FotoConservacion2011 – Logroño, Spain – June 20-23, 2011

The Permanence and Care of Analog and Digital Color Photographs

Forty-Seven Years of Research and Publications: 1966 to 2013

The Wilhelm Analog and Digital Color Print Materials Reference Collection: 1971 to 2013

By Henry Wilhelm, Carol Brower Wilhelm, Kabenla Armah, and Barbara C. Stahl

Grinnell, Iowa U.S.A.

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Thirty Years of Photograph Conservation Science

programa
schedule

2011
foto
conservación

logroño, españa, junio, 2011
treinta años de ciencia en
la conservación fotográfica

logroño, spain, june, 2011
thrity years of photograph
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www.fotoconservacion2011.org

SEDE CONFERENCIA

ESCUELA SUPERIOR
DE DISEÑO DE LA RIOJA
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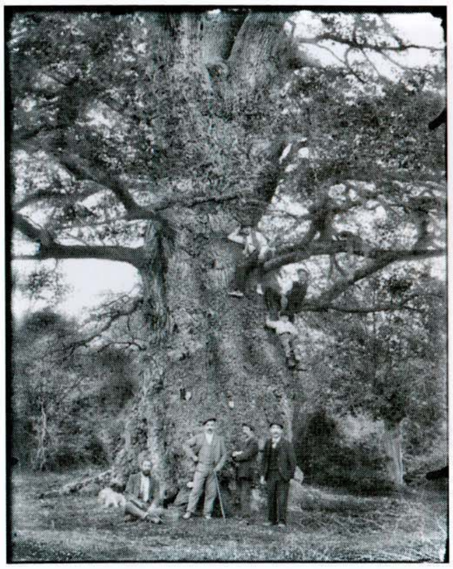
Fotografía y vino en el archivo
López de Heredia 1870-1920
Photography and wine in López de Heredia's archive

Casa de la Imagen
Logroño
Del 20 al 26 de junio

Bodegas R. López de Heredia
Haro
Del 27 de junio al 30 de septiembre



Un modelo de recuperación documental: programa 'La Rioja en la Memoria'.
A recovery documentary pattern 'La Rioja en la Memoria'.

Escuela Superior de Diseño de La Rioja
Logroño
Del 20 de junio al 10 de julio

LUNES 20 DE JUNIO

MAÑANA • MORNING

09:00 Inauguración de la Conferencia. Conference opening.

10:00 Pausa-café. Coffee break.

10:30 **JAMES REILLY**

Director del Image Permanence Institute, Rochester N.Y.

25 años de investigación en la permanencia de las imágenes. Balance de un cuarto de siglo de trabajo científico y nuevas metas. 25 years of research on image permanence. Assessment of a quarter century of scientific work. New goals.

12:00 **BERTRAND LAVEDRINE**

Director del CRCC, Centre de Recherche sur la Conservation des Collections.

La investigación científica como base de la preservación del patrimonio cultural. Scientific research as the foundation for the preservation of cultural heritage.

TARDE • AFTERNOON

16:00 **DEBRA HESS NORRIS**

Catedrática y Profesora de Conservacion de Fotografía. The Art Conservation Department en la Universidad de Delaware.

Las necesidades globales en la preservación de los materiales fotográficos. Global Needs in the Preservation of Photographic Materials.

17:30 Pausa-café. Coffee break.

18:00 **CLARA Mª. PRIETO**

Conservadora-restauradora de documento gráfico y fotográfico.

La red, ¿Mina de oro o campo de minas?. The Net, ¿A gold mine or a minefield?

MAÑANA • MORNING

10:00 **NORA KENNEDY**

Sherman Fairchild Conservadora de fotografía en The Metropolitan Museum of Art.

El papel de la conservación de fotografías en los museos. The role of photograph conservation in museums.

11:30 Pausa-café. Coffee break.

12:00 **PETER MUSTARDO**

Responsable de la sección de Preservacion en the New York City Municipal Archives desde 1985 hasta 1990, y de Regional Preservation Coordinator for the National Archives en Washington. Se estableció en práctica privada en la ciudad de New York en 1982 después de co-fundar The Better Image®.

Evolución en la metodología de la restauración en práctica privada. Evolution of restoration methodology in private practice.

TARDE • AFTERNOON

16:00 **ANNE CARTIER-BRESSON**

Directora del Atelier de Restauration et de Conservation des Photographies de la Ville de Paris.

El modelo del ARCP. La gestión integral de las colecciones fotográficas de la ciudad de París. The ARCP model. The comprehensive management of the photographic collections of the city of Paris.

17:30 Pausa-café. Coffee break.

18:00 **JOAN BOADAS I RASET**

Director del Centre de Recerca i Difusió de la Imatge (CRDI), Girona. Comisionado del Consejo Internacional de Archivos (ICA) para los Archivos Fotográficos y Audiovisuales.

La evolución de la archivística española en el tratamiento de fondos fotográficos: un camino hacia la especialización. The evolution of collection treatment in Spanish archives: a path to specialization.

MAÑANA • MORNING

10:00 **HENRY WILHELM**

Investigador y fundador de WIR Wilhelm Imaging Researc, empresa dedicada al estudio de la permanencia del color físico-químico y digital en la fotografía y cine.

Del color físico-químico al color digital, el problema de la permanencia. Estado de la cuestión. From tradicional to digital color, the problem of permanence. State of the question.

11:30 Pausa-café. Coffee break.

12:00 **PAUL MESSIER**

Paul Messier Llc. Conservation of Photographs and Works on Paper.

Los papeles fotográficos del siglo XX, Metodología para su autentificación, entendimiento y datación. 20th century photographic papers: methodology for their authentication, understanding and dating.

TARDE • AFTERNOON

16:00 **ÁNGEL Mª FUENTES**

Conservador-restaurador de patrimonio en práctica privada.

¿Fotografía o información fotográfica? El impacto de la exhibición en los originales fotográficos. Evolución en los criterios de exposición y en las técnicas alternativas de explotación cultural. Photography or photographic information? The impact of exhibition on photographic originals. The evolution of exhibition criteria and other cultural exploitation techniques.

17:30 Pausa-café. Coffee break.

18:00 **FERNANDO OSORIO**

Director de Conservación de las Colecciones de Fotografía de Fundación Televisa AC.

El papel de las instituciones privadas en las colecciones de fotografía. The role of private institutions in private collections.

MAÑANA • MORNING

10:00 **LUIS PAVÃO**

Director de Luis Pavão Limitada, Lisboa, empresa dedicada a la conservaciónrestauración de patrimonio fotográfico y a la formación de profesionales en el campo.

Evolución de los criterios de trabajo en el modelo de Portugal. Evolution of working criteria in the model of Portugal.

11:30 Pausa-café. Coffee break.

12:00 **JESÚS ROBLEDANO**

Profesor del área de biblioteconomía y documentación de la Universidad Carlos III.

25 años de conversión digital. Estado de la cuestión. 25 years of digital conversion. State of the question.

TARDE • AFTERNOON

16:00 **GRANT ROMER**

Conservador y director of Advanced Residency Program in Photograph Conservation, en el International Museum of Photogrpaphy and Film at the George Eastman House.

And now what? Pasado y futuro de los museos en la estrategia de la conservación. And now what? Past and future of museums in the strategy of conservation.

17:30 Pausa-café. Coffee break.

18:00 Cierre de la Conferencia. Closing of the conference.

2011
foto conservación

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The Permanence and Care of Analog and Digital Color Photographs

Forty-Seven Years of Research and Publications : 1966 to 2013

The Wilhelm Analog and Digital Color Print Materials Reference Collection: 1971 to 2013

Henry Wilhelm, Carol Brower Wilhelm, Kabenla Armah, and Barbara C. Stahl

Grinnell, Iowa U.S.A.

Introduction

Wilhelm Imaging Research, Inc., which is widely referred to as the world's leading independent permanence testing laboratory, was founded in 1995 by Henry Wilhelm and Carol Brower Wilhelm in Grinnell, Iowa.

The eight-factor color print permanence test methods developed by Henry and his colleagues over the past thirty-six years have become the de facto standard worldwide for evaluating the permanence of analog and digital photographs. WIR reports provide "apples-to-apples" permanence comparisons of branded products to assist photographers and consumers in making informed purchase decisions.

Despite many years of effort within ISO, there currently is no ISO predictive print permanence test method standard available that can be used to answer the question: "How long will a print last?" It appears unlikely that such an ISO standard will be available in the foreseeable future.

The test methods, light intensity and other environmental assumptions, and the set of visually-weighted endpoint criteria for fading and yellowish stain formation employed by Wilhelm Imaging Research have filled that void for more than 25 years.

WIR clients have included Hewlett-Packard, Canon, Epson, Kodak, HP Indigo, Xerox, Fuji, Lexmark, and Brother, as well as independent inkjet media suppliers in the United States and Europe.

The WIR website, www.wilhelm-research.com, is believed to be the most visited website in the world for individuals and institutions seeking information about print permanence and subzero freezer storage for preservation of photography and motion picture collections. The website consistently achieves the highest Google rankings for search queries related to print permanence, inkjet permanence, color print permanence, and subzero preservation.

Note [May 1, 2013]: This paper was presented by Henry Wilhelm on June 22, 2011 at the *FotoConservacion2011 Symposium "Thirty Years of Photograph Conservation Research"* organized by Angel Fuentes and colleagues, and was held in Logroño, Spain. <http://www.fotoconservacion2011.org/actas/?idc=36> Except for minor editing changes and updates for some data and associated dates, the document reproduced here was also submitted to the conference proceedings book using the page layout design and type fonts specified by the conference.

Beginning in 1994, all WIR publications have been produced electronically, and all are available worldwide on the WIR website at no cost. In 2003, Henry and Carol Wilhelm's 761-page book, "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures," was posted as a high-resolution PDF. To date, more than one half million copies of the book have been downloaded by individuals and institutions throughout the world. There is no advertising on the WIR website.

Henry has authored or co-authored more than twenty-five technical papers in the United States, Japan, and Europe on print permanence test methods and the long-term preservation of photographs.

Henry has been a consultant to a number of collecting institutions, including the Museum of Modern Art in New York, on various issues related to the display and preservation of both analog and digital photographic prints and films.

Since 1995, he has been an advisor to Corbis on the long-term preservation of the Corbis Bettmann photography collections in a high-security underground storage facility designed to be maintained at –20°C (–4°F) and 45% RH. With more than 20 million images, Corbis is one of the world's largest privately held photography collections.

More recently, Wilhelm served as a consultant to Corbis on the design and access workflow of a cold storage facility for the Corbis/Sygma collection in France. Located in Garnay, France, outside of Paris, the facility opened in May 2009. (As a result of legal disputes in France, Corbis/Sygma was disbanded in 2010; however, Corbis continues to operate the Garnay cold storage facility to preserve the huge remaining collection of prints, negatives, and transparencies.)

Corbis, headquartered in Seattle, Washington, is a private corporation owned by Bill Gates, the co-founder of Microsoft.

On January 1, 2010, Carol and Henry Wilhelm and their longtime associate, Harold Fuson, Jr. established The Center for the Image. This is a new non-profit organization that conducts research and develops web-based publications focused on the very-long-term preservation and access of traditional analog photographs and other historical materials. It is anticipated that WIR will be merged into The Center for the Image during 2013.

At the end of 2011, after more than ten years of research and software development, Henry Wilhelm and his colleagues completed development of the world's first practical multispectral camera based system for the full tonal scale, colorimetric evaluation of fading, staining, and deterioration of OBA's in color and black and white photographs. This was the largest – and most costly – development project ever undertaken by Wilhelm Imaging Research.

It is anticipated that The Center for the Image will begin to employ this advanced system beginning in 2013, and the new multispectral capture system will also be used to image the 800-patch Calibration Pages, Test Targets, and other materials in the Wilhelm Analog and Digital Color Materials Reference Collection.

Background: Henry Wilhelm

Henry has been involved with photography since childhood. He built his first darkroom in a closet in the family home at age twelve. In 1961-62, while attending Yorktown High School in Arlington, Virginia, he was a part-time photographer for the "Washington Daily News" and also had a summer job

Fig. 1

Wilhelm Imaging Research, Inc., widely referred to as the world's leading independent permanence testing laboratory, was founded in 1995 by Henry Wilhelm and Carol Brower Wilhelm in Grinnell, Iowa.

