PantoneLIVE Library Validation Study

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Introduction

Purpose of the Study

This paper outlines the procedures and results of a study sponsored by X-Rite/Pantone and conducted jointly with Sun Chemical and Clemson University.

The primary focus of this study is to demonstrate that PantoneLIVE-defined dependent standard color targets can be achieved within acceptable tolerances during a well-controlled ink formulation and printing processes.

In the latest update of PantoneLIVE, 18 new libraries of dependent standard colors were introduced. There are now a total of 22 dependent standard libraries available to PantoneLIVE users. All libraries contain the full range of Pantone Plus colors, including the +336 additions added to the Pantone publication in April 2012. Twenty primary packaging applications contain solid, substrate and full tint ramps (tonal data). The remaining four secondary packaging applications contain only solid, substrate and a simulated 50% tint, reflecting appropriate industry practices in the use of these printing conditions and substrates.

Complete tonal data is an important feature of these libraries, as this data can be used to reproduce the tint values of a spot color in soft proofing and digital contract proofs. Additionally, tonal data enables the evaluation and management of the tint reproduction during the print process. Overall, this means PantoneLIVE tonal data facilitates setting and assessing color reproduction expectations from design intent through final production.

Scope of the Study

It is not practical to externally validate every color standard from every library. Considering the 1,663 Pantone+ color values that are currently represented in PantoneLIVE X 22 libraries, the total of 36,586 colors to color match for specific media, print and measure would be both cost and time prohibitive.

Therefore this study tested color standards selected from a smaller palette that are representative of the overall system (see Figure 1 below).

1. Highly chromatic colors
2. Desaturated colors
3. Pastels

Using well-controlled ink formulation, printing, and measurement processes, this test seeks to validate the overall method used to produce dependent libraries on a representative set of colors. This philosophy is similar to the standard print tests used in the industry today, from G7 through to ICC Profiling, where exhaustive validation is neither feasible nor desirable.

Figure 1: Pantone Standards Selected for Testing

PantoneLIVE Standards

Master Standard

PantoneLIVE Master standards are derived from the official measurements published for the Pantone+ matching system. While these colors originated as prints on an offset substrate, the intended use is to specify a design' s intent. PantoneLIVE Master Standards specify the intent of the solid color only and make no reference to a particular print process, substrate, or ink system.

Dependent Standard

PantoneLIVE Dependent Standards are derived from Master Standards. They are distinct from Master Standards because they specify substrate and tints, and they are recognized as reproducible within the context of a particular reproduction scenario: Printing Technology, Substrate, and Ink System.

The purpose of a Dependent Standard is to set a realistic and achievable expectation for design intent and to provide achievable color standards for print production and ink formulation. This is especially valuable where production constraints are insufficient to capture the full gamut of the Pantone Master Standard Library. PantoneLIVE Dependent Standards provide an achievable target for colors, maximizing the likelihood that all members of the supply chain are able to evaluate their work objectively, rather than subjectively.

Solid Standards

The Dependent Standards were developed with no more than 3 pigments in the formulation process. If a particular Master standard was out of gamut for the Dependent Library condition, the hue of the Dependent Standard was optimized to reduce the perceptual difference.

Tint Standards

A PantoneLIVE Dependent Standard includes 11 tone values between 0% and 100%. These values are based upon actual press run data and then correlated directly to a given solid and substrate standard. These data represent how the tint will reproduce given the solid was formulated to produce the closest spectral match and lowest colorimetric difference.

Tints are defined as linear with respect to dot gain. This means that the spectral data for each tint is defined with the dot area independent of the dot gain, and solutions that implement PantoneLIVE must integrate dot gain (TVI) based on the intended specification for spot color reproduction. This method allows the reuse of the data for an unlimited set of printing conditions based off of the expectation of the user.

Substrate Standards

The substrate standards in each PantoneLIVE Library are selected to provide a general representation of what is used in the marketplace. When selecting a substrate, attention should be paid to the white point of the standard in the

PantoneLIVE library because it is the measurement of the substrate in its final printed condition. For example, if a PantoneLIVE library with an overprint varnish or clear lamination is selected, the final measurements from a press run must also include an overprint varnish or lamination for proper validation.

Validation Approach

The achievability of the solid standards in the PantoneLIVE Libraries was the primary objective for testing. PantoneLIVE Dependent Standards are absolute targets for a given print process, substrate, and ink system. The intent is that they can be achieved regardless of subtle substrate variation. These standards represent design intent and should never be modified for a particular substrate through white point mapping.

