An Overview of the Permanence of Inkjet Prints Compared with Traditional Color Prints

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Abstract

As inkjet printers move into mainstream photography markets, consumers and professionals alike are asking many questions about how the permanence of inkjet prints compares with that of traditional silver halide based, chromogenic color prints. The various factors affecting color print permanence are described. The similarities and differences between inkjet prints and traditional color prints in terms of image stability are discussed, and applicable test methods are described.

Introduction

With the recent proliferation of affordable, high-quality digital cameras, scanners, and digitized image files made from color negative and transparency originals distributed on CD-ROM discs, the Internet, and by other means, there has been tremendous growth in the use of inkjet printers for printing color photographs.

For the majority of consumer digital camera users, inkjet printers have become the primary – and often the only – method of making prints from their digital image files. For these people, inkjet prints are framed and displayed in their homes and offices, placed in albums, posted on refrigerator doors, and otherwise used in the same ways that photographs have always been used.

In the short history of high-quality pictorial inkjet printing – which on the desktop can be dated to the 1994 introduction of the first Epson Stylus Color 720 dpi printer – making long-lasting prints was not a top priority. In fact, in 1994, image stability simply was not a significant consideration. All of the photo quality inkjet printers now on the market evolved from office text printers. Readable black text and colorful graphs and pie charts were the goal. Most of the inksets currently available from the major printer manufacturers are really carryovers from inksets designed primarily for office applications.

As photographic image quality on the desktop improved very rapidly and Epson, Hewlett-Packard, Canon, and Lexmark rather suddenly found themselves in an entirely new field – serious amateur and professional photography. The evolution of the Iris inkjet printer followed a similar path – the machines were designed for direct digital proofing, technical applications, and making comps. These generally were items intended for short-term use, and were not photographs or works of art. The initial inksets provided by Iris Graphics were never intended for making prints to be matted, framed, and displayed in the same way as traditional color photographs and other fine art prints were.

This gap in the market led to the development of "archival" inksets with improved stability – the Lyson Fine Arts inkset introduced in 1994 for the Iris printer was the first. As applied to inkjet inks and papers, the word "archival" has no specific meaning in terms of how long a print might last before noticeable fading occurs when displayed, or when the print is stored in the dark (where, especially under commonly-encountered high-humidity conditions, ink bleed, color balance shifts, and yellowing can occur). Rather, the term "archival" has come to mean that when designing an inkjet product, the manufacturer intended that it would last a reasonable length of time.

The original Hewlett-Packard PhotoSmart printer, a dedicated 6-ink photo printer introduced in 1997, was the first desktop inkjet printer to provide an ink/media combination specifically designed for making prints that could compete directly with traditional RC-base color photographs – both in terms of the "look and feel" of the prints, and in terms of their image stability. The original PhotoSmart printer was discontinued after the 4-ink PhotoSmart P1000/P1100 printers were introduced in late 1999 (the new PhotoSmart printers use the same printer engine, inks, and RC-base photo media as do the 4-ink Hewlett-Packard DeskJet Professional 970C office-oriented printers introduced at the same time).

Epson's first enhanced-stability inkset was introduced in 1999 with the 6-ink Epson Stylus Photo 870 and 1270 printers; also introduced at the same time was a new RC-base glossy photo paper. During 1998–99 a number of third-party companies marketed enhanced-stability inksets in compatible cartridges for many of the Epson desktop printer models.

Most people have at least a generalized concept of how long traditional black-and-white and color photographs can last – they have pictures of themselves, their children, and other relatives that have been displayed for varying periods. Some may have been on a refrigerator door for only a few months; others may have been displayed for many years. They usually have significant numbers of photographs stored in the dark in albums, shoe boxes, and other places.

Inkjet prints, however, are an entirely different matter. The technology is both completely different and very new. Because high-quality photographs printed with desktop inkjet printers have come into wide use only during the past several years, people have no long-term experience with them and these factors have caused many people to wonder how stable inkjet prints are. "How long will inkjet prints last and how do they compare with traditional color prints?" is the question most often asked by consumers.

