

A Comparison of Some Photo-Reproduction Techniques

The display of paper artifacts—including photographs, pastels, drawings, watercolors, letters and documents—within the National Park Service is often long term. One reason is an historic interior that has been developed to show a particular period in the life of the famous inhabitant or family. Once this exhibit is developed, designed, and completed, it is difficult to change. The idea of using photo-reproductions has been dismissed in these long term exhibits in the National Park Service (NPS) because the traditional photograph's surface is too glossy, especially in historic interiors. A good example is the photo-reproduction of a pastel. The photo-reproduction is inadequate because of the reflection from the photograph's surface. Curators at NPS sites reject it as a replacement for an original because of this. Non-traditional photo-reproduction processes were tested in this project in order to find alternative, visually acceptable photo-reproduction solutions.

Because the photo-reproduction processes we explored are commercial, there are several products available. We tested six products and chose them because they were appropriate choices for different photo-reproduction criteria within the Park Service. For different situations, light stability could be the most important criteria, or color rendering, or expense, or size, or surface texture and reflectance. The first methods considered were the traditional color photographic techniques, but it quickly became apparent that the selection was wider than that. The photo-reproduction processes that we tested were:

- Fujicolor Super FA Type 5 print
- Ilford Ilfochrome print with UV laminate
- Ilford Ilfochrome print
- Kodak Professional Paper print
- Canon Color Laser Copy
- Ink Jet Print

LIGHT TEST PARAMETERS

American National Standards Institute publication IT9.9 - 1990 Standard for Stability of Color Photographic Images - Methods for Measuring outlines the parameters for methods of measuring the stability of color photographic images. This state-

ment is in the standard: "These tests are intended to simulate common use conditions. Selection of the appropriate test should be based on the conditions of intended use." The goals of the ANSI standard are commendable but it was not possible or practical for the paper conservation laboratory at the NPS to attempt these fading procedures. The fading procedures done at NPS were faced with two goals: (1) fade a series of samples to show that fading does happen, and (2) fade a variety of samples in similar conditions so the light fastness of the samples could be compared.

The NPS project did not meet the standards required by ANSI. The light test project was simply to fade the samples at an even rate with a known quantity of light and fade samples as close as possible to the ANSI standards. Characteristics of the NPS test are the following:

- The light was a Plexiglas-filtered fluorescent bulb illumination. The bulbs were Verilux Full Spectrum F40T12VLX.
- The Plexiglas was non-UV filtering Plexiglas.
- The edges of the Plexiglas and sample box were not sealed.
- The distance of the Plexiglas from the samples was 3".
- Blue wool standard control sample test strips were included in the light test.
- No end-point values were chosen for the image life parameters.
- The temperature of the samples was 81°F.
- The relative humidity of the samples was 20%.

The test box was made of acid-free matboard. That box was perforated so that it was exposed to conditioned silica gel in the box below it. At the onset, the environment in the test box was 75o F and 49% RH. Within 12 hours the test environment had changed to 85o F and 22% RH. It stayed at those levels for the entire six months of the test period, even after a fan was placed in the test area.

The following chart summarizes the applied parameters in different light tests. The two categories labeled "Wilhelm" are two different types of tests, short and long term light exposure.

The test sample preparation included having a 4"X5" color transparency made of a group of Kodak Color Separation Guides. This transparency was used to produce the prints in all but one of the techniques tested. The color xerographic copy was made in a copy machine. We found

Light test parameters compared

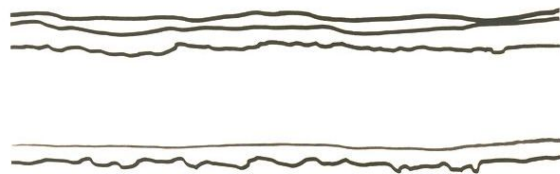
Tester	Term	Intensity	Bulb	Klux	Distance	Duration	Temp. °F	RH	Hours/day
Wilhelm	short	high	fluorescent	21.5	2"	4 mo.	75°F	60%	12
NPS	short	moderate	fluorescent	5.9	18'	2-12 Wks	85°F	22%	24
ANSI	short	high	fluorescent	6.0	?	6-12 mos.	?	?	
Wilhelm	long	low	fluorescent	1.35	5'(approx)	5-10 yrs	75°F	60%	12

the 4"X5" color transparency was the most useful film image. Color negatives could be made from it if they were needed and it could be scanned for a digital image. It is also easier to evaluate than a negative.

