Beyond Lightfastness: Some Neglected Issues in Permanence of Digital Hardcopy

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Abstract

This paper addresses physical print permanence issues beyond lightfastness and gas fastness for digital image hardcopy. Most image-life claims are based on time to unacceptable fade during high intensity exposure extrapolated to time under assumed display conditions in homes, offices, and other public areas. This neglects the potential for images to decay by other mechanisms (chemical or physical) which may, during actual use, be manifested before significant light-induced decay. Therefore, current practices of advertising image longevity by display-life have been woefully inadequate and potentially seriously misleading. The experimental work shows that inkjet prints can be sensitive to abrasion, surface cracking, and adherence to plastic page protectors in albums and glass in frames.

Introduction

The purpose of this project was to evaluate the use of existing standardized test methods on modern digital inkjet prints that were originally designed to measure the physical properties of traditional photographic materials. There has been a need to begin assessing the physical stability of digital prints over time as many of these objects enter into important family collections and some prints become increasingly more valuable as fine art. Anecdotal evidence and experimental anomalies have suggested that a variety of damaging effects (cracking, delamination, abrasion, image transfer, etc.) can occur to these objects beyond those that have already been reported (lightfastness, thermal stability, gas fastness, etc,). This project will be of primary interest to manufacturers in the imaging industry who wish to evaluate their products for potential customer problems in order to alter material formulations or provide customers with better usage guidelines. However, the information may also be helpful in guiding those already maintaining private or public collections of digital images to provide better care and handling of those materials.

While there are several digital hardcopy technologies, this paper deals only with photographic inkjet. And given the wide variety of still unexamined issues in digital hardcopy stability, this project addressed only the following properties: abrasion, brittleness, and blocking.

Abrasion

Anecdotal evidence has suggested that some digital prints are sensitive to abrasion. Abrasion can occur as the result of handling, packaging, and stacking. While some potentially abrasive surfaces are obvious others may not be; including interleaving tissues, framing materials, and storage envelopes. Materials that have been shown to be safe for traditional photographic objects cannot be assumed to also be safe for all inkjet prints.

Brittleness

Brittleness can be a critical property for traditional photographic prints since the gelatin-emulsion layer is fragile at low humidities. The embrittlement of this layer can lead to breakage of the complete print laminate. There is no information reported as to whether the swellable layer in inkjet prints is also brittle at low humidities. It is also not known whether brittleness will be a problem with inkjet images on porous paper.

Blocking

Blocking refers to any sticking, surface damage, or delamination that occurs when image surfaces are in direct contact with smooth surfaces and exposed to high humidity. This is sometimes referred to as ferrotyping, after the historical process of creating high gloss prints by drying them against heated, polished metals surfaces. The most common examples of blocking are the adherence of prints to the plastics commonly used in photo albums, to glass such as in framing packages, and to each other in stacks.

Methods

Figure 1 is a description of the print samples used in the tests and corresponding codes for identification:

Sample	Surface	Coating	Colorant
A	Glossy	AgX	None
B	Glossy	AgX	None
C	Glossy	Swellable	Dye
D	Semi-gloss	Swellable	Dye
E	Glossy	Unknown	Dye
F	Glossy	Swellable	Dye
G	Glossy	Swellable	Dye
H	Glossy	Porous	Dye
I	Semi-gloss	Porous	Dye
J	Glossy	Porous	Dye
K	Glossy	Porous	Dye
L	Matte	Porous	Dye

Figure 1*. Test sample codes and descriptions*

Abrasion

The abrasion test involves the rubbing of an abrasive material over the print surface under a controlled pressure for a set number of cycles. The apparatus used for these tests was an UGRA Rub Tester. The evaluation is qualitative and based on visual comparisons. This is not a standard ISO method but IPI has had experience with it in previous studies.

The abrasion tester has four parts: a guiding frame with counter, a gliding carriage on the frame, a 500 gram metallic block that rests within the carriage but is not carried by the carriage, a box that holds the sample and guiding frame in place for the duration of the test.

The print sample being tested is placed face-up inside the box and the guiding frame is placed on top. The abrasive sample (in these tests either sandpaper or Micromesh®) is then placed on the bottom of the metal block and this combination is placed in the guiding frame on the print sample. The gliding carriage is then moved back and forth along the entire distance of the frame for the required number of cycles (one cycle equals one back-and-forth movement).

Initially, tests were performed on papers printed with IPI's standard test target for image fade. The papers were printed, and then allowed to dry for several days at approximately 20ºC and 50%RH prior to testing. Five cycles of abrasion with 220 grit sandpaper were applied to each sample using the UGRA abrasion equipment. The test conditions were approximately 20ºC and 50%RH. Sandpaper was extremely abrasive, so tests were attempted with typical 20lb copier paper. Copier paper proved too smooth to obtain results within a reasonable number of cycles. Copier paper is also much smoother than many of the abrasive surfaces (including other paper types) that prints may come in contact with.

