



**ISO/TC 130/WG 3 N 992**  
**REPLACES: ISO/TC 130/WG 3 N 962**

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Process control and related metrology

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**N 992 Chung ISO 12647-2\_SubstrateCorrection v3a**

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# Substrate Correction in ISO 12647

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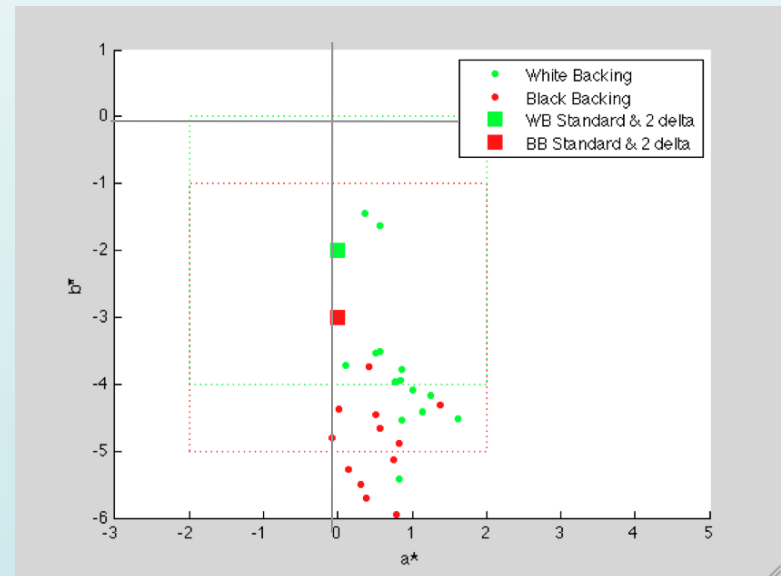
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# Problem Statement

- ISO 12647-2 specifies targets and tolerances for paper and solid colors.
  - PT1 CIELAB values of paper are (95L\*, 0a\*, -2b\*) with a tolerance of  $\pm 3\Delta L^*$ ,  $\pm 2\Delta a^*$ , and  $\pm 2\Delta b^*$ .
  - Colorimetric tolerances of solid colors are 5  $\Delta E$ .
- Paper that meets ISO 12647-2 PT1 specifications is in short supply.
  - Production stocks are getting bluer.
  - Non conformance is only getting worse as we use M1 measurement conditions.

# Problem Statement

- Substrate non-conformance is common.
  - PSO database (Courtesy of Fogra)
  - Most paper colors audited are bluer than ISO 12647-2 specifications.
  - More and more production papers are out of current tolerances.



# Problem Statement

- Paper containing OBA causes non-conformance.
- OBA also affects printed colors that do not absorb short wavelength energy.
  - As an example, a large portion of the cyan solid tolerance is consumed by paper color.

Production (McCoy Gloss)					
	L*	a*	b*	C*	h
Paper	94	2	-7	7	286

ISO Target (PT 1)						Minimum $\Delta E_{ab}$
	L*	a*	b*	C*	h	Prod & Trgt
Paper	95	0	-2	2	270	5.5 <b>X</b>
K	16	0	0	0	0	0.7
C	55	-37	-50	62	233	3.9 <b>?</b>
M	48	74	-3	74	358	0.3
Y	89	-5	93	93	93	1.5

# Significance of the Problem

- It impacts ISO 12647-2 conformance as well as characterization data set conformance.
  - RIT 2010 Printing Standards Survey (n = 90) confirms that paper containing OBA is a problem.

	Most problematic		Least problematic		Rating Average
	4	3	2	1	
weight					
Press sheet and proof do not match each other visually	<b>44</b>	18	12	15	<b>3.02</b>
Paper containing OBA does not conform to the paper white point specified in ISO 12647-2	<b>28</b>	26	17	18	<b>2.72</b>
Inks do not conform to ISO 2846	6	22	<b>48</b>	13	2.24
ISO 12647-2 only addresses a small part of my customers' needs	12	24	11	<b>43</b>	2.06

# Possible Solutions

- There are three options:
  1. Do nothing
    - This is the same as ignoring the problem.
  2. Adjust the aim points in the specifications to account for the substrate difference (key objective of this study)
  3. Adapt new standards, including new paper colors

# Correcting Aim Points

- A CGATS substrate project showed how target aims can be corrected using the tristimulus linear method per ISO 13655.
  - Kodak Approval acted as the ‘standard’ press where colorants were transferred to 13 different substrates.
  - Fortune Gloss (one of the substrates) was used as the reference to evaluate the effect of the correction.

