9. The Permanent Preservation of Color Motion Pictures

Low-Temperature, Humidity-Controlled Storage of Original Camera Negatives, Color Reversal Originals, Laboratory Intermediates, and Release Prints Is the Only Viable Way to Keep Color Motion Pictures Unchanged for Many Hundreds or Even Thousands of Years

"Nothing really lasts outside the world of art. Most societies are not remembered for their politics or their commerce, but for their composers and artists. America will be remembered for its movies."[1]

Michael Eisner, chairman
Walt Disney Company – April 16, 1982

"For a medium that gives every promise of living forever, the cinema is actually among the most fragile of art forms. It's commonly believed that at least half of all theatrical films made before 1950 have vanished forever. For the silent period (roughly 1893 to 1930), the ratio of lost films may climb to 75 percent or higher.

"*Remodeling Her Husband* (1920), the only film directed by Lillian Gish, is lost. So is *The Divine Woman* (1928), starring Greta Garbo. *The Rogue Song* (1930), a Technicolor feature directed by Lionel Barrymore and featuring Laurel and Hardy, has disappeared with hardly a trace. And so has that snappy, racy, pre-Code comedy *Convention City* (1933), starring Joan Blondell. D. W. Griffith's *That Royal Girl* (1926) with W. C. Fields is among the missing, as are *London After Midnight* (1927) with Lon Chaney, *Cleopatra* (1917) with Theda Bara, *Legion of the Condemned* (1928) with Gary Cooper and Fay Wray, and hundreds upon hundreds of mouth-watering titles from the relatively recent past."[2]

Frank Thompson
American Film – August 1991

"I don't know if it's worth trying to prevent further deterioration with most of these films because they are usually in such poor condition when they arrive here."[3]

Stanley Yates, curator
The American Archives
of the Factual Film – 1979

"We are presently presenting the only 35mm print 'in service' of the 1963 Academy Award winner, *Tom Jones,* 'Color by DeLuxe.' The vivid greens that were so vital to the marvelous photography of this film, that remain in the memory of those of us who saw it in 1963, are now just that: a memory. The whole damn thing has turned fire engine red. Tom Jones is now romping across a red countryside under pink skies. Thank you Eastman Kodak."[4]

Jack Tillmany
Gateway Cinema, San Francisco
April 23, 1980

See page 301 for Recommendations

"The visual record of twentieth century America is fading faster than our memories."[5]

Frank Hodsoll, chairman
National Endowment for the Arts
January 14, 1983

"The movie companies are like oil producers. Their backlog, or film libraries, are worth more money in the future, like oil and gas reserves."[6]

Robert Lenzner
The Boston Globe – March 1, 1981

"[Not] many people recognized how valuable film libraries would be prior to the commercial success of television during the 1950's and 60's. That created an enormous market for syndicating films. The same process was repeated with the rapid spread of VCR's and laser disk players around the world during the 1980's. Today, there are many new channels of distribution for television programming in the U.S. and in other parts of the world. The privatization of television industries in many countries is creating a demand for more programming. During the remaining 1990's, we anticipate the opening of new markets in developing countries. There are many people all over the world who have never seen thousands of movies and TV programs produced in the Western world.

This doesn't begin to address the future needs of HDTV. As we start to see an increase in the numbers of HDTV sets, VCR's and laser disk players during the 1990's, there will be a demand for software with strong entertainment and production values. The value of assets currently stored in Hollywood's film, videotape and magnetic sound libraries is incalculable. We think it is important for us to assist in protecting those assets."[7]

Joerg D. Agin, vice president
Motion Picture and Television Imaging Division
Eastman Kodak Company
Hollywood, California – May 1992

". . . Disney home video is awash in profits. In 1992 the division will have revenue of $1.1 billion. The arithmetic is simple but remarkable: The *Beauty and the Beast* videocassette carries a suggested retail price of $24.99 and wholesales for about $13.50. With [a record] 20 million units, the revenue to the company will be $270 million. Each videocassette costs about $2 to manufacture and perhaps $2 to market. So Disney's profit is $200 million in the U.S. alone."[8]

Richard Turner
The Wall Street Journal
December 24, 1992

October 1992

The color film storage vault in the Paramount Pictures Film and Tape Archive, located on the Paramount studio lot on Melrose Avenue in Hollywood, California. The color film vault, one of nine vaults in the high-security building, is maintained at 40°F (4.4°C) and 25% RH. The Paramount archive, which was Hollywood's first adequate preservation facility for color motion pictures, went into operation in June 1990. Shown here working in the color film vault, which is equipped with movable shelving to conserve space, is Robert McCracken, a supervisor in Archive Operations. McCracken and Bill Weber, director of Operations Resources at Paramount, manage the operation of the multi-million dollar, 40,000-square-foot facility. At the time this book went to press in 1992, Warner Bros. was the only other Hollywood studio to have adequate cold storage facilities for its motion picture library (the new Warner Bros. film archive is described later in this chapter).

"Under [the] agreement, Turner keeps only MGM's 3,000-film library. In effect, Turner is paying $1.2 billion for the library. . . . The company has said it intends to use the MGM films in programming its WTBS station and a possible new cable television network. Ted Turner, chairman and chief executive officer, has said he expects revenue from the MGM library to provide the company with cash flow of about $100 million a year."[9]

Michael Cieply and John Helyar
The Wall Street Journal
June 6, 1986

"The problem of color fading in film has reached a crisis point and can no longer be ignored. The instability of Kodak color stock is causing irreparable damage to our films and the films we have made in the past are deteriorating drastically or are irretrievably lost. We must find the solution to this problem, not only to eliminate this threat to present films, but to salvage those made in the past that are not beyond help. Since Eastman Kodak is the single largest manufacturer of color film in the world, and the chief source for motion picture film stock, your company must be held accountable for the color instability flaws inherent in the stock. . . . This existing 'flaw' is destroying our work."[10]

Martin Scorsese, film director
Petition sent to Eastman Kodak and signed
by hundreds of film directors and others
in the movie industry – June 12, 1980

"Dyes fade, colors fade, but our motion picture heritage is not necessarily threatened by this fact."[11]

Henry Kaska, spokesman
Eastman Kodak Company
April 17, 1981

". . . after only five years the blue is leaving the waters of *Jaws* while the blood spurting from Robert Shaw's mouth gets redder and redder."[12]

Steven Spielberg, film director
November 26, 1979

Recommendations

• Motion Picture Camera Negative Films

Recommended as the Longest Lasting:

Fujicolor Negative Film F-64, 8510 and 8610
Fujicolor Negative Film F-64D, 8520 and 8620
Fujicolor Negative Film F-125, 8530 and 8630
Fujicolor Negative Film F-250, 8550 and 8650
Fujicolor Negative Film F-250D, 8560 and 8660
Fujicolor Negative Film F-500, 8570 and 8670
Eastman Color Negative Film 7291
Eastman EXR 500T Color Negative Film 5296 and 7296

• Laboratory Intermediate Films

Recommended as the Longest Lasting:

Fujicolor Intermediate Film 8213 and 8223

Should Be Avoided (Very Poor Dye Stability):

Eastman Color Reversal Intermediate Film 5249 and 7249 (CRI film)

• Motion Picture Color Print Films

Recommended as the Longest Lasting:

Fujicolor Positive Film LP 8816 and 8826

Secondary Recommendations:

Eastman Color Print Film 5384 and 7384
Eastman Color LC Print Film 5380 and 7380

Should Be Avoided (Very Poor Dye Stability):

Agfa Print CP1 Color Print Film
Agfa Print CP10 Color Print Film

Preservation of Original Camera Negatives, Color Reversal Originals and Duplicates, Laboratory Intermediates, and Release Prints

- **Low-temperature, humidity-controlled storage is the only viable method of permanently preserving color motion pictures.** A temperature of 0°F (–18°C) or lower and a relative humidity of 30% are recommended for the long-term storage of all valuable camera color negatives, color reversal originals and duplicates, laboratory intermediates, and release prints. Extrapolations from accelerated aging tests indicate that color films stored under these conditions may be expected to last for more than a thousand years — essentially forever — with negligible change. Institutions preserving film with humidity-controlled storage at 0°F (–18°C) include the National Aeronautics and Space Administration (NASA) in Houston, Texas (color motion picture film and still photographs made during space flights), the John Fitzgerald Kennedy Library in Boston (color motion pictures and still photographs made during the Kennedy years), and the Jimmy Carter Library in Atlanta, Georgia (color motion pictures and still photographs related to the Carter presidency). The advanced motion picture preservation facility to be completed in 1996 in Gatineau, Quebec by the National Archives of Canada's Moving Image, Data and Audio Conservation Division will also operate at 0°F (–18°C) and 25% RH. It is particularly important to immediately place in low-temperature storage films that already show evidence of fading, as well as all films that are known to have inherently poor stability. This includes nearly all color films manufactured before 1982–86, as well as some current products. See Chapter 20 for discussion of cold storage facilities.

- **Moderate-temperature, humidity-controlled storage at about 40°F (4.4°C) and 25–40% RH** is satisfactory for preserving unfaded materials made on the comparatively stable film stocks recommended above for periods of perhaps 300 years. The Records Center of Kansas City and National Underground Storage, Inc. of Boyers, Pennsylvania currently offer high-security storage at moderate cost that meets these temperature and humidity requirements. Eastman Kodak will offer rental storage space in its new Hollywood film preservation vaults beginning in 1993; two storage temperatures will be available: 45°F (7.2°C) and 25% RH, and 32°F (0°C) and 25% RH. Other commercial storage facilities are expected to offer similar services in the future. Paramount Pictures constructed a film archive in Hollywood in 1990 in which all of Paramount's color negatives and intermediates are preserved at 40°F (4.4°C) and 25% RH. Warner Bros. opened a large cold storage facility in 1992 which includes color film storage vaults maintained at 35°F (1.7°C) and 25% RH.

- **Packaging films for long-term storage in humidity-controlled cold storage facilities:** Color and black-and-white motion picture films should be placed in "vented" plastic cans (e.g., the vented polypropylene film cans available from the Plastic Reel Corporation of America in Lyndhurst, New Jersey) or in high-quality, vapor-permeable cardboard containers. Because storage in standard metal and plastic film cans (taped or untaped), vapor-proof bags, and other sealed or semi-sealed containers will increase the rates of both dye fading and film-base deterioration with acetate-base films, such containers are not recommended for the long-term storage of motion picture films. To prevent contamination of films stored in "vented" film cans, it is necessary that the air in the storage area be filtered so as to be completely free of dust, lint, or other particulate matter.

- **Storage of film packaged in vapor-proof bags in refrigerated vaults with uncontrolled humidity conditions is not recommended.** Not only could the film be damaged or destroyed because of a small puncture or seal failure that may go unnoticed for years, but the cost of bags, pre-conditioning equipment, and the substantially increased labor required by this approach will in the end cost far more than controlling the humidity in the storage area. In addition, sealed or semi-sealed containers will increase the rates of dye fading and film-base deterioration with acetate-base films.

- **Motion picture films should be stored in a horizontal position,** with not more than eight cans stacked one on top of another.

- **Black-and-white separations (YCM's) are not recommended for the long-term preservation of color motion pictures.** Compared with low-temperature storage of original color negatives, intermediates, and prints, separations are extremely costly, entail potentially large losses of image quality, do not provide a visual reference for density and color balance, will become difficult or even impossible to print satisfactorily in the future when current film stocks are obsolete, and, when stored along with the originals, require four times the storage space of the originals alone. Further, because of the inherently unstable nature of silver images coupled with the limited life of the cellulose triacetate base of most motion picture separation films stored in typical room-temperature conditions, separations will not last nearly as long as original color materials in low-temperature, humidity-controlled storage.

- **If black-and-white separations are made, Eastman Panchromatic Separation Film SO-202 (polyester-base) is recommended.** Under normal storage conditions, the polyester base of SO-202 film will last much longer than the cellulose triacetate base of Eastman Panchromatic Separation Film 5235 (which for many years has been the only separation film used by the major studios). In addition to superior permanence, polyester-base films also have much better dimensional stability than triacetate-base films. This is an important consideration because separations must remain in exact registration if color fringing and loss of image sharpness are to be avoided in future printings.

- **Existing black-and-white separations made from older films are very valuable,** however, because the original color negatives from which they were made almost certainly have faded significantly during storage under typical film-industry conditions. To preserve separations, they should be placed in humidity-controlled (20–30% RH), moderate- or low-temperature storage. Normal room-temperature storage is not satisfactory for long-term storage of cellulose triacetate separations (especially if the relative humidity is above 40% for long periods of time). Pending further investigation, treatment of black-and-white separation films with polysulfide toner, selenium toner, gold chloride toner, or other image-protective treatment could not be recommended at the time this book went to press in 1992.

- **No matter how faded a particular film might be, it should never be written off as a total loss.** However, additional fading must be prevented in order to take best advantage of future digital image enhancement, grain reduction, and color restoration techniques. When severe fading has occurred, computer-aided "colorization" can be done, using the degraded magenta dye image that still survives in most faded motion picture color films as the basis for reconstruction of the color image. (Spectrophotometric analysis of maximum-density, minimum-density, and other parts of even a severely faded color image might yield significant information about the colors that originally were present.)

- **To take full advantage of the improved image quality offered by each new advance in video recording technology and television transmission systems** (digital video recording and analog and digital HDTV — high-definition television — are only the latest examples in a field that has witnessed almost constant technological change since the invention of video recording in 1956), one will have to go back to the photographic original for making video transfers each and every time an improved technology appears. With the widespread commercialization of HDTV during the late 1990's, the entire holdings of film libraries worldwide will once again have to be transferred to tape (and/or optical disk). Image quality demands will be higher than ever, and to deliver the best-quality product at the lowest possible cost, it is essential that negatives, film intermediates, and release prints be preserved in essentially unchanged condition.

- **For now and for the foreseeable future (probably the far distant future),** analog and digital videotapes, optical disks, digital image data tapes (whether or not linked to high-resolution digital film systems), and other digital or analog electronic image-storage systems cannot be considered to be viable alternatives to the long-term preservation of color photographic originals.

- **For the permanent preservation of productions originated on videotape,** the videotapes should be transferred to color negative film, and prints of the best possible quality should be made. The color negative, at least two prints, and the original videotape itself should be placed in low-temperature storage.

- **To prevent total loss of valuable films in the event of earthquake, fire, flood, tornado, theft, damage during transportation or laboratory handling, or other disaster,** the various film elements made during the course of a production should be divided between low-temperature, humidity-controlled facilities at two different geographic locations. For example, one facility should be selected to store the original conformed color negative, duplicate color negative or CRI, sound cut negative and/or magnetic master, any important outtakes, and at least one mint-condition release print (as well as a copy of each foreign-version release print). This facility would serve as a high-security "dead storage" that would not normally need to be accessed; it would be the ultimate backup should a film element in the second facility be lost or damaged. The second storage facility should be close to production and laboratory operations; it is the film elements in this facility that would normally be accessed for television transmission, videocassette and videodisc production, or theatrical re-release. This approach has been followed by NASA for permanent preservation of the color photographs made during the first manned mission to the surface of the moon in 1969, as well as other still photographs and color motion pictures documenting the U.S. space program.

- **Preservation in low-temperature storage of at least two release prints of every version of a film** (i.e., two prints each of both domestic and foreign versions) should be the central focus of all film preservation programs. One print can be used to produce videotape masters directly, and it can also serve as a timing reference print for assessing color balance and density when making new prints or video transfers from duplicate negatives. At some point in the future, because of changes in the characteristics of film stocks or the abandonment of film altogether, it may not be possible to make prints directly from the negatives now in film archives, and the availability of release prints in good condition will become crucial. The other preservation print should be kept in dead storage at a separate geographic location and not touched unless absolutely necessary (i.e., should the other print be damaged or destroyed).

- **Motion pictures in museums, archives, and film libraries should never, ever be projected.** Likewise, prints should not be routinely viewed on Steenbecks or similar equipment. These films must be preserved — saved so they can serve as printing masters for whatever film and electronic reproduction media emerge in the future. The current practice of some of the leading film archives and other collecting institutions around the world of screening original color and black-and-white prints must stop. Original prints are not expendable films to be viewed and thereby damaged for the pleasure of curators and filmgoing audiences who like to see "the real thing."

- **For viewing and study purposes, videotape copies should be made from prints;** for projection, duplicate prints should be made from a color internegative (Eastman Color Internegative Film 5272 is suitable for this purpose).

- **The American Film Institute, in conjunction with the Library of Congress,** should administer carefully designed, low-temperature, humidity-controlled storage facilities at two separate geographic locations for the long-term preservation of color and black-and-white motion pictures and videotapes. Separate areas, isolated from other storage buildings, should be provided for Technicolor nitrate prints and negatives and other nitrate motion pictures. The high-security facilities should offer low-cost storage services for commercial studios, motion picture and videotape libraries, museums, and archives.

Only In Recent Years Has the Long-Term Value of Film Libraries Begun to Be Understood

It has been only since the mid-1970's, with the advent of large-scale re-release of movies on videocassette, video-disc, cable and satellite TV, and regular network television, that the entertainment film industry has developed a genuine appreciation of the cultural significance — and, much more important to the film studios, the monetary value — of the motion pictures in their film libraries.

In 1991, the U.S. motion picture industry grossed $4.8 billion from the almost one billion movie theater tickets sold in the United States,[13] with additional billions of dollars coming from foreign distribution, licensing to TV, videocassette, video games, and other non-theatrical revenue.

More than 400 feature films released in the U.S. in 1991, not including movies made for television (among the 1991 releases, 150 were from the major studios and 23 films were reissues of earlier productions). There were more than 23,000 motion picture screens in the country, the largest total ever; more than half show first-run features. A typical feature film requires over 8 million feet of color negative and print film, and a major release may require more than twice that much.

According to the entertainment weekly *Variety*, the retail home video market in the U.S. brought in an estimated $3.8 billion to the motion picture studios and other suppliers in 1991.[14] The homevideo business has grown explosively during the past decade; with more than 60,000 outlets in the U.S. that sell or rent videotapes, the gross revenue of the homevideo business is now more than *twice* that taken in by movie theater ticket sales. About 300 million pre-recorded video cassettes were manufactured in 1991.

The majority of the programs on prime-time television are still originated on film. An average one-hour action-adventure television program involves 80,000 feet of color negative and print film; there are about 800 such shows produced each year.

Most motion pictures are now made with color negative films, such as Eastman EXR Color Negative Film 5245, Fujicolor Color Negative Film F-125, and Agfa XT 100 Colour Negative Film, which are in key respects similar to still-camera color negative films such as Kodak Gold and Ektar films, Fujicolor Super HG, and Agfacolor XRS films.

For distribution and projection, the negatives are printed on motion picture "print films" such as Eastman Color Print Film 5384 and similar print films made by Fuji and Agfa. Or, in the case of much of the filming now being done for television, the original camera negative is transferred to videotape for editing and other post-production work and subsequent broadcast.

With video having replaced motion picture film in most commercial, industrial, and educational applications, the market for reversal motion picture films has shrunk substantially in recent years and is now mostly limited to 16mm and 8mm films requiring only a single copy for viewing or a small number of copies for distribution.

Not long ago, a major market for 16mm color reversal motion picture films was television news and documentary production; since the late 1970's, however, virtually all television news footage has been originated on videotape. Among amateurs, the wildly popular video camcorder has made 8mm home movies a thing of the past. Now, many people are having all of their old 8mm home movies transferred to videotape so they can view them on their television screens.

Kodak sells most of the motion picture film used in the United States — industry observers estimate that the company currently has more than 75% of the domestic market. However, Fuji of Japan has been gaining an increasing share of the theatrical and television market in North America and sells a substantial amount of film in Asia and Europe. Agfa-Gevaert is the only other significant producer of color motion picture film in the Western world.

Making Movies Is Costly, But the Earnings Can Be Immense

Major theatrical films cost a great deal to make — the average production cost for a feature film in 1991 was a little over $26 million, with perhaps an additional $10–15 million to cover advertising and distribution expenses. Some recent films have cost much more: Arnold Schwarzenegger's 1991 science-fiction action movie *Terminator 2* (a Carolco production released by TriStar, a unit of Columbia Pictures, which is in turn owned by Sony Pictures Entertainment) had a record-breaking production cost of around $95 million; the film had grossed more than $200 million in North America by the end of 1991. Of that amount, more than $112 million went back to the studio in rental fees.

The most successful movies can earn a staggering amount: by the end of 1991, Steven Spielberg's 1982 film *E.T. The Extra-Terrestrial* had grossed an estimated $360 million in the U.S. and Canada alone, with many millions more coming in from foreign markets.

By the end of 1991, according to the entertainment publication *Variety*, ten other movies in addition to *E.T.* had grossed more than $200 million from theater ticket sales in domestic markets:[15] *Star Wars* (Fox, 1977) with $323 million gross and earning $194 million in theater rental fees; *Home Alone* (Fox, 1990) with $282 million gross and earning $140 million, which makes the film the top-grossing comedy of all time; *Return of the Jedi* (Fox, 1983) with $264 million gross and earning $168 million; *Batman* (Warner Brothers, 1989) with $251 million gross and earning $151 million; *Raiders of the Lost Ark* (Paramount, 1981) with $242 million gross and earning $116 million; *Beverly Hills Cop* (Paramount, 1984) with $235 million gross and earning $108 million; *The Empire Strikes Back* (Fox, 1980) with $223 million gross and earning $142 million; *Ghost* (Paramount, 1990) with $217 million gross and earning $98 million; *Ghostbusters* (Columbia, 1984) with $214 million gross and earning $133 million; and *Terminator 2* (TriStar/Columbia, 1991) with $204 million gross and earning $112 million in theater rental fees.

