School of Media Sciences
R·I·T | College of Imaging Arts and Sciences

RIT IQ BENCHMARK REPORT

[redacted] Color Inkjet Web Press | Production Ink-jet | Utoptia Book #45 Text

IQBench 1.5b

CROSS-MEDIA INNOVATION CENTER at RIT

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IQ Benchmark provides a framework for measuring and comparing key image quality attributes for printing systems. The report includes results collected from 1 testrun conducted on [redacted] Color Inkjet Web Press using Utoptia Book #45 Text. The results in this report are comparable with other reports generated for Production Ink-jet class printers.

This sample report is limited to a few of the tests included in the benchmark. Please refer to the attached benchmark overview slides for additional details regarding the range of image quality tests.

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Contents

This report was prepared at the School of Media Sciences at the Rochester Institute of Technology by Saleh Abdel Motaal and Christopher Bondy for [redacted] and involved contributions from Franz Sigg, Bruce Meyers, Robert Chung, and a number of members of the Faculty along with a number of members of [redacted]

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Part I. **Introduction**

I-1. **Overview**

Since the first images were rendered on primitive marking devices certain individuals have had a passion for the evaluation and refinement of the processes associated with printing. The print process, both analog and digital, is riddled with variables from imaging technology, to inks, to substrates, with many possible areas of uncertainty. RIT School of Media Sciences has built on a 75-year heritage in printing technology to develop a print production benchmark that is designed to compare the print performance of a printing system to a baseline from a number of measurable attributes.

Developing appropriate print process tests and reporting the results of the tests poses a number of difficult problems. What test should be run? How do you control the way the test are run? How will the test be evaluated? How will the test results be reported? These and many more questions were considered at the start of this project. The RIT IQ Benchmark is a results of peer discussions, industry vetting, advise from respected imaging scientists, and feedback from printing system manufactures and print service providers.

The RIT IQ Benchmark is comprised of two key components that when combined together provide a comprehensive assessment of the printing systems in reference to the test baseline. The components include an operator survey and an image quality benchmark.

1. The Operator Survey section includes three key components:
   (1) System Maintenance,
   (2) System Setup, and,
   (3) System Optimization,
   aimed at providing additional information regarding the specific settings and trade-off decisions operators made when running this the tests.

2. The Image Quality Benchmark includes 36 pages comprising of a series quantifiable test and a series of subjective test that represent real-world printing examples. The structured test are designed to establish the range of capability for a printing system in a particular test area such as: color fidelity, color appearance, image resolution, and image registration. The image quality tests are reported and plotted using graphical representation with reference to baseline from offset lithography, i.e., ISO 12647-2. The subjective tests are designed to establish the practical application of the printing system associated with certain types of printing projects, such as, direct mail, text books, etc.

When combined together the Operator Survey and the Image Quality tests provide a comprehensive view of the printing system in a detailed report that enables print system manufactures and print service providers to refine the print process and the print systems in direct reference to the information provided in the RIT IQ Benchmark.

I-2. **Methodology**

The RIT IQ Benchmark incorporates an extensive range of image quality tests conducted under tightly controlled production and measurement conditions are designed to maximize the reliability and usability of the results and the data collected during testing. Prior to running the test suite, RIT works directly with the operators to determine the most suited output parameters and to thoroughly document the output conditions including all non-routine considerations that can influence the validity of the data collected.

Key prepress and printing parameters considerations include:

(1) File format support and file conversion
(2) Raster and vector image processing
(3) Color management capabilities and policies (models, conversion... etc.)
(4) RIP specifications and settings (PostScript support, resolution... etc.)
(5) Substrate and ink specifications
(6) Paper handling and printing speed

The test suite incorporate various test targets carefully designed to be measured using appropriate devices (image scanners and spectrophotometers) in order to be objectively analyzed using the range of software tools.

Key image quality tests include:

(1) Production workflow is evaluated to ensure testing validity
(2) Device color characterization and colorimetric rendering based on spectrophotometry
(3) Color appearance based on high resolution image scans
(4) Digital imaging resolution and printing resolution based on high resolution image scans
(5) Color-to-color and side-to-side registration based on high resolution image scans

The analysis includes both predefined standard tests and proprietary tests, including tests which are still in early development stages. The results are compared with baselines only when such references are deemed applicable.

Please refer to the various sections for additional procedures and considerations applicable to individual tests.

I-3. **Executive Summary**

The RIT IQ Benchmark provides a reliable and unbiased method for evaluating the quality of a printing systems compared to ISO 12647-2 standard for offset lithography. The RIT IQ Benchmark report can include one sample data set (IQ Benchmark data from a unique printing system) compared to the baseline or multiple sample data sets compared to the baseline and a population of data sets. This IQ Benchmark Report and Executive Summary provides summary data for one data set compared to the baseline. The report includes results collected from 1 testrun conducted on [redacted] Color Inkjet Web Press using Utoptia Book #45 Text. The results in this report are comparable with other reports generated for Production Ink-jet class printers.

Operator Survey Summary

(1) System Maintenance
Operator reported taking 30 minutes to 2 hours for daily operator-level maintenance, with additional 4 to 12 hours spent per month, as well as, greater than 16 hours for weekly repairs and unscheduled by service technicians on top of scheduled maintenance operations.

(2) System Setup
Operator reported taking up to 120 minutes for paper change and for configuring the system for new paper stock, including up to 30 minutes for web handling, 5 minutes for color profiling, and 30 minutes for image quality assessment and tuning.

(3) System Optimization
Operator reported between 75% and 90% of the printed material is “salable”. Higher quality jobs requires reduced speeds to avoid problems, including ink offsetting, wrinkles, stitching. Gloss and Matte coated stocks are run reliably at 50% to 90% of the maximum print speed, while uncoated stocks may run at 90% or better of the maximum. Type and weight of substrate, and the level of quality output determine the running speed.

Image Quality Summary

(1) Production Workflow
Some concerns were identified and remedied or ignored including RIP file processing for EPS files, PANTONE® color library was not tested directly however CIELab based matching was tested instead.

(2) Color Fidelity
Device color characteristics and PANTONE® Hexachrome coverage tests were conducted successfully.

(3) Color Appearance
Ink Bleed and Ink Coalescence tests were conducted successfully.

(4) Image Resolution
Spot Addressability and Contrast-Resolution tests were conducted successfully.

(5) Image Registration
Color-to-color and Side-to-Side tests were conducted successfully.

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Part II. **Operator Survey**

II-1. **Overview**

Assessing the performance of high-speed digital production ink jet printing systems has traditionally been limited to the evaluation of a series of image quality targets. The RIT Production Ink Jet Benchmark expands from a single vantage point to incorporate a variety of application specific test samples to provide better real-world insights into the best possible usage of this technology for various print applications. Both quantified test target results compared to a baseline standard and subjective application print samples are evaluated in the first section for this report.

A third perspective is included in the RIT Production Ink Jet Benchmark process to provide an expanded set of insights and subtle system characteristics that only experienced operators can provide.

The Operator Survey section below includes three key components:

(1) System Maintenance,
(2) System Setup, and,
(3) System Optimization,

aimed at providing additional information regarding the specific settings and trade-off decisions operators made when running this the tests.

The following section includes a brief description of each segment of the Operator Survey followed by the results for each question. An overall summary for the Operator Survey is provided at the end of this section.

II-2. **System Maintenance**

The system maintenance section provides insights into the periodic system maintenance activities performed on a routine basis and for preventative measures.

Below are the operator survey questions; the results for the system maintenance section are presented in bold.

How much time do you spend doing operator-level daily maintenance?

a. **Less than 30 minutes** ◀
b. From 30 minutes to 2 hours
c. Greater than 2 hours

How much additional time do you spend per month doing additional operator-level maintenance beyond the daily operator-level maintenance covered above?

a. Less than 4 hours per month
b. **From 4 to 12 hours per month** ◀
c. Greater than 12 hours per month

How much time is spent by service techs per week doing repairs or unscheduled maintenance?

a. Less than 8 hours per week
b. From 8 to 16 hours per week
c. **Greater than 16 hours per week** ◀

How much time is spent by service techs doing scheduled maintenance per month?

a. Less than 4 hours per month
b. From 4 to 12 hours per month
c. Greater than 12 hours per month

NA Operator indicated uncertainty at R&D test site

II-3. **System Setup**

The system setup section provides insights into the specific system settings and time-frames associated with the preparation effort to run of this specific benchmark test.