The test strips were attached to cards and then placed in the light test box. We removed one test strip from each card at two week intervals so that the degree of fading could be seen as a gradual change across six test strips for each photo-reproduction process.

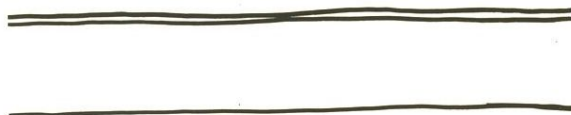
We exposed the color test strips to approximately 5.9 Klux for up to 12 weeks. The longest exposure equalled over 30 years of museum exposure at 50 lux, or 5 foot-candles. We actually used a moderate level of light, compared to other accelerated light tests, to try to diminish the reciprocity problem. The reciprocity problem in light testing occurs when accelerated light exposure causes different fading than the exhibit lighting would. That is, shorter amounts of extremely bright light do not damage colored materials in the same way as long term low light. In light-fast order, the products were:

- Fuji Super FA Type 5



FUJICOLOR SUPER FA TYPE 5

Fig. 1. Cross-section diagram of Fujicolor



ILFOCHROME

Fig. 4. Cross-section diagram of Ilfochrome

- Ilfochrome with or without the laminate
- Kodak Professional Paper
- Canon Color Laser Copy
- Ink Jet Print

After the light tests were complete, we had an image reproduced in all six processes. This was done so NPS curators who needed to chose which photo-reproduction process would best serve their needs could easily compare different processes in a notebook of samples. For example, the gloss of the Fuji, Ilfochrome and Kodak processes might be problematic compared to the complete lack of gloss on the ink jet print. An important point is that if any of these were displayed at museum light levels, in temporary exhibits, I think all of the processes tested could be useful as photo-reproductions. It is in the sometimes uncontrolled light of historic interiors that light stability can be an issue.

Each photo-reproduction process will be discussed separately in the following pages. The cross-section illustrations will show the structure of each process. A chart at the end of this article summarizes the results of the tests.

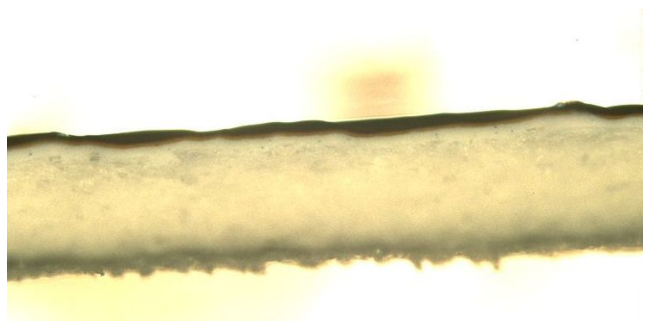


Fig. 2. 100x cross-section micrograph of Fujicolor

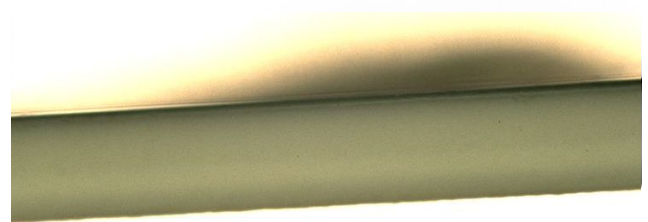


Fig. 5. 100x cross-section micrograph of Ilfochrome

FUJICOLOR SUPER FA TYPE 5

The Fujicolor Super FA type 5 is a photograph with moderate light glare compared to other photographs. It is a continuous tone image, as can be seen in the micrograph at the right (magnified 40X). The cross-section illustrations in this article (drawings and micrographs) show comparable thickness and structure of all the processes tested because they are all magnified 100X.

