Communicating the Results of Image Stability Testing

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ABSTRACT

The image stability performance of various printing technologies and printers from many suppliers is improving, yet the ability to provide comparative information to a broad range of users with changing requirements remains elusive. This paper seeks to:

- *analyze the ways that users want to print and use images*
- *define the likely environments that the prints will encounter*
- *assess the image stability of prints from a range of products and technologies*
- *match the image stability performance with the user expectations*
- *provide a proposal for a user friendly print stability rating system*

The long term stability of images produced by the leading print technologies is defined by a number of sophisticated and complex accelerated tests. The results of these tests for a large range of print systems are reviewed in order to demonstrate the difficulty of reducing the results to an easily understandable form. A methodology for communicating the results in a way that can be useful to most levels of users is proposed.

HOW PEOPLE USE PHOTOGRAPHIC IMAGES

Trends and Expectations

The digital camera revolution changed the way users make prints; it is no longer necessary in many cases to transfer an image to a print media. This brought about a significant reduction in the number of prints made annually. More recently, the most popular camera technology is changing with the proliferation of smart phones with embedded cameras. This is in turn changing the public attitude toward images and prints. The following points were culled from the Internet and though not exhaustive or definitive, do provide some clues as to likely trends in printing photos:

1. The sophistication of consumer image capture systems is declining[1]

2. People still want prints[2]

3. Photo printing at retail is increasing[3] (maybe shifting from home)

4. People either expect or are encouraged to expect retail prints to be long lasting[4]

Proposed Categories for Photo Prints

The industry assesses image stability based on at least four individual and separate exposure factors: light, gas, heat and humidity. There are at least three ways to provide comparative stability information to users. One method provides a self-referenced rating system for each exposure factor using the poor-fair-good-better-best principle. Another way, the one most used today, uses a system based on extrapolation of accelerated test results. In this system the user is provided with an estimate or projection of how many years the print will meet certain standards when exposed to various environmental factors. That is, the user is provided with numbers for light fade resistance, gas fade resistance, humidity tolerance, etc and is left to decide what that all means for a print they want to show their sister or hang up in the living room. Unfortunately image stability information comprises a much more complex system than good-better-best, and most people do not have a good understanding of the potential effects of each factor, much less how to make sense of the combination of factors. We propose that neither of these methods can be satisfactory as a means of communicating image stability information to the public. If the buyer of a print or printer is concerned about image stability, he or she is more likely to know the expected use of the print, and we propose that this makes a more informative and satisfactory starting point for the communication of image stability information. Therefore we propose to define use cases that can be used as the basis for a method of rating the stability of prints made by various technologies. Each use case defines a user who will have an expectation of long term fidelity for the printed image. We propose four use cases as follow:

Category 1 – Snapshots. This used to form the largest category of prints by volume. Snapshots today are often captured by smartphone camera, point-and-shoot etc and are often used for display in digital form only. This category may be quite small in terms of print made, many of the images being put on Picasa, Facebook or other online sites. Some images may be kept on a USB stick and displayed in a digital photoframe. Print stability is not much of an issue since prints are not often made. If prints are made they are looked at, passed around, and then consigned to storage in the proverbial 'shoebox'. For this user, long term is expected to be only a few years, or alternatively, we may say that this user has only a low to medium expectation of long term fidelity.

Category 2 – Books. People want to make a record of an event, a gathering, a person etc, and they do so by making photobooks, albums, scrapbooks, and 'show' books. This category may also include novelty items such as cards and calendars. According to the market research, this is a large and growing market for photo prints and is predominantly fulfilled through a third part supplier rather than using a home printer. Stability is important to this user, but is generally not a problem due to the low levels of exposure to light and environmental gases, the major causes of image instability. Thermal or humidity stability may be an issue for some of these users. This user has a medium to high expectation of long term fidelity.

