

Digital Proof Systems: Are Sublimation Devices Compatible With ISO 12647-2 Standard?

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Abstract

A set of Rainbow™ sublimation proof devices are studied on both densitometric and colorimetric points of view. Their performances are compared to two kinds of references: a classical Matchprint™ analog proof system, and a set of quadrichromic inks as they are presented in the ISO 12647-2 standard for offset lithographic processes through main quality criteria (solid optical density and dot gain with respect to five typical papers). The study begins by a presentation of the data content of the ISO standard 12647-2 which will be useful for the experimental investigations.

As a first preliminary work, densitometric measurements are made on a set of typical offset primary inks on two different papers. A second set of experiments leads to the densitometric and colorimetric characterization of the analog and digital proofers. It is recognized that there are no significant deviations among the digital devices. By considering the color gamuts of all the systems in the L*a*b* space, we show that their calibration slightly lower their performances, but the main result is that these performances largely fullfill the requirements of the ISO standard for offset printing.

Introduction

The reproduction of colors is the most important problem in the field of graphic communication. The accuracy with which a color is reproduced is an essential quality criterion, and there is nowadays a strong need for a reliable prediction of what the printed product is likely to look like. All the modern graphic arts prepress systems are built up on computer networks, the capabilities of which are measured by the efficiency of the various digital treatments undergone by the color data corresponding to a given original image. With such systems, once an image is digitized (by a flatbed scanner, for instance), it is normally transformed and stored as a file of values equivalent to cyan, magenta, yellow and black relative dot areas. However, the workflow under consideration will only produce the desired color at the printing stage if two important practical requirements are fullfilled:

- the devices included in the prepress network work with a sufficient stability (calibration test),
- somewhere in the system, a control device enables a "contractual" prediction of what the prints will actually be.

Traditionally, this control is performed by the production of a "proof", and the corresponding proof system is situated at the separation between the prepress network and the printing process itself. This critical position in the global workflow corresponds to the location where the transformation of the virtual digital page to a physical printing forme is occuring. This crucial step may be completed in two principal ways:

- from computer file to film + from film to plate: this process is considered as the classical way for platemaking,
- from computer file directly to plate (even directly to press or to print) without the use of any film: the most recent "CTP systems" belong to this category.

It is well known that the prepress suppliers have developped digital means to produce "control proofs" and/or "contractual proofs". The difference between these two kinds of proofs lies in the fact that control proofs are produced for internal purposes (in-house corrections), while contractual proofs have a commercial significance corresponding to an "agreement" between the printer and his customer for the delivery of a given quantity of prints in conformity with the proof. The various proof systems are based on a wide pannel of principles:

- thermal transfer,
- color electrophotography,
- thermal sublimation,
- color ink jet, ...

Nowadays, sublimation devices have reached a high level of reliability, so that they may be considered as contractual proof systems; it seems to be also the case for the latest ink jet printers. A feature to be noticed is that they avoid any printing forme; they belong to the class of "direct-to-print" devices. Proofs are produced one by one through the use of special pigments or colorants which are deposited on the surface of a special basis (or on the paper to be used during the press run) by a classical four color printing process.

At the industrial stage, the colors of an image are rendered by the combination of four organic pigments (cyan, magenta, yellow and black) included in primary inks. On the other hand, the sublimation device utilizes four mineral colorants (or dyes) which are chosen according to their thermal resistance; their spectral properties are different from the classical ink pigments and they are not submitted to the screen dot process: this process is simulated by varying the local colorant thickness. In the case of the "Rainbow"™ proof system, the primary ink colors are obtained by combinations of the mineral colorants, the proportions of which must be adapted to the four primary color inks specifications as they may be found, for instance, in existing standards for offset printing.

This study is a part of a cooperation program between IMATION-France and EFPG which is on the way since several years. The goal was to qualify Rainbow™ sublimation devices according to the requirements specified in the 12647-2:1996 ISO standard. To obtain more reliable results, the performances of the sublimation proofers were compared to those of an analog system (MatchPrint)™ which is widely known to produce "contractual proofs".

Overview of the 12647-2 ISO standard

The purpose of ISO 12647-2 standard is to specify a number of process parameters and their values to be applied when a classical offset lithographic process is utilized for the production of four color prints. An important part of this text deals with the visual characteristics of the image components; standardization relates to three basic points:

- solid optical densities of primary inks (C, M, Y, K),
- global dot gain, or 'tonal value increase (TVI)', i.e. screen dot dimension variation + optical gain in the print,
- L*a*b* colorimetric values (D50 illuminant).

