

A Consumer Guide to Traditional and Digital Print Stability

Created by Image Permanence Institute with support from Creative Memories

Most of us don't think about how long a color print will last when it's new. We are likely to consider its long-term stability only when it has started to fade or discolor, usually after it's too late to do anything to save it in its original form. The fact is that no image will last forever. Heat, humidity, light, air pollutants, and mishandling all can shorten the life of a color print. This guide is intended to help readers gain insight into some of the causes of image deterioration and learn ways to make their photographic and digital color prints last longer.

The subject of image stability has become considerably more complex in recent years. In the past, most color prints were produced using the traditional photographic process. A relatively small number of manufacturers made prints, and the prints generally exhibited similar behavior. In the last decade or so, however, there has been a marked increase in the number of images produced by digital color printers, and these newer materials differ widely in both their composition and their response to environmental factors. While being able to save images as files on a computer hard drive and print copies on demand has great appeal, the longevity of these stored files is not guaranteed. Technology changes rapidly, and equipment fails. Preservation of the color prints thus takes on greater importance.

The natural process of deterioration starts as soon as a color image is printed, whether it is produced digitally or photographically. While we cannot completely prevent this, we *can* handle, store, and display color prints in ways that will greatly extend their useful life.

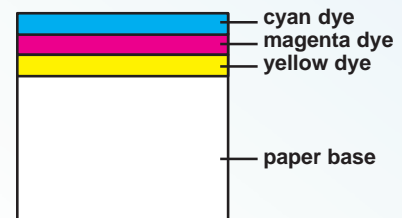
COLOR PRINT TECHNOLOGIES

A typical home image collection might contain different types of color prints; all react differently to external influences.

■ Traditional Photographic Prints

Color photographic prints came into widespread use during the 1950s. Until the 1990s, almost all color prints were made this way. These images are composed of dyes similar to those used to color some fabrics. Over the years photographic manufacturers have modified these dyes so that excellent color renditions can be obtained.

In normal practice, photographic color prints are made by first creating a negative image using a camera and color negative



Cross-section of traditional photographic paper, showing dye layers on paper base.

film. The negatives are then used to print a positive image on photographic paper. New technology has provided another option: Images can now be captured with a digital camera, and these too can be printed on photographic paper.

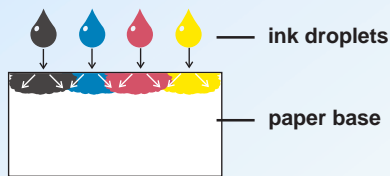
Regardless of whether the camera that recorded the image used film or digital technology, if the image is printed using traditional photographic technology, it will usually show noticeable fading or discoloration after about fifty to one hundred years if it's stored in the dark¹—in an album, for example. If it's exposed to light, the colors will deteriorate even more quickly. The permanence of these types of prints depends not on the recording method but on the inherent characteristics of the colorants and support materials used in producing them.



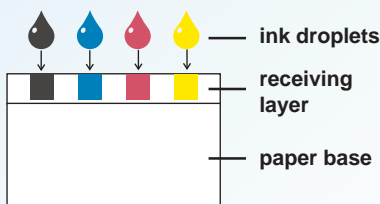
Dye fading in a traditional photographic color print usually results in an overall pinkish cast (seen in the lower image), due to the fact that the cyan and yellow dyes fade faster than the magenta dye.

■ Inkjet Prints

The rapid growth of computers during the past decade has introduced new ways of producing color prints. Images can now be converted to digital files—either by scanning traditional photographic prints or, as mentioned above, by recording them with a digital camera. These files can be sent to a home printer to produce acceptable color prints. The majority of photo-quality printers use inkjet



Cross-section of uncoated (plain) paper. Ink penetrates the paper and spreads in all directions, which may cause bleed-through and loss of image detail.



Cross-section of coated paper. Ink penetrates the receiving layer only and not the paper, resulting in a sharper, brighter image. Additional layers may be present on some papers.

technology, in which very small droplets of ink are deposited onto paper. Inkjet prints vary widely not only in the composition of the colorants and paper, but also in stability.

Inkjet images may be composed of dyes similar to those used in traditional photographic prints, or of pigments, which are the colorants used in paints. In general, pigments tend to be more stable than dyes.