Category 3 – Home Display. These images may be captured on a smartphone or point-and-shoot camera but the usage is

different from Category 1 or 2. In this case, people want to make a record but not for the purpose of putting the prints in a book or album. They may want durability for their prints because they want to frame and hang the print on a wall, or display in some other way. We cannot assume that the user will place a glass or other transparent layer over the print, as many people have 'gallery wraps' made that are intended to be displayed without covers. For this category, stability is likely to be an issue. This user has a high expectation of long term fidelity.

Category 4 – Professional. The advanced amateur using a DSLR, may want a wall print for home or competition. The professional covering weddings, yearbooks, and events (there are about 100,000 such photographers according to SLR Lounge). Other professionals shoot for stock, magazine assignment, corporate etc. Finally, this category also includes fine art photography, museums, galleries, (according to Art Market Trends 2004: 7,000 photographs were sold in auction rooms in 2004). Stability is often a crucial issue in this category; consequently the user has a very high expectation of long term fidelity.

WHY IMAGE STABILITY RATINGS ARE NEEDED

Standard tests

Tests that have been performed largely follow the developing standards and illustrations from the ANSI/ISO committees responsible for providing standards that can help users choose systems that are suitable for their intended user applications. The tests use high levels of exposure to simulate accelerated long term exposure. High Intensity Daylight (HID), High Intensity Fluorescent (HIF), gas fade using 1ppm and 5ppm ozone, thermal stability using standardized Arrhenius tests, and dark keeping at high humidity have all been applied to the series of prints. We have used these test procedures over the past three years to analyze image stability. The Table below lists most of the print systems we have tested over that time period by technology and expected location of prints made.

Printers	Type	Mfrs	Location		
			Home	Office	Retail
12	AgX	4	0	0	12
22	Inkjet	7	14	4	4
15	EP	7	4	6	5
12	Thermal	8	2	0	10

Although not totally comprehensive, a reasonable cross section of technologies from most suppliers has been evaluated. Our experience is that the most critical tests for most applications will be the HID and ozone. Since it has been demonstrated that there can be a serious reciprocity failure in ozone testing, we will present results for 1ppm ozone only. Due to the many variables between exposure equipment, placement in exposure equipment, measurement equipment etc., absolute predictions of life at lower levels of exposure are impossible to make with reliability The results of these tests on 61 different systems are summarized here in order to demonstrate the difficulty of reducing the results to an easily understandable form.

Analytical assumptions

There has been much discussion regarding endpoints for these tests. An endpoint would be defined as the level of colorant change that is considered to be a failure. In keeping with current industry practice TPR reports failures when 0.3D change has been reached in a primary color, or when 0.15D change has been reached in color balance. Studies have shown[5] that these levels may be too restrictive for most users. We propose that more relaxed endpoints are likely to be acceptable to the majority of users if they do not compare the aged print with the original. In our proposals, this would be Category 1 and 2 users at least, and possibly many Category 3 users. We will therefore present some of the results using the 'standard' endpoints plus endpoints suggested from the noted studies. As with endpoints, there has been much discussion regarding actual exposure levels that will be encountered by prints. TPR currently reports test results using 250 lux 12 hour day average exposure for HID, and 5 or 6 ppb ozone. The only definitive data for HID exposure is from a worldwide study conducted by Kodak in 2006[6] which showed that 120 lux was a more likely average exposure for wall hung prints, with the 90th percentile of all readings being 136 lux. Definitive data for ozone exposure is more difficult to find. A recent study[7] showed that geographic location variables could be used to show typical indoor ozone levels ranging from 5ppb to 20ppb. A sober consideration of these issues lead inescapably to the conclusion that projecting life in years for consumer prints based on accelerated exposure tests is at best difficult and misleading to most people, and at worst is just plain wrong.

Test Results

With the above provisions, we have analyzed the data from printer samples specified and can provide some results. We are using projected life in years, not to assert a prediction, but merely to use years as a useful comparative tool. We have grouped the results by print technology used. We have analyzed the same data using two endpoints and two assumed exposure levels to illustrate the large changes that can result. The results using only one set of endpoints and exposure levels are presented here in tabular form and are arranged by print technology used. Suppliers are listed only as a letter category.

