Conformance to Substrate-corrected Dataset, a Case Study

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Abstract

Printing certification is an attestation that a manufacturer complies with specified standards. Printing certification is a business matter because it aligns quality expectation between printing companies and their customers, and it builds trust in the global supply chain management. The primary members of the print supply chain are print buyer, the paper mill, and the printer. Printing certification is a technical matter because it enables process control, product conformance, and proof-to-print visual match in printer's routine production. Printing certification is also a standardization matter because ISO 12647-2, an existing printing standard that focuses on conformance to process control aims, and ISO/DIS 15339-1, a new printing standard that focuses on conformance to color characterization dataset, need to be harmonized to serve the standardization need of the global print supply chain. A dilemma arises when printing conformance is affected by not how the printer prints, but the choice of the paper that the print buyer wants. This research examined the relationship between process control and product conformance in a color-managed workflow. It designed printing experiments to test the print performance according to ISO/DIS 15339-1. It was found out that process control conformity does not necessarily result in dataset conformity. It validated the use of substrate corrected dataset aims and device link technology for printing conformity on OBA paper. This research also validated the use of substrate corrected dataset aims to improve the color match between prints on OBA loaded papers and proofs on non-OBA proofing substrates.

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Introduction

A dilemma is a difficult or perplexing situation requiring a choice. The difficult situation, described in this paper, is about conflicting requirements in the evolving print supply chain. The primary members of the print supply chain are print buyer, the paper mill, and the printer.

Print buyers are cost conscientious and increasingly depend on their printers to deliver performance that exceed previous expectations. Particularly, they demand proof-to-print color match, printing conformity to ISO 12647 standards, including the use of optically brightened (OBA) paper.

Paper mills manufacture various paper grades. More and more papers are optically brightened in order to meet the demand of print buyers and publishers. Being the most significant cost component in a print job, papers are often sold directly to print buyers.

Printers understand that printing is more than putting ink on paper. Printers also realize that paper is not a finished product, but its performance makes all the difference in a print job. They standardize press chemistry and mechanical settings, calibrate ink-paper-press interactions, and use color control bar and color measurement instruments to demonstrate conformance to process control aims. Printers soon find out that they can achieve printing conformity, per ISO 12647-2 (ISO/DIS, 2012), and proof-to-print color match only on paper without OBA.

The dilemma is about how to achieve printing conformity and proof-to-print color match using OBA paper. One possible solution is to revise the existing standard. The other solution is to develop a new printing standard to address the perplexing situation. The existing standard, i.e., ISO 12647-2, focusing on process control, defines printing as conformance to printing aims, including solid, TVI, and midtone spread. The new standard, i.e., ISO 15339-1 (ISO/DIS, 2011), defines printing as conformance to characterization dataset, including the use of substrate corrected color aims to account for the influence of OBA in printing paper.

There were numerous discussions about the revision of ISO 12647-2 and the development of ISO 15339-1 in the past two years in ISO TC130 Working Group 3 meetings. It appeared that ISO 12647-2, being a process control standard, will be kept simple and, hence, is limited in handling OBA matter effectively. On the other hand, ISO 15339-1 embraces the use of substrate corrected color aims to address printing conformity and proof-to-print color match using OBA paper. This research is aimed at producing use cases to better understand what it takes to conform to substrate corrected dataset and the proof-to-print color match.

Relationship between process control and product control

Figure 1 is a color-managed workflow with relevant ISO standards from data reception, to prepress and color management, to printing. ISO 12647-2 or G7 only focuses on printing process control, i.e., it begins with a limited number of color patches (solid, tint), platemaking, printing, sampling, measurement, and ends with process control related parameters (color of solids, TVI, midtone spread). By calibrating the press and demonstrating conformance to process control aims, ISO 12647-2 ensures repeatable color. Thus, color proofing, as specified in ISO 12747-7, and color management are outside the scope of ISO 12647-2.