In the cross-section, the top layer contains the three dyes that form the image - cyan, magenta and yellow. There are gelatin layers in the structure that are not visible. There is a gelatin layer between each dye layer and a protective gelatin layer with UV inhibitors on the top of the structure. Needless to say, the surface is reactive to water. Beneath the dye layers is a layer of polyethylene and titanium dioxide. Beneath that is the paper. On the bottom is another clear polyethylene layer that is textured enough to allow writing on the verso.

This process required that a color negative be made from the color transparency. An earlier version of this material was tested by Henry Wilhelm and in his book he described the Fujicolor Super FA Type 3 as one of the "finest chromogenic color papers ever made." The photograph was not affected by the spot tests of ethanol or



Fig. 3. 40x surface micrograph of Fujicolor

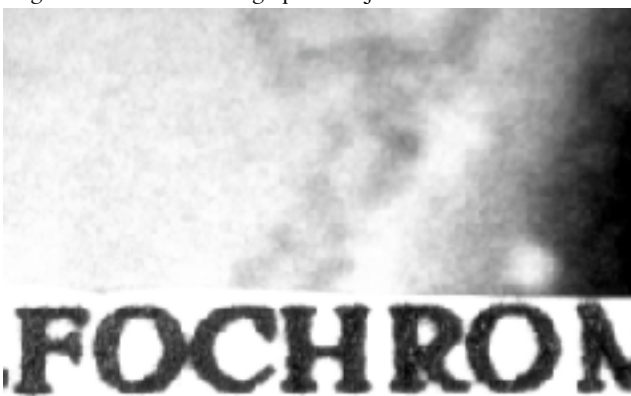


Fig. 6. 40x surface micrograph of Ilfochrome

acetone that we did. This was the most light stable of all the materials we tested.

An important aside to my remarks on this process is that it is becoming increasingly difficult to find professional photo labs that do this work, at least in the Washington area. It is a popular process, Wal Mart is using this process, but the small professional photo labs are dropping it. The explanation given to me by one photo lab was that the chemicals required for this process pose greater health concerns than the chemicals used for other processes.

ILFOCHROME

The Ilford Corporation obtained the Cibachrome process in 1991 and renamed it Ilfochrome. They are the same process. The substrate for this Ilfochrome continuous tone photograph is not paper; it is "voided polyester." This is pure polyester with irregularly shaped micro-bubbles and it is made by ICI. It is a very tough substance and cannot be torn. It is the most glossy material of all those tested. Laminates (see next section) can change the texture of the product.

The cross-section and micrograph shows the very smooth and uniform character of the material. That is the reason for its characteristic - and problematic - high gloss. The dyes in the image layer are arranged in the opposite order than is normally found in a print made with a negative because the Ilfochrome print is made using a color transparency. At the very top and bottom of the cross-section are layers of gelatin. The top gelatin layer is protective and the bottom gelatin layer is an anti-curl layer. The emulsion is softened by water, but is not affected by ethanol or acetone.

This is not the only photographic process available on polyester. There is a similar product made by Fuji called Fujiflex and a Kodak product called Duraflex,

both of which are on polyester. It is very difficult to identify one from the others because there are no identifying labels on them. The Ilfochrome is the only product we tested.

This process and Kodak professional paper (discussed later) can be made in very large sizes. New processing equipment connected to computers can generate prints approximately 5 by 65 feet or more - the entire size of a roll of material on the machine. If size is the most important criteria for a photo-reproduction, these are the best choices.

ILFOCHROME WITH LAMINATE

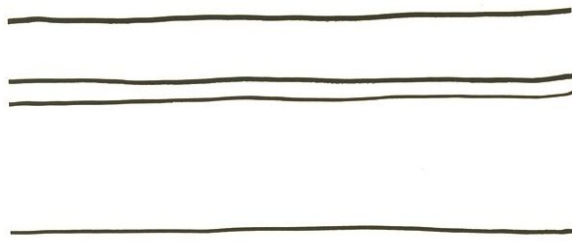
Only the laminate on the Ilfochrome will be discussed here because the photograph itself has been described. The laminate in this particular case is a sheet of transparent

vinyl with a heat sensitive adhesive. It is the Seal Company product called "Print Guard." The sheets are available in various textures like canvas, linen, satin matte, and lustre. I should warn you that this product and others like it are sold with many claims of "archival" quality and protection. There are a lot of laminates and lacquers available for covering and "protecting photographs." This is only one example.