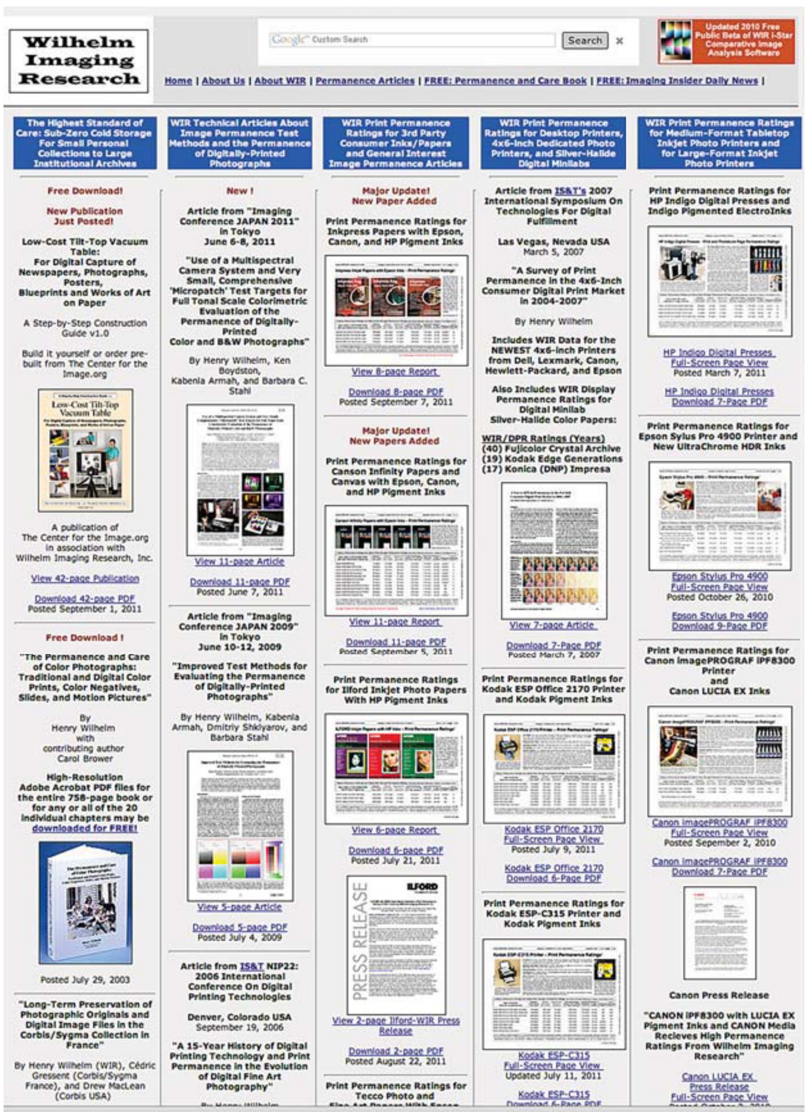


Fig. 2

The WIR website, www.wilhelm-research.com, is believed to be the most visited website in the world for individuals and institutions seeking information about print permanence and subzero freezer storage for preservation of photography and motion picture collections. The website consistently achieves the highest Google rankings for search queries related to print permanence, inkjet permanence, color print permanence, and subzero preservation.

assembling and calibrating colorimeters and other electronic instruments for measuring color and "whiteness" at Hunter Associates Laboratory, Inc.

Henry first became interested in the preservation of photographs in 1963 while working in the rain forests of Bolivia as a Peace Corps Volunteer. He was troubled by the rapid deterioration of photographs in the hot and humid tropical climate – he lived in a small, open-air thatched roof house with no windows, electricity or air-conditioning – and his alarm about the loss of family photographs and records of cultural history in such an environment would soon lead to his life's work.

In 1966, while a student at Grinnell College in Grinnell, Iowa, Henry worked as an assistant to Ansel Adams during one of Ansel's summer photography workshops in Yosemite National Park in California.

In 1969 Henry published a 26-page booklet entitled "Procedures for Processing and Storing Black and White Photographs for Maximum Possible Permanence." More than 40,000 copies of the publication were sold at 50¢ to $1 per copy.

In 1972 Henry received the first of two U.S. Patents for the design of archival washers for black and white fiber base prints; he produced the print washers in Grinnell for a number of years under the East Street Gallery name. In the early 1980s, Henry served as a volunteer technical advisor to film director Martin Scorsese in his successful efforts to persuade manufacturers of color motion picture film to improve the permanence of their products and to promote the use of humidity-controlled cold-storage for the long-term preservation of both color and black and white motion picture films.

In 1981 Henry was the recipient of a Guggenheim Fellowship for what evolved into a ten-year study of color print fading under low-level tungsten illumination that simulated museum display conditions.

With contributing author Carol Brower Wilhelm, Henry wrote "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures," published in 1993. The book was awarded a special commendation by the Society of American Archivists for ". . .writing of superior excellence and usefulness, which advances the theory and practice of preservation in archival institutions."

The complete 761-page book – the only book on this subject ever published – is available as a high-resolution 35 megabyte PDF/A at no cost from www.wilhelm-research.com.

Since the digital version of the book was posted on the WIR website in 2003, more than one-half million copies have been downloaded worldwide.

Henry Wilhelm was one of the founding members of American National Standards Institute (ANSI) Committee IT-3, which was established in 1978 and developed the ANSI IT9.9-1990 image stability test methods standard published in 1990 (revised in 1996). For the past 25 years he has served as Secretary of the group, now known as ISO Working Group 5/Task Group 3 (a part of ISO Technical Committee 42). Together with Yoshihiko Shibahara of Fuji Photo Film Ltd. in Japan, Wilhelm serves as Co-Project Leader of the forthcoming ISO WG-5/TG-3 Indoor Light Stability Test Methods Standard.

Wilhelm is the recipient of the Photoimaging Manufacturers and Distributors Association (PMDA) "2007 Lifetime Achievement Award" for his work on the evaluation of the permanence of traditional and digital color prints and for his advocacy of very low temperature cold storage (e.g., minus 20 degrees C [minus 4 degrees F] at 40% RH) for the permanent preservation of black and white and color prints, color negatives, transparencies, and motion picture films.

In 2011, Henry was awarded an Honorary Doctor of Science Degree by Grinnell College for his research and publications on the preservation of black and white and color photographs and motion pictures.

Background: Carol Brower Wilhelm

As a young child, Carol Brower demonstrated a passion for object preservation combined with a powerful drive to produce extensive "metadata" about the objects and related events, which she documented and recorded with every available device and media, including notebooks, letters, audiotapes, camcorders, PDAs, computers, digital recorders and most recently on iPhones, over a period spanning more than 50 years.

At age eleven, Carol saved allowance money to purchase resins and polishes from a local hardware store to mix and apply experimental coatings to flowers, autumn leaves, and bark in an effort to permanently protect their original colors, forms, micro-details, and essential beauty. She tried repeatedly to envelope leaves and objects in this "liquid glass," losing many specimens and paintbrushes along the way. Writing, drawing, and photographing became a more practical way to preserve life's moments (if not its objects) unfolding, maturing, and evolving as they were relentlessly vanishing.

It was in 1969, as a first year student in Pratt Institute's School of Art and Design (Brooklyn, New York), that Carol Brower first began to investigate the longevity of the photographic papers, drawing papers, pencils, inks, and paints used to create her own work.

During the summer of 1970, between freshman and sophomore years, Brower was an administrative assistant to the secretary of Dr. Nasser Sharify, Dean of the Pratt School of Library and Information Science. The following summer, upon being hired by the H. Shickman Gallery to mat and frame its comprehensive collection of James Ensor etchings, Brower was introduced to a small community of professional conservators. Shortly after, she became associated with the newly established LIGHT Gallery when cofounders Tennyson Schad and Harold Jones set out to display contemporary photographs as other fine art prints were traditionally presented – in museum mats and frames. LIGHT associate, Diana Edkins, looked for someone with experience handling fine art prints and Charles Moffett, the young European painting curator with whom Carol had worked while employed by Herman Shickman, recommended that Edkins contact Brower. (After LIGHT, Edkins went on to work with John Szarkowski at The Museum of Modern Art, Department of Photography.)

Carol prepared the museum-quality mats for LIGHT's November 4, 1971 opening and first exhibit of thirteen living photographers: Thomas Barrow, Michael Bishop, Wynn Bullock, Harry Callahan, Robert Fichter, Emmet Gowin, Roger Mertin, Bea Nettles, Doug Prince, Aaron Siskind, Keith Smith, Frederick Sommer, and Todd Walker – and thereafter nearly every print that LIGHT purchased, sold, and exhibited throughout the next ten years, including those by Alfred Stieglitz, Edward Steichen, Paul Strand, Ansel Adams, Andre Kertesz, Arnold Newman, Eikoh Hosoe, Duane Michaels, and many other legendary photographers.

Shickman and LIGHT set the stage for Carol's intimate engagement with artwork made by others, cultivating in her a profound respect for all fine prints, photographs, and drawings. Having seen progressive damage to the edges of a miniature Rembrandt etching that had survived more than 300 years in otherwise excellent condition, Carol was motivated to join an emerging crusade to preserve photographic materials and to uphold the conservators' Hippocratic Oath: "To prevent [deterioration] whenever one can, for prevention is preferable to cure." While still attending Pratt, Carol began drawing attention to the proper handling and conservation matting of photographs.

Following graduation from Pratt, Carol established fine art conservation matting studios in Park Slope, Brooklyn, and Greenwich Village, New York City. From 1971 to 1996, Carol mounted and matted thousands of the highest quality prints and drawings for many premier galleries in New York City, including Castelli Graphics (Toiny and Leo Castelli with director Marvin Heiferman), Laurence Miller (Laurence Miller, Matthew Postal), LIFE (Doris O'Neil, Marthe Smith, and Debra Cohen), Pace/MacGill (Peter MacGill, Rick Wester), and others. Among her clients were photographers and private collectors, whose prints were routinely exhibited in and/or acquired by major museums, including the Museum of Modern Art, the Metropolitan Museum of Art, and the International Center for Photography in New York City. Carol also matted the 1975 inaugural exhibit of the Center for Creative Photography in Tucson, Arizona, of which Harold H. Jones was its founding director, after being the founding director of LIGHT Gallery (1971–1975).

From the outset, it was clear that the physical survival of individual works of art depended not only on the appropriate use of long-lasting materials: presentation aesthetics could also determine an artwork's ultimate fate. Visual harmony, balance, and resonance in the mounting became another essential goal.

Carol spent thousands of hours interacting with these highly valued, sometimes unique, prints and photographs and was usually completely alone with them for extended periods. Handling, studying, and absorbing relevant details as a vigilant guardian, she was intensely focused on paper and board quality, color, tone, brightness, whiteness, graphite, fingertips, fingerprints, measurements, proportions, placement, and protecting the physical condition of every little or large masterwork. Not everything was a masterpiece, but Carol was consistently attentive and inherently suited to the job.

During that 25-year period, Carol worked one-to-one with artists, curators, private collectors, and art dealers, and matted photographs made by a broad spectrum of photographers, ranging from the little known to the historically significant, covering nearly all materials and periods from the late 1800s to 1996. She also worked directly with paper chemists, manufacturers, and distributors, providing information, product specifications and recommendations aimed at addressing the concerns of the emerging photographic conservation field.

From 1976 to 1991, Carol lived in the Greenwich Village home of noted art historian and Columbia University Professor Emeritus, Meyer Schapiro, and his physician wife, Dr. Lillian Milgram. There she met and befriended many distinguished and budding painters, poets, journalists, musicians, publishers, and others. Her closest longtime friends were Helen Gee and Helen Levitt whose decades of friendship nurtured Carol both as an artist and as a professional art service provider living and working in New York City.

In 1970 and 1972, Charles Moffett and Andre Kertesz were the first prominent individuals to ask to see Carol's artwork, which were then primarily drawings. Moffett purchased one and lobbied for more. Kertesz remarked that the drawings resembled those made by his wife, Elizabeth, so he introduced them to one another. After the tragic loss of his beloved Elizabeth, who passed away in 1977, Andre and Carol shared many hours talking, walking, observing, and expressing both reverance for the endurance of love and concern for the fragility of life, light, and leaves – yes, leaves – until Andre's death on September 28, 1985.

