Technical white paper

Archival printing with HP inkjet printers

Producing prints that meet archival requirements

Using HP Pigment Inks, HP inkjet printers produce durable prints that are suitable for applications requiring archival properties. Print durability is a key element in HP's ink and printer development programs, and the archival performance of prints made by HP inkjet printers has been certified by independent testing agencies.

Introduction

Inkjet printing has a large and growing share of world-wide printing markets because it offers speed, quality, versatility, and the ability to print in both black and full-color on a wide range of papers and other materials. These features have allowed inkjet to displace toner-based technologies—dry electrophotography or "DEP"[1]—in many applications, especially those where color and wide print formats are essential requirements. HP inkjets can print postage stamps on paper and vehicle and building wraps on self-adhesive vinyl and HDPE ...and almost everything in between.

For three decades, HP inkjet technology has set standards for printing in the office, in technical and display graphics, and in commercial high-speed print production by delivering cost-effective, reliable, and high-quality solutions.

Printing with water-based HP Pigment Inks offers many advantages to the print service provider and final print customer. These include not only high image quality with dark blacks and vibrant colors on the printing materials—plain and special papers, films, banners, and textiles—but also environmental benefits where prints are produced and where they are used. Making a water-resistant print with water-based inks is part of the challenge met by each new generation of HP Pigment Inks.

In many markets, inkjet competes with DEP. DEP has a well-earned reputation for high levels of quality, productivity, and durability. And, HP is a major world-wide supplier of both inkjet and DEP printing solutions. Since HP introduced both its first desktop inkjet ("ThinkJet") and DEP ("LaserJet") printers in 1984, DEP has set high performance and durability standards that HP inkjets were able to match after the introduction of water-based pigment inks.

Durability is typically measured by a combination of a print's resistance to fade, water, abrasion, wiping and smear, chemicals, heat, and the ability to fold printed output without cracking or damage to the image.[2] Durability has been a key attribute of HP inkjet printing solutions and part of the value HP's customers expect.

Since 1994, HP Designjet printers with HP black pigment inks have produced durable prints in design and technical graphics applications. Recently, HP Officejet printers using HP Pigment Inks have tested and certified for print durability by multiple agencies.[3] In 2014, the durability of digital blueprints made with an HP Designjet Z5400 Printer with HP Pigment Inks was tested and certified by State Archives Administration of the People's Republic of China.[4]

This white paper will discuss elements of print durability aimed at achieving archival permanence. While focusing on the performance of HP inkjet printing solutions, some mention will be made of dry electrophotographic printing.

[1] Another type of electrophotography, called liquid electrophotography—or LEP—is used in HP Indigo Presses.

[2] These are general considerations for print durability. Additional requirements may be introduced depending on the application,

[3] See the *Certifications* section for details.

[4] State Archives Administration of the People's Republic of China (http://www.saac.gov.cn/), Case Number - No. DA(2014)0501, tested according to DA/T16-1995.

Inkjet printing

At the basic level, inkjet printers place drops of ink at precise locations on paper (or other materials).[5] The dots made by ink drops form a black or color image. Each drop must be ejected from the printhead when required, and it must meet narrow specifications on speed, trajectory, and weight. HP inkjet printers have thousands and even millions of drop generators—often simply called "nozzles"—and each nozzle can print tens of thousands of drops each second.

HP inkjet printers use either scanning or pagewide printheads. In a scanning system, a carriage with the printheads prints a swath while scanning across the paper, and then paper is intermittently advanced a fraction of the swath height between scans. The printheads can pass over the same area of the print multiple times to hide nozzle errors by substituting good nozzles for those that fail to produce drops within specifications. Higher quality print modes use more passes of the printheads, and so they are slower than lower-quality "draft" modes.

In 2013, HP introduced the HP Officejet Pro X-series printers that move the paper at constant speed under a pagewide, fixed inkjet printhead. This configuration is similar to a DEP printer, where the printhead is stationary, as wide as the paper, and the paper moves at constant speed below it. With HP PageWide Technology, HP workgroup and large format printers can print faster than scanning printhead systems and still offer high-quality output that meets the needs of professional users.

Although there are many parts of an inkjet printer that are necessary to produce high-quality print quickly and reliably, the printing materials in combination with the ink have the dominant effect on print durability. So, these aspects will be the focus of this white paper.

