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

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Abstract

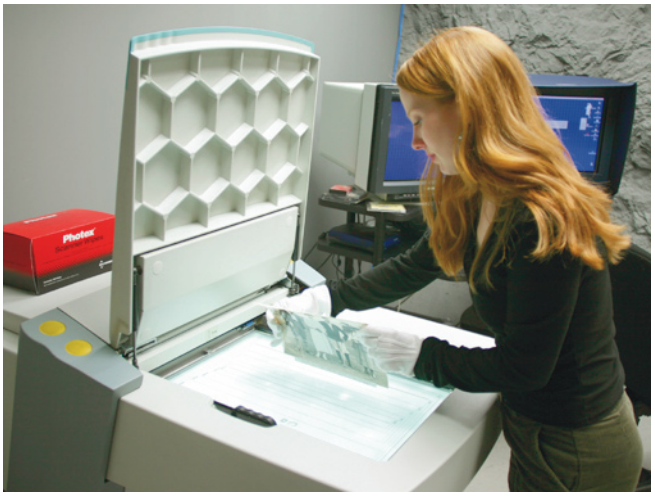
Consisting of more than 13 million B&W and color photographs, the Corbis-Bettmann Archive photography collection spans almost the entire technological history of photography. When the collection was acquired by Bill Gates in 1995, the condition of the materials ranged from almost pristine, in the case 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.

Table 1 Effect of Temperature on Dye Fading Rates at 40% Relative Humidity*

Storage Temperature	Relative Storage Time
86°F (30°C)	½X
75°F (24°C)	1X
66°F (19°C)	2X
55°F (13°C)	4X
45°F (7°C)	10X
40°F (4°C)	16X
32°F (0°C)	28X
14°F (–10°C)	100X
0°F (–18°C)	340X
–15°F (–26°C)	1000X

* Derived from: Charleton C. Bard et al., "Predicting Long-Term Storage Dye Stability Characteristics of Color Photographic Products from Short-Term Tests," *Journal of Applied Photographic Engineering*, Vol. 6, No. 2, April 1980, p. 44 (with permission). Fading rates of many dyes can be significantly greater when stored where relative humidities are higher than 40%.

Storage Temperatures and Relative Humidity

Like other historical still photographic and motion picture collections, the Corbis-Bettmann collection – which contains materials dating back more than 100 years – has suffered significant deterioration. The temperature of the storage environment is the major determinant of both color fading and degradation of cellulose acetate film base negatives and color transparencies. As shown in Table 1, lowering the storage temperature to 0°F (–18°C) and below will drastically slow deterioration processes. Relative humidity also plays a roll in both the fading of traditional photographic color images (see Table 2) and in acetate and nitrate film base deterioration, but the gains that can be achieved with controlled RH environments (e.g., 35% RH) are small compared with what can be achieved with very low temperature storage.

Storage at 32°F (0°C) is Not Cold Enough

Storage temperatures in the range of 30°F to 35°F (–1°C to 1.7°C) are simply not low enough to provide adequate long-term preservation of historical photographic and motion picture collections. For example, as shown in Table 3, Kodak Process E-3 Ektachrome Professional films, which were in widespread use until around 1980, will suffer from a "just noticeable" (10%) fading of the least stable dye in only five years when stored at a room temperature of 75°F (24°C) and 40% RH, and are predicted to fade this amount in approximately 100 years when stored at 35°F (1.7°C) *provided* that they are placed in 35°F storage immediately after processing. By dropping the storage temperature another 35°F to – 4°F (–20°C), however, the predicted storage time for a 10% dye loss increases from 100 years to 2,100 years! In other words, lowering the temperature the additional 39°F (18°C) added approximately 2,000 years to the predicted storage time.

Table 2 Effect of Relative Humidity on Fading Rates of Certain Kodak Chromogenic Yellow Dyes*

Relative Humidity	Relative Dye Fading Rate at a Specified Temperature
60%	2X
40%	1X
15%	½X

* Derived from: Charleton C. Bard et al., "Predicting Long-Term Storage Dye Stability Characteristics of Color Photographic Products from Short-Term Tests," *Journal of Applied Photographic Engineering,* Vol. 6, No. 2, April 1980, p. 43 (with permission).

With a well-engineered humidity-controlled sub-zero cold storage facility, the additional capital equipment and yearly operational costs to lower the temperature from 35°F to – 4°F are relatively small – but the long-term preservation benefits to a collecton will be absolutely enormous!

Henry Wilhelm (1)

Els Rijper, who served as Preservation Coordinator for Corbis-Bettmann prior to leaving her position in 2001, instituted zero-degree storage for the "Very Important Photographs" (VIP) program in 1997 to protect the crown jewels of the Bettmann Archive. The films and prints were stored in conventional commercial food freezers using the Critical Moisture Indicator (CMI) Packaging Method[9–11] to protect them from moisture in the non-dehumidified freezers. The CMI packages, developed by Mark McCormick-Goodhart, are available from Metal Edge, Inc.