# Tristimulus Linear Correction

$$X_2 = X_1(1 + C) - X_{\min} C$$

$$C = \frac{X_{w2} - X_{w1}}{X_{w1} - X_{\min}}$$

$X_1$  is the tristimulus value of Substrate\_1.

$X_2$  is the corrected tristimulus value of Substrate\_1.

C is a constant

$X_{w1}$  is the measured tristimulus value of Substrate\_1.

$X_{w2}$  is the measured tristimulus value of Substrate\_2.

$X_{\min}$  is the minimum tristimulus value of Substrate\_1

(may be substituted by the equivalent of  $10L^*$ ,  $0a^*$ ,  $0b^*$ )

# Research Questions

- Given that
  - Substrates containing OBA are used to print to ISO 12647-2 in offset printing
  - Linear tristimulus correction is applied
- What is the effect of substrate correction on solid color conformance?
- What is the effect of substrate correction on TVI aims?

# Methodology

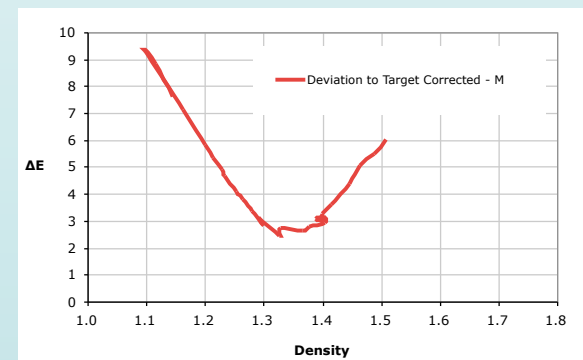
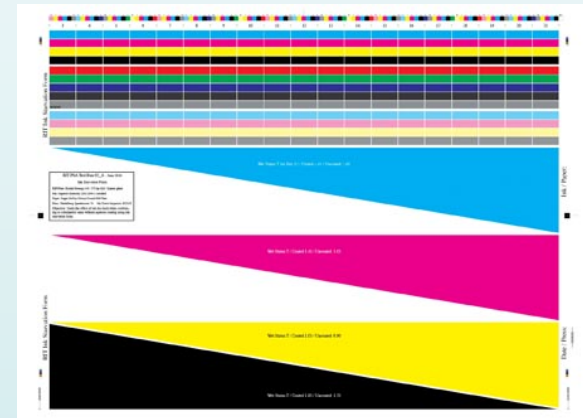
## 1. Press run organization

- Heidelberg 6-color SM 74 offset press
  - Kodak Prinergy 4; 175 lpi AM; linear plates
- Superior Biolocity; ISO 2846-1 certified inks
- Sappi McCoy Gloss; 80# Text, 19”x25”
  - Substrate color: (94L\*, 2a\*, -7b\*)
- Test forms: IT8.7/4 and ‘Ink Starvation’
- Printing aims: ISO 12647-2 PT1

# Methodology

## 2. Evaluate solid color conformance under substrate corrected aims

- Use 'ink starvation' test form to produce a range of ink film thicknesses.
- Measure with i1 Pro and locate the minimum  $\Delta E$  between production and target corrected aims.



# Methodology

3. Evaluate printed (IT8.7/4) color before & after substrate correction.
4. Evaluate TVI under target and target corrected aims.
  - Printing is not required.
  - Obtain the Fogra 39 data set.
  - Apply the substrate correction to the data set.
  - Calculate TVI values for target and target corrected aims per ISO 10128.