Inkjet inks

Not all inks and inkjet technologies are the same, and it is important to understand what is behind HP's ability to produce and demonstrate durable, archival inkjet printing solutions.

The key technologies of inkjet print durability involve a chemical- and fade-resistant colorant and an ink formulation that protects the colorant and keeps it in place on the surface of the paper.

For more than 20 years, HP Pigment Inks have delivered archival printing solutions across a wide range of markets and applications, and their performance has been certified both by independent testing laboratories and government agencies.

Ink components

Inkjet inks consist of a colorless liquid—the *ink vehicle*—that carries a *colorant* to the surface of the paper. The ink vehicle is important to the stability of the ink, the drop ejection process, reliable printhead operation, and controlling the behavior of ink on the paper's surface. Volatile components of the ink vehicle are absorbed and evaporated leaving behind a layer of colorant and solids—including binders and resins— that produce the printed image and provide durability.

Ink vehicle

In water-based inkjet inks, the ink vehicle consists of water along with liquid and solid ingredients. Water can account for more than 60% (by weight) of some ink formulations. Liquid ingredients—humectants and surfactants—help keep the ink from drying out in the nozzles and allow the ink to wet the inside of the drop generator and surface of the paper. This promotes reliable drop generator operation. On the paper, these ingredients regulate the spread and penetration of ink to produce dots of uniform size and reduce feathering[6] and color-to-color bleed.

For printers using pigment inks, solid ingredients in the ink vehicle—polymers and resins—keep particles from aggregating in the ink delivery system and printhead for reliable operation. And on the paper, these solids form a durable film that binds pigments to the paper's surface and improve durability.

Colorants

Inkjet ink colorants are made of dyes, pigments, and sometimes a mixture of both. Colorants work by absorbing specific wavelengths of light and reflecting others. The choice of colorant has a significant effect on fade resistance, color quality, drop ejection reliability, ink cost, and environmental considerations.[7]

[5] In this document, "paper" will be used to describe printing materials in general, which include cellulose-based papers, plastics, and textiles.
[6] Feathering is the spread of ink by capillary action along fibers on the surface of the paper. Feathering reduces the sharpness of lines and characters.
[7] In particular, colorants that have toxicity issues and contain heavy metals, such as nickel, are undesirable.

- **Dyes** are chemical molecules that dissolve in the ink vehicle. Dyes can have high color strength, and if they remain at or near the paper's surface, dyes can be more colorful than pigments. However, on absorbent papers, dye molecules can be carried by the ink vehicle deep into the paper's structure. When this occurs, there may not be enough dye near the surface to produce dense blacks and saturated colors. High dye concentrations can counteract this effect, but can lead to unreliable drop ejection—especially during extended decap time[8]—requiring frequent service cycles to keep the printhead ejecting drops reliably. A service cycle increases ink consumption, and productivity will be reduced when it interrupts printing.

  While dyes usually lack the durability of pigments on plain papers, dye-based inks can offer excellent color performance and improved durability on more expensive inkjet coated papers. These coatings are designed to hold the dyes near the surface and protect them from water, highlighters, ozone, and UV light. For example, HP dye-based inks used in the HP Photosmart 8750 photo printer achieved 120 years of fade resistance on HP Premium Plus Photo paper according to 3rd party testing by Wilhelm Imaging Research, Inc.[9] This long fade resistance is accomplished using a protective coating on the photo paper that absorbs and encapsulates the dyes to protect them from UV light and ozone. However, water can easily penetrate into this coating and cause the dyes to bleed. And, protective coatings are not present in plain papers or vellum used in engineering and architectural applications.

- **Pigments** are particles that are on the order of 100 nanometers in diameter. Unlike dyes, pigments do not dissolve in the ink. Pigments are kept in a stable dispersion in the ink vehicle by surface charges that produce repulsive forces between particles. Once on the paper, the chemistry of HP Pigment Inks quickly immobilizes the pigments on or near the paper surface as the ink vehicle is absorbed and evaporates. This allows HP Pigment Inks to produce high color saturation and high black optical density as well as control color bleed, feathering, water-resistance, rub-resistance, and show-through.[10]

  Compared to dye-based inks, pigment inks generally offer better resistance to water, highlighters, and fade. Pigments are the colorant of choice for applications requiring the highest levels of durability and black print density—especially on plain papers.