The same question is also increasingly being asked by professional photographers, photo labs, service bureaus, commercial galleries, fine art publishers, interior decorators, and countless other producers and users of photographs. Museums and archives also want to know the answers to this question.

For professional portrait and wedding photography, a major future growth area for high-quality inkjet printers, good print permanence is a *must*. This important market segment simply will not make a major move toward inkjet printing until the permanence of displayed prints is at least the equal of the least stable of currently available chromogenic color prints. Good dark storage stability under the wide range of temperature and humidity conditions found in homes throughout the seasons in diverse geographic locations is also essential.

Light Fading Stability

The intrinsic light fading stability of a dye-based inkset can be very much influenced by the media upon which it is printed. With a given inkset, the difference in the rates of light fading between the longest-lasting paper and the least stable paper tested by the authors can exceed a factor of 20:1. That is, the amount of fading that will take place in 20 years of display with the best paper can occur in only one year – or even less – with the worst. This is not the case with current types of traditional chromogenic color prints. With these products, the cyan, magenta, and yellow image dyes are located in individual gelatin emulsion layers, and this isolates them both from each other and from the RC ([polyethylene] resin coated) paper base material. There are, however, significant differences in light fading stability between the brands of chromogenic print materials currently on the market. But for any given manufacturer, the stability of the various available surfaces and types of color papers are usually similar, if not identical.

Displayed inkjet prints may be subject to "catalytic fading" in which areas of an image consisting of two or more inks (e.g., neutral grays, reds, greens, blues, skin colors, etc.) fade more rapidly than do pure cyan, magenta, and yellow colors. For example, in a neutral gray, the inks intermix in the wet state and the presence of the cyan ink may destabilize the magenta ink.

Table 1

Epson Photo 700 and Photo EX Printers (std. Epson inks)	
Epson Photo Paper (1998 "Improved" type)	2 years
Mitsubishi Artist Mirror Gloss Heavy Paper	2 years
Polaroid Premium Quality Photographic Paper	3 years*
Epson Photo Quality Glossy Film	1.5 years*
Imation Photographic Quality Paper	1.5 years*
Epson Photo Paper (1997 type) – Glass filter	1.2 years
Epson Photo Paper (1997 type) – UV filter	1.2 years
Epson Photo Paper (1997 type) – bare-bulb	0.9 years
Kodak Inkjet Photo Quality Paper (1997 type)	0.7 years*
Konica Photo Quality Inkjet Paper QP (old type)	0.6 years*

Hewlett-Packard, Canon, and Lexmark Printers	
HP PhotoSmart w/HP PhotoSmart Glossy Paper	6–8 years
HP 2000C w/HP Deluxe Photo Paper (HP/EK)	2.6 years*
HP 722C w/HP Deluxe Photo Paper (HP/EK)	1.1 years*
Lexmark 5700 w/Photo Inks & Photo Paper	0.9 years
Canon BJC-7000 w/Photo Inks & Photo Paper	0.6 years
Canon BJC-6000 w/Photo Inks & Photo Paper	0.6 years

* When these papers are used with the desktop printers and inks listed above, the prints may suffer serious problems when stored in the dark or displayed in commonly-encountered conditions of high relative humidity. These problems may include one or more of the following:

a) Sticking and Ink Transfer
b) Ink Bleeding (gradual lateral ink diffusion)
c) Density Changes (increases or decreases)
d) Color Balance Changes
e) "Bronzing" in High Density Areas

Current Photographic Color Negative Prints	
Fujicolor Crystal Archive Paper	60 years**
Kodak Ektacolor Edge 7 and Royal VII Papers	18 years
Kodak Ektacolor Portra III Professional Paper	14 years
Konica Color QA Paper Type A7	14 years**
Agfacolor Paper Type 11	13 years

** Predictions integrated with manufacturer's Arrhenius dark storage data

Catalytic fading is generally most pronounced in medium to high density areas of an image; because there is little intermixing of inks in low density areas of an image, lighter colors are usually much less affected. In some cases, catalytic fading may be quite pronounced, lessening the "intrinsic" light fading stability of an inkset by a factor of 10 or more. With a given inkset, the media itself can have a significant effect – either favorable or unfavorable – on the tendency for catalytic fading to occur. This means that with each ink/media combination, certain colors and specific density ranges may fade much more rapidly than do other colors and density ranges; this presents significant complications in the analysis of the light fading of inkjet prints.

