High Resolution Project

Final Report

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Introduction

The flexographic industry is on a path of continuous improvements with the ongoing advancements of technology from various aspects of our industry. A part of the area that the Flexographic Quality Consortium has decided to focus on is the results of High Resolution Printing. This multi part project involves the defining of a print target that is to include elements which will have measurable targets where one can visually and numerically assess the benefits of new technology and another part where the agreed to print target is brought to narrow web and wide web printers to test a comparative of the defined print target in a standard output mode and another print target with the full tools applied with latest output technology available at each given printer.

We would like to thank all parties that participated in this project from start to finish.

- Ann Michaud – 3M
- Alexander James – Harper
- Andrew Knapp – Flint Group
- Bettylyn Krafft – Phoenix Challenge
- Bjorn Knutson – FTA
- Brad Gasque - Clemson
- Brian Cook – MacDermid
- Bruce Ridell – Spectrum Label
- Cori Devlin - Dupont
- Duane Woolbright – FTA
- Jeremy Rohan - Accredo
- Jason Barrier – Printpack
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- Larry Goldberg – BetaScreen
- Larry Moore – Esko
- Page Crouch – Clemson
- PJ Fronczkiewicz – Flint Group
- Richard Black - APR
- Rob Frimming – Schawk
- Tom Cassano – ARC
- Sam Ingram - Clemson

Special thanks to the team leaders:

- Alexander James
- Ann Michaud
- Brian Cook

High Resolutions Printing – Part A -Print Target/Output Metrics

Executive Summary:

High Resolution printing refers to a variety of areas of active improvement in flexography. FQC has been requested to clarify the meaning of **high resolution** by members in several disciplines within the industry.

The first part of this project is to define the output improvements targeted and identify metrics within a focused print target.

Objectives:

1. Define and implement a new target image.
2. Define new tests, methods and criteria of excellence.
3. Design a new data collection sheet for characterizations and tests.

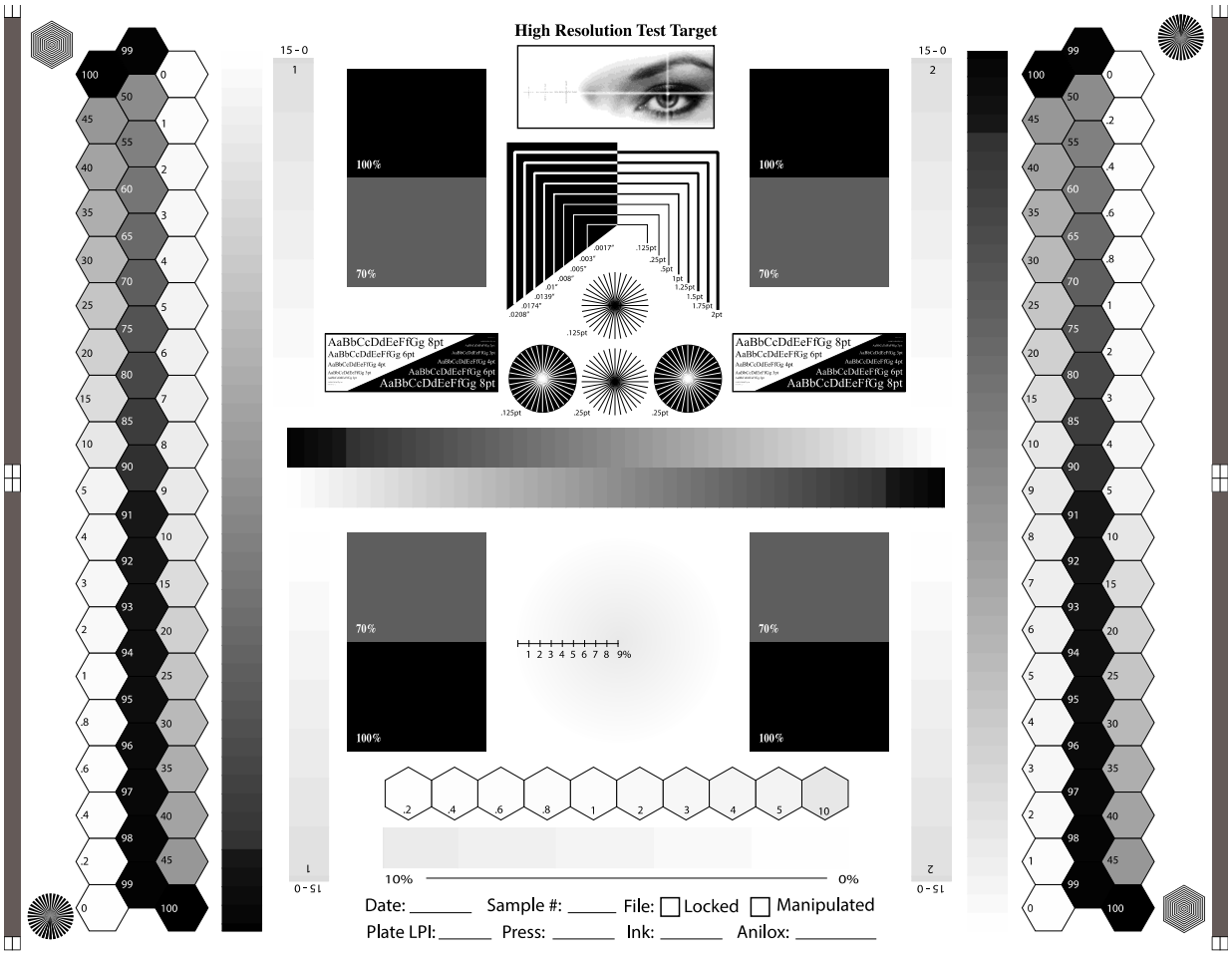
Scope:

1. Current test methods are designed to measure conformance vs. standards, not to define improvements towards excellence and improving flexography
    a. Increased print image resolution – what does this mean?
    b. Improved contrast - What does this mean? Smoothness of solids impact?
    c. Improved resolution in highlights - smallest dots reproduced?
    d. Better consistency for a longer time (phase 3) - Hold dots, keep smooth, stay clean, delta E, neutral print density/gray balance (probably can't run for long times, but need to establish metrics)
    e. Improved transitions through full tonal range - Measure TVI or density thru range
    f. Increased "color gamut" - SID, hue angle, chroma on gamut volume
    g. Quality of traps? - Process or output variable?
    h. How does it ***look***?
    i. Others as identified
2. The new criteria will be intended to be used in tests to compare and value the various new technologies under development and serve as a continuing development criteria
3. The new criteria can be used for a variety of other activities. Some process will be a combination of experiments and group expert knowledge

Project Charter Statement

1. Alignment on how to measure progress and quantify.
2. Ultimate project to enable print buyers, printers, and suppliers to share expectations of how to achieve higher flexo performance.