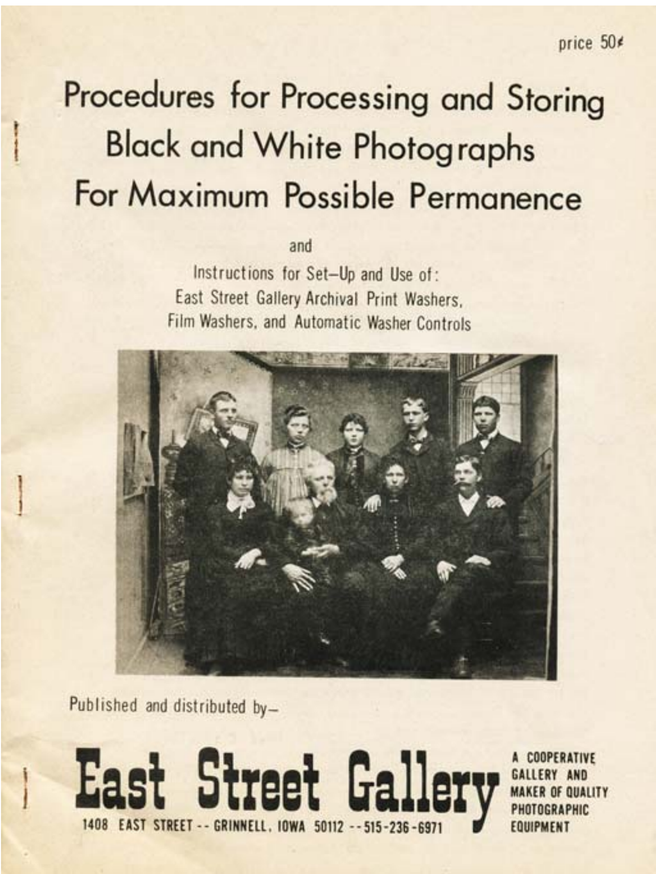
In June 1974, Carol was invited by Bella Fishko and the Forum Gallery to exhibit six of her drawings in the New Talent Festival; this resulted in offers to represent her work, additional invitations to exhibit, and praise from The New York Times art critic, John Russell (June 6, 1974). Carol was "discovered," but she remained committed to LIGHT Gallery and the photography community, and chose to take care of other artists' pictures rather than release her own into a precarious world.

Nevertheless, Carol occasionally sold drawings to collectors in the U.S. and Europe. When Barbaralee Diamonstein Spielvogel eloquently expressed her appreciation of the work, Carol happily sold Mr. and Mrs. Spielvogel two drawings and presented one as a gift. Other drawings are in the collections of Jules and Friedl Wein, Meyer and Lillian Schapiro, Miriam Grosof, Gilbert and Joyce Beldengreen, and Charles Moffett.

Carol and Henry began their collaboration on research projects in April 1978. They were married in 1991 following her move to Grinnell from New York City. As contributing author to "The Permanence and Care of Color Photographs," Carol wrote the 58-page chapter titled: "The Handling, Presentation, and Conservation Matting of Photographs." With Henry as contributing author, she also wrote the chapter titled, "Composition, pH, Testing, and Light Fading Stability of Mount Boards and Other Paper Products Used with Photographs." They have been partners ever since, editing nearly all of each other's work, discussing, debating, and brainstorming throughout the past 35 years.

In addition, Carol is significantly involved in the administration of Wilhelm Imaging Research and The Center for the Image. Carol's community activities include currently serving her sixth year as an elected public school board member for the Grinnell-Newburg Community School District (preschool through grade 12). Henry and Carol are the parents of Charles G. Wilhelm, who is a student at Grinnell College, Class of 2015. They live with their three dogs and two cats in Grinnell, Iowa.

Fig. 3
Shown here in 1963 with the Nucleo Uno village soccer team, Henry first became interested in the preservation of photographs in 1963 while working in the Alto Beni rainforests of Bolivia as a United States Peace Corps Volunteer. He troubled by the rapid deterioration of photographs in the hot and humid tropical climate – he lived in a small, open-air thatched roof house with no windows, electricity or air-conditioning – and his alarm about the loss of family photographs and records of cultural history in such an environment would soon lead to his life's work.



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Procedures for Processing and Storing Black and White Photographs For Maximum Possible Permanence

and

Instructions for Set–Up and Use of:
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Film Washers, and Automatic Washer Controls

Published and distributed by–

East Street Gallery

1408 EAST STREET -- GRINNELL, IOWA 50112 -- 515-236-6971

A COOPERATIVE GALLERY AND MAKER OF QUALITY PHOTOGRAPHIC EQUIPMENT

Fig. 4
In 1969 Henry published a 26-page booklet entitled Procedures for Processing and Storing Black and White Photographs for Maximum Possible Permanence. More than 40,000 copies of the publication were sold at 50¢ to $1 per copy.

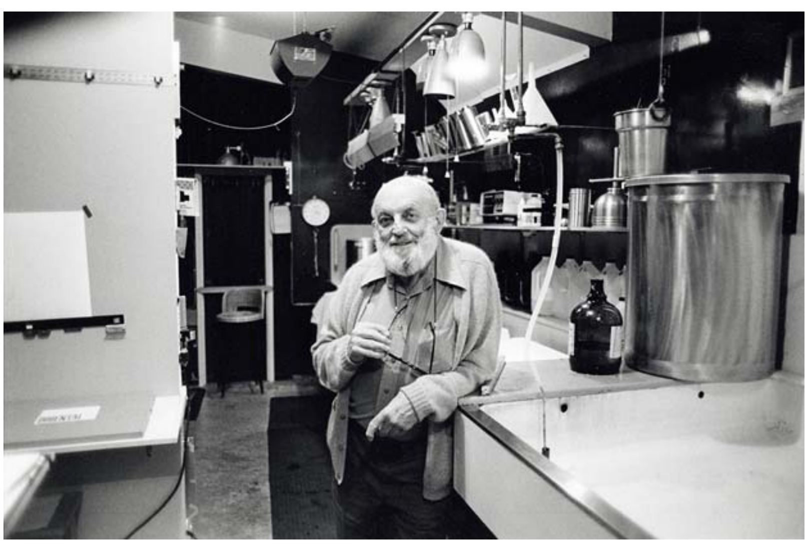

Fig. 5
In 1966, Henry was an assistant to Ansel Adams during one of Ansel's photography workshops in Yosemite National Park in California. Discussions with Ansel, who stressed the importance of "archival processing and mounting" of black and white prints, furthered Henry's interest in the preservation of photographs. The two became friends and this photograph of Ansel in his darkroom was taken by Henry in 1981 during a visit to Ansel's home in ocean-side village of Carmel, California.

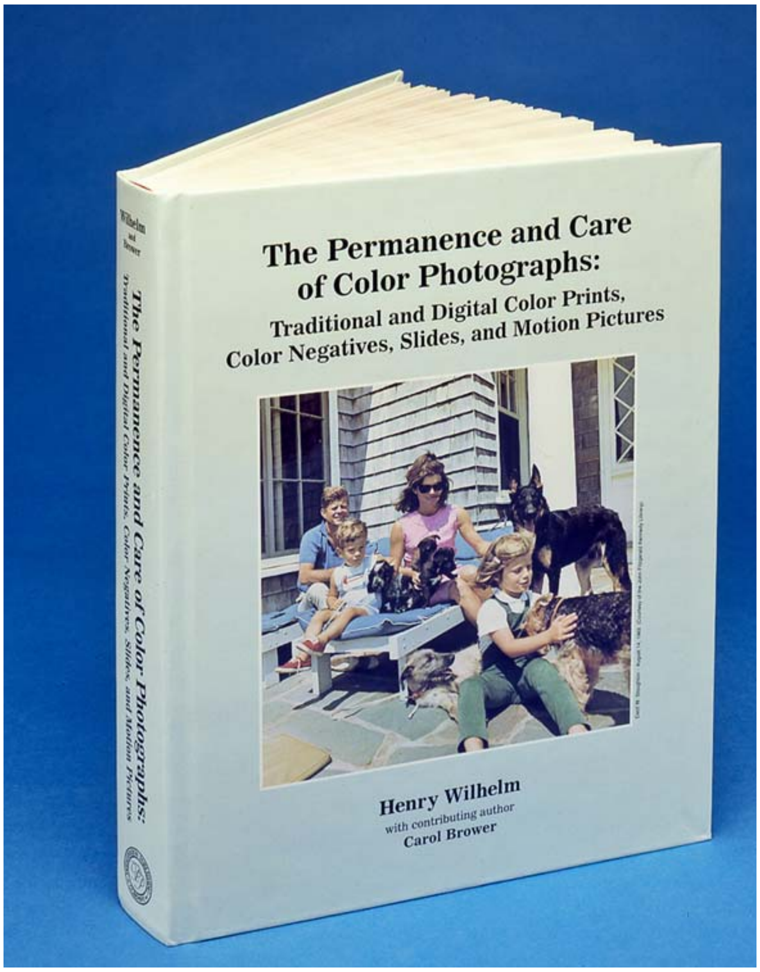

Fig. 6
With contributing author Carol Brower Wilhelm, Henry wrote "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures," published in 1993. The complete 761-page book – the only book on this subject ever published – is available as an high-resolution 35 megabyte PDF/A at no cost from www.wilhelm-research.com.

Since the digital version of the book was posted on the WIR website in 2003, more than one half million copies have been downloaded worldwide.

IS&T's 2004 Archiving Conference

High-Security, Sub-Zero Cold Storage For the PERMANENT Preservation of the Corbis-Bettmann Archive Photography Collection

Henry Wilhelm with Ann C. Hartman,[1] Kenneth Johnston,[2] and Els Rijper[3] (Corbis), and Thomas Benjamin[4] (Iron Mountain/National Underground Storage Vital Records)*
**Wilhelm Imaging Research, Inc.[5]*
Grinnell, Iowa U.S.A.

Abstract

Consisting of more than 13 million B&W and color photographs, the Corbis-Bettmann Archive photography collection spans almost the entire technological history of photography. When the collection was acquired by Bill Gates in 1995, the condition of the materials ranged from almost pristine, in the case of contemporary B&W negatives and color transparencies, to older, seriously faded color images and B&W negatives in which the acetate film base had deteriorated to the point that they were no longer recoverable. To halt further deterioration of this extraordinary collection – and ensure its survival for many thousands of years into the future – it was moved from New York City to an underground home where it would be protected from man-made and natural disasters and, literally, be frozen in eternity in secure sub-zero humidity-controlled storage.

Introduction

"When we acquired the Bettmann Archive in 1995, both Bill and I immediately recognized not only its commercial potential, but even more important, our stewardship obligation. The Corbis Film Preservation Facility, dedicated to the memory of Dr. Otto Bettmann, performs two vital functions. First, it ensures that the collection, one of the most important visual records of the 20th century, will be preserved for generations into the far-distant future. Second, the on-site digitization lab and expert photo researchers on staff who fulfill client requests daily have made the Archive collection accessible to people throughout the world in a way that was simply not possible in the past."

Steve Davis[6]
President and CEO, Corbis
Seattle, Washington <www.corbis.com>

In the Corbis sub-zero preservation vault are (L to R) Ann Hartman, Manager of Library and Records Management, and Dina Keil and Robinya Roberts, Image Library Associates. At the time this photograph was taken, parts of the collection were still being moved into the vault and, during this interim period, it was being maintained at 45°F (7.2°C) and 35% RH. In late 2004, the vault temperature will be lowered to – 4°F (– 20°C) at 35% RH to assure the permanent preservation of the collection.

Henry Wilhelm (2)

Dina Keil in the film, print, and glass plate negative scanning facility equipped with Heidelberg Topaz and Creo Scitex EverSmart scanners and located adjacent to the sub-zero vault. Individual images can be brought out of the vault in moisture-protective packaging, warmed to room temperature, and scanned in less than 45 minutes. High-speed data links allow the images to be sent to any location in the world – and the precious originals need never leave the safety of their secure underground home.

