PROPOSED SMPTE RECOMMENDED PRACTICE

RP 131
Revision of RP 131-1985

Storage of Motion-Picture Films

Introduction

It is impossible to estimate the value of the motion-picture films that have been produced during the life of this industry. These films are a rich resource representing both historical events and a unique art form. When one realizes that a major portion of the motion-pictures and television programs produced in this century have been lost or destroyed already because of improper storage, the importance and urgency of preserving those still existing are underscored.

The relatively recent conversion of motion-pictures and television programs to color films has raised concerns about the long-term stability of the dye images. Attention to this question has contributed to a general renewal of interest in the preservation of all motion pictures, both black-and-white and color.

Long-term preservation of almost any human artifact is a challenging and costly effort. There are no simple, inexpensive methods that are satisfactory for this purpose. Furthermore, extended-term storage, particularly, implies that the preserved artifact is rarely, if ever, removed from storage for examination. Proper storage of motion-picture films requires that a sufficient number of working copies be available at the time the original films are put into storage.

Proper storage is not a new subject and a variety of documents on the preservation of motion-picture films already exists. These include ANSI and ISO standards, an EBU technical bulletin, a report of the International Preservation Commission of FIAF, several SMPTE, BKSTS and SPSE articles, and a tutorial report (see annex B). Nevertheless, there is still a recognized need for guidelines for proper film storage and an SMPTE practice to fill this need. Basic recommendations for the storage of all types of processed safety photographic film are contained in ANSI IT9.11. The procedures discussed in this practice are an expansion or restatement of that document.

1 Scope

This practice defines terms, classifications, and conditions for storage of motion-picture materials.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this practice. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this practice are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

ANSI IT9.11-1991, Imaging Media — Processed Safety Photographic Film — Storage

3 Definitions

3.1 safety photographic film: Safety photographic film is film that meets the specifications with respect to hazard from fire as defined in ANSI IT9.6.

3.2 archival medium: A recording material that can be expected to retain information forever so that it can be retrieved without significant loss when properly stored. However, there is no such material and it is not a term to be used in American National Standards material or system specifications.

3.3 life expectancy (LE): The length of time that information is predicted to be retrievable in a system under extended-term storage conditions.

3.4 LE designation: A rating for the "life expectancy" (LE) of recording materials and associated retrieval systems. The number following the LE symbol is a prediction of the minimum life expectancy in years for which information can be retrieved without significant loss when stored under recommended extended-term storage conditions; e.g., LE-100 indicates that information can be retrieved after at least 100 years of storage.

3.5 active working film: Active working film is a photographic film suitable for the preservation of records which are presently in use. The term of storage for active film should be considered as less than 10 years.

3.6 active working storage conditions: Active working storage conditions are those which are suitable for ensuring a useful life of up to 10 years of active use providing the original images are of suitable quality and are not damaged by personnel or equipment handling.

3.7 medium-term storage conditions: Storage conditions suitable for the preservation of recorded information for a minimum of 10 years.

3.8 extended-term storage conditions: Extended-term storage conditions are those which are suitable for the preservation of photographic film having permanent value.

3.9 film enclosure: A film enclosure is any item in close or direct contact with the film, such as reels, cores, spools, cassettes, magazines, cartridges, can containers, envelopes, bags, and cartons.

3.10 storage housing: A storage housing is a physical structure supporting the film enclosures and may consist of drawers, racks, shelves, or cabinets.

3.11 film vault: A room or area designed for film storage and separated from temporary storage facilities, offices, or work areas. Preferably, the vault shall have air purity, temperature, and humidity controls.

4 Storage and handling

In order for motion-picture film to be protected, it must be properly stored and handled throughout its life. For convenience, the life cycle of the film has been divided into three sections: prior to processing, after processing, and in collections.

Although processing is not covered in this practice, it is imperative that black-and-white films be properly washed to prevent stains, etc., and that color films be properly washed and stabilized to prevent stains, dye fading, etc. The manufacturer's processing recommendations should be carefully followed for both black-and-white and color films.

Specifications for the stability of black-and-white silver-gelatin imaging media (film) are stated in ANSI/NAPM IT9.1.