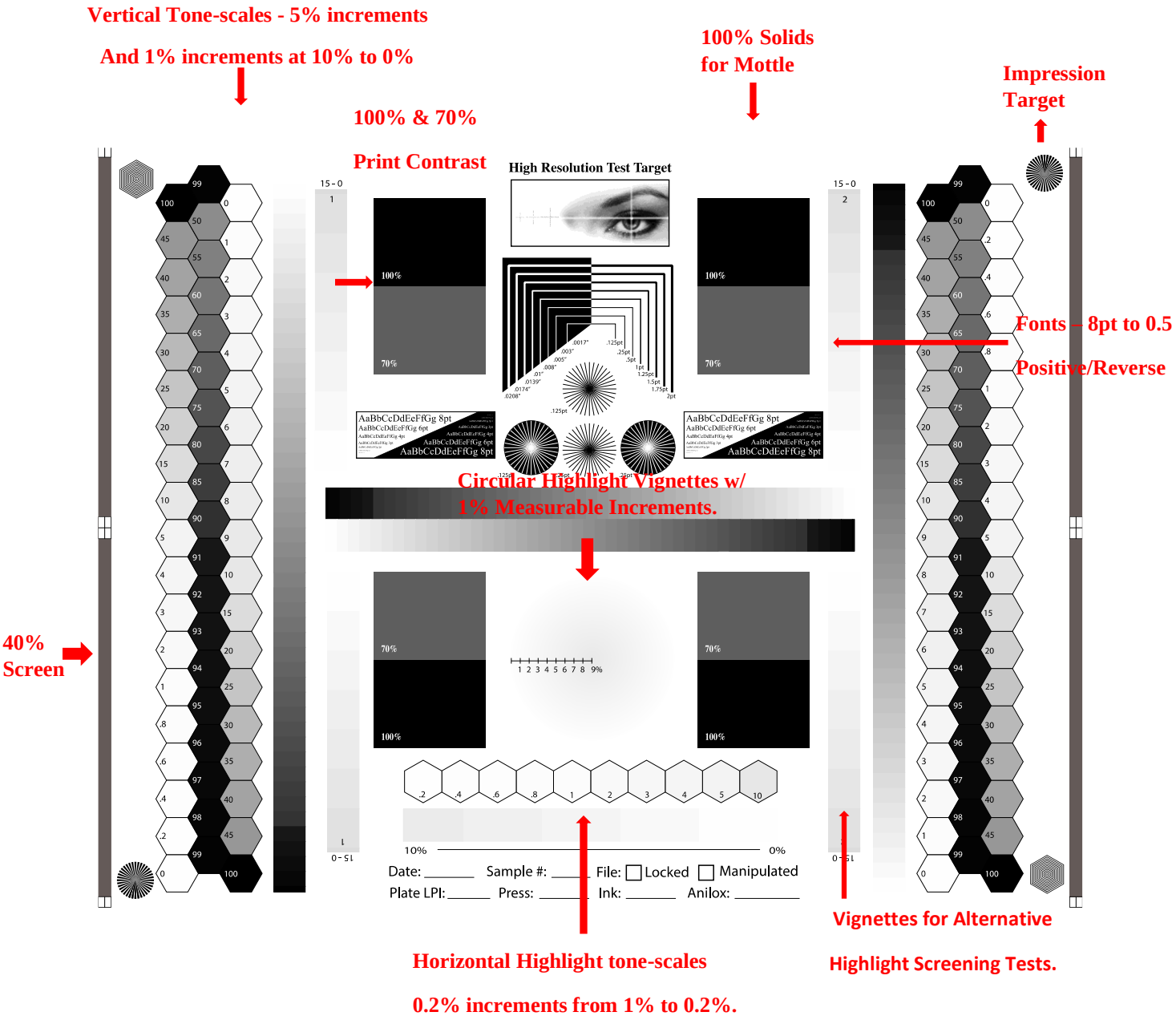
After numerous committee meetings and conference call throughout that fall of 2013 and most of 2014 a High Resolution Test Target was defined and agreed to by the group. This target will enable the printed comparison of standard output techniques compared to new advancements in in screening and plating technologies and materials.



This print target is designed to include measurable elements throughout the layout. The layout will work on narrow web presses and for a wide web setup can be stepped and repeated to fit the desired print width and print repeat.

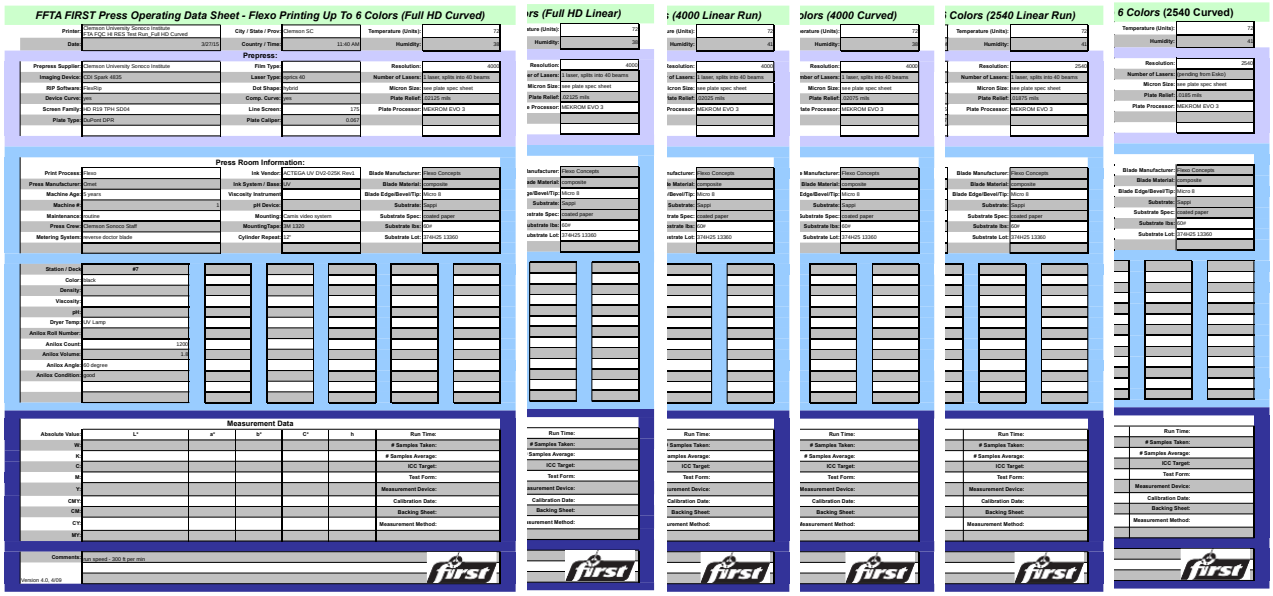
Measurables - include the following:

- Impressions Targets in the four corners.
- Left Side - Vertical Tone-scales with 5% increments and 1% increments at 10% to 0%.
- Print Contrast Target.
- Positive & Reverse line widths – 0.125pts to 1.75pts.
- Positive & Reverse - 10% circular increments – 0.125pts & 0.25pts.
- Serif Fonts – Positive & Reverse - 8pts to 0.5pts.
- Right Side – Vertical Tone-scales with 0.2% increments from 1% to 0%.
- Bear bars – 40% screen on both sides of the target.


Vertical Tone-scales - 5% increments
And 1% increments at 10% to 0%
100% Solids
for Mottle
Impression
Target
100% & 70%
Print Contrast
High Resolution Test Target
Fonts – 8pt to 0.5
Positive/Reverse
40%
Screen
Circular Highlight Vignettes w/
1% Measurable Increments.
Date: _____ Sample #: _____ File: Locked Manipulated
Plate LPI: _____ Press: _____ Ink: _____ Anilox: _____
Vignettes for Alternative
Highlight Screening Tests.
Horizontal Highlight tone-scales
0.2% increments from 1% to 0.2%.

- **Print Output Metrics**

Data Sheets with Print Output Metrics accompanied each print target for the print trials.



The Print Output metrics included data sections to document the numerous technologies used for the standard target and the High Resolution target during the print tests.

Part A – Objectives:

1. Compare the impact of various technical approached to higher resolutions flexo printing based on the print target and output metrics defined in Part A.
2. Report out what kind of end results can be anticipated and what process steps are necessary are necessary to achieve them.

Part A Summary:

The High Resolution Print Target was defined and measurables assigned to the elements within the target. The print target along with the printout put matrices data sheets will allow the documentation of each print trial as we test the comparative of High Resolution technologies compared to Standard technologies. Next steps will be to engage industry companies to find willing partners to participate in the on press trials aspect of the project.

High Resolution Printing – Part B - Narrow Web – Performance Comparison

This part of the project will require the participation of industry printers. Working with the printers we will test/compare the printed results using standard technologies with the print target and other advance technologies. The process and results will be documented and evaluated with each print test to ascertain the benefits of new technologies for a High Resolution Printing.

Special thanks to:

- Mike McGinnis – RR Donnelley
- Madison Hennessey – RR Donnelley
- Brian Cook – MacDermid
- Rick Mix – Xeikon
- Catherine Green – All Printing Resources
- Bjorn Knutson – FTA

Project Objective:

- Compare impact of various technical approaches to higher resolution flexo printing based on output metrics in Part A.
- Output the print target with standard technologies and high resolution file plus another with the full tools available – latest screening advancements/resolutions.
- Report out what kinds of end results can be anticipated.
- Initial Press Tests were conducted on Narrow Web Presses.

Scope:

1. Identify components included in high resolution concepts
    a. Advancements in imaging technology
        i. Hardware, software and firmware
        ii. Increased original image resolution
        iii. Increased print image resolution
    b. Improved screening technology
        i. Dot structures
        ii. Plate surfaces
        iii. Highlight structures
    c. Improved dot face geometry (flat/rounded)
    d. Others as identified
2. Use tribal knowledge to identify other steps that must be taken to capture the effect of these changes; experiment as needed

3. Evaluate and report on the end use impact as identified in Part A of combinations in 1. and 2. above
4. All data, as is standard process should be kept on the FTA FQC shared data file.

