HP Photosmart Pro B9180 – Print Permanence Ratings[1]

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Douglas Kirkland with a print of actress Marilyn Monroe made with the HP Photosmart Pro 9180. The photograph was one of a series made in 1961 on assignment for *Look* magazine. In a far-ranging career as a photojournalist and portrait photographer that spans five decades, Kirkland has published 10 books and his work has appeared in countless publications. Kirkland and his wife and business partner, Françoise, live in Los Angeles, California. <www.douglaskirkland.com>

Ink System: HP Vivera Pigment Inks are supplied in eight individual 27 ml HP 38 ink cartridges: Cyan, Light Cyan, Magenta, Light Magenta, Yellow, Photo Black (for glossy photo papers) or Matte Black (for matte photo papers), Light Grey. For optimum results with either glossy papers or matte papers, the printer uses Photo Black ink for glossy and semigloss RC-base photo papers and a combination of Matte Black and Photo Black inks for the highest d-max with matte papers. The pigmented inks provide very good short-term color drift behavior which is essential for color-managed workflows and proofing applications. The four HP 70 thermal inkjet heads are a semipermanent part of the printer which, if necessary, may be changed by the user.

Maximum Paper Width: Single sheet: 3x5 inches to 13x19 inches; Sheet paper sizes: 3”x5”; 4”x6”; 5”x7”; 8”x10”; U.S. letter (8.5”x11”), 11”x14”, 12”x12”, 13”x19”, (11”x17”), A3, A4, A5, A6, B4, B5, E. Panorama sizes: 4”x10”, 4”x11”, 4”x12”. A Specialty Media Tray provides a manual front-feed straight-through paper path (handles media up to 1.5mm thick).

Operating Systems: Windows 2000/XP; Mac OSX 10.3 or later. USB 2.0 and Ethernet 802.3.

Special Features: Densitometric closed-loop printer calibration system provides more accurate and consistent color. The new HP Photosmart Pro Plug-in for Adobe Photoshop combines settings from the printer driver and the Adobe Photoshop “Print with Preview” dialog box to simplify color managed workflows. Using the Specialty Media Tray and the straight-through paper path for single sheets of paper up to 1.5mm in thickness, the printer automatically passes the sheet to the back of the printer, and then feeds it forward as it is printed, so there is no need to reach behind the printer to insert individual sheets of paper.

Price: $699 (USA) HP Product No. Q5734A. Announced February 23, 2006; shipped on Sept. 1, 2006.

The HP Photosmart Pro 9180 is the first printer to use HP’s newly developed, highly stable Vivera Pigment Inks. The eight ink cartridges include both Photo and Matte black inks along with a neutral Light Gray ink for enhanced black-and-white prints and also to reduce metamerism with both black-and-white and color images.

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Paper, Canvas, or Plastic Film Media Printed with HP Vivera Pigment Inks	**Displayed Prints Framed Under Glass(3)**	Displayed Prints Framed With UV Filter(4)	Displayed Prints Not Framed (Bare-Bulb)(5)	**Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)(6)**	**Unprotected Resistance to Ozone(7)**	**Resistance to High Humidity(8)**	**Resistance to Water(9)**	**Are UV Brighteners Present?(10)**
HP Professional Satin Photo Paper	**>250 years**	>275 years	102 years	>250 years	>100 years	very high	high	no
HP Advanced Photo Paper Glossy	**>250 years**	>275 years	102 years	275 years	>100 years	very high	high	no
HP Photo Matte Paper	**>250 years**	>275 years	148 years	>300 years	>100 years	very high	moderate(11)	yes
HP Hahnemühle Smooth Fine Art Paper	**>250 years**	>275 years	127 years	>300 years	>100 years	very high	moderate(11)	some
HP Hahnemühle Watercolor Paper	**>250 years**	>275 years	121 years	>300 years	>100 years	very high	moderate(11)	no

> 250 years indicates “greater than 250 years” and that tests are being continued. This webpage will be periodically updated with the latest test results.

