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Tested System:
ID#: 328

Printer: Canon Pixma Pro-1

Inks/Colorants: Precision Colors PC29 for Canon Pro-1

Media: Red River Palo Duro Soft Gloss Rag

Coating(s): no additional coating

Sample set: AaI_20160912_SN001

Testing Status: 50 Megalux hours total light exposure
Light fade testing Is complete. Dark storage update on approximately December 10, 2019

Conservation Display Ratings (CDR) Summary to Date:

Sample(s) exposed to light, measured immediately, ie., before any dark storage time
Lower limit: 8 Megalux hours (for weakest 10% of the color patches)
Upper limit: 11 Megalux hours (for average of all the color patches)

Dark Storage control sample, no light exposure, measured after 4 years
Lower limit: excellent condition, not exceeding lower CDR limit
Upper limit: excellent condition, not exceeding upper CDR limit

*Note: a CDR with narrow range (typically less than 2:1) indicates relatively even overall fading of the image. A wide range indicates faster fading in certain local colors/tones prior to general fading of most colors/tones in the entire image. Compare ratings for different systems directly and/or use the table on page 2 to estimate time (years) on display.

* Please read document AaI_2009_0118_TA-01.pdf, **"An Overview of the AaI&A Conservation Display Ratings"**,

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Table of Contents

I Process Description (Printer Inks, Media, etc.)	**page 3**
Tone curve and gray scale neutrality	page 5
II Accelerated Light Exposure Test Results	**Page 6**
Media Whitepoint stability during lightfade test	page 6
I* Color and Tone Graph, Delta E graph	page 7
30 patch target color values (before and after)	pages 8-12
III Light Induced Low-intensity Staining/yellowing Test Results	
Section III has been omitted from this report (see comments and conclusions)	
IV Dark Storage Control Sample Test Results	**page 13**
I* Color and Tone graph	page 13
30 patch target L*a*b* values (before and after)	pages 14-15
V Comments and Conclusions	**page 16**
Addenda	**page 17**
Table to convert megalux hours to "years on display"	page 17
About this report	page 18
Conservation Display Rating Criteria	page 19

Section I: Process Description

This section contains a description of the tested print process, typically comprised of an inkjet printer, a specific set of inks, and a specific choice of media. However, the test report may also describe other photographic and/or photomechanical printing processes such as conventional chromogenic color processes, alternative B&W processes, dye subimation, xerographic processes, etc., and the tested samples may also include additional coatings or laminates applied to the print surface at a later stage in the fabrication. This section may also contain illustrations and other documentation about the the process as well.

Canon Pixma Pro-1, Precision Colors PC29 for Canon Pro-1, Red River Palo Duro Soft Gloss Rag, no additional coating

Sample Set:	**AaI_20160912_SN001** **Batch #:** Q1
Printer:	Canon Pixma Pro-1
Ink:	Precision Colors PC29 for Canon Pro-1
Media:	Red River Palo Duro Soft Gloss Rag
Coating(s):	no additional coating
Test Print Prepared by:	AaI&A member
Printed:	September, 2018
Initial Print colors measured	November 29, 2016
Test Started:	November 30, 2016
Test Image:	AaI_StandardColorSet(v2)forSRGB.tif
RIP/Driver settings:	Canon OEM driver, manual feed, Quality = High, CO= overall, PP Abrasion= on
Media Setting	Photo Paper Plus Semigloss
Profile:	AaI_Pro-1_PCink_RRPDSGR_PPPSG_HQ_Coo.icm
Profile type:	custom, supplied by AaI&A, TC918 target, BasicColor DropRGB software
Rendering intent:	perceptual

Paper White and Maximum Printed Black Values (M0 readings)

Optical brighteners Present? *no*	L*		a*		b*	
	UV inc	UV exc	UV inc	UV exc	UV inc	UV exc
M0 Media Whitepoint Color ISO 13655-2009:	98.2	98.2	0.2	0.2	0.6	0.7
	UV-inc/UV-exc ΔL*, Δa*, Δb* respectively					
	0.0		0.0		0.0	
L* = 98.2 a* = 0.2 b* = 0.6	*Calculated differences, especially for Δb*, indicate the role and magnitude of fluorescence on original paper color*					

Maximum Printed Black	L*	a*	b*	Optical Density (Dmax)
	2.0	0.3	-0.7	2.65

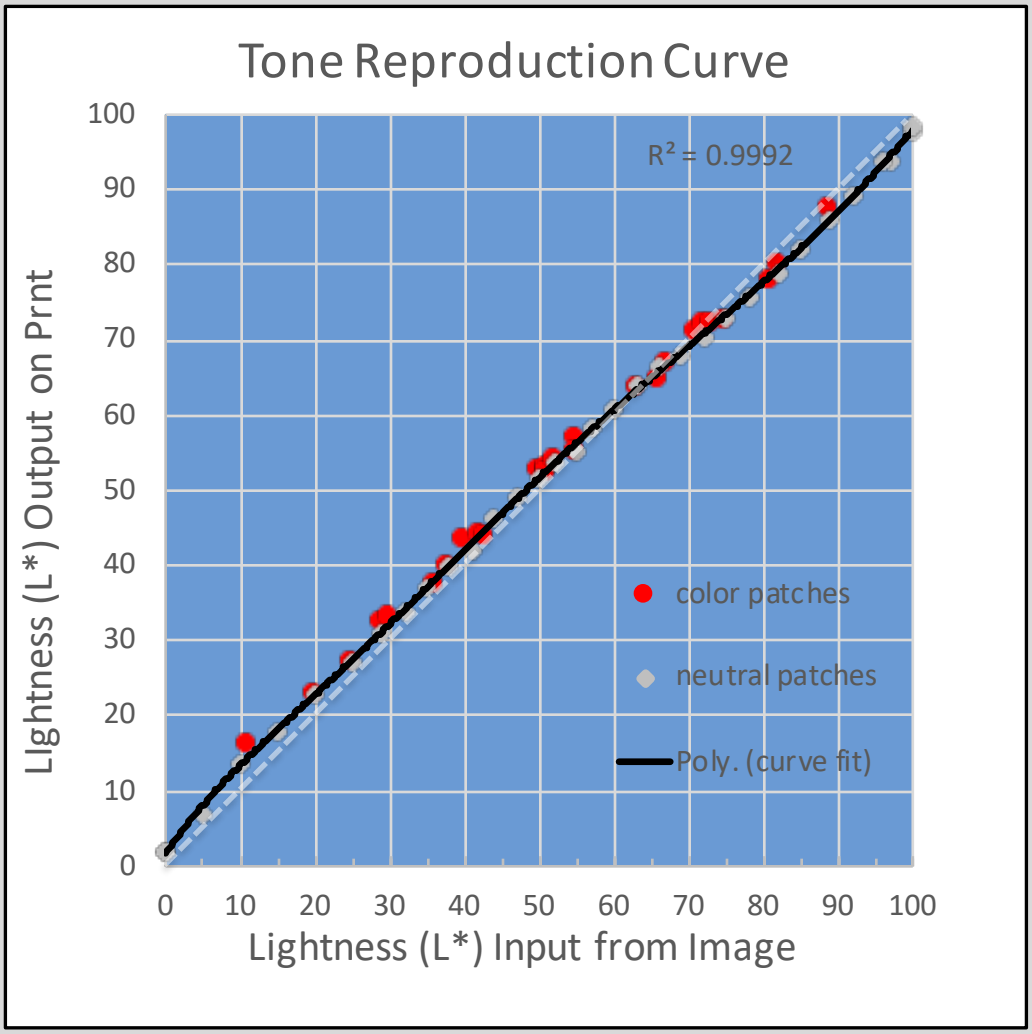
Paper White and Maximum Printed Black Values (M1 readings)

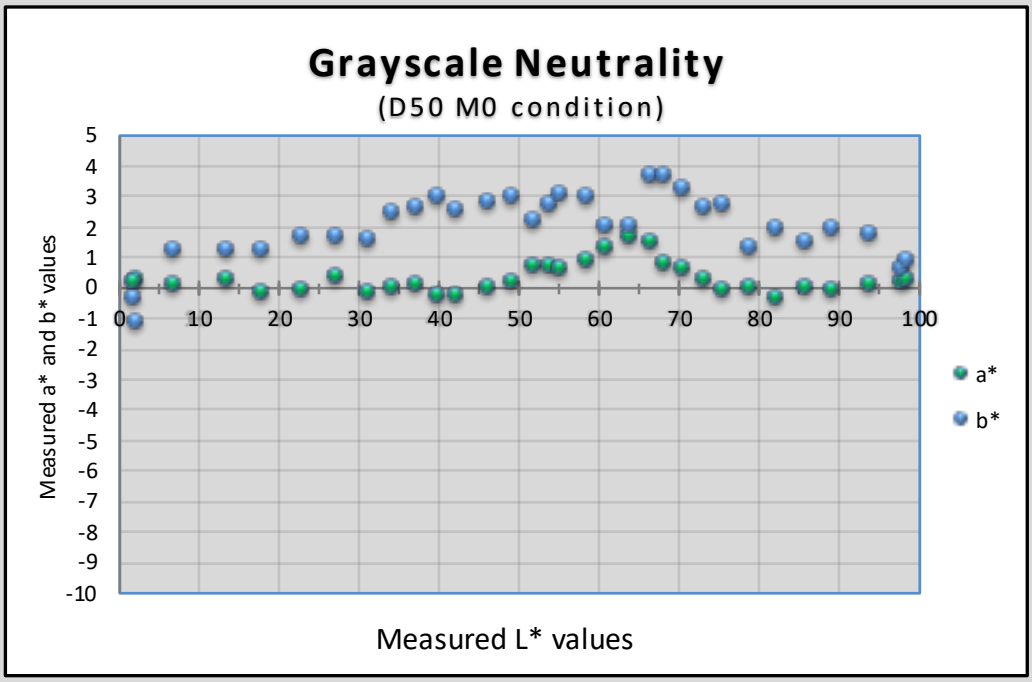
	L*		a*		b*	
	UV inc	UV exc	UV inc	UV exc	UV inc	UV exc
M1 Media Whitepoint Color ISO 13655-2009:	98.2	98.2	0.2	0.2	0.6	0.7
	UV-inc/UV-exc ΔL*, Δa*, Δb* respectively					
	0.0		0.0		0.0	
L* = 98.2 a* = 0.2 b* = 0.6	*Calculated differences, especially for Δb*, indicate the role and magnitude of fluorescence on original paper color*					

