The Scratch Sensitivity of Digital Reflection Prints

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Abstract

An increasing number of prints produced by inkjet, dye sublimation and electrophotographic technologies are now being collected by museums, libraries and archives. While there has been considerable investigation on the image stability of these materials, there has been relatively little on their physical integrity. The research reported here is focused on their scratch sensitivity and a comparison to a previous study on their sensitivity to abrasion. The apparatus and methodology described in ISO 18922 was used to scratch prints produced by the wide variety of digital print technologies in use today. However, the evaluation technique described in the ISO document was found not to be useful for these materials. Image analysis equipment and software was found to be effective in quantifying scratch sensitivity and results from this analysis are presented. These provide data which show that the abrasion sensitivity of digital prints cannot be used to predict their sensitivity to scratches. Previous work showed that pigment prints were particularly sensitive to abrasion but other types were generally not. This investigation indicates that pigment prints as well as other types of digital prints are subject to scratch damage because of loss of image colorant.

Introduction

The purpose of this investigation was to determine the scratch sensitivity of a variety of digital reflection prints as compared to offset lithographic and traditional chromogenic prints. Another objective was to compare the relative propensity of these materials to scratch versus their sensitivity to be damaged by abrasion. A survey of the field undertaken by the Image Permanence Institute(IPI) in the summer of 2008 showed that abrasion was the number one problem observed in collections of digitally printed materials. Forty-two percent of respondents from libraries, museums, and archives said that they had observed abrasion in their collections of digitally printed materials [1].The sensitivity of digital prints to abrasion was reported earlier at NIP24[2] andthe AIC 37th AnnualMeeting [3].

As indicated by Nishimura [3] abrasion differs from scratching in both form and cause. Scratches tend to appear as discrete furrows in the surface of the print from which material has been removed. They are caused by relatively narrow, sharp objects being pushed across the surface of the print (or vice versa, the print may be pushed across the sharp objects). Scratch damage may be reproduced in the lab by scraping a needle or stylus across the surface of the print. Abrasion, on the other hand, results from a large material surface being pushed across the surface of the print (or vice versa).

Scratch problems occur with photographic film, particularly motion picture film because scratch marks are very frequently observed in their projection. Several variations of scratch testing have been reported, and these involve determining the load on a sapphire stylus that first produces a scratch or measuring the haze produced by a series of scratch lines [4]. An ISO test method [5]was standardized for these procedures. But results from initial experiments at IPI with the ISO test method were difficult to evaluate and did not appear to be useful for quantifying the scratch sensitivity of paper prints. This was mainly due to the fact that the test method was developed for transparent film and the evaluation of damage required the use of transmitted light, which could not be used for paper prints.

The audience for this paper is primarily those charged with the task of caring for collections in cultural heritage institutions (e.g. museums, libraries, etc.). The goal is to provide them with good information on handlingand enclosure hazards. However, other collectors and suppliers of digital prints may find benefit especially consumers, art galleries, professional photographers and manufacturers of imaging materials.

Sample Preparation, Test Procedure and Measurements

Triplicate samples were printed with a test target. After printing, the samples were left to dry at 21°C and 50%RH for two weeks before being scratched utilizing the apparatus described in ISO 18922. This apparatus is shown in Figure 1.

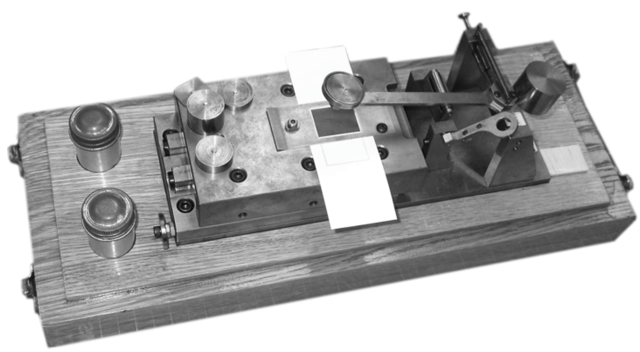

Figure 1: *Spherical stylus scratch tester from ISO 18922*

The same test target used in the abrasion study [3]was utilized in the scratch research so that a direct comparison between scratch and abrasion could be made. The black patch was exactly the correct size and shape to fit the scratch test area of the scratch apparatus. The samples were printed to a uniform Dmax black density. As was the case for the abrasion study reported at the AIC Meeting [3], the black patch was obtained by printing with all colorants dictated by the printer driver to achieve this density.

