Eastman Park Micrographics, Inc.

Micrographic Quality
D-31

Storage and Preservation of Microfilms

Contents

Introduction

Photographic film remains an important documentary material. The increasing quantity and value of microfilm records used in financial institutions, libraries, government offices, and industrial firms have focused attention on the care of such records to make certain that they last as long as possible.

The distinction between photographic film records intended for storage and those intended for use has not always been clear. Use or work copies are the predominant photographic records found in libraries or record centers and are subject to much handling due to their value as quick references. However, because of this handling, they are subject to dirt, abrasion, fingerprints, contamination with foreign materials, and exposure to excessive light, temperatures, and harmful atmospheric pollutants. As a result, these copies in daily use cannot be considered suitable for long-term preservation. For long-term storage, it is imperative to prepare duplicate copies that meet certain criteria, such as proper filming, duplicating, processing, minimum handling, controlled environment, and storage.

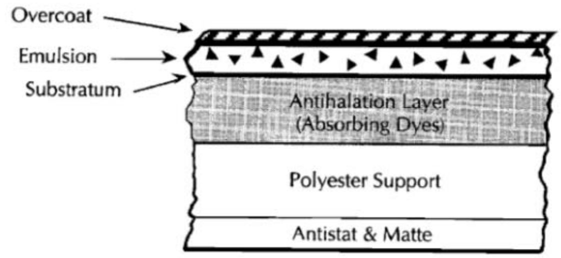
In general, the care needed for storing photographic records is similar to that for storing written paper records, although there are some requirements peculiar to the storage of photographic film.

The permanence of photographic records depends on the chemical stability of the film, how the film is processed, and the conditions under which the processed film records are stored. The stability of the film layers is determined in manufacture and processing, while storage is controlled by the user. This pamphlet discusses the composition and properties of black-and-white silver-gelatin, thermally processed silver (TPS), diazo, and vesicular films as they relate to film permanence. It also describes the essential requirements of good processing and storage practices.

NOTE: Refer to the latest revision of each ANSI or ISO Standard specified.

Definitions

To help understand storage requirements, the composition and structure of microfilm are described and definitions of commonly used terms are given.[1]



Structure of a typical black-and-white negative film.

Acetate film—(acetate base) safety film with a base composed principally of cellulose acetate or triacetate.

Antihalation undercoat—separate layer of light-absorbing dye located between the film emulsion and the base to suppress light reflection. During processing of this film, the dye layer becomes transparent.

Base or support—a flexible plastic material that is coated with a thin, light-sensitive, image- forming layer. The thickness of the base varies with different film types.

Dimensional stability—ability of photographic materials to maintain their original size and shape during and after processing and also under various conditions of temperature and humidity.

Emulsion—the image-forming layer. For unprocessed black-and-white silver-gelatin films, it is composed primarily of minute silver halide crystals suspended in gelatin. Exposure to light in a camera or printer causes no visible effect, but there is an invisible change which produces a “latent image.” To obtain a visible, usable image, the exposed material must be chemically processed.

For diazo and vesicular films, the sensitized layers are composed of light-sensitive diazonium salts. To obtain a visible, usable image with these films, the exposed material is heat-processed. Diazo films are typically heat-processed in the presence of ammonia.

Emulsion layer(s)—image or image-forming layer(s) of photographic films, papers, and plates.

Film base—the plastic support for the emulsion and backing layers.

Halation—halo or ghost around the desired image on a photographic emulsion. (This is caused by the reflection of rays of light from the base to the emulsion or by internal scattering of light within the film.)

Nitrate film—a photographic film with a base consisting of cellulose nitrate. Nitrate-base films decompose with age and are not suitable for permanent records. The manufacture of nitrate film by Eastman Kodak Company in the United States of America was discontinued in 1951, but older nitrate motion-picture films are often found in storage. It is not always possible to determine by visual examination if a film has a nitrate base. However, neither IMAGELINK nor RECORDAK Microfilms in any width were ever made on nitrate base.

Non-curl backing layer—a layer, usually made of gelatin, applied to the side of the film base opposite to that of the emulsion layer, for the purpose of preventing curl.

NOTE: It is comparable to the emulsion layer in thickness and is not removed in processing. (Antihalation or other layers removed in processing are excluded from this definition.)

Polyester film—a photographic film having a polyester base. IMAGELINK silver and non-silver films are all coated on polyester base. It is exceptionally tough and strong and has excellent dimensional stability. Microfilm emulsions on polyester base are currently supplied for many purposes.

Safety photographic film—photographic film which passes the ignition time test and burning time test as specified in ANSI and ISO Standards.

Safety poly(ethylene terephthalate) base— a polyester film base for recording materials composed mainly of a polymer of ethylene glycol and terephthalic acid. All safety films (both acetate and polyester) manufactured for Eastman Park Micrographics meet these requirements. This means that they are difficult to ignite and are slow burning.

