

# How Long Will Inkjet Prints Last? The Technology Behind Kodak's Best-in-Class Print Permanence

**Kodak**

TECHNICAL DATA / REFERENCE

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With inkjet printing, how long your pictures will last, is more than a question of lightfastness or resistance to ultraviolet (UV) radiation. Just as important to overall image stability is the "darkfastness," that is, the stability of the print to heat, humidity, and other environmental factors such as air quality or contact with album or storage materials. These factors are important not only for prints on display but also for prints in dark storage such as albums. Dark storage is very important because greater than 90 percent of consumer prints are ultimately stored in the dark.

This paper summarizes our current understanding of these different phenomena in the context of inkjet printing. The focus of this article will be the stability and durability of photographic quality inkjet prints, that is, prints made with photo-capable printers using "photo" inks (if available) printed onto glossy photographic quality papers, and intended for use in the home.

**Lightfastness and Darkfastness of Inkjet Prints.** It is important to note that lightfastness is a function of both the inks and the paper that are used to make the final print. Further, it is the choice of colorants used in the inks that have the greatest effect on the overall lightfastness of a print. Darkfastness, which includes the environmental factors other than light (atmospheric pollutants, heat, and humidity) can be driven by choice of colorants but the media type (porous versus swellable) typically has the greater effect on dark stability.

**Inks.** The inks used in consumer desktop inkjet printers contain colorants made up of either water-soluble dyes or dispersed pigments. A minimum colorant set for photo printing includes cyan (C) magenta (M), and yellow (Y) inks. Black (K) inks are also included in most photo ink sets. In some photo quality printers, additional inks such as light magenta and light cyan are used to produce a smoother tone scale and wider color gamut. KODAK All-in-One Printers, developed with Kodak's Advanced Color Science research, include C, M, Y, and "photo" K pigmented inks (in addition to a separate "text" K ink used to print text and graphics).

Additionally, KODAK All-in-One Printers use a clear protective ink, or "P-ink", which is applied differentially as a function of the amounts of colored inks in the image. This technology, which in the consumer market is unique to

Kodak inkjet printers, delivers a pleasing, uniform gloss to the photograph while also affording improved stain protection and smudge and scratch resistance. Image stability—both lightfastness and darkfastness—are inherently tied to the basic molecular structure of the colorants, be they dyes or pigments. But for similar chemical structures, pigments have an advantage: their tightly bound particles of colorant tend to be more resistant to degrading factors such as light or pollutants. That's why all KODAK All-in-One Printers use pigment technology created with Kodak's proprietary micromedia milling techniques.

Things would be easier if all that was needed from a colorant set was image stability. In addition to lightfastness and darkfastness, however, color quality is also a primary attribute of the colorant set. In many cases, ink manufacturers must make a trade-off between lightfastness and color quality. At Kodak, we believe that neither image permanence nor color quality should be compromised. That is why we have taken great pains to develop a proprietary pigmented colorant set for the KODAK All-in-One Printers that offers unsurpassed color quality and industry-leading image stability. These high-quality, premium pigmented inks, when used with Kodak's range of photo and document papers, provide best-in-class image stability for photos and documents that last a lifetime.

Further, because today's inkjet prints are often used in ways for which traditional color prints weren't intended (for example, when images are included in documents printed on plain paper), Kodak scientists have also developed pigments that are highly water resistant, even when printed on plain paper.

During the product development and commercialization phases, the image permanence of prints produced by KODAK All-in-One Printers has been demonstrated in rigorous testing both by Kodak's own Image Stability Laboratory as well as by independent laboratories. Additionally, after the products were launched, Kodak commissioned further independent testing by Wilhelm Imaging Research who reported that KODAK All-in-One Printers and Inks had achieved the highest level of overall print permanence of any current consumer desktop printing system.

**Papers.** Papers (or films) used for photographic quality inkjet printing have a special ink-receptive coating on at least one surface. This coating is designed to absorb the inks and to optimize both the image quality and image stability of the print. Again, trade-offs are often made among the various performance attributes that the overall print must satisfy. For example, polymers and other additives that are added to the coating to enhance dry time, gloss, and/or waterfastness can often adversely affect the light stability of the dye set to varying degrees.