Other films from 1991 that did very well at the box office included *Robin Hood: Prince of Thieves* (Warner Bros.) $86 million in rentals at the end of 1991; *City Slickers* (Columbia) $61 million in rentals; the Academy Award winner *The Silence of the Lambs* (Orion) $60 million; *The Addams Family* (Paramount) $55 million; *Sleeping With the Enemy* (Fox) $46 million; *Cape Fear* (Universal) $32 million; *Star Trek VI: The Undiscovered Country* (Paramount) $32 million; *Boyz N the Hood* (Columbia) $27 million; *New Jack*

Carol Brower 1987 (2)

With the great majority of the households in the United States now having videocassette recorders (VCR's), the videocassette business has underscored the need to properly preserve color and black-and-white films. Practically every film of note, and many of lesser distinction, have been released on videocassette. Cable and satellite TV have further fueled the demand for old movies. When high-definition television broadcasting, cable, VCR's, and videodisc players become commonplace in the late 1990's, producers will have to go back to their film originals to make new full-frame, high-resolution video transfers; to take full advantage of each major improvement in TV technology, the film-to-tape transfer process will have to be repeated.

City (Warner Bros.) $22 million; *Thelma & Louise* (MGM/UA) $20 million; *The Fisher King* (TriStar/Columbia) $18 million; and *JFK* (Warner Bros.) $14 million in rentals at the end of 1991.

Walt Disney estimated that following the 1987 re-release of *Snow White and the Seven Dwarfs,* the film had earned more than $62 million. This was the seventh re-release of the then 50-year-old animated film; Disney has been re-releasing many of its cartoon features on a 7-year cycle (figuring that a new generation of children would be ready to see them) since they were made. Another Disney animated film, *101 Dalmatians*, has earned Disney more than $68 million in theater rental fees since it was first released in 1961, making it the most successful animated film of all time. Many millions of dollars more were earned from videocassette sales.

In a *Variety* story about Disney's 1991 animated feature *Beauty and the Beast,* Charles Fleming reported:

> When "Beauty and the Beast" stops earning money at the box office, it will probably be the industry's most profitable movie of the year.

The Video Shack store near Times Square in New York City is one of the largest videocassette rental and sales outlets in the world. In 1987, for the first time, nationwide revenue from videocassette rentals and sales exceeded that of theater ticket receipts in the United States.

> After an estimated production cost of $25 million, and advertising and release costs of another $10 to $15 million, the film will wind up with box office totals of $120 million. That leaves the studio with cash profits, before ancillary markets are taken into account, of about $30 million. When videocassette sales are figured in, and unit sales exceed 10 million, add another $100 million in revenue to [Disney].[16]

The Rocky Horror Picture Show (Fox) has earned over $37 million in rentals from its almost continuous midnight showings around the U.S. since its release in 1976.

Most films, of course, do not earn as much as the box office hits, but following or even simultaneous with theater release, expanding aftermarkets such as videocassettes, cable TV, satellite TV, and videodiscs give most major features a very long potential market life. The most popular movies, such as *Casablanca* and *Gone With the Wind,* probably will have an indefinite appeal.

Motion Picture Films Generally Are Stored Under Poor Conditions

Considering the cost of making and marketing a major feature — and its potential earnings over the years — it is often astonishing to see how poorly most films are cared for. It is difficult to think of another industry that does so little to protect its most valuable assets. Although the major studios generally make black-and-white separation positives (YCM's) from the original color negatives of their most valuable features, only Paramount Pictures and Warner Bros. had adequate cold storage facilities for their film libraries at the time this book went to press in 1992. With only a few exceptions, separations have not been made for television productions, and cold storage is almost never provided for such films.

The great majority of films — whether made for documentary, educational, advertising, scientific, or television news purposes — are stored at normal room-temperature conditions or worse, and their eventual life will be dictated by the dye stability characteristics of the particular film stocks on which they were made.

Since 1894, when Thomas Edison, using cellulose nitrate film supplied by the Eastman Kodak Company, launched the commercial motion picture industry, the story of film preservation has been characterized by incredible neglect on the part of the moviemakers and general disregard for the importance of film-base and color-image stability on the part of Kodak and other manufacturers.

Institutional film archives in the United States — which, like those in most other countries, are ill-equipped and seriously underfunded — have generally done a poor job preserving nitrate film and have lost countless valuable movies through fires and failure to provide proper low-temperature, humidity-controlled storage.

Frank Hodsoll, a former chairman of the National Endowment for the Arts, gave a grim assessment of the situation in the United States:

> I was appalled to learn that one-half of the theatrical films produced before 1952 have already been irretrievably lost due to decay and neglect. Under present conditions, most of the remaining half will not survive this century.
>
> Of the 11,000 American feature films produced before 1930, less than one in five have escaped fire, decay, or destruction by other means.
>
> American films and American television have shaped, influenced, and substantially contributed to American Culture. Many believe that film is perhaps our most significant and most distinctive contribution to international art and culture.
>
> It is virtually impossible to conceive of a film that does not instruct us in the art, the social perspectives, and the history of a particular period. Every film is a time capsule which tells us how we saw ourselves, and how others saw us, at a point in our past. The disappearance of a film or videotape is therefore not only a loss of an artistic object, it is also partial obliteration of our nation's history.[17]

For More Than 30 Years, Eastman Color Films Suffered from Very Unstable Color Images

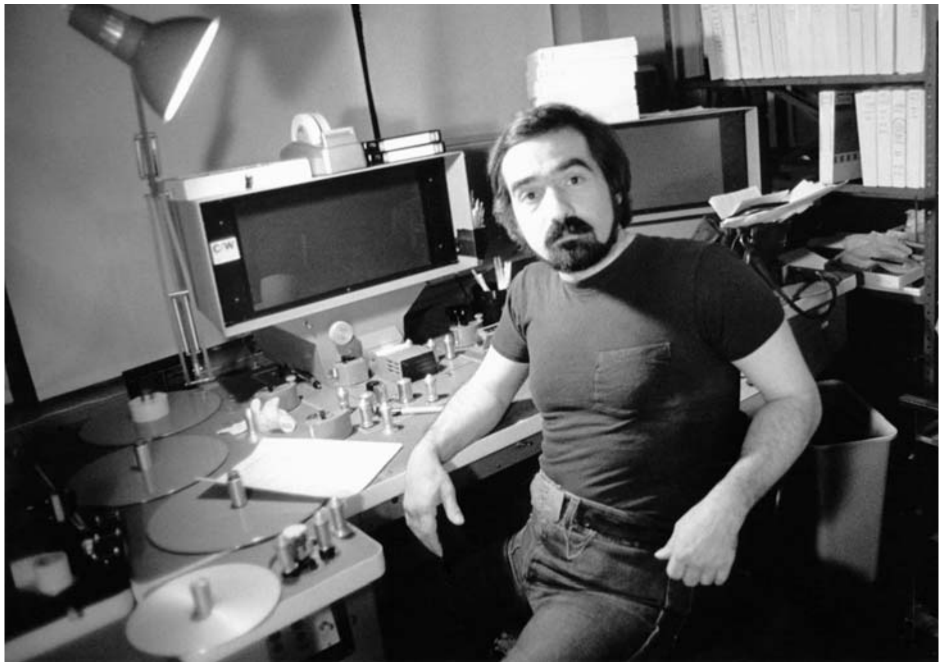
In 1950, almost simultaneously with the introduction of cellulose triacetate "safety base" film as a replacement for the hazardous cellulose nitrate film then being used by the motion picture industry throughout the world, Eastman Kodak launched the first of the Eastman Color Negative and Eastman Color Print films. These films quickly led the way to the mass conversion from black-and-white to color cinematography.

With that change came the demise of the essentially permanent Technicolor imbibition printing process (see Chapter 10) — leaving the industry with Eastman Color negative and print films, which under typical storage conditions had a far shorter life than films made by the Technicolor process.

The color fading problem was made worse by the fact that neither the movie studios nor film archivists had any clear idea of what they were dealing with and how the film had to be stored to preserve it for the future — the fading characteristics of the color films they were using and collecting were a closely held secret of Kodak and the other film manufacturers.

This sad state of affairs continued until the mid-1970's, when a series of events began that ultimately forced Kodak to abandon its policy of secrecy regarding color stability and to announce, in August 1980, that it would release information on light fading and dark-storage stability of its current and future color products. This in turn, for the first time, introduced competition in the area of color image stability among Eastman Kodak, Fuji of Japan, and Agfa-Gevaert of Germany, the major producers of color motion picture stocks in the Western world, and has already led to substantial improvements in the stability of both Kodak and Fuji motion picture print films as well as certain of their color negative products.

An important influence was a major article on the fading of color motion pictures by Bill O'Connell that appeared



July 1980

Martin Scorsese, a leader in the drive to preserve color motion pictures, has directed **Mean Streets** (1973); **Alice Doesn't Live Here Anymore** (1975); **Taxi Driver** (1976); **New York, New York** (1977); **Raging Bull** (1980); **The King of Comedy** (1983); **The Color of Money** (1986); **The Last Temptation of Christ** (1988); **Goodfellas** (1990); **Cape Fear** (1991); and **The Age of Innocence** (1993).

in the September–October 1978 issue of *Film Comment* magazine. O'Connell began:

> The house lights dim, a hush comes over the expectant audience, and a beam from the projection booth hits the screen. But the old film, so clear in a buff's memory, looks to have deteriorated before his eyes — and memory is not at fault. What was once a color film is now a jarring mixture of faded dyes in a spectrum that runs from dull, muddy pink to deep, garish purple. The sunny, windswept fields of *Oklahoma!* have turned an eerie, strident pink. Marilyn Monroe looks jaundiced. The florid gold and pastel palace in *The King and I* is now a drab, dusky rose.
>
> . . . Color fading threatens all films, and there is a growing awareness that it has not only reached epidemic proportions but has passed all other problems of film preservation.[18]

The following month, in another important article that appeared in *American Film* magazine, Paul Spehr of the Library of Congress wrote:

> Whatever the aesthetic importance of this basic change in moviemaking [the shift from black-and-white to color], potentially it is a tragedy.
>
> Why? Because the color dyes used in today's movies are so impermanent that there is little hope that the quality of color we are experiencing today will be passed on to the next generation. The hard, harsh fact is that most of the color films made since the mid-fifties will fade to indistinguishable — or at least undistinguished — shadows of their former glory.
>
> Even the precious negatives from which the films are printed have a limited life expectancy. Under the storage conditions generally in use today, many of these negatives will fade to uselessness within the lifetimes of most of us.[19]

Both the *American Film* and *Film Comment* articles included a brief account of the Technicolor dye imbibition process and showed unfaded Technicolor frames along with severely faded frames from Eastman Color prints.

Film Director Martin Scorsese Alerts the Entire Film Industry to the Fading Problem

After reading Bill O'Connell's article in *Film Comment,* film director Martin Scorsese wrote a letter to the magazine which said, in part:

> How can we sit back and allow a classic film, *2001: A Space Odyssey,* to fade to magenta? My own work has been severely affected, in that *New York, New York* was made to look like a Technicolor imbibition film. Within five years, its color will have faded beyond any recognition of the original concept, and the film will suffer for that loss. My present film, *Raging Bull,* was shot in black-and-white to avoid the color problem entirely.
>
> . . . I believe that directors, film students, and the Academy must form a unified front to combat the problem. Through benefits, fundraising, publicity, demonstration of the problem, and if need be, militant action, we must band together to face the issue and solve the problem. I personally offer my services, time, and finances to this cause, in an effort to motivate my colleagues and friends to action.[20]

The July 9, 1980 edition of **Variety,** the entertainment industry publication, featured a front-page story by Harlan Jacobson on the color film fading crisis. The **Variety** story, as well as many others that appeared in newspapers, magazines, and on television worldwide, was inspired by Martin Scorsese's campaign.

In early 1980, Scorsese, with the assistance of Mark del Costello and Donna Gigliotti of his staff and Scorsese's long-time film editor Thelma Schoonmaker, started circulating a petition asking Kodak to make permanent color motion picture film. The petition was sent to directors, actors, actresses, cinematographers, film archivists, and others in the field. Scorsese had a number of ideas for promoting the preservation of films and to pressure Kodak and other manufacturers to make more stable films (see **Appendix 9.1** on pages 343–344 at the end of this chapter).

Scorsese, the well-known director of *Mean Streets* (Warner Bros., 1973); *Alice Doesn't Live Here Anymore* (Warner Bros., 1975); *Taxi Driver* (Columbia, 1976); *New York, New York* (United Artists, 1977); *Raging Bull* (United Artists, 1980); *The King of Comedy* (Fox, 1983); *The Color Of Money* (Touchstone, 1986); *The Last Temptation of Christ* (Universal, 1988); *Goodfellas* (Warner Bros., 1990); *Cape Fear* (Universal, 1991); and *The Age of Innocence* (Columbia, 1993), has many friends in the movie business and the response to his appeal was immediate and overwhelming.

More than 200 people associated with the theatrical motion picture industry signed the petition, including Saul Bass, Bernardo Bertolucci, Peter Bogdanovich, Stan Brakhage, Kevin Brownlow, Ellen Burstyn, Vincent Canby, John Cassavetes, Michael Cimino, Jill Clayburgh, Francis Ford Coppola, Judith Crist, George Cukor, Robert DeNiro, Brian DePalma, Mia Farrow, Federico Fellini, Jane Fonda, Milos Forman, Jodie Foster, Ben Gazzara, Jean-Luc Godard, Elia Kazan, Sergio Leone, George and Marcia Lucas, Sidney Lumet, Leonard Maltin, Malcolm McDowell, Liza Minelli, and Paul Newman.

Also signing were Jack Nicholson, Joseph Papp, Arthur Penn, Sydney Pollack, Otto Preminger, Burt Reynolds, Gina Rowlands, Telly Savalas, Thelma Schoonmaker, Paul Schrader, Steven Spielberg, Mary Steenburgen, Barbra Streisand, Lily Tomlin, Francois Truffaut, King Vidor, Lina Wertmuller, Irwin Winkler, William Wyler, and many other directors, producers, actors, actresses, and film critics.

A letter written by Scorsese accompanied the petition:

> To My Friends and Colleagues:
> RE: Our Films
> Everything We Are Doing Now Means Nothing!
>
> All of our agonizing labor and creative effort is for nothing because our films are vanishing. I am not referring to the terrible problem of black and white film deterioration with which many of you are already familiar, but to something more immediate — FADING COLOR. . . . Working with film stock that is guaranteed to deteriorate in a matter of months is insulting and insane. . . .
>
> Eastman Kodak, through their total monopoly in the United States and many other parts of the world, will be responsible for the destruction of our past and current work. They are betraying us and will have to account for the conscious perversion of the future history of cinema. . . .
>
> The most practical preservation and economic solution is developing a COLOR STABLE FILM. So, if you care about your work and its future, then, for its sake, please lend your name and support. Attached is a letter to Eastman Kodak, petitioning them to take immediate action to rectify the deplorable state of the color film they supply.
>
> . . . As a first step, please join us in signing.[21]

Accompanying the petition, which was sent to Kodak in June 1980, was a "Request for Information," which is printed in full below.[22] This 2-page document had a major impact at Kodak and spurred the company to re-evaluate the importance of good image stability in the design of its color motion picture films.

Scorsese's militant approach and sometimes strident language made many curators and archivists uneasy. Some curators had never really come to grips with color motion pictures from an aesthetic point of view — instead prefer-

Mark del Costello – July 14, 1980

Pressing his demands that Kodak improve the stability of its color motion picture products and release stability data for all of its color films, director Martin Scorsese and his assistants, Mark del Costello and Donna Gigliotti, met in Scorsese's New York City apartment on July 14, 1980 with Ken Mason and Tony Bruno of Kodak's motion picture division. Scorsese, with the aid of his staff and his long-time film editor, Thelma Schoonmaker, were the leaders in a film-industry effort to force Kodak to address these issues. One month after the meeting, Kodak announced that it would make stability data public. In October 1981, Kodak announced that it was abandoning all of its existing motion picture color print films and replacing them with Eastman Color Print Film 5384 (35mm) and 7384 (16mm). These new films, supplied at no additional cost, were approximately ten times more stable than the films that they replaced. Fuji soon followed with its improved color print film. In 1987, Kodak presented Scorsese with its Career Achievement Award, in recognition of his outstanding achievements as a director and screenwriter.

ring the black-and-white films going back into the silent film era. Most had only a superficial understanding of the fading problem, how it came about, Kodak's part in creating the situation, and what might be done to solve the crisis. Some — who refused to sign the petition — even feared that associating with the Scorsese effort might hinder fund-raising efforts or alienate the film studios that were potential donors of films, money, or both, to their collections. Scorsese's "Request for Information" follows:

June 12, 1980

To: Mr. Walter Fallon, Chairman of the Board
Mr. Colby Chandler, President
Eastman Kodak Company
343 State Street
Rochester, New York 14650

Request for Information

1. We would like to have the estimated time of dark storage required for one or more of the color image dyes to reach a density loss of .10 from an original density of 1.0 when the film is stored in the dark at 75°F and 40% relative humidity for all present and past Eastman Kodak products, including camera negative stock, intermediate film stock and all release print stock.

This information is needed if we (filmmakers, studios, distributors) are to be able to determine the proper storage conditions (temperature and relative humidity) necessary to preserve each of these materials.

Further, the dark fading stability information is necessary if one is to make an intelligent choice among currently available products as to which film stocks and systems will result in the best long term keeping.

Finally, precise stability data is needed for all film stocks, especially the older materials which are no longer manufactured, in order to convince the studios and film archives of the urgent need to install cold storage vaults. Intelligent decisions about cold storage CANNOT be made unless the stability characteristics of each product are known.

Reacting to the outcry over the poor stability of Eastman Color motion picture films, the personnel at the Eastman Kodak booth during the 1980 annual conference of the SMPTE in New York City offered suggestions for proper storage of film and advocated making black-and-white separations.

2. How quickly can a PERMANENT color release print stock be produced, with quality and stability characteristics equal to or better than Technicolor Imbibition prints? A crash program in research and development will be needed, yet we believe that a color stable release print stock is achievable through current technology. The new LF print films, though a welcome improvement, are not stable enough to be acceptable.

3. How much research and development will Eastman Kodak invest into development of color stable pre-print material? For the present, we want all color pre-print material at the dark keeping stability level of E-6 Ektachrome films.

Kodak Officially Abandons Its Color Stability Secrecy Policy

Along with the petition and its signatories, the above document was probably the single most important factor forcing Kodak two months later to abandon its historic policy of secrecy regarding color stability. (The company, however, continued to keep stability data for its older color films secret, probably because the accumulated information would have made it plain that Kodak had devoted little attention to improving the stability of its products since Eastman color motion picture films were introduced in 1950 — in some cases later products were even less stable than the ones they replaced.)

Kodak also accelerated its efforts to develop new color couplers that would produce more stable dyes in its negative and print films, while at the same time avoiding any significant increase in manufacturing costs — or any major change in processing chemicals. This was important to Kodak since the company feared that even a slight rise in film costs would cause the company to lose a significant amount of the market to Fuji or Agfa-Gevaert. This was especially true in the highly competitive print film market. Kodak was well aware of the lack of concern about long-term permanence on the part of many movie producers and believed that many studios and labs would choose the cheapest product that produced acceptable images on the screen — regardless of who made it.

Scorsese's campaign received a tremendous amount of publicity in the press, with articles appearing in more than 300 newspapers and magazines in the United States and other countries. A front-page story in the July 9, 1980 entertainment industry weekly *Variety* was headlined: "Old Pix Don't Die, They Fade Away — Scorsese Helms Industry Plea to Kodak." While all the complaints about Kodak's films probably did not cause the company to lose any business, and Kodak repeatedly denied that there really was any problem if negatives "were stored as recommended," Kodak was certainly uneasy about the withering criticisms being leveled at the company and was sensitive to accusations that it was responsible for the loss of much of the world's film heritage.

Despite the fact that some of the charges against Kodak by Scorsese and others which appeared in the press were rather exaggerated — and in some cases actually incorrect — the thrust of the criticisms was valid:

(a) the stability of Eastman color motion print films was wholly inadequate;

(b) instead of being expendable, as Kodak maintained, prints were generally the only form in which films were being collected by archives around the world;

(c) the rapid fading of prints was causing moviemakers a lot of trouble and extra expense and was resulting in many very faded films being shown on television (since it was too expensive to make new prints from faded negatives — or from separations in the few instances where they were available — if the new prints would also fade away in a few years);

(d) the dye stability of camera negative and laboratory films was also inadequate, and, since few films would ever be stored under refrigerated conditions, this would result in the loss of the films in only a few more decades (with early Eastman color negatives already being seriously deteriorated);

(e) Kodak attached relatively little importance to long-term color stability of its motion picture films;

(f) Kodak was doing little to alert the industry to the need for better storage conditions (indeed, Kodak could not even talk about the subject meaningfully because it was keeping stability data secret and would not reveal the fading rate of any particular film at various temperatures and relative humidities).

Kodak Announces a Much Longer Lasting Color Print Film — Fuji Soon Follows

In October 1981, only a little more than a year after Kodak had received the Scorsese petition, the company suddenly announced that it was going to abandon all of its existing print films and would replace them with a new product, Eastman Color Print Film 5384 (35mm) and 7384

(16mm), which, according to Kodak, had an approximately ten-fold improvement in dye stability. The new print film came into general use in 1982–83.

In the course of the Scorsese campaign, Kodak also adopted a new attitude about the importance of print stability — especially in terms of the newly emerging videocassette and cable and satellite TV markets where only one print in good condition is needed for broadcast or cassette production. In the past, Kodak had maintained that prints were not intended to last long — most were physically worn out after 6 months or a year of theater projection. Kodak was persuaded that long print life was, after all, an important consideration in film design.