It should be noted that the maximum life tested varied by the test conditions, so that >60 years in an ozone test does not necessarily mean that the sample had greater permanence than another sample that is listed as having >51 years, it means that the sample did not fail the endpoint conditions for that test.

Tech	Mfr	O3 Years	HID Years
InkJet	A	60	36
InkJet	A	22	53
InkJet	A	60	22
InkJet	A	22	28
InkJet	A	60	22
InkJet	A	52	29
InkJet	A	53	22
InkJet	A	44	18
InkJet	A	>60	22
InkJet	B	**>60**	>61
InkJet	B	2	38
InkJet	K	60	29
InkJet	B	44	16
InkJet	N	37	>61
InkJet	N	>51	>61
InkJet	A	>51	28
InkJet	A	>51	21
InkJet	A	>51	18
InkJet	A	>51	20
InkJet	A	>51	17
InkJet	J	5	29
InkJet	J	>51	**16**
InkJet	N	>51	26
InkJet	B	8	**>61**
InkJet	A	>51	46
InkJet	B	7	42
InkJet	I	4	N/A

Tech	Mfr	O3 Years	HID Years
Thermal	C	>51	1
Thermal	B	34	51
Thermal	B	30	>61
Thermal	A	>51	8
Thermal	A	>51	14
Thermal	A	>51	12
Thermal	A	>51	14
Thermal	E	7	24
Thermal	A	>51	6
Thermal	C	7	44
Thermal	A	>60	12
Thermal	A	>60	12
Thermal	A	>60	15
Thermal	D	>60	2
Thermal	E	32	23
Thermal	C	>60	1
Thermal	K	>60	**0**
Thermal	A	>60	13
Thermal	L	>60	0
Thermal	M	>60	3
Thermal	E	**6**	**>61**
Thermal	G	**>60**	1
Thermal	N	60	16

Tech	Mfr	O3 Years	HID Years
AgX	A	>51	15
AgX	A	>51	31
AgX	C	>51	**55**
AgX	F	>51	4
AgX	C	>51	17
AgX	A	**>60**	21
AgX	C	>60	22
AgX	A	>60	13
AgX	F	>60	**2**
AgX	G	>60	22
AgX	C	>60	19
AgX	C	>60	18
AgX	G	>60	14
AgX	A	>60	17
AgX	A	>60	19

Tech	Mfr	O3 Years	HID Years
EP	H	>51	16
EP	B	>51	11
EP	H	>51	16
EP	A	>51	16
EP	P	>51	20
EP	Q	>51	**9**
EP	D	>60	30
EP	D	>60	16
EP	B	>60	16
EP	H	>60	15
EP	A	>60	17
EP	D	**>60**	24
EP	B	**11**	**58**
EP	O	>60	19
EP	I	N/A	9

In the tables we have highlighted the best performing sample for each exposure parameter with **bold** lettering and the worst performing with a shaded box.

If we then collate from these results to list only the 'best in technology' and the 'worst in technology', we would have the summary shown in the Table below

Tech	Mfr	O3 Years	HID Years
InkJet	B	>60	>61
InkJet	B	2	38
InkJet	J	>51	16
InkJet	B	8	>61
Thermal	K	>60	0
Thermal	E	6	>61
AgX	C	>51	55
AgX	A	>60	21
AgX	F	>60	2
EP	D	>60	24
EP	B	11	58
EP	Q	>51	9

Analysis of results

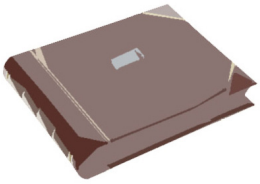
Once again, the number in years must not be interpreted as a real number, the numbers are relative. In addition, the selection of more relaxed endpoints will result in 'longer life' while the use of different exposure conditions could result in 'longer' or 'shorter life' depending upon the assumed exposure factor. We see from the final Table that choice of printing technology is not a guarantee of stability, except perhaps for silver halide's uniform resistance to gas fade. In all other cases there is a wide variation in stability from one printer to another, and this is relatively independent of supplier and technology. We also see that there are very few printers that score well in both gas fade resistance and light fade resistance. There is sufficient scatter in all of the data that we cannot provide selection guidelines based on either technology choice or supplier choice. Even though there have been great gains over the past ten years in print stability in each technology and by all suppliers, there is still a requirement to provide the consumer, amateur and professional alike with an independent method of assessing image stability.