Table 1 : Standard paper grades

Paper:	L*	a*	b*
1) Gloss-coated, wood-free:	93	0	-3
2) Matt-coated, wood-free:	92	0	-3
3) Gloss-coated, web:	87	-1	3
4) Uncoated, white:	92	0	-3
5) Uncoated, yellowish:	88	0	6
Tolerances:	±3	±2	±2

In particular, the standard defines five typical paper grades with their colorimetric values and tolerances (table 1).

Given these specifications, the standard yields a set of possibilities for the determination of reflection densities of the process colour solids, among which we chose the status T densitometric measurements because it was fitted to our device.

By setting the densitometer to 0 on the unprinted paper, we find typical values gathered in table 2 wether they are obtained without or with polarization filters. A Tonal Value Increases (TVI) list is also specified according to eight categories marked A to H, from the lowest to the highest values. For this list, a typical screen ruling of 150 lpi is considered and the reference is a control strip on a film. Finally, let us add some informations about the colorimetric requirements included in the standard; they are established under a D50 illuminant.

This illuminant is recommended for Graphic Arts; but it is interesting to gather some of these specifications in table 3 (given under a D65 illuminant, fitting our instrument), by restricting ourselves to the generic papers 1 and 2, with which some experimental data will be compared.

Table 2 : Standard density values (status T)

Paper	C	M	Y	K
1	1.45/1.55	1.40/1.50	1.00/1.05	1.55/1.85
2	1.30/1.45	1.25/1.40	0.90/1.00	1.40/1.75
3	1.23/1.43	1.25/1.33	0.86/0.91	1.45/1.75
4	0.90/1.00	0.80/0.95	0.65/0.80	1.00/1.25
5	0.90/1.00	0.80/0.95	0.55/0.70	0.95/1.20

Table 3 : Colorimetric coordinates of solids

		L*	a*	b*
a)	- unprinted paper 1	93	0	-3
	- cyan	54	-27	-47
	- magenta	47	75	-10
	- yellow	88	-12	96
	- black	18	0	-1
b)	- unprinted paper 2	92	0	-3
	- cyan	56	-25	-45
	- magenta	47	71	-7
	- yellow	88	-11	92
	- black	18	1	1

The tolerances have an order of magnitude of $\Delta E_{ab} = 4$ units, which seems a relatively low value.

Experiments with Primary Inks

Wishing to get quantitative informations about the significance of the 12647-2 ISO standard statements, we made a series of trials by printing solid areas with an IGT tester using commercial primary inks on the two following papers:

- a gloss-coated one: Contrast™
- a matt-coated one: Chromomat™

The ink weight was varied between 0 and 3 $g.m^{-2}$ in order to find the usual densitometric values in the tested range. Figure 1 shows the experimental results on the example of the magenta ink.

The shapes of the two curves show the existence of the same horizontal asymptote, which is an awaited feature; the diagram shows that the standard density values are situated in the ascending parts of the curves at an ink weight situated at an abscissa around 1 $g.m^{-2}$ (which is also a classical and non-surprising result); such a position yields a relatively high slope which, in turn, allows the offset printer to adjust the setting of his press ink delivery system with a satisfactory precision. Similar results were obtained with the other primary inks (C, M, K). Figure 2 presents the colorimetric data (under a D65 illuminant) corresponding to the same example of the magenta primary ink by projection into the plan a*, b*.

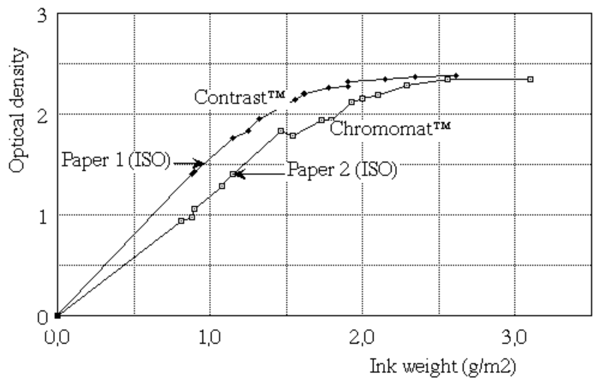


Figure 1. Densitometric curve (Magenta primary ink)

