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Lessons in Digital Print Preservation: The DP3 Project

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Abstract

The Digital Print Preservation Portal (DP3) project was a three-year effort funded by both the Andrew W. Mellon Foundation and the Institute for Museum and Library Services. The project consisted of two parts: the portal and the research.

The portal is a web-based information resource where information about the care and handling of digitally printed materials has been organized and made available to the public. Research papers coming out of the DP3 project as well as announcements of future DP3-related talks are also posted to the site. In addition, related information is available such as tools to aid in the identification of digital print processes. The portal can be found at http://www.dp3project.org.

The research part of DP3 is an experimental program, based on work already done by industry and presented at ISO standards meetings, and designed to explore beyond what is currently known. The primary driver of this research was the practical information required by institutions in order to care for their digitally printed collection materials. Unlike the work of ISO TC42/WG5/TG3, the DP3 included graphic documents in the form of text targets in addition to photograph-like images. It was not necessarily expected that final answers would come out of this research, but at the very least, a better understanding of where to concentrate efforts and resources for future initiatives would be determined.

Introduction

This paper will summarize the results of the research to date. As an exploration, the experimental program had numerous fronts making the apparent direction of the research rather unfocussed.

Table 1: Research Completed to Date

Stress Factor	Related Deterioration
Ozone	Colorant fading, yellowing, embrittlement
High humidity	Blocking, ferrotyping, sticking, colorant bleed
Low humidity	Cracking
Enclosures – image interactions	Colorant fading, image staining
Enclosures – abrasion	Colorant smear, changes in gloss and density
Silver interaction	Silver image deterioration caused by adjacent digital prints

Silver interaction is not a deterioration problem for digital prints, but will be of practical concern for any collection that contains both traditional silver-gelatin photographs and digitally printed materials potentially stored together in the same folders. Digitally printed materials in such cases might include exhibition labels, cataloging information, copies of old enclosure notes, copies of related documents, or digitally printed photographic images.

The basic digital processes included inkjet with both pigment- and dye-based ink, color electrophotography, including commercial print-on-demand, and dye sublimation, also known as dye diffusion thermal transfer (D2T2). For comparison, traditional printing methods have also been included, consisting of offset lithography, chromogenic color photographs, and black-and-white electrophotography. Inkjet prints were printed on both photo papers and document papers. Photo papers were specialty-coated papers including polymer (aka swellable) and porous coatings designed to produce good-looking images. The coatings might be on either plain paper support or on a resin-coated (RC) base. Document papers used included those intended for the printing of graphic documents and may be plain paper with no coating, specialty-sized papers, or specialty-coated papers.

Table 2: Research Pending

Stress Factor	Related Deterioration
Water (Flood)	Colorant bleed, transfer, delamination, planar distortion
Nitrogen oxides	Yellowing, colorant fading, colorant bleed
Thermal (temperature and humidity)	Yellowing

1. OZONE

1.1 TEST SUMMARY

Experiments were performed in custom chambers using 5 ppm ± 0.25 ppm of UV-generated ozone. The test chambers were kept at 25°C ± 2°C and 50%RH ± 5%RH for two weeks for a total exposure of 1680 ppm-hours of ozone. The nominally expected indoor concentration of ozone (while it may vary greatly depending on location, time of day, and time of year) is 9 ppb for a total annual exposure of 78.84 ppm-hours. Assuming that ozone obeys reciprocity law, then the test exposure is approximately equal to 21 years of nominal indoor ozone exposure. It has not yet been proven that ozone obeys reciprocity law, but industry testing is based on the assumption that equal exposure produces equal damage.

1.2 CONCLUSIONS

- Some processes such as traditional chromogenic color photographs and offset lithography show insignificant colorant fading from ozone exposure.
- Other processes such as dye-inkjet on porous-coated paper may be almost completely bleached away.
- The receiving layer of some photo papers can crack and flake off the paper from exposure to ozone.
- Both text and photographic images are more resistant to ozone fading when printed on document papers than on photo papers.
- Text is more robust than photographic images. This may be because text is more likely to be printed with a pigmented black colorant.
- Some digital press and offset lithography papers can yellow on exposure to ozone.