Below are the operator survey questions; the results for the system setup section are presented in bold.

What is the published production set-up for a new paper that has never been run before?

a. Less than 15 minutes
b. **From 15-120 minutes** ◀
c. Greater than 120 minutes

How much time do you spend to set-up a new paper that has never been run before?

a. Less than 15 minutes
b. **From 15-120 minutes** ◀
c. Greater than 120 minutes

For the paper set-up time identified above – please breakdown the set-up times associated with the following activities:

Press web handling set-up?

a. Less than 5 minutes
b. **From 5 to 30 minutes** ◀
c. Greater than 30 minutes

ICC profile set-up?

a. Less than 5 minutes
b. **From 5 to 30 minutes** ◀ For new profiles
c. Greater than 30 minutes

IQ set-up (Image Quality assessment and tuning)?

a. Less than 5 minutes
b. **From 5 to 30 minutes** ◀
c. Greater than 30 minutes

For the paper set-up time identified above – please indicate your feeling toward the customer acceptability level of the set-up time discussed above:

a. **Likely to be short enough to have high acceptance** ◀
b. In the acceptable zone
c. Likely to be too long to have high acceptance

II-4. **System Optimization**

The system optimization section provides operator insights based on the historic experience and knowledge regarding the subtleties of running the system in a production mode including production issues and trade-offs

Below are the operator survey questions; the results for the system optimization section are presented in bold.

What percentage of material running through the press is salable output?

Consider total volume of material run through the press (under regular production conditions), what is the yield (as a percentage of total material) of salable output produced on the press; consider all sources of material waste.

a. Less than 75%
b. **From 75% to 90%** ◀
c. Greater than 90%

What is the published maximum print-speed for the substrates printed in this test?

400 Feet Per Minute for Utopia Gloss, 600 Feet Per Minute for Utopia Matte.

What % of total run-time does the press run at maximum print-speed?

a. Less than 75%
b. From 75% to 90%
c. Greater than 90%

NA Operator indicated uncertainty at R&D test site

How do you run jobs with high quality requirements?

a. Maximum print-speed
b. **Reduced print-speed to avoid known problems** ◀
c. On another press that has higher quality

Is ink offsetting an issue?

a. Not an issue
b. **Sometimes an issue** ◀
c. Always, need to perform workarounds to prevent it

Are wrinkles an issue?

a. Not an issue
b. **Sometimes an issue** ◀
c. Always, need to perform workarounds or take special action to prevent

Is stitching or stitching artifacts from the print heads an issue?

a. Not an issue
b. **Sometimes an issue** ◀
c. Always, need to perform workarounds or take special action to prevent them

At what "reliable print-speed" can you run gloss-coated stocks?

Meaning, salable IQ, without offset, wrinkles, etc.

a. Don't run gloss-coated stocks
b. Less than 50% of maximum print-speed
c. **50% to 90% of maximum print-speed** ◀
d. Greater than 90% of maximum print-speed

At what "reliable print-speed" can you run matte-coated stocks?

Meaning, salable IQ, without offset, wrinkles, etc.

a. Don't run matte-coated stocks
b. Less than 50% of maximum print-speed
c. 50% to 90% of maximum print-speed
d. **Greater than 90% of maximum print-speed** ◀

At what "reliable print-speed" can you run uncoated stocks?

Means with salable IQ, without offset, wrinkles, etc.

a. Don't run uncoated stocks
b. Less than 50% of maximum print-speed
c. 50% to 90% of maximum print-speed
d. **Greater than 90% of maximum print-speed** ◀

At what percentage of maximum print-speed is acceptable IQ typically attained?

a. Less than 50% of maximum print-speed
b. From 50% to 90% of maximum print-speed
c. **Greater than 90% of maximum print-speed** ◀

At what percentage of maximum print-speed do you run most jobs on this press?

a. Less than 50% of maximum print-speed
b. From 50% to 90% of maximum print-speed
c. **Greater than 90% of maximum print-speed** ◀

What conditions cause you to run the press at less than maximum speeds (circle all that apply)?

a. **Type of substrate** ◀
b. Weight of substrate
c. Size of substrate
d. **Level of quality output expected** ◀
e. Continuous operation
f. Production schedule backlog

Other: _____ (Please Specify)

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Part III. **Image Quality**

III-1. **Overview**

Image quality covers a wide range of attributes which can subdivided into various Groupings. The RIT IQ Benchmark focuses on attributes relating to certain key aspects, including production workflow, color fidelity, color appearance, image resolution and registration, defined as follows.

Key image quality tests include:

(1) **Production Workflow:** Evaluation of RIP features and file support... etc.
(2) **Color Fidelity:** Device color characterization and colorimetric rendering from spectrophotometry.
(3) **Color Appearance:** Appearance of printed ink from high resolution image scans.
(4) **Image Resolution:** Digital imaging resolution and printing resolution from high resolution image scans.
(5) **Image Registration:** Color-to-color and side-to-side registration from high resolution image scans.

Color fidelity tests include:

DCC **Device Color Characteristics**
PHX **PANTONE® Hexachrome Coverage**

Color appearance tests include:

INKB **Ink Bleed**
INKC **Ink Coalescence**

Image resolution tests include:

SPI **Spot Addressability**
CRI **Contrast-Resolution**

Image registration tests include:

C2C **Color-to-Color Registration**
S2S **Side-to-Side Registration**

III-2. **Production Workflow**

Production Workflow Results

Production workflow provides an overview of various components assessed during preliminary pretests and while conducting the actual benchmark.

Reported RIP Information

Required data was collected and verified manually.

Supported File Formats

Required data was collected with minor concerns.

Color-Management Capabilities

Required data was collected without concerns.

Print Engine Considerations

Required data was collected without concerns.

Concern Levels

Major Concerns: Seriously degrade validity (workaround not possible)
Minor Concerns: Does not diminish validity (workaround possbile)
Normal Procedures: Ideal for comparison (workaround not needed)

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Substrate: Utopia Book #45 Text
Site: [redacted]
Output Date: 2014-02-14

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Reported RIP Information

RIP Information is supplied by the operator. PostScript based testing is ignored due to RIP limitations.

Field	Provided Information	Remarks
Name	[redacted]	RIP Product Name
Number	[redacted]	Software Release
PostScript	Level: Version:	Not available
Addressability	**X:** 600 spi **Y:** 600 spi	Symmetric Stocastic

- RIP does not support PostScript files, PostScript version and level unknown.
- RIP product name ([redacted]) and release code ([redacted]).
- RIP configured for stochastic screening at 600 x 600 spi (Visual test shows 720 spi).

File Compatibility Information

File format support based on operator feedback

- Operator reported support for PDF and PDF/X files (No Encapsulated PostScript file support).
- RIP native EPS file processing succeeded with minor failure for complex test files.
- RIP native PDF and PDF/X file processing succeeded without reported failures.
- RIP file processing was problematic but suitable for conducting the benchmark with minor concerns. (All PostScript based tests were not conducted)

Color Management Capabilities

Color-management capabilties based on operator feedback

- System honored embedded CMYK & RGB ICC profiles.
- System honored embedded Gray ICC profiles.
- System honored DeviceN and Separation color and rendered pure primaries.
- System supported CIELab color images and spot colors.
- System PANTONE color support was not tested (assumed functional). (PANTONE color specification test was not supplied to vendor)

Print Engine Considerations

Print engine considerations and accomodations needed to conduct the benchmark

- Test files were submitted in PDF format only (EPS was not supported and ignored).

III-3. **Color Fidelity**

Color Fidelity Results

Color fidelity encompasses various components of the color reproduction capabilities including color gamut and accuracy.

✔ **DCC** Device Color Characteristics (IT8.7/3)

Required data was collected with minor concerns.

! Color-management limitations required separate runs to collect data with and without ICC conversion.

✔ **PHX** PANTONE® Hexachrome Color Gamut

Required data was collected with minor concerns.

! Color-management limitations required separate runs to collect data with and without ICC conversion.