The laminate is the thick, clear, upper portion of the cross-section. In our solvent tests it was softened and distorted by acetone. At this point in the light tests, the laminate has made no visible difference in the color fading of the photograph when compared to the unprotected Ilfochrome. Its main use could be to protect the surface of the photograph from scratches and to change the high gloss of the photograph into a soft matte finish.

KODAK PROFESSIONAL PAPER

The structure of this material is the same as the Fujicolor seen earlier. In the cross-section top layer are the three dyes that



ILFOCHROME WITH LAMINATE

Fig. 7. Cross-section diagram of Ilfochrome UV

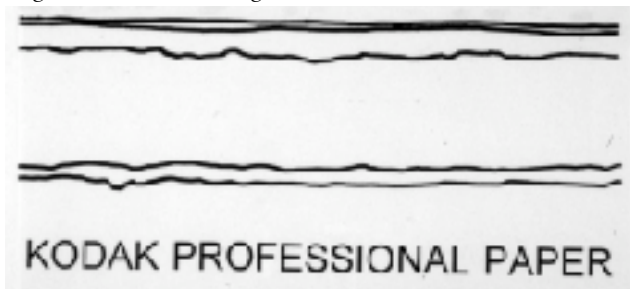
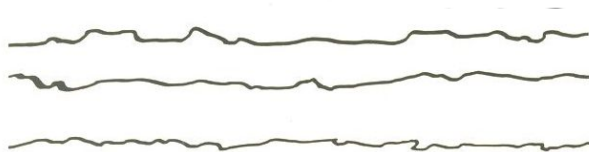


Fig. 10. Cross-section diagram of Kodak



CANON COLOR LASER COPY

Fig. 13. Cross-section diagram of Canon

make the image. Just beneath the three dye layers there is a layer of polyethylene plastic containing titanium dioxide pigment. At the bottom of the thick paper substrate, and on the back of the photograph itself, is a clear layer of polyethylene. This was the least light stable of the three traditional photographic processes tested.

"Kodak Professional" paper is what is printed on the back of the image we tested. It should correctly be identified as Ektacolor Supra II. The substrate for this continuous tone photograph is paper. The photograph is softened and the paper distorted by water. Heat makes the surface sticky. There is only moderate gloss.

CANON COLOR LASER COPY.

The Canon color laser copy is not a continuous tone image. It is made from a series of tiny layers of color laid down in waves on the sheet of paper, as can be seen in the micrograph. They

