Analyzing Relative Humidity Problems in Digital Printing

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Keywords

Humidity, Digital printing, Imaging

Abstract

This is an intermediate report of work-in-progress concerning technical issues relating to the effects of relative humidity in the growing field of digital printing.

From this pretest stage of research we identify variables and technical problems with digital printing that may be related to relative humidity.

We subjected a variety of desktop office printing devices to the test of printing a standardized file to study how they perform under normal atmospheric conditions. Substrate was standardized. Ambient temperature and relative humidity was controlled.

Printed dots of varying sizes are scanned using a digital microscope and images were captured for evaluation. ImageJ software is used to measure dot areas that are graphed and compared for variations to a reference dot. Surface plots are generated and evaluation shows variations between different printing devices.

A scanned solid block was imported into ImageJ and a line of standardized length was drawn from a solid block across a white unprinted area. Plot profiles generated in ImageJ was used to evaluate the differing changes in line shape between the images from the different devices.

First deviations were calculated and graphed to show the rate of change of pixels as the line crosses over the solid edge. The printer requiring the least number of pixels was determined to most closely represent the reference edge.

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Introduction

Atmospheric (ambient) humidity (RH), temperature and to some extent ozone levels affect digital printing machine, substrate and ink performance and eventually the finishing performance as well. When paper and toner take on humidity or lose humidity it can have a significant affect on the production of the printed job. Table 1 shows some of the characteristics that interact within a non-impact printing subsystem.

Howard (2001) observed that background and optical density was directly proportional to the relative humidity.

Moisture content of a paper strongly affects the electrical properties of a paper (Weigert 2003). Humidity conditions of certain paper grades is directly related to the transfer current and therefore the amount of toner that is transferred to the paper. Higher moisture content at a higher relative humidity reduces surface resistivity, resulting in higher conductivity of transfer current (AL-Rubaiey, 2001).

Higher ambient relative humidity results in more electrically conducive air. When relative humidity is low, conductivity is lower, significantly affecting toner charging. Toner charges to a higher level during lower humidity and can become overcharged. Since toner absorbs more water at higher humidity, toner becomes more difficult to charge and hold the charge. When toner is undercharged, the toner will be attracted to the white area of the pages which then causes print background problems. (Howard 2001)

There is a “vast difference” between printers and paper brands. Multipurpose office paper can be affected by humidity of the paper and air, which results in changes in colour-to-colour bleed, optical density and wicking during inkjet printing. However, black optical density is not affected (Hogberg 2001). Ordinary papers may exhibit a certain weakness and react to extremes in humidity (Hogberg 2001). And paper grade has been found to have a greater effect on toner transfer characteristics than does that of the machine engine itself (AL-Rubaiey, 2001).

In a 2001 study Hogberg found that on an HP printer, all colours (except black) were clearly more brilliant when humidity was increased. This increased optical density during increased humidity was because of an increased lateral spreading of the colour ink. This is because coloured inks have a lower surface tension and therefore favour spreading. The HP printer also was prone to image bleeding during higher humidity. The Canon printer had higher wicking at higher humidity levels. On the HP printer strike-through was clearly worst at 80% humidity (Hogberg 2001). The device used significantly affected results and so did the difference in paper significantly affect the results.

The relative performance of certain dye sets can be affected by humidity. Fading for certain types of colorants can depend on humidity which results in reduced print life (Meissner, 2003). Solid inks are unaffected by humidity or temperature. (Jaeger)

Environmental controls are built into production digital printers such as the NexPress 2100 (Weigert 2003). Advanced digital printing devices often deploy process control systems that have on-board humidity and temperature sensors (Owada). Some machine may use a heated pre-dryer to ensure the right environmental conditions in an inkjet printer (Hogberg 2001). Caruthers (2001) found that a robust supply control system for toner is needed to compensate for changes in humidity and temperature.