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Black-and-white prints made with HP Vivera Pigment Inks

Douglas Kirkland with a black-and-white portrait of the actress Audrey Hepburn photographed in Paris in 1965 on the movie set of *How to Steal a Million Dollars*, starring Ms. Hepburn and Peter O'Tolle. Kirkland has always driven to make his own prints. In 1946, when Kirkland was 12 years old and growing up in Port Erie, Canada, near Niagra Falls, he built his first darkroom in a closet on the second floor of the family home and taught himself to develop black-and-white films and prints. His love of printmaking has always remained with him but as his photography career advanced and he started traveling worldwide on assignment for *Life*, *Look* and other magazines, he routinely sent his film to the publication's labs for processing. For a period of many years Kirkland had no choice but to leave the printing of his photographs to others. With the arrival of the digital era, however, Kirkland was able to resume making his own, exquisite black-and-white and color prints. The Kirkland's home in the Hollywood Hills of Los Angeles has a large studio space, an Imacon film scanner, and has networked computers and printers located throughout the house. The darkroom may be gone – replaced by Macintosh computers, Adobe Photoshop, and inkjet printers – but Kirkland's love and involvement in the nuances of making his own prints has finally returned.

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Paper, Canvas, or Plastic Film Media Printed with HP Vivera Pigment Inks	Displayed Prints Framed Under Glass(3)	Displayed Prints Framed With UV Filter(4)	Displayed Prints Not Framed (Bare-Bulb)(5)	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)(6)	Unprotected Resistance to Ozone(7)	Resistance to High Humidity(8)	Resistance to Water(9)	Are UV Brighteners Present?(10)
HP Professional Satin Photo Paper	**>275 years**	>300 years	>200 years	>250 years	>100 years	very high	high	no
HP Advanced Photo Paper Glossy	**>275 years**	>300 years	>200 years	275 years	>100 years	very high	high	no
HP Photo Matte Paper	**>275 years**	>300 years	>200 years	>300 years	>100 years	very high	moderate(11)	yes
HP Hahnemühle Smooth Fine Art Paper	**>275 years**	>300 years	>200 years	>300 years	>100 years	very high	moderate(11)	some
HP Hahnemühle Watercolor Paper	**>275 years**	>300 years	>200 years	>300 years	>100 years	very high	moderate(11)	no

> 275 years indicates "greater than 275 years" and that tests are being continued. This webpage will be periodically updated with the latest test results.

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Notes on These Tests:

1) The image permanence data presented here are based on tests done with prototype HP Vivera Pigment Inks on a variety of media used in prototype HP Photosmart Pro B9180 printers. Tests are continuing and this webpage will be updated regularly (very high stability inks such as these require extended test times). Extensive “confirmation tests” with commercially packaged HP inks and papers and an HP Photosmart Pro B9180 printer purchased by WIR will also be conducted by Wilhelm Imaging Research to make certain that the products consumers actually purchase have essentially the same permanence characteristics as those of the prototype products tested earlier in the product cycle, and upon which much of the data reported here are based.

2) Display Permanence Ratings (DPR) are based on accelerated light stability tests conducted at 35 klux with glass-filtered cool white fluorescent illumination with the sample plane air temperature maintained at 24°C and 60% relative humidity. Data were extrapolated to a display condition of 450 lux for 12 hours per day using the Wilhelm Imaging Research, Inc. “Visually-Weighted Endpoint Criteria Set v3.0.” and represent the years of display for easily noticeable fading, changes in color balance, and/or staining to occur. See: Henry Wilhelm, “How Long Will They Last? An Overview of the Light-Fading Stability of Inkjet Prints and Traditional Color Photographs,” *IS&T’s 12th International Symposium on Photofinishing Technologies,* sponsored by the Society for Imaging Science and Technology, Orlando, Florida, February 2002: *<www.wilhelm-research.com> <Wilhelm_IS&T_Paper_Feb_2002.pdf>.* For a study of endpoint criteria correlation with human observers, see: Yoshihiko Shibahara, Makoto Machida, Hideyasu Ishibashi, and Hiroshi Ishizuka, “Endpoint Criteria for Print Life Estimation,” *Final Program and Proceedings: IS&T’s NIP20 International Conference on Digital Printing Technologies,* pp. 673–679, sponsored by the Society for Imaging Science and Technology, Salt Lake City, Utah, November 2004.