  HP Pigment Inks typically contain 3% -10% pigment (by weight).

Dry Electrophotography

The dry electrophotographic printing process forms an image using a dry powder, called *toner*. Toner contains a thermoplastic such as styrene, pigment(s) to produce the image, and other materials such as flow agents. DEP printers and their toners are not all the same: durability, image quality, and cost are common trade-offs in toner and DEP writing system design, and results may be highly-variable depending on the productivity objectives, fusing technology, and the economics of the market segment a specific DEP printer addresses.

To form an image, a linear, pagewide array of light-emitting diodes (LEDs) or a scanning laser beam exposes one or more rows of pixels across the width of a rotating photoconductor drum. This produces charged areas on the drum that attract toner particles from a powder supply. The particles are then transferred to the paper under pressure and fused with conductive or radiant heat.

The process of cleaning the photoconductor drum can produce ozone, and the hot fusing process can produce VOCs—volatile organic compounds— from the thermoplastic. Also, toner particles may become airborne and pose a health hazard. Filters and ventilation (in some cases) are required to prevent the release of ozone, VOCs, and toner particles into the workplace.

Melting the toner forms a durable image layer that encapsulates the pigments. Durability comes from a mechanical bond formed when toner melts and solidifies within microscopic pores on the paper's surface. This is called *keying* into the surface. The typical image layer in a monochrome DEP print is about one micron thick. This can contribute to cracking and flaking of the image layer when the print is folded.

In general, the need for a fuser that may remain powered or in standby mode during printing significantly increases energy consumption for DEP printers compared to HP aqueous inkjets.[11] Also, fuser warm-up times—10-15 minutes—may be required by some units before they can print.

[8] Decap time is the time a printhead is exposed to air between service cycles, which refresh the ink in each nozzle.

[9] For more information about fade-resistance testing, visit www.wilhelm-research.com

[10] *Show-through* occurs when the colorant migrates through the paper making the image printed on the front of a sheet visible on the back side. Show-through is generally more of an issue with dye-based inks than with pigment inks because dye molecules can be carried deep into a plain paper with the ink vehicle while pigment particles can be immobilized at or near a plain paper's surface.

[11] HP internal tests measured the power consumption of comparable low-volume inkjet and DEP printers: the HP Designjet T3500 and Océ Plotwave 360. According to tests under US EPA TEC specifications, the Océ Plotwave 360 consumed 14.21 KWh/week vs. 2.98 KWh/week for the HP Designjet T3500.

While dry toner colorants are typically chemical- and water-resistant, the mechanical durability of a dry toner image is *completely dependent on the effectiveness of fusing* and the mechanical bond fusing creates between toner particles and the paper. That means that dry and wet smear, highlighter smear, folding and cracking, and resistance to damage by abrasion is dependent on the fusing technology, the performance of the fuser, the structural integrity of the image layer, and, to some extent, the toner formulation. So, it is important to understand that the durability results from DEP printers can and do vary significantly with the toner and fusing technologies.

As for inkjet prints, the light and dark fade resistance of DEP prints depends on the pigments. Because carbon black is commonly used for both black pigment inkjet inks and black DEP toner, both technologies can deliver excellent fade resistance.

Archival considerations for papers[12]

The permanence of the paper used by inkjet and DEP printing processes is a key factor in the longevity of the print. The paper industry considers paper permanence to be the result of optimizing multiple paper properties, two of which are *acidity* and *lignin* content. Therefore, specific information about acidity and lignin content is almost always part of discussions and standards for paper permanence.

- **Acid**, as it applies to papermaking, is a water-soluble compound that can be present in paper as a result of the papermaking process. In the presence of moisture, acid may cause paper to degrade.
  - **pH** is the numerical measure of the acidity or alkalinity of a substance. A neutral solution has a pH value of 7. The pH value drops toward 0 as the acidity increases, and rises toward 14 as the alkalinity increases.
- **Lignin** is a brown, organic substance that binds to cellulose fibers and hardens and strengthens the cell walls of plants. Lignin is the primary non-carbohydrate constituent of wood and is also a major contributor to the chemical degradation of paper. As it deteriorates, lignin produces acids that cause paper to become brittle and to discolor on exposure to heat and light.