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Fig. 7
Henry Wilhelm and his colleagues at Wilhelm Imaging Research have authored or co-authored more than twenty-five technical papers in the United States, Japan, and Europe on print permanence test methods and the long-term preservation of photographs.

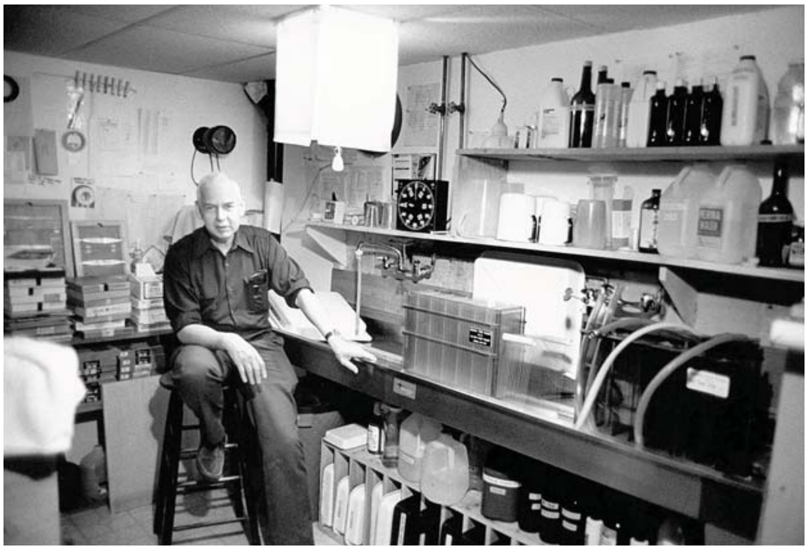

Fig. 8
David Vestal, a longtime columnist for Popular Photography magazine and currently a writer for PhotoTechniques, in his darkroom in Bethlehem, Connecticut in 1981. In the darkroom sink is an East Street Gallery Archival Print Washer, which was designed, patented, and produced by Henry in Grinnell, Iowa. Photographers using the washers included Ansel Adams, John Caponigro, Lee Friedlander, Richard Benson, Barbara Morgan, and many others.

75th ANNIVERSARY YEAR

VARIETY

PRICE $1 NEWSPAPER

Vol. 299 No. 10 — New York, Wednesday, July 9, 1980 — 102 PAGES

OLD PIX DON'T DIE, THEY FADE AWAY

Pay-TV Pirates Put On Notice In House Bill

Washington, July 8.

Pay-tv pirates would become liable for stiff fines and jail terms under legislation introduced last week by Rep. Richardson Preyer (D-N.C.).

The bill, which will be considered by the House Commerce Committee of which Preyer is a member, places damages of $100 a day up to $1,000 for anyone who intercepts any form of subscription telecommunication such as with infamous "black boxes" for foreve…

SCORSESE HELMS INDUSTRY PLEA TO KODAK

By HARLAN JACOBSON

The storm cloud of concern over the fading of color from motion pictures made post-World War II has been gathering among world-class filmmakers for some 30 years. It is perhaps only now that it is finally ready to burst.

Led by director Martin Scorsese, who claims that one reason behind his shooting his upcoming "Raging Bull" for United Artists in black and white was due to his fear of fading, the international film community has united behind a Scorsese-drafted petition to Eastman Kodak of Rochester, N.Y. to develop original camera negative and release print stock that will not bleed the 20th Century's film heritage away in the dark of a storage room.

Calling the economic forces that have led to decreased color stability and the concomitant studio disregard for expediting cold storage and other stopgap measures a "wanton, wasteful, brave-new-world of computer shredding," Scorsese has marshaled an extraordinary array of forces. (See separate stories)

They include hundreds of names — directors, talent, producers and even critics — who not only support Scorsese's plea to Kodak to spend the money to provide acceptable film and print stock, but back him in his overall campaign to make color preservation an issue that will be incorporated as boilerplate in contracts between talent and producing studios.

"I started to be concerned about this in 1972 after 'Mean Streets'."

(Continued on page 20)

Brit. Equity Coin Keeps West End 'Chicago' Floating

By JACK PITMAN

London, July 8.

Thanks to an unprecedented move by British Actors Equity, the London edition of "Chicago," which was slated to fold after last Saturday night's (5) performance at the Cambridge, instead relights tonight (Tues.) and continues until Sept. 20 when it must close because of a previous house commitment.

Equity, through its recently created theatre Emergency Fund, is providing the producers with what amounts to overall money in…

Fig. 9
In the early 1980s, Henry served as a volunteer technical advisor to film director Martin Scorsese in his successful efforts to persuade manufacturers of color motion picture film to improve the permanence of their products and to promote the use of humidity-controlled cold-storage for the long-term preservation of both color and black and white motion picture films.

Fig. 10
Peter Galassi, former curator of photography at the Museum of Modern Art in New York, discussing the design of print storage cabinets with Carol Wilhelm in the fine art photography collection cold storage preservation vault. In 1996 Henry was retained by the museum to conduct a film and print materials and condition survey of the photography collections in each of the museum's departments and served as an advisor on the design of the new cold storage facility, which was in the final stages of construction when this photograph was taken in 2004.

Fig. 11
In the summer of 1978, Carol Brower and Henry Wilhelm gave presentations on the preservation of black and white and color photographs at the Visual Studies Workshop in Rochester, New York. The week-long workshop also featured as speakers Klaus B. Hendriks of the National Archives of Canada, Frank McLaughlin, an expert on the Kodak Dye Transfer color print process at Eastman Kodak, and Guenther Cartright of the Rochester Institute of Technology.

Fig. 12
Photographer Mitch Epstein and Carol Brower working together in Carol's matting studio in New York City's Greenwich Village in 1981; the two were discussing details of mounting Epstein's Kodak Dye Transfer color prints.

An artist and photographer, Carol attended the School of Art and Design at Pratt Institute in Brooklyn, New York. Following graduation, Carol established a fine art matting studio in Park Slope, Brooklyn and, a few years later, moved the studio to Greenwich Village in New York City. Over a 25-year period, from 1971 to 1996, Carol mounted and matted thousands of the highest quality photographs and drawings for photographers, artists, galleries, museums, and private collectors in the New York City area.

Fig. 13
Carol and Henry Wilhelm holding two newspapers from the WIR Permanent Newspaper Preservation Collection inside the Wilhelm Imaging Research/Smithsonian sub-zero freezer storage vault. Maintained at minus 20°C (minus 4°F), the Collection consists of thousands of original newspapers selected to record major events in the history of the United States and of the world. In the digital age of photography, most pictures found in newspapers are the only hardcopy form of the photographs that exist.

Fig. 14

"Evaluating the Image Permanence of Full Tonal Scale Human Skintone Colors in Photographs Using the CIELAB Colorimetry Based WIR i-Star 'Retained Image Appearance' Metric" was presented at the 2009 NIP Digital Printing Conference sponsored by the Society for Imaging Science and Technology.

Current ISO and WIR methods for the evaluation of image permanence in color prints only take into account fading in cyan, magenta, and yellow patches, as well as fading and color imbalance changes in neutral scale patches (at a single density of 1.0 with ISO 18909 and at two density points,0.6 and 1.0 with WIR). The ISO and WIR methods do not directly address fading and color balance changes in human skintones. This shortcoming is particularly significant for prints made with complex inkjet inksets that, in addition to cyan, magenta, and yellow inks, may contain dilute cyan and magenta inks, as well as red,green, blue, orange, or other ink colors and multi-level black/gray inks. WIR i-Star, a CIELAB colorimetry-based, full tonal scale "retained image appearance" metric, provides a method to evaluate the permanence of human skintone colors, neutrals and near-neutrals, as well as a full range of the printable colors in sRGB or other color spaces over the full tonal scale found in photographs. The WIR i-Star metric can be used to evaluate changes in colors as well as changes in both localized and overall image contrast.

Evaluating the Image Permanence of Full Tonal Scale Human Skintone Colors in Photographs Using the CIELAB Colorimetry Based WIR i-Star "Retained Image Appearance" Metric

Henry Wilhelm and Dmitriy Shklyarov, Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.

Abstract

People are the principal subjects in the great majority of consumer photographs and the rich and vibrant reproduction of skintones in prints is an essential requirement for professional portrait and wedding photographers. Current ISO and WIR methods for the evaluation of image permanence in color prints only take into account fading in cyan, magenta, and yellow patches, as well as fading and color imbalance changes in neutral scale patches (at a single density of 1.0 with ISO 18909 and at two density points, 0.6 and 1.0 with WIR). The ISO and WIR methods do not directly address fading and color balance changes in human skintones. This shortcoming is particularly significant for prints made with complex inkjet inksets that, in addition to cyan, magenta, and yellow inks, may contain dilute cyan and magenta inks, as well as red, green, blue, orange, or other ink colors and multi-level black/gray inks. WIR i-Star, a CIELAB colorimetry-based, full tonal scale "retained image appearance" metric, provides a method to evaluate the permanence of human skintone colors, neutrals and near-neutrals, as well as a full range of the printable colors in sRGB or other color spaces over the full tonal scale found in photographs. The WIR i-Star metric can be used to evaluate changes in colors as well as changes in both localized and overall image contrast.

Introduction

It has been estimated that approximately 80-percent of amateur photographs include people in the scene and people are the central subjects in nearly 100-percent of professional portrait and wedding photographs. Despite the obvious importance of human skintone colors in photography, current image permanence test methods such as ISO 18909:2006 [1] with only a single starting density level of 1.0 and the WIR Visually-Weighted Endpoint Criteria Set v3.0 [2] with two starting density levels of 0.6 and 1.0 developed by Wilhelm Imaging Research, do not yet include full tonal scale human skintone colors in the analysis of fading, changes in color balance, or stain formation.

Figure 1. The WIR i-Star sRGBcolorspace Target (v1.0) is a generic 800 patch test target for I analysis. The target maps 12 hues with varying lightness and chroma, plus neutrals, near-neutrals, and skintone colors over the full tonal gradient and color gamut of the sRGB color space. Test targets can be made for other color spaces such as Adobe RGB and ProPhoto RGB (a large gamut colorspace also known as ROMM RGB).*

Figure 2. The human skintone colors section of the generic WIR i-Star target consists of 100 patches generated by adjusting the L values of the measured LAB values for the "Light Skin" and "Dark Skin" color patches in the Macbeth ColorChecker chart. Photographs of people may range from very high L* values in specular highlight areas to very low L* values in deep shadow areas of the face. The number of skintone color patches and neutral/near-neutral patches relative to the total number of patches in the test chart provides a means of weighting these colors in the i-Star analysis. The skintone colors section of the target can also be analyzed separately as an i-Star "Region of Interest."*

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Fig. 15

"Use of a Multispectral Camera System and Very Small, Comprehensive 'Micropatch' Test Targets for Full Tonal Scale Colorimetric Evaluation of the Permanence of Digitally-Printed Color and B&W Photographs" was presented by Henry Wilhelm at Imaging Conference JAPAN in 2011.

The paper describes the use of the MegaVision EV Multispectral Camera and image processing software used together with very small, full tonal scale test targets with 800 or more "micropatches." The test target includes human skin colors and large sets of neutral and near-neutral patches for the full tonal scale colorimetric evaluation of the permanence of digitally-printed color and monochrome photographs, and other images. Compared with the large test targets now routinely employed by printer, ink, toner, and paper manufacturers, as well as by independent test laboratories, the very small size of the "micropatch" test targets means that approximately ten to fifteen times more test targets can be accommodated in a xenon arc test unit, humidity- and temperature-controlled Arrhenius oven, or in a precision-controlled ozone test chamber.

Imaging Conference JAPAN 2011 論文集 A-18

Use of a Multispectral Camera System and Very Small, Comprehensive "Micropatch" Test Targets for Full Tonal Scale Colorimetric Evaluation of the Permanence of Digitally-Printed Color and B&W Photographs

Henry Wilhelm,* Ken Boydston,** Kabenla Armah,* and Barbara C. Stahl*
*Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.
**MegaVision, Inc., Santa Barbara, California U.S.A.