The second objective was to validate the achievability of the tints regardless of subtle variations of substrate. The pass/fail of a tint was only addressed in specific scenarios with respect to measurement of the 50% nominal tint value for direct comparisons. Measurement of 5%, 25%, 50% and 75% nominal tints was used for analysis only. The evaluation methods are described fully later in this document.

The final objective was to identify how variability in the substrate white point would affect the use of PantoneLIVE data on a like substrate that exceeds the recommended tolerance of 2 ΔE 2000 (1:1:1).

Standards Used in the validation project:

Libraries in scope for validation:

LPCV Label Offset Litho on Coated Paper with a Varnish
LPGB Carton Offset Litho on Virgin Carton Board with a Varnish
FSGB Carton Flexo Solvent on Virgin Carton Board with a Varnish

Colors in scope for validation:

P2004C	P2258C	P2142C	P199C
P273C	P162C	P188C	P100C
P2174C	P2089C	P2395C	P2707C
P2018C	P7478C	P261C	P2037

Ink Formulation

Inks were formulated by Sun Chemical using X-Rite Ink Formulation Software v6. All formulation predictions were adjusted by applying the white point of the substrate used in production. As a result, each library had a unique basis for formulation. Formulae were limited to a maximum of three pigments. To increase the chance of successful spectral reproduction of the PantoneLIVE tonal standards and to minimize metameric formulations, the color was formulated to produce the closest spectral match and lowest color difference. In keeping with commercial guidelines for color matching productivity, no more than 2 corrections were made to any given color. For the case of this study, a correction has been defined as a pigment or color correction.

Measurement Conditions

The measurement conditions listed below are a part of the overall requirement to achieve consistent and relevant results with a PantoneLIVE workflow.

Measurement Device: X-Rite eXact with Net Profiler Certification
Measurement Condition: D50 2° M0
Data Averaging: 2 Measurements
ISO Backing Material: White PantoneLIVE Munsell Backing Material (PLV-N925)

Tolerances

Measurement	Measurement	Tolerance	Used for Pass /Fail
Substrate	ΔE 2000 (1:1:1)	≤ 2	No (Relevant for Data Analysis)
Printed 5%	Best Match ΔE 2000 (1:1:1)	≤ 3	No (Relevant for Data Analysis)
Printed 25%	Best Match ΔE 2000 (1:1:1)	≤ 3	No (Relevant for Data Analysis)
Printed 50%	Best Match ΔE 2000 (1:1:1)	≤ 3	Yes
Printed 75%	Best Match ΔE 2000 (1:1:1)	≤ 3	No (Relevant for Data Analysis)
Printed 100%	ΔE 2000 (1:1:1)	≤ 2	No (Relevant for Data Analysis)

Press Run

Press trials for the FSGB dependent libraries were conducted on-site at The Sonoco Institute of Packaging Design and Graphics at Clemson University on the OMET Varyflex press. Offset dependent libraries (LPGB and LPCV) were printed at commercial printer selected by XRite/Pantone.

For each color, the press was brought up to production speed, 50 sheets/repeats were printed and samples were measured for compliance. Colors were extended as needed, however no more than 2 color corrections were made to a given color.

Evaluation of Tints

As technology has evolved in prepress, plating and pressroom, we are constantly pushing the limits of these processes to achieve more cost-effective and dynamic designs. A standard practice in the packaging industry is to minimize the number of printing units yet still faithfully reproduce brand colors and achieve the overall design intent. As a result, many print runs use 1-3+ spot colors or replace a process color (CMYK) with a spot color. In some cases, tints of spot colors are combined to create more impactful and organic designs. Consistency of the solid color and its tone values are key to the successful reproduction of these complex designs across multiple print organizations, locations, and regions.

When formulating a spot color, there is usually more than one recipe that could yield an in-tolerance match of a solid color. Considerations like pigment cost, pigment availability, and the number of pigments selected for use often impacts the precise formulation of a solid. Tints of each recipe can, however, be significantly different, despite an acceptable solid color match.