4.1 Prior to processing

4.1.1 Environmental conditions

During manufacture, the raw stock is equilibrated at the appropriate relative humidity, placed in vapor-proof containers (taped cans or foil bags), and sealed. The containers should be kept sealed until the film is to be used (exposed) to maintain the proper moisture level in the film during preexposure storage. High relative humidity should be avoided to prevent rusting of cans and deterioration of labels, tapes, and cartons. The raw stock should be kept at 13°C (55°F) or lower until exposure. If the stock must be kept for periods longer than six months, it should be stored at −18°C (0°F) or lower. Once the film is exposed, it should be processed as soon as possible. If the film must be stored after exposure and prior to processing, it should be kept at −18°C (0°F) to prevent any loss of the latent image.

Raw stock must also be protected against harmful gases, such as hydrogen sulfide, sulfur dioxide, and peroxide, and radiation. Since some gases may slowly penetrate the tape which seals the cans, even unopened raw stock should not be stored in an area where harmful gases are present, even in small amounts.

As the speed of motion-picture camera film increases, its sensitivity to radiation (X-rays, gamma rays) increases. Some stone aggregate in the concrete used to build film storage rooms can emit sufficient

radiation to fog these sensitive films. All storage rooms should be measured for their radiation levels prior to being used to store raw stock.

4.1.2 Storage enclosures

Raw stock should be kept in the original manufacturer's container until exposed. After exposure, it is suggested that the film be placed in the original container and retaped. The time between taking the film out of its container and replacing it in its bag and container should be kept as short as possible.

4.1.3 Storage rooms

As long as the new stock is sealed in its original container, the relative humidity of the storage room should not exceed 60%. Above 60%, iron will rust and fungi will grow. Provision should be made against damage by water or exposure to harmful gases.

4.1.4 Handling techniques

Raw stock or exposed unprocessed film should be handled as little as possible, and great care should be taken to keep all cameras, changing bags, winding equipment, etc., scrupulously clean. If the unexposed, unprocessed film is stored at 13°C (55°F) or lower, be sure to allow the film to warm up to room temperature before opening the can and handling the film to prevent moisture condensation which may lead to spotting of the film, loose cores, and loose winds due to the natural tendency of the base/emulsion to shrink in a below-normal temperature condition. These effects can create camera "noise" and camera/printer loading problems.

4.2 After processing

4.2.1 Environmental conditions

Processed film is no longer light sensitive, but it is still subject to change over a period of time. After processing and prior to placing the film in its final storage location, processed film should be carefully handled and prepared for storage. Whenever possible, film selected for long-term storage should contain a minimum of splices. The film should be handled in an air-conditioned area where temperature and relative humidity are monitored and controlled. Short periods of high temperature or high or low humidity should be avoided. High temperatures can hasten the fading of dye images and cause film shrinkage and physical distortions. Low humidity can cause brittleness, while high humidity can accelerate dye fading and base decomposition, and cause mold and bacteria growth.

4.2.2 Storage enclosures

Motion-picture films are normally wound on cores if they are preprint materials and on reels if they are release prints. The rolls should not be wound with high tension, nor should they be loose enough to allow movement of the film within the roll (tension of 24 oz for a 1000-ft roll is satisfactory).

4.2.3 Storage rooms

If possible, rooms and areas used for film storage should be located near the areas where the film is being used. Provision should be made against damage by water or other associated hazards.

4.2.4 Handling techniques

Proper handling of film, whether unexposed, exposed, or processed, is critical. Cleanliness and good housekeeping procedures are essential if dirt or the results of dirt are to be kept out of the final screen image. Whenever possible, film should be handled in a work area provided with positive pressure and a filtered, conditioned air supply. Any equipment or surface that may come into contact with the film should be cleaned frequently. The film itself should be handled as little as possible, only by the edges, and with gloves to protect it. Smoking should never be permitted in a film-handling area.

4.3 In collections

4.3.1 Environmental conditions

After motion-picture film, whether print or preprint, has been assigned to a collection, it should be stored under controlled relative humidity and temperature conditions. The relative humidity and temperature selected depend on the length of time the film is to be preserved (see table 1). The recommended conditions are the same as those in ANSI IT9.11.