Abstract: The paper describes the use of the MegaVision EV Multispectral Camera and image processing software together with very small, full tonal scale test targets with 800 or more "micropatches." The test target includes human skin colors and large sets of neutral and near-neutral patches for the full tonal scale colorimetric evaluation of the permanence of digitally-printed color and monochrome photographs, and other images. Compared with the large test targets now routinely employed by printer, ink, toner, and paper manufacturers, as well as by independent test laboratories, the very small size of the "micropatch" test targets means that approximately *ten to fifteen times more* test targets can be accommodated in a xenon arc test unit, humidity- and temperature-controlled Arrhenius oven, or in a precision-controlled ozone test chamber. Degradation of optical brighteners can also be measured and quantified. In medium- and large-scale permanence testing laboratories, substantial cost reductions can be achieved in equipment costs – and in operational and maintenance expenses. Sample measurement time can be reduced significantly because multiple targets – including those with very large numbers of patches – can be measured at the same time. Because the camera makes no physical contact with the sample surface, unlimited numbers of measurements can be made with no risk of damage to test targets. Taken together, the procedures described here will provide more meaningful image permanence test data, both faster and at far lower cost than current methods allow. In addition, test equipment energy requirements and environmental impacts are reduced.

Introduction

Nearly all digital cameras – and most other color imaging systems available today – rely on three color filters to define the colors recorded by the system. Such systems typically record the nominal red, green, and blue values reflected from, emitted by, or transmitted through an array of points on a scene illuminated with broadband (white) light by passing the light through filters placed between the scene and the recording sensor. Color accuracy limitations of such tri-color imaging systems are well known.

When an imaging scene or object remains stationary for the duration of the imaging process, it is possible to significantly improve spectral resolution by sequentially capturing images where each captured image records a single narrow wavelength

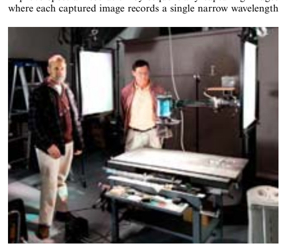

Fig. 1 Ken Boydston (left), president and head of R&D at MegaVision, Inc., and Richard Chang with the MegaVision EV high-resolution multispectral camera and image analysis system at the company's headquarters facility in Santa Barbara, California.

Fig. 2 Illumination from thirteen or more narrow wavelength LED's is used in a darkened room for sequential exposures with the MegaVision camera. Shown above is a standard 800-patch WIR iStar image permanence test target printed on 8.5 x 11-inch photo paper together with two reduced-size "micropatch" WIR iStar test targets.

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** 5765 Thornwood Drive, Santa Barbara, California 93117 U.S.A.

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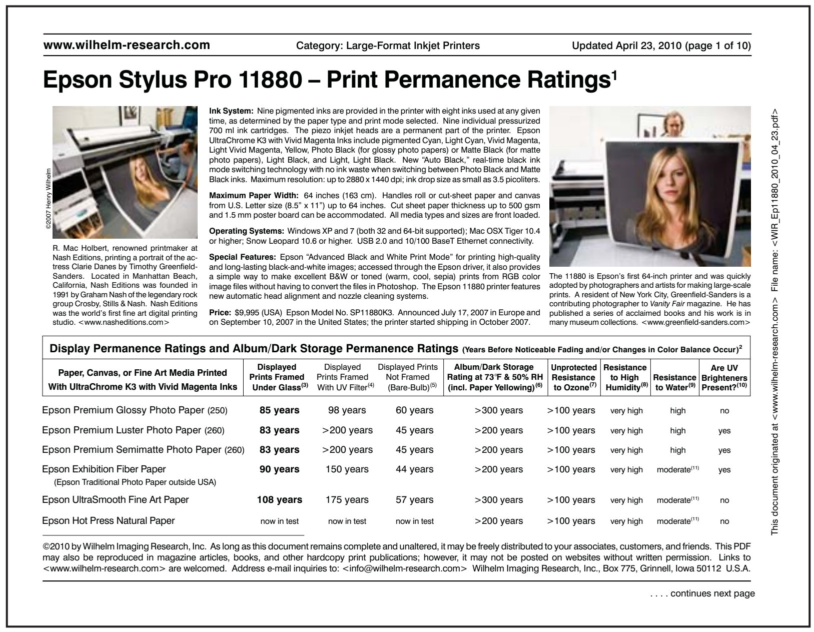
Fig. 16

A member of American National Standards Institute (ANSI) and International Standards Organization (ISO) print permanence test methods standards development groups since 1978, Henry has participated in more than sixty ANSI and ISO meetings in the U.S., Canada, Europe, and Japan; the meetings take place twice each year. Shown here is the October 2009 meeting in Tokyo, Japan. Henry Wilhelm and Yoshihiko Shibahara of Fujifilm in Japan currently serve as co-project leaders for ISO Standard 18937: Imaging Materials – Photographic Reflection Prints – Methods for Measuring Indoor Light Stability, which has been under development within ISO WG-5/TG-3 for a number of years.

Fig. 17

A wide range of WIR Print Permanence Ratings Reports are available online at no cost from Wilhelm Imaging Research. Shown here is the first page from the print permanence report for the Epson Stylus Pro 11880 printer and Epson UltraChrome K3 pigment inks with color images printed on a variety of papers and canvas materials. The comprehensive five-factor test methods developed by WIR include light stability tests (for prints framed under glass, framed with UV filtering glass, or acrylic, or displayed unframed); fading and yellowish staining that occurs over time in dark storage; resistance to exposure to atmospheric ozone; resistance to high humidity during storage or display; and resistance to damage from exposure to water. The presence or absence of optical brightening agents (OBA's) in prints is noted. These test methods are described in detail in Appendix 1.



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Epson Stylus Pro 11880 – Print Permanence Ratings[1]

©2007 Henry Wilhelm

R. Mac Holbert, renowned printmaker at Nash Editions, printing a portrait of the actress Clarie Danes by Timothy Greenfield-Sanders. Located in Manhattan Beach, California, Nash Editions was founded in 1991 by Graham Nash of the legendary rock group Crosby, Stills & Nash. Nash Editions was the world's first fine art digital printing studio. <www.nasheditions.com>

Ink System: Nine pigmented inks are provided in the printer with eight inks used at any given time, as determined by the paper type and print mode selected. Nine individual pressurized 700 ml ink cartridges. The piezo inkjet heads are a permanent part of the printer. Epson UltraChrome K3 with Vivid Magenta Inks include 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. New "Auto Black," real-time black ink mode switching technology with no ink waste when switching between Photo Black and Matte Black inks. Maximum resolution: up to 2880 x 1440 dpi; ink drop size as small as 3.5 picoliters.

Maximum Paper Width: 64 inches (163 cm). Handles roll or cut-sheet paper and canvas from U.S. Letter size (8.5" x 11") up to 64 inches. Cut sheet paper thickness up to 500 gsm and 1.5 mm poster board can be accommodated. All media types and sizes are front loaded.

Operating Systems: Windows XP and 7 (both 32 and 64-bit supported); Mac OSX Tiger 10.4 or higher; Snow Leopard 10.6 or higher. USB 2.0 and 10/100 BaseT Ethernet connectivity.

Special Features: Epson "Advanced Black and White Print Mode" for printing high-quality and long-lasting black-and-white images; accessed through the Epson driver, it 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. The Epson 11880 printer features new automatic head alignment and nozzle cleaning systems.

Price: $9,995 (USA) Epson Model No. SP11880K3. Announced July 17, 2007 in Europe and on September 10, 2007 in the United States; the printer started shipping in October 2007.

The 11880 is Epson's first 64-inch printer and was quickly adopted by photographers and artists for making large-scale prints. A resident of New York City, Greenfield-Sanders is a contributing photographer to *Vanity Fair* magazine. He has published a series of acclaimed books and his work is in many museum collections. <www.greenfield-sanders.com>

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 (250)	**85 years**	98 years	60 years	>300 years	>100 years	very high	high	no
Epson Premium Luster Photo Paper (260)	**83 years**	>200 years	45 years	>200 years	>100 years	very high	high	yes
Epson Premium Semimatte Photo Paper (260)	**83 years**	>200 years	45 years	>200 years	>100 years	very high	high	yes
Epson Exhibition Fiber Paper (Epson Traditional Photo Paper outside USA)	**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

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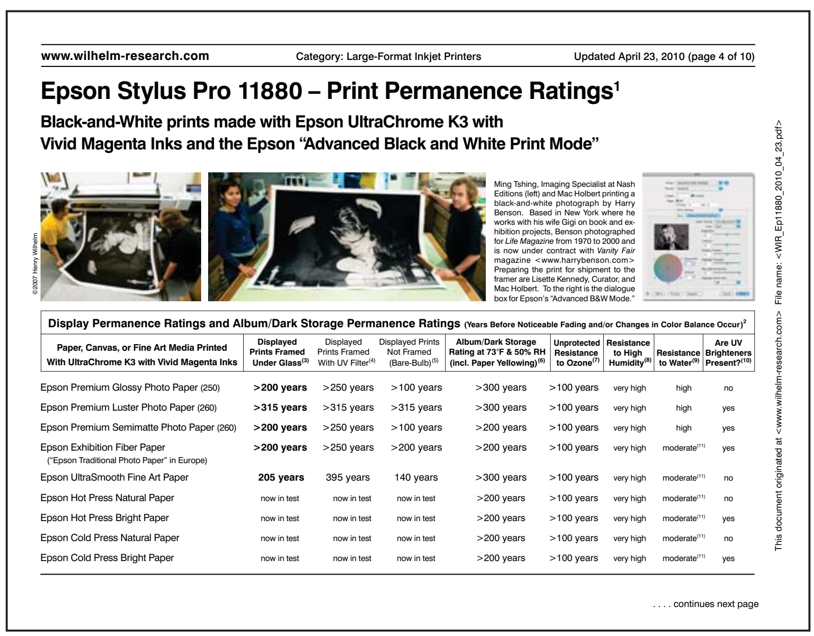
Fig. 18

WIR print permanence reports also include print permanence ratings for monochrome (black and white) images printed on a variety of papers and canvas materials.



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Epson Stylus Pro 11880 – Print Permanence Ratings[1]

Black-and-White prints made with Epson UltraChrome K3 with Vivid Magenta Inks and the Epson "Advanced Black and White Print Mode"

©2007 Henry Wilhelm

Ming Tshing, Imaging Specialist at Nash Editions (left) and Mac Holbert printing a black-and-white photograph by Harry Benson. Based in New York where he works with his wife Gigi on book and exhibition projects, Benson photographed for *Life Magazine* from 1970 to 2000 and is now under contract with *Vanity Fair* magazine <www.harrybenson.com> Preparing the print for shipment to the framer are Lisette Kennedy, Curator, and Mac Holbert. To the right is the dialogue box for Epson's "Advanced B&W Mode."