Inkjet prints can be made on either uncoated or coated paper, but only coated paper will provide photo-quality prints. Plain, uncoated paper tends to absorb the ink, resulting in a blurred image and loss of color intensity. In high-quality paper, a coating prevents the ink from bleeding into the paper; this results in brighter, more saturated color and greater image detail. Coated papers may closely resemble traditional color print supports. Two main types are available: swellable and porous. In general, acid-free, buffered, and lignin-free paper bases are recommended for long-term storage.

Swellable Paper

As its name implies, the surface of this type of inkjet paper swells in the presence of the moisture in the water-based ink, allowing the colorants to penetrate the top layers. Swellable papers

typically have three active layers: a protective top layer, a layer that fixes the ink droplets in place, and, below that, a layer that absorbs additional ink components. The paper base is sandwiched between two polyethylene layers and backed by an anti-curl coating and an antistatic layer. Premium swellable papers contain all of these layers, but less expensive ones may not.²

The polymer coating on swellable papers acts to maximize image brightness by keeping the colorants from spreading, and, to some extent, it protects the image from atmospheric pollutants. Images printed on coated paper may require a significant amount of drying time.

Porous Paper

The surface of porous paper is coated with very small, inert particles, which create numerous minute cavities in which the ink is deposited. These particles prevent the ink from spreading. Porous paper has a higher resistance to moisture and humidity. This paper requires minimal drying time, so the print can be handled immediately without fear of smudging. This type of print has no protective polymer layer; therefore, the colorants are susceptible to attack by atmospheric pollutants, such as ozone and oxides of sulfur and nitrogen, which can be present in the environment in fairly high concentrations. Porous paper is preferred when pigment inks are used.

■ Dye Diffusion Thermal Transfer Prints

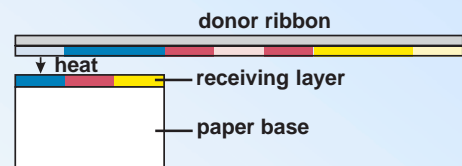
In this process, which is also referred to as dye sublimation, heat transfers colorant from a donor ribbon to the final print. Dye diffusion thermal transfer printers frequently apply a clear protective layer to the print during the transfer process to prevent the image from smearing when rubbed. This process is frequently used for snapshot-size photo printers or in photo kiosks, where customers can print images in a few minutes. The permanence of these images has not been widely studied, and there is very little information available.

■ Electrophotographic Prints

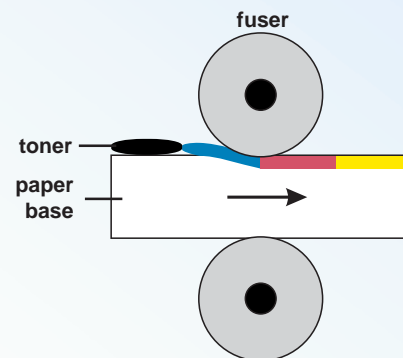
The same process used to produce office photocopies is used to make these prints. In electrophotography toner is transferred to the paper base and then fused in place. The paper is usually uncoated, and the images are reasonably stable, because the image is composed of pigment particles that are fused to the paper with a durable polymer binder material. This technology is used less widely than inkjet for photo-quality printing.

■ Miscellaneous Prints

Several proprietary technologies exist for producing prints in photo kiosks and home printers. These technologies do not fit into the categories mentioned above, and they may not have satisfactory stability for long-term preservation. Check with manufacturers for information about these miscellaneous print materials.



A full-color thermal transfer print requires yellow, magenta, and cyan dye transfer from three separate color patches.



Hot rollers permanently fuse yellow, magenta, cyan, and black toners into the paper base.

ENVIRONMENTAL FACTORS

The color print technologies discussed above produce prints that respond differently to various environmental factors.

