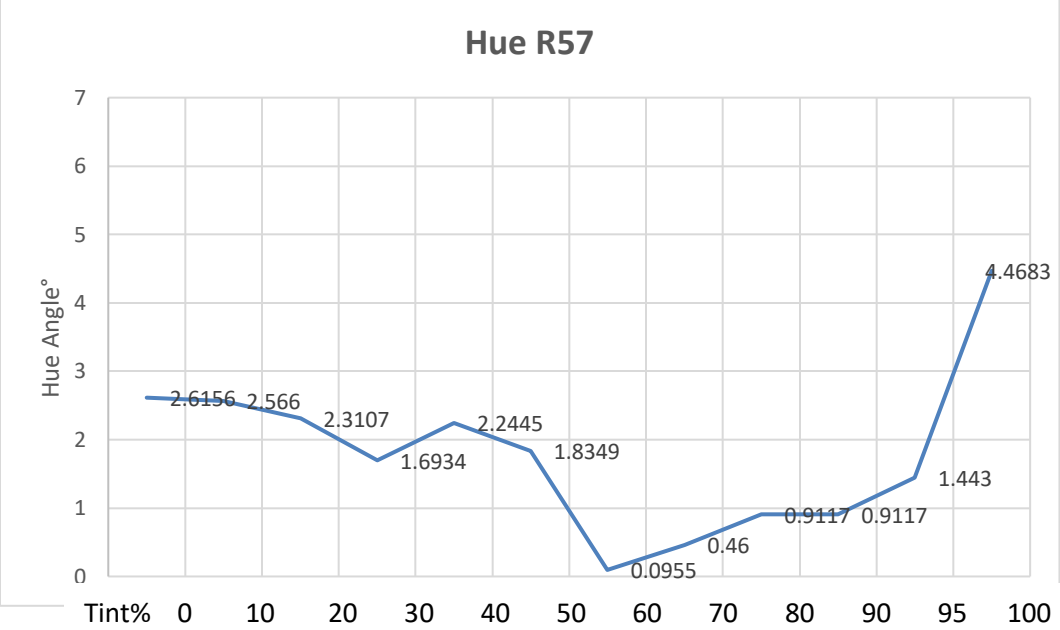

Fig. 7

Note less “hooking” with PR57 in 2.6 to 4.5 range compared with PR52 above.

Comparing Color Gamuts With Use of Each Magenta At Normal Ink Strength

Using the PR52 data, we calculated an ICC profile and compared its color gamut to that of CRPC6 (the equivalent of using PR57 magenta). The results are shown below in Fig. 8.

CRPC6 is the outline; the dots show a comparison of the color gamuts resulting from use of PR57 and PR52.

We note in the a* b* diagram in Fig. 8 that use of PR52 increases the color gamut in the red and orange areas, but reduces color gamut overall and in the magenta, purple, and blue areas.