Scratch samples were scratched five times with a stylus weight of 120 grams using the apparatus shown in Figure 1. This stylus weight was selected because it produced measurable changes with the majority of samples in preliminary trials.

Abrasion samples were abraded with envelope paper (acid-free, nonbuffered, 25% cotton fiber) for 100 cycles using a two-pound weight with a Sutherland® 2000 Rub Tester [6]. Image analysis was performed utilizing the software and hardware designed by ImageXpert®[7] of Nashua, NH. This analysis provided quantitative data based on the change in average gray level values in the black patch before and after the samples were scratched and a comparison with samples before and after they were abraded. Average gray values range from 0 to 255, where 0 is black and 255 is white. The average level for all of the pixels in the area of interest is called the average gray value. For this investigation the area of interest was 0.25 square inches and scanned at 200 dpi.An example of an initial and scratched test target are shown in Figure 2.

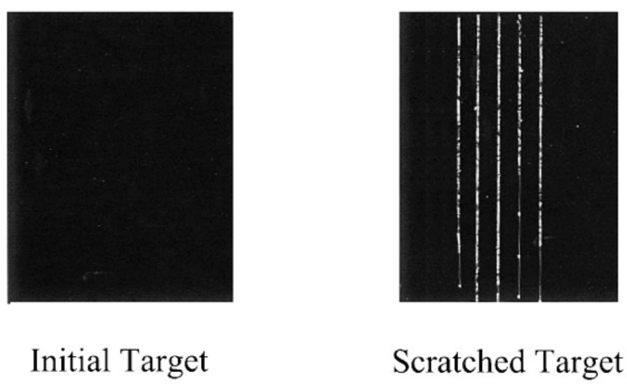

Figure 2:*Example of a scratched black patch target compared to an undamaged initial target.*

Description of Samples

Most of the same papers and printers that were studied for abrasion sensitivity and reported at the AIC meeting [3] were used for the scratch investigation so that the results could be compared. The prints were divided into three major use categories: printing (e.g. photo books, publications, etc.), photo and document. In most cases multiple examples of print types were evaluated utilizing different printers and papers of the same technology (e.g. two different dye inkjet prints on porous photo papers). Benchmark prints used for comparison were an offset and chromogenic AgX print. The sample identification used in Figures 3 through 8 are given in Table 1.

Table 1: Printer/paper combinations included in the test program.

Printer/Paper Technology	Sample Identification
Printing	
Offset Lithography	Offset
Digital Press - Dry Toner	DP Dry Toner 1
Digital Press - Dry Toner	DP Dry Toner 2
Digital Press - Liguid Toner	DP Liguid Toner
Photo	
AgX/Chromogenic Paper	AgX
Dye Sublimation/D2T2	D2T2 1
Dye Sublimation/D2T2	D2T2 2
Inkjet Pigment/Fine Art Paper	IJ Pgmt Art 1
Inkjet Pigment/Fine Art Paper	IJ Pgmt Art 2
Inkjet Pigment/Porous Photo Paper	IJ Pgmt Porous Photo 1
Inkjet Pigment/Porous Photo Paper	IJ Pgmt Porous Photo 2
Inkjet Dye/Porous Photo Paper	IJ Dye Porous Photo 1
Inkjet Dye/Porous Photo Paper	IJ Dye Porous Photo 2
Inkjet Dye/Swellable Photo Paper	IJ Dye Swell Photo
Document	
B&W EP/Plain Paper	B&W EP Plain 1
B&W EP/Plain Paper	B&W EP Plain 2
B&W EP/Plain Paper	B&W EP Plain 3
Color EP/Plain Paper	Color EP Plain 1
Color EP/Plain Paper	Color EP Plain 2
Color EP/Plain Paper	Color EP Plain 3
Color EP/Plain Paper	Color EP Plain 4
Color EP/Plain Paper	Color EP Plain 5
Color EP/Plain Paper	Color EP Plain 6
Inkjet Pigment/Plain Paper	IJ Pgmt Plain 1
Inkjet Pigment/Plain Paper	IJ Pgmt Plain 2
Inkjet Pigment/Plain Paper	IJ Pgmt Plain 3
Inkjet Pigment/Plain Paper	IJ Pgmt Plain 4
Inkjet Dye/Plain Paper	IJ Dye Plain