Concern Levels

Major Concerns: Seriously degrade validity (workaround not possible)
Minor Concerns: Does not diminish validity (workaround possbile)
Normal Procedures: Ideal for comparison (workaround not needed)

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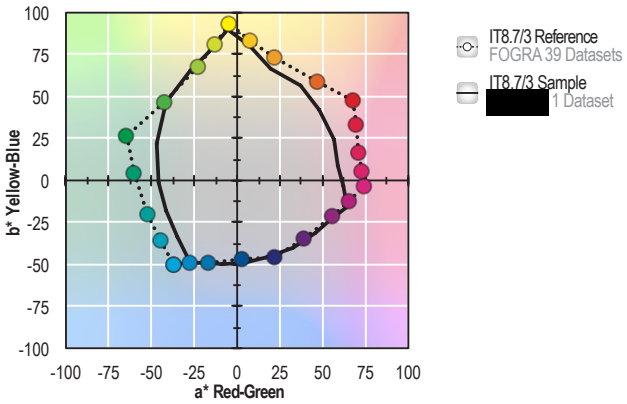
[redacted]1 Device Color Charateristics

Device color characteristics measure tone and color attributes of a system. Systems conforming to ISO 12647 (including ink and paper) produce tones and color gamut that may better match respective printing condition specifications (FOGRA 39 or 27).

Metric	Result					
ΔE Color Averages	Primaries:	9.4	ΔE	Overprints:	20.3	ΔE
ΔL* Lightness Limits	Whitepoint:	-3.7	ΔL	Blackpoint:	+15.2	ΔL
Δab Chromatic Error	Paper:	0.5	Red -Yellow	CMY Inks:	18.8	Δab



Primary colors average ΔE 9 (ISO tolerance ΔE 5 and 4 for yellow). Secondary colors average ΔE 20 and paper is ΔE 4. Paper and inks color are potential factors.

Difference in lightness for Whitepoint is ΔL -4 & Blackpoint in ΔL +15. Chromaticity offset for Paper is Δab 0 towards red--yellow & CMY inks average Δab 19.

[redacted]1 Extended Gamut Coverage

PANTONE® Hexachrome Coverage measures the ability to match a set of patches using a nearest-neighbour search for ΔEab color difference. This test is still in exploratory stage and the data provided is subject to revisions in future reports. So far, no benchmarks or points of reference available for comparison.

ΔEab Color Matches						PANTONE® Offset Matte		
≤1	9		≤5	435		Reference	**1792**	Patches
≤2	104	Patches	≤10	998	Patches	[redacted]1		
≤3	212		≤20	1653		Sample	**1792**	Patches

Overall with 1792 colors, matching 9 ≤ 1 ΔEab, 104 ≤ 2 and 435 ≤ 5; i.e. 0.5%, 5.8% and 24.3%, respectively.

Matching for 794 colors falls beyond ΔEab of 10; i.e., 44.3% of all 1792 sample colors not reproduced faithfully.

Midtones with 833 colors, matching 71 ≤ 2 ΔEab and 264 ≤ 5; i.e. 8.5% and 31.7% respectively for 46.5% of all sample colors.

Highlights with 185 colors, matching 18 ≤ 2 ΔEab and 95 ≤ 5; i.e. 9.7% and 51.4% respectively for 10.3% of all sample colors.

Shadows with 774 colors, matching 15 ≤ 2 ΔEab and 76 ≤ 5; i.e. 1.9% and 9.8% respectively for 43.2% of all sample colors.

DCC Device Color Characteristics

[redacted]

Device Color Charateristics Results

Device color characteristics measure tone and color attributes of a system. Systems conforming to ISO 12647 (including ink and paper) produce tones and color gamut that may better match respective printing condition specifications (FOGRA 39 or 27).

Definitions

- Device Color Characteristics table compares paper, primary and overprints with ISO 12647 aims.
- Chromaticity plot compares a* b* coordinates for primary and secondary colors at different tone levels with their aims.
- Gradations plot compares CIE-Lab L* lightness for primary colors at across tone levels with their aims.

Findings

1. Primary colors average ΔE 9 (ISO tolerance ΔE 5 and 4 for yellow). Secondary colors average ΔE 20 and paper is ΔE 4. Paper and inks color are potential factors.

2. Difference in lightness for Whitepoint is ΔL -4 & Blackpoint in ΔL +15. Chromaticity offset for Paper is Δab 0 towards red--yellow & CMY inks average Δab 19.

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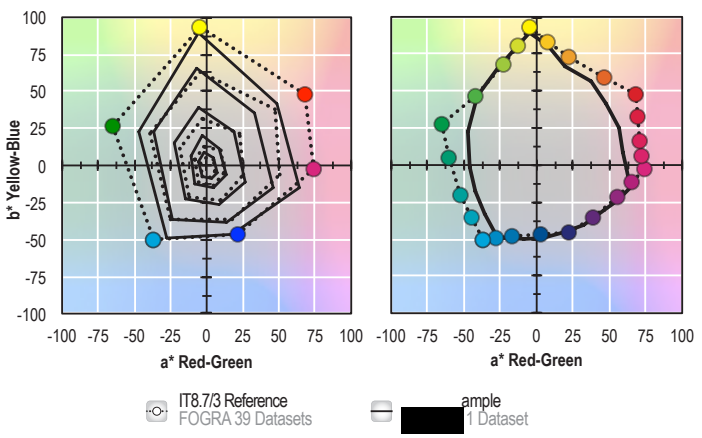
[redacted]1 vs. Fogra 39 Color Metrics

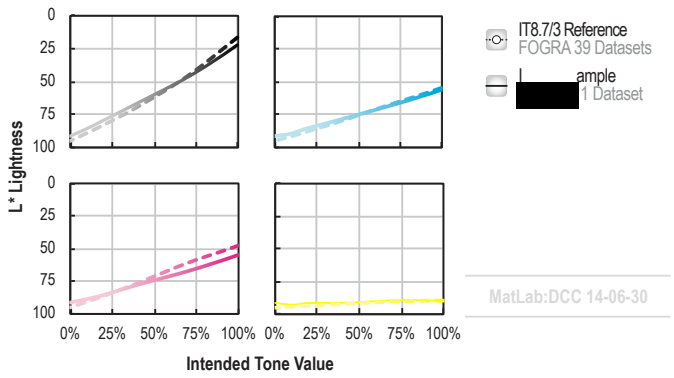
Metric	Result					
ΔE Color Averages	Primaries:	9.4	ΔE	Overprints:	20.3	ΔE
ΔL* Lightness Limits	Whitepoint:	-3.7	ΔL	Blackpoint:	+15.2	ΔL
Δab Chromatic Error	Paper:	0.5	Red -Yellow	CMY Inks:	18.8	Δab

Device Color	[redacted]1			Fogra 39			ΔE_{ab}
	L*	a*	b*	L* | ΔL	a* | Δa	b* | Δb	
Paper White	91.3	0.4	-1.8	95 -4	0 +0	-2 +0	3.7
Solid Cyan	56.6	-27.1	-49.1	55 +2	-37 +10	-50 +1	10.1
Solid Magenta	55.3	64.7	-15.5	48 +7	74 -9	-3 -12	17.2
Solid Yellow	89.1	-5.4	89.7	89 +0	-5 -0	93 -3	3.3
Solid Black	22.8	0.7	1.1	16 +7	0 +1	0 +1	6.9
Solid Red	58.3	48.2	42.0	47 +11	68 -20	48 -6	23.6
Solid Green	56.8	-46.9	22.5	50 +7	-65 +18	27 -5	19.8
Solid Blue	41.0	17.6	-46.0	24 +17	22 -4	-46 +0	17.5
Maximum Black	23.9	0.7	1.1	9 +15	0 +1	2 -1	15.2

[redacted]1 vs. Fogra 39 Chromaticity Profile



[redacted]1 vs. Fogra 39 L* Gradations



PHX **PANTONE® Hexachrome Coverage**

[redacted]

PANTONE® Hexachrome Coverage Results

PANTONE® Hexachrome Coverage measures the ability to match a set of patches using a nearest-neighbour search for ΔEab color difference. This test is still in exploratory stage and the data provided is subject to revisions in future reports. So far, no benchmarks or points of reference available for comparison.