■ Temperature and Humidity

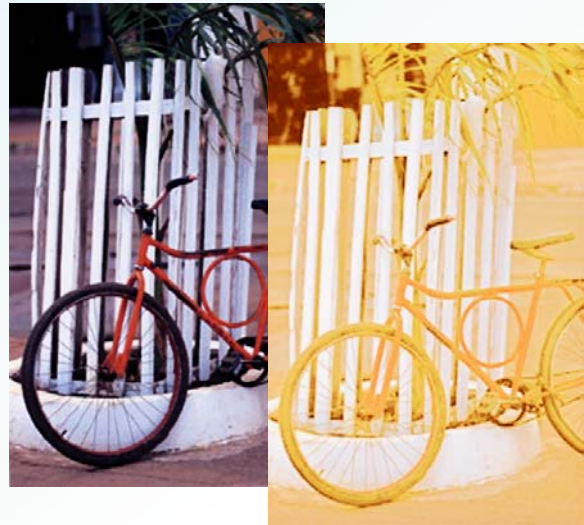
Heat and moisture are two of the most important environmental influences on the stability of color prints. Warm temperatures and dampness should definitely be avoided in the storage of all types of color images. Attics and basements are unsuitable in most cases. High temperature and humidity adversely affect all color print materials, although not to the same degree. Such elevated conditions cause the colors in traditional photographic images to deteriorate quite rapidly.¹ Electrophotographic and pigment-based inkjet prints are generally less sensitive to high temperature and humidity than traditional photographic images because they are made with pigments rather than dyes. The behavior of inkjet materials varies widely at these conditions, depending upon whether the images are dyes or pigments and whether the paper is uncoated, swellable, or porous.^{3,4} In humid conditions, inkjet images composed of dyes that have been printed on swellable coated paper can appear blurred because of dye spreading. Inkjet prints may be susceptible to overall yellowing or staining. With all technologies, sustained high humidity can produce fungal growth.

■ Gaseous Pollutants

Gaseous pollutants are not a problem with traditional color photographic or electrophotographic images.⁵ Some inkjet prints, however—primarily, but not exclusively, dye images on porous paper—are particularly vulnerable to the detrimental effects of ozone.^{5,6} Ozone is present both outdoors and indoors, and concentrations can be quite high near industrial sites or in large communities.^{7,8} Unlike temperature and humidity, the presence of ozone is not detectable by the average person, except in extreme situations such as smog. Ozone-related damage is minimized if the prints are framed behind glass or stored in albums.

■ Water

The chance of water damage increases as prints are stored for extended periods of time. The most likely problem is damage caused by floods, spills, or leaky pipes or roofs. Dye-based inkjet prints can be very susceptible to water damage; rubbing the surface of the print while it's wet will worsen the damage. Pigment-based inkjet prints are relatively water-resistant, however, even when printed on plain paper.



The inkjet print on the right shows a color shift caused by gaseous pollutants in the air. The yellow cast is due to the fading of the cyan and magenta dyes.

■ Light

Most people enjoy displaying their images, but this usually means that the images are exposed to light for prolonged periods. Exposure to light will cause colors to fade, as evidenced by the fading of colored drapery material or upholstery fabric in the average household.⁹ Color prints are no exception.^{10,11} Framed prints that are kept on display exhibit significant color loss over time. The degree of fading varies with the type of illumination and is greater with higher-intensity light. Prints displayed near windows and exposed to sunlight fade more quickly than prints that are protected from the light. Color prints that are covered with glass or plastic fade less quickly than uncovered prints, because glass and plastic block some of the ultraviolet light.



The lower inkjet print shows the effects of light exposure. The image has a greenish cast because the magenta dye fades more quickly than the cyan and yellow dyes when exposed to light.

■ Mechanical Damage

Another type of color print deterioration is mechanical abrasion caused by scrubbing or scuffing. Inkjet and electrophotographic images are more susceptible to this type of damage than traditional photographic color prints because the images are generally closer to the surface.¹²

DISPLAY OPTIONS

The life expectancy of color prints varies according to the conditions in which they are displayed. Protecting prints with glass or plastics such as Plexiglas®, Lucite®, or polycarbonate can slow the deterioration caused by exposure to light and, in the case of inkjet prints, ozone.

A common way to display prints in North America is to mount them on the refrigerator door with magnets. While this is a very easy way to view favorite images, it's not recommended if print longevity is a primary concern. Prints displayed in this way are usually exposed to fluorescent light, the high humidity associated with normal kitchen activities, and ozone.

STORAGE

Storage enclosures are often used to facilitate the organization, access, and identification of prints. Good storage enclosures can also provide protection from dust, light, and physical damage and reduce the harmful effects of airborne pollutants and high humidity. Although many people keep their prints in shoeboxes, drawers, or similar types of containers, albums are probably the best choice because they provide easy access to prints, surfaces for labeling, and rigidity for safer handling. There are many poor-quality albums on the market, however; an album to be used for storing color prints should be selected with care.