The effects of environmental conditions on the storage of motion-picture film are presented in annex A. Additional information is available from manufacturers of motion-picture film.

Table 1 – Environmental conditions

		Medium-term storage		Extended-term storage [1]	
Sensitive-layer	Base-type	Relative humidity range (percent)	Maximum temperature °C	Relative humidity range (percent)	Maximum temperature °C
Silver-gelatin	Cellulose ester	20–50	25	20–30	21
Silver-gelatin	Polyester	20–50	25	20–30	21
Color	Cellulose ester	20–30	10	20–30	2
Color	Polyester	20–30	10	20–30	2

[1] Formerly known as archival storage.

4.3.2 Storage enclosures

The recommendations in this clause are taken from 4.1 of ANSI IT9.11. Refer to that document for additional information.

Motion-picture film is wound on reels or cores and stored in roll form. Rolls should be wound emulsion in and title in, but not under extreme tension. Rolls mounted on cores, particularly those longer than 500 ft, should be stored flat (horizontal) unless the core itself is carried on a horizontal spindle to prevent the lower part of the film from supporting the load of the core. If such rolls are on spools which have flanges, a spindle is not required since the flanges support the weight of the roll.

Storage enclosures for motion-picture films may be noncorrosive metal, plastic, or acid-free board. Use of steel for reels is permissible provided that the reels are well protected by enamel, tinning, or other corrosion-resistant finishes. Steel reels may not be lacquered or laminated. Preferred plastic enclosure materials (cores and reels) are cellulose esters and polyolefins (polypropylene). Acceptable plastic materials are polystyrene and polyacrylates. Polyvinylchloride is not recommended for this use.

Plastics that might give off reactive fumes or exudations during storage, such as peroxides or chlorines, shall not be used.

Suitable containers are those with flip-top, telescoping, or slip-type lids. The materials used shall meet the same requirements as those for cores and reels. Closed containers are not air tight and may give limited access to ambient air. Therefore, if they are used, the humidity of the ambient air must not exceed recommended limits.

Previous storage recommendations included the use of sealed containers as an alternative method for providing protection from high or low humidity in a film storage area where only the temperature is controlled. In the last five years, however, a deterioration phenomenon (called vinegar syndrome) due to hydrolysis of cellulose triacetate base was discovered. This hydrolytic reaction is acid catalyzed and autocatalytic. In addition, some researchers have found that iron (magnetic oxide or rust) in physical contact with the film may act as a catalyst for the reaction. Therefore, the use of sealed containers of iron is no longer recommended for storage of cellulose acetate film. If steel containers are used, the steel must be well protected by enamel, tinning, or other inert corrosion-resistant finishes. Sealed containers of other materials may be used if hydrolysis of the base has not started. However, once the reaction has begun, the film should be separated from unaffected material and removed to another area until it can be duplicated, preferably on polyester base material.

Pressure-sensititve tape, if needed, shall be free from peroxide, and shall not be used in contact with the film, other than on the outer loop to fasten the end.

Films may have possible interactions with other films that are of a different generic type (for example, nitrate versus acetate base). Films of different generic types should not be wound in the same rolls or stored in the same containers.

Cellulose-nitrate film base in considerable quantity may be a fire hazard. As the film breaks down, it gives

off nitric oxide, nitrogen dioxide, and other gases. Films on nitrate base should never be stored in the same rolls, same containers, same housing, or same environment with films on acetate base.

Closed containers are required unless the photographic film is protected from dirt and damage by the storage housings. Containers should be made of noncorrosive material, such as anodized aluminum, stainless steel, or peroxide- and chlorine-free plastics.

4.3.3 Storage rooms

Motion-picture films having long-term value should be stored in closed housings or on shelves and racks enclosed by doors in a storage room. The shelves or cabinets shall be arranged to permit interior circulation of air to all film containers to provide uniform humidity and temperature conditions.

The lowest shelves should be at least six inches above the floor, and other precautions taken against potential water damage. Storage enclosures should never be placed in cardboard boxes and left on the floor of storage rooms. The storage room should be protected against fire and associated hazards as outlined in clause 8 of ANSI IT9.11. The storage room should be conditioned as described in clauses 6, 7, and 8 of that standard.