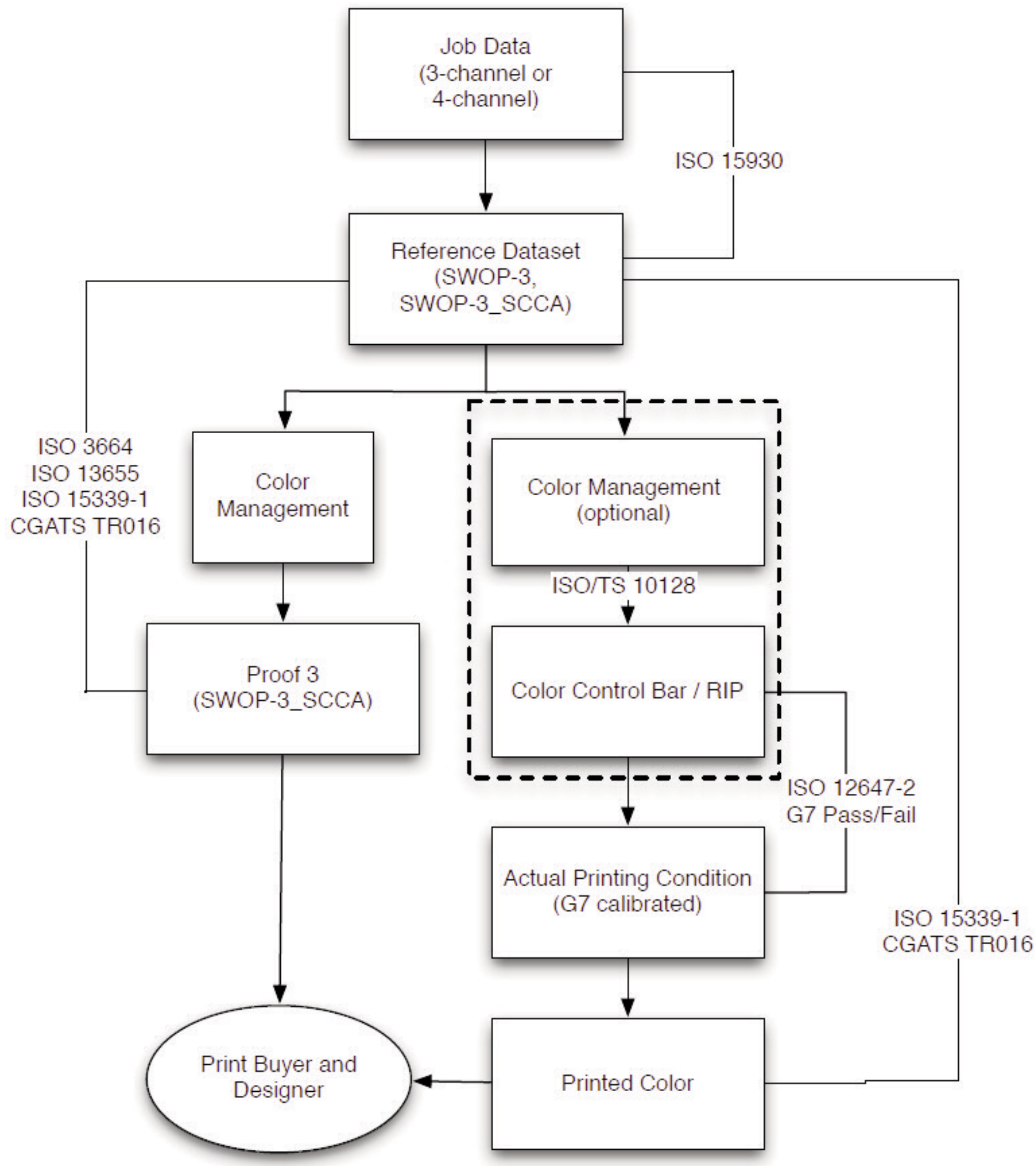


Figure 1. Color-managed workflow and printing standards

The methodology of ISO/DIS 15339-1, similar to ISO 12647-7, is based on the use of characterization data to define printing aims and the use of CGATS TR 016 to define tolerances. ISO/DIS 15339-1 recognizes characterization datasets and their associated ICC profiles as color exchange spaces. ISO/DIS 15339-1 also recognizes characterization dataset derived printing aims, but is silent on process control approaches. ISO/DIS 15339-1 conformity assessment begins with many color patches per ISO 12642 (IT8.7/4). By calibrating the press to substrate-corrected printing aims (TAGA, 2011), and by utilizing color management in prepress, ISO/DIS 15339-1 and CGATS TR 016 ensure product color conformance. CGATS TR 016 provides three levels of tolerance: Level A tolerance applies to color proofing; Level B tolerance applies to more stringent offset printing; and Level C tolerance applies to less stringent offset printing.

Based on the above discussion, ISO 12647-2 and ISO/DIS 15339-1 have different scopes. It is reasonable to have a process control standard nested inside a product conformance workflow standard, as depicted in Figure 1. In other words, ISO 12647-2 process control standard addresses printer's needs and ISO/DIS 15339-1 product conformance standard addresses print buyer's needs. Today, process control aims from ISO 12647-2 are slightly different than process control aims extracted from ISO/DIS 15339-1 dataset. These two standards are compatible as far as tolerances are concerned.

Research Questions

Two research questions are stated in this research: (1) does conformance to process control aims result in conformance to dataset? If not, what additional steps are required to achieve conformance to dataset, and (2) will the use of substrate corrected dataset aims improve the match between prints on OBA loaded papers and proofs on non-OBA proofing substrates?