Results and Discussion

Results of the average gray value changes that occurred in the black patches of scratched and abraded samples as compared to the initial undamaged samples are provided in Figures 3, 4, and 5. The effects of abrasion of digital prints were reported at NIP24 [2] and the AIC Meeting [3] and it was noted there that objectionable smearing into the adjacent white areas next to the black patches occurred before severe damage could be easily seen in the black patches. For this reason, results from changes in average gray values in the adjacent white areas of abraded samples as compared to changes in average gray values of scratched black patches are included inFigures 6, 7 and 8. Scanned images of an inkjet pigment print on plain paper after abrasion and scratches compared to the chromogenic AgX benchmark print along with quantitative data from image analysis are provided in Figure 9.

It should be noted that the average gray value changes for scratch damage are relatively small compared to the white patch abrasion changes even though these small numbers can represent significant scratch damage. This is because there is a significant black area surrounding the scratched lines. Assessments from visual examination of scratch damaged samples show that there is good agreement with the data from the average gray value changes in these samples.

Observations from this investigation are summarized below:

1. The chromogenic benchmark sample was very resistant to abrasion but was scratched significantly, and more than all but one of the inkjet pigment prints on porous photo paper. As a group the inkjet prints, both pigment and dye, were more prone to scratch damage than prints from other technologies.
2. None of the electrophotographic (EP) samples were damaged significantly in the scratch tests. The black and white EP samples were more damaged by abrasion than the color EP samples, which were not damaged at all.
3. Two of the three digital press samples, which utilized dry toner technology, were significantly damaged by abrasion; much more than the offset printed benchmark sample. The other digital press sample, which utilized liquid toner technology, was not damaged by abrasion at all. All of these prints were slightly more damaged by scratches than the offset benchmark sample, which was not damaged at all.

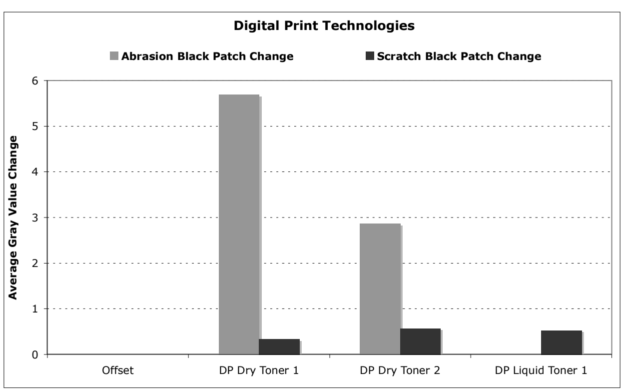

Figure 3:*Comparison of black patch average gray value change caused by abrasion and scratch damage for digital press technologies compared to an offset print.*

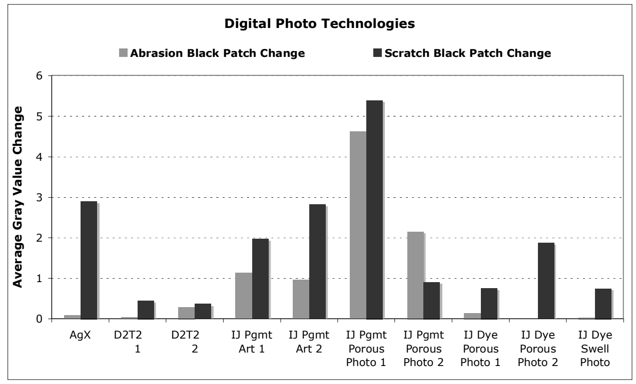

Figure 4:*Comparison of black patch average gray value change caused by abrasion and scratch damage for digital photo technologies compared to a chromogenic AgX print.*