In the paper industry, *acid-free paper* is often associated with longevity. For example, according to International Paper's ***Pocket Pal***, creating an acid-free paper is defined as a "process that gives paper over four times the life (200 years) of acid-sized paper (40-50 years)."[13]

The following organizations have established these paper specifications, standards, and test methods:

- National Information Standards Organization (NISO)—(ISO 9706 and ISO 11108)
- American National Standards Industry (ANSI)—(ANSI Z39.48 – revised 1997)
- International Organization of Standardization (ISO)—(ANSI Z39.48 – revised 1997)
- Technical Association of the Pulp and Paper Industry
- US Library of Congress (Preservation Directorate: Progress on Monitoring Pub. L)

Based on the ANZI Z39.48 standards, for example, the paper industry defines paper permanence for uncoated or coated writing or printing papers based on a pH value between 7 and 10 (from a cold-water extract) and a lignin content of no more than 1%.

Durability and archival prints

Durability commonly considers the resistance of a print to damage from exposure to light, water, and other environmental factors encountered during use and storage. For example, if a print is folded sharply, then the resistance of the image to cracking and flaking off the paper must be considered. If a highlighter is used on the print, then the smear resistance to highlighters is important.

An essential factor in archivability is the choice of paper and its long-term integrity. Papers with high acidity and/or lignin content may discolor and even decompose with extended storage—especially under hot and wet conditions.

The following are some general comments about print durability and how HP Pigment Inks produce archival prints.

[12] Source: Internal HP White Paper "Archival Papers: a report on acid-free and lignin-free paper" (2003)
[13] *Pocket Pal*, International Paper, 2000.

Fade resistance

Pigment particles are composed of tens of thousands of color-absorbing molecules. Dyes are generally composed of individual molecules. If molecules on the surface of a pigment particle are damaged by UV light, ozone, or chemical exposure, then the remaining colorant molecules preserve the image. This is why pigments generally outperform dyes in applications requiring archival durability.

HP uses industry-standard test procedures to evaluate fade-resistance. See *Test methodology* below.

Water and rub resistance

Pigment inks can provide durable prints without requiring special inkjet papers. While the pigments must be suspended in the inks for reliable operation of the printer and printhead, they can deliver high water- and rub-resistance after the ink dries. This is because resins and binders in the ink vehicle do not evaporate with the water: they remain on the paper to form a tough film that protects the pigments and binds them to the paper.

All pigment inks are not the same: without binders and resins, pigments alone can't deliver water-fastness and rub resistance. HP has developed proprietary polymers to work with the pigments in HP Pigment Inks to give high durability.

DEP toners can provide excellent water and rub resistance if they are properly fused into the paper's surface.

Flexibility/crease resistance

Thermoplastic DEP toners produce a solid layer of colorant on the surface of the print. This layer can be brittle and thick enough to crack and flake off the print when it is folded sharply. Inkjets produce a layer of colorant many times thinner than toners, and this layer remains highly-flexible: it resists cracking when the print is folded.

Figure 1 shows close-up views of printed output that has been manually folded sharply and unfolded and three (3) times to simulate storage and use. The corner where two folds cross is shown in the center of each image. The left and middle images are from LED DEP printers: the Ricoh Aficion W3601 and the Océ TDS750. The image on the right is from an HP Designjet Z5400ps Printer with HP Pigment Inks. All images are presented at the same level of magnification. Below each image, the image of the crease region is shown inverted (white becomes black) to emphasize details of the damage.

The DEP images are visibly cracked, and toner has flaked off each print affecting readability and, potentially, losing information in fine lines and text in the region of flaked toner. The image from the HP Designjet Z5400ps Printer remains completely intact across the fold region.