- Dye and pigment inkjet are more sensitive to ozone than electrophotographic, dye sublimation, or traditionally printed materials.

1.3 RECOMMENDATIONS

- Minimize air flow/exposure for inkjet on coated papers.
- Handle degraded inkjet photos with care to avoid cracking.
- Periodically monitor inkjet prints for early signs of decay.
- Dye sublimation and electrophotographic can be treated like traditional prints.

2. HIGH HUMIDITY BLOCKING, FERROTYPING, AND STICKING

2.1 METHOD SUMMARY

Samples were stacked with the recto surface in contact with seven different surfaces: envelope paper, polyester film, polypropylene film, polyvinyl chloride film, soda-lime framing glass, an equivalent print face, and the back of an identical print. These stacks were then incubated for seven days at 30°C and 90%RH under a pressure of 1.76 kPa – equivalent to being at the bottom of a stack of nine albums.

After incubation, stacks were allowed to cool at 21°C and 50%RH for 24 hours before being separated and examined.

2.2 CONCLUSIONS

- Chromogenic color and silver-gelatin photographs are most prone to blocking and ferrotyping.
- Digital prints generally fared better, but swellable-coated inkjet photo papers may also be a problem.
- The printing colorants apparently had no effect on the potential for blocking and ferrotyping.
- The face-to-face configuration showed the most severe damage, but 2/3 of the samples showed no effect so a recommendation is difficult to make.
- There was good agreement with anecdotal observations so the test simulation was probably quite accurate.
- In photo books, matte chromogenic prints blocked less than glossy chromogenic prints.

2.3 RECOMMENDATIONS

- Traditional gelatin-coated prints and swellable-coated inkjet should be considered sensitive materials.
- Sensitive materials shouldn't be stored face to face such as in photo albums or photo books without some kind of interleaving.

- Sensitive materials should be stored in paper envelopes. However, if they must remain unhoused due to limited resources, care should be taken that they be stacked front to back and not front to front.

3. HIGH HUMIDITY BLEED

3.1 METHOD SUMMARY

Samples were incubated at four different conditions: 30°C ± 1°C/75%RH ± 3%RH for two weeks, 30°C ± 1°C/85%RH ± 3%RH for two weeks, 30°C ± 1°C/75%RH ± 3%RH for four weeks, and 30°C ± 1°C/85%RH ± 3%RH for four weeks.

3.2 CONCLUSIONS

- Some document papers bled through the paper to be visible on the verso in addition to lateral bleed.
- Lateral bleed is isotropic and independent of the machine direction for paper manufacture and coating.
- Only dye-inkjet bled significantly in high humidity.
- Inkjet photo papers tended to bleed more than document papers.
- No consistency

3.3 RECOMMENDATIONS

- Dye-inkjet must be protected from exposure to high humidity even for short periods of time.
- Other printing processes won't bleed in high humidity, but may block, transfer colorant, or grow mold.

4. LOW HUMIDITY BRITTLENESS

4.1 METHOD SUMMARY

Samples were conditioned to both 23°C ± 1°C at 15%RH ± 3%RH and at 50%RH ± 3%RH for at least three days. It's not possible for a sample to "over condition" so the conditioning time beyond three days is irrelevant. The actual test conducted used the wedge brittleness apparatus described in ISO 18907 for the testing of photographic film.

4.2 CONCLUSIONS

- Three types of damage were observed:
    1. Cracking consisted of breaks through the surface coating only.
    2. Buckling was a dislocation through the entire laminate structure, but didn't break the top coating.
    3. Tearing was a gaping break through the surface coating and into the underlying support layer below.

- There were large differences in the types and extent of damage between some papers:
    - A few inkjet glossy papers cracked, a few others were torn
    - Most others buckled to some degree
    - Offset and digital press papers showed almost no effect

- There were large differences in response between variables within some papers:
    - Printed versus unprinted
    - Moderate versus low humidity
    - Some showed almost no effect from these variables

4.3 RECOMMENDATIONS

- Follow good handling practices:
    - Always move prints using a piece of stiff mat board for support.
    - Turn prints over using two pieces of mat board to maintain support during the entire operation.