Atmospheric (Ambient) Conditions				
Relative Humidity	Temperature	Ozone?		
Substrate Properties				
Multipurpose paper	Kaolin/Silica coating	Heavyweight covers	Smart papers	Photo paper
Micro/ porosity	pH/alkalinity & chemistry	Electrical resistivity	Heat capacity	Coefficient of friction
Wettability surface energy	Ink holdout/ receptivity	Smoothness/ roughness	Oil absorption	Grain/machine direction
(Relative) Humidity	Temperature	Ozone?		
Non-impact Imaging Technology				
Inkjet	Electro photographic	Bubble jet	Laser	Maintenance /repair level
RIP abilities	Imaging head technology	Imaging head gap/angle	Paper path type	Drum age /condition
Halftoning method	Fusing technology	Transfer drum method	Environmental controls	Availability of preheater
Calibration	Static control			
Relative Humidity	Temperature	Ozone?		
File Properties – Design Elements				
Heavy ink coverage	Gloss/ Matte	Screens	Archival requirements	Run length- variable data
Ink Properties				
Pigment based	Dye based	Liquid	Water based/ soluable	Powder/solid
Relative Humidity	Temperature	Ozone?		
Effects/Results				
Fade/ light fastness	Cracking	Wet rub Resistance	Dot size/ uniformity	Dot resolution
Print density	Ink spreading	Colour fidelity	Show through	Ink penetration /depth
Image noise	Hue shift	Slow drying	Saturation	Colour-to- colour bleed
Wicking	Deletions	Blistering		

Table 1. Sampling of Technical Considerations of a Non-impact Printing Subsystem

Experimental Conditions

A MAC Powerbook G4 running MAC OS 10 Tiger was used to print the standardized image using a direct cable connected to different devices. In most cases this cable was a USB–to-USB or on older devices a parallel to USB cable was used. In one case a fire-wire cable was used.

Standardized Test Form

A single standardized 8½”x11” B&W test file with several test images and control strips containing irregular shapes, lines, dots and donuts of different sizes, standard halftone step tablet, and gradated screen was created as test patches specifically for this research. Adobe Photoshop CS was used to create and assemble the images and Adobe Acrobat CS was used to finalize the .pdf high-resolution image for printing.

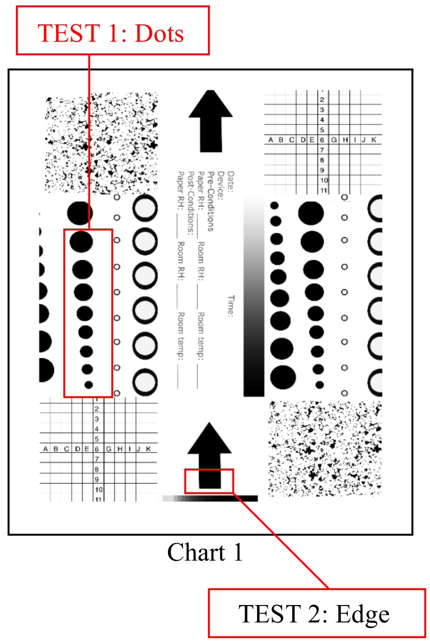


Chart 1

Control of Ambient and Substrate Conditions During Imaging

All testing was done at Ryerson University’s Graphic Communication Management facility Heidelberg Centre using different print engines in different areas of the building. Attempts were made to replicate commercial production conditions. Ambient and substrate RH and temperature were monitored and kept consistent.

Paper substrate used is 20 lb Multipurpose Bond 92 bright letter size. Substrate temperature and RH conditions were controlled by storing the paper in it’s original packaging (vapor barrier) while being transported to the imaging device. Both ambient and substrate temperature as well as relative humidity was measured before and after imaging. Immediately upon imaging, test sheets were taken to the microscope and digital photographs taken. At this point RH was low and temperature higher than the control substrate.

A Rotronic Hygromer S1 Sword Hygrometer was used to measure a stack of paper both pre-imaged and post-imaged to determine temperature and humidity.

Imaging Machine Conditions

The digital printers chosen ranged from desktop inkjet devices to a floor model electrophotographic machine, from older models to newer models, from older technology to newer technology and from inexpensive to mid to high priced machines.

No attempt was made to repair, maintain or to calibrate machines immediately prior to tests, as our aim was to test machines as they are in the every day production environments. All machines were run at factory default hardware and software settings.

Print engine (and its varying conditions such as age, etc.) was the main variable in this study. All subject machines in this study were desktop black-and-white inkjet print engines with the exception on the Canon ImageRunner, a mid-level electrophotographic production printer. All machines tested use powder toner.

Machines Tested

- HP 5000n
- HP 5100tn
- Canon ImageRunner IR5570
- Lexmark 323
- Lexmark T634
- Panafax UF-788

Experimental Process

A variety of desktop office printing devices were subjected to the test of printing a standardized file to study how they perform under normal atmospheric conditions. Substrate was standardized as a common 20# multipurpose 92 bright white bond in 8 ½" x 11" letter size. Ambient temperature and relative humidity was controlled. Substrate temperature and relative humidity was measured using a relative humidity wand (Rotronic Hygromer S1 Sword Hygrometer) and thermometer both before and after imaging.