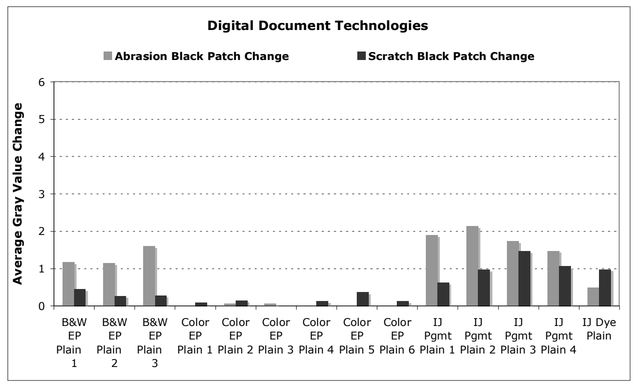

Figure 5:*Comparison of black patch average gray value change caused by abrasion and scratch damage for digital photo technologies compared to a chromogenic AgX print.*

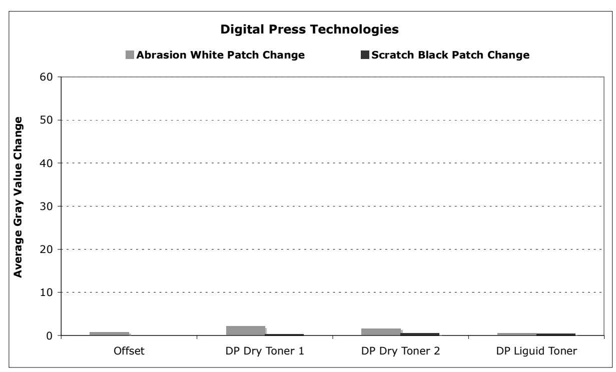

Figure 6:*Comparison of white patch average gray value change caused by abrasion and black patch average gray value change caused by scratch damage for digital press technologies compared to a benchmark offset print.*

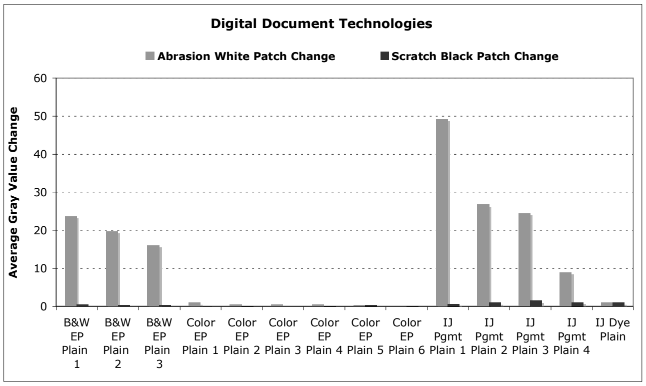

Figure 7:*Comparison of white patch average gray value change caused by abrasion and black patch average gray value change caused by scratch damage for digital photo technologies compared to a benchmark AgX chromogenic print.*

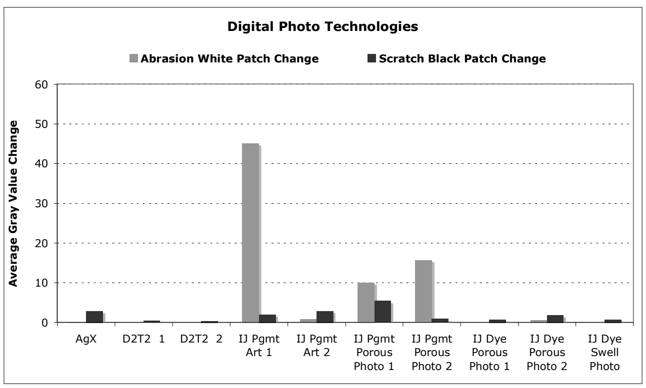

Figure 8:*Comparison of white patch average gray value change caused by abrasion and black patch average gray value change caused by scratch damage for digital document technologies.*