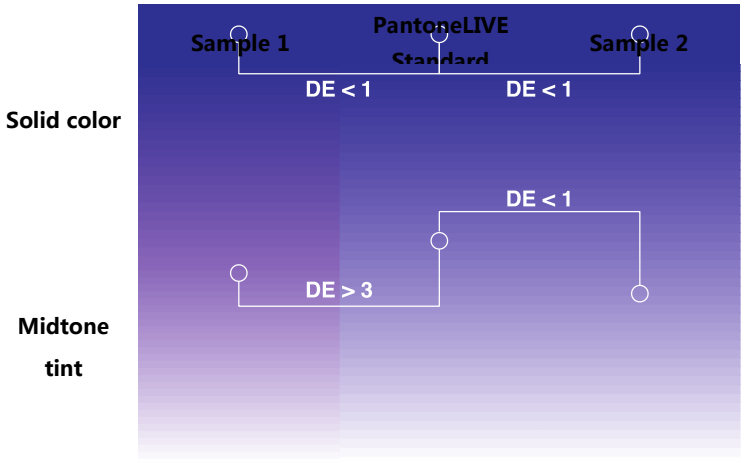

Figure 2: Tint variation of an in-tolerance solid color

This scenario is illustrated in Figure 2 where two sample vignettes with different recipes are compared to a PantoneLIVE standard. You will notice at the top of the diagram that both samples yield a solid color difference of less than 1 ΔE PantoneLIVE standard; however, the tint of Sample 1 reveals a significantly larger color difference (when measured using the Best Match method described later in this paper).

Colorimetrically, the sample on the left is pinker than the standard (ΔH >3). The sample on the right appears to have a similar tone values but is a little darker (ΔL 0.5). For consistency across runs and suppliers, printers must be able to compare a tint to a standard using a defined approach.

Approaches to Colorimetric Tint Evaluation

There are several approaches to assessing the colorimetric agreement of a tint to a standard. Colorimetric agreement is different than assessing dot area or dot gain, which only compares the effective tint coverage independent of the color result.

The most basic method is a simple ΔE00 calculation using the same tone value from the standard and the sample.

- Same Spot – Standard and sample are compared to the same tone value

Three other methods allow the standard to be selected from a full tonal scale based on how it compares to the measured sample. Then ΔE is calculated between the sample and standard.

- Best Match – The standard tone value is selected based on the smallest ΔE00 to the measured sample
- Same Density – The standard tone value is selected based on the smallest Density difference to the measured sample
- Same Lightness – The standard tone value is selected based on the smallest ΔL* to the measured sample

Below is an example of the results from the above calculations based on LPGB P100C:

Yellow P100C LPGB	Best Match	Same Density	Same Lightness	Same Spot
Sample Tone Value	62.4%	62.4%	62.4%	62.4%
Standard Tone Value	59.6%	56.8%	95.6%	62.4%
Resulting ΔE 2000	.57	1.03	9.61	.92

For the purposes of this validation study, we made use of the Best Match approach to evaluate tint results.

Results Summary

The data below consists of sixteen colors, three dependent conditions, and two data points each (solid and tint). Out of a total of 44 colors (88 results), 1 solid and 1 tint were out of compliance for a 97.7% success rate. The data shows an overall average of 1.32 ΔE00 when production samples are compared to PantoneLIVE digital reference colors. Below is a summary of the pass/fail results.

Dependent Standard		LPCV Library		LPGB Library		FSGB Library		
		Solid	Tint	Solid	Tint	Solid	Tint	
	100	1.39	1.21	1.15	0.69	1.47	1.16	
	162	1.26	0.77	1.56	1.96	1.75	0.88	
	188	0.92	1.30	1.63	0.98	1.10	2.14	
	199	1.52	0.47	1.16	1.00	1.43	0.76	
	261	1.77	2.82	0.50	0.33	NA*	NA	
	273	1.85	0.46	1.95	0.74	NA*	NA	
	2004	1.76	0.72	1.71	1.25	1.19	1.14	
	2018	1.23	0.82	0.88	2.06	1.30	0.98	
	2037	1.31	1.29	1.52	3.36	0.87	0.58	
	2089	1.73	1.02	1.72	1.00	1.02	0.86	
	2142	1.36	1.36	1.90	2.66	NA*	NA*	
	2174	0.79	1.53	1.80	1.48	0.96	0.82	
	2258	1.14	2.40	1.49	0.98	0.60	2.14	
	2395	0.22	1.06	1.66	0.74	1.92	0.82	
	2707	1.79	1.01	2.63	2.02	1.04	0.58	
	7478	1.61	1.20	1.61	1.35	NA*	NA*	
Metric		Statistical Analysis						All Data
Average		1.35	1.22	1.55	1.41	1.22	1.07	1.32
STD Deviation		0.44	0.63	0.48	0.81	0.37	0.53	0.57
2 Sigma		0.88	1.26	0.96	1.62	0.75	1.06	1.14
Range		1.63	2.36	2.13	3.03	1.32	1.56	3.14