Figure 1 – Close-up view comparing folding and creasing damage to DEP and HP inkjet prints after folding and unfolding three times

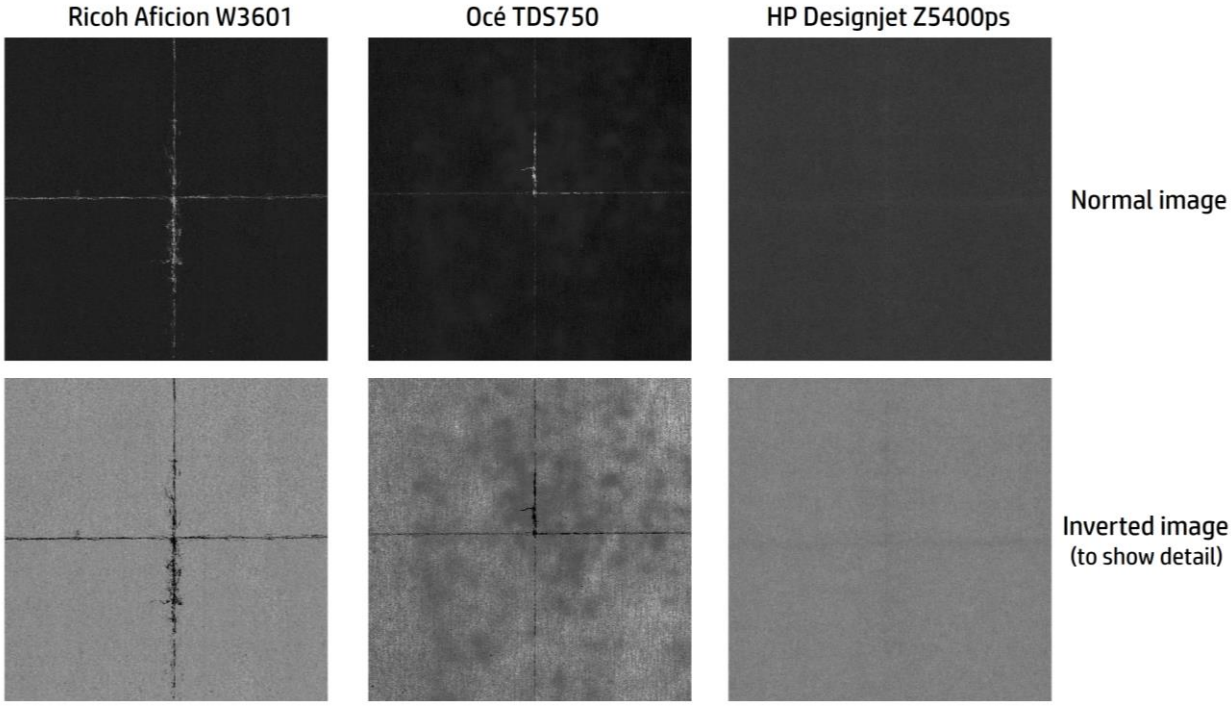

Image source: HP R&D (February 2015).

Test methodology

HP conducts internal testing—and contracts independent testing agencies—to ensure reliable claims related to print permanence and durability. And, HP inks and papers must meet rigorous tests developed by HP, international standards organizations, and independent test laboratories. In the following paragraphs, underlined text links to web pages for more information.

For documents: HP adheres to ISO 11798 Permanence and Durability Methods and to accepted acceleration methods intended to represent real-world experiences. To predict archival properties on plain paper, HP conducts accelerated dark storage tests to determine if an archived document will retain its black text and color quality for decades.

For photos: HP uses established, independent test labs—such as Wilhelm Imaging Research, inc.—to test ink and photo paper products. HP directly participates with industry standardization bodies, such as the International Organization for Standardization (ISO), that develop procedures used to test and compare products. When third-party testing is not possible, or the technology is so advanced that there isn't an industry standard, HP develops its own set of tests based on extensive experience in photo printing technology and knowledge of how HP customers use photo prints. See the Fade Resistance report for more information on photo permanence testing.

Test results – fade resistance

General comments

ISO test methods for office documents describe various procedures to evaluate durability, but they do not generally describe how to use the data to predict lifetimes. This is because the only true method to get lifetime data is to store materials under real conditions for years (part of the ISO standard introduction). Generally, it is the responsibility of the end user to specify what ISO test was done, review the results, and then determine if that performance meets their needs.