All silver-gelatin IMAGELINK Microfilms on polyester base, when processed as recommended by EPM, meet the current specifications established by the American National Standards Institute, Inc., (ANSI) for films intended for use as LE 500.

Substratum (subbing or precoat)—the layer that bonds the emulsion to the base.

Electronic Imaging

With electronic digital imaging systems, the need for continuing the quality concepts already established in the micrographics arena has evolved. Following are a few key concepts.

Digitization—use of a scanner to convert documents (on paper or microforms) to digitally coded electronic images suitable for electronic storage.

Digital—the use of binary code to record information. “Information” can be text in a binary code (e.g., ASCII), images in bitmapped form, or sound in a sampled digital form or video.

NOTE: Information is recorded digitally for accuracy in storage and transmission. Some types of data manipulation are easier in digital form.

Scanning—1.) In electronic imaging, scanning is the operation which precedes digitization, where the surface of a document is divided into pixels and analog values are collected representing the optical density (brightness and possibly color) of each pixel.

2.) In electronic imaging, OCR scanning is the conversion of marks that represent symbols into symbols for use in a data processing system. The paper or microfilm with the human-readable marks is first scanned as an image, then is analyzed to recognize the intended symbol. The result is the set of symbolic information, in a machine-readable code such as ASCII (also known as handprint character recognition, intelligent character recognition, and optical character recognition).

3.) In micrographics, scanning is the movement of an image on a reader screen in a direction perpendicular to the direction of roll-film transport.

4.) Scanning is the systematic examination of data (ISO).

Scanner—a device that electro-optically converts a document into a series of pixels by detecting and measuring the intensity of light reflected or transmitted. When initially captured, each pixel is a level of brightness (gray or color), initially an analog quantity, but potentially digitized.

NOTE: For many applications, total information about each pixel is not needed and would represent a burdensome amount of output from the scanner. Therefore, most scanners digitize the value of each pixel and reduce the amount of data output to only that which is required. For example, output might be limited to one bit per pixel for "black-and-white" scanning.

Scanner threshold—the brightness level above which a pixel is considered pure white and below which the pixel is considered pure black (sometimes set manually [lighter/darker setting], or set automatically based on the average brightness of the document).

Record Classification

On the basis of required retention, photographic records can be classified broadly as requiring medium-term storage and long-term storage.

Archival medium—recording material that can be expected to retain information forever, so that such information 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 Standard material or system specifications.

Life expectancy (LE)—the length of time that information is predicted to be retrievable in a system at 21°C and 50% RH.

LE designation—the rating for the "life expectancy" of recording materials and associated retrieval systems.

NOTE: 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.

For example, LE-100 indicates that information can be retrieved for at least 100 years of storage. Silver-gelatin films have an LE of 500; thermally processed silver (TPS) have an LE of 100 years.

Extended-term storage conditions—storage conditions suitable for the preservation of recorded information on the majority of freshly processed photographic films for 500 years.

Medium-term storage conditions—storage conditions suitable for the preservation of recorded information for a minimum of 10 years.

Methylene blue—a chemical dye formed during the testing of permanence of processed microimages using the methylene-blue method. Also called residual thiosulfate ion and silver densitometric method.

Storage Hazards and Protection

There are a number of hazards to the satisfactory storage of photographic film that apply to records intended for medium-term, long-term, or extended-term storage. In fact, it is not always possible to predict the desired life of records at the time they are made.

While films of medium-term, long-term, or extended-term interest are subject to the same hazards, the storage protection provided for them will differ in degree because of a number of factors. These include the cost of providing storage facilities, desired record life, frequency of record use, value of the records, etc. See ANSI/PIMA IT9.11-1993[5] and ANSI IT9.2-1991.[6]

Fire Protection

All IMAGELINK Microfilms are slow-burning films as defined by the American National Standards Institute, Inc.[3] Even though photographic records will burn considerably slower than paper, the same precautions against damage by fire should be taken for them as for paper records of comparable value.

Depending on the importance of the records, fire protection provided can vary from the full protection described on the following pages for valuable records to that provided by ordinary office storage.

Storage Vaults

The highest degree of protection for a large number of records is afforded by a fireproof storage vault or record room. It should be located and constructed in accordance with the local building code, Fire Underwriters' Regulations, and the requirements of the National Fire Protection Association (NFPA)[7] for a valuable record room, except that an approved, controlled, air-conditioning unit should be installed. While NFPA discourages air conditioning such an installation, the fire hazard introduced by openings for air-conditioning ducts can be overcome by the use of automatic, fire-control dampers approved by Underwriters' Laboratories, Inc. These can be installed in the ducts in accordance with recommendations of NFPA.[8] Sufficient insulation should be provided in the vault to permit satisfactory temperature control at all seasons of the year and to prevent moisture condensation from forming on the walls.