In TEST 1, printed dots of eight varying sizes were scanned using a digital microscope and images were captured for evaluation. Surface plots were generated using ImageJ software and visual evaluation done. Plot profiles done with ImageJ was used to measure dot area, measured in pixels. Graphs were created and to illustrate the variations.

In TEST 2, scanned solid blocks were imported into ImageJ where a line of standardized length was drawn between a solid block, to across a white unprinted area. Plot profiles generated in ImageJ were used to evaluate the differing changes in graph lines and shape between the images from the different devices.

Line edge function and dot spread measurement analysis was performed. Change in dot size and line length as well as change in line height when crosses over from printed to unprinted areas was evaluated. 3D surface plot of dots was visually compared.

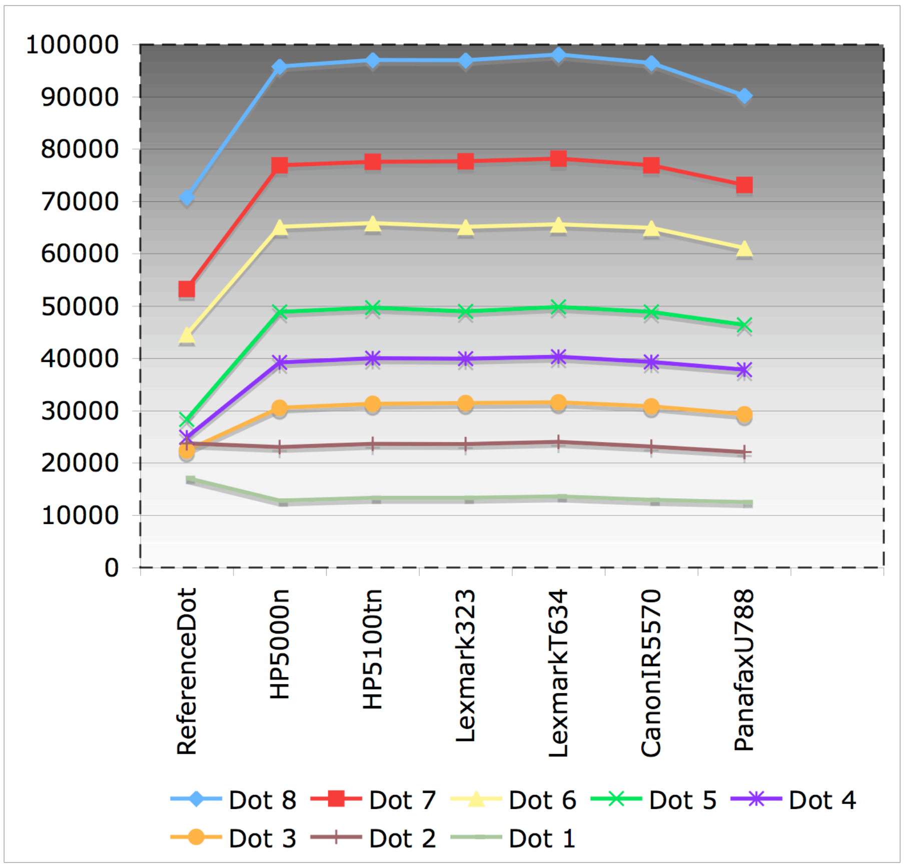
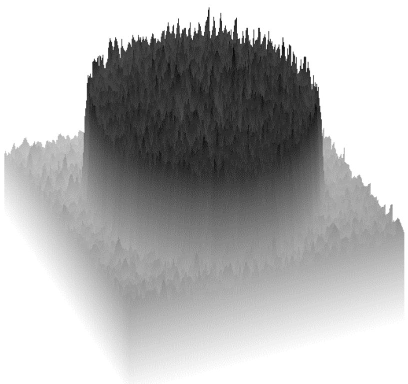
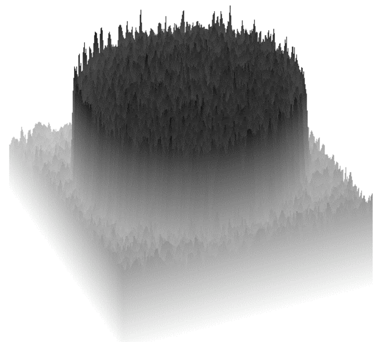