Definitions

- Gamut Metrics table shows number of references, samples and nearest-neighbour matches for ΔEab 1, 2, 3, 5, 10 & 20.
- Coverage plots show ΔEab matching potential for light, mid, and dark tones values relative to the reference, and show boiuundaries for reference in white, sample in solid black, and sample including IT8 in dotted black lines.

Findings

1. Overall with 1792 colors, matching 9 ≤ 1 ΔEab, 104 ≤ 2 and 435 ≤ 5; i.e. 0.5%, 5.8% and 24.3%, respectively.

   Matching for 794 colors falls beyond ΔEab of 10; i.e., 44.3% of all 1792 sample colors not reproduced faithfully.

2. Midtones with 833 colors, matching 71 ≤ 2 ΔEab and 264 ≤ 5; i.e. 8.5% and 31.7% respectively for 46.5% of all sample colors.

   Midtones are L* 33.3% to 66.7% with 50.0% mean.

3. Highlights with 185 colors, matching 18 ≤ 2 ΔEab and 95 ≤ 5; i.e. 9.7% and 51.4% respectively for 10.3% of all sample colors.

   Highlights are L* 66.7% to 100.0% with 83.3% mean.

4. Shadows with 774 colors, matching 15 ≤ 2 ΔEab and 76 ≤ 5; i.e. 1.9% and 9.8% respectively for 43.2% of all sample colors.

   Shadows are L* 0.0% to 33.3% with 16.7% mean.

Press: [redacted] Color Inkjet Web Press

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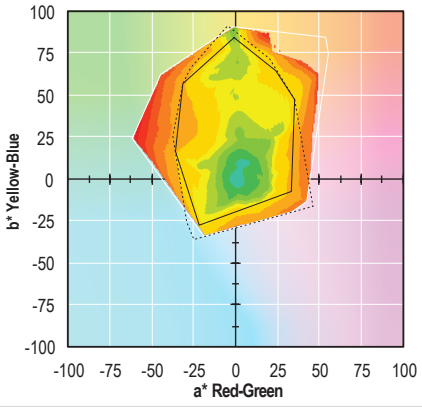
[redacted]1 vs. Offset/Matte Gamut Metrics

ΔEab Color Matches				PANTONE® Offset Matte		
≤1	9	≤5	435	Reference	**1792**	Patches
≤2	104 Patches	≤10	998 Patches	[redacted]1		
≤3	212	≤20	1653	Sample	**1792**	Patches

[redacted]1 vs. Offset/Matte Gamut Plots

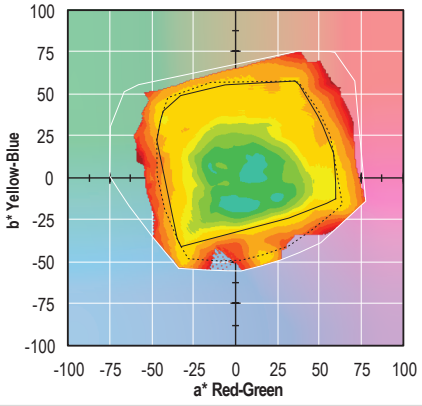


Highlights N: 185 10 %

Max: 100.0 %
L* Avg: 83.3 %
Min: 66.7 %

ΔEab ≤ 2: 18 10 %
≤ 5: 95 51 %

MatLab::PHX 14-07-10

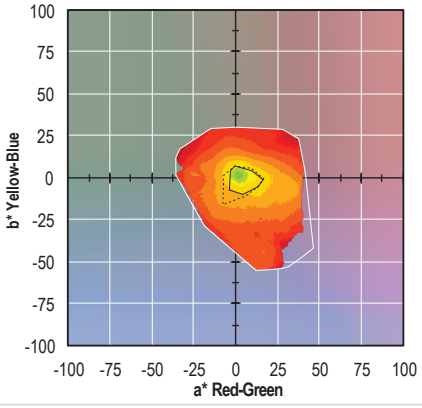


Midtones N: 833 46 %

Max: 66.7 %
L* Avg: 50.0 %
Min: 33.3 %

ΔEab ≤ 2: 71 9 %
≤ 5: 264 32 %

MatLab::PHX 14-07-10



Shadows N: 774 43 %

Max: 33.3 %
L* Avg: 16.7 %
Min: 0.0 %

ΔEab ≤ 2: 15 2 %
≤ 5: 76 10 %

MatLab::PHX 14-07-10

PANTONE® Reference Offset/Matte Dataset

PANTONE® Sample [redacted]1 Dataset

PANTONE®+IT8.7/3 Sample [redacted]1 Datasets

III-4. **Color Appearance**

[redacted]

Color Appearance Results

Color appearance encompasses attributes related to the printed color including ink bleed and coalescences.

✔ **INKB** Ink Bleed

Required data was collected following normal procedures.

✔ **INKC** Ink Coalescence

Required data was collected following normal procedures.

Concern Levels

Major Concerns: Seriously degrade validity (workaround not possible)
Minor Concerns: Does not diminish validity (workaround possbile)
Normal Procedures: Ideal for comparison (workaround not needed)

Press: [redacted] Color Inkjet Web Press
Substrate: Utopia Book #45 Text
Site: [redacted]
Output Date: 2014-02-14

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[redacted]1 Ink Bleed

Ink bleed referes to the tendency for ink to spread when printed differently on the various substrates and on the different inks due to physical interactions, measured based on the relative growth or shinkage in the line width for a series of vertical and horizontal line-sets.

Lateral bleed percentages indicate growth (+ve) or shrinkage (-ve) in the line width of the vertical line relative to the horizontal line to reflect difference in width of lines in both directions.

	K	C	M	Y
Paper	-21%	-22%	-22%	-22%
C 100%	-21%		-16%	-16%
M 100%	-21%	-21%		-16%
Y 100%	-16%	-17%	-22%	

Overprint bleed percentages indicate growth (+ve) or shrinkage (-ve) in the line width of lines overprinted on solid background relative to the lines printed directly on the substrate.

	K	C	M	Y
Average	-1%	+1%	+1%	+3%

Line width averages are K .40, C .38, M .38, Y .39, range from .37 to .40 (.37 to .40 with outliers).

Lateral bleed averages are K -20, C -20, M -20, Y -18%, range from 0% to 0% (-22% to -16% with outliers).

Overprint bleed averages are K -1, C 1, M 1, Y 3%, range from -3% to 6% for all colors.

[redacted]1 Ink Coalescence

Ink coalescence refers to the tendancy for inks to overlap uniformly to form perceptually even colors without visible patterns, i.e. graininess. To date, results for this test are not yet available.

The results for this test are based on unverified and unfinalized methods that attempt to adapt existing methods in ISO standards for measuring graininess. While the actual numbers indicated cannot offer any absolute indication of the coalescence potential of the individual systems, it is possible to gain some insights from comparing against a baseline, between systems and across colors.

	Cyan-Magenta			Magenta-Yellow			Cyan-Yellow			All
	C	M	CM	M	Y	MY	C	Y	CY	CMY
Baseline	0.5	1.1	1.0	1.1	2.2	1.2	0.5	1.6	1.0	1.1
[redacted]	0.5	0.9	0.8	0.9	1.6	0.9	0.6	1.4	1.0	0.9

The numbers in the table above reflect the average graininess values computed for each of the 2-color test blocks. In each block, average graininess is reported for the primary color tints 50-100% with 10% increments, followed by the average graininess values for all the overprint patches as well as the primary tints.

A higher value may suggest increased graininess, i.e lower coalescence potential. By comparing the values in each block for the primary tints against the overprint values it may be possible to identify which primary color contributes more to the degraded potential for coalescence.

The above findings suggest that the tested system ranks higher in quality than the baseline for ink coalescenece.

INKB **Ink Bleed**

[redacted]

Ink Bleed Results

Ink bleed referes to the tendency for ink to spread when printed differently on the various substrates and on the different inks due to physical interactions, measured based on the relative growth or shinkage in the line width for a series of vertical and horizontal line-sets.

Definitions

- Line Width factors are relatively-comparable (arbitrary) measures averaging both vertical and horiztonal solid K, C, M, Y line-pairs for all alternate solid C, M, Y backgrounds, which is adapted from ISO 24790 line width metric for different colors.
- Lateral bleed percentages indicate growth (+ve) or shrinkage (-ve) in the line width of the vertical line relative to the horizontal line to reflect difference in width of lines in both directions.
- Overprint bleed percentages indicate growth (+ve) or shrinkage (-ve) in the line width of lines overprinted on solid background relative to the lines printed directly on the substrate.
- Ink bleed test images are extracted RGB and normalized gray data for analysis, which provide a point of reference on the reported values for each patch. Problematic patches that were excluded from analysis are rendered with inverted colors.