Methodology

In the first part of the research, three press runs were conducted with the use of a Goss Sunday 2000 web offset press, Sun Chemical inks, and Sappi Opus paper. The goal is to demonstrate conformance to process control aims and conformance to substrate-corrected dataset (M1). A brief procedure to conduct the three press runs is described below:

1. The first press run was printed with linear plates conforming to solid coloration of substrate-corrected SWOP3 dataset. Printed P2P25X targets were measured with a Konica-Minolta KM FD-7 spectrophotometer in M1 conditions. These measurements were analyzed and G7 adjustment curves generated with the use of the Curve 2.2 software.

2. The second press run was printed with the G7 curved plates under the same printing condition as the first press run. Upon color measurement, G7 conformance was verified according to the G7 pass/fail requirements.

3. The IT8.7/4 characterization target from the second press run was measured and a Goss_G7 ICC profile generated. The reason for the Goss_G7 ICC profile was that we can build a device link profile, using Alwan LinkProfiler, to see if there is any significant difference in dataset conformance between a G7 calibrated press and a 'G7 plus DeviceLink' printing workflow.

   A device link profile combines an input (CMYK) profile with an output (CMYK) profile to produce a look-up-table (LUT) that translates colors from a source CMYK into a matching colors on an actual CMYK space by preserving single-channel colorants and avoiding scum dots (Figure 2).

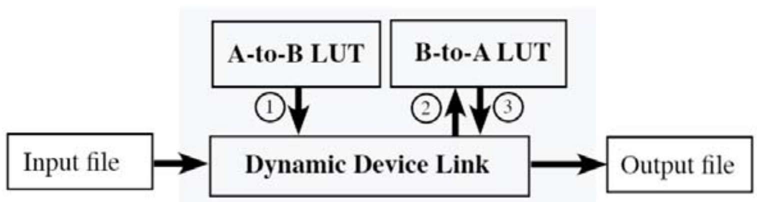


Figure 2. *Mechanism of device link ICC profile*

4. The third press run was carried out with one-half of the signature printed under G7 calibrated condition and the other half under 'G7 plus DeviceLink' conditions to see if there is any significant difference between the two treatments in achieving dataset conformity.