Because of the interrelationship between inks and media, it is essential that the formulation of *both* inks and media be optimized in order to obtain the best image stability. This creates significant challenges for third party media manufacturers; a single "one size fits all" media formulation is unlikely to satisfy the requirements of the different inkset formulations supplied by the various printer manufacturers. Exacerbating all of these problems, and contributing to drying difficulties with many types of media and their ink-receptive coatings are the presence of glycols and/or other non-volatile humectants in both piezo and thermal drop-on-demand ink formulations.

The light fading of the continuous tone images of traditional chromogenic color prints is generally characterized by approximately the same absolute density loss in both low-density parts of an image and in higher density areas. For example, when the facial highlights in a portrait with an initial density of 0.25 loses 0.10 density, the higher density, darker parts of the face (e.g., 1.0) generally will also lose 0.10 density. This means that the color and detail in low-density areas of a portrait or other type of image may be *completely* lost while the darker parts of an image are much less affected. To draw conclusions about the light fading stability of traditional chromogenic prints based on fading and color balance changes measured from an initial density of 1.0 can be very misleading. In general, an initial density of about 0.60 will provide more meaningful information.

One reason that the light fading behavior of inkjet prints can be different than that of chromogenic prints is that the individual ink dots that make up an inkjet image are, within the area of the dots themselves, printed at maximum density. Although the size of the dots may vary, and the amount of non-printed white space surrounding a given dot is a function of image density (both factors will to some degree influence light fading stability), as a general rule inkjet images better retain low density and highlight colors and detail than do traditional chromogenic color photographs.

Many desktop inkjet printers (or special "photo" ink cartridges) designed for printing photographs employ dilute cyan and magenta inks in addition to full density cyan, magenta, yellow, and black inks. The Epson Stylus Photo 750 and 1200 desktop printers, as well as the Epson Stylus Pro 9000 and Roland Hi-Fi JET wide-format printers are prominent examples. For any given density, these 6-ink systems lay down many more dots per unit area (with correspondingly less white space between dots) than do 4-ink printers and this generally results in little or no visible dot or dither pattern. In addition, 6-ink printers usually afford better tone reproduction and color saturation in low and medium density areas than do 4-ink printers.[1]

In terms of light fading stability, however, when the particular dyestuffs used in the inks and all other things are equal, 6-ink systems will generally fade between two and three times more rapidly than do 4-ink systems. This potential drawback can be mitigated by the use of intrinsically more stable inksets and optimized ink/media combinations.

The light fading stability of representative inkjet and traditional color print materials is given in Table 1. Because desktop inkjet printers generally are marketed for only a relatively short time before they are replaced with new models, many of the printers listed here, while still in wide use, are no longer being sold.

Most of the inksets currently used with desktop printers have relatively little spectral dependence in terms of fading rates. The rectangle box near the center of Table 1 gives the predicted display life for an Epson ink/media combination exposed to three different spectral conditions. As can be see, the UV-filtered condition provided little protection compared to the other two conditions, including the high-UV content bare-bulb condition. In all three cases, the primary cause of fading was visible light. In the limited number of tests conducted by the authors, UV-absorbing plastic laminates and UV-absorbing sprays offered little or no improvement, even under the bare-bulb condition. In some cases, the coatings even proved to be harmful.

The display-life predictions given here were derived from accelerated glass-filtered fluorescent light fading tests conducted at 75°F and 60% RH and are based on the "standard" indoor display condition of 450 lux for 12 hours per day employed by Wilhelm Imaging Research, Inc.[2] Illumination conditions in homes, offices, 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. The predictions given here are the years of display required for specified, easily noticeable fading, changes in color balance, and/or staining to occur. These display-life predictions apply only to the specific ink and paper combinations listed (further information on the test methods used and the specific fading and color balance endpoints employed is available from: www.wilhelm-research.com).

