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RP 131-2002
Revision of RP 131-1994

SMPTE RECOMMENDED PRACTICE

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 motion pictures and television programs produced in this century has been lost or destroyed already because of improper storage, the importance and urgency of preserving those still existing are underscored.

The 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 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 IS&T 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/PIMA 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 the 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/PIMA IT9.11-1998, Imaging Media — Processed Safety Photographic Films — Storage

Approved July 15, 2002

3 Definitions

3.1 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.

3.2 duplicate: A reproduction of a master, retaining the same polarity and size.

3.3 extended term storage conditions: Storage conditions suitable for the preservation of recorded information on the majority of freshly-processed photographic films for 500 years.

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

3.5 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, and temperature and humidity controls.

3.6 fire-protective storage: Facilities designed to protect records against excessive temperatures, water, and other firefighting agents, and steam developed by insulation of safes or caused by the extinguishing of fires and/or collapsing structures.

3.7 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 at 21°C and 50% RH; e.g., LE-100 indicates that information can be retrieved after at least 100 years storage.

3.8 life expectancy (LE): The length of time that information is predicted to be acceptable in a system at 21°C and 50% RH.

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

3.10 safety photographic film: Film that meets the specifications with respect to hazards from fire as defined in ANSI/NAPM IT9.6.

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

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 has been divided into three sections: prior to processing, after processing, and in archives.

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 minimize 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 pre-exposure 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 against 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 is increased, its sensitivity to radiation (X-rays, gamma rays) is increased. 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 remains sealed in its original container, its moisture content will not be significantly affected by the RH of the storage room. However, RH above 60%, can damage labels and cartons, iron will rust, and fungi will grow. Provisions 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, the film shall be allowed to warm up to room temperature before opening the can to prevent moisture condensation which may lead to sticking or spotting of the film. When film rolls are cold, there is greater contraction in the radial direction than in the circumferential direction which leads to loose cores, and loose winds. Handling film in such a condition can result in stepped rolls or loss of roll integrity. 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 handled carefully 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. Long 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 (24-oz tension 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. Provisions 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 house-keeping 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/PIMA 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 – Maximum temperatures and relative humidity ranges for extended-term storage

Sensitive layer	Base type	Relative humidity range %	Maximum temperature °C
Black-and-white silver-gelatin	Triacetate	20–50 20–40 20–30	2 5 7
Black-and-white silver-gelatin	Polyester	20–50	21
Color Color	Triacetate Polyester	20–50 20–40 20–30	–10 – 3 2

4.3.2 Storage enclosures

The recommendations in this clause are taken from ANSI/PIMA IT9.2 and 4.1 of ANSI/PIMA IT9.11. Refer to those documents 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.

Preferred plastic enclosure materials (cans, cores, and reels) are polyolefins (polypropylene). Acceptable plastic materials are polystyrene and polyacrylates. Polyvinyl chloride is not recommended for this use.

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 necessarily 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.

Sealed containers can be used as an alternative method for providing protection from high or low humidity in a film storage area where only the temperature is controlled. However, researchers have found that cellulose acetate film base is subject to a deterioration phenomenon called vinegar syndrome. This hydrolytic reaction is acid catalyzed and auto catalytic. Recent studies with sealed containers indicate that adding silica gel (a desiccant) or a zeolite commonly called a molecular sieve to the container will reduce the moisture content of objects inside the container and absorb acetic acid generated by the degrading film base. Removal of the moisture and the acetic acid can slow down the degradation and can also impart additional dye stability to color films. 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 pass the photographic activity test in ANSI/NAPM IT9.16. Pressure-sensitive tape 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 base type (for example, nitrate versus acetate base).

Cellulose-nitrate film base in considerable quantity is 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, containers, housing, or environment with films on acetate base (see ANSI/NFPA 40).

Closed containers are required unless the 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 housings and 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; other precautions should be 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/PIMA IT9.11. The storage room should be conditioned as described in clauses 6, 7, and 8 of that document.

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, and 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 are duplicated, and the duplicate placed in extended-term storage, the copy should be on polyester film base.

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 impurities, especially in urban and industrial atmospheres, are sulfur dioxide and oxides of nitrogen which even in small concentrations are likely 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. At 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.

Photographic papers 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 contract 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.

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 within the limits specified in table A.1 and the container is allowed to warm up naturally to ambient temperature before opening (see annexes D and E in ANSI/PIMA 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, the 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 preference.

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)
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