The second part of the research demonstrates how to use the substrate-corrected dataset (M1) as the proofing aim where OBA print and no_OBA proof will match each other visually under the ISO 3664 (2009) compliant viewing condition. A brief procedure is described below:

1. The print, from Part One of this research, represents a SWOP3 conforming print. The paper, Sappi Opus, contains optical brightening agent (OBA).

2. Three color-managed proofs were made with the use of the GMG color proofing system with different source ICC profiles.

   a) Proof_1 matches the SWOP3 dataset with a white point of (93L*, 0a*, and 0b*), i.e., ignoring white point of the printing paper.

   b) Proof_2 matches the substrate-corrected SWOP3 dataset with a white point of (93.1 L*, 1.8a*, and -4.8b*), as measured by the M0 illuminant.

c) Proof_3 matches the substrate-corrected SWOP3 dataset with a white point of (93.4L*, 1.7a*, and -6.5b*), as measured by the M1 illuminant.

3. A M0 spectrophotometer is used to assess proofing conformity because proofing paper does not contain OBA.

4. Examining visual agreement between proofs and the reference print under ISO 3664 compliant lighting conditions.

Results

Conformance to process aims versus conformance to dataset

In terms of G7 press calibration, the results showed that the first press run was not G7 conformed due to excessive deviations in average and in maximum of ΔL* and ΔC_h, as shown in Figure 3.

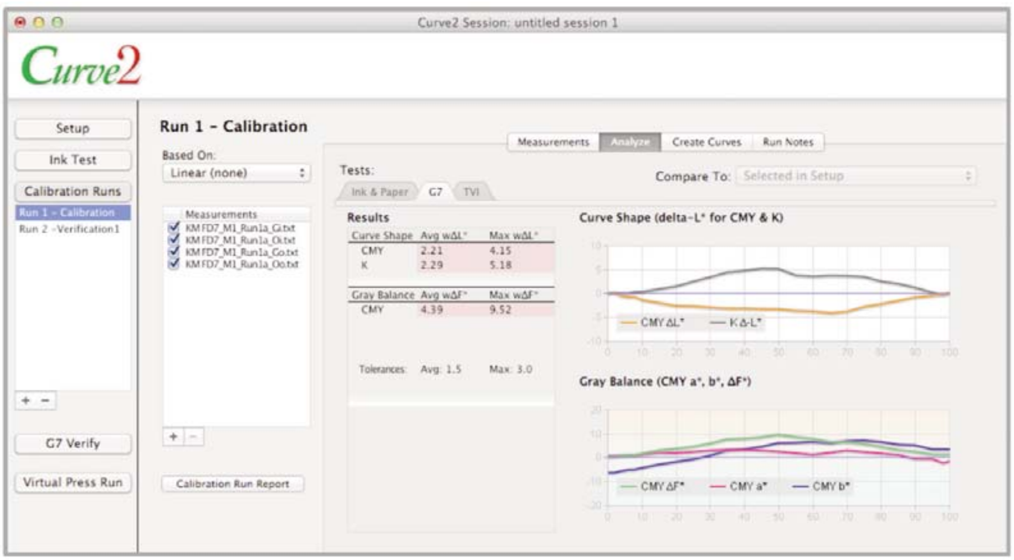


Figure 3. *First press run or before G7 calibration*

By applying the G7 adjustment curves during the CTP operation and print consistently, the second press run conformed to G7 requirements (Figure 4).