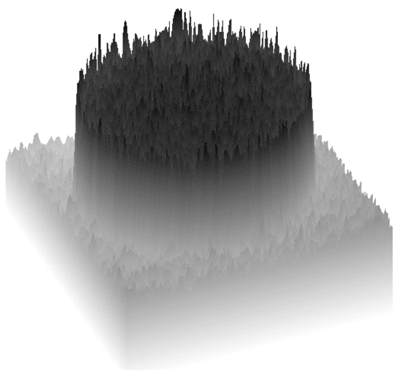
Chart 2. Graph of Eight Dot Sizes on Six Different Machines



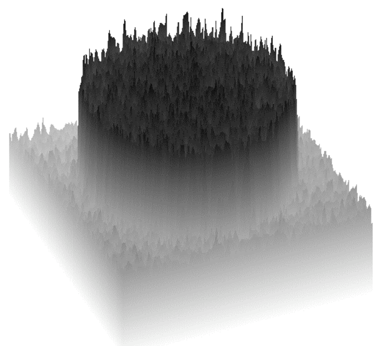
HP 5000n 10x



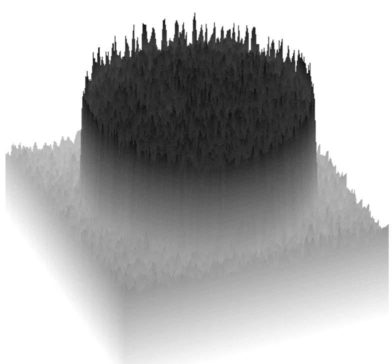
HP 5100tn 10x



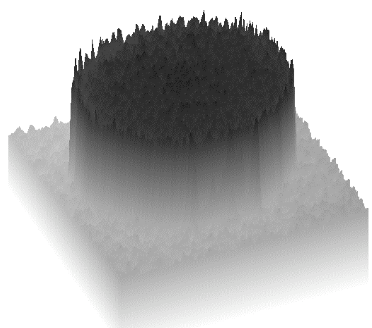
Lexmark 323 10x



Lexmark T634 10x

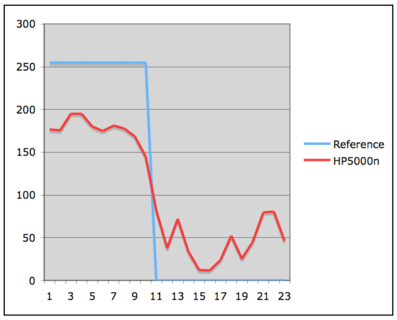


Canon ImageRunner 5570 10x

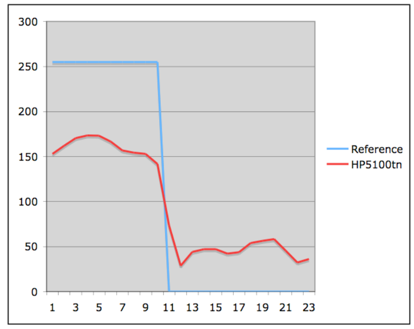


Panafax UF-788 10x

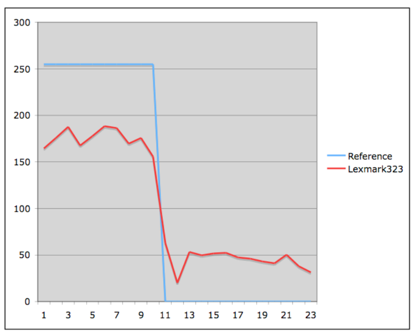
Figure 1. Surface Plots of Dot1



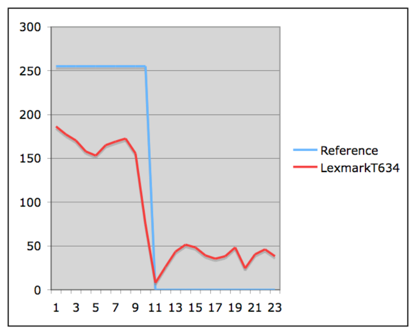
HP 5000n 10x



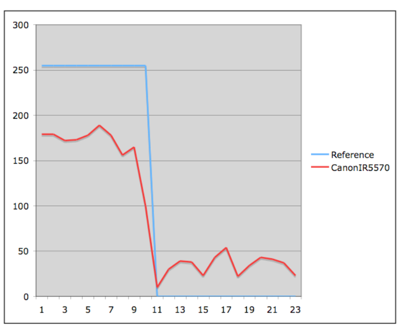
HP 5100tn 10x



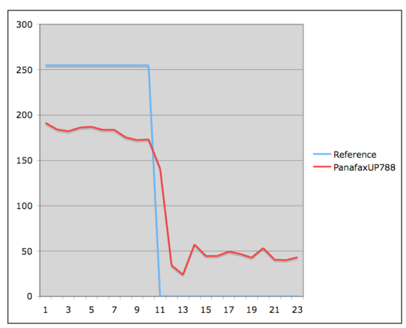
Lexmark 323 10x



Lexmark T634 10x

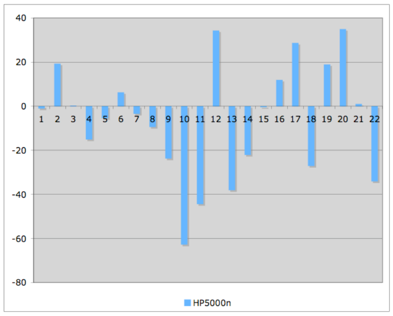


Canon ImageRunner 5570 10x

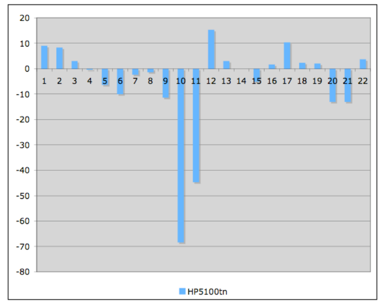


Panafax UF-788 10x

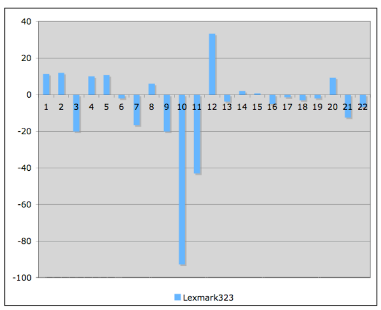
Chart 3. Line Crossing From Solid Area to White Space



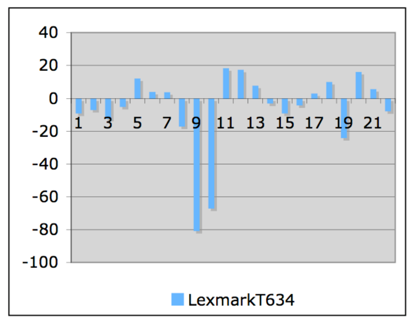
HP 5000n 10x