Cabinets and Safes

For smaller quantities of records, a fire-resistant cabinet or safe of the type described by NFPA[7] will provide considerable protection. Such a safe should protect records against a severe fire for at least four hours.

Many fire-resistant safes and cabinets use a type of insulation that when heated releases moisture and thus fills the interior of the safe with steam during a fire. This can cause melting or stripping of the film emulsion layer and loss of the image. For protection, films stored in such a safe should be placed in moisture-tight cans, as described under "Humidity Control" in this publication.

It is preferable to use fire-resistant safes that are available with an inner chamber sealed against moisture. These are classified by Underwriters' Laboratories, Inc., as Class 150 Record Containers.[9] Film damage caused by steam is not a problem with these safes.

The question is sometimes raised as to whether microfilm stored in drawers or cabinets designed to resist fire for several hours might, in case of a fire, generate enough pressure to damage or explode the cabinet. There is practically no danger of an explosion from the storage of either polyester or acetate base safety film under these conditions. There are small amounts of organic materials in acetate film base, as well as moisture, which will expand under heat and, under some conditions, might generate slight pressure. However, such intense heat would be required on the outside of the fire-resistant cabinet that the cabinet would be seriously damaged from the fire before appreciable pressure developed.

Effects of High Temperatures

In addition to complete loss by fire, damage to film records can also occur if they are exposed to very high temperatures. Excessive heat causes film to buckle because of shrinkage at the edges. When severe, this distortion affects the ease with which the information can be taken from microfilms, either by projection (for reading) or by printing onto another film.

Silver-gelatin films that have been conditioned at a relative humidity of 50% or lower will withstand 121°C (250°F) for 24 hours without significant loss in readability or printability. At 149°C (300°F), severe distortion can occur in a few hours.

Films that have been conditioned at a relative humidity above 50% may show objectionable distortion in somewhat shorter times or at lower temperatures. Higher humidities, however, are undesirable for other reasons, as explained later.

Thermally processed silver films will build up background densities fairly rapidly at temperatures of 93°C (200°F) and above. At these temperatures, even a few hours will produce significant loss in readability or printability. At 149°C (300°F) or above, severe distortion can occur in a few hours.

Diazo films, while quite stable, contain dye images that can fade and/or discolor as a result of high temperatures. IMAGELINK Diazo Microfilms can withstand a week at 93°C (200°F) without image loss. At 149°C (300°F) or above, severe distortion can occur in a few hours. High temperature is the greatest enemy of vesicular film. Although IMAGELINK Thermal Print Films can withstand 71°C (160°F) for several hours, high temperatures can cause a complete loss of images if care is not taken with regard to temperature control.

Water Protection

Film records should be protected from possible water damage, such as from leaks, fire-sprinkler discharge, and flooding. If possible, storage facilities should be located above basement levels. Storage cabinets should be raised so that the lowest shelf or drawer is at least 15.2 cm (6 in.) off the floor and should be constructed so that water cannot splash through ventilating louvers onto the records. Drains provided should have adequate capacity to keep water from a sprinkler discharge from reaching a depth of 7.6 cm (3 in.).

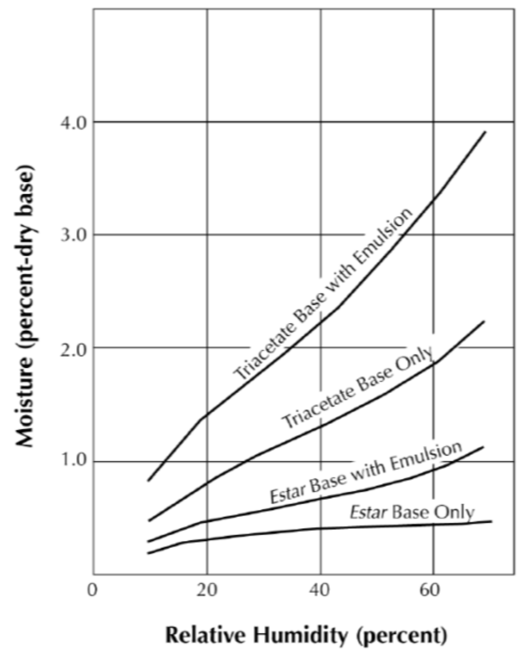
If the record-storage area should become flooded, prompt steps should be taken to reclaim any immersed records. Allowing microfilm records to dry, even partially, will cause the layers to stick together. If there are no local facilities for rewashing and drying the films immediately, promptly place the films in a water-filled container and send them to a laboratory where they can be washed and dried properly.

Effects of High and Low Relative Humidities

The choice of humidity level for storage depends on the type of photographic film and the humidity of the work area. In order to minimize subsequent moisture conditioning in storage, the humidity of the work area should not be markedly different from that of the storage area. Very large humidity differences may lead to some physical distortion. The best relative humidity for storage is the lowest that can be achieved practically and controlled reliably, within the limits specified in ANSI/PIMA IT9.11-1998 and ISO 18911[5] or their latest revisions.