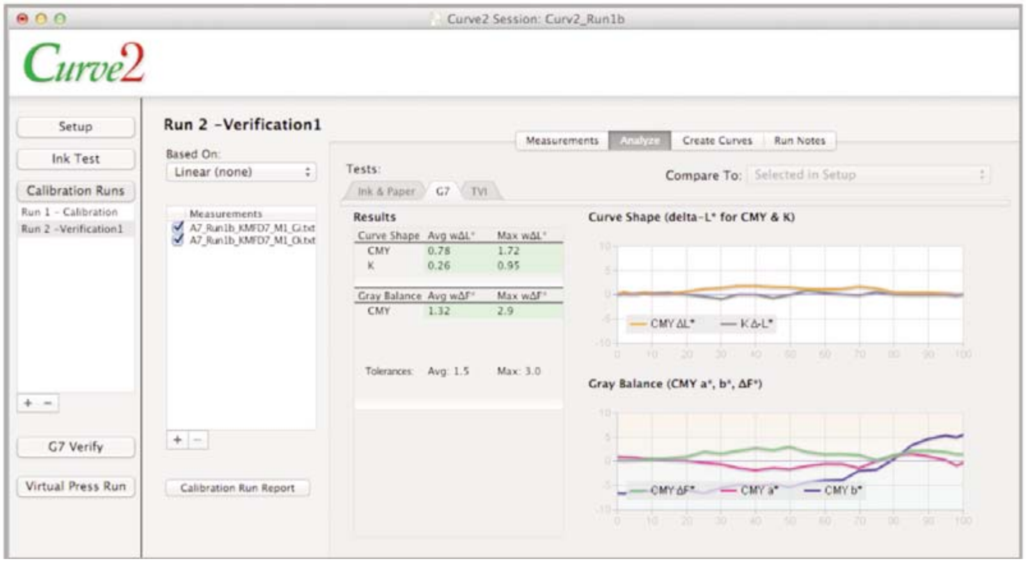
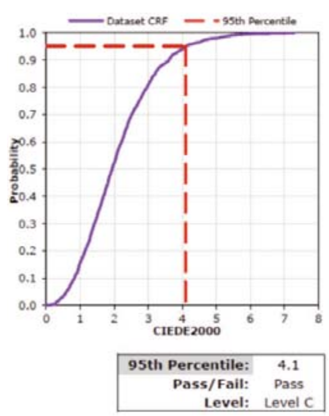


Figure 4. *Second press run or after G7 calibration*

In terms of dataset conformance, the table, situated in the middle of Figure 5, is the tolerances according to CGATS TR 016. The second press run (left of Figure 5) barely missed dataset conformance, i.e., Y midtone conformance failed and the 95% of CRF_ΔE00 at 4.1. Using device link between the source or target color space and a calibrated or the actual printing condition, the third press run (right of Figure 5) achieved the dataset conformance according to CGATS TR 016, i.e., all 9 patches passed and the 95% of CRF_ΔE00 at 2.8.



Tagret description		Tolerance (CIEDE2000)		
		Level A	Level B	Level C
95th percentile of all patches of ISO 12642-2		3.0	4.0	5.0
Solid	100C, 100M, 100Y	1.5	2.4	4.0
	100K	2.4	3.6	6.0
50% input tint	50C, 50M, 50Y, 50K	1.5	2.0	2.5
Near-neutral	50C/40M/40Y	3.0	3.5	5.0

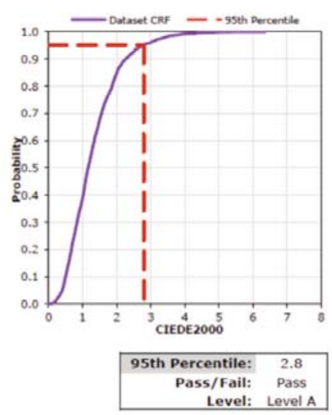


Figure 5. *'G7 plus DeviceLink' demonstrates SWOP3 (SCCA) conformance*

Proofing to SWOP3 and Substrate-corrected Datasets

Color management involves the use of a source profile, a destination profile, and a color rendering intent. The color rendering intent is 'absolute colorimetric,' and the GMG color management software dictates the destination profile. The only variable is the source ICC profile.

The first source profile is generated directly from the SWOP3 dataset. The second source profile is generated from the substrate-corrected (M0) SWOP3 dataset. The third source profile is generated from the substrate-corrected (M1) SWOP3 dataset. The three white points of the datasets and their color differences are shown in Table 1.