As shown in Table 1, traditional color prints have better light fading stability than the desktop inkjet products listed. This is especially true with Fujicolor Crystal Archive Paper which, under the display conditions simulated by the accelerated tests used to produce these data, can be displayed for 60 years before noticeable fading will occur. It should be remembered that today's chromogenic color prints have had the benefit of over sixty years of research and development. The Kodak Kodacolor prints of the 1940's and other early color print processes were not nearly as stable, either when exposed to light on display or when stored in the dark.

The light fading stability of desktop inkjet prints made with dye-based inks and media specifically engineered to enhance the life of the specific ink/media combination is expected to improve dramatically in the next few years. High-stability pigmented inks, already in use with many wide-format printing systems, are likely to find significant application with desktop printers as well.

Dark Storage Stability

Dark storage stability refers to fading, color balance changes, and base or overall image discoloration (usually a yellowish stain) that occurs over time in the dark. Dark storage stability is generally evaluated by the Arrhenius accelerated test method in which print samples are incubated at a series of elevated temperatures and constant relative humidity. From these data, extrapolations may be made to storage at room temperature or other temperatures of interest (including freezer storage for very long term preservation). Applicable tests methods are described in *ANSI IT9.9-1996 – American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring*.[3] The Standard also describes light fading tests to simulate various use conditions. It is important to note that the relative humidity selected for both light fading and dark storage tests can have a major influence on the results.

Historically, both dark fading (especially of cyan dyes) and gradual yellowish staining have been a problem with chromogenic color prints; however, beginning with the introduction of Konica Color Paper Type SR in 1984, the dye stability of chromogenic color papers is now much improved. Major progress has also been made in reducing the rate of yellowish stain formation that occurs over time in dark storage; the first of these improved "low-stain" color negative products was Fujicolor SFA3 Paper, introduced in 1992.

Although little data have been published, the inks used in inkjet printers in and of themselves appear to have very good dark storage stability. With concern currently focused on light fading stability problems of desktop inkjet prints and the humidity-fastness issues discussed below, less attention has been paid to evaluating the dark storage stability of the many types of available inkjet media; concerns with the media include potential base yellowing and/or physical embrittlement, cracking, etc.

Water-Fastness

A fortunate consequence of the historical evolution of traditional wet-processed silver halide photographs is that they inherently have excellent water resistance. This is not to say that they do not have water-related preservation problems. For example, if a moist drinking glass is set on a print, it likely will have a visible difference in surface gloss in the area of the wet ring left by the glass after the print is allowed to dry. If wet prints are stacked together, they will stick to each other. Prolonged storage in high-humidity conditions may result in mold growth (moist gelatin is an excellent nutrient).

The water-based inks used with most current desktop inkjet printers have very poor water fastness when printed on plain papers. Good water fastness is an important design goal for inks and media used with inkjet photo printing, and the ink-receptive coatings used with many current "photographic" inkjet papers impart a high degree of water resistance to the images.

The three principle types of water fastness tests include: a) water immersion tests; b) water droplet tests; and c) water droplet tests. Of these, the water immersion test is the generally the least severe, and the water droplet test (in which droplets of water are individually placed on the surface of a horizontal print and allowed to dry undisturbed) is usually the most critical. The water drip test, in which a measured quantity of water is dripped on the surface of a print placed at a 45-degree angle, is probably the most common type of test currently used for water fastness evaluation.