A brochure distributed by Kodak at the time the film was announced read, in part:

> **5384. A longer print life for your life's work.**
> Whatever you do in motion pictures — whether you're involved in producing or distributing — 5384 will mean a longer print life for your life's work.
>
> Prints stored at normal room temperature . . . at about 40-percent relative humidity . . . will provide excellent color pictures that will last for decades. Tests indicate that storage at a lower temperature, such as 55°F [12.8°C], could increase the useful life of your films by as much as five times.
>
> 5384. Created so the films in which you invest so much of yourself can live on.
>
> **5384. Eastman's continuing commitment to the motion picture industry.**
> Eastman Kodak Company has always appreciated the cultural value of motion pictures. We know what they mean, in America and around the world.
>
> So — while 5384 is new — our commitment to the preservation of motion pictures is longstanding.
>
> We've devoted years to the improvement of color dye stability. All the while we've invested in research. Made recommendations for proper film storage. Developed technical publications and information programs. Maintained a continual dialogue with those who share our commitment: the archivists, the technical societies, and professional associations.[23]

A full-page ad appearing in *American Cinematographer* in July 1983 was entitled "Our Descendants Will See Their Ancestors as We Really Were" and read:

> Throughout this ever-changing world, a filmmaker wants a production to last decades into the future. You want audiences fifty or more years from now to see your film as it looked originally.
>
> Eastman color print film 5384/7384 makes it possible with its exceptional color reproduction and retention. It is the color release print film intended to last up to a century — even when stored at normal room temperature (approximately 75 degrees Fahrenheit and 40-percent relative humidity). In fact, when 5384 is carefully stored under recommended conditions (40 degrees Fahrenheit and 40-percent relative humidity), it can last much, much longer.
>
> It is the print film whose color images can look the best and last the longest.
>
> Our new Eastman color print film's unique color images will last for decades so our descendants will see their ancestors as we really were. Just say, "Print mine on Eastman film."
>
> Eastman film. It's looking better all the time.[24]

Another ad for 5384, appearing in the January 1984 issue of *American Cinematographer*, read, in part:

> Whether you're involved in production or distribution, you'll be pleased to know that the film in which you have invested your time and talent can enjoy longer runs and wider audiences. Decades from now it can still have the crisp, bright colors of its world premiere exhibition.
>
> Order it by name — Eastman film.[25]

The new film, and the above ads — nothing like them had ever appeared before in the motion picture industry — ushered in a new era of concern about color film stability and started, for the first time, genuine competition on image stability among Kodak, Fuji, and Agfa-Gevaert.

A copy of Scorsese's petition was also sent to Fuji, and his appeal reportedly spurred the rapid development of new color couplers that would produce significant improvements in the dye stability of Fujicolor negative film (Fujicolor Negative Film A 8511/8521 and Fujicolor High Speed Negative Film AX 8512/8522) along with a new print film, Fujicolor Positive LP Film 8816. Fuji introduced the new films in 1983; many additional improved-stability films have followed since that year.

In 1990 Scorsese, together with noted film directors Woody Allen, Francis Ford Coppola, Stanley Kubrick, George Lucas, Sydney Pollack, Robert Redford, and Steven Spielberg, established The Film Foundation, an organization for promoting and coordinating motion picture preservation and restoration projects.[26]

A Brief History of Eastman Color Motion Picture Films

Eastman color motion picture films, which were introduced in 1950, trace their beginnings to the Kodacolor amateur still negative and print processes introduced in 1942 (see Chapter 1). Kodak very early realized the practical advantages of a color negative film — instead of a reversal transparency film — for the camera original, and then using the negative to make prints for viewing (paper prints in the case of the Kodacolor system, or "prints" on transparent film for motion picture projection). The negative can be designed for optimum performance in the camera; for example, color negatives are made with low-contrast, multilayer emulsions that have both high-speed and slow-speed layers within the cyan, magenta, and yellow dye-forming

Arnold Schieman of the National Film Board of Canada in Montreal, Quebec, with the original camera negative of the 1951 production **Royal Journey**, a film documenting Princess Elizabeth's tour of Canada. The film was the first feature-length production made on the then-new Eastman Color negative film and print film. When these photographs were taken in 1980, the negative was still being stored under non-refrigerated conditions at the National Film Board. In 1989, the color negative was moved to the National Archives of Canada in Ottawa, and it is now stored at 28°F (–2.2°C) and 28% RH.

Rolls of the original Eastman Color Negative Film, Type 5247 from **Royal Journey**. In 1996, the negative will be moved to the National Archives' new facility in Gatineau, Quebec and will be preserved at 0°F (–18°C) and 25% RH.

Black-and-white separation positives were made from the original color negative, and a new intermediate color negative for producing prints or video transfers can be made from the separations, but at great expense.

layers. This gives color negatives much wider exposure latitude than color reversal films (which have a high-contrast emulsion so that slides have the proper visual appearance when projected on a screen in a darkened room).

With color negatives, extensive corrections can be made for exposure errors and deviations in color balance when color intermediates and prints are made. Modern color negative films have considerable latitude in this respect, and moviemakers put this to good advantage in creating the proper color balance and "mood" for a scene when the film is timed (i.e., when prints are adjusted for color balance and density).

Although the exposure latitude of the early Kodacolor system made it suitable for the ordinary box camera — Kodak knew a wide-latitude color film was needed in order to enter the mass market for amateur snapshots made with non-adjustable cameras — the color reproduction of the prints was poor and not adequate to compete with established motion picture processes such as the Technicolor three-strip camera and imbibition color print system.

The image stability of Kodacolor negatives and prints was also very poor — all of the Kodacolor prints made from 1942 until around 1953 have turned orange and faded to various degrees, whether or not they were exposed to light on display. Although the orange-staining problems were significantly reduced in 1953, the dye-image stability difficulties inherent in the early Kodacolor process were carried directly into the Eastman motion picture color negative and print films.

When Kodak perfected the colored-coupler masking method of color correction in negatives, it was finally able to make a negative-positive system with color and tone reproduction good enough to compete with the Technicolor process. Colored-coupler masking was first included in a commercial product by Kodak in the Ektacolor still camera film introduced in 1947; the technology was applied to Kodacolor amateur negative films soon thereafter. Experience gained with the still color negative films was essential in developing the color negative motion picture film introduced by Kodak in 1950 and the many films that have followed (see film listing in **Table 9.1** on the following page). Eastman Color Print Film, also introduced in 1950, was closely related to the Ektacolor print film put on the market in 1947 at the same time as Ektacolor negative film.

With the introduction of Eastman color negative and print films, it was evident that Kodak was focusing its efforts on essentially the same negative-positive chromogenic processes for both motion picture and still photography; this allowed a concentration of research efforts which benefited both lines of products. As an example, DIR (developer inhibitor releasing) couplers and other improvements in emulsion design which allowed much sharper and finer-grain images than previously possible with color negative films were incorporated into Eastman Color Negative II Film 5247, and into Kodacolor II Film for still cameras, both introduced in 1972.

Although they use different processing chemicals, the current Kodak still and motion picture color negative films are otherwise so similar that some photographers use the motion picture film in their still cameras, printing the images on conventional Ektacolor paper (a practice not recommended by this author).

Causes of Color Motion Picture Fading

Even after repeated projections, the fading of the dye images in motion picture print films is almost entirely a "dark fading" reaction. Since each frame is exposed to light for only a small fraction of a second during each projection, the total light exposure even after hundreds of projections is so small as to be almost inconsequential.

Dark fading rates are a function of the inherent stability of the organic dye images in a particular film, the temperature of storage, and, usually to a lesser extent, the relative humidity of the storage area. Improper processing and washing can also reduce the stability of a negative or print film — in some cases deviations from recommended processing may result in drastic losses in image stability.

Research disclosed by Eastman Kodak in late 1992 showed that storing films in sealed or semi-sealed containers such as standard taped or untaped metal or plastic film cans (or vapor-proof bags) could significantly increase the rates of both dye fading and film-base deterioration compared with storage in ventilated containers surrounded by circulating air. In a rather controversial recommendation on how to deal with this problem, Kodak suggested packaging films in taped film cans containing a substance that strongly absorbs moisture and acetic acid vapors. This subject is discussed later in this chapter.

When a color negative fades in dark storage, the fading is roughly proportional throughout the full density range of the image. That is, if a 20% loss of density occurs in a low density area of an image (for example, blue density drops from an original density of 1.20 to 0.96), approximately the same percentage will be lost in the maximum density parts of the image (for example, blue density drops from an original density of 2.40 to 1.92). This results in a loss of *contrast* of the blue record (yellow dye image) of the image. While it is possible to correct the overall density of a print made from a faded negative, and to achieve a balanced flesh tone or some other selected color by re-timing the negative for printing, it is *not* possible to correct for the contrast imbalance with normal equipment and procedures.

As the cyan, magenta, and yellow dyes in all current color negative films fade at significantly different rates, severely faded negatives exhibit contrast imbalances that result in off-colored shadows and highlights. With early Eastman Color negatives that have poor-stability cyan and yellow dyes, for example, images generally will print with blue shadows and yellow highlights if the negatives are re-timed to print correctly balanced midtones.

How noticeable negative fading is not only depends on the degree of fading and the resulting contrast imbalance among the cyan, magenta, and yellow dyes, but can also be very scene-dependent. When a print is made from a faded negative, the changes in some scenes are usually more noticeable than are others. The changes in image color balance — especially in detailed highlight and shadow areas — can be particularly distracting as a film cuts from one scene to another.

Re-timing and printing problems are exacerbated when faded film stocks are intercut (e.g., when camera negative film is intercut with a different type of film used for special effects) because different types of film generally have different fading characteristics.

Table 9.1 Eastman Color Negative, Laboratory Intermediate, and Color Print Films for Motion Pictures

Boldface Type indicates a film that was commercially available when this book went to press in 1992; the other products listed had been either discontinued or replaced with newer materials. Under Eastman Kodak's system of film designation, Type 52 films are 35mm or wider camera and laboratory films; Type 72 films are 16mm or narrower camera and laboratory films; Type 53 films are 35mm or wider color print films (printed from color negatives or internegatives); and Type 73 films are 16mm or narrower color print films.

Camera Negative Films	Year of Introduction
Eastman Color Negative Film, Type 5248 (35mm only)	1952
Eastman Color Negative Film, Type 5250 (35mm only)	1959
Eastman Color Negative Film, Type 5251 (35mm only)	1962
Eastman Color Negative Film, Type 5254 (35mm only)	1968
Eastman Color Negative II Film 5247 (35mm only) [1st version]	1972
Eastman Color Negative II Film 7247 (16mm only)	1974
Eastman Color Negative II Film 5247 (35mm only) [2nd version]	1976
Eastman Color Negative II Film 5247 (35mm only) [3rd version]	1980
Eastman Color High Speed Negative Film 5293 (35mm only)	1982
Eastman Color Negative Film 7291 (16mm only)	**1982**
Eastman Color High Speed Negative Film 5294 and 7294	**1983**
Eastman Color Negative Film 5247 (35mm only) (name change only; same as 1980 version of 5247)	**1985**
Eastman Color High Speed Negative Film 7292 (16mm only)	**1986**
Eastman Color High Speed SA Negative Film 5295 (35mm only)	**1986**
Eastman Color High Speed Daylight Negative Film 5297 and 7297	**1986**
Eastman EXR Color Negative Film 5245 and 7245	**1989**
Eastman EXR Color Negative Film 5248 and 7248	**1989**
Eastman EXR 500T Color Negative Film 5296 and 7296	**1989**
Eastman EXR Color Negative Film 5293 and 7293	**1992**

Laboratory Intermediate Films	Year of Introduction
Eastman Color Internegative Safety Film, Type 5243 (35mm only)	1952
Eastman Color Internegative Film, Type 5245 (35mm only)	1953
Eastman Color Internegative Film, Type 5270 and 7270	1956
Eastman Color Intermediate Film, Type 5253 and 7253	1956
Eastman Color Internegative Film, Type 5271 and 7271	**1968**
Eastman Color Reversal Intermediate Film 5249 and 7249	**1968**
Eastman Color Intermediate II Film 5243 and 7243	1978
Eastman Color Internegative II Film 7272 (16mm only)	**1980**
Eastman Color Intermediate Film 5243 and 7243 Improved	**1986**
Eastman EXR Color Intermediate Film 5244 and 7244 (triacetate); **2244** (polyester)	**1992**

Color Print Films	Year of Introduction
Eastman Color Print Safety Film, Type 5381 and 7381	1950
Eastman Color Print Film, Type 5382 and 7382	1953
Eastman Color Print Film, Type 7383 (16mm only)	1959
Eastman Color Print Film, Type 5385 and 7385	1962
Eastman Color Print Film, Type 7380 (8mm and Super 8mm only)	1968
Eastman Color Print Film, Type 7381 (8mm and Super 8mm only)	1970
Eastman Color Print Film, Type 5381 and 7381	1972
Eastman Color SP Print Film, Type 5383 and 7383	1974
Eastman Color LF Print Film 5378 and 7378 (7378 was little used; 5378 saw virtually no use)	1979
Eastman Color LFSP Print Film 5379 and 7379 (7379 was little used; 5379 saw virtually no use)	1979
Eastman Color Print Film 5384 and 7384	**1982**
Eastman Color LC Print Film 5380 and 7380 (low-contrast version of 5384 for TV applications)	**1983**

The Original Eastman Color Negative of *Spartacus* Has Faded Beyond Use

When film archivist Robert A. Harris and his associate James Katz became involved with MCA/Universal in the project to restore the epic 1960 film *Spartacus* for its re-release in 1991, it was found that the original Eastman Color negative had faded beyond use:

> Universal took very, very good care of it, but it was thirty years old. The yellow layer was gone; we made some tests with the camera negative and ended up with blue shadows and yellow facial highlights.[27]

Directed by Stanley Kubrick and produced by and starring Kirk Douglas, *Spartacus* was made with a budget exceeding $12 million and employed more than 10,000 people. The film won an Academy Award for color cinematography. At the time it was made, *Spartacus* was the most expensive film ever produced in Hollywood. Writing about the film in the May 1991 issue of *American Cinematographer*, Frank Thompson said "audiences who experienced the dazzling Super Technirama 70 [wide-format] images and brilliant six-track sound have never forgotten the film's impact."

In the restoration of *Spartacus,* Robert A. Harris, who was also the person behind the 1988 restoration of the 1962 classic *Lawrence of Arabia,* not only had to deal with the problem of the fading of the original color negative, but also had to rebuild the complex six-track soundtrack and reinsert scenes that were "snipped by order of the censors" in 1960. The restored *Spartacus* had a number of theater engagements around the country in 1991, was shown on television, and has been released on videocassette and videodisc.

Fortunately, the black-and-white separations (YCM's) made from the original color negative of *Spartacus* in 1960 still existed in good condition, and they were successfully used to reconstruct an intermediate color negative which in turn was used to make new prints (the existing prints from the 1960's are now severely faded). Except for major theatrical features, separations were never made for most of the movies shot on Eastman Color and similar motion picture color negative film during the past four decades. Good-quality prints can no longer be struck from many of these negatives.

This worldwide cultural and financial tragedy, which grows worse with each day that the films continue to sit in non-refrigerated storage on archive and film library shelves, could easily have been averted *entirely* by simply providing humidity-controlled cold storage. For *Spartacus*, the cost of refrigerated storage for the original color negative during the 30 years dating from when it was made in 1960 until it was re-released in 1991 would have been insignificant compared to what was spent for making and storing separations and in the recent restoration of the film.

The Profound Influence of Storage Temperature on Color Film Fading Rates

To determine the proper storage temperature for a particular motion picture film, it is first necessary to reach a decision about how long the film could conceivably be of value — and how much image deterioration could be tolerated during that time.

Image-life predictions for a specific type of film stored under various temperature and relative humidity conditions are obtained with the complex, multi-temperature Arrhenius accelerated dark fading test specified in *ANSI IT9.9-1990, American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring.*[28] The Arrhenius test method is discussed in Chapter 2 and Chapter 5 of this book.

Kodak has released fading-rate data for many of its films, and this information can be used to compute the predicted image-life of the films in storage at normal room temperature (see **Table 9.2**) or at some other temperature. Estimates can also be made concerning the effect of relative humidity on the rate of dye fading. Note that the image-life estimates given in this book for Eastman, Fuji, and Agfa films are based on Arrhenius tests with free-hanging film samples surrounded by rapidly circulating air. As will be discussed later, such tests may considerably overstate the actual stability of a film when it is stored in the closed environment of a standard film can or other sealed or semi-sealed container.

The image-life estimates given in this book for motion picture films are probably reasonably accurate when films are stored in "vented" plastic film cans or in permeable cardboard boxes, as recommended by this author.

Thus far, Kodak has refused to make public stability data for its earlier motion picture films; however, it is known that all of these films have very poor image stability. The fading characteristics of Eastman Color Negative II Film 7247 can be considered representative of early Eastman color negative films, and Eastman Color SP Print Film 5383 is probably typical of the earlier print films.

For this book, Fuji Photo Film Co., Ltd. has furnished estimates for a 10% loss of the least stable dye for its motion picture films, and these are given in **Table 9.3**. Fuji prefers to evaluate color negative films in terms of the loss in *image contrast* of the least stable image dye. According to Fuji, its accelerated tests indicate that current Fuji F-series color negative films could be stored for approximately 180 years at 75°F (24°C) and 40% RH before a 10% loss in image contrast of the least stable dye would occur.

While one can argue that, because of changes in colored coupler masking densities that can occur with color negatives in dark storage and because of density and color corrections that can be made during printing, loss of image contrast is a better approach for the evaluation of color negative deterioration than is using simple "dye loss" data. The "contrast loss" method, however, is not specified in the current ANSI color stability standard.

After repeated requests, Agfa-Gevaert somewhat reluctantly agreed to provide accelerated test data for its color motion picture films for this book, and 10% dye loss estimates are given in **Table 9.4**. Agfa said that its research has indicated that there can be considerable uncertainty in the predictions obtained in Arrhenius tests. Nevertheless, this author believes that the Agfa image-life estimates are useful. They suggest, for example, that Agfa XT 100, improved-type Agfa XT 320, and Agfa XTS 400 color negative films have image stability that is as good or better than

(continued on page 317)

Table 9.2 Unofficial Kodak Estimates for Number of Years Required for the Least Stable Image Dye of Motion Picture Films to Fade 10% from an Original Density of 1.0 When Stored at Room Temperature (75°F / 24°C)*

Boldface Type indicates a film that was commercially available when this book went to press in 1992; the other products listed had been either discontinued or replaced with newer materials.

Camera Negative Films	Years of Storage at 40% RH*	Years of Storage at 60% RH*
Eastman Color Negative II Film 5247 (1974 version)	6 (–Y)	3 (–Y)
Eastman Color Negative II Film 5247 (1976 version)	12 (–C)	NA
Eastman Color Negative II Film 5247 (1980 version)	28 (–Y)	14 (–Y)
Eastman Color Negative Film 5247 (1985 name change)	**28 (–Y)**	**14 (–Y)**
Eastman Color High Speed Negative Film 5293 and 7293	(not disclosed)	
Eastman Color High Speed Negative Film 5294	**(not disclosed)**	
Eastman Color High Speed SA Negative Film 5295	**(not disclosed)**	
Eastman Color High Speed Daylight Negative Film 5297	**(not disclosed)**	
Eastman Color Negative II Film 7247 (1972–1983)	6 (–Y)	3 (–Y)
Eastman Color Negative Film 7291	**50 (–M)**	**NA**
Eastman Color High Speed Negative Film 7294	(not disclosed)	
Eastman Color High Speed Negative Film 7292	**(not disclosed)**	
Eastman Color High Speed Daylight Negative Film 7297	**(not disclosed)**	
Eastman EXR Color Negative Film 5245 and 7245 (1989—)	**22 (–Y)**	**11 (–Y)**
Eastman EXR Color Negative Film 5248 and 7248 (1989—)	**30 (–Y)**	**15 (–Y)**
Eastman EXR Color Negative Film 5293 and 7293 (1992—)	(not disclosed)	
Eastman EXR 500T Color Negative Film 5296 and 7296 (1989—)	**50 (–Y)**	**25 (–Y)**

Laboratory Intermediate Films	Years of Storage at 40% RH*	Years of Storage at 60% RH*
Eastman Color Internegative Film, Type 5271 and 7271	5 (–Y)	3 (–Y)
Eastman Color Internegative Film, Type 7272	**23 (–C)**	**NA**
Eastman Color Reversal Intermediate Film 5249 and 7249	**8 (–Y)**	**4 (–Y)**
Eastman Color Intermediate II Film 5243 and 7243	22 (–C)	NA
Eastman Color Intermediate Film 5243 and 7243 Improved	**(not disclosed)**	
Eastman EXR Color Intermediate Film 5244 and 7244 (triacetate)**; 2244** (polyester) (1992—)	**(not disclosed)**	

Color Print Films	Years of Storage at 40% RH*	Years of Storage at 60% RH*
Eastman Color Print Film 5381 and 7381	5 (–C)	NA
Eastman Color SP Print Film 5383 and 7383	5 (–C)	NA
Eastman Color Print Film 5384 and 7384	**45 (–Y)**	**23 (–Y)**
Eastman Color LC Print Film 5380 and 7380 (low-contrast version of 5384 for TV applications)	**45 (–Y)**	**23 (–Y)**

***Notes:** The estimates given here should serve only as general guidelines. Estimated times for storage at 75°F (24°C) have been derived by this author from data in **Dye Stability of Kodak and Eastman Motion Picture Films** (data sheets), Kodak Publications DS-100-1 through DS-100-9, May 29, 1981; G. L. Kennel, R. C. Sehlin, F. R. Reinking, S. W. Spakowsky, and G. L. Whittier, "Eastman Color High-Speed Negative Film 5293," **SMPTE Journal,** Vol. 91, No. 10, October 1982, pp. 922–930; K. J. Carl, J. W. Erwin, S. J. Powell, F. R. Reinking, R. C. Sehlin, S. W. Spakowsky, W. A. Szafranski, and R. W. Wien, "Eastman Color Print Film 5384," **SMPTE Journal,** Vol. 91, No. 12, December 1982, pp. 1161–1170; R. C. Sehlin, F. R. Reinking, S. W. Spakowsky, D. L. Clifford, G. L. Whittier, and W. A. Szafranski, "Eastman Color Negative Film 7291," **SMPTE Journal,** Vol. 92, No. 12, December 1983, pp. 1302–1309; and other sources.