*Colors with NA were not tested

Table 1: Test Results & Statistical Analysis (ΔE 2000 1:1:1)

Conclusion

The PantoneLIVE Dependent solid and tint standards tested were matched within tolerance for a 97.7% success rate and an average ΔE00 of 1.32. The substrate variance between the PantoneLIVE standard and the printed sheet was the source of two out of tolerance results, LPGB P2707C Solid and LPGB P2037C Tint. The substrates chosen for testing were near or outside of the specified tolerance window to show how the PantoneLIVE standards would perform under varied substrate conditions.

Within the scope of our testing, one substrate fell within the tolerance of ΔE00 ≤ 2, and two substrates exceeded that tolerance. The results of the solid and tint data shown above in Table 1 indicate that our specified tolerance performs well in general practice. Out of forty-four colors, only one solid and one tint fell outside our pass/fail requirements. These data show that despite the substrate variation from the standard, it did not adversely affect the ability to match color as a whole. The ΔE00 results of 1.35, 1.22, and 1.55 to their respective libraries shows that while the conformance of the substrate to the PantoneLIVE standard is suggested, it is not a requirement.

Code	Library Name	ΔE
LPCV	Label Offset Coated Paper Varnish	1.39
LPGB	Carton Offset Virgin Carton Board Varnish	2.46
FSGB	Carton Flexographic Solvent ink Virgin Carton Board Varnish	2.67

As seen below in Figure 3, the printed solid LPGB P2707 measured ΔE00 of 2.63 to the Dependent Standard, which exceeded our tolerance specification. Likewise colors in this similar color family, 2174 and 2142, were in the top 4 highest ΔE00. Further investigation revealed that the substrate standard in this library contained small amounts of OBA's (optical brightener additives) and the substrate used in testing did not.

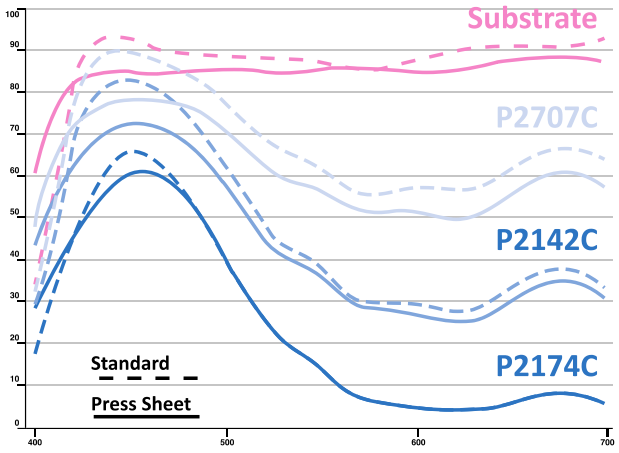

Figure 3: Comparing the spectral curves of 3 colors in the LPGB Library

While the presence of OBA' s in the LPGB Library (Figure 3) does conform to the paper type that is in general use in this packaging market segment, the lack of OBA' s in the printed substrate affected the ability to accurately formulate this color and therefore was out of tolerance. While all other colors in this library did pass the tolerance requirement, the substrate did complicate the ability to easily formulate and reproduce the solids and tints on press.

The substrate plays a critical role in the reproduction of solid and tint values. One of the three key components (print process, substrate, and ink system) that set Dependent Standards apart from the Master Standards is that the standard was developed specifically for a given substrate. Therefore when you select a Dependent Library that matches the print process and ink system, you must ensure that your substrate is in general agreement. The results discussed above confirm that color is just one of many elements you should evaluate when selecting a substrate to be used for a PantoneLIVE Dependent Library Condition. Detailed specifications as to white point, OBA' s, the use of varnish or lamination, ink film thickness, etc. are available on the PantoneLIVE link noted below.

PantoneLIVE Library Specifications or www.pantone.com/live

In general, given the fact that Dependent Libraries were developed as a general standard for a given print process, substrate, and ink system, you can assume that the closer you align to that standard, the more colors will be reproducible or in tolerance within your process. Similarly the farther away you move from that standard, the more likely you are to receive out of tolerance results.

Ongoing Testing

This study was not intended to be exhaustive, but procedures can be used for ongoing testing and analysis of different standards, different libraries or for additional print attributes and characteristics.


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