# Density-equivalent TVI\*

Magenta and  
Black

$$TVI = 100 \left( \frac{Y_p - Y_t}{Y_p - Y_s} \right) - TV_{Input}$$

Yellow

$$TVI = 100 \left( \frac{Z_p - Z_t}{Z_p - Z_s} \right) - TV_{Input}$$

Cyan

$$TVI = 100 \left[ \frac{(X_p - 0.55Z_p) - (X_t - 0.55Z_t)}{(X_p - 0.55Z_p) - (X_s - 0.55Z_s)} \right] - TV_{Input}$$

\* ISO 10128, Annex A, 2008

# Results

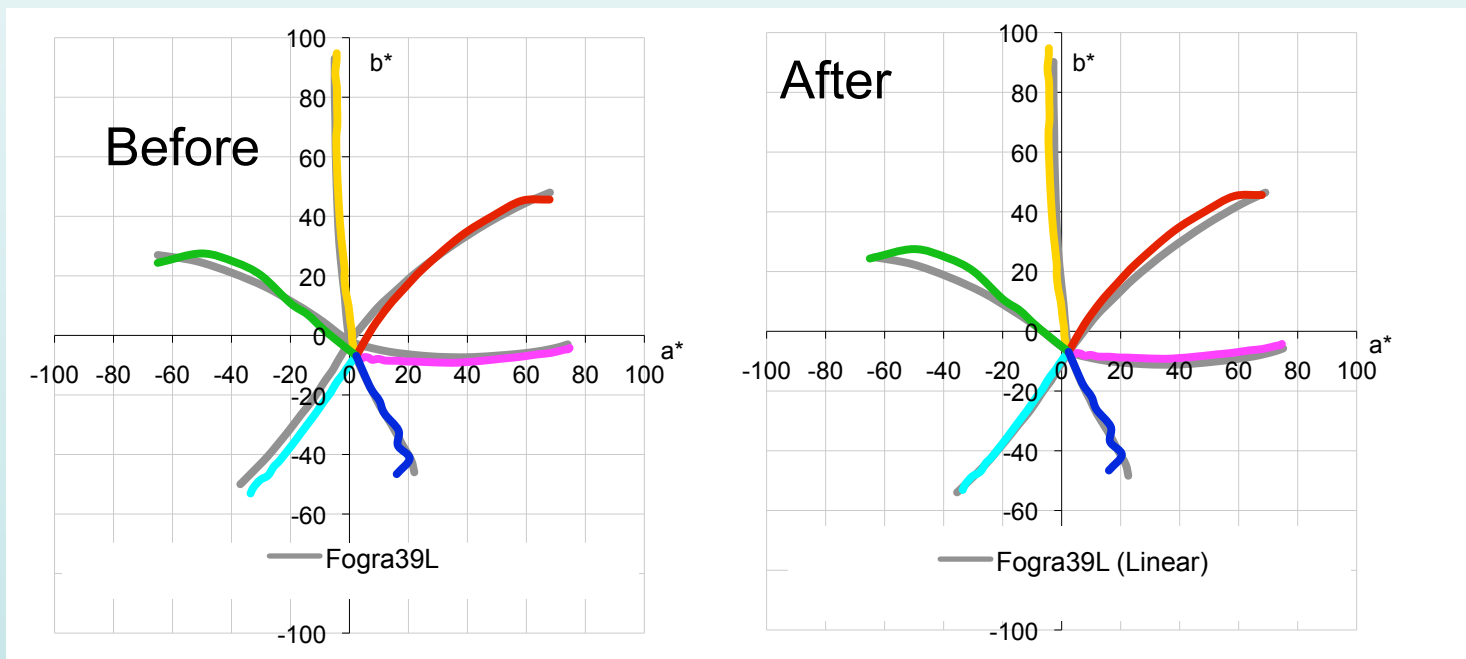
- Solid color conformance -- Production vs. substrate-corrected aims
  - When ISO 12647-2 aim points are adjusted for substrate difference, paper is in conformance; cyan conformance is also improved.

