

How Long Will Your Digital Prints Last?

You May Be Surprised

by Nils Miller, Ph.D.

Photography is a wide-ranging field that engenders passion in its practitioners, and like all great forms of expression creates opinions formed through experience and reflection. In its early days one of the great debates was: *Is Photography Art?* This was the subject of many essays and heated discussions among players and spectators. Today, issues such as film vs. digital, format choices, the validity of computer generated images, photography as exploitation or revealer, and even the merits of ink jet vs. silver prints cause similar debate. We are opening this department up to readers, manufacturers, and retailers—in short, everyone who lives and breathes photography and who has an opinion about anything affecting imaging today.

Here's how to get involved: write us an e-mail at editorial@shutterbug.com or send us a letter with a proposed topic and a synopsis of your idea. Once approved, we'll ask you to send us about 500-1000 words on the subject chosen. The idea here is not to push any product or wave any flag, but to create discussion about photo and imaging topics of the day. We reserve the right to edit whatever you send in, although we will never edit intention or opinion but only for length and, hopefully, for clarity. We reserve the right to publish your work on our website as well, so you can join the archives and be a resource for opinion for years to come.

So, get thinking and writing and share your Point of View.

—George Schaub

Editor's Note: In a recent editorial in "Shutterbug" we called for information from manufacturers about the state of the art of digital imaging today, with one main topic being the longevity of "digital" prints. We are very pleased to offer this very precise and informative contribution from Dr. Nils Miller, a senior scientist with HP (Ink & Media division).

Digital photography has dramatically changed the way we capture, store, and manipulate images. But the proof is in the print. Photo prints turn digital images into something tactile, vibrant, transportable, and *physical*—something you could proudly display, sell, or purchase at a high-end art gallery.

This transformation brings with it the expectation that the photo print should last for many years. Most early examples of digital photo printing technology did not live up to that expectation. Even today there are digital photo printing choices that will likely not meet longevity expectations.

There are good options for long-lasting digital prints. Following is a discussion about the general types of printing and paper technologies, and the methods by which permanence science predicts longevity for display and storage.

The Three Types Of Photo Prints

There are three primary digital printing technologies used today: ink jet, dye sublimation, and digital silver halide (e.g., lab processed). Ink jet and dye sublimation printers are the most flexible in terms of location. Ink jet printers are the most common way to produce digital photo prints.

There are two main types of ink jet ink: pigment based and dye based. Pigment-based inks contain "particles" of colorant that, due to their relatively large size, reside on the surface of the print.

Although pigment-based inks typically achieve 50 to over 100 years of display life, the tradeoff between image quality attributes (e.g., gloss, gray neutrality) and display life present a challenge for the ink designer. Photo paper choice can affect this longevity by a factor of two.

Dye-based inks contain molecular colorants that *penetrate* the paper surface. Early generations of ink jet dyes and even many dye-based inks available today have poor print display life—less than 10 years. Fortunately, dye chemistry advances have enabled 50 or even 100+ years of display life while still preserving the smooth surface finish and vibrant colors inherent to dyes. But this level of performance requires innovative dye-based inks (such as HP Viverra Inks) and the right "matched" paper for that particular ink.

The Two Types Of Ink Jet Paper Technologies

In general, ink jet papers fall into one of two categories. The first category is "instant dry" porous-coating photo papers (this includes "micro porous" and "nano porous"). These inorganic coatings are thick enough to absorb most or all of the ink, and do so by using extremely high surface area particles. This design spreads out the dyes over a very large surface, which makes them susceptible to fading from air pollutants such as ozone (discussed later). Pigmented inks will form pigment layers on top of these paper coatings.

The second category is papers that encapsulate ink jet dyes. For example, on HP Premium Plus Photo Paper these organic, polymeric coatings swell in thickness as they absorb the ink, and thus encapsulate and protect the dye from air fade. A subcategory might be called "partially encapsulating" uncoated papers such as watercolor papers.

Print Technology	Display Permanence (Glass Protected)	Air Fade Resistance	Storage Permanence
Digital Silver Halide	17-40 years, depending on brand	Decades	100+ years w/quality processing
Ink Jet	100+ years for some branded ink/papers; but less than 5 years for other combinations	Decades (pigments, or dyes + encapsulating paper); months (most dyes + porous paper)	100+ years, premium brands (200+ years some brands)
Dye Sublimation	4-8 years lightfastness (one brand: 26 years)	Decades (most brands)	Currently unknown

[Note: Summary based primarily on Wilhelm-Research.com data and HP Image Permanence Lab data.]