Annex A (informative)
Environmental conditions

Five factors are of primary importance in the storage and preservation of motion-picture films, both black-and-white and color: container, film base, temperature, humidity, and air purity.

In a properly designed film vault, solid particles, which may abrade film or react with the image, are removed by mechanical filters, preferably HEPA filters, as described in the Institute of Environmental Sciences standard for HEPA filters.

Gaseous impurities such as sulfur dioxide, hydrogen sulfide, peroxides, ozone, ammonia, acidic fumes, and nitrogen oxides may cause deterioration of the base or degradation of the image in some films. The level of these compounds should be monitored and minimized where possible. The critical concentrations and exposure times are currently under investigation. They can be removed from the air by suitable washers operating with treated water and activated charcoal absorbers. The most frequently encountered impurity, especially in urban and industrial atmospheres, is sulfur dioxide which, even in small concentrations, is likely

Automatic air-conditioning equipment that controls both temperature and humidity is most desirable. Slightly positive air pressure should be maintained within the storage area. Provision should be made to clean the air supply of harmful gases and to minimize dust in the room.

4.3.4 Handling techniques

Prior to storage, film should be inspected, repaired if necessary, and cleaned. Wet immersion cleaning is preferred to wiping or dry cleaning. Wet cleaning may not be desirable for some specially treated films; for example, lacquered films. Preprint materials should be wound on suitable cores and prints on cores or reels. If the films are to be stored in a room or vault with controlled temperature and humidity, they should be placed inside clean noncorrosive containers, preferably one roll to a container.

If a film which has been kept at a reduced temperature is removed from the storage room, ample warm-up time is necessary to permit the film to reach ambient room temperature before being used.

4.3.5 Duplication and inspection

When motion-picture films will be duplicated, and the duplicate placed in extended-term storage, the copy should be on polyester film base.

to produce detrimental effects. Hydrogen sulfide is not a common impurity, but is very active and can occur in air conditioners or air washers containing decomposed biological slime.

The moisture content of air must always be considered in relation to its temperature. The higher the temperature, the greater the weight of water air can hold. For any particular temperature, the amount of water in the air, described as a percentage of the maximum that the air will hold at that temperature, is the relative humidity (RH). Absolute humidity is simply the weight of water per unit volume.

Certain coatings, photographic paper, and film bases absorb moisture from the air to a greater or lesser extent, depending on the nature of the material. A negative or a print surrounded by dry air will give up moisture to the air, while those surrounded by damp air will absorb moisture until a balance, or equilibrium, is reached. The quantity of moisture held by a photographic material at equilibrium depends on the RH of the surrounding air. At a high RH (60%

or more), the moisture content of a material reaches the upper limit of safety if physical damage and biological attack are to be avoided.

Dampness, or high RH, accelerates the effect of any residual processing chemicals that happen to be in the material and causes gelatin to become soft, sometimes to the point where it sticks to anything that may be in contact with it. *High RH may cause irreversible size change, a particularly* important matter in the storage of motion-picture films and black-and-white separation sets from color originals. There are always fungus spores in the air and at RH values above 60% to 65%, these will germinate and the fungus will spread.

The effects of dryness, or low RH, are not very serious unless the condition prevails for several weeks at a time. RH below 20% may result in brittleness of film as well as excessive curl. Acetate film will shrink markedly if stored in a dry environment. However, this effect is usually reversible, and the size may be recovered on rehumidifying. Gelatin tends to become brittle in very dry conditions and it may crack or craze. Dye fading generally proceeds at a lower rate at lower relative humidity than it does at high relative humidity.

However, 20% to 30% RH is recommended for storage to avoid the brittleness and curl associated with storage at a lower RH. Cycling of relative humidity should be no greater than ± 5 percentage points over a 24-hour period.

Temperature is not as critical as relative humidity in the storage of black-and-white films, but the effects of temperature and humidity must be considered in relation to one another. Temperatures exceeding 24°C (75°F) coupled with RH greater than 60% are the most damaging of all conditions, but a higher temperature can be tolerated for a considerable time if the RH remains less than 40%. (The foregoing remarks do not apply to color films or to the storage of films on cellulose nitrate base, because the rate of decomposition of this material approximately doubles *with each 6°C [10°F] increase in temperature.*)

Fading of color dyes is a chemical reaction which generally proceeds faster as the temperature is increased, as indicated by table A.1, which gives relative fading rates at 40% relative humidity.

