

# The Transition from Silver Halide to Digital Printing and Its Effect on Print Quality

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## Abstract

*Printing technology is changing from traditional silver halide based photographic printing to alternative digital printing methods. As this change takes place, image quality differences alter the appearance of the photographic print in subtle but definite ways. These differences are particularly noticeable when migrating from continuous tone printing to electrophotographic systems that require halftone technologies to simulate the continuous tone. Creative Memories has changed the technology for producing its standard digital scrapbook page from traditional photographic printing to electrophotography. This presentation highlights image quality and other differences between the two systems, as well as customer responses to the change.*

## Introduction

Photograph derives from ancient Greek photos meaning light and graphein meaning write. The word has existed in its current form, essentially unchanged since Sir John Frederick William Herschel used it in 1839: "I succeeded in producing a photograph on glass [1]." Originally, photograph accurately reflected the process required to reproduce an image. Now, photograph frequently means an electrophotographic printed image bound in a high-quality photo book. Clearly something has changed.

Ancient Greek		Meaning
φωτος	Photos	light
γραφειν	Graphein	write

Although some dictionaries still cling to an outmoded definition for photograph, the Oxford English Dictionary [1] explicitly recognizes the transition that has taken place:

### Photograph, *n.*

1. A picture or image obtained by photography; (originally) a picture made using a camera in which an image is focused on to sensitive material and then made visible and permanent by chemical treatment; (later also) a picture made by focusing an image and then storing it digitally.

The definition recognizes the fact that the average person does not care how a photograph was produced. It also recognizes that an image taken with a digital camera, displayed on a computer screen, and never printed is still a photograph.

The Creative Memories Page Print includes photos and artwork and is intended to be a digital replacement for a

conventional scrapbook page. The Page Print is created with Creative Memories StoryBook Creator software for the PC, and more recently sbcStudio for the Macintosh. Page Prints are available as 12x12-inch and 8x8-inch in matte and glossy, with 12x12-inch representing approximately 90% of sales. The larger volume of 12x12 sales reflects the popularity of the 12x12 size, as well as the fact that most home printers are unable to print 12x12.

## Experimental

Glossy Page Prints were produced with the Kodak Nexpress with the NexGlossser. Matte Page Prints were produced with a textured clear coat designed to simulate a traditional matte silver halide photographic print.

Image analysis was conducted with the PIAS-II from QEA following the procedures given in ISO 13660. Gloss measurements were carried out with BYK Gardner Micro TRI Gloss 4520 following the procedures given in ISO 19799. Light stability was measured with an Atlas Ci3000 Weather-Ometer with an L37 filter using initial densities of 0.5, 1.0, and 1.5 with failure criteria of 40% dye loss, 20% change in color balance or  $\Delta E$  of 10 for Dmin. Lifetimes were determined assuming 250 lux illumination for 12 h days.

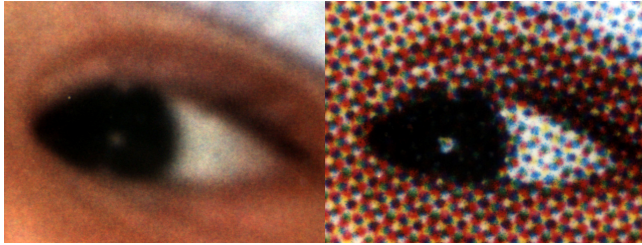
## Results and Discussion

The most important factor in evaluating a photograph is image quality. Consumers are not interested in the absolute image quality, but instead judge whether it meets their expectations and whether they are pleased with the results. In some cases, consumers evaluating digital prints simply state that they are not photographic, without really understanding why that is the case.

Two factors contribute to the "non-photographic" appearance of a printed image: image structure and gloss differential. Image structure differences result from the need to approximate a true continuous tone image with halftoned dots of varying size and density. Gloss differential represents the tendency for gloss to vary with printing density, resulting in the gloss for high density areas differing from the gloss in low density areas.

### Image Structure

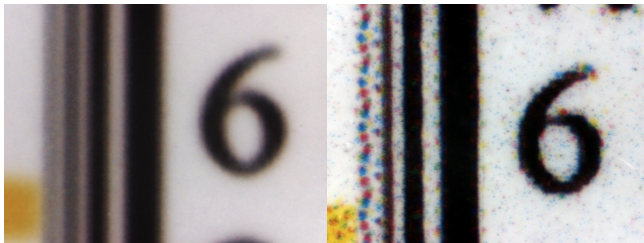
Image structure relates to the appearance of an image, particularly the perception of human faces. The difference in image structure is obvious when an image is enlarged and the halftoning algorithms become readily apparent, Figure 1.



**Figure 1.** Image structure comparison (11.5x) between silver halide photographic print (glossy) and electrophotographic print (glossy). Similar results are seen for matte prints.

At normal viewing distances, the halftone dot structure is not readily perceptible; however, for some people it translates into dissatisfaction with the “photographic” quality of the resulting print.

The halftone process of electrophotographic printing significantly improves the sharpness of text and lines that are present in the print, Figure 2. With electrophotographic printing, edge blur decreases from 0.183 mm to 0.100 mm and line blur decreases from an average value of 0.137 mm to 0.084 mm. Electrophotographic printing also clearly resolves closely spaced lines that are not resolved in traditional silver halide prints.



**Figure 2.** Sharpness comparison (11.5x) between silver halide photographic print (glossy) and electrophotographic print (glossy). Similar results are seen for matte prints.

Text sharpness is particularly critical for Page Prints, since the majority of these prints contain journaling and other text. Page prints may also contain artwork and other high-contrast elements that benefit from electrophotographic printing.