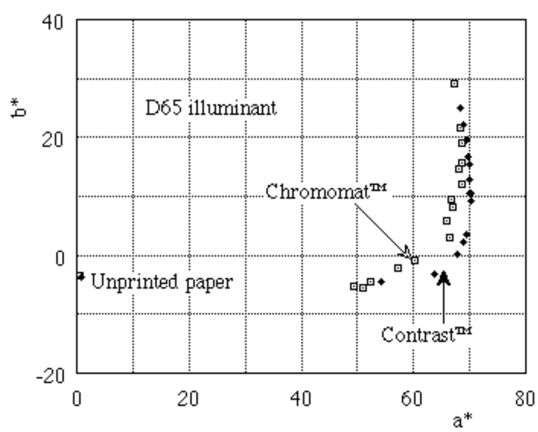


Figure 2. Colorimetric curve (magenta primary ink)

This figure demonstrates that the curvature of the projection presents an orientation towards the red sector of the diagram: when the magenta ink thickness increases, the pigment seems visually redder and redder, which is again a known result. In this case, the positions of the color points (shown by arrows) corresponding to the ink weights in figure 1 only allow narrow hue variations; this is in favor of a relatively good color stability. It may similarly be shown that the cyan ink curve exhibits an orientation towards the blue sector of the diagram when the ink weight increases.

Table 4 summarizes the experimental ink weights in the typical case of the Chromomat™ paper which gave the better fit with the standard requirements.

The values of table 4 are to be compared with those of the generic paper grade 2 in table 2. The agreement between the two sets of data is relatively good.

Table 4 : Densities of solids (matt-coated paper)

	Weight	Density	L*	a*	b*
Unprinted	-	-	96	1	-3
Cyan	1.25 g/m^2	1.44	56	-28	-43
Magenta	1.15 g/m^2	1.40	46	60	-1
Yellow	0.95 g/m^2	1.00	86	-2	83
Black	1.05 g/m^2	1.68	19	0	-2

Experiments on Analog Proofs

A second set of experiments consisted in making analog proofs with a so-called M atchPrint™ Low Dot Gain' system. The objective of the trials was to obtain an unquestionable proof reference and to characterize it on both the densitometric and colorimetric points of view. Table 5 presents the experimental data which were obtained from these measurements.

The results of table 5 are to be compared with the data proposed in table 2 and 3 for the gloss-coated generic paper 1. Both the densitometric values and the colorimetric coordinates of the primary solids in the proof are in good agreement with the specifications of the ISO standard (within the precision and tolerances).

Table 5 : MatchPrint™ analog proof

	Density	L*	a*	b*
White basis	-	99	1	0
Cyan	1.42	56	-27	-46
Magenta	1.46	49	76	-6
Yellow	1.05	92	-11	100
Black	1.71	15	-2	0

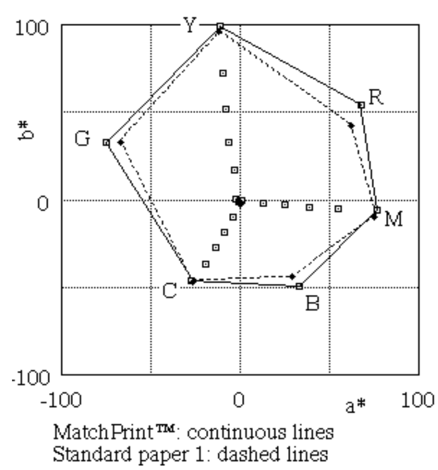


*Figure 3. Color gamuts (Projection a*b*)*

The white basis of the MatchPrint™ proof is brighter than the typical standard gloss-coted paper 1, and the black solid of the proof is darker than the generic one (within the tolerances specified in the 12647-2 ISO standard).

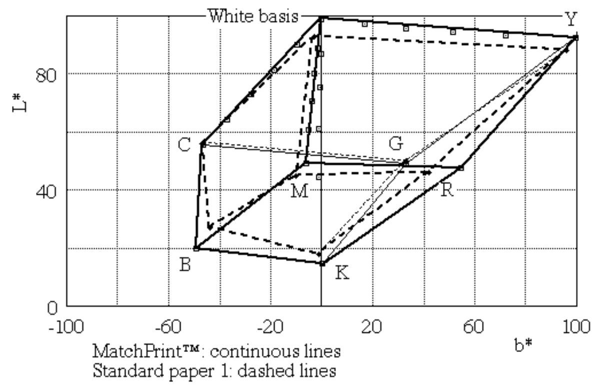


*Figure 4. Color gamuts (Projection L*b*)*

These features are confirmed in figures 3 and 4, where it may be seen that the color gamut of the standard print on the generic paper 1 is almost completely included within the MatchPrint™ color gamut. The other color points of figures 3 and 4 are related to film dot areas rangeing from 0% to 100% (step 20%). It is important to notice that their behavior is significantly different from that of the ink weight variations presented in figure 2): they may be joined by an almost straight line (with no visible curvature). Subsequently, we may conclude that no important hue variation is likely to occur by tonal value increase (i.e. dot area increase).