5. ENCLOSURES

5.1 METHOD SUMMARY

Paper enclosures were simulated using buffered pure cotton paper, unbuffered pure cotton paper, groundwood paper, and samples of Whatman #1 filter paper treated with 0.1 N sodium hydroxide and 0.1N hydrochloric acid solutions.

Enclosure simulations were tested using the PAT method of ISO 18916, but using digital print samples in place of the prescribed detectors in ISO 18916.

Digital print samples were also rubbed against a typical envelope paper, a typical interleaving paper, polyester film, and the verso of an identical print to simulate unhoused prints in a stack using a Sutherland® Rub Tester with a two pound weight on the arm for a pressure of 0.25 psi or 1.7 kPa. One hundred rub cycles were used.

In addition, several people have submitted examples of damage from ink and adhesives on various kinds of digital prints.

5.2 CONCLUSIONS

- Digital prints are sensitive to groundwood papers like traditional prints.
- Buffering is not harmful to digital prints (or traditional).
- pH of paper enclosures has little effect on the fading or staining (but may affect the paper support).
- Abrasion caused three types of damage:
    1. Colorant smearing was most disfiguring
    2. Density change was less disfiguring
    3. Gloss change was least disfiguring

- Pigment inkjet was substantially more sensitive than any other print process to colorant smearing.
- Out of the three enclosure and interleaving materials, polyester produced the least abrasion damage.

5.3 RECOMMENDATIONS

- Use enclosures that meet ISO 18902 *Imaging materials – Processed imaging materials – Albums, framing and storage materials*
- Follow the storage recommendations from ISO 18920 *Imaging materials – Processed photographic reflection prints – Storage practices*
- Pigment inkjet prints should be stored in smooth plastics or housed in such a way as to avoid contact with an adjacent surface (such as a sink mat.)
- Avoid the use of adhesives directly on prints
- Avoid the use of ink (pen ink or stamp ink) on prints

6. SILVER IMAGE REACTIVITY

6.1 METHOD SUMMARY

Treating digitally printed samples as enclosure material samples, they were tested for reactivity using the PAT as described in ISO 18916.

6.2 CONCLUSIONS

- Some digital prints are reactive with silver images.
- It is not possible to classify reactive digital prints. Therefore, all must treated as reactive.

6.3 RECOMMENDATIONS

Photographic materials using silver as the image material should ideally be stored out of contact with digitally printed materials. If this is not possible due to storage arrangement, both types of prints should be kept out of contact by the use of appropriate plastic enclosures.

FINAL CONCLUSIONS

During the course of the DP3 project, two things became very clear: 1) Successful preservation would require a high level of print identification including the ability to distinguish pigment ink from dye ink and the ability to identify the numerous types of paper that might be printed on especially with inkjet printing. 2) Research data was variable with so many products behaving as individuals and not as families, making it so recommendations couldn't be made based on the research data alone.

As a result, IPI is exploring the far limits of what technology is required in order to be able to distinguish a porous-coated photo paper from a swellable-coated photo paper (possibly destructively initially) and pigment ink from dye ink. Because printers may "overload" a paper with ink, either kind of ink can leave a coating of colorant on the surface of the paper. In addition, IPI is preparing to convene a symposium of collection care professionals: curators, archivists, registrars, and conservators to examine the laboratory results produced by the DP3 project and to make group recommendations that are based on more that IPI's opinion.

Lastly, IPI has received a grant from the Andrew W. Mellon Foundation in support of continued research into the preservation of digitally printed materials in cultural heritage institutions. This is a three-year extension of the DP3 Project. Additional funding will permit further study of the deteriorating effects of abrasion, humidity and light and their prevention. The project also initiates two new areas of study: the thermal stability of digital-print colorants and the permanence of bound digitally printed objects such as periodicals and monographs. Ultimately, the grant from the Mellon Foundation will allow IPI research scientists to refine the data sets upon which best practices for the long-term care of digitally printed materials can be based.

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