Business Impact:

Ultimate project goal is to enable print buyers, printers, and suppliers to share expectations of how to achieve higher flexo performance and the impact of various approached on these results.

Print comparison protocols:

Narrow Web Requirements:

Plate Screen Ruling:	175 lpi or greater
Substrate Type:	Coated Paper
Ink Color:	Process Cyan or Magenta
Ink Type:	UV or water based
Ink Density:	Run to *FIRST* 5.1 target
	Cyan: 1.35 (1.3-1.4)
	Magenta: 1.25 (1.2-1.3)

Document Plate Technology:

Plate Manufacturer, Plate Type, Screening Technology

Define conditions for Print Comparison

- Standard Resolution – Linear (Optional)
- Hi Resolution – Linear
- Hi Res Condition – Full Tools Applied

Resolution: _____

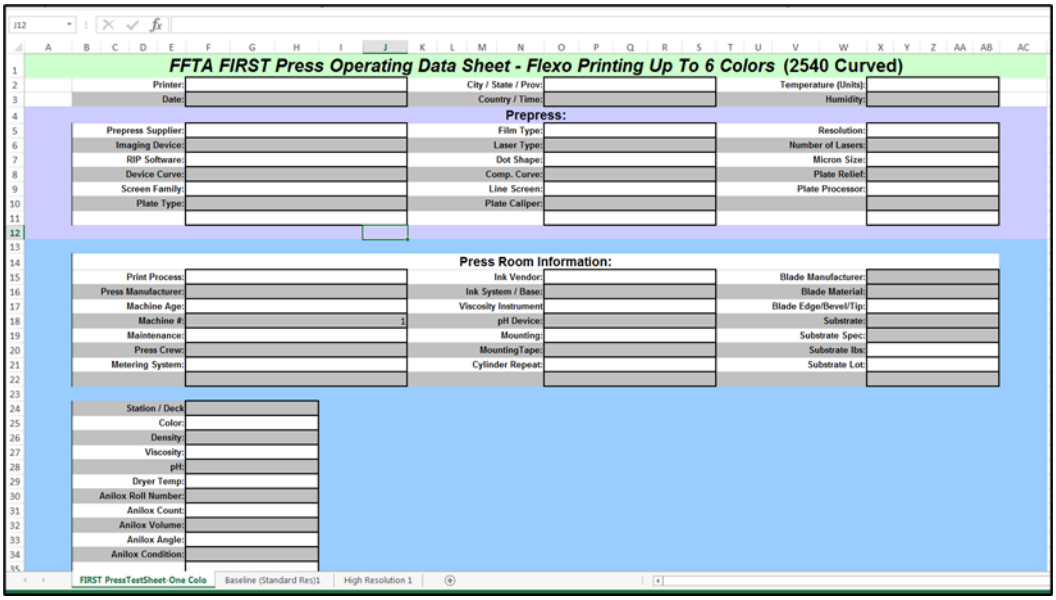
Curve Applied: _____

Screening Technology: _____

All Technologies are In Scope for Hi Res Full Tools Applied

Print Comparison Protocols:

On-press Documentation – record the constants on-press.



FFTA FIRST Press Operating Data Sheet - Flexo Printing Up To 6 Colors (2540 Curved)

Printer:		City / State / Prov:		Temperature (Units):	
Date:		Country / Time:		Humidity:	

Prepress:

Prepress Supplier:		Film Type:		Resolution:	
Imaging Device:		Laser Type:		Number of Lasers:	
RIP Software:		Dot Shape:		Micron Size:	
Device Curve:		Comp. Curve:		Plate Relief:	
Screen Family:		Line Screen:		Plate Processor:	
Plate Type:		Plate Caliper:			

Press Room Information:

Print Process:		Ink Vendor:		Blade Manufacturer:	
Press Manufacturer:		Ink System / Base:		Blade Material:	
Machine Age:		Viscosity Instrument:		Blade Edge/Bevel/Tip:	
Machine #:	1	pH Device:		Substrate:	
Maintenance:		Mounting:		Substrate Spec:	
Press Crew:		MountingTape:		Substrate lbs:	
Metering System:		Cylinder Repeat:		Substrate Lot:	

Station / Deck	
Color:	
Density:	
Viscosity:	
pH:	
Dryer Temp:	
Anilox Roll Number:	
Anilox Count:	
Anilox Volume:	
Anilox Angle:	
Anilox Condition:	

FIRST PressTestSheet-One Colo | Baseline (Standard Res)1 | High Resolution 1

- Print and Sample Collection
  - Print a minimum of 30 impressions per condition
  - Select 3 press sheets per condition for data collection at printer
  - Select 3 press sheets per condition for submission to third party measurement location

- Data Collection
  - Printer will measure 3 press sheets per condition
  - Record data in data measurement spreadsheet provided
  - 3rd party location will measure a subset of data

Print Trial Comparison Results:

- Print evaluations completed at 4 printers
- Pre-press and press room conditions are reported for each printer
- Print results are pooled for all 4 printers
- Analysis and summary are based on pooled results

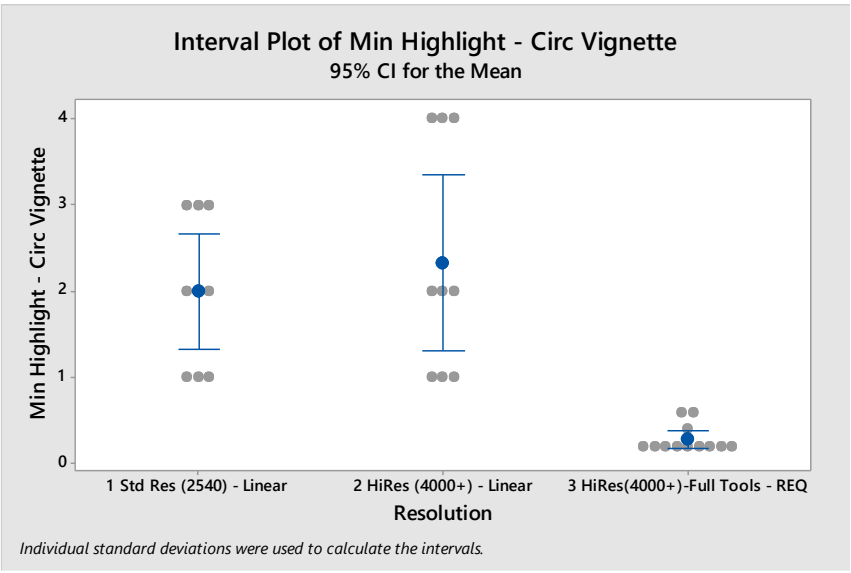
	Printer A	Printer B	Printer C	Printer D
Imaging Device:	CDI4260	Esko Spark CDI		NX
RIP Software:	Nexus	Esko	FlexRip	Prinergy
Screen Family:	C25	HD C36 MC16		NX
Plate Type:	DuPont EFX	Flint ACT	DuPont DSR	Kodak NX
Durometer:	65 - 67 Sh A	n/a		67 Sh A
Laser Type:		Optics 40	Optics 40	SquareSpot
Dot Shape:		Round	conventional (round top)	1:1 Flat top

	Printer A	Printer B	Printer C	Printer D
Line Screen:	175 lpi	175	175	175
Plate Caliper:	0.067"	0.067”	0.067”	0.067”
Resolution:	4000	4000	4000	2400
Relief:	.019" - .020"	0.021”	0.025”	
Plate Processor:	Thermal	Flint FIII processor	Nyoflex Flowline	Kodak conventional

Print Comparison Results continue:

- Circular Vignette – Minimum Highlight Dot
- Clearest Min Font – Positive & Reverse
- Clearest Min Line – Positive & Reverse
- Solid Ink Density
- Print Contrast