<b>Production (McCoy Gloss)</b>					
	<b>L*</b>	<b>a*</b>	<b>b*</b>	<b>C*</b>	<b>h</b>
<b>Paper</b>	<b>94</b>	<b>2</b>	<b>-7</b>	<b>7</b>	<b>286</b>

	<b>ISO Target (PT 1) Corrected</b>					<b>Minimum ΔEab</b>
	<b>L*</b>	<b>a*</b>	<b>b*</b>	<b>C*</b>	<b>h</b>	<b>Prod &amp; Trgt Corr</b>
<b>Paper</b>	<b>94</b>	<b>2</b>	<b>-7</b>	<b>7</b>	<b>286</b>	<b>0.0</b> ✓
<b>K</b>	<b>16</b>	<b>0</b>	<b>-1</b>	<b>1</b>	<b>292</b>	<b>0.2</b>
<b>C</b>	<b>54</b>	<b>-36</b>	<b>-54</b>	<b>65</b>	<b>237</b>	<b>2.1</b> ✓
<b>M</b>	<b>48</b>	<b>75</b>	<b>-6</b>	<b>75</b>	<b>356</b>	<b>2.5</b>
<b>Y</b>	<b>88</b>	<b>-3</b>	<b>90</b>	<b>90</b>	<b>92</b>	<b>1.3</b>

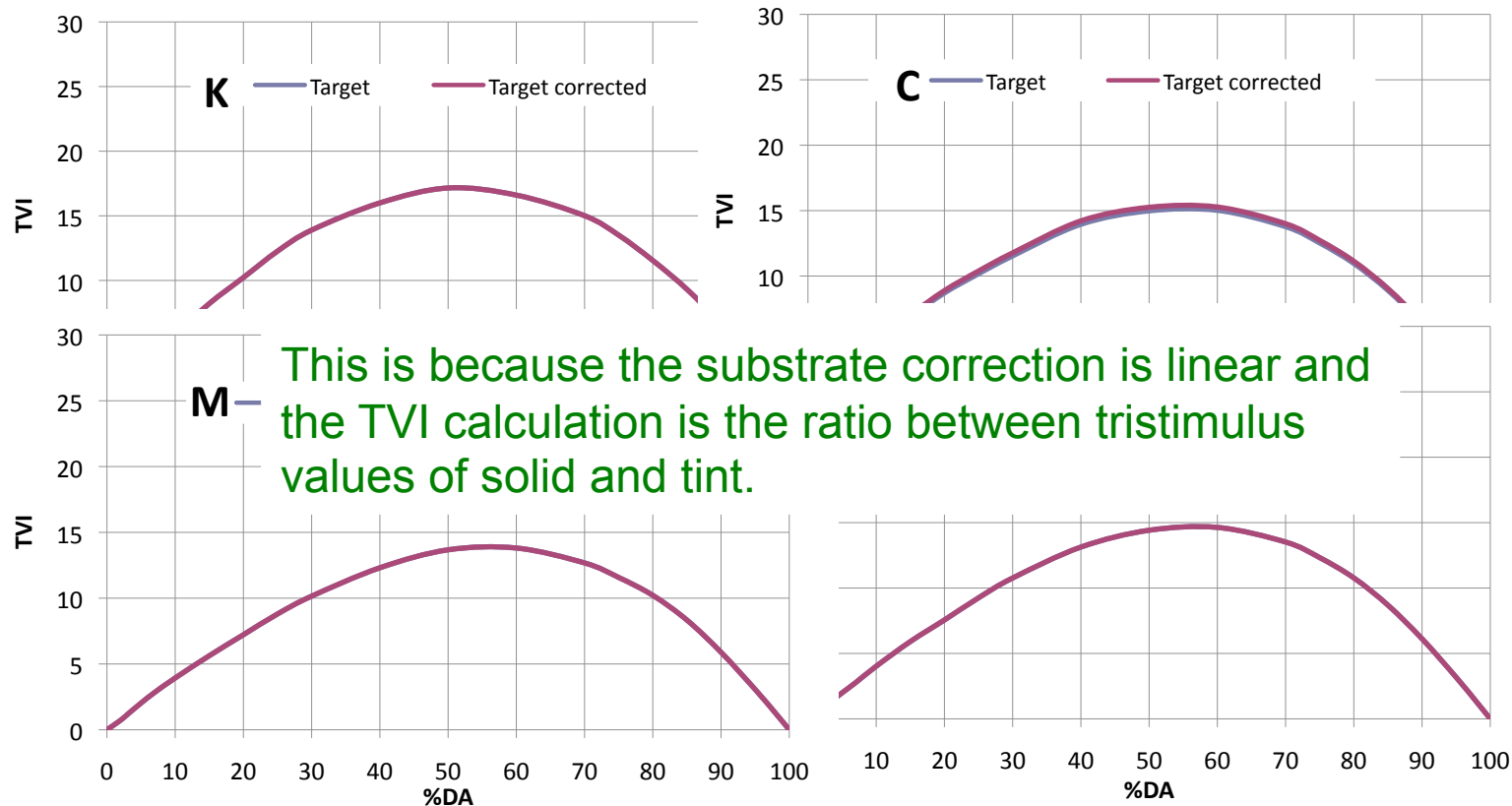
# Results

- Substrate corrected aims improve conformance of printed colors with low ink coverage.
  - In this case, it also improved cyan solid conformance.