Maximum Printed Black	L*	a*	b*	Optical Density (Dmax)
	2.0	0.3	-0.7	2.64

Light source:	Phillips Colortone F40T12/C50 – 5000˚K full spectrum fluorescent. Color rendering Index (CRI) =92)
Light Exposure Cycle:	~12klux illumination, 24 hours per day
Average Temperature:	25.1˚C over full test duration, 25.5˚C during light exposure.
Average Relative humidity:	54.4%RH over full test duration, 54.6%RH during light exposure.
CIELAB measurements:	D50 2˚ observer, Xrite i1Pro2, M0,M1, and M2 conditions where applicable

Initial Image Reproduction – Tone Curve and Grayscale Neutrality

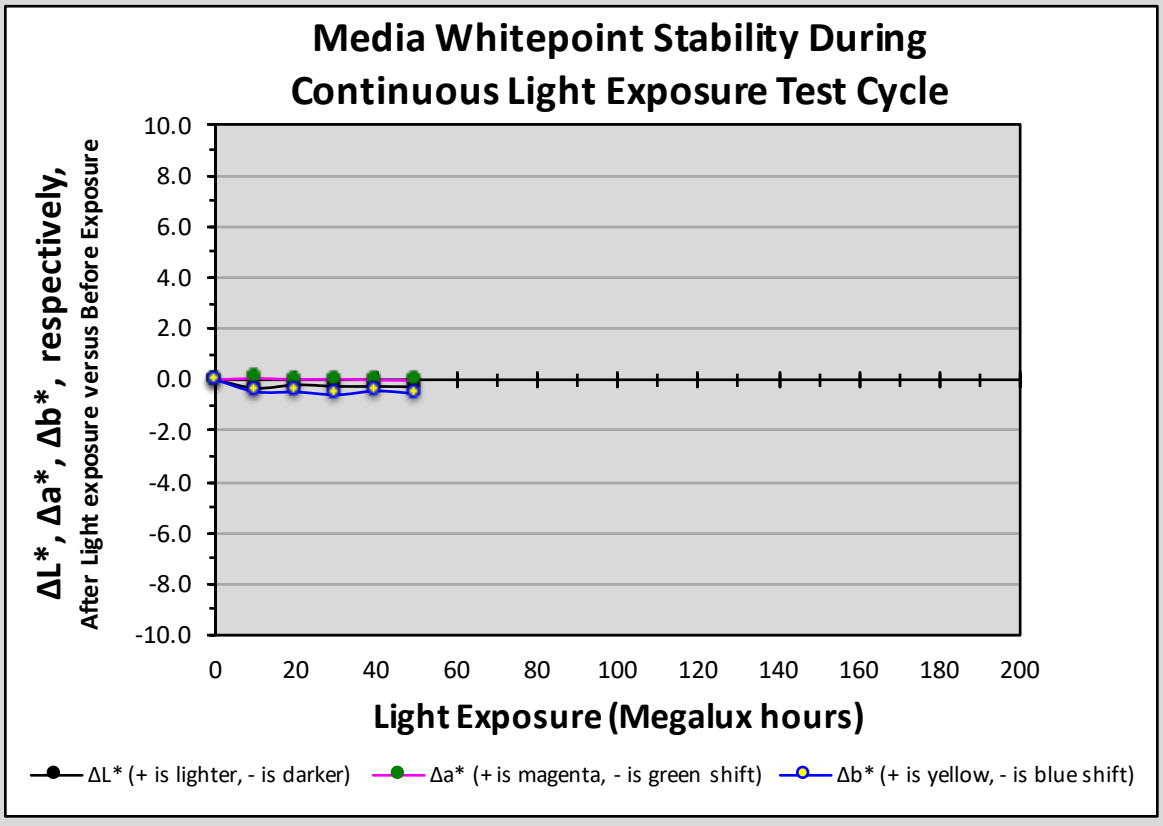


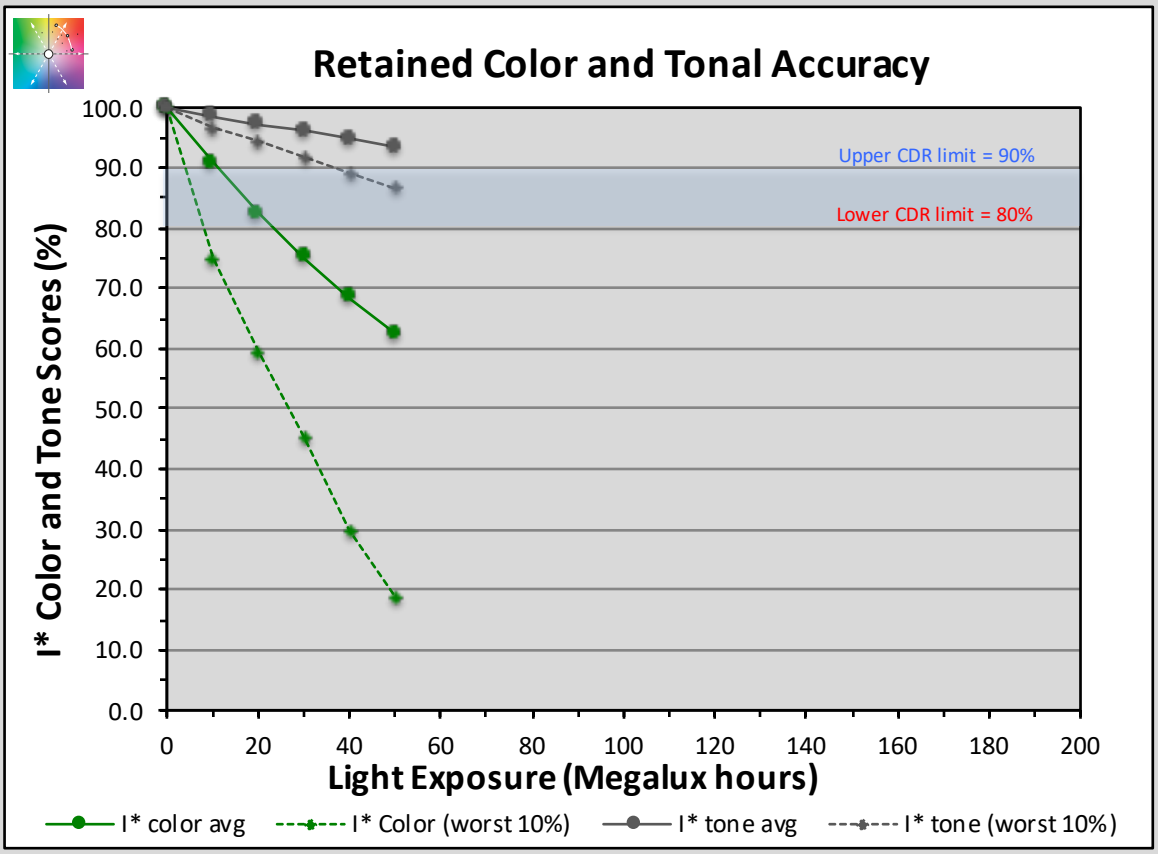


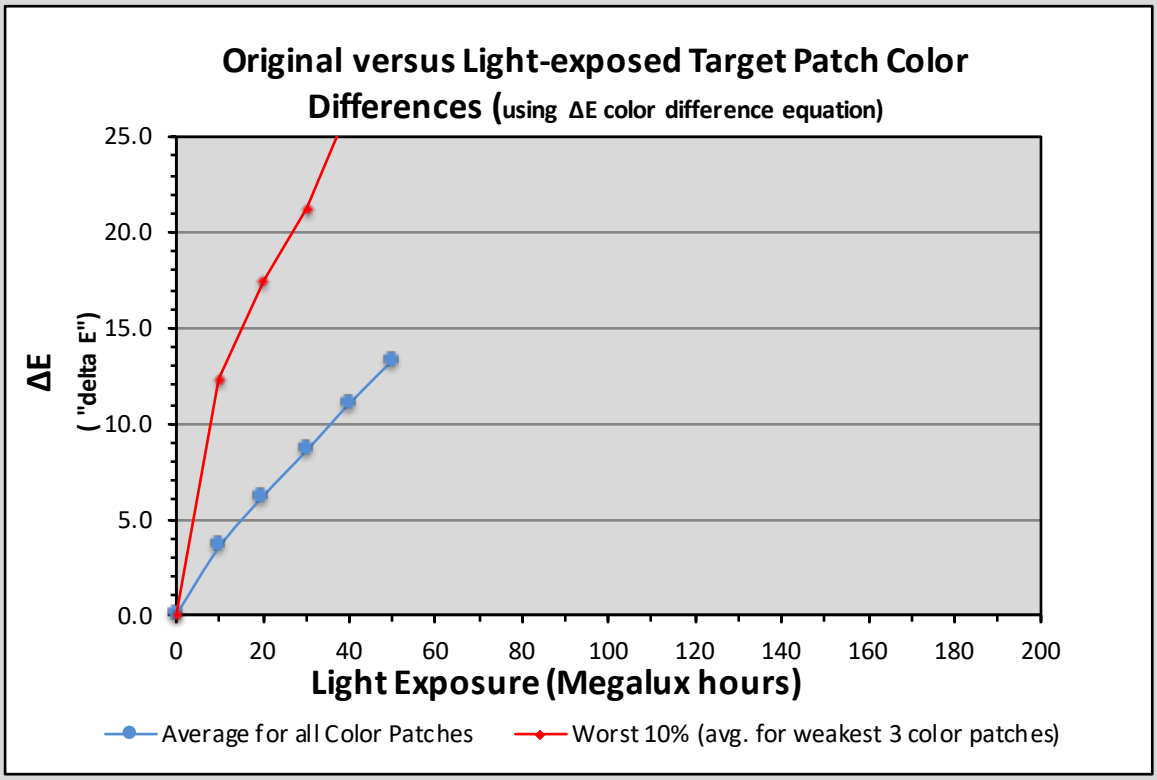
Section II: Accelerated Light Fade test results