Permanence Science Overview—The Four Permanence Factors

Modern permanence science must consider all key factors when determining how long a photo will last when it is either stored or displayed. Four primary factors limit the years of useful print life: Light (if displayed), Temperature, Airborne pollutants, and Humidity.

Sites for additional information on these factors include www.hp.com/go/premiumplusphoto (click on "Learn more about HP and WIR photo testing"), and www.Wilhelm-Research.com. HP and many other major manufacturers consider Wilhelm Imaging Research, Inc., as the *de facto* industry standard for permanence predictions.

Light Fade

For most types of digital photo prints light fade is the dominant factor to consider when predicting display permanence (an exception is dye-based ink jet prints made on instant-dry photo papers). To accelerate light fade, scientists construct very bright chambers that maintain a temperature and relative humidity similar to a typical home. Photographers who want to be confident about light fade predictions based on the Wilhelm standard should be aware of several points:

First, the Wilhelm calculation assumes a brightly lit indoor room—450 lux *average* for 12 hours per day. The published Kodak method assumes a less brightly lit room—120 lux/12 hours per day. Thus, the Kodak method will predict more years of lightfastness than the Wilhelm method.

Second, the Wilhelm standard also uses a stringent definition of failure—the tests are conducted until just a noticeable amount of fading has occurred, and 17 failure criteria are tracked.

Finally, as a reality check, long-term (>1 year) "slow fade" rate studies are conducted in light chambers that are only

2-10 times brighter than the nominal real-world condition.

Room-Temperature Thermal Degradation Or "Dark Fade"

This factor is the relatively slow thermal degradation of colorants and paper that occurs even at room temperature. Historically called "dark fade" because traditional silver-halide photos could change significantly even when stored in the dark, this factor also applies to displayed photos. The accelerated test requires long-term tests of more than a year at several elevated temperatures (e.g., 55°C-70°C). The results are then extrapolated to a room temperature (e.g., 25°C) prediction.

Fortunately, ink jet colorants (dye and pigment) are very stable and typically can last 100+ years at room temperature, so dark fade is usually not a limiting permanence factor for ink jet photo prints as long as high-quality paper is used. Thermal degradation was historically a significant issue for traditional color silver-halide photos due to residual chemicals from the development process. Wilhelm-Research.com has published a variety of thermal degradation data for ink jet and silver-halide photos. Dye sublimation photos cannot withstand the elevated temperatures required by the accelerated test, so long-term longevity is unknown at this time for dye sublimation prints.

Air Fade Or "Ozone Fade"

Ink jet photos made with dye-based inks on highly porous (e.g., "instant dry") photo papers can experience noticeable air fade within months of exposure. Many customer complaints about premature fading of ink jet prints were actually due to air fade on these highly porous papers; light fade may have been a minor contributor. These complaints could have been prevented by avoiding instant-dry photo papers and choosing encapsulating

papers instead, or by protecting the prints with glass or lamination.

Air fade of an ink jet photo print is caused by direct contact with airborne gases and pollutants, primarily ozone. Accelerated tests use exposure to a high level (> 1 ppm) of ozone until noticeable fading occurs. Next, the months (or years) of ozone fade resistance is calculated based on indoor data averages (e.g., 40 ppm-hours of ozone equivalent to one year "real world"). Manufacturers' claims for air fade are currently not based on a common method; fortunately, Wilhelm-Research.com is now collecting ozone fade data to enable product comparisons.

Silver-halide photos have a protective layer that can greatly reduce air fade. Ink jet photos made on papers with self-encapsulating "swellable" layers (e.g., HP Premium Plus Photo Paper), or ink jet photos made with pigmented inks, in general are quite resistant to air/ozone fade and should last decades even if displayed without a protective cover. According to Wilhelm-Research.com, dye sublimation ozone resistance ranges from approximately one decade to many.

Humidity Fastness

Significant exposure to relative humidity higher than about 80 percent can cause colorants to migrate, thereby causing color changes or loss of sharpness. Long exposure to very high humidity can cause microbial growth and discoloration. Test labs can expose prints to elevated humidity for a period of weeks to qualitatively rank the relative humidity fastness of different products based on measured color changes. As with light fade, humidity fastness is typically improved by using the manufacturer's branded paper that is matched to that particular brand of ink.

How Long Will My Photo Last?

The answer to this question depends on what type—and brand—of print technology are used, and whether the photo is displayed or stored (see table).

Regardless of which digital printing technology you select, it is always a good practice to display photos behind glass for protection and to avoid display locations with direct sunlight, excessive humidity, or high temperature. Don't rely just on manufacturers' claims, but consult independent test lab results.