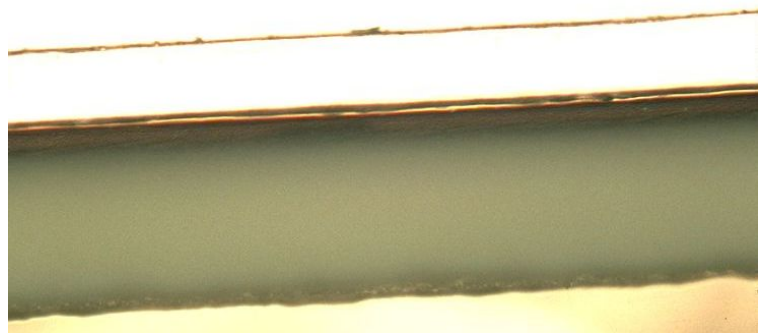


Fig. 8. 100x cross-section micrograph of Ilfochrome UV

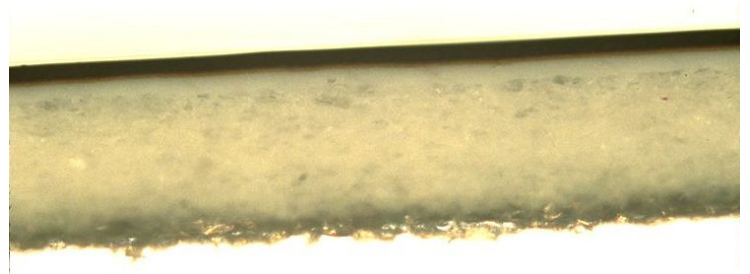


Fig. 11. 100x cross-section micrograph of Kodak

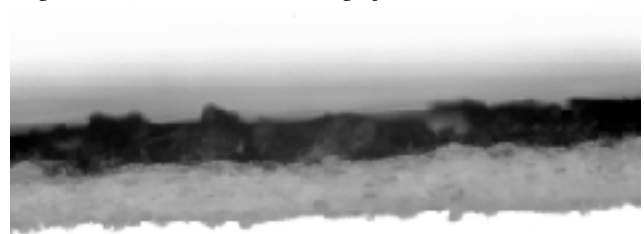


Fig. 14. 100x cross-section micrograph of Canon

have a slight sheen. The image is made by means of electrostatic transfer with a combination of four colorants and toner. The colorants are cyan, magenta, yellow, and black. The toner is a thermoplastic that is not very stable and can be attacked by plasticizers, especially those in poor quality vinyl storage enclosures. Therefore, the Canon color laser copies need to be stored in polyester or polypropylene. The image is fixed with a heat roller.

As can be seen in the cross section, the paper is quite thin, about a 24-pound weight. In our tests the inks bled with ace-



Fig. 9. 40x surface micrograph of Ilfochrome UV



Fig. 12. 40x surface micrograph of Kodak



Fig. 15. 40x surface micrograph of Canon

tone. The Canon color laser copies are considered one of the more stable color xerography techniques. This was tested because it is suitable for some archival preservation copies.

INK JET PRINT

The ink jet print is not a continuous tone image. This image was with in a very high quality (not an office quality) ink jet printer. This particular printer was an Iris printer, but there are other kinds of ink jet printers. The inks used were Iris and Lyson Fine Arts inks. The Washington area company that made these prints, Old Towne Editions, has worked with Henry Wilhelm and used the most stable inks available at the time for ink jet prints. This technology is changing so rapidly that six months after the sample print was made, new inks were being used. There is no intrinsic stability to the Iris ink jet process. I encourage you to use caution when buying such a product for use in high light level exhibits.

The big advantage to ink jet prints is that there is no gloss from the surface of the print. The inks are applied in a minute pattern of dots, visible in the micrograph. Although the inks used for this test were the new "archival" inks made for the ink jet print market, they were still the least light stable media that we tested. With the application of water, the paper distorts and the inks bleed.

The cross-section shows the most common current structure for art quality Iris ink jet print. As can be seen from the cross-section, still only magnified 100X like the others, the ink jet print is on the thickest paper. This is good quality, heavy weight Arches paper. Some of the high end ink jet printers can make prints up to 3 by 4 feet in size. They can also print on a variety of materials, including woven fabrics.

OTHER TESTING OF PROCESS

We also compared other characteristics like solvent reactions, surface texture, expense, and size. The most dramatic test results have been mentioned in the individual process sections. I want to emphasize that we did not compare color reproduction quality. That can be very subjective. It also can sometimes be irrelevant to archival preservation photo-reproduction issues. We did not try to evaluate the techniques in that way. We were primarily interested in light stability, physical characteristics, available sizes, and cost.

The organic solvent solubility of a photo-reproduction process can determine how it can be mounted, or if it can be mounted at all. Water solubility and reactivity can be an important factor when high relative humidity will be a problem. The strength of the polyester film support in the Ilfachrome process could be the determining characteristic for some applications. In some cases, just the size of the photo-reproduction matters, as with the large, continuous prints possible in Fuji flex, Duraflex and Ilfochrome. Thus,