This section of the report contains the light exposure test results measured immediately after each exposure interval is completed. Samples are pulled directly from the light fade test unit, measured within a few hours using an Xrite i1 Pro2 spectrophotometer, and then returned to the test unit for additional ongoing exposure. This methodolody is a traditional scientific approach to light fastness testing of photographic materials, and provides insight into the fade resistance of the image forming colorants as well as the fade and discoloration resistance of the media when exposed to continuous illumination on display. However, it does not acccount for any photochemical reaction products which may require longer time periods at ambient room temperature and relative humidity levels to form additional staining or yelowing appearance. Some reaction products are metastable and thus light bleachable, appearing and/or reappearing only over time when the print is displayed under significantly lower average illumination levels or stored in the dark when not continuously on display. See section III for test conditions designed to track this other potential media yellowing issue.

Canon Pixma Pro-1, Precision Colors PC29 for Canon Pro-1, Red River Palo Duro Soft Gloss Rag, no additional coating

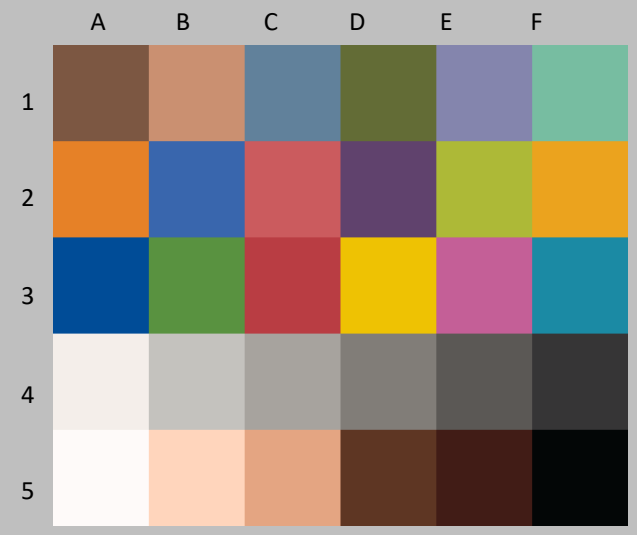




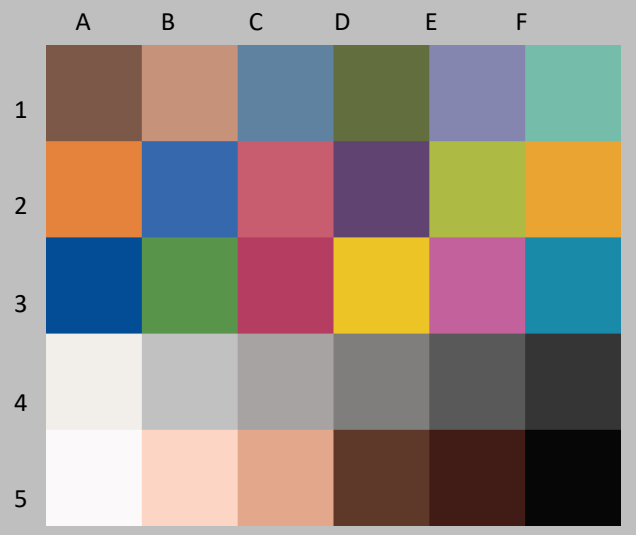


Canon Pixma Pro-1, Precision Colors PC29 for Canon Pro-1, Red River Palo Duro Soft Gloss Rag, no additional coating

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



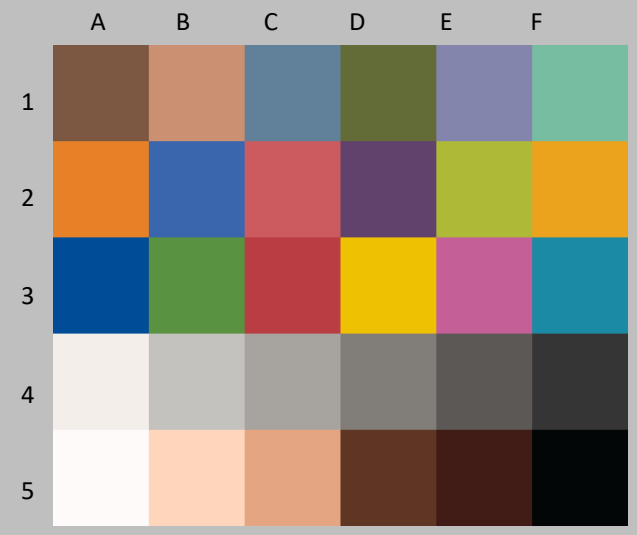
Colors After light exposure

Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	82.9	4.2	40.4	40.7	12.0	12.0	18.2	14.0
B1	Light Skin	85.5	4.8	64.6	65.0	16.5	16.4	24.6	19.8
C1	Blue sky	95.5	1.4	52.6	53.0	-4.8	-4.6	-18.3	-19.6
D1	Foliage	91.0	3.4	43.9	44.2	-13.2	-13.3	28.8	25.5
E1	blue flower	99.0	0.8	56.8	57.2	8.0	7.6	-21.4	-22.0
F1	bluish green	85.4	4.9	71.4	71.8	-29.1	-28.1	7.4	2.6
A1	orange	89.0	8.1	64.1	64.5	32.2	30.8	60.9	53.0
B2	purplish blue	99.9	0.6	43.6	43.9	6.9	6.3	-42.1	-42.1
C2	moderate red	79.3	10.5	53.0	53.3	43.9	44.3	20.4	9.9
D2	purple	99.2	0.8	33.1	33.3	21.5	21.0	-20.0	-20.6
E2	yellow green	93.4	4.8	72.1	72.5	-21.2	-21.4	61.0	56.2
F2	orange yellow	92.8	5.7	72.2	72.5	16.2	15.0	70.5	64.9
A3	blue	99.5	0.8	32.7	33.0	10.2	9.5	-46.6	-46.3
B3	green	93.6	3.8	55.4	55.8	-35.2	-35.2	37.3	33.5
C3	red	67.6	18.3	44.4	44.8	49.3	50.8	24.5	6.2
D3	yellow	94.7	4.8	80.2	80.3	0.7	-0.2	81.1	76.4
E3	magenta	97.4	1.7	54.2	54.4	45.8	45.2	-12.4	-14.0
F3	cyan	95.1	2.0	53.4	53.8	-20.8	-20.3	-22.3	-24.2
A4	white	94.7	1.0	94.4	94.1	0.4	0.4	2.7	1.7
B4	neutral 8	89.9	1.5	78.3	78.2	-0.8	-0.8	1.8	0.4
C4	neutral 6.5	89.7	1.5	67.1	67.3	-0.1	-0.1	2.7	1.3
D4	neutral 5	85.2	1.9	52.4	52.8	0.2	0.4	2.9	1.0
E4	neutral 3.5	83.8	2.1	37.7	38.0	-0.4	-0.2	1.8	-0.2
F4	black	96.4	0.8	22.8	22.9	0.2	0.2	0.4	-0.4
A5	paper white	100.0	0.6	98.5	98.2	0.2	0.3	0.6	0.2
B5	Skin highlight L*=88	78.1	5.1	88.1	88.3	10.6	10.4	18.3	13.2
C5	Skin highlight L* =75	85.0	5.4	73.1	73.4	18.5	18.2	27.0	21.6
D5	Skin shadow L*=28	87.6	3.6	27.4	27.7	15.3	15.1	20.1	16.4
E5	Skin shadow L*=13	98.7	0.8	15.8	15.8	16.7	16.9	11.6	10.8
F5	Maximum Black	98.0	0.7	2.0	1.9	0.4	0.2	-0.8	-0.1

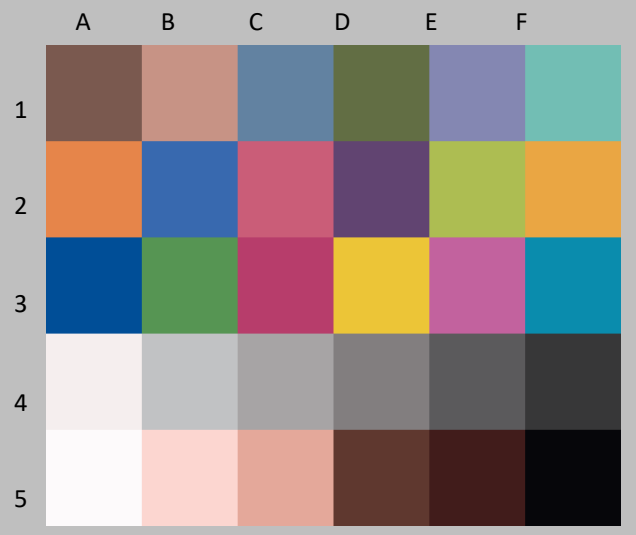
Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	90.9	98.5	3.6
Worst 10% (3 lowest scoring patches)	75.0	96.7	12.3