Table 3 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%.**

	Years of Storage at:[8]			
Color Papers	**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				
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				
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

	Years of Storage at:[8]			
Color Negative Films	**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				
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				
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				
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**

Kenneth Johnston, Manager of Historical Collections at Corbis, examining some of the thousands of photographs taken during the Vietnam War by Japanese photographer Kyoichi Sawada, who began working for United Press International in 1961 and was awarded a Pulitizer Prize in 1965 for his coverage of the Vietnam War. Sawada was killed in Cambodia in 1970 while documenting the murderous regime of the Khmer Rouge.

These Kodak Ektachrome-X color slide films were actually in Sawada's cameras in the jungles of Vietnam when the photographs were made on February 15, 1968 while covering the battle at the Citadel in Hue, Vietnam during the Tet Offensive. A primary goal of the Corbis sub-zero preservation effort is to permanently preserve important historical artifacts such as these Ektachrome transparencies in their original, unchanged form.

"Zero-Tolerance" for Further Deterioration

The storage temperature recommendations for prints and films given in applicable ISO standards[12–13] are for optimally processed photographs that are placed in controlled storage *almost immediately* after they are made. In practice, with historical and other collections that are assembled over long periods of time, many photographs will have already exceeded the "maximum" acceptable limits of deterioration by the time cold storage is even considered. To prevent further, unacceptable changes in the images, sub-zero cold storage is essential. One of the goals of the Corbis-Bettmann sub-zero preservation effort is to serve as a model to other institutions as to how to best preserve the photographic era of the past 150 years in a permanent, secure, accessible, and cost-effective manner.[14–18] Fortunately, with a complete digital infrastructure already in place, Corbis is now seamlessly moving forward into the age of digital cameras, scanners, digital image catalogs, and worldwide digital image distribution!

A critical part of every historical collection is the identifying information found on deteriorating negative envelopes, caption sheets, rubber stamp impressions, and pressure sensitive stickers on the backs of prints. Sub-zero storage preserves not only the photographic originals, but also the "metadata" that supplies the essential information about "when, where, and who?"

Henry Wilhelm (4)

The Corbis-Bettmann collection of 13 million original and duplicate negatives, prints, glass plates, and color transparencies is also a museum of the era of traditional photography which will, essentially, be at an end by 2010. Sub-zero storage preserves everything, including blue "Ditto" spirit duplicator caption slips, card catalogs, magazines, newspapers, and books.

The guarded entrance to the Iron Mountain/National Underground Storage Vital Records facility, located in a secluded area about an hour's drive northeast of Pittsburgh, Pennsylvania.

The home to a large number of paper-based, film-based, and digital records centers serving the U.S. government, business, and Hollywood motion picture industry, armed guards and electronic surveillance systems provide security 24 hours a day.

Housed in a former limestone mine that at one time served the Pittsburgh steel industry, new areas in the mine are being cleared for construction of additional records preservation centers.

With an LCD video display showing photographs from the Corbis collection, the entrance to the Corbis Film Preservation Facility has a somewhat otherworldly appearance when one first encounters it deep within the underground limestone mine.

Dina Keil (1)

In the newly-named Otto Bettmann Preservation Vault are (L to R) Henry Wilhelm (Wilhelm Imaging Research, Inc.); Thomas Benjamin (Vital Records Product Manager, Iron Mountain); Ann Hartman (Records Management, Corbis); Charles Doughty (Vice President of Engineering, Iron Mountain); and Thomas Roth (General Manager, Vital Records, Iron Mountain).

Henry Wilhelm (5)

Refrigeration, dehumidification, and air-filtration systems are located outside the vault for non-disruptive servicing. The year-round 55°F (12.8°C) ambient temperature in the mine provides a steady-state environment for energy-efficient HVAC systems.