- **Clearest Printed Vignette Highlight, Min Dot**

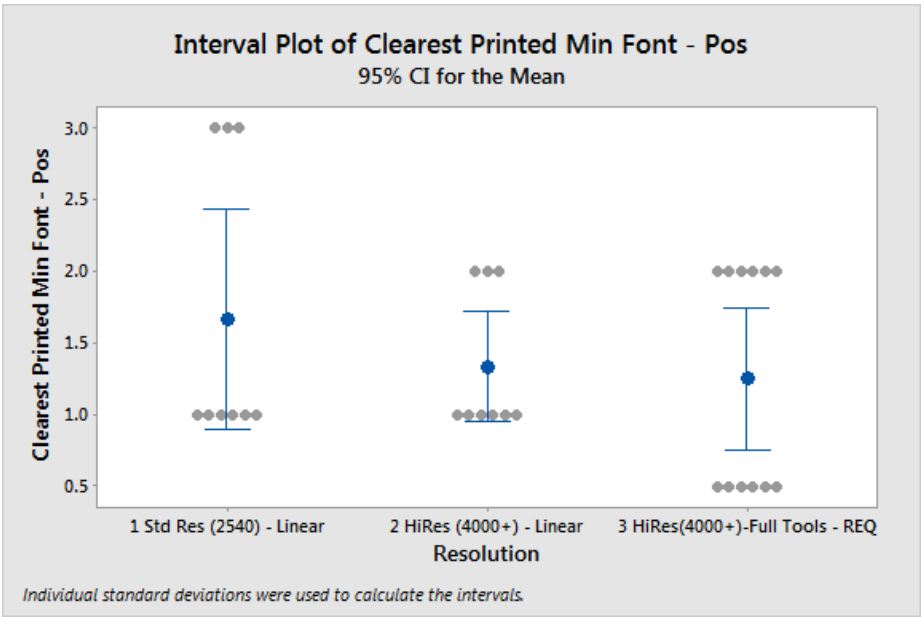


Standard Resolution

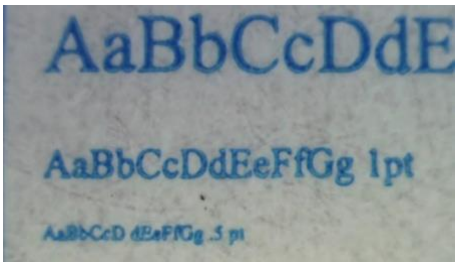
Hi Res -Full Tools Applied

Data indicates a significant reduction in mean for Clearest Printed Minimum Dot for Full Tools Applied as compared to Standard Resolution Linear and High Resolution Linear.

- **Clearest Printed Font – Positive Type**



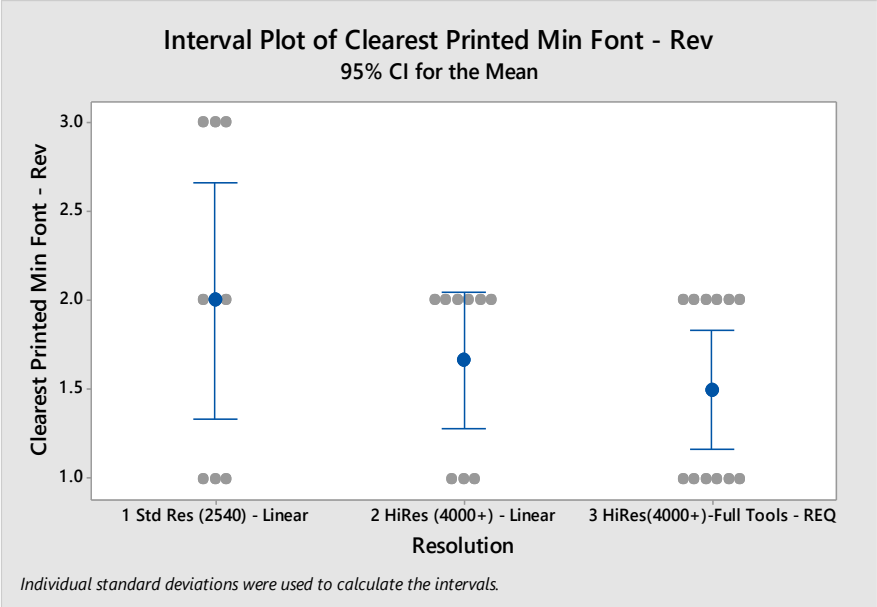
Standard Resolution



Hi Res – Full Tools Applied

Data indicates a reduction in the mean Minimum Positive Font for Full Tools Applied as compared to Standard Resolution Linear and High Resolution Linear.

- **Clearest Printed Font – Reverse Type**

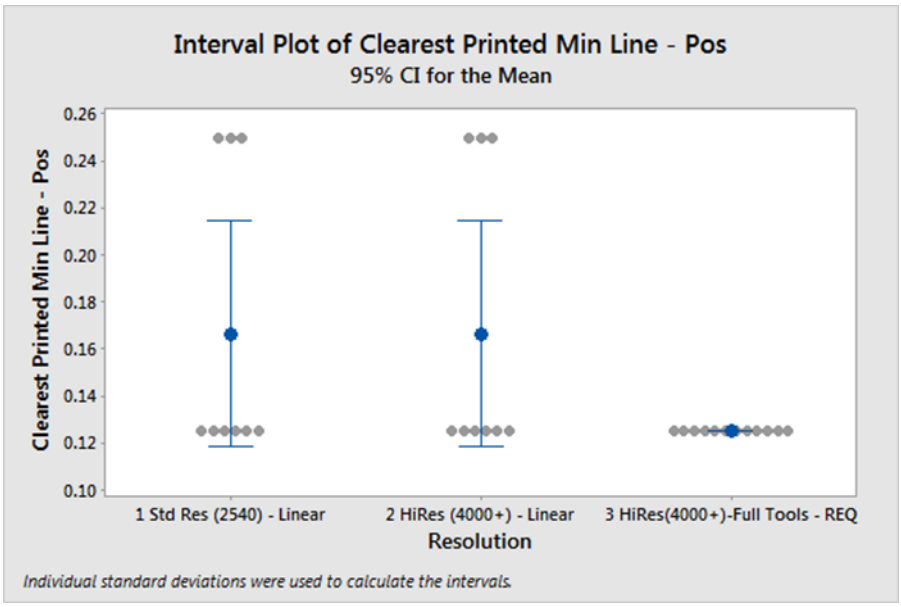


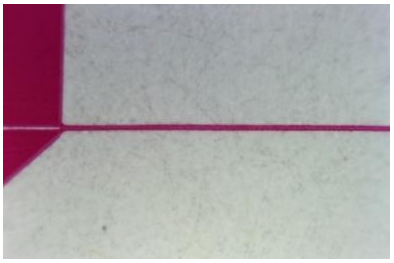
Standard Resolution

Hi Res - Full Tools Applied

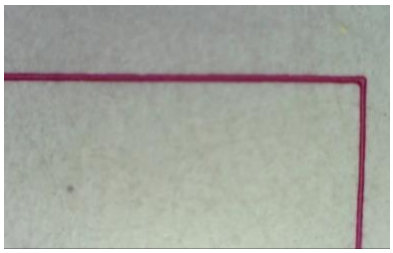
Data indicates a reduction in mean for Clearest Reverse Type Font for both High Resolution Linear and Full Tools Applied for as compared to Standard Resolution Linear.

- **Clearest Printed Min Line - Positive**





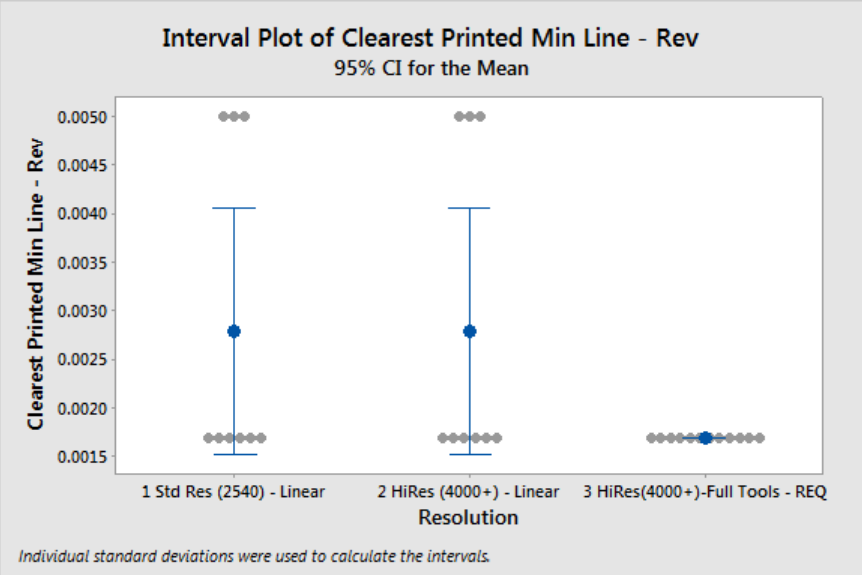
Standard Resolution

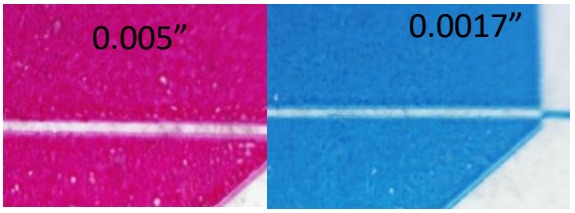


Hi Res- Full Tools Applied

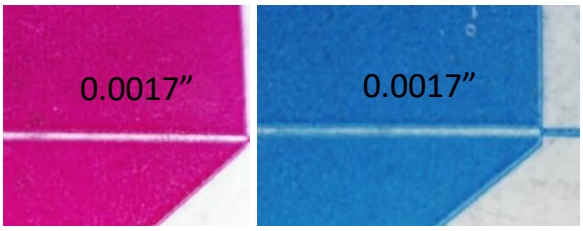
Data indicates a reduction in mean Clearest Printed Minimum Line for Full Tools Applied as compared to both Standard Resolution Linear and High Resolution Linear.