In internal HP accelerated testing under controlled office lighting and environmental conditions (23°C/ 50% RH), representative HP Pigment Inks on ColorLok papers showed no degradation in black optical density over a 40 years in accelerated time, and showed some loss of color at greater than 60 years in accelerated time. The endpoint in this test was for *just noticeable degradation from the original, not in loss of information content*. These studies were intended to determine fade resistance lifetimes.

Based on the display lifetime and on anecdotal data of pigment-based prints stored under typical office conditions—in folders, no light, 30-50% RH—it is reasonable to expect documents to have information content preserved for a long time. If the documents are printed on archival media, as specified by ISO 9706-1994 and ISO 11108-1996 standards and stored using best practices—ambient temperature, 30-50% RH, no light, pollutant-free atmosphere—then a storage lifetime of a 100 years would be expected for black text, although color pigments may have shorter lifetimes.

HP Permanence testing

HP's image permanence testing equipment covers a wide range of acceleration factors, and is temperature- and humidity-controlled in order to replicate and predict image permanence under conditions that are representative of how customers actually store and display prints. For fluorescent light fade, the permanence predictions in HP's laboratories correlate very well to permanence test results published by Wilhelm Imaging Research, Inc. ("WIR"), a leading image permanence test lab.

HP's image permanence testing equipment is highly specialized and cannot be readily duplicated without substantial investment in capital and trained operators. For example,

- Typical light fade tests are performed at 23°C and 50% relative humidity even in the presence of extremely bright illumination (up to 350 times brighter than typical room): these conditions are challenging to achieve and maintain.
- Trained personnel are needed to generate samples, take periodic measurements, and check and calibrate the equipment operating conditions.
- Acceleration factors between 2.5X to 350X normal daily light levels are used to span the range between "real world but very slow" and "highly accelerated" test conditions. Depending on the test model, both fluorescent and xenon arc light sources are used to simulate residential indoor and commercial application daylight window fade conditions.

Although there is no official industry standard for light fade testing, HP follows the general testing method developed and used by Wilhelm Imaging Research, Inc. The WIR method has also been used by many other inkjet printer manufacturers including Epson, Canon, Lexmark, and Fuji.

As a best practice, HP regularly submits its photo papers, inks and printers to WIR for light fade and dark storage stability testing. When available, HP uses WIR results as its primary substantiation for fade resistance claims on prints produced with HP photo systems. Table 1 compares HP's fade resistance testing methods with those developed and used by WIR.

Table 1 – Comparison of Wilhelm Imaging Research, Inc. and HP test methods for fade resistance[14]

Specification	Wilhelm Imaging Research, Inc.	HP
Environment: Refers to temperature and relative (RH) humidity in the test chamber.	24° C, 60% RH	23° C, 45-50% RH (depending on chamber)
Indoor display light level: This is the exposure used to predict display life. It is based on research of the amount of light that a typical photo receives per day. Actual photo samples are tested at Lux levels 35X to 200X greater to accelerate test results. Otherwise, results would take decades to obtain.	450 lux per 12 hr day	Same as WIR
Sample cover: This refers to whether test photos are covered with glass in the test chamber. Covered photos can resist noticeable light fade considerably longer and simulate the manner in which many photos are displayed.	Uncovered, glass-covered, and UV-filter covered samples	Uncovered and glass-covered samples
Initial density: This refers to color density of the test sample colors after printing and before fading has begun. For black, cyan, magenta and yellow, color squares with these three densities are identified. Generally, higher densities contain more ink and less white space. A density of 1.0 would appear as dark yellow, dark blue, black etc., 0.6 would be lighter blue, light yellow, light gray etc. Testing only 1.0 densities would not be simulating the reality of most photos as photos contain many subtle shades and are not printed with purely dark colors.	0.6 and 1.0	Same as WIR
Dry down time: Photos are allowed to dry before testing begins. A long dry down time (in dark) is important to stabilize the colors and completely eliminate any effects the residual ink solvent may have on the test. This is to model more accurately true photo display behavior. A typical print has a long time to dry before light exposure is significant.	2 weeks 24° C, 60% RH	2 weeks 23° C, 50% RH

In 2009, HP conducted a study to test the archival properties of HP 940 Officejet pigment inks in combination with leading plain papers. Print samples were kept in a controlled environment at a high temperature, following ISO 18924, which is designed to accelerate color fading. Optical density of black, cyan, magenta and yellow color targets, as well as the rate of paper discoloration—or yellowing—were measured and tracked over multiple points in time. The results were then extrapolated to reflect the typical document storage temperature of 23°C.