The estimates for 60% RH storage are based on Kodak research that showed that the fading rate of typical yellow dyes in Kodak films approximately doubles when the relative humidity is increased from 40% to 60%. Furthermore, the dye stability data given here were based on Arrhenius tests conducted with free-hanging film samples exposed to circulating air. Research disclosed 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 untaped 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**, San Francisco, California, December 10, 1992.)

Table 9.3 Official Fuji Estimates for Number of Years Required for the Least Stable Image Dye of Motion Picture Films to Fade 10% from an Original Density of 1.0 When Stored at Room Temperature (75°F / 24°C)

Boldface Type indicates a film that was commercially available when this book went to press in 1992; the other products listed had been either discontinued or replaced with newer materials. Under Fuji's old system of film designation, type 851 films were 35mm camera color negative films and type 852 films were 16mm equivalents. Under the current designation system, adopted in 1988, type 85 are 35mm camera color negative films and type 86 are 16mm equivalents. Type 881 films are 35mm color print films (printed from color negatives or internegatives); type 882 films are 16mm equivalents.

Camera Negative Films	Years of Storage at 40% RH	Years of Storage at 60% RH
Fujicolor Negative Film A 8517 and 8527	40 (–C)	— (–C)
Fujicolor Negative Film A 8511 and 8521	100 (–Y)	— (–Y)
Fujicolor Negative Film A250 Type 8518 and 8528	40 (–C)	— (–C)
Fujicolor High-Speed Negative Film AX, 8512 and 8522	100 (–Y)	— (–Y)
Fujicolor High-Speed Negative Film AX, 8514 and 8524	100 (–Y)	— (–Y)
Fujicolor Negative Film F-500 8514 and 8524	100 (–Y)	— (–Y)
Fujicolor Negative Film F-64 8510 and 8610	**100 (–Y)**	**— (–Y)**
Fujicolor Negative Film F-64D 8520 and 8620	**100 (–Y)**	**— (–Y)**
Fujicolor Negative Film F-125 8530 and 8630	**100 (–Y)**	**— (–Y)**
Fujicolor Negative Film F-250 8550 and 8650	**100 (–Y)**	**— (–Y)**
Fujicolor Negative Film F-250D 8560 and 8660	**100 (–Y)**	**— (–Y)**
Fujicolor Negative Film F-500 8570 and 8670	**100 (–Y)**	**— (–Y)**
Laboratory Intermediate Films		
Fujicolor Intermediate Film, 8213 and 8223	**100 (–Y)**	**— (–Y)**
Color Print Films		
Fujicolor Positive Film HP, 8814 and 8824	9 (–C)	8 (–C)
Fujicolor Positive Film LP, 8816 and 8826	**>50 (–Y)**	**50 (–Y)**

Table 9.4 Official Agfa-Gevaert Estimates for Number of Years Required for the Least Stable Image Dye of Motion Picture Films to Fade 10% from an Original Density of 1.0 When Stored at Room Temperature (75°F / 24°C)

Boldface Type indicates a film that was commercially available when this book went to press in 1992; the other products listed had been either discontinued or replaced with newer materials

Camera Negative Films	Years of Storage at 40% RH	Years of Storage at 60% RH
Agfa XT 125 Colour Negative Film	10 (–C)	— (–C)
Agfa XT 100 Colour Negative Film	**35 (–Y)**	**— (–Y)**
Agfa XT 320 High Speed Colour Negative Film (original type)	**10 (–C)**	**— (–C)**
Agfa XT 320 High Speed Colour Negative Film (improved type: 1993—)	**35 (–Y)**	**— (–Y)**
Agfa XTS 400 High Speed Colour Negative Film (1993—)	**35 (–Y)**	**— (–Y)**
Color Print Films		
Gevacolor Print Film 982 (original type)	5 (–C)	— (–C)
Gevacolor Print Film 982 (improved type)	5 (–C)	— (–C)
Agfa Print CP1 Colour Print Film (triacetate or polyester base)	**5 (–C)**	**— (–C)**
Agfa Print CP10 Colour Print Film (polyester base) (a triacetate base version of CP10 was planned for introduction in 1993)	**5 (–C)**	**— (–C)**

that of most Eastman color negative films. The Agfa image-life estimates also indicate that the dye stability of Agfa print films continues to be very poor compared with that of Fuji and Eastman color print films.

Image-Life Predictions for Long-Term, Humidity-Controlled Cold Storage

Image-life predictions for storage at temperatures lower than 75°F (24°C) are based on research by Eastman Kodak indicating that, compared with room-temperature storage at 75°F (24°C), the fading rates of chromogenic image dyes in typical Kodak films are reduced by a factor of approximately 4.5X when the storage temperature is reduced to 55°F (12.8°C), by a factor of 20X when the temperature is reduced to 35°F (1.7°C), and by a factor of 340X when the temperature is reduced to 0°F (–18°C). As can be seen in **Table 9.5**, low-temperature storage affords a *tremendous* increase in the useful life of color motion picture film. Low-temperature storage not only preserves the dye image itself, it also preserves the film base and the gelatin emulsion. Humidity-controlled cold storage also totally eliminates the possibility of fungus growths on films.

A 10% Loss of the Least Stable Dye Is the Most Fading That Should Be Tolerated

The image-life predictions given here are based on the number of years that it will take for the least stable of the cyan, magenta, and yellow image dyes in a film to fade 10% (e.g., for the least stable dye to lose 0.10 density from an initial density of 1.0). A 10% dye loss is a useful yardstick for comparing the stability of one film with another, and is a good figure to work with when selecting the appropriate cold storage vault temperature for the long-term preservation of valuable motion picture films.

A 10% dye loss in a color negative is not a great deal of fading, and such a dye loss can generally be corrected by re-timing a negative for printing or producing a new intermediate negative. While one could argue that it is possible to satisfactorily correct for a greater amount of fading in a color negative, this author believes that in a serious preservation program, it is better to take a conservative stance and opt for the least possible change over time. Especially when different film stocks are intercut (e.g., two or more types of camera negative films, special effects films, etc.) — each of which may have a different amount of fading and a different degree or direction of color shift — it is much easier to make a new print that is close to the density and color values of the original production when negative fading is held to an absolute minimum.

In long-term preservation programs, little or no fading should be tolerated in motion picture prints as well. Pulling a print from cold storage and making a videotape or optical disc transfer is a simple task if one has an assurance that color and density are absolutely unchanged from the original, and that there has been no increase in d-min stain level. The color will be brilliant, the highlights clean, and the shadows deep and neutral. As television moves toward fully digital high-definition systems, the demands for image quality will correspondingly increase. What passes as "acceptable" today will not be adequate in the future.

With low-temperature, 0°F (–18°C) storage, color fading ceases for all practical purposes. With most collections, the money and aggravation this will save will in the long run far exceed the costs of cold storage. The older these "like new" motion pictures get, the more valuable they will become.

If one could draw an analogy to the costly process of "colorizing" old black-and-white films,[29] it is much easier and far less expensive to prevent color films from fading in the first place than it is to "restore" or to otherwise attempt to put back the color in a faded film.

Most Older Color Films in Collections Have Already Faded Much More Than 10%

Probably the most compelling reason for adopting a very tight limit for "acceptable" dye fading in deciding what temperature is required in a long-term cold storage facility is that most films found in film libraries and archives today have already suffered more than a 10% dye loss. With many films, the amount of fading will *far* exceed a 10% dye loss. The reader can appreciate that letting such films fade an additional 20 or 30% — on top of the fading that has already taken place — simply cannot be tolerated. In such situations, *no* additional fading is acceptable. Depending on the degree of fading that has taken place in a particular film, the additional dye loss could very well push the film past the limit where acceptable prints can be made.

With seriously faded films, the additional dye loss could also prevent successful restoration using film-resolution digital intermediate systems or computer-based image-enhancement techniques. When fading passes a certain point, there simply is not enough color information left for adequate separation of the red, green, and blue densities that represent the cyan, magenta, and yellow dye images.

The realization that color motion picture films can be preserved essentially *forever* at moderate cost has convinced an increasing number of film studios, archives, museums, and other collecting institutions to construct humidity-controlled cold storage vaults to protect their holdings. Some of these facilities are discussed in this chapter (also see Chapter 20, *Large-Scale, Humidity-Controlled Cold Storage Facilities for the Permanent Preservation of Color Films, Prints, and Motion Pictures*).

The Influence of Relative Humidity on Color Film Fading

The image dyes in different films vary in their sensitivity to relative humidity; Kodak has indicated that the rates of fading of some of the yellow dyes in its products approximately double when the relative humidity is increased from 40% to 60%. If yellow is the least stable of the three dyes in a particular film, the life of the film will be correspondingly reduced if the film is stored in a higher relative humidity. As discussed below, high relative humidity also has a very detrimental effect on cellulose triacetate, cellulose nitrate, and other cellulose ester films.

ANSI IT9.11-1991, American National Standard for Imaging Media – Processed Safety Photographic Film – Storage specifies a relative humidity level of 20–30% for extended-term storage of both color and black-and-white films.[30]

Table 9.5 Estimates for Number of Years Required for the Least Stable Image Dye of Eastman Motion Picture Films to Fade 10% from an Original Density of 1.0 in Storage at Various Temperatures and 40% RH*

Boldface Type indicates a film that was commercially available when this book went to press in 1992; the other products listed had been either discontinued or replaced with newer materials.

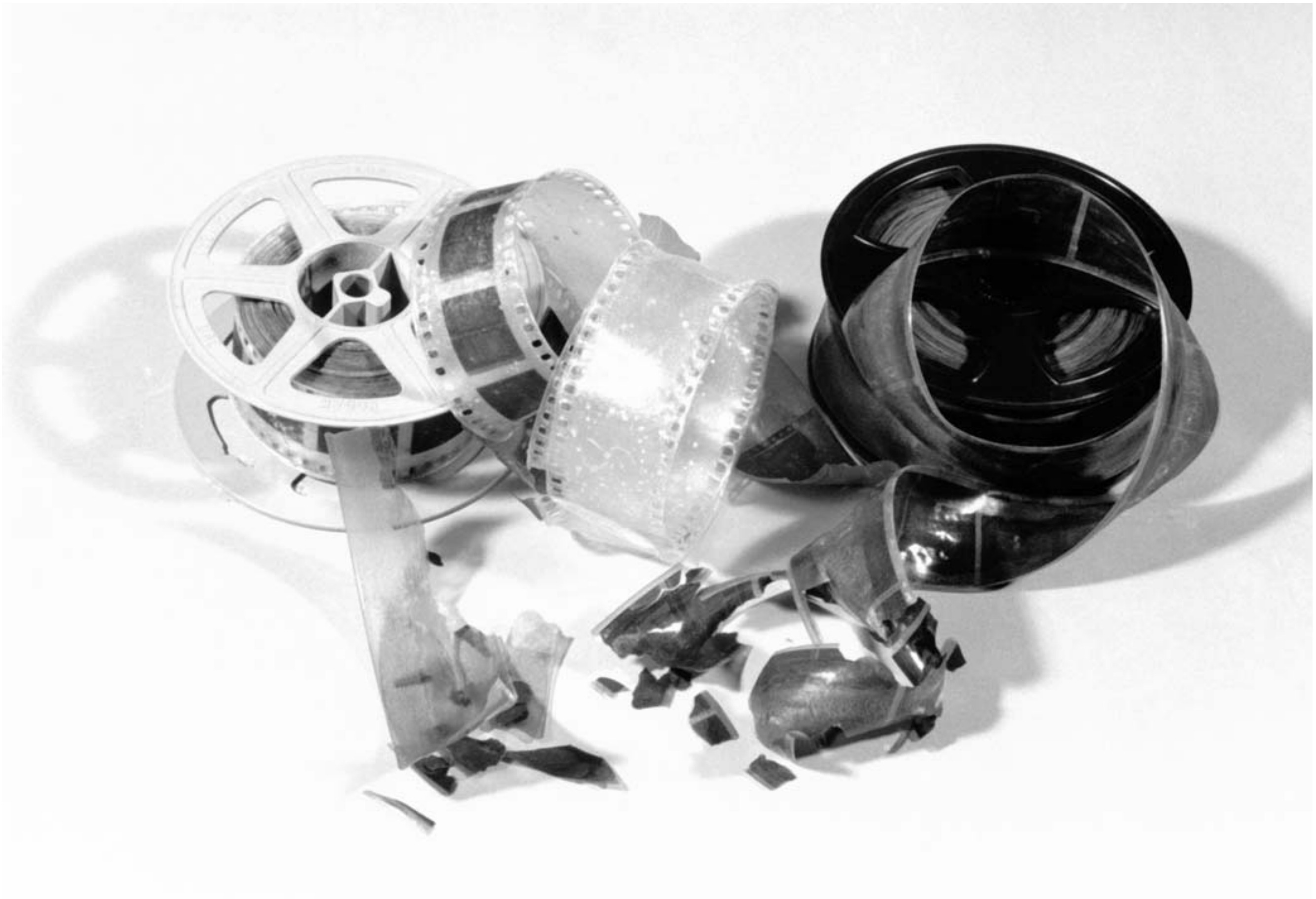
Camera Negative Films	Years of Storage at 40% RH:* 75°F (24°C)	55°F (12.8°C)	35°F (1.7°C)	0°F (–18°C)
Eastman Color Negative II Film 5247 (1974 version)	6	27	120	2,000
Eastman Color Negative II Film 5247 (1976 version)	12	55	240	4,000
Eastman Color Negative II Film 5247 (1980 version)	28	125	560	9,500
Eastman Color Negative Film 5247 (1985 name change)	**28**	**125**	**560**	**9,500**
Eastman Color High Speed Negative Film 5293		(not disclosed)		
Eastman Color High Speed Negative Film 5294		**(not disclosed)**		
Eastman Color High Speed SA Negative Film 5295		**(not disclosed)**		
Eastman Color High Speed Daylight Negative Film 5297		**(not disclosed)**		
Eastman Color Negative II Film 7247 (1974–83)	6	27	120	2,000
Eastman Color Negative Film 7291	**50**	**225**	**1,000**	**17,000**
Eastman Color High Speed Negative Film 7294		(not disclosed)		
Eastman Color High Speed Negative Film 7292		**(not disclosed)**		
Eastman Color High Speed Daylight Negative Film 7297		**(not disclosed)**		
Eastman EXR Color Negative Film 5245 and 7245 (1989—)	**22**	**100**	**440**	**7,500**
Eastman EXR Color Negative Film 5248 and 7248 (1989—)	**30**	**135**	**600**	**10,000**
Eastman EXR Color Negative Film 5293 and 7293 (1992—)		**(not disclosed)**		
Eastman EXR 500T Color Negative Film 5296 and 7296 (1989—)	**50**	**225**	**1,000**	**17,000**

Laboratory Intermediate Films	Years of Storage at 40% RH:* 75°F (24°C)	55°F (12.8°C)	35°F (1.7°C)	0°F (–18°C)
Eastman Color Internegative Film, Type 5271 and 7271	5	23	100	1,700
Eastman Color Internegative Film 7272	**23**	**105**	**460**	**7,800**
Eastman Color Reversal Intermediate Film 5249 and 7249	**8**	**36**	**160**	**2,500**
Eastman Color Intermediate II Film 5243 and 7243	22	100	440	7,500
Eastman Color Intermediate Film 5243 and 7243 Improved		**(not disclosed)**		
Eastman EXR Color Intermediate Film 5244 and 7244		**(not disclosed)**		

Color Print Films	75°F (24°C)	55°F (12.8°C)	35°F (1.7°C)	0°F (–18°C)
Eastman Color Print Film 5381 and 7381	5	23	100	1,700
Eastman Color SP Print Film 5383 and 7383	5	23	100	1,700
Eastman Color LF Print Film 5378 and 7378	20	90	400	6,800
Eastman Color LFSP Print Film 5379 and 7379	20	90	400	6,800
Eastman Color Print Film 5384 and 7384	**45**	**200**	**900**	**15,000**
Eastman Color LC Print Film 5380 and 7380	**45**	**200**	**900**	**15,000**

***Notes:** The estimates given here should serve only as general guidelines. The predicted times for storage at 75°F (24°C) have been derived by this author from data in **Dye Stability of Kodak and Eastman Motion Picture Films** (data sheets), Kodak Publications DS-100-1 through DS-100-9, May 29, 1981, and other sources (see note in Table 9.2). Predictions for storage at temperatures lower than 75°F (24°C) are based on research by Kodak indicating that, compared with room-temperature storage at 75°F (24°C), the fading rates of image dyes in typical Kodak films are reduced by a factor of approximately 4.5X when the storage temperature is reduced to 55°F (12.8°C), by a factor of 20X when the temperature is reduced to 35°F (1.7°C), and by a factor of 340X when the temperature is reduced to 0°F (–18°C).

Research disclosed 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 untaped 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**, San Francisco, California, December 10, 1992.)



1986

These rolls of Agfa, DuPont, and Gevaert cellulose acetate safety-base microfilm from the 1950's have deteriorated to uselessness. The films are so brittle that they crumble to the touch, and the images on the films are beyond recovery. The decomposing film base smells strongly of vinegar (acetic acid). These films have been stored in Venezuela under semi-tropical temperature and humidity conditions; although the warmth and humidity hastened the decomposition of the films, all cellulose acetate-base microfilms eventually will suffer the same fate unless humidity-controlled cold storage is provided to preserve them. Polyester-base films are expected to last far longer than cellulose triacetate-base films and should be used for all motion picture separations (YCM's) and black-and-white and color microfilms.

Extended-term storage conditions are defined as "Storage conditions suitable for the preservation of record information having permanent value." (Extended-term storage was formerly known as archival storage; beginning in 1991, the word "archival" was being deleted from all ANSI standards as they were revised.) For medium-term storage (storage for a minimum of 10 years), *ANSI IT9.11-1991* specifies 20–30% RH for color films and 20–50% RH for black-and-white films.

Kodak has chosen 40% RH for reporting image stability data for most of its color materials. In most geographic locations, higher average humidity levels are common, and this is especially true in the warmer parts of the world. In addition to 40% RH data, Fuji has also furnished data using a more representative 60% RH storage condition for Fujicolor print films (see **Table 9.3**).

It is interesting to note that unlike most chromogenic yellow dyes, the yellow dye in Fujicolor LP print film shows very little increase in its fading rate when stored at 60% RH compared with storage at 40% RH, according to the Fuji data.

The Influence of Temperature and Relative Humidity on Film-Base Deterioration

The focus of efforts to preserve color motion picture films has rightly been on the fading of dye images themselves, with film-base stability generally being of much less concern. It has been a question of the weakest link, and, since the introduction of Eastman Color negative and print films in 1950, dye fading unquestionably has been the weakest link.

This is not to say that film-base stability is unimportant. Film-base stability generally is the most critical factor in the deterioration of black-and-white separations (YCM's) which, because of poor dye stability and inadequate storage of virtually all older original color negatives, must now be relied upon for the long-term preservation of many theatrical features.

Also affected are the camera separation negatives made with Technicolor 3-strip cameras, separation interpositives and duplicate negatives made from the original 3-strip negatives, and, of course, those few but priceless full-color Technicolor dye-imbibition prints that still exist. (Unlike the comparatively unstable dye images in Eastman Color and other chromogenic motion picture films, the color images in Technicolor imbibition prints are essentially permanent in dark storage — see Chapter 10.)

With further improvements in the dye stability of Eastman Color, Fujicolor, and Agfa color motion picture films, it is possible that the stability of the film base could become of concern for these films as well.

Beginning around 1950, when highly flammable cellulose nitrate motion picture film was replaced with cellulose triacetate film, almost everyone in the film industry felt that the long-standing "film base problem" had been finally solved. The many assurances by Eastman Kodak, other manufacturers, and the U.S. National Bureau of Standards that cellulose acetate film base was essentially permanent were based on aging studies dating back a number of years.

Typical was a 1936 study of the comparative aging stability of cellulose nitrate and cellulose acetate films that concluded, based on rather simplistic accelerated aging tests at very high temperatures, that cellulose acetate films were far more stable than cellulose nitrate films:

> The best evidence of the high stability of acetate film is furnished by results of viscosity measurements. When heated for 72 hours at 100°C, the specific viscosity decreased about 2 percent, and after 30 days of aging only 9 percent. With nitrate film, the decrease was 35 percent in 72 hours and 95 percent in 30 days of aging.
>
> While it is not possible to predict the life of acetate film from these results, the data show that chemical stability of the film, with respect to oven-aging, is greater than that of papers of maximum purity for permanent records.[31]

Unfortunately, with the passage of not too many years, cellulose triacetate and other types of cellulose acetate safety-base films kept under normal storage conditions proved in some cases to be no more stable than cellulose nitrate film, and nowhere near as stable as "papers of maximum purity." Within 10 years after Kodak's introduction of cellulose triacetate film, the company received its first field report of the deterioration of this new "permanent" film base material. "This film, from the Government of India, had been stored in a hot, humid climate. Subsequent trade complaints were also from locations where adverse storage conditions could be encountered."[32]

As the years went by, serious deterioration of cellulose acetate safety films was seen in more and more collections; motion picture films, microfilms, and still-camera films were all affected. By the mid-1980's there was serious concern about the problem in the museum and archive fields. The problem became known as the "vinegar syndrome," in reference to the pungent odor of acetic acid present in storage areas and film cans that contain decomposing cellulose acetate-base film (acetic acid, which has a strong and distinct odor, is the principal acidic component in vinegar).

In 1987, David Horvath of the University of Kentucky published a landmark survey of film deterioration in various institutions around the country,[33] and this report confirmed the worst fears of many in the archive community: that is, under commonly encountered storage conditions, cellulose acetate film base could have a far shorter life than previously believed. In short, modern cellulose triacetate film wasn't permanent after all.

This realization, which caused alarm and dismay among those entrusted with microfilm and motion picture collections, prompted a flurry of studies and technical papers by Michele Edge and Norman Allen working at Manchester Polytechnic in England; Eastman Kodak; Agfa-Gevaert; and the Image Permanence Institute in Rochester, New York.