- **Clearest Printed Min Line - Reverse**





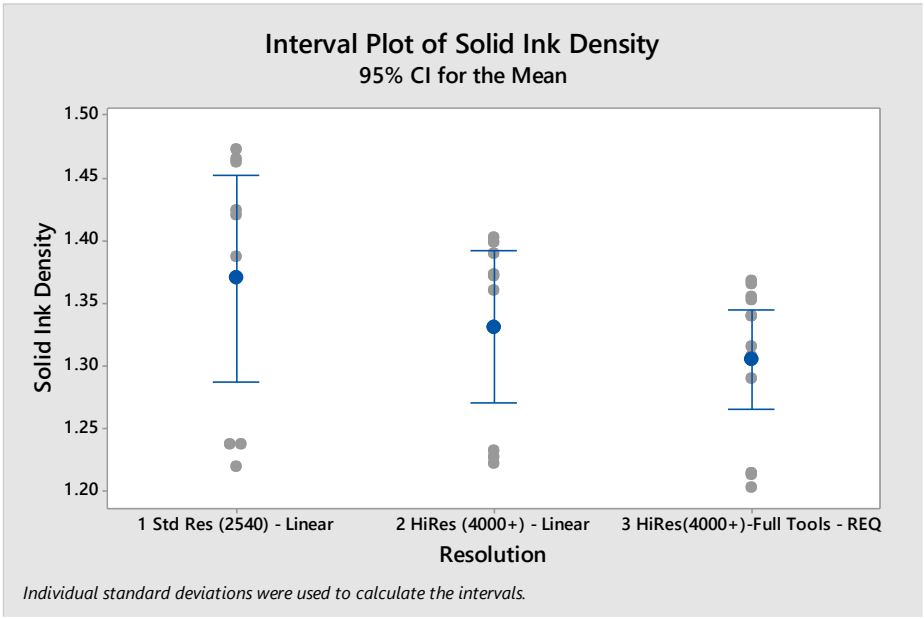
Standard Resolution



Hi Res – Full Tools Applied

Data indicates a reduction in mean for Clearest Printed Minimum Reverse Line for Full Tool Applied as compared to both Standard Resolution Linear and High Resolution Linear.

- **Solid Ink Density**

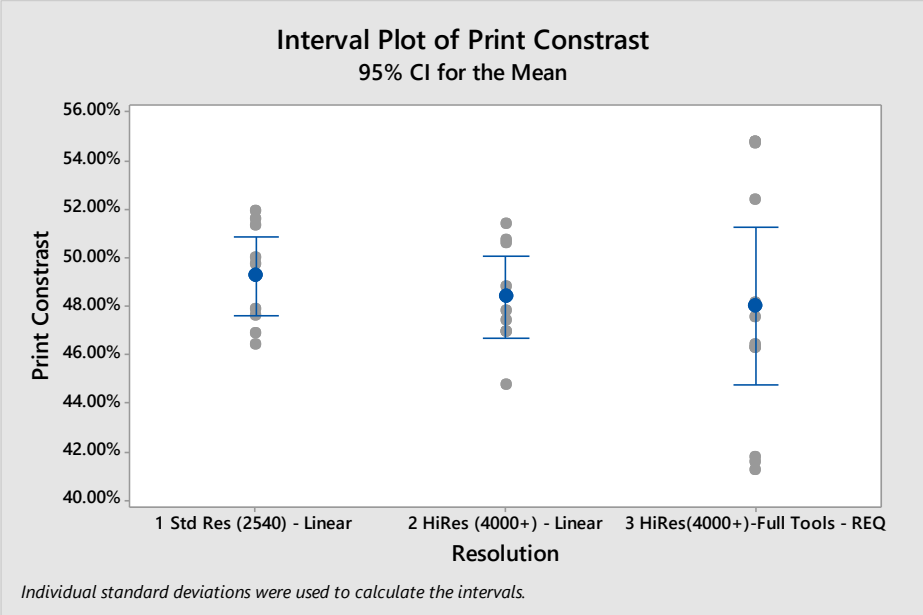


Standard Resolution

Hi Res – Full Tools Applied

Data indicates slight statistical difference in mean for Solid Ink Density for Full Tool Applied as compared to both Standard Resolution Linear and High Resolution Linear.

- **Print Contrast**



Standard Resolution

Hi Res – Full Tools Applied

- Data indicates no statistical difference in mean for Print Contrast for Full Tool Applied as compared to both Standard Resolution Linear and High Resolution Linear.

- **Hi Res – Narrow Web Print Trial Summary**
  - Based on statistical and visual evaluation the printed results showed an across-the-board benefit when Hi Resolutions Full Tools are applied.

	Standard Res Mean	Hi Res Full Tools Mean
Circular Vignette – Min Dot (%):	2%	0.2%
Clearest Printed Font – Positive (pt):	1.67	1.25
Clearest Printed Font – Reverse (pt):	2.00	1.50
Clearest Min Line – Positive (pt):	0.167	0.125
Clearest Min Line – Reverse (in):	0.0845	0.0017
Solid Ink Density:	1.37	1.31
Print Contrast:	49.3%	48.0%

Summary and Conclusions:

These print tests were conducted primarily with Narrow Web printers, using UV inks. Given the stability of UV inks, it was quite interesting to see and find measurable differences and benefits when using the latest technologies. Fortunately, we are constantly seeing new output screening advancements and various surface patterns, available both digitally and manufactured in materials. These tests prove that sticking with standard technologies will result in printed results that will be subpar with compared to printers using the latest available technologies.

High Resolution Printing – Part B - Wide Web – Performance Comparison

Special thanks to:

- Chuck Buscaglia (Berry Global)
- Jason Cagle (MacDermid)
- Bob Fiala (ProAmpac)
- Jason Galloway (Bema)
- Alex James (Kodak)
- Mike McGinnis (RR Donnelly)
- Ann Michaud (3M)
- Joe Riccardella (Berry Global)
- Jason Wills (Sun Chemical)
- Bjorn Knutson – FTA

Project Objective:

- Compare impact of various technical approaches to higher resolution Wide Web flexo printing based on the output metrics in Part A.
- Report out what kinds of end results can be anticipated for Wide Web film presses.

Scope:

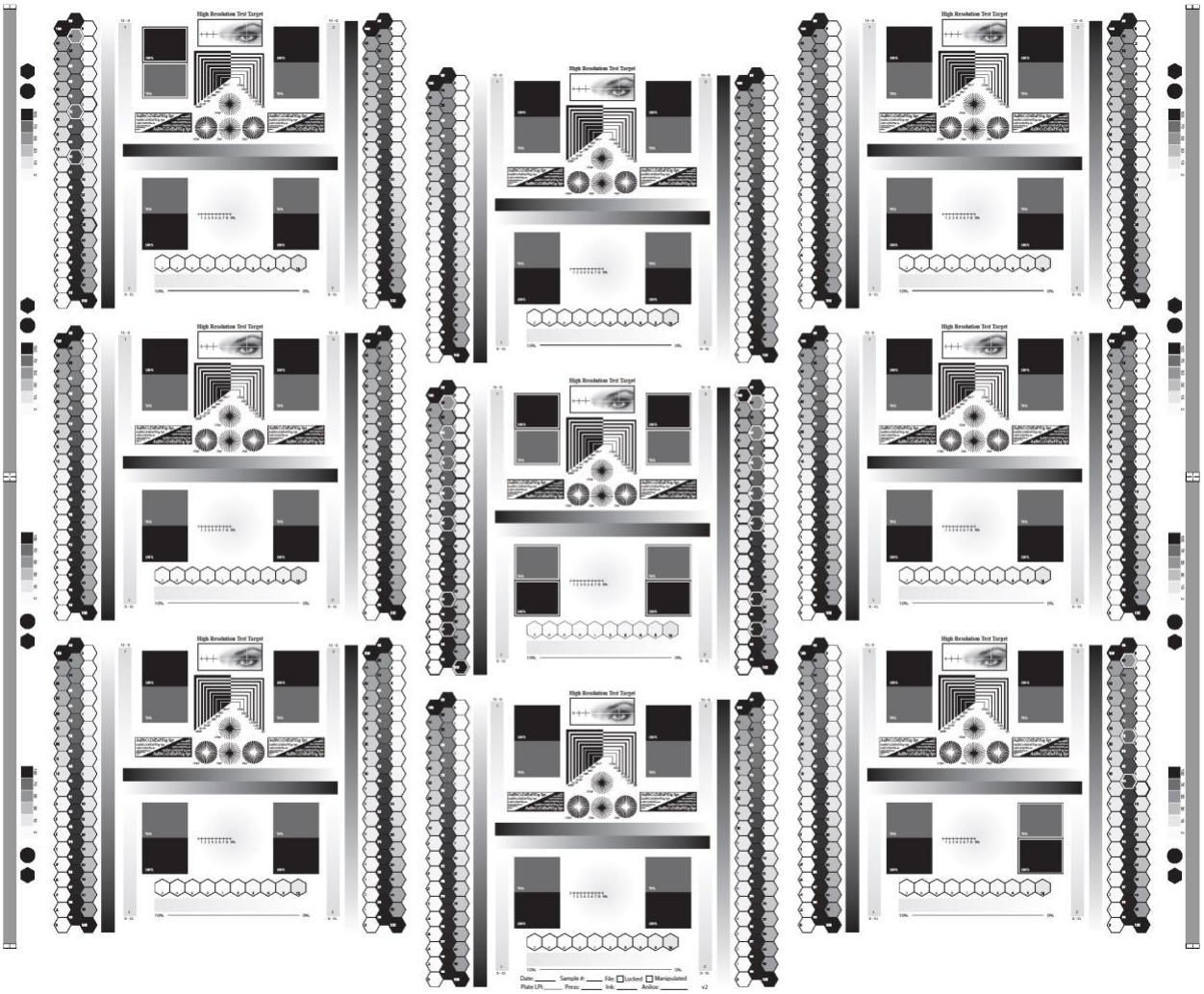
1. These remained the same as High Resolution Printing – Part B - Narrow Web.
2. Current test methods are designed to measure conformance vs. standards, not to define improvements towards excellence and improving flexography
    a. Increased print image resolution – what does this mean?
    b. Improved contrast - What does this mean? Smoothness of solids impact?
    c. Improved resolution in highlights - smallest dots reproduced?
    d. Better consistency for a longer time (phase 3) - Hold dots, keep smooth, stay clean, delta E, neutral print density/gray balance (probably can't run for long times, but need to establish metrics)
    e. Improved transitions through full tonal range - Measure TVI or density thru range

f. Increased “color gamut” - SID, hue angle, chroma on gamut volume
g. Quality of traps? - Process or output variable?
h. How does it ***look***?
i. Others as identified

3. The new criteria will be intended to be used in tests to compare and value the various new technologies under development and serve as a continuing development criteria.
4. The new criteria can be used for a variety of other activities. Some process will be a combination of experiments and group expert knowledge.

The team adapted the High Resolution target defined in Part A and utilized for printing in Part B narrow web by stepping and repeating the target to fit a print repeat of 26” with a width of 33”. This approach was necessary to avoid re-approving agreed upon image elements. The measurable elements for this target remained the same as those defined in Part A on page 5.

Wide Web target :



High Resolution Wide Web target

Print Comparison Protocols:

The documentation previously developed for the earlier Part A & B research was adapted for Wide Web data collection. The data collection sheet was also modified.

Conditions for the Print Comparison remained the same as Part B – Narrow Web

- Standard Resolution – Linear (Optional)
- Hi Resolution – Linear
- Hi Res Condition – Full Tools Applied

Resolution: _____

Curve Applied: _____

Screening Technology: _____

All Technologies are In Scope for Hi Res Full Tools Applied

Print Requirements for Wide Web:

Plate Screen Ruling:	150 lpi or Greater
Substrate Type:	White LDPE
Ink Color:	Process Cyan or Magenta
Ink Type:	Solvent or Water Based
Ink Density:	*FIRST* 6.0 Targets
Cyan:	1.30 (1.25-1.35)
Magenta:	1.20 (1.15-1.25)

White LDPE material was preselected to minimize the variables on press for the wide web print trials, which restricted the testing to surface print only.

Press Trial Protocols:

A Pre-Trial Meeting was held prior to each press test to ensure clear communication and execution. Press specific data was collected utilizing the FTA press operating data sheet used previously. At press, print samples were pulled until the sample met the agreed upon print specifications. Each condition printed for one minute at production speeds before the press was stopped and six samples taken per condition. Data was collected from three press repeats for each condition utilizing the top left, middle, and bottom right targets to maintain a reasonable number of measurements per sample while maintaining enough data for statistical integrity.

Plates, print samples, and the completed datasheets were submitted to Mike McGinnis at RR Donnelly for verification after each trial.

Print Trial Results:

- Print evaluations completed at 5 printers: Bema, ProAmpac, Fox Valley Technical College, American Packaging, Berry Global
- Print results were pooled for all 5 printers
- Analysis and summary are based on pooled results

Technologies Represented:

Traditional Round Top Digital

In-line UV LED Exposure

Flat Top Dot (FTD) with Intermediate Step Required

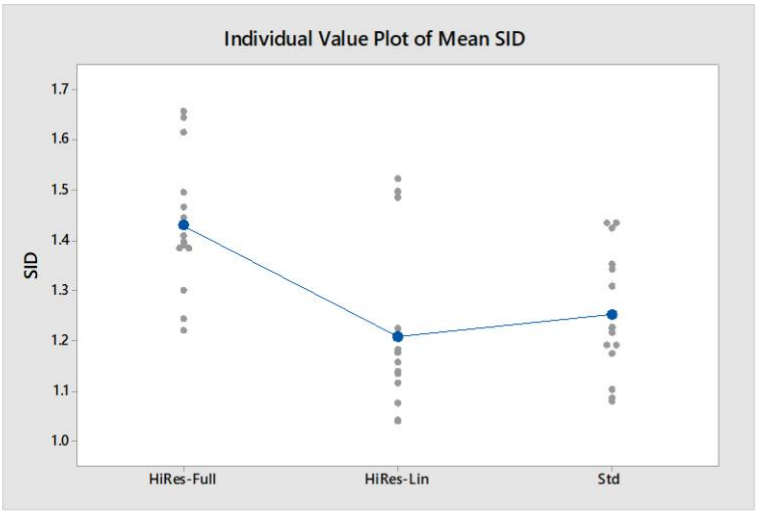
FTD Out of the Box

Solvent and Thermal plate Processing

Both Circular and Hybrid Screening included

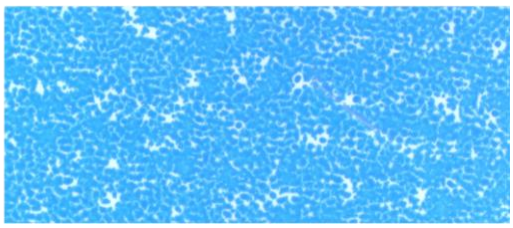
Print Trial Comparison Results:

Solid Ink Density (SID)