Experiments on Digital Proof Systems

A third set of experiments consisted in making the same trials on a set of sublimation digital Rainbow™ proof devices (2720, 2730 and 2740). The first feature to mention is that there is no significant difference between the three devices, specially on the densitometric point of view. They were compared to both the analog MatchPrint™ and the ISO standard paper 1. It is important to add that these systems need a 'calibration' to adjust their performances.

Table 5: Calibration of the Rainbow™ proof system

		L*	a*	b*	ΔE
White basis		97	2	-6	-
Cyan	uncalibrated	46	-19	-49	
	calibrated	58	-24	-40	16.1
Magenta	uncalibrated	45	81	1	
	calibrated	51	73	-10	15.0
Yellow	uncalibrated	92	-19	102	
	calibrated	92	-17	96	6.7
Black	uncalibrated	14	-4	-8	
	calibrated	22	-4	-3	10.1

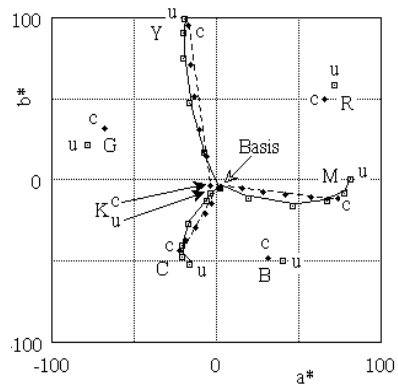


Figure 5. Calibration of a Rainbow™ device

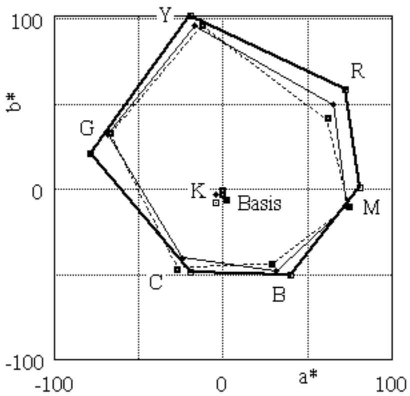
The effect of the calibration process may be seen in Table 5, on the typical example of the 2740 device. We may observe tendancies to an increase of the L* values (slight darkening of the colors) and to a decrease of the color saturation: the color gamut of the device is significantly narrowed by the calibration. The solid hues are also slightly modified, specially in the cases of cyan and magenta. Another important feature is to notice in figure 5: due to the sublimation process used in the Rainbow™ system, tonal value variations are interpreted by dye thickness variations; in the uncalibrated situation, these dyes behave like the ink pigments of figure 2, exhibiting a significant curvature; on another hand, after calibration, the primary color behavior may be approximated by a straight line, as already pointed out for the MatchPrint™ proof.

Table 6 allows to compare the solid colors L*a*b* values of the calibrated Rainbow™ 2740 device with the standard print on type 1 gloss-coated paper (under D65 illuminant).

Table 6: Calibrated Rainbow™ and standard print

	Calibrated proof			Standard print			
	L*	a*	b*	L*	a*	b*	ΔE
Basis	97	2	-6	93	0	-3	5.5
Cyan	58	-24	-41	56	-27	-47	7.4
Mag.	51	73	-10	45	75	-10	6.4
Yellow	92	-17	96	88	-12	96	6.0
Black	22	-4	-3	18	0	-1	6.2

The color difference values ΔE remain less than 7.4 units, which is a rather moderate value: the calibration makes the color gamuts of the digital proof system and the ISO standard be very similar as it may be seen in figure 6.



Calibrated Rainbow™: light continuous lines
ISO standard 1: dashed lines

Figure 6. Comparison between Rainbow™ and ISO standard

Conclusion

Our experiments show that the Rainbow™ digital sublimation proof systems may preview a standardized print. The calibration process is intended to simulate the behavior of offset primary inks, specially in the case of tonal value variations; when it is applied, the digital proofs undergo a reduction of their color gamuts.

Biography of the presenter

Gerard BAUDIN was born in 1944. He graduated from INSA-Lyon (France) in 1966 achieving Physical Engineering. He obtained his PhD from the Claude Bernard Scientific University of Lyon in 1970. Then, he was a teacher for Applied Sciences in scientific african universities. Since 1978, he joined the French Engineering Faculty for Papermaking and Printing (EFPG - Grenoble) where he became a Professor in Process Engineering applied to Graphic Arts, directing Master- and PhD theses, and teaching prepress and printing techniques.