Findings

1. Line width averages are K .40, C .38, M .38, Y .39, range from .37 to .40 (.37 to .40 with outliers).
2. Lateral bleed averages are K -20, C -20, M -20, Y -18%, range from 0% to 0% (-22% to -16% with outliers).
3. Overprint bleed averages are K -1, C 1, M 1, Y 3%, range from -3% to 6% for all colors.
4. There were issues analyzing some patches which explain the skewed results for Magenta over Cyan, but this issue seems to be a software-related problem not system related.

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Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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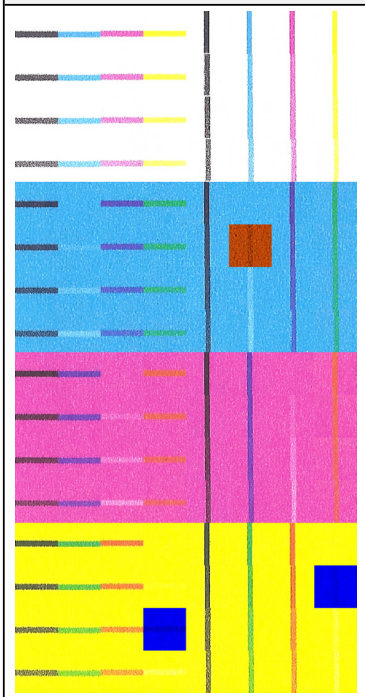
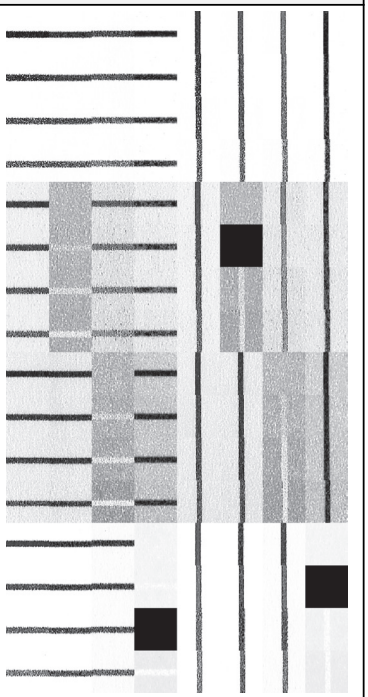
[redacted] 1 Ink Bleed Table

	K	C	M	Y
Line Width Factors				
Paper	0.40	0.38	0.38	0.38
C 100%	0.40		0.39	0.39
M 100%	0.40	0.40		0.39
Y 100%	0.39	0.37	0.38	
Lateral Bleed Percentage				
Paper	-21%	-22%	-22%	-22%
C 100%	-21%		-16%	-16%
M 100%	-21%	-21%		-16%
Y 100%	-16%	-17%	-22%	
Overprint Bleed Percentage				
Mnimum	-3%	-3%	0%	+3%
Average	-1%	+1%	+1%	+3%
Maximum	0%	+6%	+3%	+3%

[redacted] 1 Ink Bleed Test Images

Extracted Patch Images	Normalized Patch Images
	

[redacted] 1 Ink Bleed Test Image Validation

- ✓ Proper scan alignment & resolution
- ✓ No misaligned patches (all lines visible)
- ✓ No unexoected faulty patches (w/ Inverted Col
  Faults exprected for same color overprints

INKC **Ink Coalescence**

[redacted]

Ink Coalescence Results

Ink coalescence refers to the tendancy for inks to overlap uniformly to form perceptually even colors without visible patterns, i.e. graininess. To date, results for this test are not yet available.

Definitions

Findings

Press: [redacted] Color Inkjet Web Press

Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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Ink Coalescence Case-Comparison Table

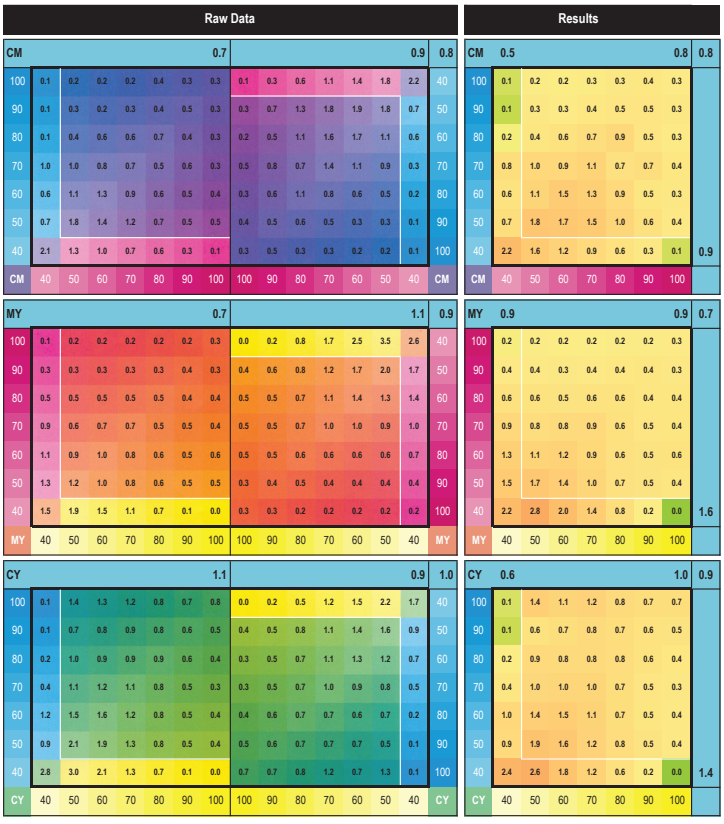
The results for this test are based on unverified and unfinalized methods that attempt to adapt existing methods in ISO standards for measuring graininess. While the actual numbers indicated cannot offer any absolute indication of the coalescence potential of the individual systems, it is possible to gain some insights from comparing against a baseline, between systems and across colors.

	Cyan-Magenta			Magenta-Yellow			Cyan-Yellow			All
	C	M	CM	M	Y	MY	C	Y	CY	CMY
Baseline	0.5	1.1	1.0	1.1	2.2	1.2	0.5	1.6	1.0	1.1
[redacted]	0.5	0.9	0.8	0.9	1.6	0.9	0.6	1.4	1.0	0.9

The numbers in the table above reflect the average graininess values computed for each of the 2-color test blocks. In each block, average graininess is reported for the primary color tints 50-100% with 10% increments, followed by the average graininess values for all the overprint patches as well as the primary tints.

A higher value may suggest increased graininess, i.e lower coalescence potential. By comparing the values in each block for the primary tints against the overprint values it may be possible to identify which primary color contributes more to the degraded potential for coalescence.

[redacted]1 Ink Coalescence Detail Table



The above results are based on a very preliminary measurement method and are provided without claim of reliability and without any points of reference. Actual test results will be provided once the measurement method is finalized.

III-5. **Image Resolution**

[redacted]

Image Resolution Results

Image resolution encompasses both the addressability and resolution potential for the individual printing channels of the press, from screening to print.

✔ **SPI Addressability**

Required data was collected following normal procedures.

✔ **CRI Contrast-Resolution**

Required data was collected following normal procedures.

Concern Levels

Major Concerns: Seriously degrade validity (workaround not possible)
Minor Concerns: Does not diminish validity (workaround possbile)
Normal Procedures: Ideal for comparison (workaround not needed)

Press: [redacted] Color Inkjet Web Press
Substrate: Utopia Book #45 Text
Site: [redacted]
Output Date: 2014-02-14

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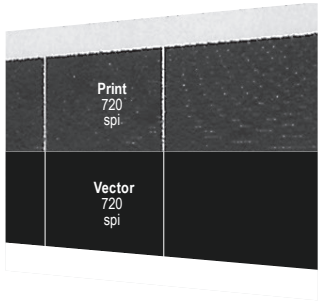
[redacted]1 Spot Addressbility

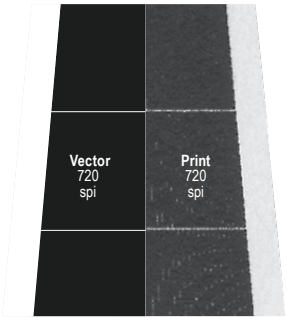
Addressability is the smallest imaging unit used to render images, with "Intended Addressability" selected by the operator to be honoured and "Reported" by the RIP during PostScript normalization, then also achieved and "Actual" rendered by the RIP and the printer.