See also: Henry Wilhelm, “A Review of Accelerated Test Methods for Predicting the Image Life of Digitally-Printed Photographs – Part II,” *Final Program and Proceedings: IS&T’s NIP20 International Conference on Digital Printing Technologies,* pp. 664–669, sponsored by the Society for Imaging Science and Technology, Salt Lake City, Utah, November 2004. Also available, with *color illustrations: <www.wilhelm-research.com> <WIR_IST_2004_11_HW.pdf>.* High-intensity light fading reciprocity failures in these tests are assumed to be zero. Illumination conditions in homes, offices, museums, and galleries do vary, however, and color images will last longer when displayed under lower light levels; likewise, the life of prints will be shortened when displayed under illumination that is more intense than 450 lux. Ink and paper combinations that have not reached a fading or color balance failure point after the equivalent of 100 years of display are given a rating of “more than 100 years” until such time as meaningful dark stability data are available (see discussion in No. 6 below).

Table 1. “Standard” Home Display Illumination Levels Used by Printer, Ink, and Photo Paper Manufacturers

120 lux/12 hrs/day	450 lux or 500 lux/10 hrs/day or 12 hrs/day
Kodak	Fuji Hewlett-Packard Epson Canon Lexmark Ilford Konica Minolta Agfa-Gevaert DuPont Ferrania InteliCoat Somerset Arches LexJet Lyson Luminos Hahnemühle Premier Imaging Products American Inkjet MediaStreet

Eastman Kodak bases its home display-life calculations on 120 lux/12 hours per day, rather than 450 lux/12 hours per day. Some of Kodak’s display-life predictions for Kodak Ultima Picture Paper are *almost 15X* longer than the predictions obtained in the more conservative tests conducted by WIR for this ink/media combination, and can be accounted for by differences in the two test methodologies. For example, Kodak uses 80 klux UV-filtered cool white fluorescent illumination; WIR uses 35 klux glass-filtered cool white fluorescent illumination. Kodak uses a starting density for fading measurements of only 1.0; WIR uses starting densities of both 0.6 and 1.0. Kodak uses the “ISO Illustrative” endpoint criteria set; WIR uses the visually-weighted WIR Endpoint Criteria Set

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Notes on These Tests (continued from previous page):

Table 2. Filtration Conditions Used by Printer, Ink, and Paper Manufacturers with CW Fluorescent Illumination

UV Filter	Glass Filter
Kodak	Fuji
	Hewlett-Packard
	Epson
	Canon
	Lexmark
	Ilford
	Agfa-Gevaert
	Konica Minolta
	DuPont
	Ferrania
	InteliCoat
	Somerset
	Arches
	LexJet
	Lyson
	Luminos
	Hahnemühle
	Premier Imaging Products
	American Inkjet
	MediaStreet

v3.0. Kodak's display environment light exposure assumption for calculating display life is 120 lux for 12 hours per day (UV filtered); WIR uses 450 lux for 12 hours per day (glass filtered). Kodak maintains 50% RH in their accelerated tests; WIR uses 60% RH. Key aspects of Kodak's test methodology and assumptions for calculation of "years of display" are also very different from those used by most other manufacturers of printers, inks, and media. The display lux level assumption of 120 lux (see Table 1) alone makes Kodak's display-life predictions 3.75X greater than the display-life predictions provided by other manufacturers and by WIR. With many ink/media combinations, Kodak's use of a UV filter instead of the glass filter used by other companies in accelerated light fading tests (see Table 2) further increases Kodak's display-life predictions. For a description of the Kodak tests, see: D. E. Bugner, C. E. Romano, G. A. Campbell, M. M. Oakland, R. J. Kapusniak, L. L. Aquino, and K. E. Maskasky, "The Technology Behind the New KODAK Ultima Picture Paper – Beautiful Inkjet Prints that Last for Over 100 Years," *Final Program and Advanced Printing of Paper Summaries – IS&T's 13th International Symposium on Photofinishing Technology,* pp. 38–43, Las Vegas, Nevada, February 8, 2004. See also: D. E. Bugner, C. E. Romano, G. A. Campbell, M. M. Oakland, R. J. Kapusniak, L. L. Aquino, and K. E. Maskasky, *The Technology Behind the New Kodak Ultima Picture Paper – Beautiful Inkjet Prints that Last for Over 100 Years – Update – May 8, 2004,* Eastman Kodak Company, Rochester, New York. Available as a PDF file from <www.kodak.com>. Together with Kodak's own test data, the articles also include light stability data for Kodak Ultima Picture Paper obtained from ongoing tests conducted by the Image Permanence Institute at the Rochester Institute of Technology (Rochester, New York), and from Torrey Pines Research (Torrey Pines, California). The tests were conducted using the Kodak test procedures and included the use of a UV filter with cool white fluorescent illumination; the Image Permanence Institute and Torrey Pines Research also based print-life calculations on 120 lux for 12 hours per day.