Estimates for document failure points, when an image is considered to *first show signs of noticeable fade*, were made using the Wilhelm Imaging Research, Inc., endpoint criteria "WIR Visually-Weighted Endpoint Criteria Set v3.0."[15]

In Table 2, the fade resistance of leading plain paper products for the office were tested with HP 940 Pigment Inks. The results are believed to be a fair representation of standard quality plain papers available in the market.

Table 2 – Typical fade resistance ratings with HP 940 Pigment Inks on a representative group of plain papers[16,17]

Paper	Typical document storage archive rating
Domtar® Multi-system Ultra 20 lb	> 31 years
Boise® X-9™ 20 lb	> 46 years
Georgia-Pacific Premium Multi-Purpose Paper 20 lb	> 36 years
Steinbeis Vision Classic White 80 gsm	> 41 years
Asia Pulp & Paper Paperline Gold 80 gsm	> 42 years
JK Copier 75 gsm	> 48 years
HP Multipurpose Paper 20 lb with ColorLok	> 34 years
Rey Office Document 80 gsm with ColorLok	> 36 years
Mondi IQ with ColorLok	> 29 years

[14] Source: HP document "Light fade testing methods: HP Image Permanence Labs & Wilhelm Imaging Research" August 2004.
[15] For details, visit www.wilhelm-research.com.
[16] Source: HP Document "Archiving business documents" (2009)
[17] These results remain valid for both HP 950/951 and HP 932/933 Pigment Inks used in HP Officejet Pro printers.

Certifications

Tables 3 and 4 present recent certifications of HP Pigment Inks used in HP Officejet printers and an HP Designjet Z5400 large-format printer. According to a statement in the SP certificates (ISO 11798) for HP Officejet printers, "This certificate relates to documents produced on archival and permanent paper."

Key to understanding these certifications is that they affirm that **prints made by HP inkjet printers with HP Pigment inks are suitable for applications requiring archival properties**.

- **ISO 11798:** This certification provides independent validation of print archivability administered by SP Labs in Sweden. It is a certification used by Nordic Governments and is referenced throughout Europe as a standard of print archivability.
- **DOTot/PTS certification:** This provides an independent validation of print durability. It is an anti-forgery certification used by German Notaries and is referenced throughout Europe as a standard of print durability.
- **Cheque and Credit Clearing Company**: C&CCC is a document anti-forgery certification administered by PIRA Labs in the UK. It is used in the UK by financial institutions for assuring the validity of negotiable documents.
- **State Archives Administration of the People's Republic of China (SAA-PRC):** a durability standard from the Archive Science and Technology Research Institute.

The attributes relating to durability and anti-forgery properties evaluated by each of the above certifications are listed in Table 3. Details of tests and their results are included with each certificate.

Table 3 –Tests directly relating to print durability in ISO 11798, DOTot, C&CCC, and SAA-PRC certifications

Test	ISO 11798	DOTot	C&CCC	SAA-PRC
Light fastness	✓	✓	✓	✓
Erasability		✓[18]	✓	
Water resistance	✓	✓		✓
Highlighter smear		✓		
Wet and dry wipe resistance		✓		
Ink adhesion: crease resistance (folding)	✓	✓		
Abrasion resistance (wear)	✓	✓	✓	
Image stability during accelerated aging		✓		
Resistance to chemical removal of image			✓[19]	✓[20]
Transfer of recorded image	✓			
Resistance to heat	✓[21]			✓

See footnote 15 for the chemical removal test under the C&CCC certification test. HP 970 Black Pigment inks achieved the *highest-possible rating* for all chemical exposures (i.e., Grade1 out of 4). Quoting the Smithers/PIRA report "only 'Grade 1' printers can produce cheques which are comparable with impact or laser printed cheques in their resistance to fraudulent attack." This test directly relates to print durability under exposure to acidic and alkaline liquids.