High Humidity

Storage in moist air, such as that frequently found in basement rooms, and storage humidities above 50% should be avoided; relative humidities of 40% or less are recommended for minimizing the possibility of growth of microscopic blemishes. At humidities above 60%, there is the additional danger of fungus growth.



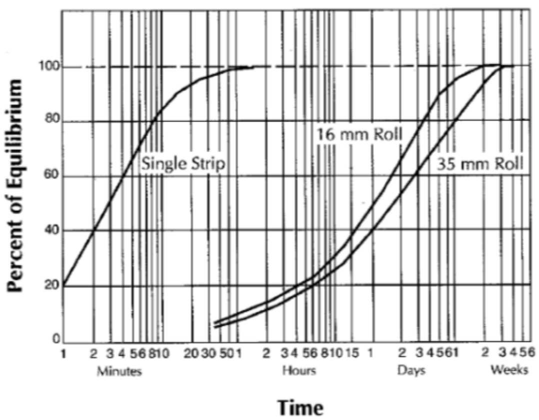
These curves show the relationship between relative humidity and the moisture content of a typical emulsion, triacetate film base, polyester base, and a complete film at equilibrium of various relative humidities at 21°C (70°F).

Low Humidity

At low humidities, problems of brittleness or static might arise if the films are to be handled frequently. However, in the case of inactive films (regardless of their intended permanence), the increased protection that low humidity gives against microscopic blemishes might be desirable. The recommended humidity is 30% for silver-gelatin polyester-base film and15% for silver-gelatin acetate-base film and all other silver and non-silver films.[5]

Very low humidities have, in the past, caused film to be brittle. However, film of current manufacture has not been found to exhibit brittleness or breaking tendencies under normal handling, even at relative humidities as low as

15%. Old film that is found to be brittle at low humidity should be reconditioned to a higher humidity before use. One day's storage is usually sufficient for conditioning a dry 16 mm roll halfway to a higher ambient relative humidity; to bring it to full equilibrium requires about a week. In each case, both sides of the roll should be exposed to the air.



Rate of conditioning a typical safety film from 20% to 50% relative humidity at 21°C (70°F).

Low humidity affects the curl of silver-gelatin film, causing a slight contraction of the emulsion layer and resulting in a slight curl toward that side. This is generally believed to be an advantage because the concave emulsion surface is better protected against abrasion. However, excessive curl may cause difficulty in focusing images in some microfilm readers. This can be avoided by conditioning the film to a relative humidity of 30-50% before use. The curl of diazo, TPS, and vesicular films is virtually unaffected by humidity.

Film handled at very low humidities may also develop a static charge as it passes through a reader or rewinder. This static charge will attract dust particles that can damage the emulsion by chemical action or physical abrasion. Therefore, it is important that any film handling area be kept clean. If film is kept in a dry storage area, it may be necessary to use the film in an office area of higher humidity to minimize static problems. However, as previously noted, large humidity differences may lead to conditioning problems.

Molecular Sieves

Molecular sieves are capable of absorbing most of the potential film degradation agents such as moisture, oxidants, solvents, and others when kept in close proximity with the films under confined storage. Therefore, Eastman Park Micrographics recommends the use of molecular sieves with triacetate and polyester-based films to reduce the physical aging of films and increase the longevity of black-and-white images under confined storage. It also prevents ferrotyping (mold/fungal growth on films), as it reduces the moisture content of film.

Tests have shown that molecular sieves prevent vinegar syndrome associated with acetate-based films and micro-blemishes, and arrests the oxidation of silver images due to peroxides and ozone in the atmosphere. Using molecular sieves slows the rate of these degradation reactions under confined storage and thus extends the keeping and longevity of older film collections.

A single molecular sieve packet inserted into the existing flip-top boxes containing microfilm will last for five to seven years, under recommended storage conditions. Microfilm should be inspected periodically to offer an opportunity to replace the molecular sieves.

The sieves must be replaced at some interval, depending on storage conditions. The use of molecular sieves is cited by the American National Standards Institute (ANSI) as another procedure to reduce redox blemishes caused by high humidity conditions and oxidants in the air. For more information or to obtain molecular sieves (listed below), call Multisorb at 1-800-445-9890.

Molecular Sieves			
Part No.	**Film**	**Format**	**Content**
41 ag 43	16 mm	3.5 grams	400
41 ag 47	35 mm	7.0 grams	200
41 ag 51	105 mm	12.5 grams	125

With or without molecular sieves, it is very important to follow current industry recommended practices for film storage, such as keeping film under proper temperature and relative humidity conditions. However, placing recommended amounts of molecular sieves inside flip-top boxes will extend the life of the films significantly. *This adds additional protection by slowing the deterioration process.*

Humidity Control

Control of relative humidity is required for preservation of permanent records.