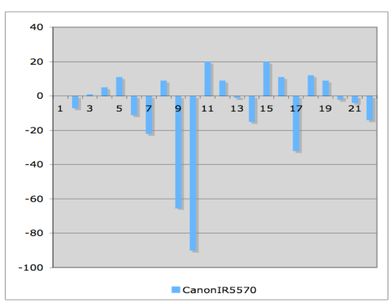
HP 5100tn 10x



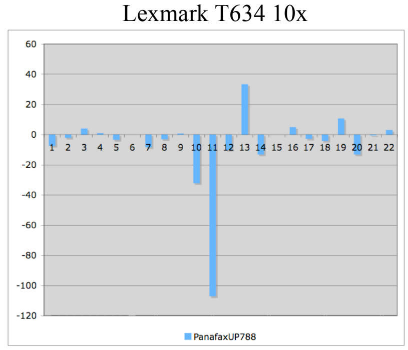
Lexmark 323 10x



Lexmark T634 10x



Canon ImageRunner 5570 10x



Panafax UF-788 10x

Chart 4. Graph of First Deviation Pixels as Line Crosses From Solid Black to White Area

Results and Discussion

Table 1 shows that there are a significant number of technical variables that affect each other to determine digital print quality.

Visual evaluation shows a number of known problems resulting from the digital imaging done in our test. Banding is most apparent on the HP5000n printer. Ink density is low in some cases and heavy in a few cases. Some of these problems may have resulted from poor maintenance or long-term disuse, as print heads tend to dry and clog when not used over an extended period of time. When toner level is low, density tends to drop. Mottling is also present on some images. Deletions, which are white dots where ink is unable to adhere, is apparent on the HP5100tn and the Panafax UF-788 machines.