The reader is referred to the many research reports and other publications on the subject by these organizations; particularly valuable is the two-part series of articles by Peter Z. Adelstein, James M. Reilly, and co-workers at the Image Permanence Institute published in the May 1992 issue of the *SMPTE Journal*.[34,35] The articles discuss the findings of the Image Permanence Institute's groundbreaking research on the permanence of cellulose acetate and cellulose nitrate film base, and the influence of temperature and humidity on rates of deterioration. The articles also include relevant references to the work of other researchers in this area.

Among the conclusions of the Image Permanence Institute's research were:[36]

1. The chemical stability of different cellulose ester base films is generally quite similar. There have been reported cases where films from a particular manufacturer, or which were made during a certain time period, have poorer stability. However, there is no evidence to suggest that diacetate, triacetate, or mixed esters have *inherently* different stabilities because of their chemical differences. The often-repeated statement that the obsolete diacetate films are less stable than more recent films is not supported by this study.
2. The stability of cellulose nitrate base film *can be* of the same order of magnitude as cellulose triacetate base films. More work is required to establish whether this is characteristic of most nitrate films now in storage. However, it has been established that cellulose nitrate film in storage will not necessarily degrade faster than other cellulose ester base films.
3. Film archivists should give highest priority for duplication to the film that shows some incipient signs of degradation, regardless of base type. Decisions should not be based solely on the chemical composition of the film base. However, it is recognized that priority should be given to cellulose nitrate films when safety (i.e., flammability) is a concern.
4. The superior chemical stability of polyester base films supports the conclusions of earlier studies.
5. A very significant increase in film life is possible when the storage humidity is lowered below 50% RH. This study is the basis for the recent ANSI recommendation of 20 to 30% RH where extended life of films is desired.
6. The temperature coefficient of improved chemical stability with decreased storage temperature is similar for all cellulose ester films and for all the basic film properties. The use of cold-storage facilities should be considered in order to prolong the chemical stability of valuable and unique photographic films.

February 1989

Some of the many hundreds of film-base specimens tested by the Image Permanence Institute at the Rochester Institute of Technology in Rochester, New York. Groups of film specimens were moisture-conditioned to 20, 50, 60, and 80% RH in a humidity-controlled room prior to being sealed in vapor-proof packages and placed in accelerated aging ovens. Incubations were made at temperatures of 50, 70, 80, 90 and 100°C.

May 1991

James M. Reilly, director of the Image Permanence Institute, checking one of the ovens used to conduct the Arrhenius multi-temperature accelerated aging tests with film-base specimens. The ovens, which have precise temperature and humidity controls, can also be used for accelerated tests with color materials. More than 15,000 measurements were made of the physical properties of the test specimens during the course of the IPI film-base study.

7. The beneficial effects of low-temperature and low-humidity storage are additive. The combination of low temperature and low relative humidity represents the optimum storage condition for cellulose ester base films.

Adelstein, Reilly, and co-workers showed that for typical cellulose ester-base films stored at a given temperature, lowering the relative humidity from 50% to 20% will increase the life of the film 3 to 4 times. Film stored at 80% RH will have only about one-quarter of the life of film stored at 50% RH. The benefit offered by low-temperature storage can be much greater. Lowering the storage temperature from 80°F (26.7°C) to 30°F (–1.1°C) will increase the life of a film approximately 32 times. Lowering the temperature to 0°F (–18°C) is predicted to increase the life of a film more than 200 times over storage at 80°F (26.7°C)!

While reducing the storage relative humidity to the recommended 20–30% level is very beneficial in and of itself, low humidity should not be thought of as a substitute for humidity-controlled cold storage. Preserving cellulose acetate and cellulose nitrate film indefinitely *requires* cold storage. Humidity control alone is perhaps more appropriate for film collections that are financially unable to construct (or rent) cold storage facilities. It will generally be possible to install dry-desiccant dehumidifiers in existing buildings at moderate cost to achieve year-round low humidity (see Chapter 16).

Storage of Acetate-Base Motion Picture Films in Standard Film Cans Will Increase the Rates of Both Dye Fading and Film-Base Deterioration

In a very important disclosure in late 1992 by A. Tulsi Ram and his co-workers at Eastman Kodak, it was reported that storing acetate-base films in sealed or semi-sealed containers such as standard taped or untaped metal or plastic film cans (or vapor-proof bags) could significantly increase the rates of both dye fading and film-base deterioration compared with films stored in the open and surrounded by circulating air.[37] It was demonstrated that storage of motion picture films in humid environments was particularly harmful.

There have been a number of reports in recent years pointing to the fact that sealing cellulose acetate and cellulose nitrate films in film cans or other closed containers can accelerate the degradation process by retaining acetic acid vapors and other deterioration by-products which contribute to an autocatalytic acetate film-base deterioration process. But the investigations by Ram and his co-workers at Kodak were the first to show that film-base deterioration by-products could also increase rates of dye fading.

The principal mechanism involved is the evolution of acetic acid vapors from slowly deteriorating cellulose acetate film base which, over time, lowers the pH of the emulsion and that this in turn increases the fading rates of many chromogenic dyes, with the pH-sensitive yellow dyes used in many films being particularly affected. The result, according to Ram and his co-workers, is that the image dyes in color motion picture films packaged in standard metal or plastic film cans or other sealed or semi-sealed containers can fade more rapidly — in some cases, much more rapidly — than is predicted by accelerated dark storage tests with free-hanging specimens using the test procedures specified in *ANSI IT9.9-1990* (see Chapter 2).

To avoid this problem with acetate-base films, Ram and his co-workers recommend packaging films in taped cans with a sodium aluminum silicate "molecular sieve"[38] to absorb moisture, acetic acid vapors, and other gases that could potentially affect dye and film-base stability. Placing an amount of the sodium aluminum silicate molecular sieve equal to about 2-percent of the weight of the film in the can was recommended. The molecular sieve, which is contained in a tubular Tyvek package that is wrapped around the outside of the film roll (which has been wrapped with a sheet of polyethylene), should be replaced about every 2 to 3 years when the film is stored at room temperature, and every 10 to 15 years if the storage condition is maintained at 35°F (1.7°C) and 20–30% RH. If the relative humidity of the storage area is not maintained at a low level (e.g., 30% RH), the cans should be taped during storage.

Pending the outcome of further studies of the proposed molecular sieve film-storage method — including the costs, labor requirements, and the long-term physical effects on various types of films — it is believed by this author that the increase in the life of color motion picture films that will be obtained with the use of molecular sieves in sealed film cans can be achieved at lower cost and with less labor by storing films in "vented" plastic film cans[39] (or in high-quality, vapor-permeable cardboard boxes[40]) and lowering the storage temperature an appropriate amount.

This author does, however, highly recommend the molecular sieve method to greatly extend the life of B&W separation films (YCM's), sound negatives, microfilms, and other types of B&W and color motion picture films (including nitrate films and Technicolor nitrate-base IB prints) that are stored under non-refrigerated conditions.

Film vaults used to store film packaged in vented film cans or permeable cardboard boxes should be equipped with activated charcoal filtration systems to remove acetic acid vapors and other potentially harmful by-products of film-base deterioration. In addition, air filters should be provided to remove dust, lint, and other particulate matter from the airstream that over time could contaminate films stored in vented film cans.

Nitrate Film Buried and Abandoned in Yukon Permafrost Preserved for 50 Years

In a dramatic example of the benefits of cold storage (in this case with *no* humidity control whatsoever), over 500 cellulose nitrate motion pictures were buried in the frozen ground of Dawson City in the Yukon Territory in the northwest part of Canada in 1929. When the films were found and dug out of the permafrost in 1978, they were for the most part still in fairly good condition. The discovery was described in the movie business publication *Variety* in 1988:

> The cache included one-reelers, serials, and news films dating from 1903 to 1929. It included some films by famous people and some by people never mentioned in film histories.
>
> All on 35mm nitrate stock, these movies had found their way to the Yukon during the gold rush that started in 1896.
>
> When the gold fever subsided, the reels of film were left behind in the basement of the local Carnegie Library. Then, in 1929, they were used as fill for an open-air swimming pool the town had decided to get rid of.
>
> They remained there until 1978 when workmen found them while breaking ground for a new recreation center.[41]

The recovery and restoration of the films was supervised by Sam Kula of the National Archives of Canada, and the films, many of which exist nowhere else, are now part of the Archives' motion picture collection.

Low-Temperature, Humidity-Controlled Storage versus Black-and-White Separations

At present there are only two approaches to the long-term preservation of color motion picture films. One method is to make black-and-white silver separations (also called YCM's or Protection Masters) from the original camera color negative and to then rely on these separations for future reconstructions of the color image. The other approach to long-term preservation is to store the original color negative (or reversal film), color intermediates, magnetic masters, sound negatives, and release prints in humidity-controlled cold storage (i.e., 0°F [–18°C] at 30% RH).

When low-temperature storage is used, the making of expensive black-and-white separations is completely unnecessary; in fact, accelerated aging data — and years of experience with black-and-white films — show conclusively that color originals stored at low temperatures will last far longer than silver separations kept in normal air-conditioned room storage.

The availability of color release prints in perfect condition is one of the most valuable aspects of the low-temperature approach to film preservation. A print can be readily accessed for transfer to videotape for television transmission and videodisc production, or for future forms of electronic theatrical release and other applications where only a single top-quality print is required. There will be no laboratory costs for color correcting a faded print, or for making a new composite print from separations or from faded original color negatives or intermediates.

In the event of future theatrical film release, a preserved print can be used as a visual guide for the proper timing (adjustment of overall density and color balance) of new print production. Without a well-preserved original print, there will probably be no way to time new printings — or video transfers — to closely match the way the original film looked when it was made.

Separations Have Been Recommended Since the Early Days of Color Motion Pictures

The making of black-and-white separations has long been recommended as the best way — or even the only way — to preserve color motion picture images for long periods of time. Graham, Adelstein, and West, writing in the *Journal of the SMPTE* in 1970, said that "This method is the ultimate for long-time preservation of color photographic records although the cost of making black-and-white separations is high."[42] The widespread use of color separations in the motion picture industry had its start with the introduction of the 3-strip Technicolor camera in 1934; this complex camera used three rolls of black-and-white film to make direct separations of moving scenes. The separations were used to prepare gelatin-relief matrix films for printing by the Technicolor dye-imbibition process (see Chapter 10).

Later, separation negatives were prepared in the laboratory from original Kodachrome and Anscocolor motion picture films as a step in making prints by the Technicolor process. Unfortunately, prior to 1950, virtually all the film stocks supplied to the professional motion picture industry were made on cellulose nitrate supports. Because of dimensional instability, separations made using these older films generally print out of registration unless special equipment is used to register the separations on a scene-by-scene or even frame-by-frame basis (the use of original cellulose nitrate camera separation negatives in recent restorations of *Gone With the Wind* and other Technicolor dye-imbibition movies is discussed in Chapter 10).

When Eastman Kodak introduced chromogenic Eastman Color Negative Film in 1950, separation positives were used for the preparation of duplicate negatives for volume printing on Eastman Color Print Film; initially, no color intermediate films were available from Kodak, so this was the only way duplicate color negatives could be made.

Separation positives have come to be known as YCM's in reference to the fact that one separation is a record of the yellow dye layer of the color negative, the second is the record of the cyan dye layer, and the third is a record of the magenta dye layer. YCM's generally are printed from the original color negative. YCM's are usually timed during printing (after a trial answer print has been made). Some, however, are printed with only one light. Separations are sometimes made from fully-timed color interpositives; in such cases, the separations have negative images and properly are called separation negatives or "RGB" separations.

The Technicolor Corporation made separations from Eastman Color Negative films as a step in making dye imbibition release prints until the process was phased out by the firm in favor of the chromogenic Eastman color print process in the mid-1970's.

After Eastman Color Negative Film came into wide use in the 1960's, it was common practice to make separation positives (YCM's) for major theatrical productions; this was done both to have assurance that a new, duplicate color negative could be prepared for making prints when the original color negative had faded to an unacceptable degree, and to provide an immediate back up for the original negative should it be physically damaged during laboratory printing operations. However, because of the great expense involved in making separations, they have only rarely been made for films other than major theatrical releases in the United States and Europe.

Eastman Panchromatic Separation Film 5235, which has been used for many years by the entertainment film industry for making separations (YCM's), has always been manufactured with a cellulose triacetate base. A polyester-base version of 5235 is available as Eastman Panchromatic Separation Film SO-202; this film, which is far superior to 5235 because of its much better permanence and dimensional stability, has been available since around 1990 and is now supplied by Kodak as a stock item.

One of the unfortunate results of the continued reliance of the major film studios on separations for long-term preservation has been to discourage the construction of low-temperature, humidity-controlled film storage facilities.[43] Since it was believed that in most cases the major films had been preserved, for most studios there has been little incentive to worry about the general state of motion picture preservation.

The Now-Discontinued NASA Separation Negative Project for Spaceflight Color Films

In 1976, the U.S. National Aeronautics and Space Administration (NASA) instituted a major project to produce separation negatives for the off-site backup preservation of color transparency films made during manned space flights starting with the first suborbital flight by astronaut Alan Shepard on May 5, 1961, and continuing through the joint Russian-American Apollo-Soyuz mission which took place in July 1975. Other than in the theatrical motion picture industry, the NASA separation project is probably the only large-scale attempt in the U.S. to use separations for backup preservation purposes.

The NASA separation program is described here *not* to encourage the making of separations. Rather, it is to illustrate just how involved and expensive such procedures can become if one wants to have an assurance that the separations will be usable for high-quality color image reconstructions in the distant future when current film stocks are no longer available.

By 1980, the NASA collection of color films taken during space flights and the historic 1969 landing on the surface of the moon — NASA refers to such films as "flight films" — consisted of about 20,000 feet of 16mm film, about 3,000 feet of 35mm film, 15,000 feet of 70mm film, and about 5,000 feet of 5-inch film. These films included both still and motion picture footage. Black-and-white separations had been made of the bulk of the 1961–1975 footage by the end of 1979.

NASA considers the original space flight films to have extraordinary historical value, and separations were made from the 1961–1975 films as backups should anything happen to the original color transparencies. NASA had kept the original films in moderate-temperature cold storage at about 55°F (12.8°C) and 50% RH during the years following the original space flights. However, upon the realization that much lower storage temperatures were necessary to permanently preserve the films, a new vault was completed in 1982 which is maintained at 0°F (–18°C) and 20% RH.

According to Noel Lamar, formerly with NASA's Image Sciences Division, the decision to make black-and-white separations instead of originally storing the color originals at low temperatures was made for several reasons.[44] Two reasons were that making separations for long-term keeping was the usual recommendation given in the literature dealing with this subject, and it was also the recommendation given by Eastman Kodak Company at that time.

An additional consideration was that there was no certainty that the original films would always be kept in cold storage during future years. For example, at the time the separation project was planned, the U.S. National Archives did not have a cold storage facility for color films, and if the space flight originals were handed over to the National Archives, they would have ended up being stored under inadequate conditions. (Regrettably, the National Archives did not include a 0°F [–18°C] storage vault in its new building in College Park, Maryland which is scheduled to open in December 1993.)

Because of the extreme historical importance of the manned space flight photographs, Lamar said that "morally we felt we should make separations" to assure the preservation of the images. NASA also transferred video-

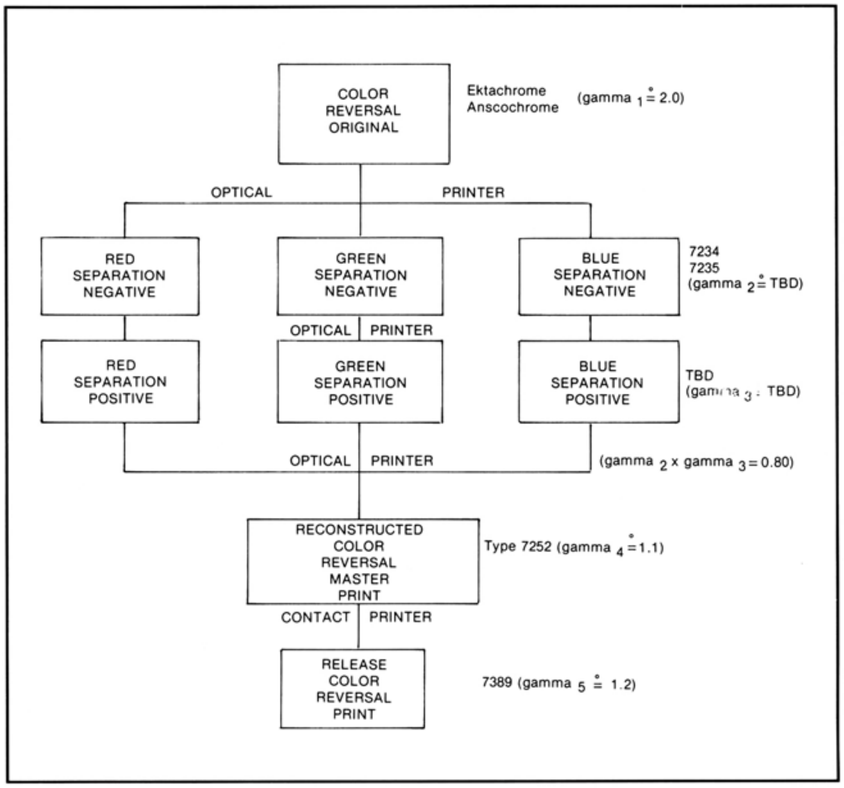


Figure 9.1 NASA's tentative procedure for reconstructing color images from the black-and-white separation negatives that were made from spaceflight reversal originals in NASA's now-discontinued separation negative program. Because the original color films are stored at 0°F (–18°C), it is unlikely that the polyester-base separation negatives NASA has made will ever be needed. They were produced as an off-site backup for the irreplaceable originals at a time when separations were recommended to protect the images of valuable color originals. Except for test samples, separation positives have not been prepared from the separation negatives because the sensitometric characteristics of future film stocks are unknown. (From: **Black-and-White Separations of Spacecraft Original Film**, Technical Report, by Lincoln Perry, Photographic Technology Division, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, 1975.)

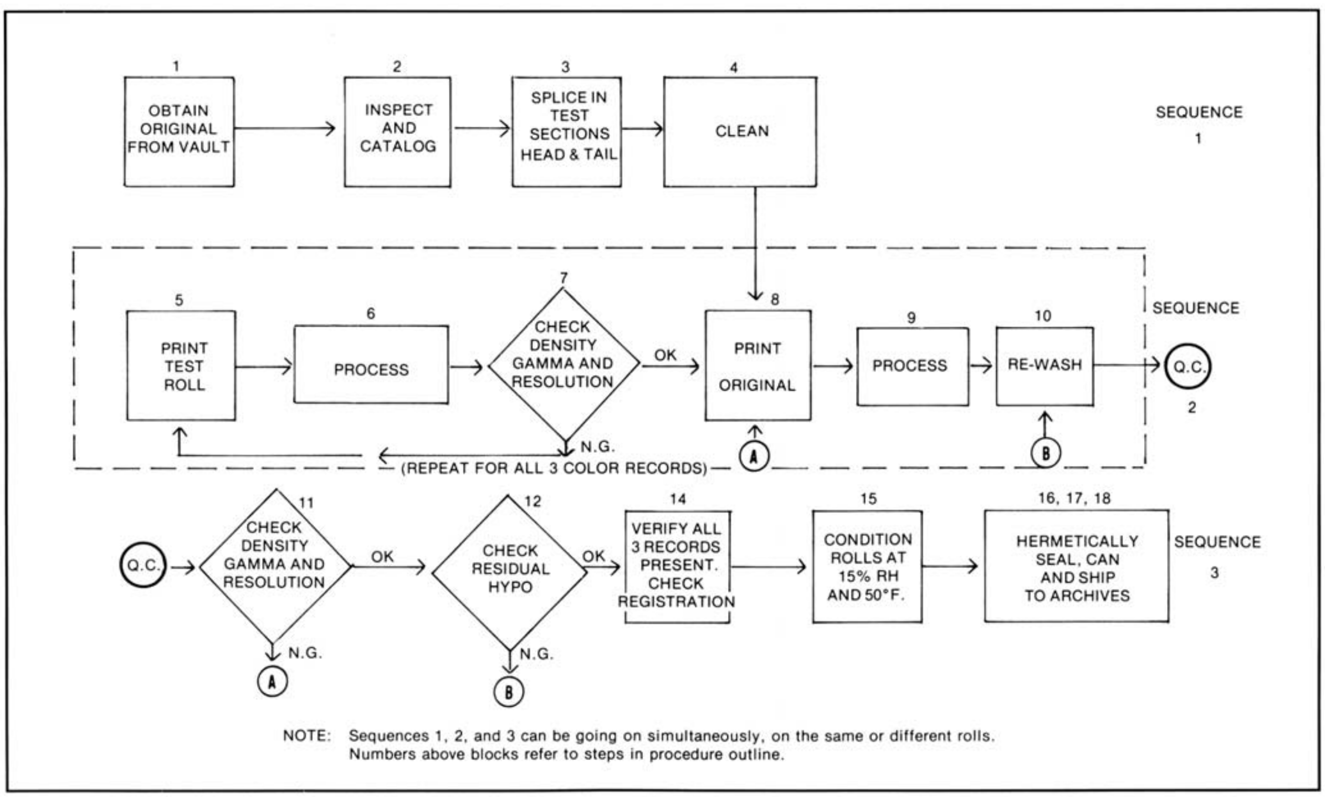


Figure 9.2 The flow chart used by NASA for preparation of black-and-white separation negatives from color reversal spaceflight originals. NASA employed an elaborate series of quality control checks to ensure that the density and gamma of the separation negatives were correct and that the films were properly processed and washed.