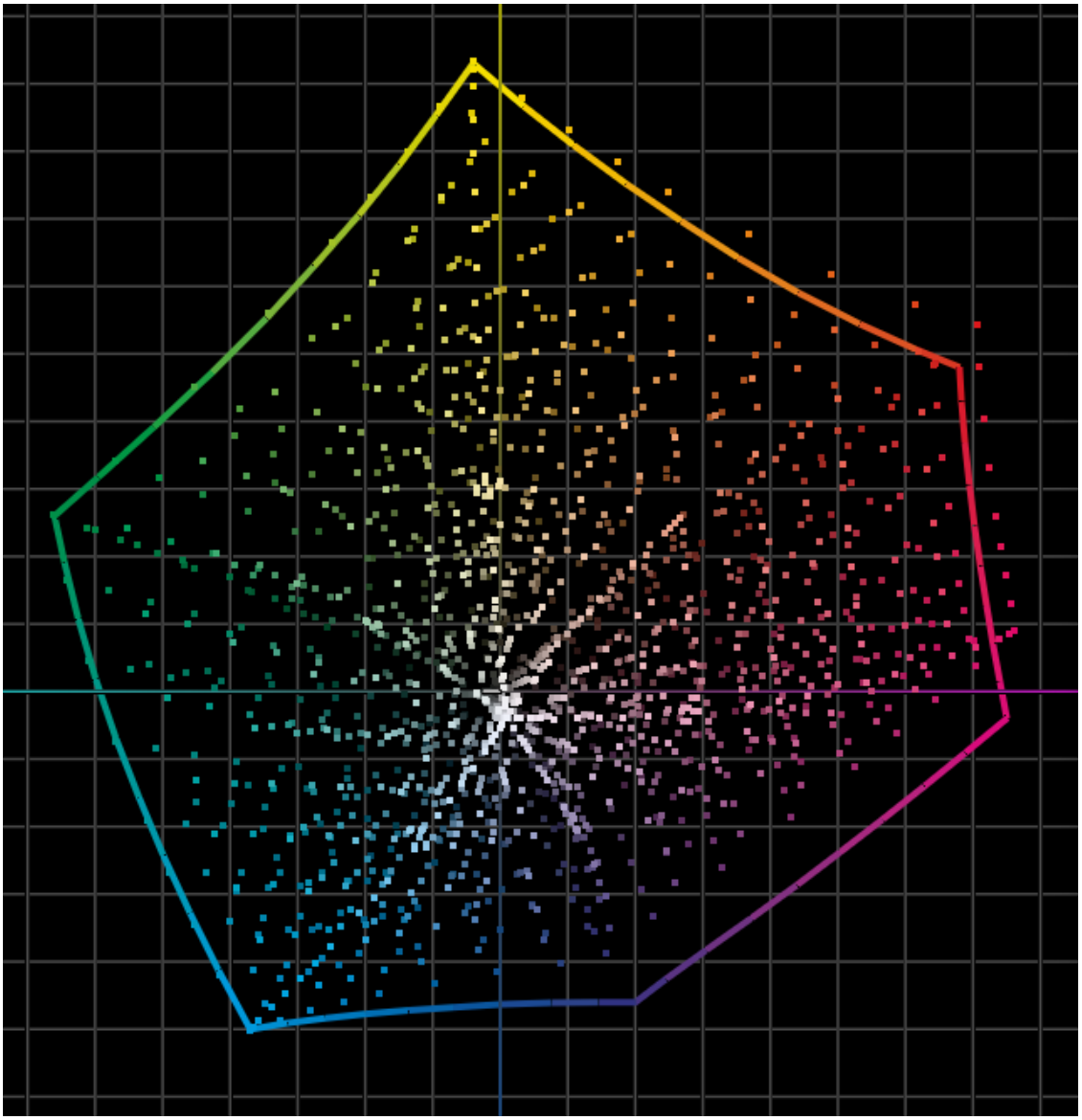

Fig. 8

Calculation of gamut volume show that using PR57 over PR52 results in color gamut greater by nearly four percent. Fig. 9 shows a skeletal plot of the data — an alternate view also described in Fig. 8.

Absolute Colorimetric	L*a*b* Volume	%
CGATS21 CRPC with magenta simulating PR52	338239	100%
CGATS21_CRPC6	351469	103.9%
sRGB	826794	244.4%
AdobeRGB	1179791	348.8%

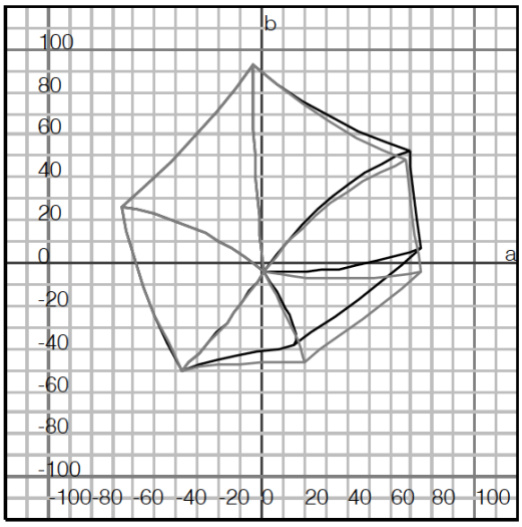

Fig. 9

Phase 2 — The Results

We then performed actual test runs using IT8 charts in order to create characterization data sets and compare the resulting color gamuts to each other and to CRPC6. Results of CMYK aims for each of the two inks are shown below in Fig. 10.