3) In typical indoor situations, the "Displayed Prints Framed Under Glass" test condition is considered the single most important of the three display conditions listed. *All* prints intended for long-term display should be framed under glass or plastic to protect them from staining, image discoloration, and other deterioration caused by prolonged exposure to cigarette smoke, cooking fumes, insect residues, and other airborne contaminants; this precaution applies to traditional silver-halide black-and-white and color photographs, as well as inkjet, dye-sub, and other types of digital prints.

4) Displayed prints framed with ultraviolet filtering glass or ultraviolet filtering plastic sheet generally last longer than those framed under ordinary glass. How much longer depends upon the specific print material and the spectral composition of the illuminate, with some ink/paper combinations benefitting a great deal more than others. Some products may even show reduced life when framed under a UV filter because one of the image dyes or pigments is disproportionately protected from fading caused by UV radiation and this can result in more rapid changes in color balance than occur with the glass-filtered and/or the bare-bulb illumination conditions. For example, if a UV filter protects the cyan and magenta inks much more than it protects the yellow ink in a particular ink/media combination, the color balance of the image may shift toward blue more rapidly than it does when a glass filter is used (in which case the fading rates of the cyan,

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Notes on These Tests (continued from previous page):

magenta, and yellow dyes or pigments are more balanced in the neutral scale). Keep in mind, however, that the major cause of fading with most digital and traditional color prints in indoor display conditions is visible light and although a UV filter may slow fading, it will not stop it. For the display permanence data reported here, Acrylite OP-3 acrylic sheet, a "museum quality" UV filter supplied by Cyro Industries, was used.

5) Illumination from bare-bulb fluorescent lamps (with no glass or plastic sheet between the lamps and prints) contains significant UV emissions at 313nm and 365nm which, with most print materials, increases the rate of fading compared with fluorescent illumination filtered by ordinary glass (which absorbs UV radiation with wavelengths below about 330nm). Some print materials are affected greatly by UV radiation in the 313–365nm region, and others very little. "Gas fading" is another potential problem when prints are displayed unframed, such as when they are attached to kitchen refrigerator doors with magnets, pinned to office walls, or displayed inside of fluorescent illuminated glass display cases in schools, stores, and offices.

Field experience has shown that, as a class of media, microporous "instant dry" papers used with dye-based inkjet inks can be very vulnerable to gas fading when displayed unframed and/or stored exposed to the open atmosphere where even very low levels of ozone and certain other air pollutants are present. In some locations, displayed unframed prints made with microporous papers and dye-based inks have suffered from extremely rapid image deterioration. This type of premature ink fading is not caused by exposure to light. Polluted outdoor air is the source of most ozone found indoors in homes, offices and public buildings. Ozone can also be generated indoors by electrical equipment such as electrostatic air filters ("electronic dust precipitators") that may be part of heating and air conditioning systems in homes, office buildings, restaurants, and other public buildings to remove dust, tobacco smoke, etc.

Electrostatic air filtration units are also supplied as small "tabletop" devices. Potentially harmful pollutants may be found in combustion products from gas stoves; in addition, microscopic droplets of cooking oil and grease in cooking fumes can damage unframed prints. Because of the wide range of environmental conditions in which prints may be displayed or stored, Display Permanence Ratings for the bare-bulb illumination condition will not be listed for paper/ink combinations of known susceptibility to gas fading. For all of the reasons cited above, prints made with microporous papers and dye-based inks should always be displayed framed under glass or plastic.