November 1979

Until 1982, original spaceflight films were stored at NASA in a room maintained at 55°F (12.8°C) and 50% RH. When densitometric measurements of step wedges in the headers of the specially-coated polyester-base Ektachrome EF and MS films revealed that the color images were slowly fading in the 55°F environment, the entire preservation program was re-evaluated and three new 0°F (–18°C), 20% RH vaults were constructed to halt further fading of these priceless records.

tapes generated during the Apollo missions to color film, and separations were then made from these films.

NASA developed a complex two-stage separation procedure which consists of making separation negatives from the color originals and then, at a later date, making gamma-adjusted separation positives from the separation negatives.[45] This procedure avoids the problem of not knowing what gamma and reproduction characteristics of a future reconstruction process will be. The general process is outlined in **Figure 9.1**. The entire reproduction procedure was tested with a number of test examples; however, for most films, only the first stage of the process — the separation negatives — was completed. The remaining steps need not be done until some future time when there may be a reason to reconstruct the color images from separations instead of making duplicates from the color originals.

The separations were made on polyester-base roll films of the same width as the originals; the separation film emulsion is similar to that used in Kodak Panatomic-X still-camera film. NASA used an elaborate quality control program for the making of separations in which process quality, residual chemicals, and registration were carefully checked — the procedures are outlined in **Figure 9.2**. The NASA procedures were more exacting — and far more costly — than the methods used by the theatrical motion picture industry. While most of NASA's separations were made from reversal originals, thus producing a separation negative instead of the separation positive which results when a separation is made from a color negative, the basic difficulties of reconstructing accurate color images from black-and-white separations with future color films of unknown sensitometric characteristics remain.

After the completion of a 0°F (–18°C) and 20% RH cold storage vault 1982, NASA concluded that making black-and-white separations was no longer necessary, and the separation negative project was discontinued. With two off-site backup sets of duplicates also kept at 0°F (–18°C), NASA now relies on low-temperature storage for the permanent preservation of original spaceflight color films.

Potential Long-Term Problems with Black-and-White Separations (YCM's)

As current film stocks become obsolete and are replaced with new materials of different sensitometric characteristics, it may be a difficult and costly process to print existing negatives or separations without significant losses in image quality. As an example — even if differential shrinkage were not a factor — separations made with the obsolete Technicolor 3-strip cameras may be incorrectly matched to current color film stocks:

> Making new prints of a film photographed by means of the Technicolor three-strip process involves a number of unique problems stemming from the fact that separation elements for such

The original Ektachrome EF and MS films used by the astronauts for photography on the historic Apollo mission to the moon on July 16–24, 1969, together with original color still photographs and motion pictures from other space missions, are permanently preserved at 0°F (–18°C) and 20% RH at NASA headquarters in Houston, Texas. Shown here are NASA staff members Frank Zehentner (left) and Terry Slezak preparing to remove an aluminum case containing uncut rolls of color film originals. As part of the most sophisticated color film preservation effort in the world, a complete set of duplicates is stored in a second 0°F (20% RH) facility in Houston, and a third set is kept in a 0°F (20% RH) vault at White Sands, New Mexico.

October 1987 (3)

Cans of cataloged rolls of color spaceflight films from the Apollo missions to the moon were placed in waterproof aluminum cases for storage in the Houston vault. Included are the original 70mm Ektachrome color transparencies photographed by astronauts Neil A. Armstrong and Edwin E. Aldrin, Jr. after they landed on the moon on July 20, 1969. Because these films were actually on the surface of the moon, no duplicates or high-resolution digitized copies — no matter how perfect — can ever approach the value of the originals as historic objects. Now stored at 0°F (–18°C) and 20% RH, NASA intends to preserve these films in essentially unchanged condition forever. A plaque left on the moon by the astronauts is engraved: "Here men from the planet Earth first set foot upon the Moon, July 1969, A.D. We came in peace for all mankind."

Signs on the NASA storage vault door warn of the potentially life-threatening carbon dioxide fire extinguishing system. Because the original spaceflight films are never used for routine printing (color internegatives and duplicate transparency printing masters were made from uncut rolls shortly after processing), this is a dead storage vault and is entered only infrequently. NASA operates a sophisticated color processing laboratory in the building where the vault is located, so the original spaceflight films need never leave the high-security facility.

Temperature and relative humidity conditions inside the vault are constantly monitored; alarms will sound to alert NASA staff if preset limits are exceeded.

Table 9.6 Estimated Cost of Cold Storage Rental Per Year for Motion Picture Film (0°F [–18°C] and 30% RH)*

Conformed original color negative — 9 cans (if A and B rolls: 18 cans @ $ 72.00)	$ 36.00
Color interpositive (5243 or 5244) — 9 cans	$ 36.00
Color internegative (5243 or 5244) or CRI (5249) — 9 cans	$ 36.00
Magnetic master — 9 cans	$ 36.00
Sound negative — 9 cans	$ 36.00
Release or answer print (5384) — 9 cans	$ 36.00
Total Per Year:	$ 216.00

* 9,000 feet of 35mm film in nine 1,000-foot cans; $30.00 rental per cubic foot per year (7.4 cans per cu. ft.)

Table 9.7 Cost of Film Elements to Be Put in Cold Storage (9,000-Foot 35mm Feature Film)

1)	Original color negative (A rolls or A and B rolls)	none*
2)	Color interpositive and internegative (5243 or 5244) (also called color "master positive" and color "duplicate negative")	none*
3)	Release print (5384) @ $0.22/ft. (new, non-projected print; part of initial print order)	$ 1,980
	Total:	$ 1,980

* Costs of original camera negative, color intermediates, magnetic master, and sound negative already covered as a normal expense of film production.

> a Technicolor picture were tailored not only to the requirements of the Technicolor system, but also quite often were modified for the specific production. The net result is that the contrast or density of the separations may be inappropriate for printing directly onto current Eastman color stocks. If the contrast of a separation is too high the net result will be that the new color negative will yield contrasty prints which compare unfavorably with a well-preserved imbibition print of the same subject. Duping the separations and adjusting the gamma and density in the process before making the color negative may alleviate the contrast problem, but it will involve other compromises in the image quality which may or may not be considered less desirable.[46]

Other potential problems of silver separations are differential shrinkage of the cellulose triacetate film base (which would cause the images to be printed slightly out of registration) and fading or discoloration of the silver image. Even slight silver image irregularities which occur as a result of fading or staining will result in uneven color reproduction when the separations are printed in future years; such irregularities would likely be difficult or even impossible to correct.

Further, in light of the discussion concerning cellulose triacetate film base degradation earlier in this chapter, it should be noted that the separation film normally used for motion picture work, Eastman Panchromatic Separation Film 5235, is supplied by Kodak on a cellulose triacetate base. An Estar polyester-base version of 5235 is available as Eastman Panchromatic Separation Film SO-202; this film is supplied by Kodak as a stock item and is far superior to 5235 for separations because of its much better permanence and dimensional stability.

Costs of B&W Separations versus Cold Storage for Long-Term Preservation

When one compares the high cost of making separations with the relatively low costs of keeping films in low-temperature cold storage, there would appear to be little justification for the continued use of separations for preservation purposes. Using a base rental figure of $30 per year per cubic foot of humidity-controlled 0°F (–18°C) cold storage space in a commercial facility,[47] it would be possible to store all the important elements of a typical 9,000-foot theatrical motion picture for about $216 per year (see **Table 9.6**). As all the elements of a film, except an additional release print, are normally made during the course of production, there is little additional expenditure for the materials to be placed in cold storage (**Table 9.7**).

The costs of producing B&W separation interpositives ("YCM's" or "Protection Masters") and a comparison with the costs of cold storage are given in **Table 9.8** and **Table 9.9**. Black-and-white separation interpositive costs, new color internegative, answer print, and other costs were based on prices quoted by Technicolor, Inc. (Hollywood) in September 1992 and were typical of the prices charged for these services by major motion picture laboratories in Hollywood and New York at the time this book went to press.

In **Table 9.2**, which was discussed earlier in this chapter, estimates based on published Kodak data for a visually detectable dye loss of 10% for many current Kodak motion picture color negative and color print films stored at 75°F (24°C) are given. In **Table 9.5**, corresponding estimates for a 10% dye loss are given for the same films stored at

Table 9.8 Cost of Motion Picture Film Elements for Preservation by B&W Separation Procedure (9,000-Foot Feature Film)

Set of three B&W separation interpositives (YCM's) (SO-202 or 5235) @ $3.71/ft. (additional costs if A and B roll original)	$ 33,390
Additional costs to obtain new print from B&W separations:	
Internegative from separations (YCM's) (5243 or 5244) @ $4.70/ft.	$ 42,300
Color print from internegative (5384) @ $1.67/ft. (fully timed answer print)	$ 15,030
Total Cost:	$ 90,720

Note: Additional prints (5384) @ $1.52/ft. may be required for timing purposes. $ 13,680

Second color internegative may be required if large numbers of prints are needed for theatrical release. $ 42,300

Table 9.9 Comparison of Costs for Cold Storage and B&W Separation Approaches to the Preservation of Color Motion Picture Films

Cold Storage Approach:	
Annual cold storage for release print only	$ 36
Annual cold storage for all elements of a feature film	$ 216
Cost of additional release print for cold storage	$ 1,980
B&W Separation Approach:	
Cost of making three B&W separation interpositives (YCM's)	$ 33,390*
Cost of making new internegative and single answer print from B&W separation interpositives (YCM's)	$ 57,330

* Does not include cost of storage for separations, magnetic master, and sound negative.

55°F (12.8°C), 45°F (7.2°C), and 0°F (–18°C).

In **Table 9.10**, estimates are given for the number of years various original color film elements could be stored for the cost of making separations, and reconstructing new prints from the separations and sound negatives.

Optical Disk, Magnetic Tape, and Other Digital Image Storage Systems Are Not Satisfactory Substitutes for Preservation of Film Originals

Many film archivists have long held a dream that someday a "perfect" film preservation system would be devised to allow transfer of color motion picture images onto some sort of extremely high-resolution and essentially permanent digital medium that could be stored under ordinary room-temperature and humidity conditions forever. Such a system, it has been hoped, would give quick access to each and every film stored in huge collections and would be able to produce perfect "film-resolution" transfers or videotape and laserdisc copies of the films on demand — and at low cost.

With the commercial introduction of the Kodak Cineon Digital Film System in 1993, and other "film-resolution" digital intermediate systems, the interest in such a fully digital preservation system is certain to increase.

Although intended for special effects, scene salvage (elimination of scratches), restoration of damaged frames, and image compositing — with the capability of writing the edited digital file on a color photographic intermediate film for seamless intercutting of original negatives — the Kodak Cineon system could conceivably be used to produce "film-resolution" digital tapes or optical disks of full-length color motion pictures. (For an overview of practical applications of digital technology in the motion picture industry, the reader is referred to an article by Bob Fisher entitled "The Dawning of the Digital Age," which appeared in the April 1992 issue of *American Cinematographer*.[48])

Working with the Kodak Cineon system is an expensive proposition. Scanning costs about $6 per frame and writing digital images back to film is an additional $8 per frame. Cineon workstations cost from $250,000 to over $1 million (prices do not include film scanner and film recorder hardware — these services must be contracted from Kodak). Rental of a Cineon facility can cost up to $1,500 per hour.

With approximately 40 megabytes of non-compressed digital data *per frame* (2,600 lines x 3,600 pixels),[49] the file size for 1 second (24 frames) of 35mm Academy aperture color film exceeds 1 gigabyte (one-billion bytes).[50]

A "one-hour" D-1 videocassette holds about 72 Gbytes of digital data; therefore, a full D-1 videocassette can store "film-resolution" data for only about 1 minute of film!

Even if a "film-resolution" digital preservation system for full-length motion pictures eventually becomes a cost-effective alternative to storage of film itself, significant problems remain. Aside from uncertainties about the long-term stability of the various forms of digital magnetic tapes and optical disks in this rapidly changing industry, there is the much more serious problem of *hardware* and *software*

Table 9.10 Number of Years That a Motion Picture Film Can Be Kept in Cold Storage for Cost Equal to That of Making B&W Separations and Other Film Elements

a)	All elements in cold storage for cost of separations	155 years
b)	All elements in cold storage for cost of separations plus new color internegative and new print	420 years
c)	Original negative in cold storage for cost of separations	930 years
d)	Original negative in cold storage for cost of separations plus new color internegative	2,100 years
e)	Print only in cold storage for cost of separations	925 years
f)	Print only in cold storage for cost of separations plus new color internegative and new print	2,520 years

obsolescence.[51, 52] One need only to look at the large number of incompatible videotape formats that have been in existence since video recording was commercialized in 1956 by the California-based Ampex Corporation to realize just how serious such problems have become. The reader is referred to two sobering articles on this subject by John C. Mallinson, formerly the manager of research at the Ampex Corporation: "Archiving Human and Machine Readable Records for the Millenia,"[53] and "Magnetic Tape Recording: History, Evolution, and Archival Considerations."[54]

Like color films, videotapes, digital data tapes, and optical disks can probably be preserved for extended periods in low-temperature, humidity-controlled storage. However, the necessary playback equipment *cannot* be maintained in working order indefinitely. Further complicating the long-term digital data preservation picture is the fact that current and near-future digital data compression-decompression software/hardware systems likely will not be supported in future years as improved systems are developed.[55]

Despite the appeal of digital recording systems — which offer the hope of almost limitless re-recording without generational image-quality losses — the industry is nowhere near the time when one could even consider abandoning color originals and color release prints as the primary preservation medium for film-originated productions.

Humidity-Controlled Cold Storage Facilities for the Permanent Preservation of Valuable Color Motion Picture Films

When it is important to protect major productions and other very valuable footage from catastrophic loss which could occur as a result of earthquakes, equipment failure, fire, theft, or damage during transportation or laboratory handling, the various film elements made during the course of a production should be divided between low-temperature, humidity-controlled cold storage facilities at two different geographic locations.

For example, one cold storage installation should be used to store the original conformed color negative, master positive, duplicate color negative or CRI, sound cut negative and/or magnetic master, and two mint-condition release prints, including a copy of each foreign-version release print (as many as 250 rolls of pre-print elements may be involved in a major production; some classic films have more than 1,000). This remote facility would be used as a high-security dead storage area which would not normally need to be accessed; it would serve as the ultimate backup should a film element in the second facility become lost or damaged.

The second low-temperature storage installation should be close to production and laboratory facilities; it is the color film and sound elements in this facility that would normally be used for videocassette and videodisc production, television transmission, and theatrical re-release.

In the long run, a perfectly preserved release print — which has integral, synchronized sound tracks and the exact scene-by-scene density and color balance called for by the film's director — may prove to be the only readily usable element from current film productions. As digital high-definition television systems evolve in coming years, it will always be desirable — and in many cases absolutely necessary — to go back to the color photographic original in order to obtain the maximum image quality of which each of these new electronic systems will be capable.

Illustrated on the following pages are the color film cold storage facilities at Paramount Pictures, Warner Bros., Turner Entertainment Co. (at the Records Center of Kansas City), the Library of Congress, and the National Archives of Canada. These and other cold storage facilities are also described in Chapter 20, *Large-Scale, Humidity-Controlled Cold Storage Facilities for the Permanent Preservaton of Color Films, Prints, and Motion Pictures.*

In 1996, the National Archives of Canada Will Open the World's Most Advanced Color Motion Picture Storage Facility

In 1996 the National Archives of Canada plans to open a new film preservation facility near Ottawa in Gatineau, Quebec that will include a large color film storage vault maintained at 0°F (–18°C) and 25% RH for the permanent preservation of the Archives' vast collection of color motion pictures and still-camera photographs.[56] The new installation, which will be operated by the Moving Image, Data and Audio Conservation Division of the National Archives of Canada, will replace a current color film storage vault kept at 28°F (–2.2°C) and 28% RH (see pages 337–338). The new vault will include a sophisticated air-filtration system to remove acetic acid vapors, oxidizing gases, dust, and other contaminants which could harm motion picture film.

The National Archives is the designated repository for films produced by the National Film Board of Canada and other government agencies.

The color film storage vault in the Paramount Pictures Film and Tape Archive, located on the Paramount studio lot on Melrose Avenue in Hollywood, California. The color film vault, one of nine vaults in the high-security building, is maintained at 40°F (4.4°C) and 25% RH. The multi-million dollar facility went into operation in 1990. Shown here in the color film vault, which is equipped with movable shelving to conserve space, is Robert McCracken, a supervisor in Archive Operations.

The Paramount Pictures Film and Tape Archive: Hollywood's First Modern Humidity-Controlled Cold Storage Facility for Color Film Preservation

In 1990, Paramount Pictures opened a new cold storage facility in Hollywood for preservation of its vast film and video collection. Consisting of nine vaults, which operate at different temperature and relative humidity conditions depending on the film or video elements stored in them, the facility currently houses more than 270,000 rolls of motion picture film, as well as a large amount of videotape from the studio's television productions. The facility, which was built at the behest of former Paramount studio head Frank Mancuso, was designed with enough space to accommodate Paramount's expected film and video production for the next 20 years.

Like most other Hollywood studios, Paramount has a strict policy of dividing the various pre-print elements for a given film between two or more geographic locations. In recent years the Hollywood studios have become acutely aware of the potential for catastrophic loss of their entire collections because of fires, earthquakes, or other disasters. Paramount has been making sets of separations (YCM's) for its feature films since the 1930's, and these are stored in a high-security underground facility in Pennsylvania.

Facing a Hollywood-style re-creation of a New York City street, the front wall of the Film and Tape Archive is covered with a facade of a row of red brick townhouses. The back of the high-security building is covered with Paramount's landmark blue-sky backdrop that has been used in the filming of many movies. Hidden from view within the Archive structure is the refrigeration and air-filtration equipment. The fire- and earthquake-resistant building has its own backup generating system which can supply electrical power for the entire building for an indefinite period in case of a power outage.

Specially designed shelves hold each roll of film in a separate slot, which simplifies locating a specific roll and avoids the handling difficulties that can occur when rolls are stacked. Paramount has inaugurated a program to repackage films in special, alkaline-buffered cardboard boxes to prevent the gradual accumulation of acetic acid vapors that can occur in regular film cans as a result of acetate film-base decomposition (the "vinegar syndrome"). If acetic acid vapors are not vented or otherwise removed, both dye fading and film-base deterioration can be accelerated. The air in the vault is filtered to remove acid vapors and other contaminants. McCracken is shown here pulling a can containing a roll of the original camera negative from Francis Ford Coppola's 1974 classic, **The Godfather, Part II**. The film, which won six Academy Awards, including Best Picture, Best Director, and Best Screenplay, starred Robert DeNiro, Robert Duvall, Diane Keaton, and Al Pacino.

Each roll of film and videotape is bar-coded and tracked with a sophisticated computer-based inventory system. The location of a particular roll can be quickly determined by its slot, rack, row, and vault number. When rolls of film are removed for lab work, the vacated slots are reassigned to incoming rolls by the computer system.

Paramount Pictures has an extensive television output, including **Entertainment Tonight** (the show has more than 100,000 interview and show tapes) and the **Star Trek** series. Shown here is the main videotape vault. Since 1987, all of Paramount's feature films and television productions have been transferred to digital videotape.

October 1992 (3)

October 1992 (2)

One of the three film storage vaults in the new Warner Bros. high-security motion picture cold storage building on the Warner Bros. studio lot in Burbank, California. The color film vault, which is maintained at 35°F (1.7°C) and 25% RH, and the other vaults were operating and in the final phase of testing when this photograph was taken on October 8, 1992. Warner Bros. began moving its film collection into the vaults a few weeks later. Shown here in the larger black-and-white film vault, which, like the two other vaults in the building, is equipped with movable shelving that permits high-density film loading, are John Belknap, manager of Film Vaults/Assets, and Bill Hartman, manager of Asset Inventory Management and Research in Corporate Film Video Services at Warner Bros. The $9-million cold storage facility was designed under the direction of Peter R. Gardiner, vice president of Operations in Corporate Film Video Services at Warner Bros.

The Sophisticated Warner Bros. Cold Storage Facility for Color and B&W Motion Picture Films

Warner Bros. opened a new humidity-controlled cold storage facility on its Burbank studio lot in October 1992. One of the three vaults is for color film and is maintained at 35°F (1.7°C) and 25% RH. A second vault is used for separations (YCM's) and other black-and-white films and is kept at 45°F (7.2°C) and 25% RH. The third vault is used to store less-critical duplicate film elements and circulating materials and is maintained at 50°F (10°C) and 45% RH. An advanced air-filtration system is provided to remove acetic acid vapors and other gases resulting from film degradation — and from Los Angeles air pollution.

Warner Bros. is a part of Time Warner Inc. which, with Home Box Office (HBO), a far-flung cable TV system, and extensive publishing operations, is the world's largest entertainment company. In mid-1992 Time Warner inaugurated an experimental 150-channel interactive cable TV service in Brooklyn, New York. In addition to broadcasting a large number of movie titles around the clock, the new system is potentially capable of sending pay-per-view movies to individual subscribers' homes upon request. When such expanded systems are installed on a large scale, it is expected that there will be a tremendous increase in the demand for movie titles and other programming.

The high-security building has only one entrance so that all incoming and outgoing shipments can be carefully checked.

Prior to moving films into the new facility, Warner Bros. instituted a massive program to re-can all of its film in new bar-coded “vented” plastic film cans to prevent the “vinegar syndrome” — the accumulation of acetic acid vapors and other harmful acetate film-base deterioration by-products within the film cans. The building is equipped with a redundant activated charcoal air-filtration system to remove acetic acid vapors, peroxides, formaldehyde, and other potentially harmful substances from the air.

The new facility has a sophisticated air-quality monitoring system to detect the presence of acetic acid vapors, oxidizing gases, and other potentially harmful substances. Air samples are periodically withdrawn from the vaults through small Teflon tubes that are connected to an automated gas-analysis unit. Shown here at a terminal connected to the building’s systems-control computer is Ed Cunningham, an engineer with Turner Construction Company, the general contractor for the new facility.

Cargocaire continuous desiccant dehumidifiers and other air-handling equipment for one of the film storage vaults.