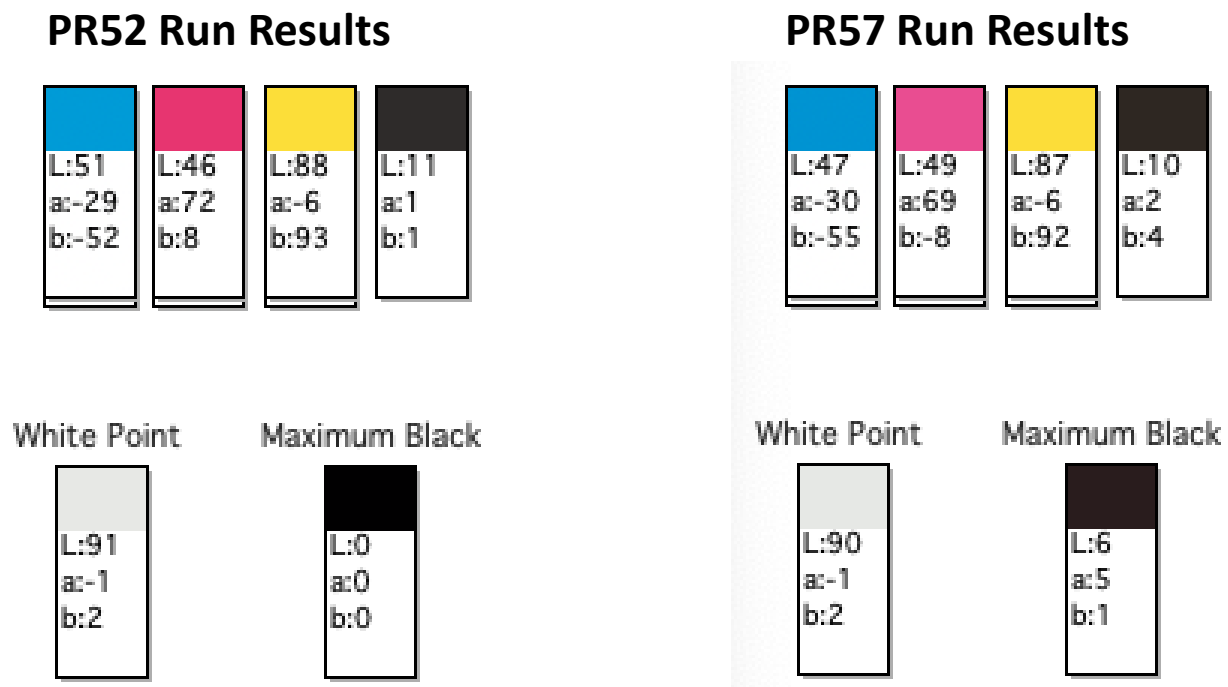

Fig. 10

Gamut Evaluation

As expected, results of the actual press runs were similar to what had been modeled and predicted with the synthetic data and models.

In Fig. 11, we plotted comparisons of the resulting color gamuts. With PR57, yellow-green, green, violet, and violet-to-magenta areas of the color gamut are all larger than with PR52. Red gamut is larger with PR52 over PR57.

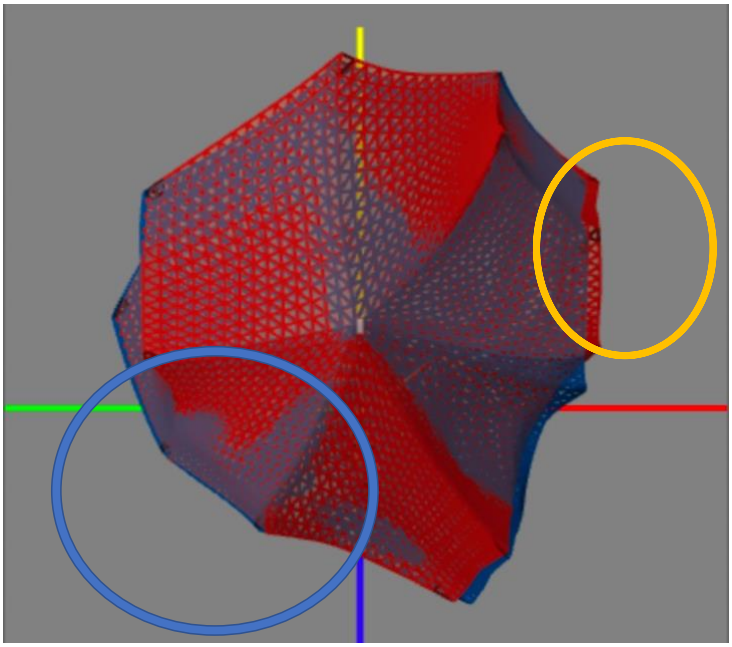

Fig. 11

Fig. 12 shows that PR57 increased the color gamut volume over PR52 by 7%. This falls in line with our earlier prediction based on synthesized data.