Humidity-Fastness

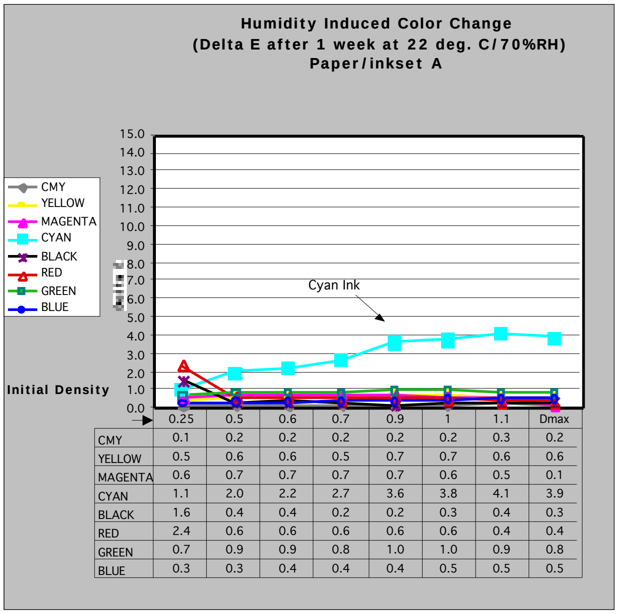
Persistently high humidity will damage most works of art on paper, and photographs are no exception. The glass transition temperature (T_g) of the gelatin binder layer in traditional photographs is a function of moisture content. The T_g of gelatin is reduced to typical ambient room temperature (i.e., 21°C) when the photograph is equilibrated to approximately 75 to 80% RH. Under these conditions, the gelatin returns to the gel state rather than remaining a hard and dry polymer. It ceases to have any real protective properties. Silver oxidation (in B&W prints), ferrotyping, and mold damage are to be expected when photographs are stored under such humid conditions. The rate of dark fading and staining of chromogenic color prints is also increased by a factor of two to four under high humidity conditions, but even at this higher rate, noticeable color changes are not observed within weeks or months. The dyes are well anchored in their respective image forming layers and will not diffuse to other locations within the substrate upon short term exposure to high humidity.

On the other hand, inkjet prints vary considerably in their sensitivity to high relative humidity environments, and the colorants are often able to migrate when moisture content in the substrate is high. This situation exists in part because ink jet users have a wide variety of substrate choices supplied not only from the device manufacturer but from third party vendors. Indeed, part of the appeal of inkjet printing is this substrate independence. Many of the available ink jet papers are also sold today with the claim that they can be printed on by more than one type of ink jet technology. Yet piezo, thermal, and continuous flow ink jet systems have markedly different colorant and liquid vehicle components. Rapid absorption of the ink into the paper is given a very high engineering priority since the ink is being applied at a very high rate by the inkjet nozzles. Without rapid diffusion into the substrate the ink will puddle on the surface and give a mottled appearance. However, long term image permanence places an additional constraint on the design. Once the ink has penetrated the substrate, the liquid vehicle must evaporate and the pigments or dyes must now become resistant to further migration. Ideally, this should occur simultaneously with the customer's perception that the print is now dry. Properties such as water fastness and image permanence in high humidity conditions depend on the elimination of further dye or pigment migration.

As with light fastness, the humidity resistance of an inkjet print is dependent on both the paper and the ink. Figures 1 through 6 reveal significantly different degrees of humidity induced color changes in three different paper/ink combinations. The three media sets were exposed to 70% RH and 80% RH steady-state conditions for one week at a temperature of 22°C. These environmental conditions are essentially non-accelerated tests since they occur with seasonal regularity in many real world storage and display situations. Targets with color patches of cyan, magenta, yellow, black, red, green, and blue, were printed at initial optical densities of 0.25, 0.5, 0.6, 0.7, 0.9, 1.0, 1.1 and maximum print density. Neutral patches were also printed using C, M, and Y inks only. For example, the CMY patch at .6 had initial status A densities for the red, green, and blue filter values nominally equal to 0.6. Similarly, a blue patch at 1.0 density had status A density values for red and green filters equal to 1.0. while the red ink patches measured 1.0 for the green and blue filter values.