10 Megalux hours

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



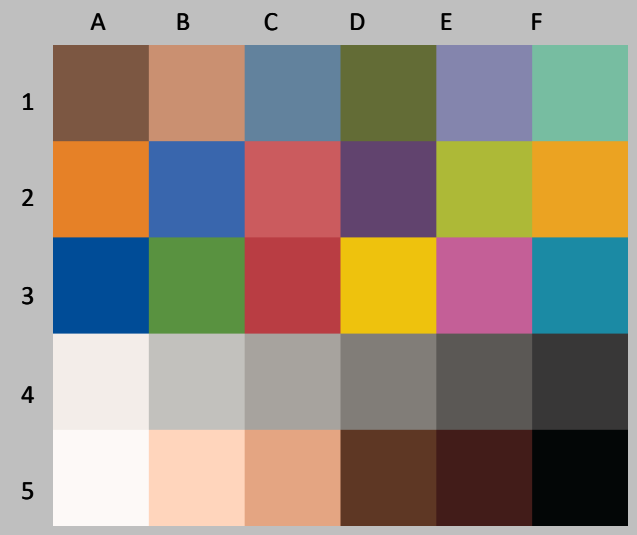
Colors After light exposure

Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	70.9	6.9	40.4	41.1	12.0	12.3	18.2	11.4
B1	Light Skin	70.0	9.4	64.6	65.6	16.5	16.9	24.6	15.2
C1	Blue sky	91.3	2.3	52.6	53.4	-4.8	-4.4	-18.3	-20.4
D1	Foliage	80.1	6.9	43.9	44.7	-13.2	-13.0	28.8	22.0
E1	blue flower	97.2	1.4	56.8	57.6	8.0	7.7	-21.4	-22.5
F1	bluish green	68.3	10.1	71.4	72.3	-29.1	-26.8	7.4	-2.4
A1	orange	80.5	13.9	64.1	65.0	32.2	30.7	60.9	47.1
B2	purplish blue	99.8	0.9	43.6	44.2	6.9	6.3	-42.1	-42.3
C2	moderate red	71.1	14.5	53.0	53.7	43.9	44.7	20.4	5.9
D2	purple	98.6	1.0	33.1	33.6	21.5	21.0	-20.0	-20.7
E2	yellow green	84.7	10.4	72.1	73.2	-21.2	-21.3	61.0	50.6
F2	orange yellow	85.2	11.2	72.2	73.1	16.2	14.6	70.5	59.5
A3	blue	99.2	1.0	32.7	33.1	10.2	9.4	-46.6	-46.3
B3	green	84.1	8.7	55.4	56.4	-35.2	-35.0	37.3	28.7
C3	red	57.3	24.0	44.4	45.2	49.3	51.8	24.5	0.6
D3	yellow	88.1	10.2	80.2	81.0	0.7	-0.7	81.1	71.0
E3	magenta	96.0	2.4	54.2	54.7	45.8	45.2	-12.4	-14.7
F3	cyan	89.7	3.7	53.4	54.2	-20.8	-19.6	-22.3	-25.7
A4	white	88.1	1.6	94.4	94.4	0.4	0.5	2.7	1.1
B4	neutral 8	76.0	2.8	78.3	78.4	-0.8	-0.6	1.8	-0.9
C4	neutral 6.5	74.4	3.0	67.1	67.8	-0.1	0.1	2.7	-0.2
D4	neutral 5	72.4	3.2	52.4	53.2	0.2	0.6	2.9	-0.2
E4	neutral 3.5	73.1	3.1	37.7	38.3	-0.4	0.0	1.8	-1.2
F4	black	88.4	1.6	22.8	23.2	0.2	0.5	0.4	-1.2
A5	paper white	100.0	0.5	98.5	98.3	0.2	0.2	0.6	0.2
B5	Skin highlight L*=88	54.1	10.2	88.1	88.7	10.6	11.0	18.3	8.1
C5	Skin highlight L* =75	67.1	11.3	73.1	74.1	18.5	18.7	27.0	15.8
D5	Skin shadow L*=28	75.7	6.7	27.4	28.4	15.3	15.0	20.1	13.4
E5	Skin shadow L*=13	90.4	2.5	15.8	16.0	16.7	17.0	11.6	9.1
F5	Maximum Black	100.0	0.3	2.0	2.3	0.4	0.4	-0.8	-0.7

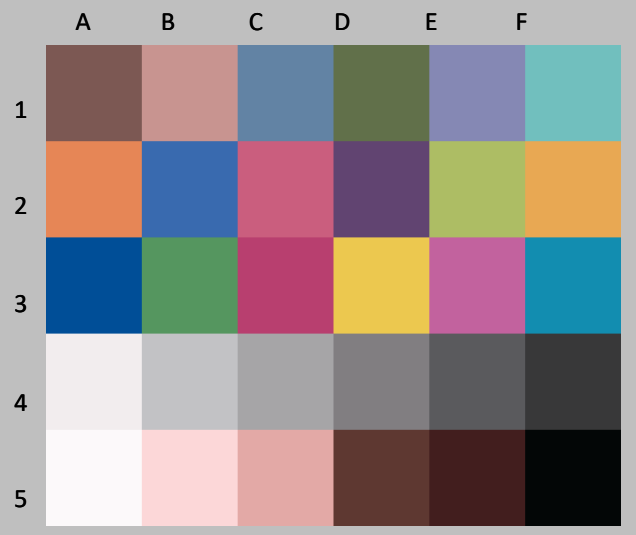
Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	82.4	97.2	6.2
Worst 10% (3 lowest scoring patches)	59.5	94.3	17.5

20 Megalux hours

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



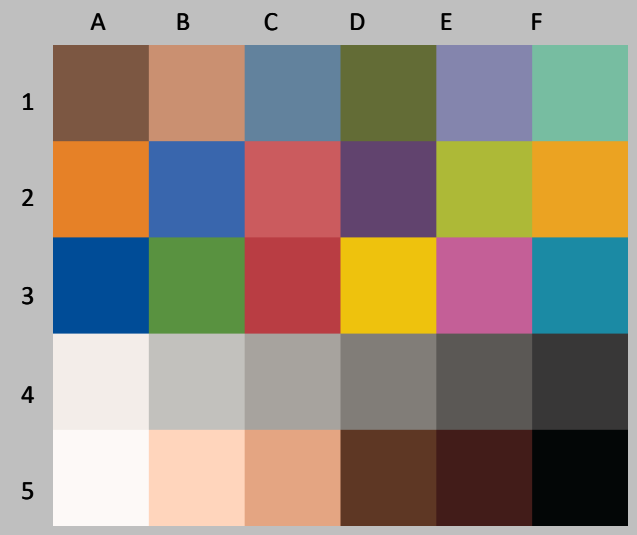
Colors After light exposure

Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	61.3	8.9	40.4	41.3	12.0	12.6	18.0	9.1
B1	Light Skin	52.9	14.5	64.8	66.1	16.7	17.8	24.6	10.1
C1	Blue sky	87.9	3.0	52.8	53.8	-4.7	-4.2	-18.3	-21.1
D1	Foliage	69.5	10.2	43.9	44.9	-13.3	-12.6	28.7	18.6
E1	blue flower	95.6	1.8	56.9	57.9	8.1	7.8	-21.5	-23.0
F1	bluish green	52.3	14.7	71.4	72.6	-28.9	-25.2	7.1	-7.1
A1	orange	71.2	20.4	64.1	65.4	32.2	30.6	60.9	40.6
B2	purplish blue	99.8	1.1	43.7	44.6	6.8	6.3	-42.0	-42.3
C2	moderate red	64.8	17.5	53.0	54.0	43.9	45.0	20.3	2.8
D2	purple	98.4	1.1	33.3	33.9	21.3	20.9	-20.0	-20.9
E2	yellow green	73.4	17.7	72.2	73.9	-21.1	-20.5	60.9	43.2
F2	orange yellow	75.9	17.9	72.1	73.5	16.1	14.5	70.1	52.3
A3	blue	98.4	1.5	32.7	33.4	10.1	8.9	-46.6	-46.2
B3	green	73.7	14.0	55.4	56.9	-35.2	-34.2	37.1	23.2
C3	red	54.6	25.4	44.4	45.4	49.1	51.7	24.2	-1.0
D3	yellow	79.7	16.8	80.1	81.5	0.7	-0.8	80.0	63.3
E3	magenta	95.2	2.9	54.2	55.0	45.6	45.1	-12.5	-15.2
F3	cyan	85.5	5.0	53.4	54.5	-20.8	-19.1	-22.3	-26.9
A4	white	82.0	2.2	94.2	94.3	0.3	0.6	2.7	0.5
B4	neutral 8	65.0	3.8	78.1	78.5	-0.9	-0.5	1.9	-2.0
C4	neutral 6.5	61.4	4.3	67.0	68.0	-0.1	0.4	2.7	-1.5
D4	neutral 5	62.6	4.2	52.4	53.5	0.2	0.8	2.9	-1.1
E4	neutral 3.5	66.6	3.7	37.8	38.6	-0.5	0.1	1.7	-1.9
F4	black	87.0	1.8	23.0	23.5	0.3	0.3	0.4	-1.3
A5	paper white	99.0	0.6	98.2	98.0	0.2	0.2	0.7	0.1
B5	Skin highlight L*=88	34.3	14.4	88.1	89.0	10.5	11.6	18.3	4.0
C5	Skin highlight L* =75	48.9	17.3	73.0	74.6	18.5	19.6	27.0	9.8
D5	Skin shadow L*=28	72.8	7.2	27.6	28.2	15.1	15.4	19.3	12.2
E5	Skin shadow L*=13	86.7	3.2	16.1	16.3	16.6	16.9	11.3	8.2
F5	Maximum Black	100.0	0.4	2.1	2.1	0.4	0.1	-1.0	-0.6