Air Conditioning

Properly controlled air conditioning of the storage area is definitely recommended for the optimum long-term preservation of permanent records. The air should be filtered to remove dust, cleansed of gaseous contaminants, if present, and controlled to the desired relative humidity and temperature. Slightly positive air pressure should be maintained within the storage room or vault. Film should be conditioned to this environment and then placed in containers.

Where air conditioning is not available and high humidities are likely to be present, the humidity of the storage area can be lowered by electrical refrigeration-type dehumidifiers. These are readily available and inexpensive. The storage space should first be vapor-sealed by covering the walls with asphalt or aluminum paint or, better yet, paper-laminated aluminum foil or other water- vapor barriers. Painting the storage area is suggested, but follow the painting precautions. A humidistat set at the desired level of humidity should be used to control the dehumidifier. The humidity level should be checked frequently with a reliable hygrometer, such as a sling psychrometer. For added protection against short-term moisture effects, such as dehumidifier failure, tape the containers as described in the following section, "Moisture-Tight Containers."

Dehumidifiers using desiccants should be used with caution. They may create a danger of fine dust particles getting on the film and causing abrasion when the film is used. Also, when some chemical-desiccant particles are trapped in rolls of microfilm, they may form bleached spots. Therefore, inert desiccates should be used, and it is essential that the system be designed so that particulate material cannot enter the storage area. The use of molecular sieve packets is recommended, as this is an efficient desiccant. Chemically pure silica gel may also be used as a desiccant, provided that filtration is used to remove particle layers larger than 0.3 micron. See ANSI/PIMA IT9.11-1998 and ISO 18911-1998[5] or their latest revisions.

Moisture-Tight Containers

If humidity control of the storage area is not possible, the storage of film in moisture-tight containers is required to maintain the film's humidity limits. The film must be conditioned to the required humidity before being sealed in the container. This requires the temporary use of an air-conditioned cabinet or room, or an electrical dehumidifier. Smaller quantities of film can be conditioned for two or three weeks in a desiccator containing activated silica gel, and then removed and quickly sealed.

Only properly sealed metal or glass containers are considered moisture- and gas-proof. They are preferred when long-term air conditioning is not practical, when gaseous impurities may regularly be present, or when low-temperature storage is used.

Plastic boxes, such as IMAGELINK Microfilm Plastic Storage Cartons (CAT No. 8498966, 994NYDQ—16 mm; CAT No. 8418741, 994NYFU—35 mm), can be used as protective containers in controlled areas. They provide satisfactory protection against short-term problems of moisture or gaseous impurities, such as might occur with floods, dehumidifier failures, smoke from a fire, or moisture released by insulation (upon exposure to heat) in certain fire-resistant safes and cabinets.

With both metal and plastic containers, all materials (including any gaskets and protective paints or lacquers) must be non-corroding and free of peroxides, reactive fumes, and exudations during storage. Closed containers with friction-type or threaded twist-on lids may require no other seal, but should be tested for imperviousness.

If the container is in an area having the prescribed humidity and known to be free of harmful gases, taping is not required. If these conditions are not met, taping will provide satisfactory protection.

Plastic boxes or cans are preferable, as they provide more insulation in case of fire.

Humidification

Humidification is not necessary or desirable unless the prevailing relative humidity is under 15%—under 30% for polyester-base films—for long periods of time and unless the film is used frequently and physical troubles are encountered. Neither water trays nor saturated chemical solutions should be used for humidification of storage cabinets because of the more serious danger of overhumidification. Even humidification controlled by instrumentation is risky unless "fail-safe" devices are installed.

Fungus Growth

Fungus spores are found in the air everywhere. They germinate and grow under favorable conditions. When silver-gelatin films are stored for any length of time in an atmosphere having a relative humidity of above 60%, fungus (often called mold or mildew) has a tendency to grow on the emulsion surface, the back of the film, or on the film reel. The higher the relative humidity, the greater the chance of fungus attack and the more abundant its growth. The only real protection against fungus growth is to make certain that conditions are unfavorable for its growth.

If fungus growth progresses far enough, it can cause serious and permanent damage to film. This takes the form of distortion of the emulsion and eventually causes chemical breakdown so that the gelatin becomes sticky and readily soluble in water. *Water or water solutions should not be used for the removal of fungus growth because either may lead to disintegration of the image.* Clean affected film by wiping it with a soft plush or cotton pad moistened with an approved film-cleaning liquid, such as isopropyl alcohol.