### Gloss

The absolute value of gloss is less important than the gloss differential when evaluating photographic quality. Matte and glossy photographic paper show significant differences in gloss; yet both appear photographic. Within a single photograph, however, customers expect white snow, green trees, blue skies, and black text to have the same gloss.

The procedure for measuring gloss differential given in ISO 19799 involves measuring mean gloss for 40 colors, Gm, calculating differential gloss, Dg, and determining the subjective perceptual difference gloss, Sg.

60° Gloss	Gm	Dg	Sg
Photographic Paper Glossy	82.7	24.8	2.19
Page Print Glossy	84.9	14.6	0.73
Photographic Paper Matte	37.5	5.6	3.80
Page Print Matte	24.9	11.1	9.53

Note: Sg for 60° Gloss measurements with mean gloss, Gm, above 70 are not considered reliable.

In this evaluation, differential gloss is actually less for the glossy electrophotographic print than for the traditional silver halide print, indicating that the electrophotographic print was, in fact, more photographic than the traditional silver halide print. For matte prints, electrophotographic prints have a higher Dg than traditional photographic prints; however, the absolute value of 9.6 for Sg was within acceptable limits, as defined by our target market.

### Image Stability

In general, photos that are printed in photo books are preserved “due to low levels of exposure to light and environmental gases, the major cause of image stability [2].” However, we cannot control how consumers will use products, and products such as Page Prints may be displayed or otherwise exposed to light or atmospheric pollutant. Fortunately, the light stability of electrophotographic prints is significantly greater than traditional silver halide photographic prints.

Sample Description	Hours	Display Lifetime (Years)	Failure
Page Print Glossy	675	54	Dmin density
Page Print Matte	1200 (est.)	96 (est.)	Dmin density
Kodak Royal	194	16	0.5 yellow
Fuji Crystal Archive	208	17	0.5 red color balance

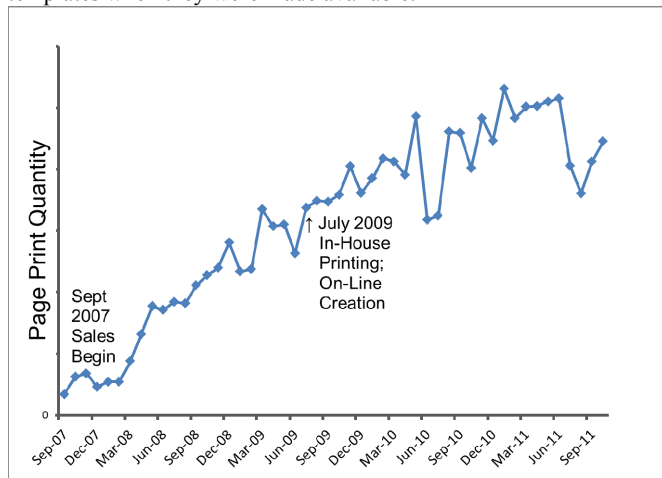
The failure mode for light stability of electrophotographic samples was yellowing of the paper base. Stability of the yellow pigment indicates a display lifetime for the colorants of approximately 160 years. Of course, these results are highly dependent on the specific display conditions and may change significantly with different digital printing technologies.

### Market

At Creative Memories, we performed an experiment with Page Prints in 2009. Actually, it was more of a business decision, based on the cost of outsourcing photographic printing compared to in-house printing, than an experiment, but it had the same effect.

On July 1, 2009, we replaced traditional photographic prints with an electrophotographic prints from the Kodak Nexpress, as part of bringing printing in-house. Glossy prints took advantage of the Nexpress NexGlosser, while matte prints used a textured clear coat to simulate the appearance of a traditional photographic print.

Even though we received a significant number of comments from customers objecting to this change, sales were largely unaffected, Figure 3. At this time, we also added the ability to create Page Prints online. The ability to create Page Prints online prove largely unnecessary, as only 2% of orders used online templates when they were made available.



**Figure 3.** Relative monthly Page Print sales since product introduction in September 2007.

### Digital Printing

Page Prints highlight the continued importance of the printed image. Sales continue to grow as existing customers transition to and new customers begin digital scrapbooking.

Recent studies comparing digital display with printed output have shown that consumers generally prefer a printed photo book, when given the choice between a photo book and viewing on a computer [3]. Specifically, consumers indicate that photo books are tangible, they prefer hard copies, and photo books are easier to look/flip/show. On screen display also contributes to eye fatigue [4].

Page Prints and photo books also provide context, which is generally missing when an image is displayed on screen [5].

Finally, some studies have suggested that prints may, in fact, be more environmentally friendly than on-screen display [6]. After all, once a Page Print or photo book is printed, it is permanent and no additional energy is required.

### Conclusion

At this time, silver halide prints are not better than electrophotographic, nor are electrophotographic prints better than silver halide. They are just different, and each technology has a place. However, the decline of silver halide printing is inevitable, as the image quality for electrophotography and other printing technologies improves. The Creative Memories Page Print illustrates how this transition is taking place. In this case, the economic advantage and convenience of dry printing was simply compelling.

### References

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### Author Biography

At Creative Memories, Mark Mizen leads the team that develops high-quality digital photo products, including photo books, calendars, and photo gifts. He previously established and was Director of the in-house Technology Center, which rigorously tests and evaluates Creative Memories products. Mark Mizen is the Chair of ISO WG-5 TG-2 Imaging Materials - Storage and Mechanical Properties, which is responsible for standards for digitally produced photo books, as well as the photo safety of traditional products. He is also a member of IS&T, ASQ, and ACS. Mark Mizen has a Ph.D. in Organic Chemistry from M.I.T. and a B.S. in Chemistry from the University of Illinois.