Paper Type	Intended		Reported		Effective	
	X	Y	X	Y	X	Y
Utopia Book #45 (Matte)	600 spi	600 spi	N/A	N/A	720 spi	720 spi
(Gloss)	N/A	N/A	N/A	N/A	N/A	N/A
(Uncoated)	N/A	N/A	N/A	N/A	N/A	N/A

X Addressability



Y Addressability

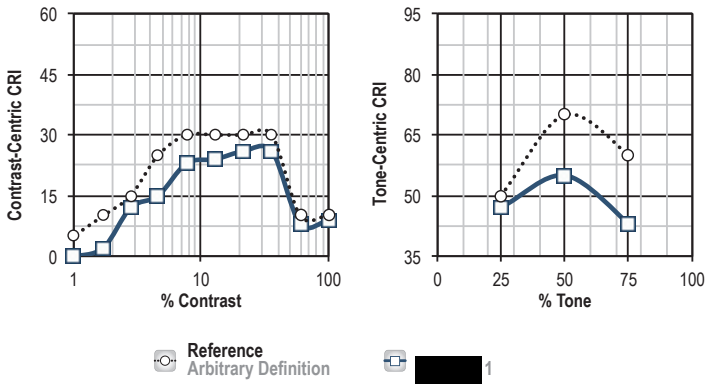


Vendor-defined inteded addressability (X:600 Y:600 spi) is not the same as actual measured (X:720 Y:720 spi) from prints (PostScript reported SPI not available).

Inteded and actual addressability both are symmetric on the X and Y directions.

[redacted]1 Contrast-Resolution

Contrast-Resolution index (CRI) measures a system's spatial resolution limits for rendering discernable detail between line-pairs at various tone and contrast levels. Quality factors include screening algorithm, printed dot, holdout and ink bleed, and imaging resolution.



Tone-Centric CRI for all three tone levels average -12% relative to the ideal reference which is higher than the maximum tolerance -10%. The data indicates superior average resolution for contrast levels above 4.6 but also severe issues below contrast level of 4.6.

Contrast-Centric CRI for all contrast levels average -5% below ideal reference which is on par with the average tolerance -5% and indicates good screening and printer dot quality.

SPI Spot Addressability

Spot Addressbility Results

Addressability is the smallest imaging unit used to render images, with "Intended Addressability" selected by the operator to be honoured and "Reported" by the RIP during PostScript normalization, then also achieved and "Actual" rendered by the RIP and the printer.

Definitions

- Intended addressability reflects spot-addressability setting as configured in the RIP based on vendor-defined capabilities and operator preferences.
- Reported addressability reflects spot-addressability setting reported by the RIP using PostScript calculations (for PostScript supporting system).
- Raster addressability reflects addressability setting visually determined from soft proof renditions exported directly from the RIP (if made available).
- Print addressability reflects spot-addressability setting visually determined from prints based on graduated addressability indicator targe.

Findings

1. Vendor-defined inteded addressability (X:600 Y:600 spi) is not the same as actual measured (X:720 Y:720 spi) from prints (PostScript reported SPI not available).

2. Inteded and actual addressability both are symmetric on the X and Y directions.

Press: [redacted] Color Inkjet Web Press

Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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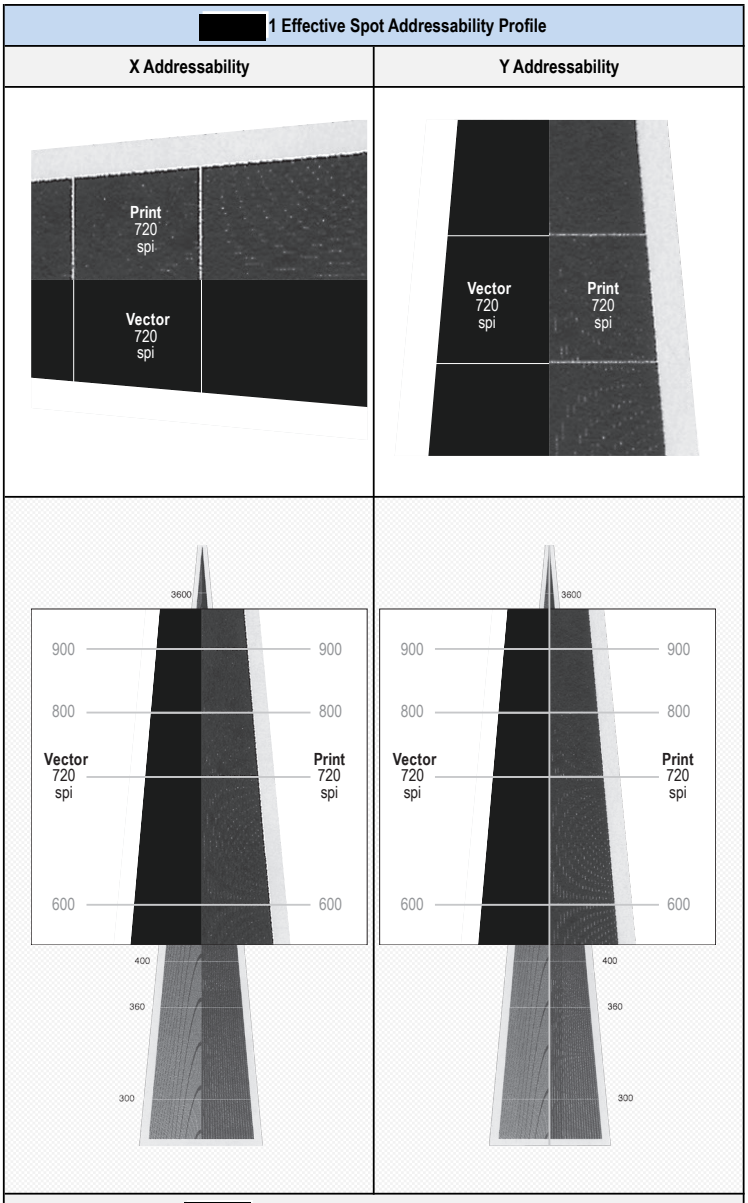
[redacted]1 Spot Addressbility Table

Paper Type	Intended		Reported		Actual	
	X	Y	X	Y	X	Y
Utopia Book #45 (Matte)	600 spi	600 spi	N/A	N/A	720 spi	720 spi
(Gloss)	N/A	N/A	N/A	N/A	N/A	N/A
(Uncoated)	N/A	N/A	N/A	N/A	N/A	N/A

[redacted]1 Effective Spot Addressability Profile



[redacted]1 Spot Addressbility Test Image Validation

- ✓ Printed image available
- ✓ Print scanned at 600 ppi
- ! Soft proof image not available
- ! Vector scales and renders at printer resolution

CRI Contrast-Resolution

Contrast-Resolution Results

Contrast-Resolution index (CRI) measures a system's spatial resolution limits for rendering discernable detail between line-pairs at various tone and contrast levels. Quality factors include screening algorithm, printed dot, holdout and ink bleed, and imaging resolution.

Definitions

- Contrast-Resolution index (CRI) is computed from the Contrast-Resolution Limit Curves (CRLC's) series.
- Contrast-centric CRI value is determined for each contrast levels by averaging the spatial frequency limits across all three CRLC's.
- Tone-centric CRI value is determined for 25, 50 and 75% tone levels by averaging the spatial frequency limits across contrast levels within each CRLC.

Findings

1. Tone-Centric CRI for all three tone levels average -12% relative to the ideal reference which is higher than the maximum tolerance -10%. The data indicates superior average resolution for contrast levels above 4.6 but also severe issues below contrast level of 4.6.

2 Contrast-Centric CRI for all contrast levels average -5% below ideal reference which is on par with the average tolerance -5% and indicates good screening and printer dot quality.