The values in table A.1 do not apply exactly to all color films, but are close enough for most practical purposes. To predict how long a specific color film will last, the custodian must first define what degree of dye loss is objectionable for a particular application and under what conditions the film has been and will be stored. This information, along with dye stability data on that particular film supplied by the manufacturer, should provide a reasonable estimate of the useful life of the film.

Low temperature will not damage either black-and-white or *color films as long as the relative humidity of the storage* container or area is maintained between 20% and 30% RH, and the container is allowed to warm up naturally to ambient temperature before opening to prevent moisture condensation. (See annex C in ANSI IT9.11.)

Consequently, the best method for preserving color films is to control the temperature, relative humidity, and chemical environment of the storage room or vault. Temperature and humidity control requires established methods of air conditioning or refrigeration.

Improvements in vault construction, insulation, and temperature and humidity control allow for lower temperature storage to be attained and maintained economically. It is, therefore, suggested that when the recommended environmental conditions can reasonably be met, lower maximum temperatures and smaller RH variations given above will be beneficial to all preprint materials stored for any time period.

It should be noted that if black-and-white and color films are stored in the same vault, the recommended conditions for color film storage take precedence.

Table A.1 – Effects of temperature on dye-fading rates (40% relative humidity)

Storage temperature	Relative fading rate	Relative storage time
30°C (86°F)	2	1/2
24°C (75°F)	1	1
19°C (66°F)	1/2	2
12°C (54°F)	1/5	5
7°C (45°F)	1/10	10
–10°C (14°F)	1/100	100
–26°C (–15°F)	1/1000	1000

Annex B (informative)
Bibliography

ANSI/NAPM IT9.1-1992, Imaging Media (Film) — Silver-Gelatin Type — Specifications for Stability

ANSI IT9.2-1991, Imaging Media — Photographic Processed Films, Plates, and Papers — Filing Enclosures and Storage Containers

ANSI IT9.6-1991, Photography — Photographic Films — Specifications for Safety Film

ANSI IT9.9-1990, Imaging Media — Stability of Color Photographic Images — Methods for Measuring

European Broadcasting Union Technical Bulletin 3202, Storage of Magnetic Tapes and Cinefilms

Adelstein, P.Z., Graham, C.L. and West, L. E. Preservation of motion-picture color films having permanent value. Journal of the SMPTE 79(11):1011-1018; November 1970.

Adelstein, P.Z. and McCrea, J.L. Stability of processed polyester base photographic films. Journal of Applied Photographic Engineering 7(6):160-167; December 1981.

Adelstein, P.Z., Reilly, J.M., Nishimura, D.W., and Erbland, C.J. Stability of cellulose ester base photographic film: Part 1 — Laboratory testing procedures. SMPTE Journal 101(5):336-346; May 1992.

Adelstein, P.Z., Reilly, J.M., Nishimura, D.W., and Erbland, C.J. Stability of cellulose ester base photographic film: Part 2 — Practical storage considerations. SMPTE Journal 101(5):347-353; May 1992.

The book of film care. Eastman Kodak Company Publication No. H-23, September 1992.

Brems, K.A.H. The archival quality of film bases. SMPTE Journal 97(12):991-993; December 1988.

Brems, K.A.H. Vinegar syndrome update. Image Technology 73(3):94-95; March 1991.

Carroll, J.F. and Calhoun, J.M. Effect of nitrogen oxide gases on processed acetate film. Journal of the SMPTE 64(9):501-507; September 1955.

Ram, A.T. Archival preservation of photographic films — A perspective. Polymer Degradation and Stability 29:3-29; 1990.

Ram, A.T. and McCrea, J.L. Stability of processed cellulose ester photographic films. SMPTE Journal 97(6):474-483; June 1988.

Technical aspects on the preservation of moving images. International Preservation Commission of the International Federation of Film Archives (FIAF), November 1977.