The certification from the State Archives Administration of the People's Republic of China according to DA/T16-1995 defines four results: "Durable", "Quite Durable", "Not Durable", and "No Certifications". The HP Designjet Z5400 achieved the following result for Case No. DA(2014)0501 when printing digital blueprints:[22]

> HP Designjet Z5400 Digital Blue Print Sample "Color Variance (delta E)" is within the defined range of DA/T16-1995. No obvious spread observed during testing. According to DA/T16-1995, the HP Designjet Z5400 Digital Blue Print Sample (Blue) is hereby certified as "**Quite Durable.**"

[18] Includes mechanical means, solvents, and aggressive chemicals.

[19] Chemicals tested include industrial methylated spirits (IMS), acetone, toluene, **acid** (1 molar hydrochloric acid), **alkali** (1molar sodium hydroxide), brake fluid, antifreeze, corrector bille, and bleach.

[20] Specifically, tests include expose to acid and alkali.

[21] Test conditions are (90 ±1)°C and (50 ±2)% RH for 12 days after which optical density (black and color) are evaluated according to Section 4.1 of the standard.

[22] A digital blueprint emulates a diazo print, also known as the "blue-line process." The image is formed using cyan and magenta inks (printing blue) on a plain paper with a blue background.

Table 4 lists details of the certifications for HP Pigment Inks in HP Officejet printers and an HP Z5400 Designjet printer.

Table 4 – Certifications of HP Officejet inkjet printers with HP Pigment Inks[23, 24]

Certification	Agency and number	HP Inks	Date
ISO 11798:2000	SP Technical Research Institute of Sweden, Certificate No. 45 04 10	HP Pigment Inks: HP 970/970XL Black, HP 971/971XL Cyan, HP 971/971XL Magenta, HP 971/971XL Yellow HP 980 CMYK	June 2014
DA/T16-1995 HP Designjet Z5400	State Archives Administration of the People's Republic of China, Case No. DA(2014)0501	HP Pigment Inks: HP 772 Cyan HP 772 Magenta used in digital blueprints.	May 2014
ISO 11798:2000	SP Technical Research Institute of Sweden, Certificate No. 45 04 05	HP Pigment Black Inks: 950/950XL, 930/932XL, 960/960XL	February 2014
For an inkjet printing device to determine its suitability for producing Originals, Official Copies, and Certified Copies of Notarial Deeds pursuant to Section 29 of the German Service Regulations for Notaries (DOTot)	Papiertechnische Stiftung (PTS) Test Certificate No. 3774-2012-31.025E	HP 970 Black Pigment Ink	November 2012
C&CCC Certification	Cheque and Credit Clearing Company (C&CCC, formerly APACS). Smithers Pira reference: 12-114421	HP 970 Black Pigment Ink	September 2012

[23] Note: HP ink designation refers to cartridge selectivity number. "XL" is a larger capacity cartridge.
[24] Copies of these certifications are available from HP.

Summary

Print durability is an important element of the way HP communicates the performance of its printing products to customers. Print durability is a key value customers expect from HP inkjet printing solutions across all of the markets HP serves. Achieving outstanding print durability with HP aqueous inks is a primary focus of HP's ink research and development investments.

Compared to dye-based inks, pigment inks generally offer better resistance to water, highlighters, chemicals, and fade. Pigments are the colorant of choice for applications requiring the highest levels of archivability, durability, and print quality—especially on plain papers. HP Pigment Inks produce prints with high color saturation and high black optical density. Resins and binders in HP Pigment Inks form a film on the surface of the print that protects the pigments to deliver long-term durability. And, unlike prints made by some dry electrophotographic printers, the thin, flexible image layer produced by HP Pigment Inks allows prints to be folded multiple times without damage to the image.

Taking together all the test criteria required to earn four key certifications—ISO 11798, DOTot, C&CCC, and SAA-PRC—prints made with HP Pigment Inks have been certified to deliver a wide range of archival properties, and this makes these prints suitable for applications requiring high durability under use and long-term storage conditions.

For more than 30 years, HP inkjet printing technology has steadily evolved to higher levels of performance and customer value. Today, HP inkjets provide versatile printing solutions that offer customers economical hardware and consumables, high productivity, formats from the desktop to 3.2 m (126 in.) wide, energy efficiency, and the ability to print both black and color on a wide range of materials. And, with HP's continued investment in inkjet research, development, and product manufacturing, the evolution of inkjet printing technology will continue.

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