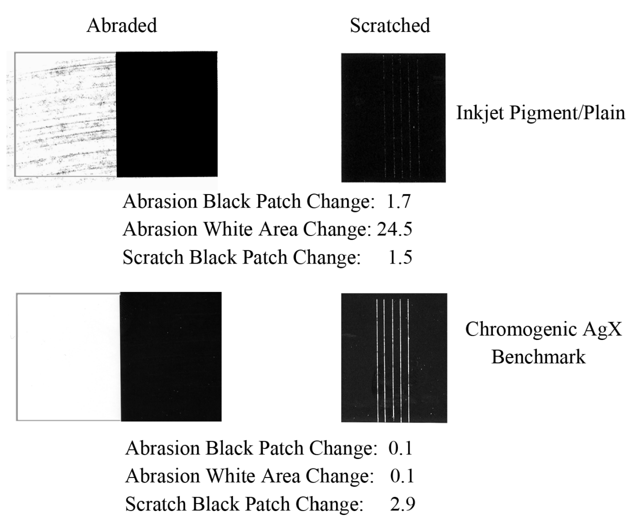

Figure 9:*Scanned images of an inkjet pigment print on plain paper after abrasion and scratches compared to the chromogenic AgX benchmark print along with quantitative data from image analysis.*

Conclusions and Recommendations

Conclusions and recommendations from this investigation are summarized below:

1. There is no correlation between damage to digital prints from abrasion and from scratches. For example, some of the inkjet samples showed both abrasion and scratch damage, but some were damaged from scratches but not abrasion. And two of the three digital press samples were damaged by abrasion, but not from scratches.
2. All digital prints need to be protected from abrasion and scratches with the possible exception of dye sublimation and color electrophotographic prints. These appear to be quite resistant to both types of damage. Clean, smooth polyester or polyethylene sleeves (as suggested from the previous work cited) can provide this protection. Of course, no contact with adjacent surfaces, which is achieved with window-matted prints, is also effective in preventing damage from abrasion and scratches.
3. Previous scratch experience with chromogenic prints in a collection might be a useful guide for predicting whether there could be a problem with digital prints because the chromogenic prints appear to be quite easily scratched.

References

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[2]Salesin, E., et al. 2008. Abrasion of Digital Reflection Prints.*Technical Program andProceedings NIP 24*. Society for Imaging Science and Technology 24th International Conference on Digital Printing Technologies, Pittsburgh. Springfield, VA: IS&T. 228–230.

[3] Nishimura, D., et al. 2009. Abrasion of Digital Reflection Prints: The Abrasiveness of Common Surfaces and the Vulnerability of Print Processes. The Book and Paper Group Annual 28 (2009) 47

[4] J. F. Carroll and J. O. Paul, *Test methods for rating abrasion resistance of photographic film*, Photographic Science and Engineering 5, 288 (1961).

[5] ISO 18922-2003 Imaging materials – Processed photographic films – Methods for determining scratch resistance (ISO, Geneva), www.iso.org.

[6] Available from Danilee Co., 27223 Starry Mountain, San Antonio, TX 78260

[7] Available from ImageXpert Inc., 460 Amherst St., Nashua, NH 03063

Author Biography

Gene Salesin, Research Assistant, received a B.S. in chemical engineering from the University of Michigan and an M.S. and Ph.D. in chemistry from Case Western Reserve University in 1960 and 1962, respectively. He retired in 1997 after 36 years of employment in the research laboratories and several manufacturing divisions at Kodak. He held a management position during his last few years there, leading the staff involved with providing the technical instructions and specifications for the manufacture of black-and-white films. Dr. Salesin joined IPI in 2004 and has been involved in the permanence properties of magnetic tape and digital prints.