All printers had a difficult time printing one point and two point lines. Most printers had difficulty printing the step tablet especially for halftone dots above 55%, where halftone dots filled in and become solid, halftone dots disappearing all together. The halftone dots of the step tablet were almost completely filled in on the Panafax test form, which bodes poorly for having proofs faxed, especially if they contain any screened images.

Chart 2 shows the variation in dot growth. For example, when compared to the reference dot, on the HP5000n, dot 8 grew by approximately 25%. Part of this drastic area change from the reference dots reflects the generational change as all prints dots went from print, to scan to ImageJ. Imaging on multipurpose bond also resulted in image bleeding and spreading into the paper, causing the dot to grow.

The dot printed by the Panafax UF-788 was closest to the reference dot, followed by the Canon ImageRunner 5570.

In Figure 1, the surface plot of the dots once again shows visually the difference in dot size and shape.

Chart 3 shows the result of a straight line crossing over from the solid ink to inkless areas and how the line breaks. The reference line has a sharp edge. These graphs visually show that the Canon ImageRunner 5570 and Panafax UF-788 reproduced an image closest to the reference line.

We calculated and graphed the second deviation pixels as shown in Chart 4. We see that the HP 5000n is worst at reproducing the image as it uses more pixels to create the image while the Panafax UF-788 uses the least number of pixels and therefore is better at reproducing the image.

Conclusions

Our literature search found that the majority of published papers on the topic of digital printing were published more than five years ago. This is a significant time period when technology is still advancing rapidly for this process.

This research confirmed that ImageJ software is a relevant analytical tool in studying line edge function and dot spread of digitally printed images.

This pretest stage, proved to be successful as the initial step of a longer-term study. The next stage is to continue this test by varying the substrate humidity of multipurpose paper by conditioning it in a humidity chamber. Other variables such as ambient temperature and humidity will be controlled. Additional analysis will be conducted.

References

Al-Rubaiey, H., & Oittnen, P. (2001). Transfer current and efficiency in toner transfer to paper. [Electronic version]. ***NIP17: International conference on digital printing technologies,*** Fort Lauderdale, Florida, *Volume 17* 648-652. Retrieved Jan. 23/2006, from the IS & T Publications Catalog database.

Caruthers, E., Viturro, E., Larson, J., & Gibson, G. (2001). Custom color printing with liquid toners. [Electronic Version]. *NIP17: International conference on digital printing technologies,* Fort Lauderdale, Florida, *Volume 17* 653-656. Retrieved Jan.23/2006, from the IS&T Publications database.

Clark, R., & Craig, D. (2005). Xerox nuvera technology for image quality. [Electronic Version]. *IS&T's NIP21: International conference on digital printing technologies,* Baltimore, MD, *Volume 21* 671-674. Retrieved Jan.23/2006, from the IS&T Publications database.

Hogberg, O., Talaskivi, M., & Strom, G. (2001). Humidity effects on plain paper in inkjet printing. [Electronic Version]. *NIP17: International conference on digital printing technologies,* Fort Lauderdale, Florida, *Volume 17* 874-877. Retrieved Jan.23/2006, from the IS&T Publications database.

Howard, L., & Tiong, H. (2001). The effect of relative humidity on the toner in the developing process. [Electronic Version]. *NIP17: International conference on digital printing technologies*, Fort Lauderdale, Florida, *Volume 17* 848-851. Retrieved Jan.23/2006, from the IS&T Publications database.

Jaeger, C. W. Color solid ink printing *The Society for Imaging Science and Technology*

Meissner, M., Baumann, E., & HofMann, R. (2003). The role of humidity cycling in accelerated light fastness tests. [Electronic Version]. *2003 international conference on digital production printing and industrial applications ,* Barcelona, Spain, *Volume 2* 203-204. Retrieved Jan.23/2006, from the IS&T Publications database.

Owada, A. (2005). Konica minolta's production printing system. [Electronic Version]. *IS&T's NIP21: International conference on digital printing technologies,* Baltimore, MD, *Volume 21* 675-678. Retrieved Jan.23/2006, from the IS&T Publications database.

Rasband, W.S., ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA, http://rsb.info.nih.gov/ij/, 1997-2006.

Weigert, J. (2003). Solutions to reduce the impact of paper properties to print quality and runnability in the NexPress 2100. [Electronic Version]. *2003 international conference on digital production printing and industrial applications,* Barcelona, Spain, *Volume 2* 216-217. Retrieved Jan.23/2006, from the IS&T Publications database.