6) Prints stored in the dark may suffer slow deterioration that is manifested in yellowing of the print paper, image fading, changes in color balance, and physical embrittlement, cracking, and/or delamination of the image layer. These types of deterioration may affect the paper support, the image layer, or both. Each type of print material (ink/paper combination) has its own intrinsic dark storage stability characteristics; some are far more stable than others. Rates of deterioration are influenced by temperature and relative humidity; high temperatures and/or high relative humidity exacerbate the problems. Long-term dark storage stability is determined using Arrhenius accelerated dark storage stability tests that employ a series of elevated temperatures (e.g., 57°C, 64°C, 71°C, and 78°C) at a constant relative humidity of 50% RH to permit extrapolation to ambient room temperatures (or other conditions such those found in sub-zero, humidity-controlled cold storage preservation facilities). Because many types of inkjet inks, especially those employing pigments instead of dyes, are exceedingly stable when stored in the dark, the eventual life of prints made with these inks may be limited by the instability of the paper support, and not by the inks themselves. Due to this concern, as a matter of policy.

Wilhelm Imaging Research does not provide a Display Permanence Rating of greater than 100 years for any inkjet or other photographic print material unless it has also been evaluated with Arrhenius dark storage tests and the data indicate that the print can indeed last longer than 100 years without noticeable deterioration when stored at 73°F (23°C) and 50% RH. Arrhenius dark storage data are also necessary to assess the physical and image stability of a print material when it is stored in an album, portfolio box, or other dark place. The Arrhenius data given here are only applicable when prints are protected from the open atmosphere; that is, they are stored in closed boxes, placed in albums within protective plastic sleeves, or framed under glass or high-quality acrylic sheet. If prints are stored, displayed without glass or plastic, or otherwise exposed to the open atmosphere, low-level air pollutants may cause significant paper yellowing within a relatively short period of time. Note that these Arrhenius dark storage data are for storage at 50% RH; depending on the specific type of paper and ink, storage at higher relative humidities (e.g., 70% RH) could produce significantly higher rates of paper yellowing and/or other types of physical deterioration.

7) Tests for resistance to ozone are conducted with an accelerated ozone exposure test using a Hampden Test Equipment Ltd. Model 903 Automatic Ozone Test Cabinet (with the test chamber maintained at 23°C and 60% RH) and the reporting method outlined in: Kazuhiko Kitamura, Yasuhiro Oki, Hidemasa Kanada, and

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Notes on These Tests (continued from previous page):

Hiroko Hayashi (Seiko Epson), "A Study of Fading Property Indoors Without Glass Frame from an Ozone Accelerated Test," *Final Program and Proceedings – IS&T's NIP19: International Conference on Digital Printing Technologies,* sponsored by the Society for Imaging Science and Technology, New Orleans, Louisiana, September 28 – October 3, 2003, pp. 415–419. WIR test methods for ozone resistance are described in: Michael Berger and Henry Wihelm, "Evaluating the Ozone Resistance of Inkjet Prints: Comparisons Between Two Types of Accelerated Ozone Tests and Ambient Air Exposure in a Home," *Final Program and Proceedings: IS&T's NIP20 International Conference on Digital Printing Technologies,* pp. 740–745, sponsored by the Society for Imaging Science and Technology, Salt Lake City, Utah, November 2004. Also available in PDF format from *<www.wilhelm-research.com> <WIR_IST_2004_11_MB_HW.pdf>.*

8) Changes in image color and density, and/or image diffusion ("image bleeding"), that may take place over time when prints are stored and/or displayed in conditions of high relative humidity are evaluated using a humidity-fastness test maintained at 86°F (30°C) and 80% RH. Depending on the particular ink/media combination, slow humidity-induced changes may occur at much lower humidities – even at 50–60% RH. Test methods for resistance to high humidity and related test methods for evaluating "short-term color drift" in inkjet prints have been under development since 1996 by Mark McCormick-Goodhart and Henry Wilhelm at Wilhelm Imaging Research, Inc. See: Mark McCormick-Goodhart and Henry Wilhelm, "New Test Methods for Evaluating the Humidity-Fastness of Inkjet Prints," *Proceedings of "Japan Hardcopy 2005" – The Annual Conference of the Imaging Society of Japan,* Tokyo, Japan, June 9, 2005, pp. 95–98. Available in PDF format from <www.wilhelm-research.com> <WIR_JapanHardcopy2005MMG_HW.pdf>