Fungus can grow on most surfaces, including diazo and vesicular films; however, these films are more resistant to fungus growth than silver-gelatin films. If necessary, clean these film types by wiping with a soft, plush or cotton pad, moistened with water. *Do not use solvents on diazo, vesicular, or thermally processed silver films.*

The EPM Disaster Recovery Laboratory offers no charge evaluation of suspect microfilm and can be reached at (1-800-352-8378)

Microscopic Blemishes

Some processed silver-gelatin microfilms in storage for two to twenty years have developed microscopically small colored spots or blemishes. The fogged leader at the outside of the roll is most frequently affected by the blemishes, which are generally red or yellow in color and smaller in size than the image characters (e.g., a typewritten letter reduced 20X) on the microfilm. On occasion, these spots progress further into the roll and appear in image areas. A more detailed description of the blemishes and of the techniques used in inspecting microfilm is given in *National Bureau of Standards Handbook 96*.[11]

The spots are caused by local oxidation of image silver, resulting in the formation of minute deposits of yellow- or red-colored colloidal silver.[12,13] Possible oxidizing agents entering from outside the roll of microfilm are aerial oxygen, whose action on the film is strongly accelerated by moisture, and atmospheric contaminants such as peroxides, ozone, sulfur dioxide, hydrogen sulfide, and nitrogen oxides, which all occur in industrial atmospheres.

Assuming that your microfilm was processed to established quality control standards, microscopic blemishes (redox) may occur due to the oxidation of the metallic silver image by the presence of oxidants in the storage area: peroxides, ozone, nitrogen oxides, oil-based paint fumes, organic solvents, floor-cleaning agents, cardboard cartons, excessive temperature and humidity, or a variety of other materials that generate peroxides which attack silver microfilms.

The use of low concentrations of potassium iodide in the fixing bath (0.2 g/L) has been recommended and has been found to provide a good degree of protection against these blemishes.[13] IMAGELINK Microfilm and IMAGELINK Archive Processor Fix contain this stability-enhancing iodide.

Once the deterioration of the microfilm occurs, it cannot be reversed. Silver film duplication, IMAGELINK Brown Toner, and the use of molecular sieves can be used to stabilize the reaction.

The conditions under which microfilm is stored have been found to play an important role in the development of microscopic blemishes. Storage in cool, dry air that is free of oxidizing gases or vapors is an effective means for arresting their formation and growth. Storage in sealed, metal cans is a sound preventive measure, if this is practical and consistent with the humidity requirements.

Additional protection can be obtained by adding molecular sieves to the storage containers or toning the film with toners such as IMAGELINK Brown Toner (CAT No. 2220928—2L IMAGELINK Brown Toner). For information about the use of brown toner as a treatment to extend the life of microfilm, order IMAGELINK Publication A-1671.

Toning

The life expectancy of your microfilm, processed to established quality control standards and stored under ideal environmental conditions, can be many years. However, we do not have control of environmental surroundings at all times.

Therefore, you should consider taking the extra precaution of toning your films against oxidative attack. Toning can be accomplished by use of sulfide toning agents such as IMAGELINK Brown Toner. Other types of toners, such as selenium or gold, are also accepted but not commonly used. ANSI/PIMA IT 9.1-1998 (ISO 18901) now recognizes that films toned with toners like this can still be considered to meet the standards for records of permanent or long-term value. Brown toning is a service offered by the EPM Disaster Recovery Laboratory. The lab can be reached at 1-800-352-8378).

Chemical Contamination

Air contaminants may add an oxidizing or reducing effect to the atmosphere. This in turn may cause deterioration of the film base and a gradual fading of the photographic image, as well as the formation of the microscopic blemishes mentioned above. Typical contaminants are paint fumes, peroxides, nitrogen oxides, hydrogen sulfide, sulfur dioxide, and similar gases. If an area is to be painted, any films stored there should be removed beforehand and should not be returned to the area for three months. The removal of contaminating gases from the air requires special consideration.[5,14,15,16,17]

Contaminants can come from illuminating gas, coal gas, automobile exhaust, and certain chemical plants. They are present in harmful concentrations in most industrial and urban areas. Other contamination can come from ozone and ammonia produced by certain photocopying devices. For this reason, a long-term storage vault should be located as far as possible from such areas. When a contaminated atmosphere cannot be avoided, steps should be taken either to eliminate the fumes by air conditioning the storage area or to protect the film from contact with the atmosphere by sealing it in containers.

In addition to atmospheric contaminants, care should be taken about other materials kept or used in the storage area. It has already been mentioned that nitrate-base films should never be used for permanent-record films. Furthermore, such films should never be stored with safety-film records (either in the same room or in rooms connected by ventilating ducts in the same building) because the gases given off by decomposing nitrate film will damage or destroy images on safety-film records.

Films not of the silver-gelatin type (e.g., diazo and vesicular) should not be wound on the same rolls, stored in the same containers, or be in physical contact with silver-gelatin films. In addition, some older vesicular films have been known to give off acidic fumes and require a separate storage housing with a separate circulating air system.[4]

Avoid using rubber bands around rolls of film, since residual sulfur from rubber vulcanization promotes the growth of microscopic blemishes. Adhesive tapes, tape splices, bleached papers, and printing inks also cause undesirable effects.