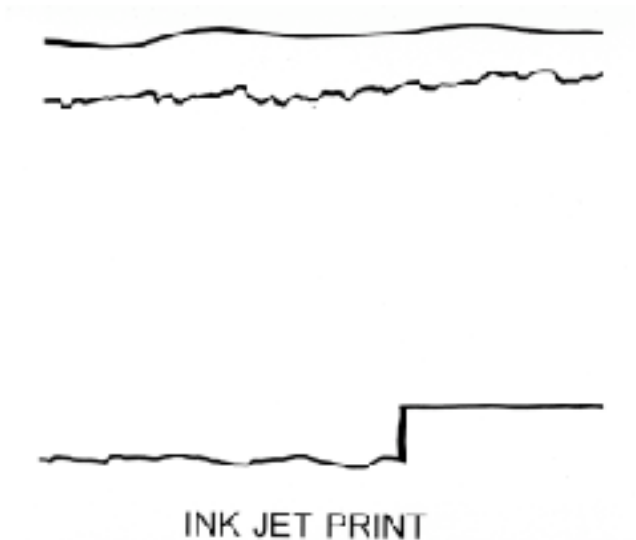


Fig. 16. Cross-section diagram of Inkjet

possible criteria for photo-reproduction process choices include:

- light stability
- surface texture
- expense
- size
- color quality
- solubility and sensitivities
- size
- strength

Given the high amount of light used in these tests, I think all of the processes tested could be useful in given circumstances. The situations in which they would be useful differ, but I think all have potential. Hopefully, the qualities and characteristics reported here will be helpful to some one when selecting a photo-reproduction process.

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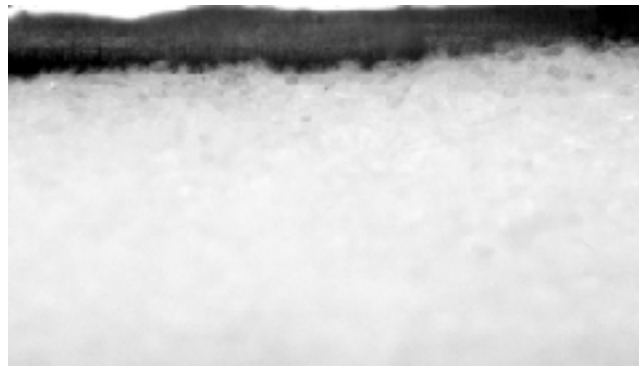


Fig. 17. 100x cross-section micrograph of Inkjet



Fig. 18. 40x surface micrograph of Inkjet

	FUJI SUPER FA TYPE 5	ILFOCHROME WITH UV LAMINATE	ILFOCHROME	KODAK PAPER	CANON COLOR LASER COPY	INK JET PRINT
Substrate	Photographic paper	Polyester photographic substrate	Polyester	Paper	20-28 lb. paper— various qualities, some archival quality	Artist quality paper (Arches, Strathmore, etc.)
Emulsion	Gelatin?	Covered by a matte plastic laminate of polyester, polypropylene or (probably) polyvinyl chloride. The adhesive is probably an acrylic with UV stabilizers.	Gelatin?	Gelatin?	None. A double component toner (toner and fuser oil) is applied to the paper when the print is made. It is fixed with heat.	None
Solvent Test— Water	Emulsion softened	No reaction	Emulsion softened	Emulsion softened	Paper distorts	Inks bleeds
Solvent test— ethanol	No reaction	No reaction	No reaction	Paper distorts	No reaction	Paper distorts
Solvent test— acetone	No reaction	Laminate softened and distorted	No reaction	No reaction	Inks bleed	No reaction
Heat Test	Sticky Emulsion	No reaction	Slightly sticky emulsion	Sticky emulsion	No reaction	No reaction
Tear Test	Tears	Could not be torn	Could not be torn	Tears	Tears	Tears
Tape Test	No change	No change	No change	No change	Ink lifted	Skins paper
Tested by Wilhelm?	Yes. Earlier version— "...finest chromogenic color papers ever made."(Wilhelm 1993)	Yes. The laminates did not reduce the rate of fading in his tests.	Yes. Earlier version	Yes. Several Kodak papers tested	Yes. Among those deserving particular note.	Yes, earlier, Iris company, version. The inks in NPS sample are newer, more "archival" inks.
NPS Light Test Ranking	Most light stable	Laminate did not make visible difference	Good light stability	Least stable traditional photographic process	Less stable than photographs, but one of the more stable xerography techniques.	Less stable than photographs, but most stable ink jet inks available.
Cost	\$61 each	\$53 each	\$45 each	\$2.50 each	\$60 each	\$45 each