See also, Henry Wilhelm and Mark McCormick-Goodhart, "An Overview of the Permanence of Inkjet Prints Compared with Traditional Color Prints," *Final Program and Proceedings – IS&T's Eleventh International Symposium on Photofinishing Technologies,* sponsored by the Society for Imaging Science and Technology, Las Vegas, Nevada, January 30 – February 1, 2000, pp. 34–39. See also: Mark McCormick-Goodhart and Henry Wilhelm, "Humidity-Induced Color Changes and Ink Migration Effects in Inkjet Photographs in Real-World Environmental Conditions," *Final Program and Proceedings – IS&T's NIP16: International Conference on Digital Printing Technologies,* sponsored by the Society for Imaging Science and Technologies, Vancouver, B.C., Canada, October 15–20, 2000, pp. 74–77.

See also: Mark McCormick-Goodhart and Henry Wilhelm, "The Influence of Relative Humidity on Short-Term Color Drift in Inkjet Prints," *Final Program and Proceedings – IS&T's NIP17: International Conference on Digital Printing Technologies,* sponsored by the Society for Imaging Science and Technology, Ft. Lauderdale, Florida, September 30 – October 5, 2001, pp. 179–185; and: Mark McCormick-Goodhart and Henry Wilhelm, "The Correlation of Line Quality Degradation With Color Changes in Inkjet Prints Exposed to High Relative Humidity," *Final Program and Proceedings – IS&T's NIP19: International Conference on Digital Printing Technologies,* sponsored by the Society for Imaging Science and Technology, New Orleans, Louisiana, September 28 – October 3, 2003, pp. 420–425.

9) Data from waterfastness tests are reported in terms of three subjective classes: "high," "moderate," and "low." Both "water drip" tests and "standing water droplets/gentle wipe" tests are employed.

10) Fluorescent brighteners (also called "UV brighteners," "optical brighteners," or "optical brightening agents" [OBA's]) are white or colorless compounds added to the image-side coatings of many inkjet papers – and nearly all "plain papers" – to make them appear whiter and "brighter" than they really are. Fluorescent brighteners absorb ultraviolet (UV) radiation, causing the brighteners to fluoresce (emit light) in the visible region, especially in the blue portion of the spectrum. Fluorescent brighteners can lose activity – partially or completely – as a result of exposure to light. Brighteners may also lose activity when subjected to high temperatures in accelerated thermal aging tests and, it may be assumed, in long-term storage in albums or other dark places under normal room temperature conditions. With loss of brightener activity, papers will appear to have yellowed and to be "less bright" and "less white." In recent years, traditional chromogenic ("silver-halide") color photographic papers have been made with UV-absorbing interlayers and overcoats and this prevents brighteners that might be present in the base paper from being activated by UV radiation. It is the relative UV component in the viewing illumination that determines the perceived "brightening effect" produced by fluorescent brighteners. If the illumination contains no UV radiation (for example, if a UV filter is used in framing a print), fluorescent brighteners are not activated and, comparatively speaking, the paper appears to be somewhat yellowed – and not as "white." This spectral dependency of fluorescent brighteners makes papers containing such brighteners look different depending on the illumination conditions. For example, prints displayed near windows are illuminated with direct or

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Notes on These Tests (continued from previous page):

indirect daylight, which contains a relatively high UV component, and if an inkjet paper contains brighteners, this causes the brighteners to strongly fluoresce. When the same print is displayed under incandescent tungsten illumination, which has a low UV component, the brighteners have little effect. Another potential drawback of brighteners is that brightener degradation products may themselves be a source of yellowish stain. These problems can be avoided by not adding fluorescent brighteners to inkjet photographic papers during manufacture. When long-term image permanence is of critical importance – with museum fine art collections, for example – papers with fluorescent brighteners should be avoided where possible.

11) Although the waterfastness of the color image itself is very high with this paper, the absorbent paper base itself may become cockled, curled, and physically distorted after contact with water. For this reason, the waterfastness of this paper/ink combination is listed as "moderate."