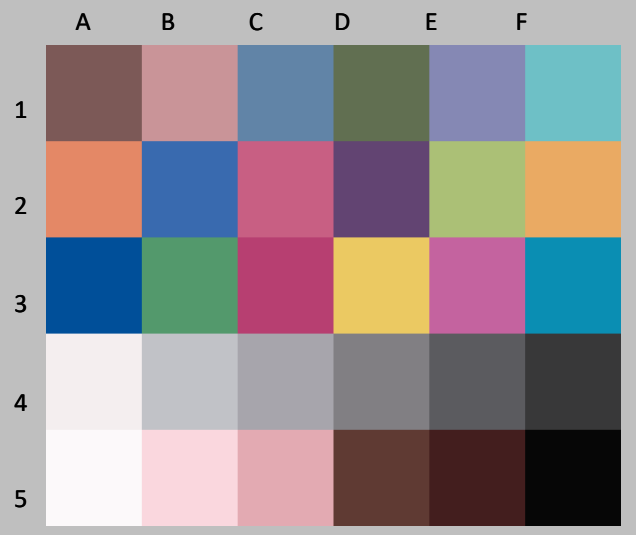
Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	75.2	96.1	8.6
Worst 10% (3 lowest scoring patches)	45.2	91.6	21.2

30 Megalux hours

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



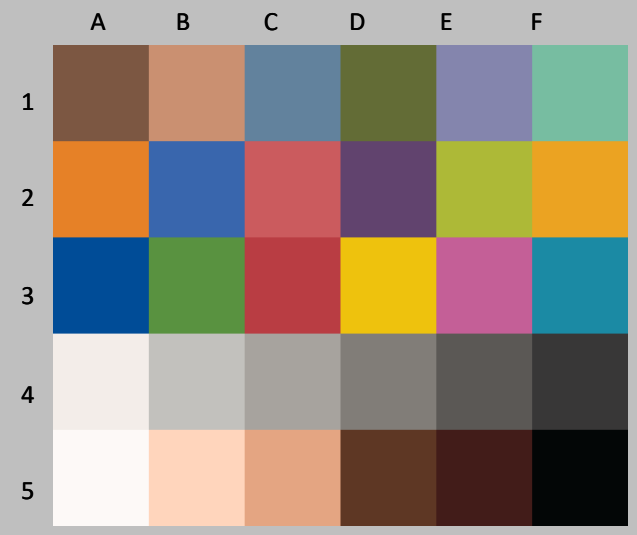
Colors After light exposure

				L*		a*		b*	
Patch #	Description	I* Color	ΔE	Before	After	Before	After	Before	After
A1	Dark Skin	52.1	10.9	40.4	41.6	12.0	12.9	18.0	7.2
B1	Light Skin	38.0	19.0	64.8	66.5	16.7	18.6	24.6	5.8
C1	Blue sky	85.2	3.5	52.8	54.0	-4.7	-4.0	-18.3	-21.6
D1	Foliage	57.2	14.1	43.9	45.2	-13.3	-11.9	28.7	14.8
E1	blue flower	95.0	2.1	56.9	58.2	8.1	7.9	-21.5	-23.1
F1	bluish green	38.6	18.8	71.4	72.8	-28.9	-23.8	7.1	-10.9
A1	orange	60.9	27.5	64.1	65.8	32.2	31.0	60.9	33.5
B2	purplish blue	99.6	1.3	43.7	44.8	6.8	6.1	-42.0	-42.2
C2	moderate red	59.4	20.1	53.0	54.3	43.9	45.3	20.3	0.3
D2	purple	98.9	1.2	33.3	34.1	21.3	20.7	-20.0	-20.6
E2	yellow green	60.8	25.8	72.2	74.6	-21.1	-19.7	60.9	35.2
F2	orange yellow	65.5	25.4	72.1	74.1	16.1	14.6	70.1	44.8
A3	blue	97.8	1.8	32.7	33.7	10.1	8.8	-46.6	-45.9
B3	green	61.0	20.5	55.4	57.5	-35.2	-32.9	37.1	16.8
C3	red	53.0	26.3	44.4	45.5	49.1	52.0	24.2	-1.9
D3	yellow	69.1	25.3	80.1	82.1	0.7	-0.8	80.0	54.9
E3	magenta	94.6	3.2	54.2	55.2	45.6	45.0	-12.5	-15.5
F3	cyan	82.1	6.1	53.4	54.7	-20.8	-18.6	-22.3	-27.8
A4	white	77.8	2.6	94.2	94.4	0.3	0.8	2.7	0.1
B4	neutral 8	57.3	4.6	78.1	78.5	-0.9	-0.2	1.9	-2.7
C4	neutral 6.5	50.1	5.4	67.0	68.1	-0.1	0.6	2.7	-2.5
D4	neutral 5	53.6	5.1	52.4	53.7	0.2	1.1	2.9	-1.9
E4	neutral 3.5	60.4	4.4	37.8	38.8	-0.5	0.3	1.7	-2.5
F4	black	86.0	1.9	23.0	23.7	0.3	0.4	0.4	-1.4
A5	paper white	100.0	0.5	98.2	98.0	0.2	0.2	0.7	0.2
B5	Skin highlight L*=88	19.2	17.6	88.1	89.0	10.5	12.3	18.3	0.8
C5	Skin highlight L* =75	32.0	22.9	73.0	75.0	18.5	20.6	27.0	4.3
D5	Skin shadow L*=28	66.4	8.8	27.6	28.8	15.1	15.2	19.3	10.6
E5	Skin shadow L*=13	84.6	3.7	16.1	16.8	16.6	16.7	11.3	7.7
F5	Maximum Black	96.1	1.0	2.1	2.5	0.4	0.0	-1.0	-0.2

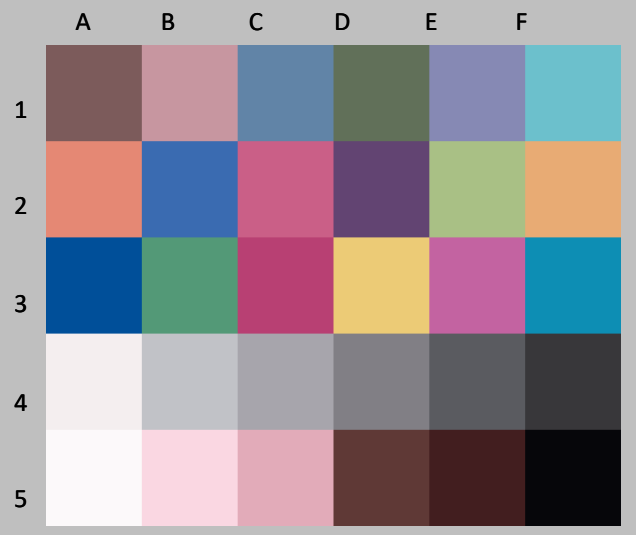
Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	68.4	94.8	11.0
Worst 10% (3 lowest scoring patches)	29.7	89.0	26.5