References

1. Ann C.Hartman is Manager of Library and Records Management at the Corbis Film Preservation Facility (FPF), located in the underground high-security Iron Mountain/National Underground Vital Records Facility in Boyers, Pennsylvania 16020 <www.corbis.com>.
2. Kenneth Johnston, who joined the Bettmann Archive in 1985, is Manager of Historical Collections at Corbis, 902 Broadway, New York, New York 10010 <www.corbis.com>.
3. Els Rijper joined the Bettmann Archive in 1984 and served as Preservation Coordinator at the 902 Broadway location in New York City until she left her position 2001. Els established the Corbis "Very Important Photographs" (VIP) collection to protect and preserve particularly valuable (or vulnerable) images in 0 °F (–18 °C) freezers using the Critical Moisture Indicator (CMI) packaging method. Working with Kenneth Johnston, Bill Hannigan, Christopher Wendt, and others at Corbis, Els was instrumental in developing the long-term preservation strategy that led to the collection being moved from New York City to secure sub-zero cold storage at the Iron Mountain/National Underground Storage Vital Records Facility.
4. Thomas Benjamin is Product Manager, Vital Records, at the Iron Mountain/National Underground Vital Records Facility in Boyers, Pennsylvania. The corporate offices of Iron Mountain are located at 745 Atlantic Avenue, Boston, MA 02111 <www.ironmountain.com>.
5. Henry Wilhelm of Wilhelm Imaging Research, Inc. serves as the lead consultant to Corbis on the preservation of its photographic collections. Responding to an invitation in 1994 from Els Rijper, Wilhelm began an examination of the condition of the wide variety of black-and-white and color film and print materials that make up the collection – and of the then quite inadequate environmental conditions in which the photographs had long been housed on the 5th floor of a older building located at 902 Broadway, near 20th Street in New York City. After Bill Gates acquired the Bettmann Archive in late 1995, an expanded study of the collection was undertaken with the goal of developing a plan for its very-long-term preservation. This work culminated in a report submitted to Corbis in November 1997 (with minor revisions, the final report was submitted in September 1999) entitled: *A Strategy for the Permanent Preservation of the Corbis-Bettmann Photographic Collections*. Among the key recommendations in the report were that the collection be placed in sub-zero storage as quickly as possible, and that this could best be accomplished by moving the collection out of New York City to the Iron Mountain/National Underground Vital Records Facility, where a suitable humidity-controlled cold storage facility could be constructed for the collection. After considering a range of possible alternatives, Corbis management accepted the plan as the best long-term solution – and also the most cost-effective solution – to the permanent preservation of this historically, culturally, and technologically important collection. The official opening of the new humidity-controlled, sub-zero Corbis Film Preservation Facility took place on April 26, 2002. Henry Wilhelm continues to advise Corbis on preservation and handling issues related to the collection.
6. Steve Davis, President and CEO of Corbis, personal communication with the author, February 27, 2004.
7. Henry Wilhelm and Carol Brower (contributing author), *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures,* Preservation Publishing Company, Grinnell, Iowa, 1993. The entire 758-page book or any of the book's 20 individual chapters are available in Adobe Acrobat PDF format and may be downloaded at no cost from: <www.wilhelm-research.com>. See especially Chapter 9: *The Permanent Preservation of Color Motion Pictures,* pp. 299–344, and Chapter 20: *Large-Scale, Humidity-Controlled Cold Storage Facilities for the Permanent Preservation of B&W and Color Films, Prints, and Motion Pictures*, pp. 687–726.
8. The estimates given here have been derived from data in *Evaluating Dye Stability of Kodak Color Products,* Kodak Publication No. CIS-50, January 1981, and subsequent CIS-50 series of dye-stability data sheets through 1985; *Kodak Ektacolor Plus and Professional Papers for the Professional Finisher,* Kodak Publication No. E-18, March 1986; *Dye Stability of Kodak and Eastman Motion Picture Films* (data sheets); Kodak Publications DS-100-1 through DS-100-9, May 29, 1981; *Image-Stability Data: Kodachrome Films,* Kodak Publication E-105 (1988); *Image-Stability Data: Ektachrome Films,* Kodak Publication E-106 (1988); and other published sources. For many products, including Process E-6 Ektachrome films; Vericolor III, Vericolor 400, Kodacolor VR, Kodacolor Gold (formerly Kodacolor VR-G), Kodak Gold, and Kodak Gold Plus color negative films; and Eastman color motion picture films, storage at 60% RH will result in fading rates of the least stable dye (yellow) approximately twice as great as those given here for 40% RH; that is, the estimated storage time for reaching a 10% dye-density loss will be cut in half. Furthermore, the dye stability data given here were based on Arrhenius tests conducted with free-hanging film samples exposed to circulating air. Research published by Eastman Kodak in late 1992 showed that storing films in sealed or semi-sealed containers (e.g., vapor-proof bags and standard taped or non-taped metal and plastic motion picture film cans) could substantially increase the rates of dye fading and film base deterioration. Therefore, the estimates given here for color motion picture films probably considerably overstate the actual stabilities of the films when they are stored in standard film cans under the listed temperature and humidity conditions. See: A. Tulsi Ram, D. Kopperl, R. Sehlin, S. Masaryk-Morris, J. Vincent, and P. Miller [Eastman Kodak Company], "The Effects and Prevention of 'Vinegar Syndrome'," presented at the 1992 Annual Conference of the Association of Moving Image Archivists (AMIA), San Francisco, California, December 10, 1992.
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Paper by Henry Wilhelm (Wilhelm Imaging Research, Inc.) with Ann C. Hartman, Kenneth Johnston, and Els Rijper (Corbis) and Thomas Benjamin (Iron Mountain/National Underground Storage Vital Records), entitled: "High-Security, Sub-Zero Cold Storage For the PERMANENT Preservation of the Corbis-Bettmann Archive Photography Collection" appeared on pages 122–127 in:

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