Press: [redacted] Color Inkjet Web Press

Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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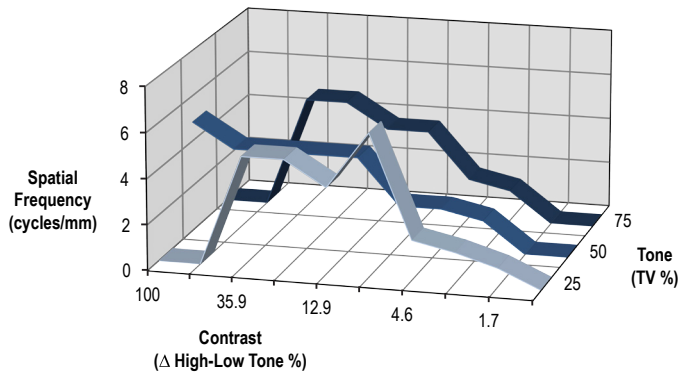
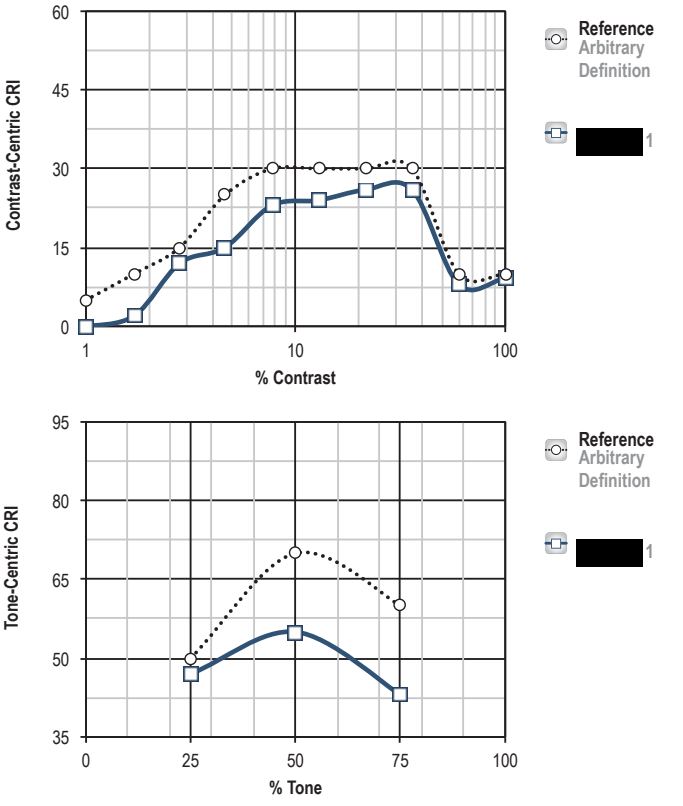
[redacted]1 Contrast-Resolution Limits



		100	59.9	35.9	21.5	12.9	7.7	4.6	2.8	1.7	1.0	Aim	CRI
Tone	25%	0	0	9	9	8	10	5	4	2	0	50	47
	50%	9	8	8	8	8	5	5	4	0	0	70	55
	75%	0	0	9	9	8	8	5	4	0	0	60	43
Contrast	Aim	10	10	30	30	30	30	25	15	10	5		-12%
	CRI	9	8	26	26	24	23	15	12	2	0	-5%	ΔCRI

[redacted]1 Contrast- vs. Tone-Centric Contrast-Resolution Profiles



III-6. **Image Registration**

[redacted]

Image Registration Results

Color appearance encompasses attributes related to the printed color including ink bleed and coalescences.

✔ **C2C** Color-to-Color Registration

Required data was collected following normal procedures.

✔ **S2S** Side-to-Side Registration

Required data was collected following normal procedures.

Concern Levels

Major Concerns: Seriously degrade validity (workaround not possible)
Minor Concerns: Does not diminish validity (workaround possbile)
Normal Procedures: Ideal for comparison (workaround not needed)

Press: [redacted] Color Inkjet Web Press
Substrate: Utopia Book #45 Text
Site: [redacted]
Output Date: 2014-02-14

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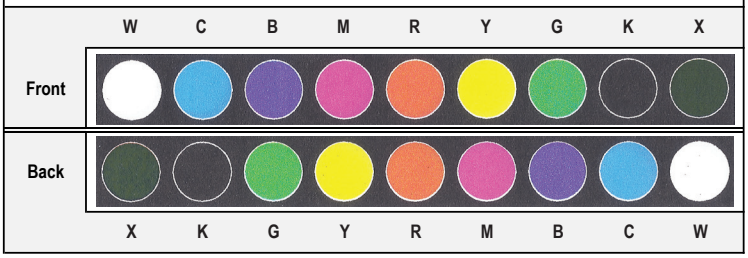
[redacted]1 Color-to-Color Registration

Color-to-Color Registration refers to the extent by which the printing units are able to align Cyan, Magenta and Yellow images, relative to Black and relative to one-another, indicating offset angles and magnitudes.

	Front Side		Back Side		Average Misregistration (Front & Back)			
21 px/µ	Distance	Angle	Distance	Angle	X-Offset	Y-Offset	Distance	Angle
C > K	0 µ	0 °	250 µ	270 °	-0 µ	-125 µ	125 µ	270 °
M > K	0 µ	0 °	250 µ	270 °	-0 µ	-125 µ	125 µ	270 °
Y > K	175 µ	270 °	250 µ	270 °	-0 µ	-213 µ	213 µ	270 °
M > Y	175 µ	270 °	0 µ	0 °	-0 µ	-88 µ	88 µ	270 °
C > Y	175 µ	270 °	0 µ	0 °	-0 µ	-88 µ	88 µ	270 °
C > M	0 µ	0 °	0 µ	0 °	+0 µ	+0 µ	0 µ	0 °

Average misregistration distance for the primary colors C, M, Y relative to K is 125 µ. Maximum distance is 213 µ and maximum angle difference is 0 ° degrees.

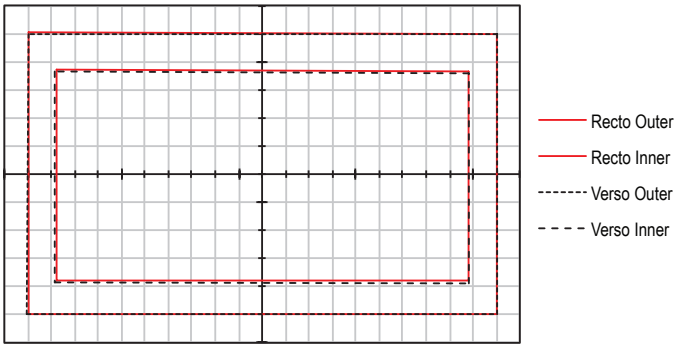
Average misregistration for the CMY pairs for the secondary color overprints is 88 µ. Maximum distance is 88 µ and maximum angle difference is 90 ° degrees.



[redacted]1 Side-to-Side Registration

Side-to-Side Registration refers to the extent by which the printing units are able to align images printed on the back side relative to the front, indicating distortion and offset factors along the axial and circumferential directions.

Offset	X	+870 µ	Distance	870 µ	microns	**Distortion**	X	+791 µ	microns
	Y	-30 µ	Anlge	-0.1°	degrees		Y	-27 µ	microns



Estimated front-to-back offset is X: +870 Y: -30 microns, which translates to a distance of 870 microns with a -0° tilt Estimated front-to-back distortion is X: +791 Y: -27 microns.

C2C Color-to-Color Registration

[redacted]

Color-to-Color Registration Results

Color-to-Color Registration refers to the extent by which the printing units are able to align Cyan, Magenta and Yellow images, relative to Black and relative to one-another, indicating offset angles and magnitudes.

Definitions

- Color-to-key misregistration reflects the distance and angle between each CMY patch relative black. X/Y-Offsets are computed from distance and angle.
- Color-to-color misregistration reflects the combined distance and angle between two primary CMY colors derived from the color-to-key X/Y-offset pairs.
- Average X/Y-Offset combine misregistration for both sides to compute average distance and angle.

  Average values maybe highly skewed when colors are misalign in opposite directions, which makes it essential to always include data for both sides.
- Color-to-color test images are used to compute front/back misregistation by extracting CMYK patches from 1200 dpi scanned targets

  Proper color management should result in pure color patches for more accurate computations.