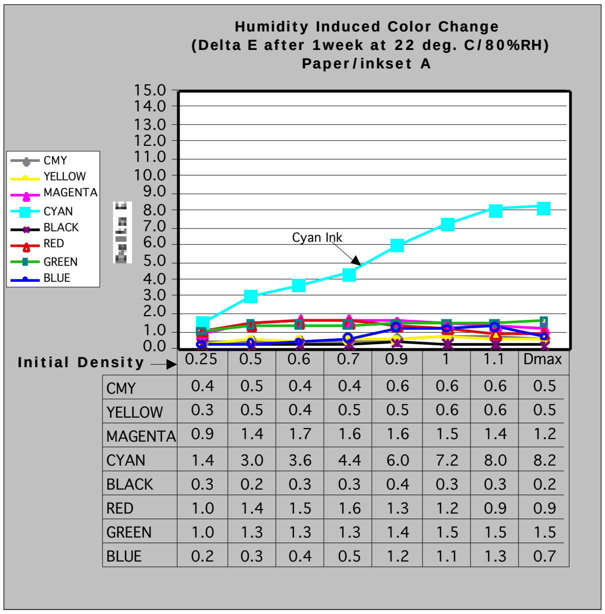
Humidity-induced color changes were then measured using CIELAB colorimetry. L*a*b* values of the various color patches were measured before and after one week of steady exposure to the elevated humidity levels of 70 and 80% RH. The Delta E values were then calculated and are plotted on the Y axis in Figures 1 through 6. Prior to this one week exposure period, all samples had been printed and then stored for several weeks at humidity conditions less than or equal to 60%RH. Paper/inkset A shown in figures 1 and 2 is a dye set printed on a traditional watercolor paper. With one week exposure to 80% RH conditions, a significant color shift occurs in the pure cyan printed color. At 70% RH the amount of change is considerably less, but the trend is still present. It is interesting to note that in this ink/substrate combination the other pure dyes are not nearly as affected, and also the presence of one or more other dyes in the color patch stablilizes the cyan dye. Paper/inkset B, shown in Figures 3 and 4, employs a coating layer which enhances color gamut but yields much less lightfastness than paper/inkset A or C. However, as can be seen by comparing paper/inkset B to paper/inksets A and C, it performed the best in terms of humidity resistance. This is significant because increased humidity resistance may very well cause this paper to outperform paper/inkset A or C in overall longevity on display depending on the environmental conditions even though the other sets are significantly more lightfast. Paper/inkset C is also a coated paper stock with excellent color gamut. However, this coating allows much higher migration of the selected ink upon exposure to high humidity. Lateral migration of the magenta colorant, for example, caused "dot gain" in the lower density patches and consequently high delta E values at the low density end of the plot. Moreover, mixing cyan with the magenta in this set caused very high Delta E values for the blue color patches. In contrast, the cyan ink mixed with yellow ink created remarkably more stable green colors than would be expected on the basis of the cyan ink behavior alone.

The results shown in Figures 1 through 6 illustrate the challenge of designing an inkjet receiver sheet which



Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2
YELLOW	0.5	0.6	0.6	0.5	0.7	0.7	0.6	0.6
MAGENTA	0.6	0.7	0.7	0.7	0.7	0.6	0.5	0.1
CYAN	1.1	2.0	2.2	2.7	3.6	3.8	4.1	3.9
BLACK	1.6	0.4	0.4	0.2	0.2	0.3	0.4	0.3
RED	2.4	0.6	0.6	0.6	0.6	0.6	0.4	0.4
GREEN	0.7	0.9	0.9	0.8	1.0	1.0	0.9	0.8
BLUE	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5

Figure 1. Paper/inkset A exposed to 22°C and 70% RH for one week.



Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	0.4	0.5	0.4	0.4	0.6	0.6	0.6	0.5
YELLOW	0.3	0.5	0.4	0.5	0.5	0.6	0.6	0.5
MAGENTA	0.9	1.4	1.7	1.6	1.6	1.5	1.4	1.2
CYAN	1.4	3.0	3.6	4.4	6.0	7.2	8.0	8.2
BLACK	0.3	0.2	0.3	0.3	0.4	0.3	0.3	0.2
RED	1.0	1.4	1.5	1.6	1.3	1.2	0.9	0.9
GREEN	1.0	1.3	1.3	1.3	1.4	1.5	1.5	1.5
BLUE	0.2	0.3	0.4	0.5	1.2	1.1	1.3	0.7

Figure 2. Paper/inkset A exposed to 22°C and 80% RH for one week.

will absorb ink quickly yet dry to a water and humidity resistant final state. While direct contact with water can be avoided in most circumstances, the susceptibility of ink jet media to high relative humidity conditions must be addressed. Greater humidity resistance is required of most inkjet media in the marketplace today in order to achieve image permanence that meets or exceeds the performance of traditional photographic prints. Although display environments can be regulated by HVAC systems to avoid high relative humidity, storage areas with poor climate control or HVAC mechanical failures, tropical countries, and shipping and transportation conditions often subject photographic prints to short term high humidity conditions which are both cumulative and more severe than the 1 week exposure which generated the data shown in Figures 1 through 6.