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 (250)	**>200 years**	>250 years	>100 years	>300 years	>100 years	very high	high	no
Epson Premium Luster Photo Paper (260)	**>315 years**	>315 years	>315 years	>300 years	>100 years	very high	high	yes
Epson Premium Semimatte Photo Paper (260)	**>200 years**	>250 years	>100 years	>200 years	>100 years	very high	high	yes
Epson Exhibition Fiber Paper ("Epson Traditional Photo Paper" in Europe)	**>200 years**	>250 years	>200 years	>200 years	>100 years	very high	moderate(11)	yes
Epson UltraSmooth Fine Art Paper	**205 years**	395 years	140 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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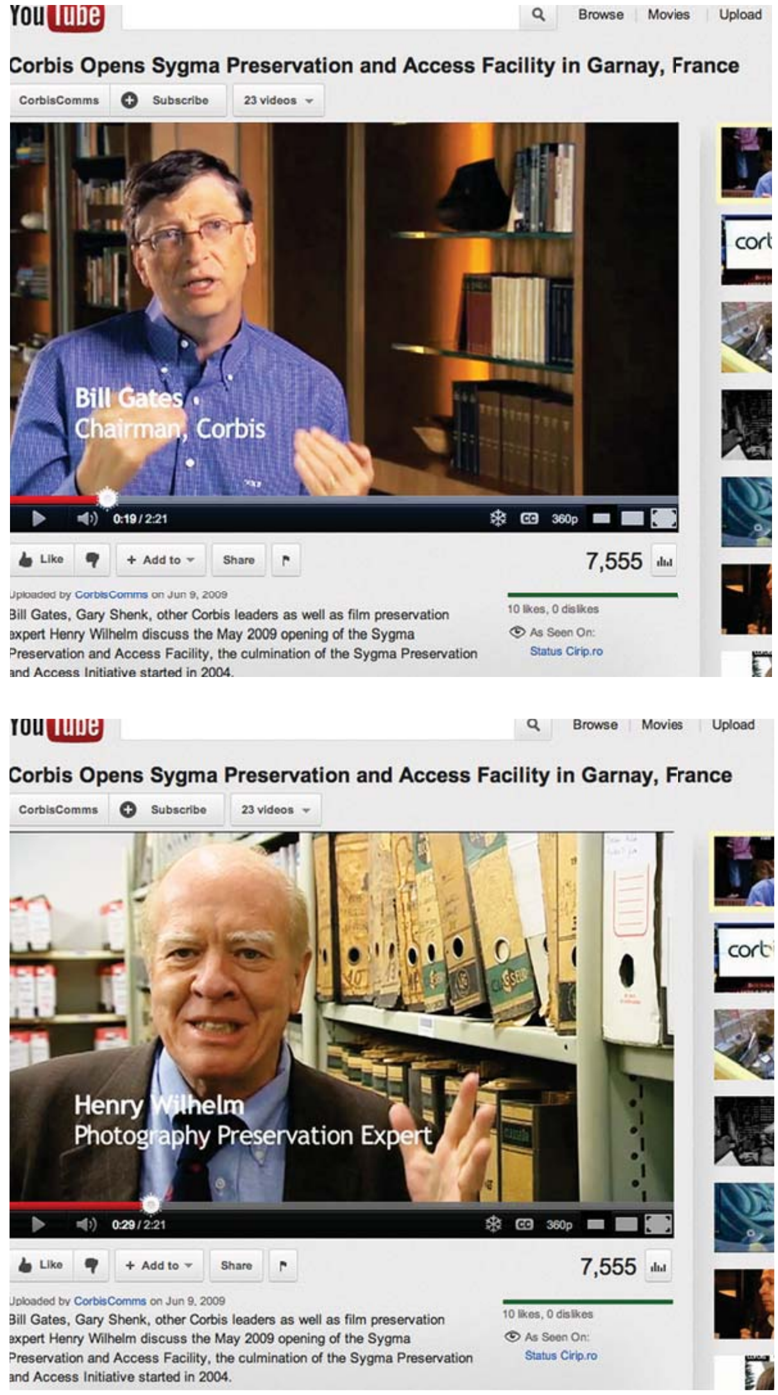


Fig. 19
A video featuring Bill Gates, the owner of Corbis, Henry Wilhelm, preservation consultant to Corbis, and Corbis CEO Gary Shenk, discussing the Preservation and Access Facility in France is available on YouTube: http://www.youtube.com/watch?v=cykhmDTvoaQ

Fig. 20
Henry Wilhelm with Ann Hartman of Corbis and officials of the high-security underground Iron Mountain Vital Records Center, which is located in an isolated area of Pennsylvania, northeast of Pittsburgh. The Corbis cold storage facility was designed to preserve the more than 20 million prints, negatives, color transparencies, and glass plate negatives in the collection for thousands of years.

Table 1 Estimated Number of Years for "Just Noticeable" Fading to Occur in Various Kodak Color Materials Stored in the Dark at Room Temperature and Three Cold-Storage Temperatures (40% RH)[7]

Time Required for the Least Stable Image Dye to Fade 10% from an Original Density of 1.0

Boldface Type indicates products that were being marketed at the end of 1992; the other products listed had either been discontinued or replaced with newer materials. These estimates are for dye fading only and do not take into account the gradual formation of yellowish stain. **With print materials in particular (e.g., Ektacolor papers), the level of stain may become objectionable before the least stable image dye has faded 10%.**

Color Papers	Years of Storage at:[8] 75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Ektacolor 37 RC Paper (Process EP-3) ("Kodacolor Print" when processed by Kodak)	10	95	200	4,150
Ektacolor 78 and 74 RC Papers (Process EP-2) ("Kodacolor Print" when processed by Kodak)	8	75	160	3,330
Ektacolor Plus Paper **Ektacolor Professional Paper** (Process EP-2) ("Kodacolor Print") ("Kodalux Print") ("Kodalux Print")	**37**	**350**	**750**	**15,400**
Ektachrome 2203 Paper (Process R-100)	7	65	140	2,900
Ektachrome 22 Paper (R-3)	8	75	160	3,330

Color Transparency Films	75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Ektachrome Films (Process E-3)	5	48	100	2,100
Ektachrome Films (Process E-4)	15	140	300	6,250
Kodak Photomicrography Color Film 2483 (Process E-4)	**3**	**28**	**60**	**1,250**
Ektachrome Films (Process E-6) ["Group I" types since 1979]	**52**	**500**	**1,100**	**21,600**
Ektachrome Plus & "HC" Films **Ektachrome 64X, 100X, & 400X Films** **Ektachrome 64T and 320T Films** ["Group II" types since 1988] (Process E-6)	**110**	**1,000**	**2,200**	**45,750**
Kodachrome Films (Process K-14) [all types]	**95**	**900**	**1,900**	**39,500**

Color Negative Films	75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Kodacolor II Film	6	55	120	2,500
Kodacolor VR 100, 200, 400 Films	**17**	**160**	**340**	**7,100**
Kodacolor VR-G 100 Film ("initial type") (Kodacolor Gold 100 Film in Europe)	12	115	240	5,000

Color Negative Films	Years of Storage at:[8] 75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Vericolor II Prof. Film Type S	6	55	120	2,500
Vericolor II Prof. Film Type L	**3**	**28**	**60**	**1,250**
Vericolor II Commercial Film Type S	3	28	60	1,250
Vericolor III Prof. Film Type S **Ektacolor Gold 160 Prof. Film**	**23**	**220**	**460**	**9,570**
Vericolor Internegative Film 6011	**5**	**48**	**100**	**2,100**

Motion Picture Color Negative Films	75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Eastman Color Negative II Film 5247 (1974)	6	57	120	2,500
Eastman Color Negative II Film 5247 (1976)	12	115	240	5,000
Eastman Color Negative II Film 5247 (1980)	28	270	550	11,650
Eastman Color Negative Film 5247 (1985 name change)	**28**	**270**	**550**	**11,650**
Eastman Color Negative II Film 7247 (1974–83)	6	57	120	2,500
Eastman Color Negative II Film 7291	**50**	**475**	**1,000**	**20,800**
Eastman EXR Color Negative Film 5245 and 7245	**22**	**210**	**440**	**9,150**
Eastman EXR Color Negative Film 5248 and 7248	**30**	**285**	**600**	**12,480**

Motion Picture Laboratory Intermediate Films	75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Eastman Color Reversal Intermediate Film 5249 & 7249	**8**	**75**	**160**	**3,330**
Eastman Color Intermediate II Film 5243 and 7243	22	210	440	9,150

Motion Picture Print Films	75°F (24°C)	45°F (7.2°C)	35°F (1.7°C)	–4°F (–20°C)
Eastman Color Print Film 5381 & 7381	5	48	100	2,100
Eastman Color SP Print Film 5383 & 7383	5	48	100	2,100
Eastman Color Print Film 5384 & 7384	**45**	**430**	**900**	**18,700**

Table 2 – WIR Display Permanence Ratings for Selected Digital Print Materials 1991–2006[a]

Type of Inkjet Printer/Ink/Paper Combination and Digital Silver-Halide or Digital Silver Dye-Bleach Color Papers Printed with RGB Laser/LED Digital Photo Printers **(Year listed is the date stability tests were conducted by Wilhelm Imaging Research, Inc.)**	**Displayed Prints Framed Under Glass**	**Displayed Prints Framed With UV Filter**
1991 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris ID Inks (4-ink dye-based inkjet prints)		
Arches BFK Heavy Watercolor Paper (uncoated 100% cotton fine art paper)	4 years	4 years
Iris Semi-Matte coated inkjet proofing photo paper	1.4 years	1.8 years
1994 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lyson FA Inks (4-ink dye-based inkjet prints)		
Arches BFK Heavy Watercolor Paper (uncoated 100% cotton fine art paper)	14 years	17 years
Iris Semi-Matte coated inkjet proofing photo paper	4 years	5 years
1994 – **Durst Lambda 130 digital printer** (first large-format RGB laser silver-halide printer)		
Printed with Fujicolor SFA3 Color Negative Paper (silver-halide color prints)	36 years	40 years
Printed with Cibachrome print material (silver dye-bleach color prints)	29 years	33 years
Printed with Kodak Ektacolor Portra II Color Negative Paper (silver-halide color prints)	12 years	12 years
1994 – **Epson Stylus Color printer** (first "photo-quality" 720 dpi desktop inkjet printer)		
Printed with Epson Inks and Epson Inkjet Paper (4-ink dye-based inkjet prints)	<0.5 years	<0.5 years
1996 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with American Inkjet Corporation "NE" [Nash Editions] inks consisting of AIJ cyan and magenta inks and Lyson FA-I yellow and black inks printed on Somerset Velvet uncoated 100% cotton fine art paper (4-ink dye-based inkjet prints)	22 years	25 years
1997 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris Longevity inks (4-ink dye-based inkjet prints)		
Arches for Iris 100% cotton fine art paper	2 years	– na –
1997 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lysonic FA II inks (4-ink dye-based inkjet prints)		
Somerset Velvet uncoated 100% cotton fine art paper	22 years	25 years
Liege Inkjet Fine Art Paper matte-coated fine art paper	2 years	3 years
1997 – **Hewlett-Packard PhotoSmart printer** (HP's first "photo-quality" desktop inkjet printer)		
Printed with HP PhotoSmart inks and HP PhotoSmart Paper (6-ink dye-based inkjet prints)	6 years	– na –
1998 – **Hewlett-Packard DesignJet 2500 and 3500 printers** (HP's first pigmented inkjet color printers)		
Printed with HP "UV" inks and matte-coated fine art papers (4-ink pigmented inkjet prints)	>200 years	>250 years
1999 – **Roland Hi-Fi Jet printers** (Roland's first large-format pigmented inkjet printers)		
Printed with Roland inks and Legion Concorde Rag paper (6-ink pigmented inkjet prints)	125 years	– na –
1999 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lysonic i W2 inkset consisting of Lysonic i Cyan #006, i Magenta, i Yellow #005, and i Black (neutral) (4-ink dye-based inkjet prints)		
Lysonic Standard Fine Art Paper matte-coated fine art paper	30 years	– na –
Somerset Enhanced Velvet matte-coated fine art paper	4 years	– na –
2000 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris Equipoise inks (4-ink dye-based inkjet prints)		
Arches Cold Press uncoated 100% cotton fine art paper	34 years	– na –
Somerst Velvet uncoated 100% cotton fine art paper	22 years	– na –
Iris Canvas	17 years	– na –
Lysonic Standard Fine Art Paper matte-coated fine art paper	8 years	– na –
Somerset Enhanced Velvet matte-coated fine art paper	3 years	– na –
2000 – **Iris Graphics 3047 printer** (introduced in 1989, the first large-format inkjet photo printer)		
Printed with American Ink Jet Pinnacle Gold Iris inks (4-ink dye-based inkjet prints)		
Somerst Velvet uncoated 100% cotton fine art paper	70 years	– na –
Arches for Iris 100% cotton fine art paper	32 years	– na –
Pinnacle Gold Enhanced Watercolor fine art paper	24 years	– na –
UltraStable Canvas	19 years	– na –
2000 – **Epson Stylus Photo 870 and 1270 desktop printers** ("improved stability" dye-based photo inks)		
Printed with Epson photo inks (6-ink dye-based inkjet prints)		
Epson Matte Paper – Heavyweight (matte-coated paper)	25 years	– na –
Epson Premium Glossy Photo Paper	10 years	– na –
Epson Photo Paper	7 years	– na –

Table 2 – WIR Display Permanence Ratings Continued[(a)]. . . . .