Proof_ID	Source white point	CIELAB	ΔE
Proof_1	SWOP3	93L*/0a*/0b*	---
Proof_2	Opus (M0)	93.1L*/1.8a*/-4.8b*	5.1
Proof_3	Opus (M1)	93.4L*/1.7a*/-6.5b*	6.7

Table 1. *White points of the three source color spaces*

By measuring the IT8.7/4 target of each of the three proofs and analyzing the measurements and their corresponding dataset aims, all three color proofs demonstrated conformity according to CGATS TR 016. Proof conformity assessment alone only answers the question if a proof passes or fails against established tolerance.

Visual ranking of proofs with print as the reference

More information can be obtained if we correlate visual assessment of pictorial color image reproduction under the ISO 3664 compliant lighting conditions with some aspects of the colorimetric analysis. In this regard, ISO pictorial color reference images, Bar Set, are examined for colorcast.

When the three proofs and the offset print, described as the reference, were placed randomly in the ISO 3664 (2009) compliant viewing booth, observers were asked to pick one proof that was most different in color appearance than the print reference. Proof_1 was often picked. This was because the yellowness of Proof_1, made from SWOP3 as the source profile, and the blueness of the printing paper are most visually noticeable. To continue the visual ranking experiment, observers were likely to place Proof_2, made from SWOP3_SCCA(M0) as the source profile, between Proof_1 and the offset print. Finally, Proof_3, made from SWOP3_SCCA(M1) as the source profile, between Proof_2 and the offset print.

Visual simulation of proofs and print

Figure 6 simulates the appearance of the three proofs and the reference print with the color management procedure, first demonstrated by Don Hutcheson at the CGATS meeting (CGATS N1317, 2012). The simulation is described below:

Figure 6. *Simulation of the visual ranking of pictorial color reproduction*

1. Assigned the legacy CMYK file to a number of ICC profiles:

    a. The SWOP3 derived ICC profile was assigned to the legacy CMYK image and renamed as, CMYK_Proof_1 (far left).

    b. The SWOP3_SCCA(M0) derived ICC profile was assigned to the legacy CMYK image and renamed as, CMYK_Proof_2 (second from left).

    c. The CMYK_SWOP3_SCCA(M1) derived ICC profile was assigned to the legacy image CMYK and renamed as, CMYK_Proof_3 (second from right).

    d. The Goss_Opus (M1) derived ICC profile was assigned to the legacy CMYK image and renamed as CMYK_Print (far right).

2. These CMYK files were converted to the Adobe RGB color space using absolute colorimetric rendering intent, and placed in the Microsoft PowerPoint.

3. A screen capture of the PowerPoint was placed in the Word document, as shown in Figure 6. If displayed in a calibrated display, these images resemble the hardcopy proofs and the offset print, including color of the substrates, closely.

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Conclusions

Printers need process control standards to ensure color repeatability. ISO 12647-2 answers such a need in a straightforward manner, but cannot solve the OBA dilemma as the result of print buyer's demand. Print buyers expect printed colors to be predictable, including the optical effect of OBA in paper and in print and proof color match. ISO 15339-1 addresses the dilemma by introducing substrate corrected color aims. This case study is a validation of such a concept. A process control standard, when nested inside a color-managed workflow, is complimentary to the product conformance standard.

This case study demonstrated the press calibration using the G7 methodology. Conformance to process control aims, i.e., G7 pass/fail requirements, does not equal to conformance to dataset. The inclusion of the device link in a calibrated and repeatable printing condition may be necessary to achieve dataset conformance.

Printing conformance and proof-to-print match are achievable when the substrate-corrected dataset serves as the common aim. The enablers for proof-to-print match are ISO 3664 (2009) D50 viewing conditions and ISO 13655 (2009) M1 measurement condition when printing on paper contains OBA. The results show that ignoring the effect of OBA in proofing leads to mismatch, or colorcast, between proof and print. By incorporating the substrate-corrected dataset as the source color space during proofing, the print-to-proof visual match improves.

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