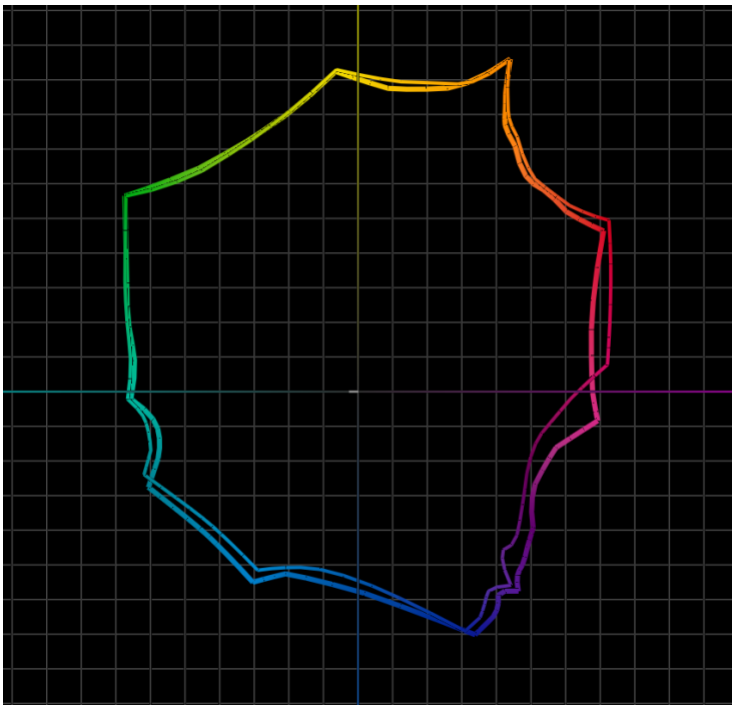

Fig. 12.

Discussion — Visual Results and Expectations

Using magenta with a 357° hue angle resulted in the following:

- Improved print contrast — using magenta with 357° hue delivers a more neutral overprint with improved contrast when combined with yellow and cyan.
- "Better" blues. Blues were purer due to magenta not being as red. Combinations of red and blue produce a greater gray component, resulting in less contrast.
- Reds and oranges tend not to vary as much during print runs when moving away from PR52.
- Most of the issues seen with 7-color proofs have been the variation of +/- .07 density can cause PR52 to hook up to 12°. Proofs cannot simulate such a shift in color with slight density changes.

357° magenta was standardized in the offset industry in 2006 – 2009, with print contrast improved and variation reduced. We show that similar results can be expected using the flexographic technology and processes.

Summary and Conclusions

Over the last several years, ink suppliers have phased out use of Pigment Red 52 for formulating and manufacturing magenta inks in the flexographic market. Inks are now manufactured using Pigment Red 57. Magenta ink made with PR52 typically had a 12° hue angle; magenta made with PR57 typically has a 357° hue angle.

This has created a dilemma and a conundrum for the flexographic printing industry: what effects will the hue angle shift have in printing, particularly in process color materials?

We learned that the most noticeable color shifts — as expected — occurred in saturated reds and oranges. PR52 provides for slightly more saturated, “brighter” colors in the outer areas of red and orange in the color gamut.

We learned that color gamut is larger overall when using PR57 magenta, demonstrably between 104% to 107%, with increased gamut in outer areas of greenish yellow, green, blue, violet, and magenta.

We learned that purer blues are typical with PR57.

We learned that print contrast is improved with PR57 magenta.

We learned that reds and oranges may remain more stable during press runs.

We learned that reducing pigment levels in ink formulation can produce magentas of similar hues.

Offset printers went through a similar upheaval when inks were standardized 15 years ago. Flexo printers are now at a crossroads in which they can run magentas to previous hue angles with amended formulations, or run to the 357° hue angle to more closely match commercial offset and published CRPC specifications.

Appendix/Footnotes

[1] **CGATS 21-2-CRPC6** Reference Data: http://www.npes.org/Portals/0/standards/docs/CGATS21-2-CRPC6.txt

[2] **ISO 12647-6** Process control for the production of half-tone color separations, proofs and production prints — Part 6: Flexographic printing.