In addition to the stability of the image itself, the overall lightfastness and darkfastness of the materials used in the paper substrate and the ink-receptive coating are also critical. Cheaper, non-photographic paper bases are prone to yellowing, as are some of the components that have been used in the ink-receptive coatings of some non-Kodak products. This yellowing in turn leads to objectionable color shifts in the image, even if the colorants themselves are stable. The papers used by Kodak for inkjet printing are the same paper substrates that have been developed over many years for traditional standard photo prints. They are designed to withstand many generations of light exposure and dark keeping without yellowing or physically degrading.

**Systems.** The inks and papers must function together as components of a printing system to deliver the best overall performance. In view of the trade-offs already described, it is not surprising then that the most stable inkjet prints today are those that have been optimized as a complete system dedicated to printing photos, like the Kodak AiO ink and paper combination.

For example, Kodak has designed its highly stable pigmented inks to work optimally with its instant-drying porous paper technologies. In less than 15 milliseconds—far less time than the blink of an eye—the ink is absorbed into the paper, leaving only dry, water-resistant pigment on the surface, eliminating the problems of image smear while still offering unsurpassed image quality and industry leading lightfastness. Kodak inkjet papers are also designed to provide high quality, long-lasting prints when used with printers and modern inks from leading inkjet manufacturers.

**Display Conditions.** Answering the question "How long will my inkjet prints last?" necessitates knowing the conditions for displaying the prints. The type of light source and duration of the exposure are key factors in how fast a given print will fade. Light sources rich in the higher energy ultraviolet end of the spectrum, such as sunlight through a window or unfiltered fluorescent lights, tend to accelerate print fade relative to incandescent sources. To complicate matters, it is not unlikely that a print will experience more than one type of light exposure in the home. For optimum print life, we recommend that a print be displayed out of direct sunlight. Light intensities typically found in the home vary both by location and time of day from under 120 lux to over 450 lux.

A further complication is the fact that environmental factors such as temperature, humidity, and air quality can all affect image stability, both independently and in combination with light exposure. With certain ink and paper combinations, these environmental factors can even dominate and/or greatly accelerate light fade. A recommended range of temperature and humidity for print display is 68-77°F (20-25°C) and 40-60% relative humidity. Studies have shown that these ranges of temperature and humidity are commonly found in an average home. Air quality has become an increasing concern in homes, especially where there is significant exchange of outdoor air in polluted areas. Certain combinations of dye-based inks and paper have been shown to be particularly susceptible to premature fade due to airborne pollutants, especially ozone, which is also a by-product of some air purifiers.

**Relatively Speaking.** In general with most consumer inkjet systems, light or atmospheric pollutants are often the limiters of print life. Pollutants can become the primary limiter over light with porous media, especially with dye-based inks. When prints are carefully prepared and displayed under optimum conditions of temperature, humidity, and air quality, light fade alone can become the primary limiter of print life. Although it may be difficult to precisely answer the question of how long a specific print will last, accelerated light fade tests allow us to make direct comparisons between prints under a set of controlled conditions of exposure and environment. However, the use of accelerated conditions to estimate print life for the same prints under real world conditions can be risky, especially if precautions are not taken. This danger is due primarily to a phenomenon known as reciprocity failure. Stated simply, reciprocity is the property of a light-induced change, e.g., print fade, such that an equivalent cumulative exposure produces a constant change independent of the intensity of the exposure. Reciprocity failure, therefore, occurs when prints fade differently under high intensity, accelerated conditions, than under low intensity real world conditions. While it is difficult, because of time constraints in testing, good testing protocols include checks at multiple light levels to understand its impact on predictions.

**Balance.** As already noted, inkjet prints, whether displayed or stored in the dark, are subject to degradation by more than just light alone, including heat, humidity, and pollutants (primarily ozone). When trying to extrapolate from accelerated test methods to estimate print lifetime, it is important to keep these factors in balance, that is, in proportion to the levels that will be found in a typical consumer home. If not, predictions are unlikely to be correct and may even incorrectly rank one product relative to another. This is why Kodak researchers have taken hundreds of thousands of measurements of environmental conditions in homes around the world in studies spanning more than 20 years.