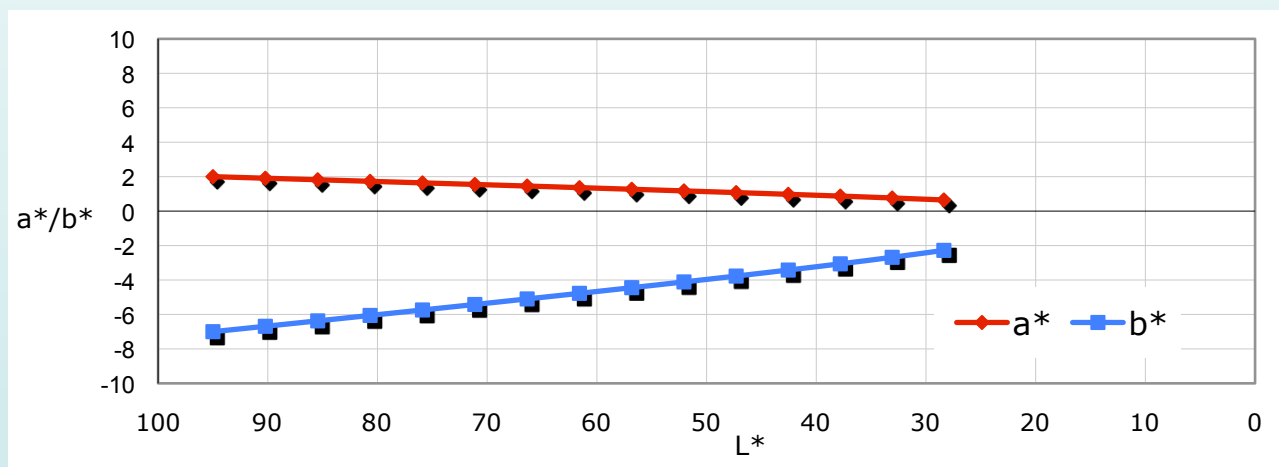
# Results

- Substrate correction has no impact on target vs. target corrected TVI.



# Discussion

- The tristimulus linear method can also be used to compute a substrate-based gray reproduction ramp from an ideal gray ramp (varying  $L^*$ ,  $0a^*$ ,  $0b^*$ ).



# Conclusions

1. Paper aim point and tolerances in ISO 12647-2 (2004) is no longer representative of production paper.
  - ISO/TC 130 needs to come up with a solution.
2. Paper is the fifth color -- colors printed with low ink coverage and those do not absorb short wavelength energy, their hues are affected by paper color.

# Conclusions

3. By correcting colorimetric aims for substrate difference as described, it not only grants production stock conformance, but also significantly reduces OBA induced measurement bias in printed colors.
4. Substrate corrected aims have no effect on TVI aims.

# Recommendation to TC130/WG3

- Correct target aims for OBA-induced difference.
  - The study confirms the benefit of substrate correction to ISO conformance of
    - Substrate itself
    - Printed colors with low ink coverage, and
    - Printed colors that do not absorb short wavelength energy.
- Substrate-corrected gray reproduction ramp has been proposed by ISO 12647-2. We should adapt substrate-corrected colorimetric aims.

# Reference

- 2010 RIT Printing Standards Survey, a PIC monograph (To be published in Nov., 2010)
- USTAG and CGATS Substrate Project Description and Summary Report, US TAG N3634, February 4, 2010
- ISO 13655 Graphic technology-Spectral measurement and colorimetric computation for graphic arts images, 2009
- ISO/TS 10128 Graphic technology — Methods of adjustment of the colour reproduction of a printing system to match a set of characterization data, 2009