The refrigeration machinery room. To avoid cooling and dehumidification failures, all systems are fully redundant.

The building is equipped with an advanced fire-detection and intrusion alarm system. Access to film vault areas is electronically restricted to certain key personnel.

Haylon gas fire-suppression systems are provided for each of the film vaults in the fire- and earthquake-resistant building. Security systems are monitored 24 hours a day.

October 1987

Original camera color negatives, color interpositives, YCM's, sound negatives, and other pre-print elements in the Turner Entertainment Co. Film Library are stored in the high-security underground facility operated by the Records Center of Kansas City, located in the rural outskirts of Kansas City, Missouri. Turner Entertainment, which purchased the film library in 1986 at a cost of more than $1 billion, and the major Hollywood studios routinely store backup elements of all their films in remote, high-security facilities to avoid the possibility of a catastrophic loss of their entire collections due to fire, earthquake, tornado, sabotage, civil disturbance, or nuclear attack. When this photograph was taken in 1987, Turner had over 50,000 cans of film in storage in the Kansas City facility. With film, videotape, and computer tape storage vaults kept at 38°F (3.3°C) and 40% RH, the Records Center of Kansas City offers some of the best storage conditions available in a rental facility.

The Turner Entertainment Co. Backup Film Library at the Records Center of Kansas City

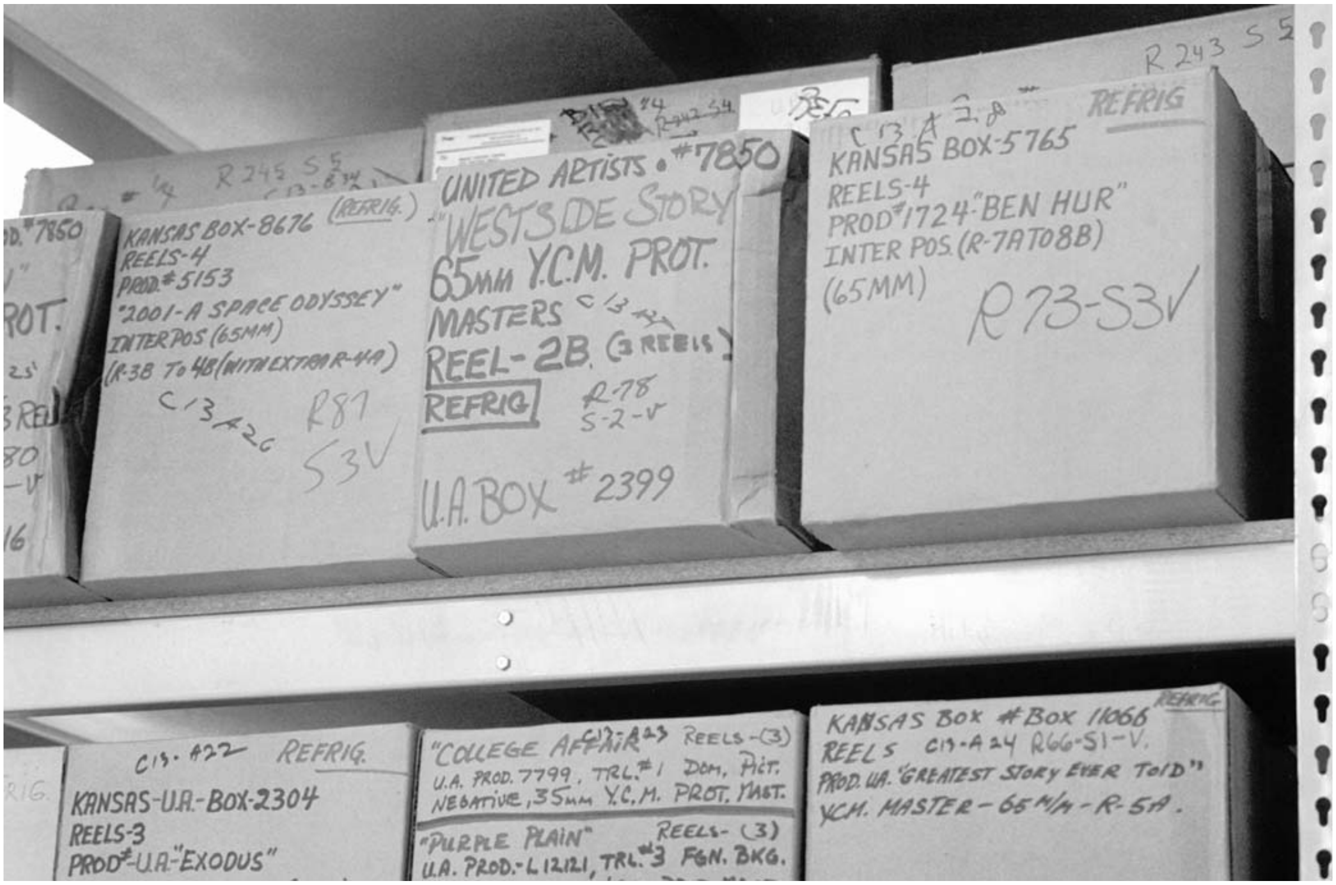
Located in a high-security complex constructed 175 feet below ground in a worked-out section of a huge limestone mine in Kansas City, the Records Center of Kansas City's large refrigerated rental facility is maintained at 38°F (3.3°C) and 40% RH.

Among the materials stored in the underground vault are original color negatives, interpositives, and other color pre-print elements for films in the Turner Entertainment Co. Film Library that was acquired when Ted Turner's Atlanta, Georgia based Turner Broadcasting System Inc. purchased MGM/UA in 1986 for about $1.5 billion (included in the library were most pre-1950 Warner Bros. films, which MGM/UA had acquired in a previous purchase). Turner subsequently sold the MGM Metrocolor film lab and most of the other assets acquired in the purchase; MGM Communications now operates as an independent company.

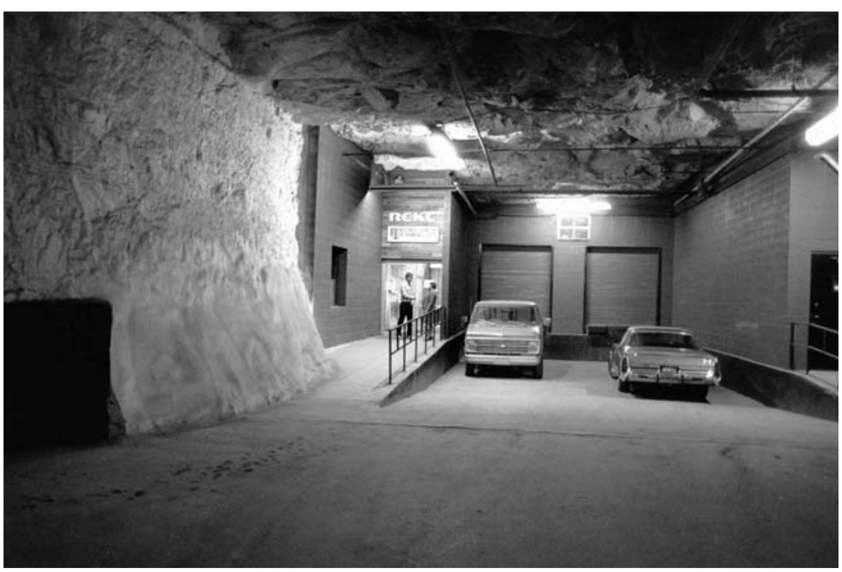
As the operator of CNN (the worldwide Cable News Network) and WTBS television, a "superstation" that broadcasts nationwide by satellite and over cable systems, Turner was primarily interested in acquiring the more than 2,200 movies in the MGM Film Library. By purchasing the MGM library, such film classics as *Gone With the Wind, Casablanca, The Wizard of Oz, 2001: A Space Odyssey,* and *Ben Hur* became available to Turner for broadcast, sale on videocassette and videodisc, and worldwide syndication to other television broadcasters.

The Turner Entertainment Co. film library has since been enlarged and now includes the RKO domestic market film library. In all, Turner now owns more than 3,300 feature films. The pre-print film elements stored in Kansas serve as a high-security, refrigerated backup for Turner Entertainment's main film library at the company's headquarters in Los Angeles, California. (At the time this book went to press in 1992, Turner did not have cold storage facilities for its film library in Los Angeles.)

The Records Center of Kansas City is a division of Underground Vaults and Storage, Inc., which also operates a deep underground, non-refrigerated film storage rental facility in Hutchinson, Kansas, where Turner Entertainment stores YCM's and other black-and-white film elements.



Boxes containing cans of various pre-print film elements stored in the underground Kansas City vault provide a refrigerated, high-security backup for color films kept at the Turner Entertainment Co. headquarters facility in Los Angeles, California. At the time this photograph was taken in 1987, Turner was storing a number of films for United Artists (e.g., **West Side Story** and **Exodus**) under a distribution agreement; these films have since been returned to United Artists.



The loading dock and entrance to the high-security Records Center of Kansas City facility, constructed against the side of one of the many massive limestone pillars that were left during mining operations to support the limestone roof of the mine. The Records Center is in the Hunt Midwest Underground complex, which has its own security force and fire department.

Safety-base duplicate black-and-white separations for **Gone With the Wind**. The classic 1939 Technicolor 3-strip film has often been called the crown jewel of the Turner Entertainment collection.

The cold storage vault at the National Archives of Canada in Ottawa. The facility was constructed in 1986 and is maintained at 28°F (–2.2°C) and 28% RH. Shown here working in the vault, which is used to preserve the Archives' collection of release prints of Canadian feature films and other color motion pictures, is William O'Farrell, chief of Film Conservation and Custody. O'Farrell wears gloves and a winter coat for protection from the cold. A new, much larger humidity-controlled cold storage installation will be completed in late 1996 near Ottawa in Gatineau, Quebec; the color film storage vault in the new facility will operate at 0°F (–18°C) and 25% RH. This will be the most advanced facility of its kind in the world.

The Advanced Film and Video Preservation Program at the National Archives of Canada

In late 1996, the Moving Image, Data and Audio Conservation Division (Roger Easton, director) of the National Archives of Canada will open a new installation, near Ottawa in Gatineau, Quebec, that will include the world's most advanced large-scale motion picture and color photography preservation facilities. A large vault maintained at 0°F (–18°C) and 25% RH will be provided for the Archives' vast collection of color and black-and-white motion pictures; the vault will also be used for still photographic materials and to preserve selected paper documents.

Other temperature- and humidity-controlled vaults in the new facility will be provided for storage of audio materials, videotapes, and computer tapes, disks, and other EDP records. A separate storage area maintained at 65.5°F (18°C) and 50% RH will be used to store oil paintings. In all, the new building will have eight separate controlled-environment zones, each of which will meet specific requirements for temperature and relative humidity. A sophisticated air-filtration system will keep acetic acid vapors, oxidizing gases, dust, and other airborne contaminants at low levels in all storage areas.

The National Archives serves as a centralized collection for all Canadian government agencies, including the National Film Board of Canada (which does not have its own cold storage facility). The Archives also has a purchase program for Canadian theatrical feature films. Release prints normally are supplied, but producers increasingly are asking the Archives to store pre-print elements for safekeeping. The majority of the color films now in the cold storage vault were acquired through this program.

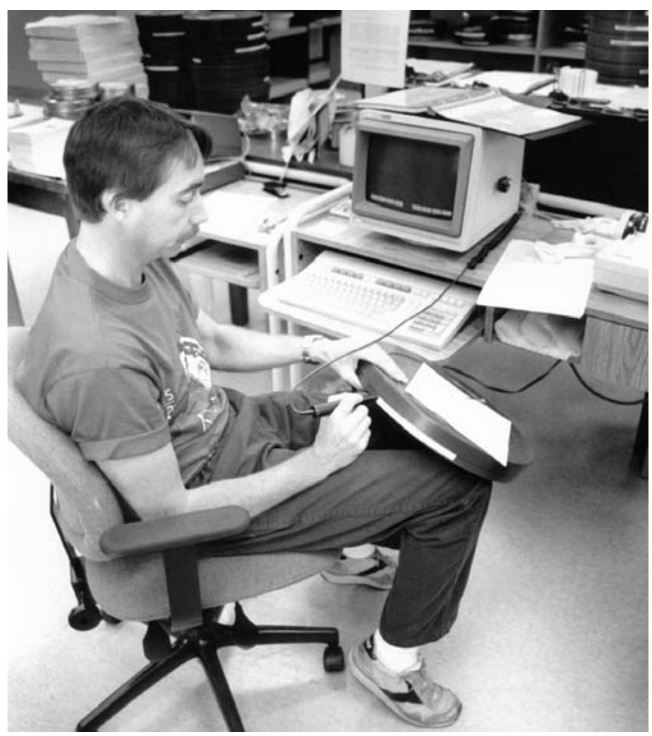
The National Archives collection includes a sizeable amount of video material in a wide variety of tape formats. Audio materials, including phonograph records, tapes, and CD's, as well as computer tapes, floppy disks, and optical disks are also collected in ever-increasing quantities.

The Archives' humidity-controlled 0°F (–18°C) facility that will open in 1996 will establish new standards for color and black-and-white motion picture preservation in film libraries, archives, and museums worldwide.

June 1989 (3)

Unlike most film archives, the National Archives of Canada operates a video conservation laboratory equipped with extensive video and film-to-tape transfer equipment. Because of the range of video materials in the Archives' collections, the lab has become what amounts to a museum of video tape recorders, ranging from the Ampex 2-inch quadruplex machines of the late-1950's to the latest digital D-1 and D-2 video tape recorders. Satellite downlinks are provided for around-the-clock taping of television broadcasts from the CBC (the Canadian Broadcasting Corporation) and CTV (the Caldwell Television Network) for the National Archives' collections.

Continuous dry-desiccant dehumidifiers manufactured by Munters Cargocaire (a subsidiary of the Munters Group in Sollentuna, Sweden) are used to maintain 28% RH in the color film vault. Most of the cold storage vaults in the U.S. and Canada use similar Cargocaire dehumidifiers.



Senior film conservator Dennis Waugh with a bar-code reader entering inspection data into a Hewlett-Packard mini-computer terminal. The metal cans of incoming films are replaced with color-coded plastic cans; recently, the Archives has started using "vented" plastic film cans.

November 1987

The Library of Congress color film storage facility located in Landover, Maryland, just outside of Washington, D.C. The humidity-controlled vault is maintained at 37°F (2.8°C) and 25% RH. Shown here in the vault is David Parker, assistant head of the curatorial section of the Motion Picture, Broadcasting, and Recorded Sound Division of the Library of Congress. Still-camera color photographs, including the color materials in the valuable **Look** magazine collection, are also stored in the color vault. Several larger vaults for storing black-and-white motion pictures are kept at 55°F (12.8°C) and 25% RH.

The Library of Congress Cold Storage Facility for Color and Black-and-White Motion Pictures

As the registrar of U.S. copyrights, the Library of Congress receives a release print of virtually every U.S. entertainment film production at no cost. In addition, the Library's collection includes many films from the American Film Institute, which does not maintain its own storage facilities. As a result, the Library now holds the most complete entertainment film collection in the country. (U.S. government film and video productions, including Defense Department materials, are preserved by the National Archives — see description on page 719.)

Because of budget and space constraints, not every film and video production that is registered for copyright is retained by the Library for its research and study collection. Although most theatrical and documentary films are kept, the Library is more selective about television productions, educational films, and religious material. At the time this book went to press in 1992, the Library had about 136,000 cans of black-and-white and color film in storage at its Landover, Maryland cold storage facility, which opened in 1978. Another 197,000 cans of safety-base film were being stored at various non-refrigerated locations. In addition, 117,000 cans of cellulose nitrate film were being stored at 50°F (10°C) and 30% RH in vaults near the Library's preservation facility at Wright-Patterson Air Force Base in Ohio (see **Appendix 19.1** on page 675).

June 1989

Preserved at the Library's nitrate film storage facility at Wright-Patterson Air Force Base near Dayton, Ohio, is this rare nitrate-base Technicolor imbibition print of the 1944 MGM production **Meet Me in St. Louis**, which was directed by Vincente Minnelli and starred Judy Garland.

Until around 1970, the Library did not consider preservation to be a primary goal; rather, the films were treated as a reference collection. All of the Library's Eastman Color prints and films made on similarly unstable Gevacolor, Fujicolor, and Ansco Color stocks from the 1950's through the 1970's were not refrigerated, and most have become severely faded. Even today, as pictured here in a storage room in the Library's motion picture division on Capitol Hill in Washington, D.C., thousands of rolls of color motion pictures continue to be stored under room temperature conditions; with new films arriving every day, budget constraints preclude providing cold storage for all of this material.

The availability of video releases of most films in recent years has lessened considerably the demand to view motion picture prints in the Library's collection. If a requested title has not been released on video, the Library makes a videotape reference copy. Films are transferred to tape with a Rank Cintel machine (shown in the picture at the left with audio and video lab engineer Paul V. Chrisman). In the picture above, Chrisman and Parker study the color balance of a scene as a tape transfer is being made. After transfer, films are placed in cold storage.

Notes and References

Note: This chapter had its origins in a presentation by this author entitled "A Cost-Effective Approach to the Long-Term Preservation of Color Motion Pictures," at the **123rd Technical Conference and Equipment Exhibit of the Society of Motion Picture and Television Engineers**, Los Angeles, California, October 28, 1981. The use of low-temperature, humidity-controlled cold storage to preserve color motion pictures and cellulose nitrate films was further discussed by this author in "Color Photographs and Color Motion Pictures in the Library: For Preservation or Destruction?", a chapter in **Conserving and Preserving Materials in Nonbook Formats**, (Kathryn Luther Henderson and William T. Henderson, editors), pp. 105–111, 1991. The book contains the papers presented at the **Allerton Park Institute**, sponsored by the University of Illinois Graduate School of Library and Information Science, held November 6–9, 1988 at the Chancellor Hotel and Convention Center, Champaign, Illinois. Published by the University of Illinois Graduate School of Library and Information Science, Urbana-Champaign, Illinois.

1. Ben Stein, "A Studio Head With a Human Face," **The Wall Street Journal**, April 16, 1982, p. 16.
2. Frank Thompson, "Fade Out – What's Being Done to Save Our Motion-Picture Heritage?", **American Film**, Vol. XVI, No. 8, August 1991, pp. 34–38, 46. See also in the same issue: Wolf Schneider, "Film Preservation — Whose Responsibility Should it Be?", p. 2.
3. Stanley Yates, curator, The American Archives of the Factual Film, Iowa State University, Ames, Iowa, interview with this author, 1979.
4. Jack Tillmany, letter to Martin Scorsese, April 23, 1980.
5. Frank Hodsoll, "Film Preservation: A Large Piece of Americana Is Fading Away," **Daily Variety**, January 14, 1983, p. 28.
6. Robert Lenzner, "Hollywood Mystique," **The Boston Globe**, March 1, 1981.
7. Eastman Kodak Company, excerpts from an interview with Joerg D. Agin, vice president and general manager of the Motion Picture and Television Imaging Division of Eastman Kodak Company, **Kodak Press Release ES592149-bNR**, May 1992, p. 4.
8. Richard Turner, "Disney Leads Shift From Rentals to Sales in Videocassettes," **The Wall Street Journal**, December 24, 1992, p. 1.
9. Michael Cieply and John Helyar, "Turner Pact to Sell MGM Assets Boosts Prospects of Broadcaster and 2 Buyers," **The Wall Street Journal**, June 6, 1986, p. 6.
10. Martin Scorsese, cover letter for a petition sent to Walter Fallon, chairman of the board, and Colby Chandler, president, Eastman Kodak Company, June 12, 1980. The letter and petition were accompanied by a list of demands, including that Kodak make more stable motion picture film and that the company make its secret color stability data public. The petition was signed by hundreds of well-known film directors, actors and actresses, producers, film critics, and film curators.
11. Linda Gross, "Any Solution to Film Color Fading Away?", **Los Angeles Times**, April 17, 1981, Part VI, p. 1.
12. Steven Spielberg, letter to Martin Scorsese, November 26, 1979.
13. Claudia Eller and John Evan Frook, "'91 B.O. Down, Spirits Up at Confab," **Variety**, Vol. 346, No. 6, February 24, 1992, p. 5.
14. Marc Berman, "Rentals Reap Bulk of 1991 Vid Harvest," **Variety**, Vol. 345, No. 12, January 6, 1992, p. 22.
15. Gerald Putzer, "'Terminator 2' Takes Ring in $200 Mil Year," **Variety**, Vol. 345, No. 12, January 6, 1992, p. 5.
16. Charles Fleming, "Studios Walking the Bottom Line," **Variety**, Vol. 345, No. 12, January 6, 1992, p. 105.
17. Frank Hodsoll, see Note No. 4.
18. Bill O'Connell, "Fade Out," **Film Comment**, Vol. 15, No. 5, September–October 1979, pp. 11–18.
19. Paul C. Spehr, "Fading, Fading, Faded — The Color Film Crisis," **American Film**, Vol. V, No. 2, November 1979, pp. 56–61.
20. Martin Scorsese, "Letter to the Editor," **Film Comment**, January–February 1980.
21. Martin Scorsese, letter "To My Friends and Colleagues," April 5, 1980.
22. Beginning in April 1980, this author served as a voluntary technical advisor on the stability of color motion picture film to Martin Scorsese and his staff during Scorsese's campaign against fading and helped formulate Scorsese's "Request for Information" sent to Kodak along with the petition on June 12, 1980. This author was to attend a meeting on July 14, 1980 in Scorsese's New York City apartment with Ken Mason and Tony Bruno of Eastman Kodak and Scorsese and his staff. Shortly before the meeting was to take place Kodak informed Scorsese that if this author was present, Kodak would not attend. As a result of Kodak's threat to cancel the meeting, this author went to Scorsese's office and did not attend the gathering. At the meeting, Ken Mason of Kodak indicated that Scorsese's demand that Kodak make public its secret color film stability data would be met by the company.