40 Megalux hours

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



Colors After light exposure

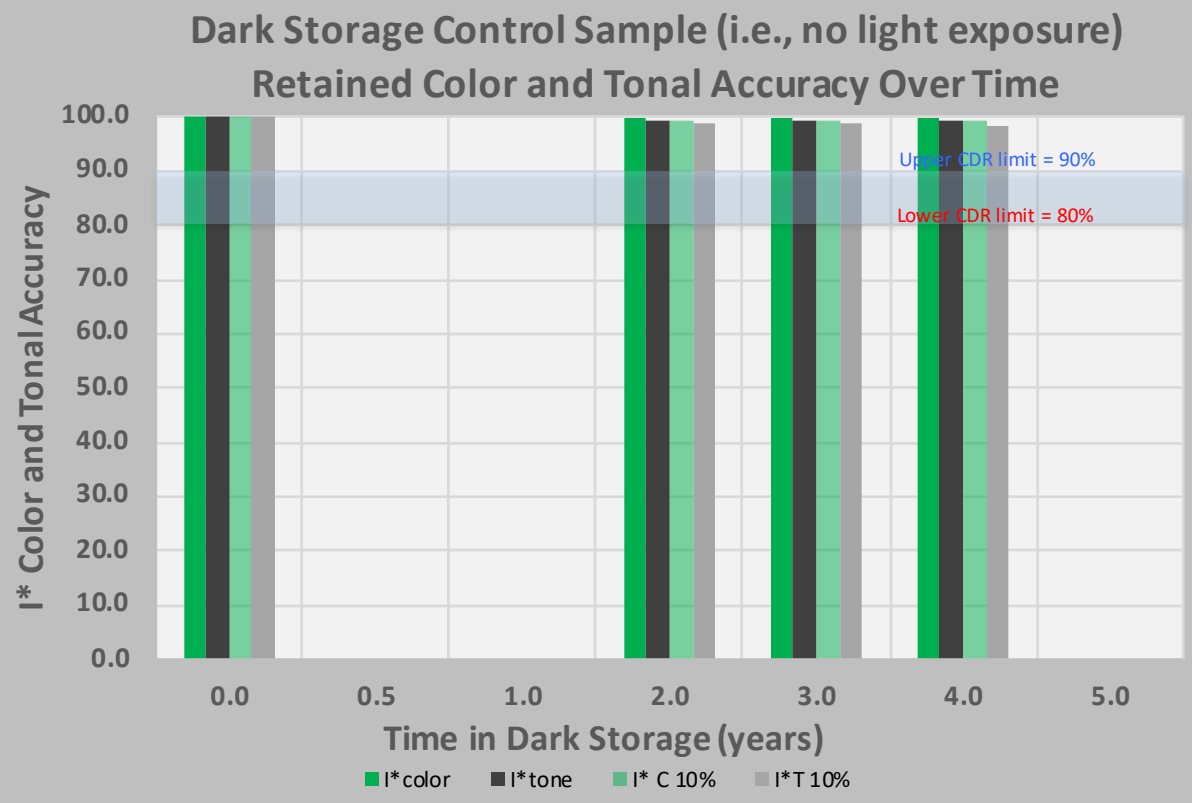
Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	43.2	12.8	40.4	41.8	12.0	13.3	18.0	5.3
B1	Light Skin	26.0	22.6	64.8	66.9	16.7	19.4	24.6	2.3
C1	Blue sky	83.1	4.0	52.8	54.2	-4.7	-3.8	-18.3	-21.9
D1	Foliage	45.1	17.9	43.9	45.5	-13.3	-11.2	28.7	11.0
E1	blue flower	94.2	2.3	56.9	58.4	8.1	8.0	-21.5	-23.3
F1	bluish green	28.6	21.8	71.4	72.9	-28.9	-22.6	7.1	-13.7
A1	orange	50.6	34.6	64.1	66.2	32.2	31.5	60.9	26.4
B2	purplish blue	99.5	1.5	43.7	45.0	6.8	6.1	-42.0	-42.1
C2	moderate red	54.8	22.4	53.0	54.5	43.9	45.7	20.3	-2.0
D2	purple	98.7	1.3	33.3	34.3	21.3	20.7	-20.0	-20.6
E2	yellow green	47.7	34.3	72.2	75.1	-21.1	-18.6	60.9	26.8
F2	orange yellow	54.1	33.6	72.1	74.6	16.1	15.1	70.1	36.6
A3	blue	97.5	2.0	32.7	33.8	10.1	8.6	-46.6	-45.8
B3	green	48.6	26.9	55.4	58.0	-35.2	-31.4	37.1	10.6
C3	red	51.8	27.0	44.4	45.7	49.1	52.1	24.2	-2.5
D3	yellow	57.6	34.5	80.1	82.7	0.7	-0.4	80.0	45.6
E3	magenta	93.8	3.6	54.2	55.4	45.6	45.1	-12.5	-15.9
F3	cyan	79.4	7.0	53.4	54.9	-20.8	-18.2	-22.3	-28.5
A4	white	73.3	3.0	94.2	94.4	0.3	0.9	2.7	-0.3
B4	neutral 8	51.1	5.2	78.1	78.6	-0.9	0.0	1.9	-3.2
C4	neutral 6.5	42.0	6.2	67.0	68.3	-0.1	0.8	2.7	-3.3
D4	neutral 5	45.7	5.8	52.4	53.9	0.2	1.2	2.9	-2.7
E4	neutral 3.5	53.8	5.0	37.8	38.9	-0.5	0.5	1.7	-3.1
F4	black	82.3	2.3	23.0	23.7	0.3	0.6	0.4	-1.7
A5	paper white	99.5	0.6	98.2	98.0	0.2	0.2	0.7	0.1
B5	Skin highlight L*=88	10.2	19.5	88.1	89.2	10.5	12.7	18.3	-1.0
C5	Skin highlight L* =75	20.2	26.7	73.0	75.4	18.5	21.4	27.0	0.5
D5	Skin shadow L*=28	61.3	10.1	27.6	28.6	15.1	15.6	19.3	9.3
E5	Skin shadow L*=13	81.7	4.2	16.1	16.5	16.6	17.1	11.3	7.2
F5	Maximum Black	100.0	0.5	2.1	2.2	0.4	0.1	-1.0	-0.7

Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	62.5	93.5	13.3
Worst 10% (3 lowest scoring patches)	18.8	86.6	34.5

50 Megalux hours

Section IV: Ongoing Dark Storage Test Results

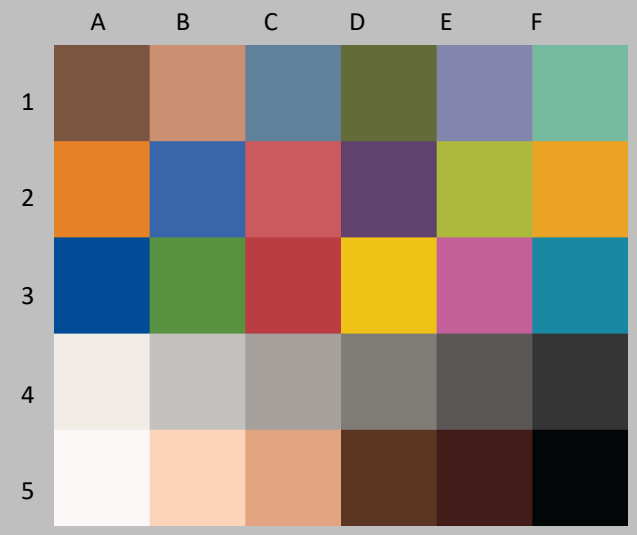
This section of the report tracks a sample of this print process (i.e., printer/ink/media) that remains in an amibient room temperature/moderate RH dark storage environment and has not been subjected to light exposure tests like the other samples. It is essentially a "control" sample that will remain in natural aging conditions (e.g., photo album storage) while the other light fastness tests are ongoing, and then in the Aardenburg Archives under simliar conditions indefinitely along with the retired light fade samples. The chart below will be rescaled to longer time intervals once total acumulated storage time exceeds 5 years.



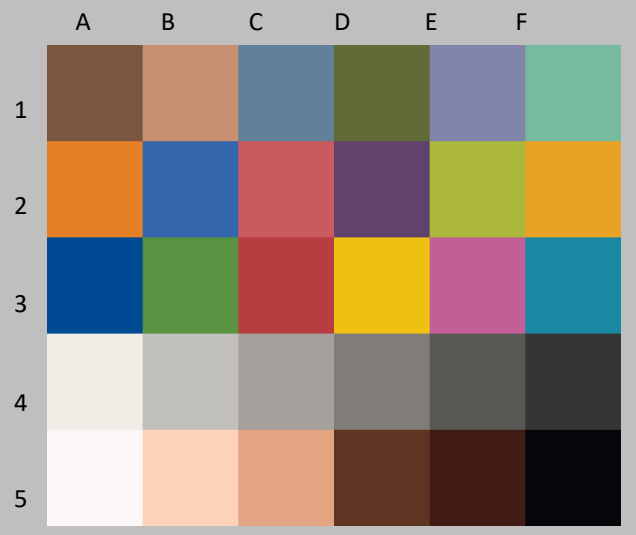
Time in Storage Summary for Dark Storage Control Sample

Years	*I*color (worst 10%)*	*I* Tone (10%)*	I* Color	I* tone	ΔE avg.	ΔE (worst 10%)
0.0	100.0	*100.0*	100.0	100.0	0.0	0.0
0.5						
1.0						
2.0	99.4	*98.6*	99.9	99.4	0.4	0.6
3.0	99.4	*98.5*	99.9	99.5	0.4	0.7
4.0	99.1	*98.5*	99.8	99.3	0.5	0.7
5.0						

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



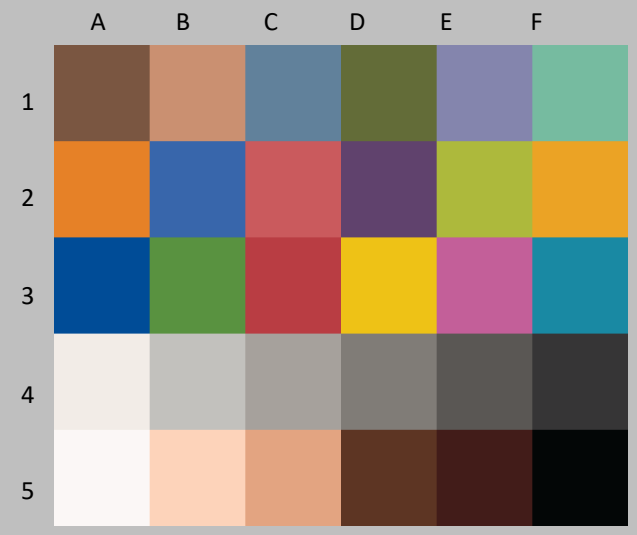
Colors after additional time in dark storage

Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	100.0	0.3	40.0	39.9	11.9	11.8	17.8	18.1
B1	Light Skin	100.0	0.3	64.6	64.5	16.6	16.5	24.7	24.9
C1	Blue sky	100.0	0.5	52.6	52.6	-4.7	-5.0	-18.3	-17.9
D1	Foliage	100.0	0.3	43.8	43.7	-13.2	-13.2	28.3	28.6
E1	blue flower	100.0	0.5	56.7	56.6	8.0	7.7	-21.3	-20.9
F1	bluish green	99.5	0.7	71.2	71.0	-28.7	-29.0	7.0	7.6
A1	orange	100.0	0.3	63.8	63.6	32.2	32.1	61.0	60.8
B2	purplish blue	100.0	0.5	43.3	43.3	6.6	6.4	-42.0	-41.5
C2	moderate red	100.0	0.3	52.7	52.6	43.8	43.7	20.2	20.3
D2	purple	100.0	0.3	33.1	33.1	21.3	21.1	-20.0	-19.7
E2	yellow green	100.0	0.3	72.0	71.9	-20.9	-20.8	58.9	59.0
F2	orange yellow	100.0	0.2	72.1	71.8	16.0	16.0	69.4	69.4
A3	blue	100.0	0.4	32.4	32.3	10.0	9.8	-46.8	-46.4
B3	green	100.0	0.2	55.2	55.1	-35.1	-35.0	37.0	37.2
C3	red	100.0	0.2	44.2	44.1	49.2	49.0	24.4	24.5
D3	yellow	100.0	0.2	80.0	79.8	0.6	0.6	79.4	79.4
E3	magenta	100.0	0.4	54.1	53.9	45.8	45.5	-12.5	-12.2
F3	cyan	100.0	0.5	53.1	53.0	-20.9	-21.1	-22.4	-22.0
A4	white	100.0	0.4	93.8	93.6	0.2	0.0	2.5	2.9
B4	neutral 8	100.0	0.4	77.9	77.7	-0.9	-1.0	1.9	2.2
C4	neutral 6.5	100.0	0.4	66.8	66.7	0.0	-0.2	2.7	3.0
D4	neutral 5	100.0	0.3	52.2	52.1	0.2	0.0	2.9	3.2
E4	neutral 3.5	100.0	0.3	37.4	37.4	-0.4	-0.5	1.8	2.0
F4	black	100.0	0.2	22.9	22.8	0.2	0.1	0.3	0.5
A5	paper white	100.0	0.1	97.6	97.5	0.2	0.1	0.7	0.7
B5	Skin highlight L*=88	100.0	0.3	87.5	87.4	10.4	10.3	18.2	18.4
C5	Skin highlight L* =75	100.0	0.3	72.7	72.6	18.4	18.4	26.9	27.3
D5	Skin shadow L*=28	100.0	0.4	27.2	27.2	15.2	15.1	19.4	19.8
E5	Skin shadow L*=13	100.0	0.4	15.9	15.8	16.9	16.8	11.3	11.7
F5	Maximum Black	98.6	0.7	2.1	2.4	0.3	0.1	-1.1	-0.5

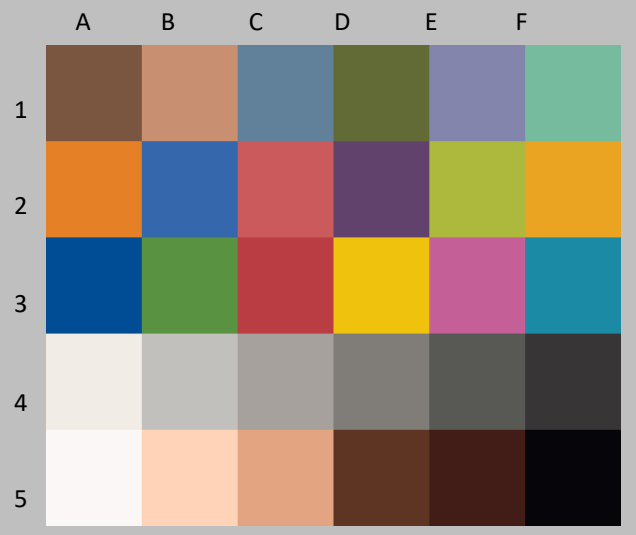
Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	99.9	99.4	0.4
Worst 10% (3 lowest scoring patches)	99.4	98.6	0.6

DS Control at 2 years

Printer: Canon Pro-1000 **Ink:** Precision Colors PC29 **Media:** Red River Palo Duro Soft Gloss Rag, no additional coating



Original Print Colors before light exposure



Colors after additional time in dark storage

Patch #	Description	I* Color	ΔE	L* Before	L* After	a* Before	a* After	b* Before	b* After
A1	Dark Skin	100.0	0.4	40.0	40.0	11.9	11.8	17.8	18.2
B1	Light Skin	100.0	0.3	64.6	64.5	16.6	16.6	24.7	24.9
C1	Blue sky	99.4	0.6	52.6	52.6	-4.7	-5.1	-18.3	-17.8
D1	Foliage	100.0	0.3	43.8	43.7	-13.2	-13.2	28.3	28.7
E1	blue flower	99.8	0.5	56.7	56.7	8.0	7.7	-21.3	-20.9
F1	bluish green	99.3	0.7	71.2	71.1	-28.7	-29.0	7.0	7.7
A1	orange	100.0	0.1	63.8	63.7	32.2	32.1	61.0	60.9
B2	purplish blue	100.0	0.5	43.3	43.3	6.6	6.4	-42.0	-41.6
C2	moderate red	100.0	0.3	52.7	52.7	43.8	43.7	20.2	20.5
D2	purple	100.0	0.4	33.1	33.1	21.3	21.1	-20.0	-19.7
E2	yellow green	100.0	0.4	72.0	72.0	-20.9	-20.8	58.9	59.3
F2	orange yellow	100.0	0.4	72.1	72.0	16.0	16.0	69.4	69.8
A3	blue	100.0	0.5	32.4	32.4	10.0	9.7	-46.8	-46.4
B3	green	100.0	0.4	55.2	55.2	-35.1	-35.1	37.0	37.4
C3	red	100.0	0.3	44.2	44.2	49.2	49.2	24.4	24.7
D3	yellow	100.0	0.2	80.0	79.9	0.6	0.7	79.4	79.6
E3	magenta	100.0	0.4	54.1	54.0	45.8	45.6	-12.5	-12.2
F3	cyan	99.7	0.6	53.1	53.2	-20.9	-21.2	-22.4	-21.9
A4	white	99.9	0.5	93.8	93.8	0.2	0.0	2.5	3.0
B4	neutral 8	100.0	0.5	77.9	77.8	-0.9	-1.0	1.9	2.3
C4	neutral 6.5	99.7	0.5	66.8	66.8	0.0	-0.2	2.7	3.1
D4	neutral 5	100.0	0.4	52.2	52.3	0.2	0.0	2.9	3.3
E4	neutral 3.5	100.0	0.4	37.4	37.4	-0.4	-0.6	1.8	2.1
F4	black	100.0	0.4	22.9	22.8	0.2	0.1	0.3	0.6
A5	paper white	100.0	0.2	97.6	97.6	0.2	0.1	0.7	0.8
B5	Skin highlight L*=88	99.6	0.6	87.5	87.5	10.4	10.2	18.2	18.7
C5	Skin highlight L* =75	99.9	0.5	72.7	72.7	18.4	18.4	26.9	27.5
D5	Skin shadow L*=28	100.0	0.4	27.2	27.2	15.2	15.1	19.4	19.8
E5	Skin shadow L*=13	100.0	0.5	15.9	15.9	16.9	16.7	11.3	11.8
F5	Maximum Black	99.4	0.6	2.1	2.4	0.3	0.2	-1.1	-0.6

Summary Results	I* Color	I* tone	ΔE
Average Score for all patches	99.9	99.5	0.4
Worst 10% (3 lowest scoring patches)	99.4	98.5	0.7

DS Control at 3 years

Section V: Comments and Conclusions

ID# 328

Print Quality:

A custom ICC profile was created for this test of the Precision Colors PC29 ink set. As can be seen on page 5 in this report, the tone reproduction curve is very good and the gray scale neutrality is satisfactory. Amateur printmakers who switch over to the Precision Color PC29 inks are likely to be pleased with initial image quality even though it isn't a perfect match to the Pixma Pro-1's OEM PGI-29 ink set (see ID# 331 for the Pro-1/ OEM PGI-29/Red River Palo Duro Soft gloss test results).

Print Longevity:

The PC29 ink set is rated in our testing at 8-11 Megalux hours of total exposure where little or no noticeable fading will be observed compared to the Canon OEM ink set which received an Aardenburg Conservation Display rating of 47-66 Megalux hours. Hence the OEM ink is 6x more fade resistant in the early stages before fading becomes easily noticeable. As always, the use of third party ink is a trade-off between image quality and print longevity versus cost savings. Only the enduser can determine whether that trade-off makes sense.

In view of the poor overall lightfastness of the PC29 ink set, this printer/ink/media combination was not evaluated for further light Induced Low-intensity Staining (LILIS). Therefore, section III was omitted from this report.

LILIS is a media related issue. It contributes to the final Aardenburg Conservation Display rating only when the media exhibits the problem and those results are then factored into the score. Because Red River Palo Duro Soft Gloss Rag (RRPDSG) contains no optical brighteners nor does it use TiO2 as a whitening pigment, it does not suffer from the LILIS problem. This conclusion has been confirmed for RRPDSG in other testing of both Epson and Canon OEM inks on this paper (e.g., see ID# 330 and/or ID# 331 for those extended test results).

This report also includes remeasurments of the dark storage control sample after two years and after four years in storage. These results show that although the lightfastness (and possibly ozone gas fade resistance) of the Precision Colors PC29 ink set is significantly lower than the Canon OEM PGI-29 ink set, the thermal stability and humidity resistance is not showing any obvious weakness after four years in dark storage. Thus, prints made with the PC29 inks on Red River Palo Duro Soft Gloss paper can remain in very good condition for many years, even decades if care is taken to reduce illumination levels on display (e.g., to 100 lux or less) and/or mainly keep the prints in photo albums or archival document boxes where light exposure is effectively eliminated and ozone attack is greatly mitigated.

Third party inks do have a relevant place in today's home do-it-yourself (DIY) inkjet printing market. Nevertheless, it is advisable to use Canon's OEM PGI-29 inks whenever the printed image is not easily reprintable, and the print is considered to have enduring artistic, historic, and/or sentimental value.

Mark H. McCormick-Goodhart

Table to Convert Megalux-hours of Light Exposure to estimated "Years on Display" Light Fastness Ratings.