References

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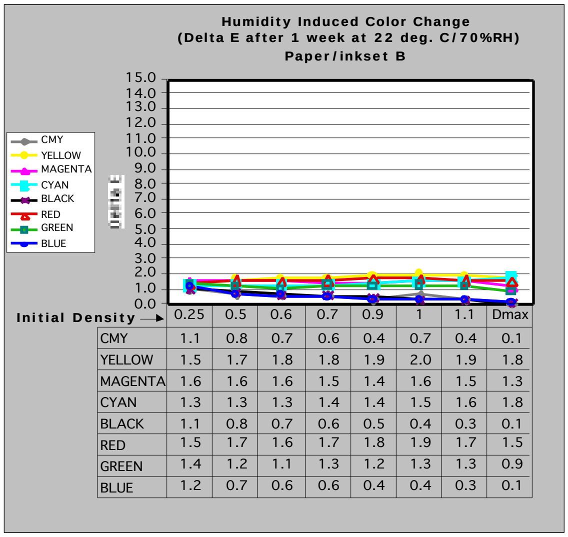
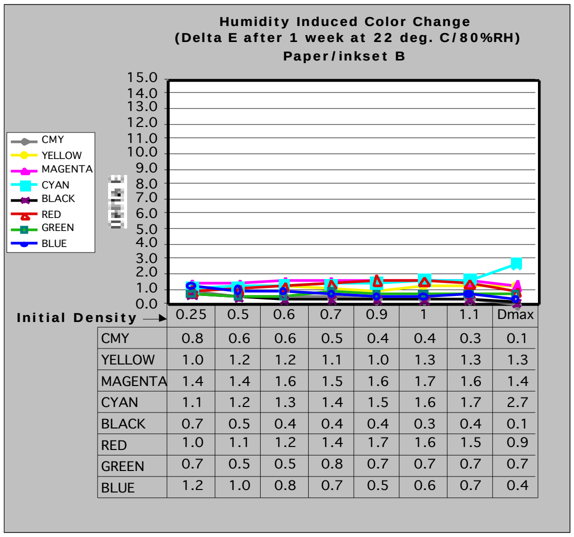


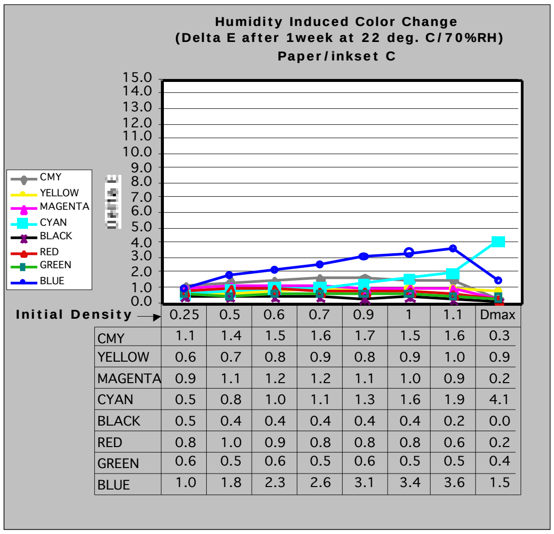
Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	1.1	0.8	0.7	0.6	0.4	0.7	0.4	0.1
YELLOW	1.5	1.7	1.8	1.8	1.9	2.0	1.9	1.8
MAGENTA	1.6	1.6	1.6	1.5	1.4	1.6	1.5	1.3
CYAN	1.3	1.3	1.3	1.4	1.4	1.5	1.6	1.8
BLACK	1.1	0.8	0.7	0.6	0.5	0.4	0.3	0.1
RED	1.5	1.7	1.6	1.7	1.8	1.9	1.7	1.5
GREEN	1.4	1.2	1.1	1.3	1.2	1.3	1.3	0.9
BLUE	1.2	0.7	0.6	0.6	0.4	0.4	0.3	0.1

Figure 3. Paper/inkset B exposed to 22°C and 70% RH for one week.