Much progress has been made in recent years in developing suitable albums for long-term print storage. Many early photograph albums had paper pages that contained ingredients that are harmful to prints. Today, conscientious album manufacturers make sure that their album pages meet the requirements set down in two International Standards Organization (ISO) standards.^{13,14} Among other things, these standards specify that a paper must pass a photographic activity test (PAT) to ensure that none of its components will cause damage to photographic materials.¹³ The standards also recom-

mend that the paper meet specific requirements for acidity and physical properties. Certain specifications regarding album construction are also included.¹⁴ Paper is considered safe for use in album pages if it is acid-free, buffered, and lignin-free.¹⁵ Requirements for enclosure materials are that they are chemically stable, have the appropriate dimensions, and are strong enough to protect the enclosed items. Polyester, polypropylene, polyethylene, and polystyrene plastics are considered safe for use in albums. Polyvinyl plastics and cellophane are not recommended, because they are not stable and may become brittle over time.

Little work has been done specifically on storing digital prints; however, one study showed that inkjet prints may yellow when placed on poor-quality paper.¹⁶ At this time, the best guideline for preserving digital prints is to look for albums that meet all photo safety requirements for traditional photographic prints.

HANDLING

Any object intended for long-term keeping should be handled as little as possible. Fingerprints can leave permanent marks and may be a particular problem with inkjet prints. Because inkjet prints on swellable paper may require over a week to dry, it's particularly important to avoid handling them during this period.

Stacking color prints can also cause damage. Although this is not a concern for photographic prints, the colors of some dye diffusion thermal transfer, electrophotographic, and inkjet prints may bleed onto an adjacent sheet. This can be a particular problem if prints are interleaved with plasticized vinyl sheeting (a form of plastic known as PVC, which can be identified by the familiar odor of an inexpensive plastic shower curtain).

CONSUMER CHOICES

■ Identification and Selection of Print Types

It's not always easy for consumers to know the relevant facts about the color print technology they are using. While color negative film is usually printed on traditional color photographic paper, digital files can be printed on inkjet, electrophotographic, or dye diffusion thermal transfer materi-

als, as well as traditional color photographic paper. Within inkjet technology, the choice of printer brand, paper, and ink greatly affects print quality and longevity. Unfortunately, manufacturers and retailers seldom provide consumers with information on whether an ink is dye- or pigment-based or whether a paper is swellable or porous.

Nevertheless, there are a few ways the consumer can determine paper type. Swellable papers frequently have higher gloss than porous papers. Papers that are advertised as having short drying times are usually porous. Swellable and porous papers also can be distinguished by touch. Most porous papers feel slightly sticky; swellable papers generally feel smooth. Another method is the “rub test”: A drop of water rubbed across the surface of a sheet of swellable paper will “melt” the surface layer and form a slippery film. A drop of water on a sheet of porous paper will simply be absorbed by the paper’s surface, causing little change.

Ink type can be determined visually or by differences in water resistance. Prints made with pigment inks often display an obvious difference in surface gloss between areas with high ink density and areas where no ink is present. Pigment-based inkjet prints will be water-resistant even if printed on plain paper; dye-based prints will not.

Consumers who are concerned with long-term stability and who wish to better care for their color prints should make an effort to determine the technology of the print system they are using and then look for specific information on image stability.

■ Life-Expectancy Predictions

Some manufacturers of imaging materials advertise a predicted life expectancy. These predictions should be treated with a great deal of caution. As we have pointed out, print decay can be due to a number of factors: age; damage from light, liquid water, high temperatures, humidity, or air pollution; or some combination of these. No single life expectancy description could include all these variables. Most published life-expectancy predictions are based only on the results of light-exposure testing, which accounts for only one of the possible causes of print deterioration. Moreover, these light tests are usually performed at a single humidity level, light intensity, and type of illumination, and the test conditions are likely to differ significantly from the actual conditions experienced by prints in real-world situations.

