Epson Stylus Photo R2880 – Print Permanence Ratings[1]

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Jack Reznicki in his New York City studio with an Epson R2880. Specializing in advertizing, portrait, children, and lifestyle photography, Reznicki is also widely known for his lectures on photography and printing. He is a past president of the Professional Photographers of America. <www.reznicki.com>

Ink System: Eight inks in the printer; nine individual ink cartridges total. Epson UltraChrome K3 pigmented Cyan, Light Cyan, Vivid Magenta, Light Vivid Magenta, Yellow, Photo Black (for glossy photo papers) or Matte Black (for matte photo papers), Light black, and Light, Light Black. For optimum results with either glossy papers or matte papers, the user can change between Photo Black and Matte Black ink cartridges respectively. The three-level black inks are used over the complete tonal scale to improve the printer's gray balance and eliminate color casts in neutrals and near-neutrals. Maximum resolution: up to 5760 x 1440 dpi. The piezo inkjet heads are a permanent part of the printer.

Maximum Paper Width: Single sheet: 13 inches; roll paper: 4", 8.3" and 13"; maximum printable area: 13 x 44 inches. Sheet paper sizes: 4"x6"; 5"x7"; 8"x10"; U.S. letter (8.5"x11"), 11"x14", 12"x12", 13"x19", B (11"x17"), A3, A3+, Super B (13"x19"), user definable; 4", 8.3", and 13" roll paper; borderless sizes: 4"x6"; 5"x7"; 8"x10"; 8.5"x11"; 11"x14"; 12"x12"; 13"x19"; panoramic sizes. Four paper paths: sheet, roll, manual, and straight-through (up to 1.3mm thick media).

Operating Systems: Windows Vista, XP; Mac OSX 10.3.9, 10.4x, 10.5x. USB 2.0 and PictBridge.

Special Features: Epson "Advanced Black and White Print Mode" for printing high-quality and long-lasting black-and-white images. The "Advanced Black and White Print Mode" also provides a simple way to make excellent B&W or toned (warm, cool, sepia) prints from RGB color image files without having to convert the files in Photoshop.

Price: $799.99 (USA) Epson Model No. C11CA16201. Announced May 24, 2008.

The Epson R2880 features the new UltraChrome K3 With Vivid Magenta pigment inks for improved reproduction of blues, purples, and reds. The three-level gray and black inks provide excellent neutrality throughout the tonal scale for beautiful and long-lasting B&W prints.

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

Paper, Canvas, or Fine Art Media Printed With UltraChrome K3 with Vivid Magenta 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]
Epson Premium Glossy Photo Paper	**85 years**	98 years	60 years	>300 years	>100 years	very high	high	no
Epson Premium Luster Photo Paper	**83 years**	>200 years	45 years	>200 years	>100 years	very high	high	yes
Epson Exhibition Fiber Paper	**90 years**	150 years	44 years	>200 years	>100 years	very high	moderate[11]	yes
Epson UltraSmooth Fine Art Paper	**108 years**	175 years	57 years	>300 years	>100 years	very high	moderate[11]	no
Epson Hot Press Natural Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	no
Epson Hot Press Bright Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	yes
Epson Cold Press Natural Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	no
Epson Cold Press Bright Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	yes

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

Paper, Canvas, or Fine Art Media Printed With UltraChrome K3 with Vivid Magenta 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]
Epson Watercolor Paper Radiant White	**118 years**	>200 years	68 years	>200 years	>100 years	very high	moderate[11]	yes
Epson Velvet Fine Art Paper	**61 years**	125 years	34 years	>200 years	>100 years	very high	moderate[11]	some
Epson Velvet Fine Art Paper w/PremierArt™Spray[12]	**82 years**	168 years	55 years	>200 years	>100 years	very high	moderate[11]	some
Epson Enhanced Matte Paper[13]	**82 years**	110 years	48 years	110 years	>100 years	very high	moderate[11]	yes
Epson Premium Canvas – Satin	**75 years**	132 years	46 years	>200 years	>100 years	very high	moderate[11]	no
Epson Premium Canvas – Satin w/PremierArt™ Print Shield Spray[12]	**85 years**	142 years	60 years	>200 years	>100 years	very high	moderate[11]	no
Epson Premium Canvas – Satin w/PremierArt™ Eco Print Shield Coating[12]	**>100 years**	>100 years	>100 years	now in test	now in test	very high	moderate[11]	no
Epson Premium Canvas – Matte	to be tested	to be tested	to be tested	to be tested	to be tested	to be tested	to be tested	–

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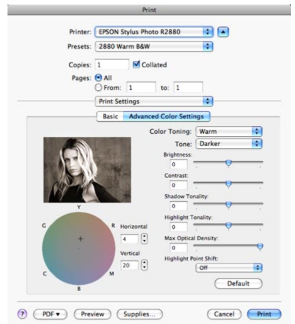
Epson Stylus Photo R2880 – Print Permanence Ratings[1]