Composition of Enclosure Materials

Paper

Paper should be made from rag, bleached sulfite or bleached kraft pulp with an alpha-cellulose content greater than 87%. It should be free from highly lignified fibres, such as ground wood, as determined by the phloroglucinol spot test.

For paper in direct contact with black-and-white photographic material, the pH should be between 7.5 and 9.5. The pH should be close to 7.0 when in direct contact with color or diazo material. There should be an alkali reserve of at least 2% (m/m). The alkali reserve should be obtained by the incorporation of an alkaline earth carbonate. Neutral or alkaline-sizing chemicals should be employed and the material should be essentially free from particles of metal. *Glassine envelopes should not be used.*

Plastic

Suitable plastic enclosure materials are photographic film support materials such as uncoated polyester (polyethylene terephthalate) polypropylene and polyethylene. Chlorinated or nitrated sheeting should not be used and cellulose nitrate, in particular, should be avoided.

Metal

Metal enclosures should be noncorrosive materials such as anodized aluminum or stainless steel. The use of steel is permissible, provided that the surface is well protected by lacquer, enamel, tinning, plating, or some other corrosion- resistant finish. Lacquer, which might give off reactive fumes, peroxides, or exudations during storage should not be used.

Adhesive

Some photographic images can be damaged by adhesives incorporating impurities such as sulfur, iron, copper, or other ingredients that might react with image silver or gelatin. Pressure- sensitive adhesives and ether-linked products should be avoided.

Rubber-based products such as rubber cement should not be used. Not only might they contain harmful solvents or plasticizers, but they might be compounded with photographically damaging sulfur, usually as a vulcanizer, accelerator, or stabilizer. Even some “low-desensitizing” or “sulfur-free” rubbers contain sulfur.

Photographic-quality gelatin and many polyvinyl acetate and cellulose ester adhesives are suitable for use with paper enclosures. Heat sealing and mechanical sealing should be used when possible.

Printing Inks

Printing inks are known to cause microscopic spots in fine-grain silver microfilm; consequently, there should be no printed matter on the inside of the filing enclosure. The ink used for imprinting the outside of filing enclosures should not bleed, spread, or transfer, and it should not be a source of products that attack the photograph or the enclosure itself.

For additional specifications, see ANSI/PIMA IT9.11-1998[5] (ISO 18911) and ANSI/PIMA IT9.2-1991[6] (ISO 18903).

Theft Protection

Safes provide good protection against the theft of valuable records. Where such records are large in number, vaults of burglar-proof construction may be required. Theft of important records involves double peril—that of classified films falling into unauthorized hands and the complete loss of valuable information. Protection against the latter can, of course, be provided by storing duplicate records in another location.

Processing for Permanence

Silver-Gelatin Films

Processing is one of the most important factors affecting the potential permanence of photographic records. The removal of residual processing chemicals, the exclusion of dirt contamination, and uniform drying are factors normally controlled by proper processing.

Processed film, for long-term storage or permanent records, must meet the requirements of ANSI/PIMA IT9.1-1992 (R1996) or ISO 18901.2 The ability to meet most of these requirements is controlled in film manufacture, but films must be fixed and washed adequately, whether given conventional or full-reversal processing, to meet residual thiosulfate requirements. Films processed without fixation, such as in halide- reversal processes and certain reversal processes with only redevelopment, may give a "visible, usable image," but do not come under the scope of the long-term storage standards.

If fixing and washing are inadequate, thiosulfates or silver salts, or both, will be retained by the film. These can break down, especially under poor storage conditions, to produce yellow stain in clear areas and fading in areas containing image silver.

Fixing Baths

In the fixing step, undeveloped silver-halide crystals in the emulsion are converted to soluble silver compounds which can be washed away with water. The chemicals most commonly used for fixing are sodium or ammonium thiosulfate (commonly called "hypo"). The fixing bath may also contain other chemicals to maintain a desirable pH, provide hardening, stabilize the solution, protect the image from microscopic blemishes, etc.

To make sure that there is enough time for the fixing reaction to be completed, specific recommendations for each type of film should be followed. Undeveloped silver halides are dissolved by the fixer as complex ions of silver and thiosulfate. As the silver content of the fixer increases with processing, the silver-thiosulfate complex becomes increasingly difficult to wash from the film. This can be avoided by frequent replacement or proper replenishment of the fixing bath or by in-line recirculating electrolytic recovery of silver from the fixer.

Recovery of silver from fixer is advisable for reasons of economics, conservation and ecology. There are three principal methods of silver recovery:[18] metallic replacement, electrolytic and sulfide precipitation.

Washing

Adequate washing is essential to the permanence of silver-gelatin microfilm. After all undeveloped silver halide is converted, the emulsion is still saturated with fixing bath and some dissolved silver compounds. If these are not removed by washing, they will slowly decompose and attack the image, causing discoloration and fading. The effect is accelerated greatly by high humidity and temperature. The smaller the grain size of the image, the greater this reaction is. Microfilms, being very fine grained, are very sensitive to this effect.