In a second set of tests, the papers were printed with a uniform gray area (RGB values = 135 for each channel). The papers were printed, and then allowed to dry for 30 days at approximately 20ºC and 50%RH prior to testing. Fifty cycles of abrasion with 3200 Micromesh® (Micro-Surface Finishing Products Inc.) were applied to each sample using the UGRA abrasion equipment. The test conditions were approximately 20ºC and 60%RH.

Blocking

A test procedure for blocking of photographic films is described in ISO 18901 (Imaging materials - Processed silver-gelatin type black-and-white films - Specifications for stability). This method specifies conditioning the prints to 62% R.H. and placing them in image to image contact for 3 days at 40ºC. The films are placed under a uniform pressure of 35 kPa. Upon separation, the image surfaces are visually examined for damage. Since inkjet prints may perform differently than photographic films in terms of blocking, new conditions for temperature, relative humidity, pressure and duration may need to be determined.

Samples printed with individual cyan, magenta, yellow and black ink patches and an area of Dmin were placed against plastic films of the types commonly found in photographic enclosures (polypropylene, PVC, or polyester) or the back side of another print to simulate stacking. Weights were added to further simulate the effect of stacked albums or prints. The weights provided a load similar to that found in the bottom album of a stack of 10 albums. The assembled stacks were placed in an incubation chamber (Espec LHU-112) at the selected conditions for the selected duration. After incubation the sample stacks were removed from the chamber and allowed to reach room temperature (20ºC and 50%RH) before disassembly. The stacks were then disassembled and the print materials evaluated for print adherence to the plastic or print back, or for modification of the print's surface.

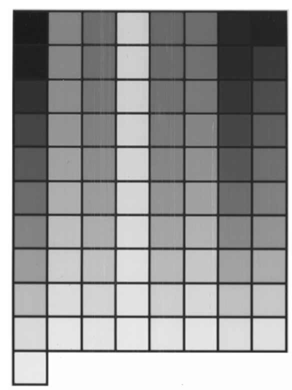
Brittleness

Unprinted media samples were conditioned at 20ºC and 60%RH and subjected to the test method outlined in ISO 18907 (Imaging materials - Photographic films and papers - Wedge test for brittleness). In this procedure a fixed wedge is used to curl the media at ever smaller diameters until the first diameter of curvature at which surface cracking occurs can be determined.

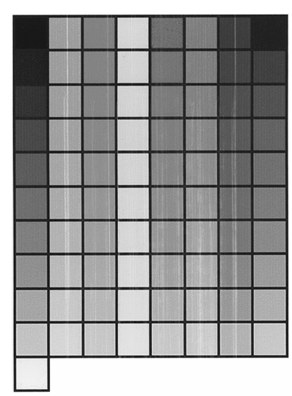
Results and Discussion

Abrasion

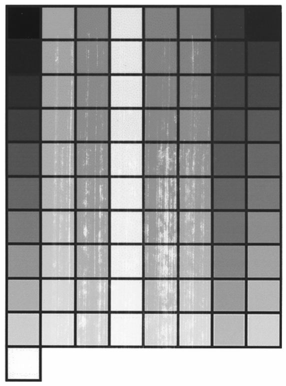
The chromogenic print was the most resistant to abrasion. Its surface was scratched by the 220 grit sandpaper but not so deeply that colorant was removed creating white line scratches (Figure 2). The dye swellable and dye porous inkjet prints both suffered readily visible abrasion with the porous print showing the most damage. Swellable media may provide a greater resistance to abrasion damage as the colorant is absorbed into the polymer later.



a)



b)



c)

***Figure 2**. UGRA Rub test performed on a) Chromogenic b) Inkjet Swellable/Dye c) Inkjet Porous/Dye*

In the next test, a variety of dye inkjet prints on three porous papers with different surfaces and one swellable glossy print were abraded with 50 cycles of 3200 Micromesh® (Figure 3).

The evaluation of abrasion in this test was qualitative. However, qualitative ranking was not possible due to variation in abrasion patterns. The effects of abrasion seem to be dependent on the following factors:

- Initial print density
- Ink adhesion to the media
- The surface texture of the media
- The type of colorant used (dye or pigment)
- Hardness of the receiver coating

This approach to abrasion may be further enhanced if quantifiable levels or types of abrasion can be cataloged with standard descriptions or if a quantifiable analysis using image analysis software can be employed to measure abraded area vs. non-abraded area.