Indoor Light Levels for Print Display		Multiply Mlux-hrs by	Megalux-hours in test									
Light Exposure	**Description**		**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
≤ 10 Lux 24 hours per day	Interior rooms, storage areas, or hallways without windows, illuminated sparingly by artificial lighting	**11.42**	**114**	**228**	**342**	**457**	**571**	**685**	**799**	**913**	**1027**	**1142**
50 Lux 12 hours per day	"Museum Standard" display condition	**4.57**	**46**	**91**	**137**	**183**	**228**	**274**	**325**	**365**	**411**	**457**
120 Lux 12 hours per day "Kodak Display Years" (1)	Average home illumination level for photos is ~ 60 lux. 90% of all displayed photos do not exceed 120 lux (1).	**1.90**	**19**	**38**	**57**	**76**	**95**	**114**	**133**	**152**	**171**	**190**
228 Lux 12 hours per day	Relatively bright home or office. Note the simple 1:1 relationship between "years on display" and Mlux-hr values at this condition.	**1.00**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
450 Lux 12 hours per day "WIR Display Years" (2) Also equals 500 lux for 11.8 hours per day	A bright home or commercial office building illumination level is 200-500 lux. Also, good illumination for color critical viewing and color matching tasks begins at about 500 lux.	**0.51**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**41**	**46**	**51**
2000 Lux 12 hours per day	Commercial Gallery. Also, critical color evaluation standards call for 2000 lux and a D50 illumination source.	**0.114**	**1.1**	**2.3**	**3.4**	**4.6**	**5.7**	**6.8**	**8.0**	**9.1**	**10.3**	**11.4**
5000 Lux 12 hours per day	E.g., Sunlight through a window striking print at an angle.	**0.046**	**0.5**	**0.9**	**1.4**	**1.8**	**2.3**	**2.7**	**3.2**	**3.7**	**4.1**	**4.6**
10,000 Lux 12 hours per day	South-facing window in U.S.A. , e.g., storefront display with photos directly facing window.	**0.023**	**0.2**	**0.5**	**0.7**	**0.9**	**1.1**	**1.4**	**1.6**	**1.8**	**2.1**	**2.3**

Light levels commonly encountered in the real world fluctuate widely throughout indoor print display environments and produce large variations in how long it takes for artwork to acquire light-induced damage. Use this table as a guide to estimate how many "years on display" (denoted in red text) it takes to accumulate an equivalent light exposure dosage. Review the test results to decide which Megalux-hour dose has caused fading to your level of concern (e.g., just noticeable, easily noticeable, objectionable, etc.). Then choose the "Light Exposure" description that best represents how your print is likely to be displayed. You may want to obtain a lux meter and make some measurements in your own display environment!

Note that as the years of display time increase, light-induced fading can be eclipsed by other serious aging mechanisms such as fading and/or staining caused by heat, humidity, and air pollutants. Mould damage can also occur at high humidity. Even when colorants remain water fast, direct contact with liquids may result in physical deformation and staining of the substrate. Also, temperature and especially strong seasonal humidity fluctuations can cause physical cracks and/or flaking, etc., over time. Handling damage such as scratching, abrasion, tears and creases, and catastrophic damage by smoke, fire, flood, etc., also destroy print quality over time. Thus, as illumination levels are reduced other forms of print degradation take on greater probability of occurrence.

(1) Eastman Kodak cited this exposure condition with a 90% confidence limit as a rationale for estimating print fading times of traditional color photo materials in typical home display environments. However, for light fading claims regarding its line of pigment-based inkjet printers, Kodak adopted the higher level of 450lux/12 hours per day which is also used by Wilhelm Imaging Research, Inc. (See below).

(2) Wilhelm Imaging Research (WIR) standardized its light fastness ratings on 450 lux for 12 hours per day in order to estimate the years on display necessary to reach "easily noticeable" fading. This average daily light exposure dosage, at an assumed 75˚F/60%RH temperature and humidity level, has become a de facto industry standard for most industry-sponsored predictive "years of life" light fading estimates in the absence of a published International Standards Organization (ISO) test standard. The table above readily shows how much error occurs in such "print lifetime" predictions as actual real world light levels for prints on display routinely deviate above and below the assumed 450 lux intensity value.

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About this Report

This report contains light fastness information about a sample test print produced by a specific digital printing system. "System" refers to all hardware, software, and materials used to make the finished print. The hardware, software, material components, and printmaker's skills contribute to the final image quality and image permanence. The tested sample is made with current or recently discontinued stocks of commercially available products unless otherwise stated. Each sample has been prepared by Aardenburg Imaging & Archives or one of its members in accordance with customary print making practices unless otherwise noted. The sample may also contain additional finishing materials such as overcoats and laminates which are also noted when used. Finally, the sample has been tested under standardized conditions that are defined on the Sample Description page (see page 4). AaI&A makes every effort to ensure but cannot guarantee that the samples are properly identified and documented and that test results are accurate. For this reason, AaI&A also strives to test independently produced sample replicates in order to increase sampling confidence and to provide information on process variability. Please compare the results in this report to replicate test samples when the data become available.



The magnitude and visual appearance of fading depends not only on the chosen printing system but the chosen image as well. In other words, different images are comprised of different colors, and the fading relationships between those colors dictate how the image will look as it fades. The sample print in this test report was made by reproducing the digital image shown on the left. It contains 30 standard colors. 24 of the colors are colorimetrically matched to the Macbeth ColorChecker™ chart viewed under D50 illumination. The remaining six colors supplement the ColorChecker™ array with four additional skin tone colors, one patch for paper white, and another for maximum black. The additional colors

Information about the fading characteristics of the product is provided in three ways:

1) You can visually assess the fading. The target images reproduced in this report are digitally reconstructed from the spectrally measured color data rather than scanning or otherwise reproducing the physical print by conventional techniques. This method ensures a colorimetrically accurate representation of the print appearance as the print fades. A calibrated monitor is recommended to experience the best possible reproduction of the test sample appearance. The side-by-side "before and after" presentation of the target images simulates looking at a perfect copy of the unexposed original print along side the same print after light exposure. You can also use Adobe Reader's full screen mode to cycle through the pages and "animate" the fading.

2) I* Color and tonal accuracy scores are reported. This report includes I* metric scores that compare the color and tonal relationships of the light exposed samples to the color and tonal relationships existing in the original print prior to light exposure. Perfect I* scores of 100% can be approached when no significant fading occurs. Average scores above 90% generally indicate excellent retention of original quality, 80% good, 70% fair, etc., but your conclusions may vary depending on your image quality requirements. I* color rates the retained color accuracy (hue and chroma) while I* tone rates the retained tonal accuracy (lightness and contrast). The score is on a percentile scale where 100% is a perfect match between the comparison image (e.g., "after" light exposure) and the reference image (e.g., "before" any light exposure). 0% I* color means no color accuracy is left. 0% I* tone means essentially no tonality remains and all image information content is lost. Negative I* values have significance as well and contribute to the average I* score when they occur. Negative I* color values mean false color has occurred, for example, when a skin tone turns green or a neutral gray becomes distinctly colorful. Negative I* tone scores mean visual contrast between colors has become inverted (i.e., like the tonal relationships in a photographic film negative). Serious image quality problems must arise before false colors and/or tones appear. For more information on the I* metric, please refer to the AaI&A web site.

3) Color changes are also reported using the classic color difference model, ΔE. Note that ΔE values lose perceptual scaling significance when they become large (e.g., > 15). Also, the ΔE equation does not unambiguously measure changes in image contrast. This limitation is generally not a problem for paints and textiles, but can be a serious oversight when evaluating photographic images. Properly tracking changes in image contrast was a major reason behind the development of the I* metric.

Table I: The Conservation Display Rating Criteria Set	
Upper Exposure limit (calculated from the average score for all sampled colors)	Overall average I* Color score ≥ 90% and overall average I* tone score ≥ 90%
Lower Exposure limit (calculated from the average score for the worst 10% of the sampled colors)	I* Color score for worst ten percent of sampled colors ≥ 80% and I* tone score for worst ten percent of sampled colors ≥ 80%
Physical Properties Requirement	No cracking, crazing, flaking, delamination, or physical deformation of image receiver layer observed during the ***conservation display rated*** exposure range.
"Worst ten percent" refers to those 10% of the color samples from within the sampled image population that exhibit the greatest amount of change.	

The I* metric was conceived as a colorimetric algorithm to measure and track changes in image color and tonal accuracy with respect to an original reference image.[1,2] It scores the retained color and tonal accuracy on a percentile scale from a state of perfect matching (i.e., 100%) to a state of no color and tonal accuracy (i.e., 0%). It also scores any state where false rendering of the reference image tone and color quality has occurred (i.e., negative I* values for color and tone which signify falsely substituted colors and/or tonal reversals). The I* metric is an excellent foundation upon which to build criteria for acceptable change in color and tonal accuracy.

For more information on the Aardenburg Conservation Display ratings, please see the article entitled: : "An Overview of the Aardenburg Imaging Conservation Display Ratings".

Other relevant articles are:

1) Mark McCormick-Goodhart, Henry Wilhelm, and Dmitriy Shklyarov,"A 'Retained Image Appearance' Metric For Full Tonal Scale, Colorimetric Evaluation of Photographic Image Stability," IS&T's NIP20: International Conference on Digital Printing Technologies, Final Program and Proceedings, IS&T, Springfield, VA, October 3–November 5, 2004, pp. 680–688.

2) Mark H. McCormick-Goodhart, "An Introduction to the I* Metric," Aardenburg Imaging & Archives, February 7, 2007

These papers and more are available in PDF format on the documents page of the Aardenburg website:

https://www.aardenburg-imaging.com/documents/