B&W prints made with Epson UltraChrome K3 with Vivid Magenta inks and the “Advanced Black and White Print Mode”

Note: The Display Permanence Ratings given here are based on long-term testing with the current generation of UltraChrome K3 with Vivid Magenta inks indicates that significant increases in Display Permanence Ratings for black-and-white prints can be expected because the three-level, highly-stable carbon pigment based black inks in the UltraChrome inksets largely replace the cyan, magenta, and yellow color inks in B&W prints when they are made with the “Advanced Black and White Print Mode.” Very high stability inks such as these require extended test times; tests are continuing and this webpage will be updated regularly. “>200 Years” means “greater than 200 years,” and that tests are continuing.



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

Paper, Canvas, or Fine Art Media Printed With UltraChrome K3 with Vivid Magenta 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]
Epson Premium Glossy Photo Paper	**>200 years**	>250 years	>100 years	>300 years	>100 years	very high	high	no
Epson Premium Luster Photo Paper	**>315 years**	>315 years	>315 years	>200 years	>100 years	very high	high	yes
Epson Exhibition Fiber Paper	**>200 years**	>250 years	>200 years	>200 years	>100 years	very high	moderate[11]	yes
Epson UltraSmooth Fine Art Paper	**>205 years**	>300 years	>138 years	>300 years	>100 years	very high	moderate[11]	no
Epson Hot Press Natural Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	no
Epson Hot Press Bright Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	yes
Epson Cold Press Natural Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	no
Epson Cold Press Bright Paper	now in test	now in test	now in test	>200 years	>100 years	very high	moderate[11]	yes
Epson Velvet Fine Art Paper	**>115 years**	>125 years	>112 years	>200 years	>100 years	very high	moderate[11]	some
Epson Velvet Fine Art Paper w/ PremierArt™Spray[12]	**>178 years**	>145 years	>118 years	>200 years	>100 years	very high	moderate[11]	no
Epson Watercolor Paper Radiant White	**>200 years**	>200 years	>200 years	>200 years	now in test	very high	moderate[11]	yes
Epson Enhanced Matte Paper[13]	**>110 years**	>110 years	>110 years	110 years	>100 years	very high	moderate[11]	yes

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Epson Stylus Photo R2880 – Print Permanence Ratings[1]

B&W prints made with Epson UltraChrome K3 with Vivid Magenta inks and the “Advanced Black and White Print Mode”

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

Paper, Canvas, or Fine Art Media Printed With UltraChrome K3 with Vivid Magenta 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]
Epson Premium Canvas – Satin	**>105 years**	>150 years	>100 years	>200 years	>100 years	very high	moderate[11]	no
Epson Premium Canvas – Satin w/PremierArt™ Print Shield Spray[12]	**>150 years**	>150 years	>100 years	>200 years	now in test	very high	moderate[11]	no
Epson Premium Canvas – Satin w/PremierArt™ Eco Print Shield Coating[12]	**>150 years**	>150 years	>100 years	now in test	now in test	very high	moderate[11]	no
Epson Premium Canvas – Matte	to be tested	to be tested	to be tested	to be tested	to be tested	to be tested	to be tested	–

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Epson Stylus Photo R2880 – Print Permanence Ratings[1]

Notes on These Tests:

1) The image permanence data presented here are based on tests done with prototype Epson UltraChrome K3 with Vivid Magenta inks on a variety of media and on long-term tests with the previous generation of UltraChrome inks used in several different Epson large-format printers. Tests to date indicate that with color images, UltraChrome, UltraChrome K3, and UltraChrome K3 with Vivid Magenta, and UltraChrome HDR inks have similar permanence characteristics. With black and white prints the display permanence ratings with UltraChrome K3 and HDR inks are significantly improved because the three-level, highly-stable carbon pigment based black inks in the UltraChrome K3 inkset are used over the entire tonal scale and largely replace the less stable cyan, magenta, and yellow color inks in B&W prints when they are made with the "Advanced Black and White Print Mode." 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 an Epson Stylus Photo 2880 printer and commercially packaged inks and papers are also being 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) There are currently no ISO or ANSI standards which provide a means of evaluating the permanence of inkjet or other digitally-printed photographs. As a member of ISO WG-5/TG-3 permanence standards group, WIR is actively involved in the development of a new series of ISO standards for testing digital prints. However, as of January 2010, no dates have been announced for the completion and publication of these new ISO standards. The WIR Display Permanence Ratings (DPR) given here 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. This paper may be downloaded in PDF form at no charge from: *<http://www.wilhelm-research.com/pdf/is_t/WIR_ISTpaper_2002_02_HW.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 in-

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
	Hewlett-Packard
	Epson
	Canon
	Lexmark
	Fuji
	Ilford
	Canson
	DNP Konica
Kodak (for Kodak silver-halide papers and Kodak dye-sub prints)	Kodak (for Kodak consumer inkjet prints)
	Ferrania
	InteliCoat
	Somerset
	Harman
	LexJet
	Lyson
	Luminos
	Hahnemuhle
	Premier Imaging Products
	American Inkjet
	MediaStreet

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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 (for Kodak silver-halide papers and Kodak dye-sub prints)	Hewlett-Packard Epson Canon Lexmark Fuji Ilford Canson DNP Konica Kodak (for Kodak consumer inkjet prints) Ferrania InteliCoat Somerset Harman LexJet Lyson Luminos Hahnemuhle Premier Imaging Products American Inkjet MediaStreet

tense 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. 5 below).