Type of Inkjet Printer/Ink/Paper Combination and Digital Silver-Halide or Digital Silver Dye-Bleach Color Papers Printed with RGB Laser/LED Digital Photo Printers (Year listed is the date stability tests were conducted by Wilhelm Imaging Research, Inc.)	Displayed Prints Framed Under Glass	Displayed Prints Framed With UV Filter
2000 – Epson Stylus Pro 7500, 9500, Stylus Photo P2000 printers (Epson's first pigmented inkjet printers)		
Printed with Epson Archival pigmented inks (6-ink pigmented inkjet prints)		
Epson Premium Luster Photo Paper	>225 years	>250 years
Epson Watercolor Paper – Smooth (matte-coated 100% cotton fine art paper)	>225 years	>250 years
2002 – Hewlett-Packard DesignJet 5000 printer (HP's first 6-ink pigmented inkjet printer)		
Printed with HP "UV" inks and select fine art papers (6-ink pigmented inkjet prints)	>200 years	>250 years
2002 – Epson Stylus Pro 4000, 7600, 9600, Stylus Photo 2200 printers (2-level pigmented black inks)		
Printed with Epson UltraChrome pigmented inks (7-ink pigmented inkjet prints)		
Epson UltraSmooth Fine Art Paper (matte-coated 100% cotton fine art paper)	108 years	175 years
Epson Premium Luster Photo Paper (250)	71 years	165 years
Somerset Velvet for Epson (matte-coated 100% cotton fine art paper)	61 years	125 years
2004 – Durst Lambda, Océ LightJet, and other RGB laser/LED digital printers		
Printed with Fujicolor Crystal Archive color negative paper (silver-halide color prints)	40 years	49 years
Printed with Ilfochrome Classic [Cibachrome] Material (silver dye-bleach color prints)	29 years	33 years
Printed with Kodak Edge Generations color negative paper (silver-halide color prints)	19 years	17 years
2004 – Hewlett-Packard DesignJet 130 printer (HP's first 18x24-inch desktop inkjet photo printer)		
Printed with HP 84/85 inks (6-ink dye-based inkjet prints)		
HP Premium Plus Photo Paper and other HP swellable RC-base photo papers	82 years	100 years
2004 – Canon i9900 and (in 2005) **PIXMA iP8500 printers** (Canon's first 8-ink desktop inkjet printers)		
Printed with Canon ChromaPLUS inks (8-ink dye-based inkjet prints)		
Canon Matte Photo Paper MP-101 [see Note B below]	10 years	12 years
Canon Photo Paper Pro PR-101 (glossy) [see Note B below]	6 years	8 years
2004 – Epson Stylus Photo R800 and (in 2005) **R1800 printers** (first use of clear "gloss-optimizer" ink)		
Printed with Epson UltraChrome Hi-Gloss pigmented inks (7-ink pigmented inkjet prints)		
Epson Watercolor Paper – Radiant White (matte-coated fine art paper)	200 years	>250 years
Epson Premium Glossy Photo Paper Paper	104 years	>175 years
Epson Premium Luster Photo Paper	64 years	>150 years
2005 – Hewlett-Packard Photosmart 8750 desktop printer (HP's first 9-ink inkjet printer)		
Printed with HP Vivera inks (9-ink dye-based inkjet prints)		
HP Premium Plus Photo Paper and other HP swellable RC-base photo papers	108 years	140 years
2005 – Epson Stylus Pro 4800, 7800, 9800, Stylus Photo R2400 printers (3-level pigmented black inks)		
Printed with Epson UltraChrome K3 pigmented inks (8-ink pigmented inkjet prints)		
Epson UltraSmooth Fine Art Paper (matte-coated 100% cotton fine art paper)	108 years	175 years
Epson Premium Luster Photo Paper (250)	71 years	165 years
Somerset Velvet for Epson (matte-coated 100% cotton fine art paper)	61 years	125 years
2006 – Canon PIXMA Pro9500 printer (Canon's first 10-ink desktop pigmented inkjet printer)		
Printed with Canon Lucia pigmented inks (9-ink pigmented inkjet prints)		
Canon Fine Art Photo Rag Paper and select other Canon matte-coated fine art papers	>100 years	>150 years
Canon Luster Photo Paper, Canon Photo Paper Pro, and select other Canon photo papers	>100 years	>150 years
2006 – HP Photosmart Pro B9180 printer (HP's first 8-ink desktop pigmented inkjet printer)		
Printed with HP Vivera Pigment inks (8-ink [7-inks w/ glossy papers] pigmented inkjet prints)		
HP Advanced Photo Paper Glossy (improved version with 10.5 mil paper thickness)	>230 years	>230 years
HP Photo Matte Paper (matte-coated fine art paper)	>230 years	>230 years
HP Hahnumühle Smooth Fine Art Paper (matte-coated fine art paper)	>230 years	>230 years
2006 – Canon imagePROGRAF iPF5000 and iPF9000 printers (Canon's first 12-ink inkjet printers)		
Printed with Canon Lucia pigmented inks (11-ink pigmented inkjet prints)		
Canon Fine Art Photo Rag Paper and select other Canon matte-coated fine art papers	>100 years	>150 years
Canon Luster Photo Paper, Canon Photo Paper Pro, and select other Canon photo papers	>100 years	>150 years

(a) The WIR Display Permanence Ratings given here were derived from accelerated glass-filtered cool white fluorescent light fading tests conducted at 24°C (75°F) and 60% relative humidity and are based on the "standard" indoor display condition of 450 lux for 12 hours per day employed by Wilhelm Imaging Research, Inc. 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 the changes in color balance, and/or staining specified in the visually-weighted WIR Ver. 3.0 Endpoint Criteria Set to occur; with most types of images, these changes are easily noticeable in side-by-side comparisons with an unfaded original. **(b)** Because of the disproportionately rapid light fading of the red (orange) ink in the 8-ink Canon ChromaPLUS dye-based inkset used in the Canon i9900 printer, which is not properly assessed by the Status A densitometrically-based WIR 3.0 Endpoint Criteria Set, the Display Permanence Ratings should in reality be lower than the figures given here. The disproportionately rapid fading of the red (orange) ink is particularly noticeable in skintones.

New Printers and Pigment Ink Systems Introduced in 2006:

- Canon ImagePROGRAF iPF 5000 (17"x24"), iPF8000 (44") and iPF9000 (60") with 12-ink Canon Lucia pigment inks; Canon PIXMA Pro 9500 (13"x19") with 10-ink Canon Lucia pigment inks.
  WIR Display Permanence Ratings COLOR = >100 years (tests in progress)
  WIR Display Permanence Ratings B&W = >200 years (tests in progress)

- Epson Stylus Pro 3800 (17"x22") with 9-ink Epson UltraChrome K3 pigment inks.
  WIR Display Permanence Ratings COLOR = 61 years to 108 years
  WIR Display Permanence Ratings B&W = >200 years (tests in progress)

- HP Designjet Z3100 (24" and 44") with 12-ink HP Vivera pigment inks; Z2100 (24" and 44") and B9180 (13"x19") with 8-ink HP Vivera pigment inks.
  WIR Display Permanence Ratings COLOR = >150 years to >200 years
  WIR Display Permanence Ratings B&W = >250 years (tests in progress)

Fig. 21
In 2000 Epson pioneered the use of pigment inks for photographic printing with the introduction of the Epson Stylus Pro 7500 and 9500 printers and the Epson Archival Inkset. This was followed in 2002 with the introduction of new printers using the improved Epson UltraChrome pigment inkset and, in 2005, a series of new printers using the Epson UltraChrome K3 inkset with multi-level gray/black inks for improved monochrome prints. In 2006 both Canon and Hewlett-Packard joined Epson in offering large-format printers with high-stability pigment inksets offering multi-level gray/black inks. These new printers from all three manufacturers quickly replaced printers using less stable dye-based inks in professional photography and fine art markets.

Advantages of Pigment Inks vs. Dye-Based Inks:

- High light stability on a wide variety of photo papers, fine art matte coated papers, and canvas materials.
- Good ozone resistance on all types of papers.
- Good to excellent waterfastness on most types of papers.
- Excellent humidity-fastness on all types of papers.
- Excellent short-term color drift behavior ("dry down") which is ESSENTIAL for tightly color managed workflows, proofing applications, and built-in printer calibration and profiling systems such as that used in the HP Z-series printers and suitably equipped Epson and Canon printers.

Table 3

WIR Print Permanence Ratings for the 4x6-Inch Digital Printer Category in 2004–2007 (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[1]

Printer/Ink/Photo Paper Printed With Inkjet, Dye-Sub, Silver-Halide Printers	Displayed Prints Framed Under Glass[(2)]	Displayed Prints Framed With UV Filter[(3)]	Displayed Prints Not Framed (Bare-Bulb)[(4)]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[(5)]	Unprotected Resistance to Ozone[(6)]	Resistance to High Humidity[(7)]	Resistance to Water[(8)]	Are UV Brighteners Present?[(9)]
HP Photosmart Express (retail inkjet kiosk printer) **HP Vivera pigment inks/HP RPS Photosmart Paper**	**>200 years**	>250 years	102 years	>200 years	>100 years	very high	high	no
Lexmark P350 Portable (4x6-inch inkjet printer) **Lexmark Evercolor 2 pigment inks/PerfectFinish Paper**	**>100 years**	>100 years	now in test	now in test	now in test	very high	high	no
Epson PictureMate (original) (4x6-inch inkjet printer) **Epson PictureMate pigment inks/PictureMate Paper**	**104 years**	124 years	65 years	>200 years	>100 years	very high	high	yes
Epson PictureMate PM-200 (4x6-inch inkjet printer) **Epson PictureMate dye-based inks/PictureMate Paper**	**96 years**	147 years	17 years	>200 years	17 years	now in test	high	no
HP Photosmart 325 and 475 (4x6-inch inkjet printer) **HP Vivera 95 dye-based inks/Premium Plus Photo Paper**	**82 years**	105 years	42 years	>200 years	>100 years	now in test	low	no
HP Photosmart 145 and 245 (4x6-inch inkjet printer) **HP Vivera 57+ dye-based inks/Premium Plus Photo Paper**	**68 years**	77 years	32 years	>200 years	>100 years	now in test	low	no
HP Photosmart A616/A717 (5x7-inch inkjet printer) **HP Vivera 110 dye-based inks/Advanced Photo Paper**	**51 years**	53 years	16 years	>200 years	16 years	now in test	high	no
Canon PIXMA 260 (4x6-inch inkjet printer) **Canon ChromaLife 100 dye-based inks/Photo Paper Pro**	**now in test**	now in test	now in test	>200 years	now in test	now in test	high	no
Canon Selphy DS700 (4x6-inch inkjet printer) **Canon BCI-16 dye-based inks/Photo Paper Pro**	**41 years**	44 years	2 years	>200 years	2 years	now in test	high	no
Fujicolor Crystal Archive (silver-halide color print) **Fuji Frontier 370 minilab/Fuji washless chemicals**	**40 years**	50 years	26 years	>100 years	>100 years	very high	high	no
Kodak PictureMaker (retail kiosk dye-sub printer) **Kodak Xtralife dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Kodak EasyShare Printers (4x6-inch dye-sub printer) **Kodak Xtralife 4x6-inch dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Dell Photo Printer 540 (4x6-inch dye-sub printer) **Dell 4x6-inch dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Fuji Xerox 7/11 (retail kiosk xerographic photo printer) **Fuji Xerox color toner/Fuji Xerox glossy photo paper**	**23 years**	25 years	21 years	now in test	>100 years	very high	high	no
Agfacolor Sensitas (silver-halide color print) **Agfa d-lab.2plus minilab/Agfa washless chemicals**	**22 years**	26 years	14 years	>100 years	>100 years	very high	high	no
Kodak Edge Generations (silver-halide color print) **Noritsu QSS-3011SM minilab/Kodak washless chemicals**	**19 years**	18 years	18 years	>100 years	>100 years	very high	high	no
Sony PictureStation (retail kiosk dye-sub printer) **Sony dye-sub printer ribbon and paper**	**18 years**	28 years est.	13 years	now in test	>100 years	very high	high	no
HP Photosmart 145 and 245 (4x6-inch inkjet printer) **HP 57 dye-based inks/HP Premium Plus Photo Paper**	**18 years**	20 years	15 years	>200 years	>100 years	now in test	low	no
Konica Minolta Impressa (silver-halide color print) **Konica R2 Super 1000 minilab/Konica washless chemicals**	**17 years**	19 years	16 years	>100 years	>100 years	very high	high	no
Lexmark SnapShot P315 (4x6-inch inkjet printer) **Lexmark 33 dye-based inks/Lexmark Premium Photo Paper**	**16 years**	18 years	10 years	>200 years	now in test	now in test	low	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **HP 57 dye-based inks/Kodak "100 Year" Ultima Picture Paper**	**11 years**	13 years	10 years	now in test	>100 years	now in test	low	no
Sony DPP-FP55 PictureStation (4x6-inch dye-sub printer) **Sony 4x6-inch dye-sub printer ribbon and paper**	**10 years**	18 years	6 years	now in test	>100 years	very high	high	no
Olympus P-10 Printer (4x6-inch dye-sub printer) **Olympus 4x6-inch dye-sub printer ribbon and paper**	**8 years**	10 years	6 years	now in test	>100 years	very high	high	no
Canon CP500 Printer (4x6-inch dye-sub printer) **Canon 4x6-inch dye-sub printer ribbon and paper**	**7 years**	9 years	6 years	now in test	>100 years	very high	high	no
Sony DPP-FP30 PictureStation (4x6-inch dye-sub printer) **Sony 4x6-inch dye-sub printer ribbon and paper**	**6 years**	6 years	5 years	now in test	>100 years	very high	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **Staples refilled HP 57 ink cartridge/Photo Supreme Paper**	**3 years**	3 years	3 months	now in test	3 months	now in test	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **OfficeMax refilled HP 57 ink cartridge/Professional Photo Paper**	**2 years**	2 years	2 months	now in test	2 months	now in test	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **Office Depot refilled HP 57 ink cartridge/Professional Paper**	**4 months**	4 months	2 months	now in test	2 months	now in test	high	yes