P Value: 0.676

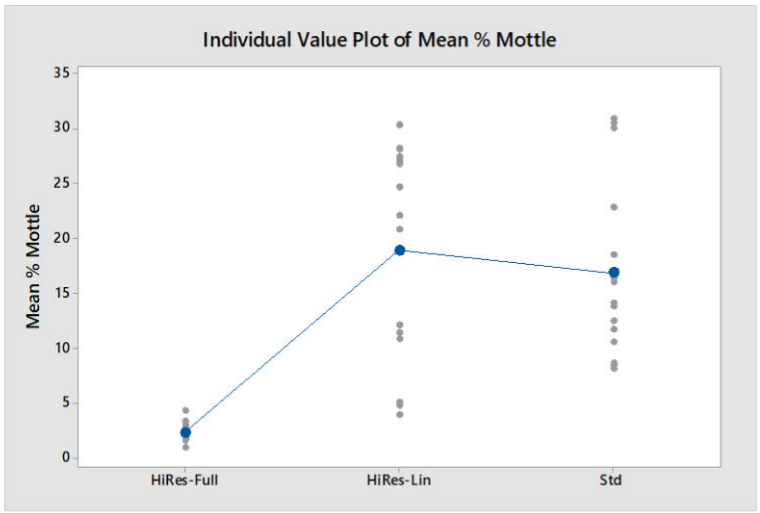
Standard Resolution

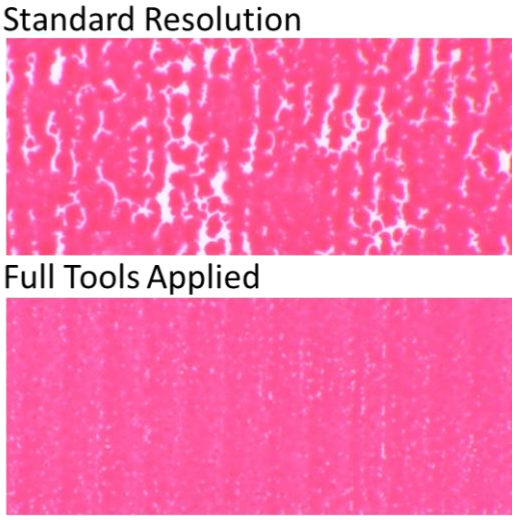


Full Tools Applied

The pooled data shows no significant difference between Standard, High-resolution linear, and High resolution Full Tools, solid ink densities (SID). This is likely because at least one printer utilized flexographic plates that contained an inherently roughened surface that is also used in the industry to improve SID. On average, the High Resolution – Full Tools pooled data is higher and may benefit from a more narrowly focused study in the future.

Mottle

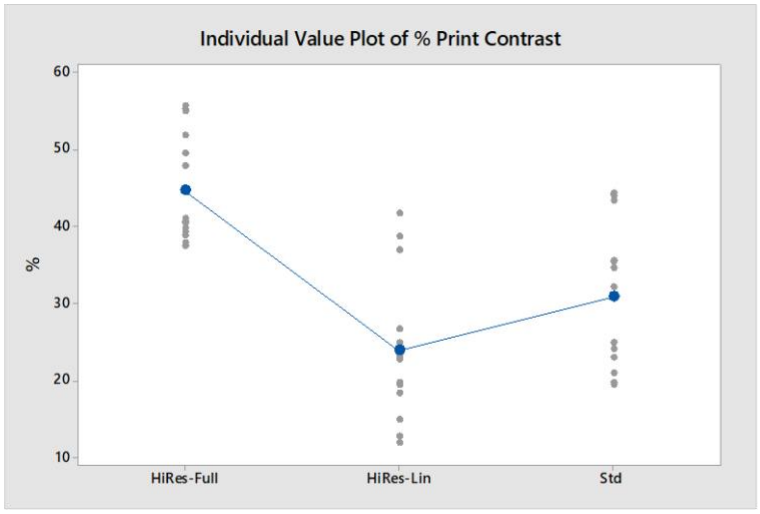


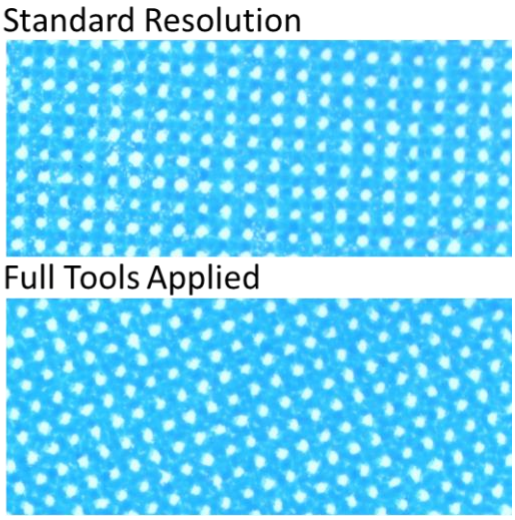


P Value: 0.000

The pooled data indicates a significant difference between High Resolution - Full Tools applied and the Standard and High Resolution – Linear plates. High Resolution - Full Tools shows more consistency regarding lower mottle values (less voids in the printed ink film layer). Visually, the High Resolution - Full Tools solid areas of the plate have a uniform distribution of the ink on the substrate as well.

Print Contrast

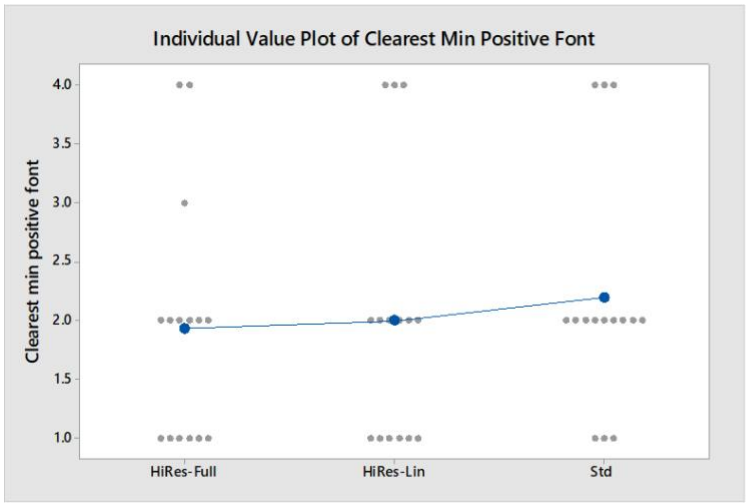


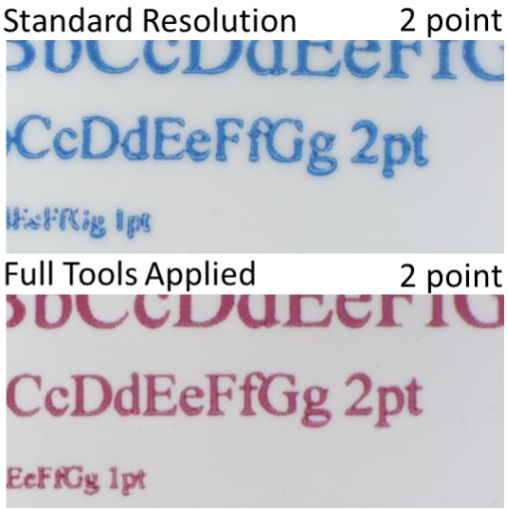


P Value: 0.526

The pooled data indicates no significant difference of print contrast among the variables tested.

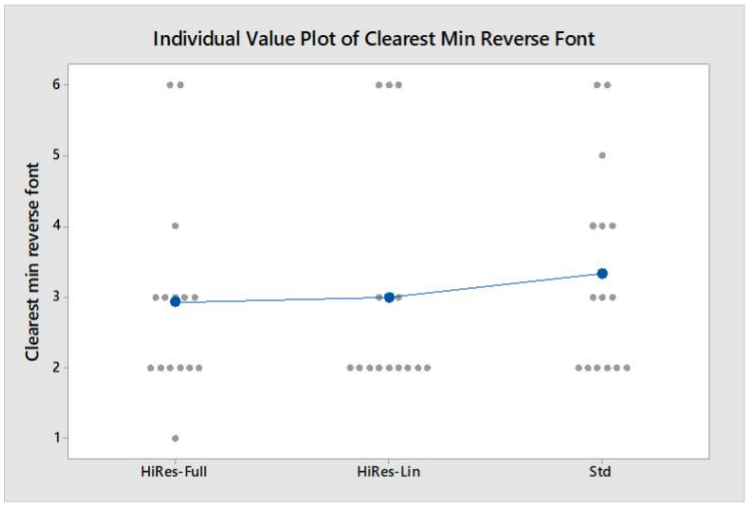
Sharpest Min Font – Positive & Reverse

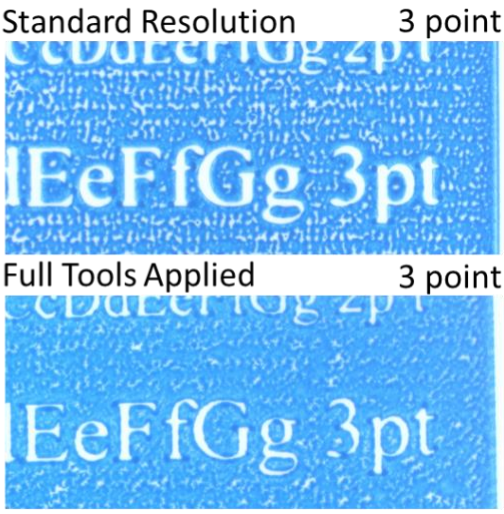




P Value: 0.930

The pooled data indicates no significant difference for the sharpest positive minimum font though the printed quality of the High Resolution positive type may be improved versus standard resolution.