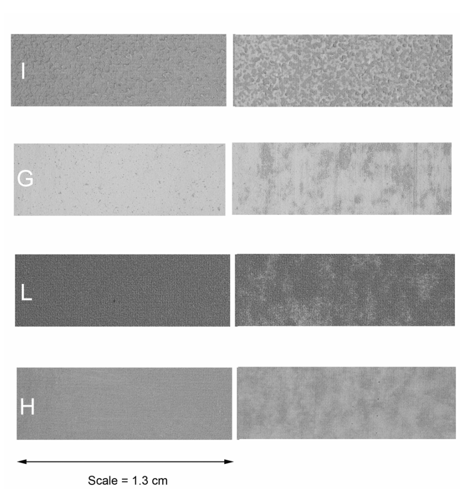


***Figure 3**. UGRA Rub test performed on Sample I: Inkjet Luster Porous/Dye, Sample G: Inkjet Glossy Swellable/Dye, Sample L: Inkjet Matte Porous/Dye and Sample H: Inkjet Glossy Porous/Dye. Images on left: before treatment; images on right: after treatment.*

Blocking

The initial test used the ISO 18901 temperature of 40°C but increased the RH above the recommended 62% to 90% to simulate potential extreme user conditions.

Blocking test: 40ºC 90%RH 7 days

Media	Coating	PET	PP	PVC	Print Back
B	AgX	3	1	3	1
F	Swellable	1	1	1	1
D	Swellable	2	2	2	1
J	Porous	0	0	0	0
H	Porous	0	0	0	0

***Figure 4.** Scale: 0: Nothing; 1: Sticking but no surface modification; 2: Sticking and surface modification; 3: Sticking, surface modification, and binder damage*

From the test results it was clear that swellable inkjet prints are sensitive to the sort of blocking that is seen with traditional silver-halide print materials. Both the traditional prints and the swellable inkjet prints can become damaged at conditions that may be encountered in high-humidity consumer storage environments (such as during summer months). These conditions do not need to be long lasting as durations as short as one week or less may be sufficient to initiate block.

The porous prints did not block and indicate a potential determining factor for print material in extreme climates of uncontrolled storage.

Brittleness

The minimum diameters of print curvature until first surface crack (in inches) are given in Figure 5.

Process	Surface	Coating	50%	25%
AgX	Glossy	Gelatin	0.62	1.05
Inkjet	Glossy	Porous	0.15	0.18
Inkjet	Glossy	Porous	0.10	0.13
Inkjet	Glossy	Swellable	0.08	0.17
Inkjet	Glossy	Swellable	0.29	0.30*
Inkjet	Matte	Porous	0.61	0.83

***Figure 5.** Diameter of curvature to first cracking in inches*

At 50% relative humidity the samples could be ranked from bad to worse; however, most of the radii-to-first-cracking were fairly small. Reducing the relative humidity from 50% to 25% increased the radius at which the samples cracked. The traditional photo paper was the most sensitive to this change. The matte inkjet paper was also sensitive, and it should be noted that both of these papers do not have RC coatings.

For the porous samples, beyond the limit of the readily visible cracking that was used to measure endpoint, there existed further cracking visible under the microscope. It is not known what effect this will have on future stability of the print. It is certainly an important area for further study. The micro-cracks are not present in the sheet directly from the manufacturer's packaging, but they can be easily created by flexing the sheet.

Conclusions

- Of the three test methods, the abrasion and blocking tests need further development. The brittleness test is adequate in its current form for the evaluation of inkjet print media.
- All inkjet print users should be cautious when handling, packaging, or storing their prints to avoid abrasion and marring of the image surface.
- Those using inkjet prints in low-humidity environments should be extra careful when handling prints to avoid cracking of the print surface.
- Those using porous inkjet prints should always be extra careful when handling prints to avoid micro-cracking of the print surface, as the effect of micro-cracking on future print deterioration is unknown.
- Those using inkjet prints in high-humidity environments may wish to choose porous media for their prints or be extra cautious to keep print surfaces from contact with smooth surfaces like plastics or glass.

The project has resulted in establishing the issues of physical stability as ones for serious concern. Through future work the methods described can be refined to increase their usability for manufacturers and independent testing organizations. In addition, the information will be valuable to both those responsible for the longevity of their family photographic collections as well as those charged with the care of public cultural collections shared by all.

Acknowledgments

The authors would like to acknowledge Ryan Boatright for his assistance in creating images of the samples.

References

[1] ISO 18901 Imaging materials – Processed silver-gelatin type black-and-white films – Specifications for stability

[2] ISO 18907 Imaging materials – Processed films and papers – Wedge test for brittleness.

[3] ISO 18922 Imaging materials – Processed photographic films – Methods for determining scratch resistance.

Author Biography

Daniel Burge received his B.S. degree in Imaging and Photographic Technology from the Rochester Institute of Technology in 1991 and has been a full-time member of the Image Permanence Institute (IPI) staff for the last 16 years. His current research interest is the development of guidelines and tools for the preservation of digital hardcopy for consumers to cultural institutions. Correspondence pertaining to this paper should be emailed to Daniel.Burge@rit.edu.