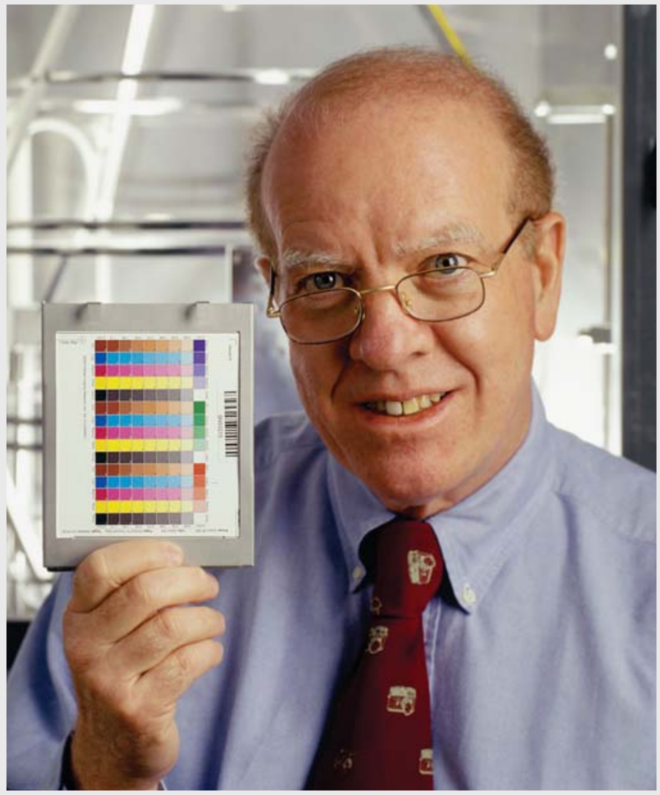
***Note:** Products listed with an "*" have been tested with non-recommended, third-party inks and/or papers and do not represent the performance of OEM inks and papers supplied by that printer's manufacturer.

April 18, 2013

The Wilhelm Analog and Digital Color Print Materials Reference Collection

- **Analog and Digital Color Print Materials**
- **Digital Black and White Print Materials**
- **Definitive Product and Process Identification and Dating**
- **Comprehensive 380–730nm Spectral Data from 800-Patch Color and Neutral Scales**
- **Extensive Multiple-Factor Print Permanence Test Data**
- **Sortable/Searchable Databases**

1971 to 2013… The Largest Collection of Its Kind in the World



The Wilhelm Analog and Digital Color Print Materials Reference Collection

"The Wilhelm Analog and Digital Color Print Materials Reference Collection" is a continually expanding resource that consists of more than three thousand unique, documented samples of analog color, digital color, and digital black and white photographic print materials coupled with extensive 380–730nm spectral data, print permanence test data, and comprehensive product permanence reports. It is the largest collection of its kind in the world.

The Reference Collection was created and organized by Henry and Carol Wilhelm and their colleagues over the course of more than 40 years of laboratory research on the permanence properties and long-term preservation of color photographs.

It is the Wilhelms' intention that the Reference Collection of print materials and permanence databases will be located within a major research university where the collection will continue to expand and be made available worldwide to photography conservators, conservation research scientists, curators, collectors, dealers, archivists, historians educators, students, and others seeking information about the identification, dating, characterization, authentication, and image permanence properties of analog and digital color photographic materials.

"The Wilhelm Analog and Digital Color Print Materials Reference Collection" grew out of the research on the permanence and long-term preservation of black and white and color photographs that Henry Wilhelm began in the mid-1960s.

In late 2009, the black and white fiber-base and RC papers that were accumulated over the years were donated to Paul Messier and have now been integrated into the "Paul Messier Historic Photographic Papers Collection."

Separately, each of the two collections – the Wilhelm Reference Collection and the "Paul Messier Historic Photographic Papers Collection" – is the largest of its kind in the world.

Together, the two collections encompass the entire era of analog black and white, digital color, and digital black and white photography from 1900 to 2013.

Description of the Wilhelm Print Materials Reference Collection

(Updated on April 18, 2013)

The Wilhelm Analog and Digital Color Print Materials Reference Collection consists of analog color, digital color, and digital black and white photographic print materials, with associated permanence test data and reports organized in sortable/searchable databases

1) Analog color film and print materials from 1971 to 1993 (includes permanence test data): **~475 products**
2) Analog and digital color print materials from 1993 to 2000 (includes permanence test data): **~1,216 products**
3) Digital color and B&W print materials from 2000 to 2013 (with spectral data from 380 to 730 nm in 10 nm increments for 800-patch neutral, cyan, magenta, yellow, red, green, and blue color scales): **~2,073 products**
4) Total identified film, print paper, and printer/ink/paper products from 1971 to 2013 (41 years): **~3,765 products**
5) Multiple targets for each printer/ink/media combination subjected to eight separate WIR permanence tests: (1) display permanence (light stability) tests with five different light exposure conditions: glass filter with 5mm air-gap and glass in direct contact with sample surface; (2) acrylic UV filter with 5mm air-gap and acrylic UV filter in direct contact with the sample surface; and (3) unfiltered "bare-bulb" light exposure; (4) multi-temperature Arrhenius dark storage tests; (5) unprotected ozone resistance; (6) resistance to high humidity; (7) water resistance; and (8) determination of the presence or absence of optical brightening agents (OBAs)
6) "Natural Aging" test targets stored in the dark at ambient room temperature (24°C/60% RH) and "Long-Term Freezer Preservation" instrument calibration and visual reference test targets stored at –20°C (–4°F)
7) Individual, documented test targets included in the digital portion of the collection: **~18,324 test targets**
8) TOTAL number of calibration pages and digital and analog test targets in the collection: **~27,600 individual items**
9) Individual test target measurements in the digital portion of the collection: **~126,800 target measurements** (an average of 35 test targets, each with 135 individual color and neutral patches, are measured daily)
10) Individual spectral measurements made of the color and neutral (including full-image monochrome) patches in the test targets for all materials in the digital portion of the collection: **>520 million spectral measurements**
11) Data storage, backed-up off-site daily, for spectral measurements and permanence reports: **>175 gigabytes**
12) Microsoft Access database with a WIR programmed Borland Delphi interface, providing search/sort capabilities

The Core of the Wilhelm Digital Print Materials Collection:

WIR 800-Patch Printer/Ink/Paper Calibration Pages and Associated Spectral Measurements

Above are the contents of Inventory Folder IN01869. This is a typical folder, although not every inventory folder holds the same items. This folder has two calibration pages, a print-out of RGB values (generated after measuring the calibration pages), five pristine never-in-test ozone targets,and five pristine never-in-test light-fading targets (same target style as for dark-storage Arrhenius Tests).

Also in this folder is a measured "Dark-In-Envelope" reference sample for the Arrhenius Test, which was conducted with this particular printer, ink, and paper combination. Inventory folders typically contain from two to twenty or more virgin targets that have never been measured nor subjected to an accelerated aging test.

This stack of paper is a print-out of the total spectral data gathered from the spectral measurements from a single calibration page, which yielded 117 printed pages of numerical data!

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Appendix 1

The Eight-Factor Test Methods Developed by Henry Wilhelm and Wilhelm Imaging Research for the Comprehensive Evaluation of the Permanence of Analog and Digital Color and Black and White Photographs

Described below, the test methods include light stability tests for fading, shifts in color balance, and formation of yellowish stain during display (includes separate tests for prints framed under glass, framed with UV filtering glass, or acrylic, or displayed unframed); fading and yellowish staining that occurs over time in dark storage; resistance to exposure to atmospheric ozone; resistance to high humidity during storage or display; and resistance to damage from exposure to water. The presence or absence of optical brightening agents (OBA's) in prints is noted.

1) 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 the permanence of digital prints. ISO (The International Organization for Standardization) is headquartered in Geneva, Switzerland. However, despite many years of effort within ISO, there currently is no ISO predictive print permanence test method standard or "Specification" available that can be used to answer the question: "How long will a print last?," and it appears unlikely that such a predictive ISO standard will be available in the foreseeable future.
   The WIR Display Permanence Ratings (DPR) given here are based on accelerated light stability tests conducted at 30 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 intense than 450 lux. Ink and paper combinations that have not reached a fading or color balance failure point after the equivalent of 100 years of display are given a rating of "more than 100 years" until such time as meaningful dark stability data are available (see discussion in No. 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 Permanence Institute and Torrey Pines Research also based print-life calculations on 120 lux for 12 hours per day.

2) 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.

3) 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.

4) 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.

5) Prints stored in the dark may suffer slow deterioration that is manifested in yellowing of the print paper, image fading, changes in color balance, and physical embrittlement, cracking, and/or delamination of the image layer. These types of deterioration may affect the paper support, the image layer, or both. Each type of print material (ink/paper combination) has its own intrinsic dark storage stability characteristics; some are far more stable than others. Rates of deterioration are influenced by temperature and relative humidity; high temperatures and/or high relative humidity exacerbate the problems. Long-term dark storage stability is determined using Arrhenius accelerated dark storage stability tests that employ a series of elevated temperatures (e.g., 57°C, 64°C, 71°C, and 78°C) at a constant relative humidity of 50% RH to permit extrapolation to ambient room temperatures (or other conditions such those found in sub-zero, humidity-controlled cold storage preservation

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

120 lux/12 hrs/day	450 lux or 500 lux/10 hrs/day or 12 hrs/day
Kodak (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

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

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.

6) 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>.

7) Changes in image color and density, and/or image diffusion ("image bleeding"), that may take place over time when prints are stored and/or displayed in conditions of high relative humidity are evaluated using a humidity-fastness test maintained at 86°F (30°C) and 80% RH. Depending on the particular ink/media combination, slow humidity-induced

changes may occur at much lower humidities – even at 50–60% RH. Test methods for resistance to high humidity and related test methods for evaluating "short-term color drift" in inkjet prints have been under development since 1996 by Mark McCormick-Goodhart and Henry Wilhelm at Wilhelm Imaging Research, Inc. See: Mark McCormick-Goodhart and Henry Wilhelm, "New Test Methods for Evaluating the Humidity-Fastness of Inkjet Prints," Proceedings of "Japan Hardcopy 2005" – The Annual Conference of the Imaging Society of Japan, Tokyo, Japan, June 9, 2005, pp. 95–98. Available in PDF format from <www.wilhelm-research.com> <WIR_JapanHardcopy2005MMG_HW.pdf>

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

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

8) 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.

9) 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.

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