SUMMARY

Color prints, not electronic files, are the best way to ensure that digital images will be preserved for future generations. Many options, including traditional photographic prints, are now available for producing color prints from digital images. When properly stored, dye-based inkjet and dye diffusion thermal transfer prints have stability comparable to that of traditional photographic prints. Pigment-based inkjet and color electrophotographic prints are even more stable. All technologies may be vulnerable to damage from light, air pollution, and improper handling. Understanding the differences between available technologies and proper storage of the resulting prints is the key to long-lasting color prints.

BIBLIOGRAPHY

- ¹ J. M. Reilly, *Storage Guide for Color Photographic Materials* (Albany, NY: The University of the State of New York, New York State Education Department, New York State Library, The New York State Program for the Conservation and Preservation of Library Research Materials), 1998.
- ² J. Tarrant, "Coated Inkjet Papers: The Hole Truth," *British Journal of Photography*, 149, Aug. 7, 2002, pp. 29-31.
- ³ D. E. Bugner and P. Artz, "A Comparison of the Image Stability of Digital Photographic Prints Produced by Various Desktop Output Technologies," *Final Program and Proceedings, IS&T's NIP18 International Conference on Digital Printing Technologies*, San Diego, CA, Oct. 2002, pp. 306-309.
- ⁴ S. Guo, N. Miller, and D. Weeks, "Assessing Humid Permanence of Inkjet Photos," *Final Program and Proceedings, IS&T's NIP18 International Conference on Digital Printing Technologies*, San Diego, CA, Oct. 2002, pp. 319-325.
- ⁵ P. Wight, "Features of Reciprocity Failure and Ozone Fading in Ink Jet Images," *Final Program and Proceedings, IS&T's NIP18 International Conference on Digital Printing Technologies*, San Diego, CA, Oct. 2002, pp. 334-336.
- ⁶ M. Oakland, D. Bugner, R. Levesque, and R. Vanhanehem, "Ozone Concentration Effects on the Dark Fade of Inkjet Photographic Prints," *Final Program and Proceedings, IS&T's NIP17: International Conference on Digital Printing Technologies*, Fort Lauderdale, FL, Oct. 2001, pp. 175-178.
- ⁷ B. J. Finlayson-Pitts and J. N. Pitts, *Atmospheric Chemistry: Fundamentals and Experimental Techniques* (New York: John Wiley & Sons, 1986).
- ⁸ G. Thomson, *The Museum Environment*, 2nd Ed., (London: Butterworth-Heinemann, Ltd.), 1990.
- ⁹ T. Padfield and S. Landi, "Light-fastness of the Natural Dyes," *Studies in Conservation*, 11, 1966, pp. 181-196.
- ¹⁰ G. Van Ackere, H. Kanova, M. Graindourze, H. Friedel, and S. Lingier, "Interpretation of Life-of-Display Prediction Calculated from Accelerated Light Fading Tests," *Final Program and Proceedings, IS&T's NIP17: International Conference on Digital Printing Technologies*, Fort Lauderdale, FL, Oct. 2001, pp. 213-217.
- ¹¹ *ANSI/NAPM IT9.9-1996 Imaging Materials – Stability of Color Photographic Images – Methods for Measuring*, (New York: American National Standards Institute), 1996.
- ¹² R. Hofmann, "Imaging Permanence: Professional Photography," *Final Program and Proceedings, IS&T's NIP17: International Conference on Digital Printing Technologies*, Fort Lauderdale, FL, Oct. 2001, pp. 159-161.
- ¹³ *ISO 14523 Photography – Processed photographic materials – Photographic activity test for enclosure materials* (Geneva: International Standards Organization), 1999.
- ¹⁴ *ISO 18902 Imaging Materials – Processed photographic films, plates and papers – Filing enclosures and storage containers* (Geneva: International Standards Organization), 2001.
- ¹⁵ D. M. Burge, J. M. Reilly, and D. W. Nishimura, "Effects of Enclosure Papers and Paperboards Containing Lignins on Photographic Image Stability," *Journal American Institute for Conservation*, 41, 2002, pp. 279-290.
- ¹⁶ M. B. Mizen and C. M. Mayhew, "Influence of Enclosure and Mounting Materials on the Stability of Inkjet Images," *Final Program and Proceedings, IS&T's NIP 17: International Conference on Digital Printing Technologies*, Fort Lauderdale, FL, Oct. 2001, pp. 231-234.



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