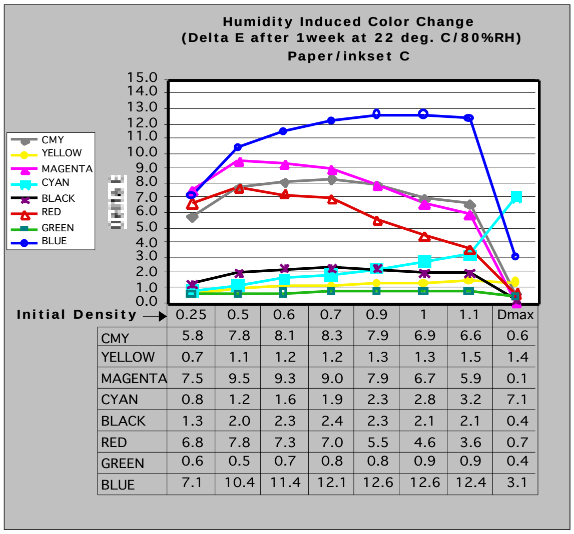
Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	0.8	0.6	0.6	0.5	0.4	0.4	0.3	0.1
YELLOW	1.0	1.2	1.2	1.1	1.0	1.3	1.3	1.3
MAGENTA	1.4	1.4	1.6	1.5	1.6	1.7	1.6	1.4
CYAN	1.1	1.2	1.3	1.4	1.5	1.6	1.7	2.7
BLACK	0.7	0.5	0.4	0.4	0.4	0.3	0.4	0.1
RED	1.0	1.1	1.2	1.4	1.7	1.6	1.5	0.9
GREEN	0.7	0.5	0.5	0.8	0.7	0.7	0.7	0.7
BLUE	1.2	1.0	0.8	0.7	0.5	0.6	0.7	0.4

Figure 4. Paper/inkset B exposed to 22°C and 80% RH for one week.



Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	1.1	1.4	1.5	1.6	1.7	1.5	1.6	0.3
YELLOW	0.6	0.7	0.8	0.9	0.8	0.9	1.0	0.9
MAGENTA	0.9	1.1	1.2	1.2	1.1	1.0	0.9	0.2
CYAN	0.5	0.8	1.0	1.1	1.3	1.6	1.9	4.1
BLACK	0.5	0.4	0.4	0.4	0.4	0.4	0.2	0.0
RED	0.8	1.0	0.9	0.8	0.8	0.8	0.6	0.2
GREEN	0.6	0.5	0.6	0.5	0.6	0.5	0.5	0.4
BLUE	1.0	1.8	2.3	2.6	3.1	3.4	3.6	1.5

Figure 5. Paper/Inkset C exposed to 22°C and 70% RH for one week.



Initial Density	0.25	0.5	0.6	0.7	0.9	1	1.1	Dmax
CMY	5.8	7.8	8.1	8.3	7.9	6.9	6.6	0.6
YELLOW	0.7	1.1	1.2	1.2	1.3	1.3	1.5	1.4
MAGENTA	7.5	9.5	9.3	9.0	7.9	6.7	5.9	0.1
CYAN	0.8	1.2	1.6	1.9	2.3	2.8	3.2	7.1
BLACK	1.3	2.0	2.3	2.4	2.3	2.1	2.1	0.4
RED	6.8	7.8	7.3	7.0	5.5	4.6	3.6	0.7
GREEN	0.6	0.5	0.7	0.8	0.8	0.9	0.9	0.4
BLUE	7.1	10.4	11.4	12.1	12.6	12.6	12.4	3.1

Figure 6. Paper/inkset C exposed to 22°C and 80% RH for one week.

Article by Henry Wilhelm and Mark McCormick-Goodhart (Wilhelm Imaging Research, Inc.) entitled: “On Overview of the Permanence of Inkjet Prints Compared with Traditional Color Prints” appeared on pages 34–39 in:

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