COMMUNICATING THE RESULTS OF IMAGE STABILITY

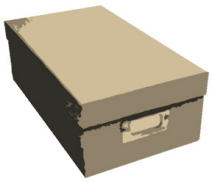
A methodology for communicating the results in a way that can be useful to most levels of users is proposed. This methodology uses a pictorial image or icon for each of the Categories described above to provides the user with a visual representation of the intended use of the print. The icon can be used on a printer box, in literature, or on a Web page to indicate the image stability rating. The recommended icons will be described as:

ARCHIVAL

DISPLAY



ALBUM



SHOEBOX

Better icons can of course be found, but these serve to illustrate the concept. The stability criteria for the Shoebox category is minimal. The Album category needs to have good resistance to humidity and thermal exposures, but only minimal to light and gas fade. The Display category needs to have high resistance to all exposures. The Archival category needs to have the highest possible resistance to all exposures, and may be used to communicate the fact that photo images may be the most durable of all, and can represent the safest long term storage medium, probably better than digital storage.

Additional analysis needed

We believe that this method is the most helpful and useful method of communicating image stability to the widest range of people that want to make prints. It does not however solve the basic problem of how to analyze and interpret the image stability test data and group the results into these four categories. This work remains to be done in the future, and we are willing to share the results of our testing with all who seek to solve this problem.

AUTHOR BIOGRAPHY

Peter Mason *has more than 30-years experience in the development of printers and printer technologies. He is an early developer of laser printing and is responsible for several of the basic patents in the field. Mr. Mason is a current member of the ANSI/ISO committees developing standards for the stability of photographic images. He also manages a premier image stability research and testing capability at Torrey Pines Research and is President of Xactiv, Inc.*

REFERENCES

[1] 43% of people use their cell phone as their primary camera. PC Magazine survey June 2011. Apple's iPhone 4 is officially the most popular camera for uploading photos to Flickr. Flickr June 2011.

[2] 2009 InfoTrends survey. The average person in a survey printed 37 photos every 3 months.

[3] "We expect revenues from photo books, cards, and calendars to jump from $940 million in 2008 to $1.5 billion in 2010. We expect strong growth through end of our forecast period, which runs through 2013." David Haueter Associate Director of InfoTrends' Photo Printing Trends and Photo Merchandise Trends services. PMA 2009. "Recent respondents to InfoTrends` surveys indicated that two of the main reasons they print at retail are that they expect the prints to be higher quality and also have greater longevity." Ibid.

[4] Recent respondents to InfoTrends` surveys indicated that two of the main reasons they print at retail are that they expect the prints to be higher quality and also have greater longevity." David Haueter 2009. Creative Memories and Snapfish both emphasize archival or long lasting prints on their Web sites. Shutterfly specifies Fuji Crystal Archive paper

[5] D. J. Oldfield, G. Pino, R. K. Segur, S. F. Odell, and J. P. Twist, "Assessment of Current Light-Fade Endpoint Metrics Used in Determination of Print Life—Part 1," *Journal of Imaging Science and*

D. J. Oldfield and J. P. Twist, "Assessment of Current Light-Fade Endpoint Metrics Used in Determination of Print Life—Part 2," *Proc. IS&T's Archiving Conference*, 2004, (Springfield, VA: Society for Imaging Science and Technology) 2004.

[6] D. Bugner, J. LaBarca, J. Phillips and T. Kaltenbach, A Survey of Environmental Conditions Relative to the Storage and Display of Photographs in Consumer Homes (Journal of Imaging Science and Technology, Vol 50, No 4) 2006

[7] P. Mason, "Accuracy in Photo Print Life Prediction" *IS&T's Non-Impact Printing Conference*, 2008