    See: Harlan Jacobson, "Old Pix Don't Die, They Fade Away — Scorsese Helms Industry Plea to Kodak," **Variety**, Vol. 299, No. 10, July 9, 1980, pp. 1, 28–29. This was a major article on the poor image stability of Kodak motion picture color negative and print films; the writer described film director Martin Scorsese's campaign to pressure Kodak into producing improved film stocks. See also: "Signers of No Fade Petition to Kodak Span All Industry Ranks," **Variety**, Vol. 299, No. 10, July 9, 1980, p. 29. See also: Robert Lindsey, "Martin Scorsese's Campaign to Save a Film Heritage," **The New York Times**, October 5, 1980, pp. 19ff. See also: Patricia O'Brian [Knight News Service], "Movies (and Snapshots) Are Losing Their Color," **San Francisco Chronicle**, May 11, 1980. This article also appeared under various titles in many other newspapers.

    See also: Jack Garner, "Films Fade – Director Protests; Kodak's 'Working on It'," **Democrat and Chronicle**, Rochester, New York, May 13, 1980, pp. 1C, 2C. See also: Richard Harrington, "Old Movies Never Die – They're Just Fading Away," **The Washington Post**, July 20, 1980.
23. Eastman Kodak Company, **Eastman Color Print Film 5384 — The Film to Take You Into the Future**, Eastman Kodak Brochure V3-351, October 1981.
24. Eastman Kodak Company, "Our Descendants Will See Their Ancestors as We Really Were," advertisement in **American Cinematographer**, Vol. 64, No. 7, July 1983, inside back cover.
25. Eastman Kodak Company, "Simply Beautiful . . . Beautifully Simple," advertisement in **American Cinematographer**, Vol. 65, No. 1, January 1984, pp. 8–9.
26. The Film Foundation, 7th Floor, 445 Park Avenue, New York, New York 10022; telephone: 212-906-8800 (Fax: 212-906-8891).
27. Frank Thompson, "Spartacus: A Spectacle Revisited," **American Cinematographer**, Vol. 72, No. 5, May 1991, pp. 35–40.
28. American National Standards Institute, Inc., **ANSI IT9.9-1990, American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring**, American National Standards Institute, Inc., New York, New York, 1991. Copies of the Standard may be purchased from the American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900 (Fax: 212-398-0023).
29. See, for example: Lelise Bennetts, "'Colorizing' Film Classics: A Boon or a Bane?", **The New York Times**, August 5, 1986, pp. 1 and 21; "Directors Fight Copyrighting of Tinted Old Films," (Associated Press), **The Des Moines Register**, October 16, 1986, p. 3A; Susan Linfield, "The Color of Money," **American Film**, Vol. XII, No. 4, January–February, 1987, pp. 29ff; and, in a comprehensive review of the technology of the colorization process, Mark A. Fischetti, "The Silver Screen Blossoms Into Color," **IEEE Spectrum**, Vol. 24, No. 8, August 1987, pp. 50–55 (published by The Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, New York 10017; telephone: 212-705-7555). The cost of "colorizing" a movie may run from $2,000 to $3,000 per minute of film, or a total cost of $200,000 to $300,000 for a typical feature film. During 1990 Turner had 36 films scheduled for colorization at an estimated cost of $9 million; in 1989, 37 films were colorized by Turner, up from 27 in 1988. In addition, Turner planned to spend $1.5 million in 1990 to "recolorize" 25 already colorized films using enhanced computer technology. At the present state of technology, "colorization" is practical only for video transfers although it is expected that in the future, with film-resolution digital intermediate systems and more sophisticated image-processing software, the colorization process could also be used to create high-resolution transfers on color motion picture film that are suitable for theatrical projection.
30. American National Standards Institute, Inc., **ANSI IT9.11-1991, American National Standard for Imaging Media – Processed Safety Photographic Film – Storage**, American National Standards Institute, Inc., New York, New York, 1991. Copies of the Standard may be purchased from the American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900 (Fax: 212-398-0023).
31. John G. Bradley, "Stability of Motion Picture Film," **Journal of the Society of Motion Picture Engineers**, December 1936.
32. P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, and C. J. Erbland, "Stability of Cellulose Ester Base Photographic Film: Part I — Laboratory Testing Procedures," **SMPTE Journal**, Vol. 101, No. 5, May 1992, pp. 336–346.
33. David G. Horvath, **The Acetate Negative Survey: Final Report**, University of Louisville, Louisville, Kentucky, 1987. The project was funded by the University of Louisville and the National Museum Act. Copies of the 91-page report may be purchased for $8 (which includes first class postage) from: University of Louisville, Photographic Archives, Ekstrom Library, Louisville, Kentucky 40292; telephone: 502-588-6752.
34. P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, and C. J. Erbland, "Stability of Cellulose Ester Base Photographic Film: Part I – Laboratory Testing Procedures," **SMPTE Journal**, Vol. 101, No. 5, May 1992, pp. 336–346; and P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, and C. J. Erbland, "Stability of Cellulose Ester Base Photographic Film: Part II – Practical Storage Considerations," **SMPTE Journal**, Vol. 101, No. 5, May 1992, pp. 347–353. See also: Karel A. H. Brems [Agfa-Gevaert], "The Archival Quality of Film Bases," **SMPTE Journal**, Vol. 97, No. 12, December 1988, pp. 991–993. In the article, Brems discussed the degradation of cellulose triacetate film base and the "vinegar syndrome." Among his recommendations for storage, Brems included:

    "In film archives, cellulose nitrate-based materials must be stored separately from other materials. Film should be conditioned at 25 to

30% RH at room temperature, sealed air-tight, and stored at as low a temperature as possible, preferably –18°C [0°F].

"The literature concludes that triacetate film base, if not contaminated by other layers or products and if stored under the proper conditions, will last for at least a few hundred years. Recent practical experience in the archival world indicates, however, that in certain circumstances, which cannot be considered extreme, a risk for hydrolysis exists. Therefore, polyethylene terephthalate [polyester] is believed to be a safer choice as a support for film material that will be archived."

35. P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, and C. J. Erbland, see Note No. 32, pp. 336–346.
36. P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, and C. J. Erbland, see Note No. 34, p. 353.
37. 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**, San Francisco, California, December 10, 1992.
38. Sodium aluminum silicate is available from W. R. Grace & Company, Davison Chemical Division, P.O. Box 2117, Baltimore, Maryland 21203-2117; telephone: 410-659-9000. The material is also available from the Union Carbide Corporation.
39. "Vented" polypropylene film cans are available from the Plastic Reel Corporation of America, Brisbin Avenue, Lyndhurst, New Jersey 07071 (telephone: 201-933-5100). Also: Plastican Corporation, 10 Park Place, P.O. Box 58, Butler, New Jersey 07405 (telephone: 201-838-4363).
40. Suppliers of custom-made, high-quality cardboard film-storage boxes include: Conservation Resources International, Inc., 8000-H Forbes Place, Springfield, Virginia 22151 (telephone: 703-321-7730); The Hollinger Corporation, 4410 Overview Drive, P.O. Box 8360, Fredericksburg, Virginia 22404 (telephone: 703-898-7300); and Light Impressions Corporation, 439 Monroe Avenue, P.O. Box 940, Rochester, New York 14607-0940 (telephone: 716-271-8960).
41. Earl Green, "Canada Restoring 500 Pix Frozen Since 1929," **Variety**, Vol. 331, No. 6, June 1, 1988, p. 48.
42. Peter Z. Adelstein, C. Loren Graham, and Lloyd E. West, "Preservation of Motion-Picture Color Films Having Permanent Value," **Journal of the SMPTE**, Vol. 79, No. 11, November 1970, pp. 1011–1018.
43. Archives for Advanced Media, Inc., 838 N. Seward Street, Hollywood, California 90038 (telephone: 213-466-2454). In 1982 the company attempted to interest clients in the Hollywood area in low-temperature storage (e.g., 0°F [–18°C] at 30% RH); however, the company did not think there was enough potential business to proceed with the construction of such a facility. Archives for Advanced Media offers film and magnetic media storage at about 55°F (12.8°C) and 50% RH. At the time this book went to press in late 1992, to this author's knowledge, there was no commercially available humidity-controlled, low-temperature (0°F [–18°C] and 25% to 35% RH) film storage rental space available anywhere in the world.
44. Noel Lamar, Photographic Technology Division, National Aeronautics and Space Administration, telephone discussion with this author, 1977.
45. Lincoln Perry, **Black-and-White Separations of Spacecraft Original Film**, Technical Report (Contract NASA 9–11500, Task Order HT–133), Photographic Technology Div., National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, 1975.
46. Richard Patterson, "The Preservation of Color Films," **American Cinematographer**, Vol. 62, No. 8, August 1981, pp. 792ff.
47. In October 1981, Jack B. Goldman, at the time with Iron Mountain Group, Inc., Boston, Massachusetts, gave this author an estimated commercial storage cost of $18 per year per cubic foot of space for 0°F (–18°C) 30% RH motion picture film storage; this estimate has been increased to $30 per year per cubic foot by this author as an adjustment for inflation. Goldman had conducted a cold storage feasibility study for Iron Mountain Group, Inc. and gave a presentation entitled "A Commercial Service for Low Temperature Color Film Storage" at the 123rd Conference and Equipment Exhibit of the Society of Motion Picture and Television Engineers, Los Angeles, California, October 28, 1981. Because no commercial facility offering 0°F (–18°C), 30% RH storage was in operation at the time of this writing, this author has used the $30 per cubic foot cost as the best available estimate. The actual cost would depend on — among other factors — the size of the facility; a very large facility would have much lower unit costs than a small installation. At the time of this writing, Iron Mountain Group had not constructed a low-temperature facility. Along with Bill Lawler, Goldman left the company to start Archives for Advanced Media, Inc. in Hollywood (see Note No. 43 above).
48. Bob Fisher, "The Dawning of the Digital Age," **American Cinematographer**, Vol. 73, No. 4, April 1992, pp. 70–86.
49. Glenn Kennel, manager of product development, advanced technology products, Motion Picture and Television Imaging Division, Eastman Kodak Company, Hollywood, California, telephone discussion with this author, December 9, 1992.
50. B. Hunt, G. Kennel, L. DeMarsh, and S. Kristy [Eastman Kodak], "High-Resolution Electronic Intermediate System for Motion-Picture Film," **SMPTE Journal**, Vol. 100, No. 3, March 1991, pp. 156–161.
51. P. Z. Adelstein, "Status of Permanence Standards of Imaging Materials," **Journal of Imaging Science and Technology**, Vol. 36, No. 1, January–February 1992, pp. 37–41.
52. National Archives and Records Service, **Strategic Technology Considerations Relative to the Preservation and Storage of Human and Machine Readable Records** (White Paper prepared for the National Archives and Records Service by Subcommittee C of the Committee on Preservation), July 1984.
53. John C. Mallinson, "Archiving Human and Machine Readable Records for the Millenia," **Second International Symposium: The Stability and Preservation of Photographic Images** (Printing of Transcript Summaries), the Society of Photographic Scientists and Engineers, Springfield, Virginia, pp. 388–403, 1985. (The symposium was held August 25–28, 1985 in Ottawa at the National Archives of Canada.) See also: John C. Mallinson, "Preserving Machine-Readable Archival Records for the Millenia," **Archivaria**, No. 22, Summer 1986, pp. 147–152. See also: John C. Mallinson, "On the Preservation of Human- and Machine-Readable Records," **Information Technology and Libraries**, Vol. 7, No. 1, March 1988, pp. 19–23.
54. John C. Mallinson, "Magnetic Tape Recording: History, Evolution and Archival Considerations," chapter in **Proceedings of the International Symposium: Conservation in Archives**, pp. 181–190. The symposium was held May 10–12, 1988 in Ottawa and was sponsored by the National Archives of Canada and the International Council on Archives. The proceedings were published by the National Archives of Canada, 1989. Copies of the proceedings are available from the International Council on Archives, 60, rue des Francs-Bourgeois, 75003 Paris, France.
55. W. Stackhouse (chairman), "Report of the Task Force on Digital Image Architecture," **SMPTE Journal**, Vol. 101, No. 12, December 1992, pp. 855–891. (Note especially the discussion in Sec. 7.4 "Compression Quality Level," pp. 886–887, and in Sec. 7.9 "Audio Quality," p. 889.)
56. The 0°F (–18°C) and 25% RH conditions that will be maintained in the new color film storage facility scheduled to open in late 1996 were recommended by Klaus B. Hendriks, director of the Conservation Research Division of the National Archives of Canada.

Additional References

Eileen Bowser and John Kuiper, eds., **A Handbook for Film Archives**, Federation Internationale des Archives du Film, Brussels, Belgium, 1980.

Eastman Kodak Company, **The Book of Film Care**, Kodak Pub. No. H-23, Eastman Kodak Company, Rochester, New York, June 1983.

European Broadcasting Union, **Storage of Magnetic Tapes and Cinefilms**, Tech. 3202-E, Technical Centre of the European Broadcasting Union, Brussels, Belgium, August 1974.

FIAF, FIAT, and IASA, **Archiving the Audio-Visual Heritage – A Joint Technical Symposium**, held May 20–22, 1987 in Berlin, Germany. Sponsored by the Federation Internationale des Archives du Film, the Federation Internationale des Archives de Television, and the International Association of Sound Archives, published by Stiftung Deutsche Kinemathek, Berlin, Germany, 1988.

FIAF, **The Preservation and Restoration of Colour and Sound in Films**, Federation Internationale des Archives du Film, Brussels, Belgium, 1981.

Peter Hay, **MGM: When the Lion Roars**, Turner Publishing, Inc. (a division of Turner Broadcasting System, Inc., the parent company of Turner Entertainment Co.), One CNN Center, Atlanta, Georgia 30348), 1991.

Lawrence F. Karr, ed., **Proceedings – Conference on the Cold Storage of Motion Picture Films**, American Film Institute and Library of Congress, Washington, D.C., April 21–23, 1980.

Gert Koshofer, **Farb Fotografie**, (Books 1, 2, and 3), Verlag Laterna magica, Munich, Germany, 1981.

Gert Koshofer, **Color — Die Farben Des Films**, Wissenschaftverlag Volker Spiess GmbH, Berlin, Germany, 1988.

Joseph McBride, "Par Dusting Off Its Heritage, **Daily Variety**, Vol. 277, No. 38, April 27, 1990.

Daniel McKinny, "Networks Keep Pace in Post Race," **American Cinematographer**, Vol. 73, No. 9, September 1992, pp. 44–52.

Munters Cargocaire, **The Dehumidification Handbook – Second Edition**, 1990. Cargocaire Engineering Corporation, 79 Monroe Street, P.O. Box 640, Amesbury, Massachusetts 01913-0640; telephone: 508-388-0600 (toll-free: 800-843-5360); Fax: 508-388-4556.

Patricia O'Brian, "Treasures Lost as Color Film Fades," **Des Moines Sunday Register**, May 18, 1980, p. 6/H.

Richard Patterson, "The Preservation of Color Films – Part I," **American Cinematographer**, Vol. 62, No. 7, July 1981, pp. 694ff; and Richard Patterson, "The Preservation of Color Films – Part II," **American Cinematographer**, Vol. 62, No. 8, August 1981, pp. 792ff.

Roderick T. Ryan, **A History of Motion Picture Colour Technology**, The Focal Press, London, England, 1977.

Curt Sanburn, "The Race to Save America's Film Heritage – Of the 21,000 Movies Made Before 1951, More than Half Are Missing," **Life**, Vol. 8, No. 8, July 1985, pp. 68–80.

Ralph N. Sargent, **Preserving the Moving Image**, The Corporation for Public Broadcasting and The National Endowment for the Arts, Washington, D.C., 1974.

*(See **Appendix 9.1** on following pages . . .)*

Appendix 9.1 – "Outline for a Preservation Strategy," Written by Film Director Martin Scorsese and His Staff in 1980

An Introductory Word:

This outline for a Color Preservation Strategy comes as a result of watching and loving films for the past 36 years. In that time I have witnessed the deterioration and sometimes the destruction of most films I have seen. With the introduction of Eastman Kodak color film in 1950, any hope for color stability vanished. All films made in the Eastman color process are about to deteriorate beyond repair. Some have already done so. Methods of restoration are so costly that if a film is not considered important, it is left to die.

The problem of color stability is inherent to the film stock. Eastman Kodak is the world's largest film manufacturer — although they are not entirely to blame in this issue. Other film companies must share responsibility, and filmmakers and filmgoers must recognize the problem and take action to solve it.

The Problem is not simple, but it can be simply stated:

1. Unstable film stock.
2. Deterioration of existing films (prints and negatives).
3. A need for research and development of a new print stock equal to or better than Technicolor Imbibition.
4. Research and development of new methods of film restoration.
5. Research and development of new methods of film storage (storage data and more compact film storage).

The Solution starts with an understanding of film and our responsibility. We all agree that film is the twentieth century art form — the American art form. But, it is also the immediate reflection of world culture and history. Film must be preserved for man's heritage.

Not only theatrical films, but anthropological and historical still photographs and video — for they record, reflect and shape history. The future will know and judge the past from these records of living time. They must be kept intact. This is the responsibility not only of those who record the past, but of those who furnish the means to do it.

Advancement in technology is so fast that the gap of silence between those who make the images, express ideas or objectively record events and those who have control over the knowledge and status of preserving these materials must be closed. An open dialogue must be established between all members of the industry. Film deterioration is not some esoteric problem of formulas, emulsions, temperature and profit curves. It is a perverse method of cultural and historical suicide. We've got to fight for the past, for the future.

No Value Judgments: All films must be saved. No committees should decide which film lives or dies, whether or not TV commercials are less important than movie trailers. Preserving only commercially successful films, or Academy Award winners and nominees or film festival winners, is a step in the right direction, but far from enough. Very often, as in the case of *The Magnificent Ambersons* or *The Searchers*, it is only time itself which lets a film's true value shine through.

Creation and Purpose of a New Organization: A new organization should be composed of representatives of every group in the industry: from studios, producers and actors to museums, archives and universities; from film preservation experts and film manufacturers to experts in advanced technologies. It is important that the group not be affiliated or obligated to any branch of the industry.

The new organization would be a "clearing house" for the diverse branches of the media which:

1. Will establish and sustain an exchange of new ideas.
2. Will learn about the best new technological advancements and educate those concerned about them.
3. Will, with proper counseling and discussion by its expert members, encourage new methods of research and development.
4. Will, through this research and development, begin to work on the color preservation problem and on the deplorable condition of black and white films — old and new.
5. Will explore new methods of film restoration for those nitrate, black and white, imbibition and other films in danger of being lost and discover new forms of materials on which to transfer film elements (negatives, soundtracks, CRI's, YCM's, etc.) which are in danger of destruction. This research will lead also to proper storage of these film elements.
6. Will encourage building of new cold storage vaults, sustaining those that already exist, and establishing the "norm" for the preservation of film elements.
7. We are already aware that most studios and archives have storage facilities that function with varying degrees of efficiency. A "norm" would insure that every

method of storage functions with an equal degree — a maximum degree — of efficiency.

8. Will act as a clearing house for paper materials related to film. These materials, (posters, scripts) can be either stored in a new archive built by the industry, or collected together to form a traveling "archive" for students.

Perseverance: The goals outlined in this proposal may seem hopelessly idealistic. Just on the basis of today's advancing technology we know, on the contrary, that they are an attainable reality. But equally important elements are: **1)** Our own perseverance. The determination to achieve the best we can, and when we do, not to be content, but to continue to develop new ideas resulting in more sensible, economical and permanent preservation methods and **2)** Unity — All branches of the industry must put aside disagreements and unite in this one common cause, which is, after all, a common interest. We must unite to preserve.

Obstacles: In the course of taking action we will undoubtedly run into many obstacles which have helped establish this crisis.

Ignorance and Apathy: There is never any time for details. When we do find the time, the details are too complicated. So, apathy sets in — "What's the use," "If it's good, it'll survive". The matter is not whether it is good or bad, what great talents we may all be. The matter is knowledge and the survival of these materials themselves. This is not a crusade for self-importance.

Judging from the response we have received from so many branches of the industry it seems that at least a dialogue has begun among us and that indeed, we can all work past self-interest toward a common goal.

Economics: It's cheaper to keep the situation the same. The monetary pressures on the studios and distributors — which eventually affect the filmmaker through budget and recoup — force them to be concerned only with the short term goal: get it on the screen with the best quality in the fastest and cheapest way. From a business point of view, what happens after is unimportant. This can mean that if a film is not successful, there is even less chance of its preservation.

If a film is a hit, new Eastman prints will be struck for its re-release. They will look good for a while, but, as in the case of *2001: A Space Odyssey*, only for a while. By 1978, the print revived at the Rivoli Theatre in New York City was pink as a boiled shrimp. It was unwatchable.

It must be understood that whatever the precautions taken by studios and distributors, all films, recent ones and classics, profitable and unprofitable, are obviously in severe danger.

Technological advances are re-shaping and renewing the industry. Digital printing, laser transfers, cable outlets, satellite stations, tapes, videodiscs, all will continue to open new areas where an incredible demand for product — new and old — will be needed. How will the product — especially the older product — be preserved for use? Why ignore preservation and destroy assets?

Support and Funding: Some initial ideas.

1. **Individual Initiative.** We can insist on the latest and best methods of preservation — contractually. We can also volunteer one percent of our salaries and profits from the film we're working on to insure that our work is preserved in the way we want. All should contribute: directors and studios, actors, distributors, writers and cameramen.

2. **Studios.** A certain percentage of each film's budget should be used for preservation.

3. **Government Support.** Especially in the case of films where restoration is of most importance, or where rights are in question.

4. **Congressional Action.** Film and its related materials should be declared national archive material to be protected.

Meetings: An industry-wide symposium is being planned for the fall of this year [1980] in Los Angeles. Many other meetings will take place before that and the results will be reported to everyone. As a first step, here is a list of questions for Eastman Kodak. We should very much appreciate and anticipate direct and honest answers. [Scorsese's "Request for Information" to Kodak is reprinted on pages 308–309.]