**Standardized Methods.** New standards specifically for digital media are under development.

Because the current ISO test methods standard was developed before the emergence of photo quality consumer inkjet systems, the standard does not explicitly address some of the image permanence issues unique to these newer technologies, such as additional colorants or pollutant sensitivity. The International Standards Organization (ISO) has announced its intent to develop updated standards to more fully address these new systems. Additionally, continuing research conducted by Kodak scientists and other researchers in homes around the world has shown that there may be better choices than fluorescent light to simulate display in the consumer home environment. As new products are developed and researchers learn more about how prints fade, testing protocols will need to change to keep pace and provide the consumer with the best predictions of how long your pictures are likely to last.

With the current lack of applicable ANSI and ISO standards for testing digital prints Kodak has made use of independent, third-party, testing laboratories, including Wilhelm Imaging Research, to evaluate the permanence of Kodak inkjet prints. Results from Wilhelm Imaging Research are included below and provide a means for direct, apples to apples comparison of the permanence of Kodak consumer inkjet printer systems to other consumer inkjet systems on the market.

**KODAK EASYSHARE 5000 Series Inkjet Printers /  
KODAK ESP 3 All-in-One Printer  
Independent Third Party Permanence Test Results**

Light Fastness	120+ years
Album/Dark Storage	120+ years
Unprotected Ozone Resistance	100+ years
Water Resistance	Moderate to high
Humidity Resistance	Very high

Based on testing by Wilhelm Imaging Research, September 2008.  
See website in endnotes for details.

## Summary

To summarize, the colorants used in the inks have the greatest impact on the overall permanence of an inkjet print. High quality pigmented inks, such as those used exclusively in all KODAK All-in-One Printers, have inherent stability advantages over the dye-based inks found in most other consumer ink jet printers. Photo quality receivers that employ true photographic paper bases are also critical to provide rapid drying and avoid unwanted yellowing of the print. Because of the many trade-offs involved in optimizing a system, matched ink and paper systems that are designed for printing photos tend to yield the best image permanence. Complicating matters is the fact that the nature and duration of the light exposure, in combination with the other environmental conditions under which a print is displayed, are all-important determinants of the life of a print. A further complication to the use of high-intensity accelerated fade conditions for estimating useful print life is that reciprocity failure for inkjet prints can be significant and unpredictable.

More than 100 years of Kodak image science research lies behind the company's proprietary pigmented inkjet inks and advanced photo paper technologies, resulting in best-in-class image stability without compromising the brilliant color and exceptional image quality Kodak is known for.

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## Glossary

Cumulative exposure — the product of exposure intensity and the duration of the exposure, expressed in units of klux-yrs.

Dyes — colorants that can be dissolved in a liquid, often water, and exist as distinct molecules.

Intensity — a measure of the strength of the light under which the print is being displayed, usually expressed in units of klux (thousand of lux).

Ozone — a highly reactive form of oxygen gas considered to be a pollutant and formed from oxygen by natural process, such as lightning, and as a product of human industrial processes.

Pigments — colorants in particle form that are usually suspended or dispersed in a liquid

Print-life estimate — assuming no reciprocity failure, the extrapolation of the cumulative exposure at the first end-point criterion reached under an accelerated condition to the length of time in years that it would take to reach the same cumulative exposure under standard conditions in the home or office.

Reciprocity — the property of a light-induced change such that an equivalent cumulative exposure produces a constant change independent of the intensity of the exposure. For example, an exposure of 10 klux for 1 year should produce the same amount of fade as an exposure of 1 klux for 10 years (cumulative exposure = 10 klux-yrs in each case). Any deviation in the amount of change that occurs between two equivalent cumulative exposures is termed reciprocity failure.

Standard day — the average cumulative light exposure that a home or office environment receives per 24-hour period.

## Endnotes

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Kodak is a trademark.

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