Eastman Kodak has licensed WIR image permanence data for the Kodak line of consumer inkjet printers, and WIR data for these printers are posted on the WIR website (see, for example, *<http://www.wilhelm-research.com/kodak/esp9.html>* WIR's tests with the Kodak consumer inkjet printers are performed using the exact same methodologies employed for all other inkjet printers and other print products posted on the WIR website.

Kodak's internally-developed print permanence test methodologies have been used by the company for many years and the company continues to base its home display-life calculations for Kodak silver-halide (chromogenic) color papers and Kodak dye-sub (thermal dye transfer) prints on 120 lux/12 hours per day, rather than the 450 lux/12 hours per day adopted by WIR. It is important to understand this and other differences between WIR's test methods and Kodak's test methods (see, for example, the article by Charlie Brewer titled "At Least For Ink Jet Print Permanence, WIR and Kodak Mend Fences," *The Hard Copy Supplies Journal,* Lyra Research, Newtonville, MA 02460, March 2008, pp. 1–2. The article is available for download at <http://www.wilhelm-research.com/hc/Kodak-WIR_Permanence2008_03.pdf>). Some of Kodak's display-life predictions for the now-obsolete Kodak Ultima Picture Paper (a swellable inkjet paper designed for dye-based inks) were *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 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. 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

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Notes on These Tests (continued from previous page):

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, 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. Resistance to ozone exposure varies considerably, depending on the specific type and brand of dye-based inks and photo paper. In some locations, displayed unframed prints made with certain types of 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, the data given here will be limited by the "Unprotected Resistance to Ozone" ratings. That is, when ozone resistance tests are complete, in cases where the "Unprotected Resistance to Ozone" predictions are less than the "Display Permanence Ratings" for displayed prints that are NOT framed under glass (or plastic), and are therefore exposed to circulating ambient air, the "Display Permanence Ratings" will be reduced to the same number of years given for "Unprotected Resistance to Ozone" even though the "Display Permanence Rating" for unframed prints displayed in ozone-free air is higher. For all of the reasons cited above, all prints made with microporous papers and dye-based inks should always be displayed framed under glass or plastic. For that matter, ALL displayed prints, regardless of the technology with which they are made, should be framed under glass or plastic sheets. This includes silver-halide black-and-white and color prints, dye-sub prints, and inkjet prints made with dye-based or pigmented inks on swellable or microporous papers, canvas, or other materials.

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

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Notes on These Tests (continued from previous page):

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 "Unprotected Resistance to Ozone" are conducted with an accelerated ozone exposure test using a SATRA/Hampden Test Equipment Ltd. Model 903 Automatic Ozone Test Cabinet (with the test chamber maintained at 23°C and 50% RH) and the reporting method outlined in: Kazuhiko Kitamura, Yasuhiro Oki, Hidemasa Kanada, and 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: Henry Wilhelm, Kabenla Armah, Dmitriy Shklyarov, Barbara Stahl, and Dimitar Tasev, "A Study of 'Unprotected Ozone Resistance' of Photographs Made with Inkjet and Other Digital Printing Technologies," *Proceedings: Imaging Conference JAPAN 2007, The 99th Annual Conference of the Imaging Society of Japan,* June 6–8, 2007, pp. 137–140. See also: 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. The IS&T article is 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 Degra-

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Notes on These Tests (continued from previous page):

dation 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 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."

12) PremierArt™ ECO Print Shield, a water-based protective overcoat made specifically for inkjet prints made with water-resistant canvas, and PremierArt™ Print Shield, an easy-to-apply "low-solids" spray supplied in aerosol spray cans for protecting inkjet prints are available from Premier Imaging Products, Inc. <www.premierart.info> and<www.premierimagingproducts.com>, 121 Lombard Street, Oxnard, California 93030; tel: 805-983-1472; fax: 805-988-0213.

13) In these tests, the UV-Filter Display Permanence Rating for Epson Enhanced Matte Paper was 155 years; however, because the Album/Dark Storage Rating for this paper is 110 years (40 years less than the 155-year UV-Filter Display Permanence Rating), the Display Permanence Rating is being limited to 110 years for both color and black-and-white prints.