Findings

1. Average misregistration distance for the primary colors C, M, Y relative to K is 125 µ. Maximum distance is 213 µ and maximum angle difference is 0 ° degrees.

2. Average misregistration for the CMY pairs for the secondary color overprints is 88 µ. Maximum distance is 88 µ and maximum angle difference is 90 ° degrees.

Press: [redacted] Color Inkjet Web Press

Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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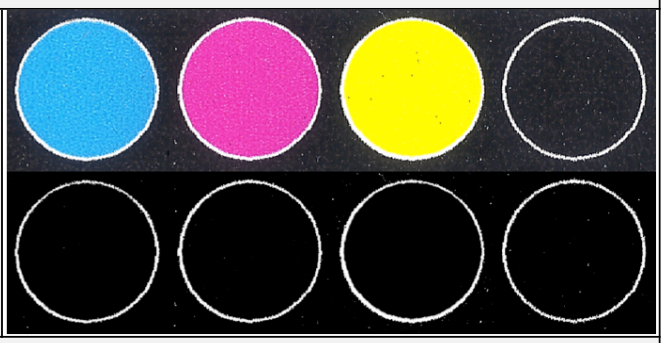
[redacted] 1 Color-to-Color Registration Table

	Front Side		Back Side		Average Misregistration (Front & Back)			
21 px/µ	Distance	Angle	Distance	Angle	X-Offset	Y-Offset	Distance	Angle
C > K	0 µ	0 °	250 µ	270 °	-0 µ	-125 µ	125 µ	270 °
M > K	0 µ	0 °	250 µ	270 °	-0 µ	-125 µ	125 µ	270 °
Y > K	175 µ	270 °	250 µ	270 °	-0 µ	-213 µ	213 µ	270 °
M > Y	175 µ	270 °	0 µ	0 °	-0 µ	-88 µ	88 µ	270 °
C > Y	175 µ	270 °	0 µ	0 °	-0 µ	-88 µ	88 µ	270 °
C > M	0 µ	0 °	0 µ	0 °	+0 µ	+0 µ	0 µ	0 °

[redacted] 1 Color-to-Color Registration Test Images

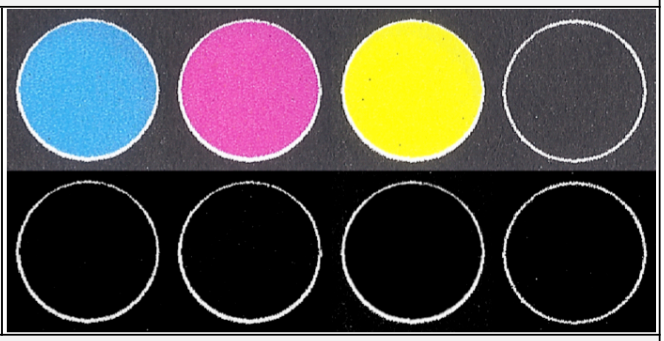
Extracted CMYK Patch Close-ups

Front



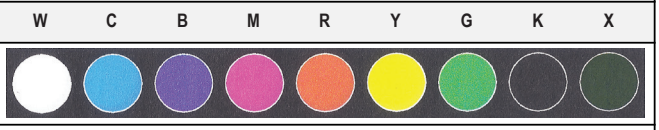
Cyan Magenta Yellow Black

Back



Scanned Registration Bar

Front



Back

[redacted] 1 Color-to-Color Registration Test Image Validation

- ✓ Front-Side Image (1200 dpi / 8-bit RGB)
- ✓ Back-Side Image (1200 dpi / 8-bit RGB)
- ✓ All CMYK patches pass validity criteria
- ✓ Proper separations (No CMY interferences)

S2S Side-to-Side Registration

[redacted]

Side-to-Side Registration Results

Side-to-Side Registration refers to the extent by which the printing units are able to align images printed on the back side relative to the front, indicating distortion and offset factors along the axial and circumferential directions.

Definitions

- Overall X/Y-Offsets represent distance between centers of two matching ROIs on either side,

  Centers are determined based on the relative corner offsets for each side independently.

- Corner Offsets represent the relative distance between repspective corners on each side.

  Positions of each corner point is detemined relative to the closest cropped corner of the scanned image.

- Inner corner close-ups simulates the estimated side-to-side misregistration for each corner of the matching ROI's, evenly scaled across quadrants.

- Inner and outer plot simulate the measured relative positions of the scanned image corners and the ROI corners for both sides.

  Accuracy of estimated misregistration is improved with the better alignment of the outer corners.

Findings

1. Estimated front-to-back offset is X: +870 Y: -30 microns, which translates to a distance of 870 microns with a -0° tilt
2. Estimated front-to-back distortion is X: +791 Y: -27 microns.

Press: [redacted] Color Inkjet Web Press

Substrate: Utopia Book #45 Text

Site: [redacted]

Output Date: 2014-02-14

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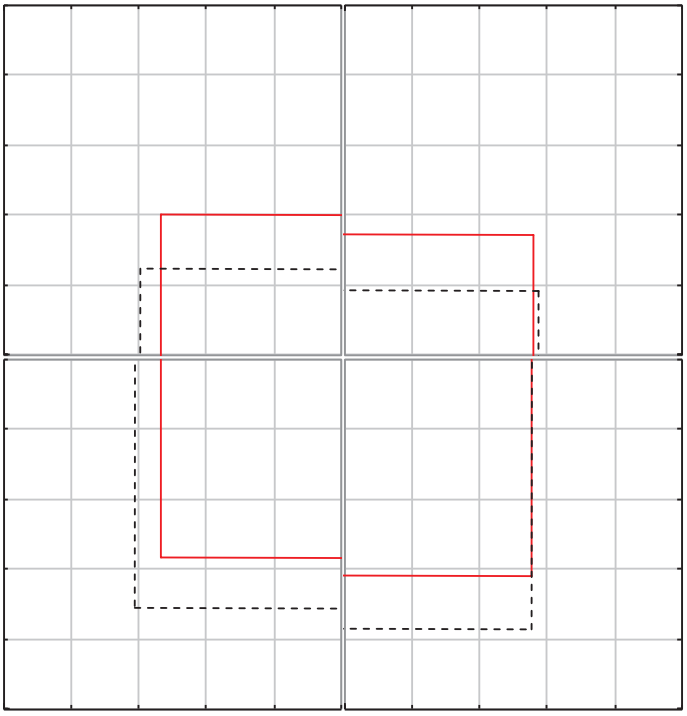
[redacted]1 Side-to-Side Registration Table

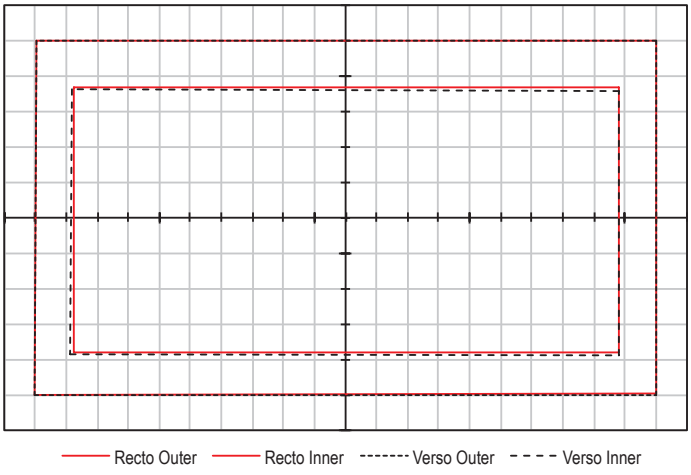
		Overall	Top		Bottom		
		X/Y	Left/Right	Right/Left	Left/Right	Right/Left	
Offsets	**X**	+870 µ	-902 µ	-6 µ	-698 µ	+145 µ	**Front/Back Offset**
	Y	-29.7 µ	-838 µ	-868 µ	-899 µ	-929 µ	870.0 microns
Distortion	**X**	+791 µ					**Front/Back Title**
	Y	-27 µ					-0.1° degrees

[redacted]1 Side-to-Side Registration Plots

Inner Corners Side-to-Side Registration Close-up



Inner and Outer Side-to-Side Registration Overall



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