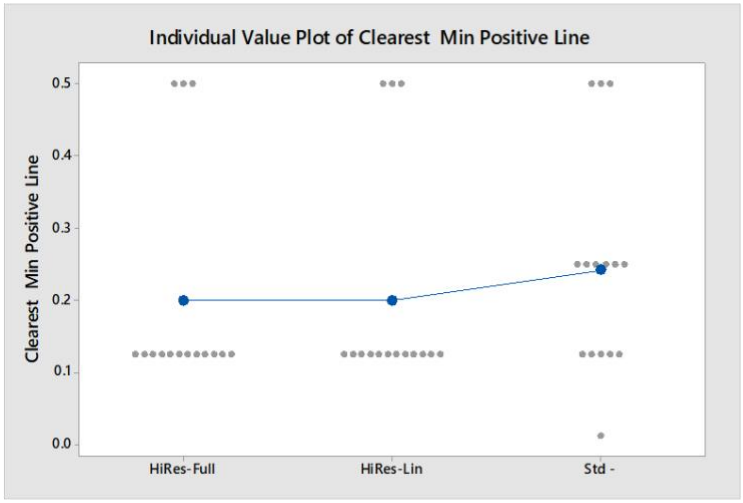


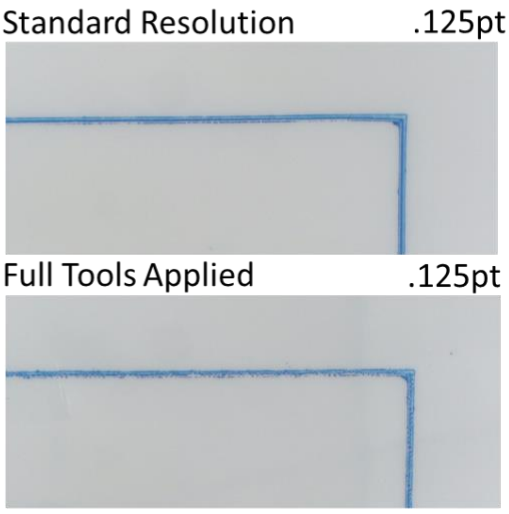


P Value: 0.953

The pooled data indicates no significant difference for the sharpest reverse minimum font.

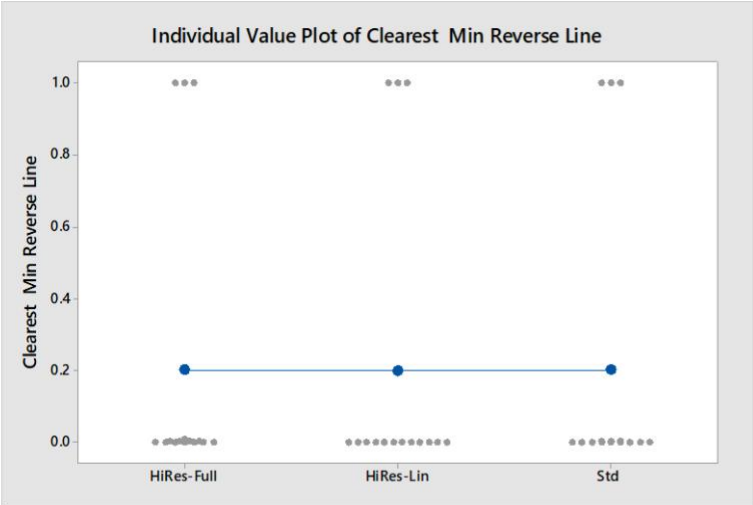
Sharpest Min Line – Positive & Reverse



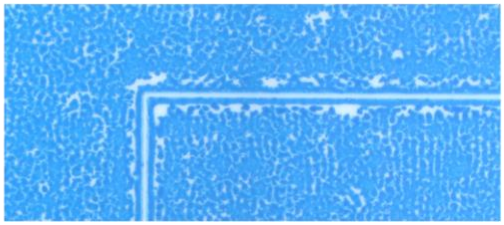


P Value: 0.997

The pooled data indicates no significant difference for the clearest minimum positive line.



Standard Resolution

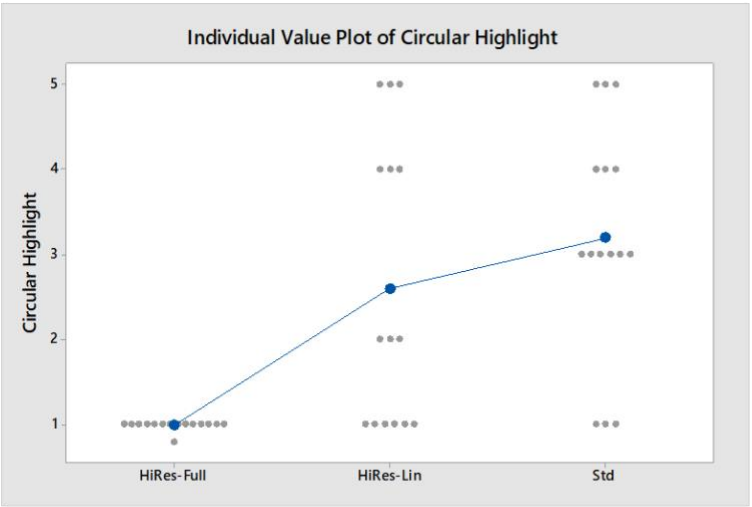


Full Tools Applied

P Value: 1.000

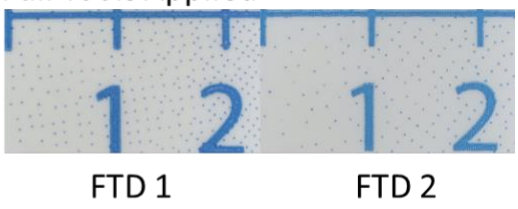
The pooled data indicates no significant difference for the clearest minimum reverse line. Practically, High Resolution – Full Tools captured image data suggest a possible overall quality improvement in minimum reverse lines.

Circular Vignette – Minimum Highlight Dot



Standard Resolution

Full Tools Applied



P Value: 0.000

The pooled data indicates a significant difference for the minimum highlight dot when using High Resolution – Full Tools applied. However, both the Standard Resolution and High Resolution – Linear targets did not have a bump applied. Also, both Round Top Dot (RTD) and Flat Top Dot (FTD) plates or FTD methods were included which is why there is a large range (1% - 5%) of minimum highlight dots held for the Standard and High Resolution – Linear targets.

Summary

	Standard	High Res	Full Tools
Solid Ink Density:	1.25	1.21	**1.43**
Mottle:	16.91	18.93	**2.39**
Print Contrast:	30.95%	23.96%	**44.72%**
Clearest Printed Font – Positive (pt):	2.20	2.00	1.93
Clearest Printed Font – Reverse (pt):	3.33	3.00	2.93
Clearest Min Line – Positive (pt):	0.24	0.20	0.2
Clearest Min Line – Reverse (in):	0.0019"	0.0017"	0.0024"
Circular Vignette – Min Dot (%):	3.20%	2.60%	**1.0%**

Conclusions - High Resolution Part B For Wide Web

Solid Ink Density

Though the pooled data indicated no significant difference between Standard, High-resolution linear, and High resolution - Full Tools plates, solid ink densities (SID) on average for the High Resolution – Full Tools pooled data were higher and may benefit from a more narrowly focused study in the future.

Improved Ink Coverage (Lowers Mottle)

The pooled data indicated a significant difference and thus an improvement between High Resolution - Full Tools applied and the Standard and High Resolution – Linear plates.

Yields Smallest Minimum Highlight Dot

The pooled data indicates a significant difference for the minimum highlight dot when using High Resolution – Full Tools applied.

Summary and Conclusions

Looking at results from the Narrow Web – Part B and the Wide Web – Part A on this project, one can conclude that there are benefits for the use and implementation of the latest available imaging and plating technologies. Different segments of this report could be part of a more narrowly focused test using specific ink systems with the latest available plate screening technologies. Technological advancements continue to raise the bar of the printed results throughout our industry and with such leads to increased production efficiencies and better printed products for the brands.

The scope of this project involved a wide range of talented volunteers throughout our industry and covered a range of technologies and plating materials for various suppliers within the industry. A heart felt thank you to all involved and to all the suppliers and printers who gave so generously of their time and materials.