For good washing, a rapid flow of fresh water should be used. The water should be filtered to remove dirt particles. To improve washing, countercurrent and spray systems are frequently used in processing-machine construction. Washing efficiency decreases rapidly with decreased temperature and is very low at temperatures below 16°C (60°F). High wash-water temperatures produce the most efficient washing, but emulsion reticulation can result if the wash-water temperature is too high and not kept close to that of the other processing solutions. In some cases, extremely soft water can also cause reticulation

Squeegees

It is important to use an adequate squeegee where the film leaves the water wash and enters the drying section. Otherwise, residual water droplets will dry and form visible surface defects and, in some cases, cause physical sticking of the film laps. In wound-up rolls, these spots may provide places where microscopic blemishes can form. Inspect squeegees regularly (particularly blade and roller types) to make sure that they do not cause film scratches.

Drying

Drying should be uniform. The drying air should be filtered so that airborne particles of dirt or potentially harmful chemical dusts, often present in processing laboratories, will not become imbedded in the emulsion while it is tacky.

In machine processing, the recommendations of both the equipment and film manufacturer for operating conditions and processing chemicals should be followed.

In other modes of processing, the following factors are involved.

Residual Hypo Test

The accepted criterion for adequate washing is the methylene blue method described in ANSI/PIMA IT9.17-1998.[20] IT9.17-1998 also describes the silver densitometric method, which has been suggested by the Association for Information and Image Management (AIIM) as a simpler and less expensive alternative. If the silver densitometric density difference is 0.02 or less, AIIM considers that the methylene blue requirements for extended-term storage record films have been met. In both methods, a clear area of the film is tested and residual hypo tests may be run up to two weeks after processing

NOTE: For satisfactory residual hypo levels in films, both fixing and washing must be acceptable—inadequacies in one cannot be compensated by the other.

Residual Silver Compound Test

ANSI/PIMA IT 9.17-1998[20] and ISO 18917-1999 contain a test designed to indicate residual silver salts in the film. Such salts are an important cause of image layer degradation in aged-processed photographic films.

Protective Coatings

It should be recognized that while lacquers and other coatings have advantages for working prints receiving hard use, they are not within the scope of the ANSI long-term storage specifications.

Processing of Other Film Types

Thermally Processed Silver (TPS)

This film should be processed in accordance with the manufacturers' recommendations for optimum image stability. ANSI/PIMA IT9.19-1994 and ISO-18919-1999[24] give specifications for stability of TPS films.

Diazo Films

The proper processing of diazo films can also affect keeping qualities. In the diazo process, the film should be processed to completion for maximum storage stability. ANSI/PIMA IT9.5-1992[4] and ISO 18905-1999 give specific details for methods and measurements for proper development for image stability.

Also, as with conventional silver films, if processing equipment utilizes squeegees and dryer chambers, regular inspections should be made to make sure that the process is scratch- free and free from airborne dirt and chemicals.

Vesicular Films

The only variables in processing thermal or vesicular films are the processing temperature and time. Insufficient processing can increase the possibility of fading in the heat of the reader and potentially shorten keeping life. Processing within manufacturers' recommendations should maximize keeping qualities. In addition to monitoring process temperature and time, regular checks should be made to make sure that scratch-free film is being produced. ANSI/PIMA IT9.12-1995 and ISO 18912-1999,[22] "Specifications for Stability of Processed Vesicular Film," discuss the criteria for proper development.

Special Storage and Hazards

Underground Storage

Most large industrial organizations and government agencies have developed methods for safeguarding vital records in the event of a war or a natural catastrophe. Many keep their vital records in underground repositories located many miles from large metropolitan areas. When microfilm is kept underground in caves, mines, tunnels, subbasements, or similar locations, special care should be taken to make certain that there is adequate control of the relative humidity.

Film should not be stored where the relative humidity exceeds the limits recommended for storage. See Table 1 of ANSI/PIMA IT9.11-1998 or ISO 18911-1999.[5] If humidity cannot be controlled satisfactorily, film must be dried (as described under "Air Conditioning"), then placed in a moisture-proof container. The film must also be protected, as in other types of storage, against airborne dirt or chemical contamination.

In underground situations, proper film-storage conditions can often be achieved by simply heating the cool, moist air that is present. For example, conditions in a typical mine may be 10°C (50°F) and 85% relative humidity; by heating the storage area to 21°C (70°F), the relative humidity is reduced to 40%. Where it is not practical to lower the relative humidity adequately by this means, supplementary dehumidification may be required.

Effects of Nuclear Explosions

The protection of vital microfilm records against the effects of nuclear explosions is mostly a matter of providing sufficient blast and fire protection. Processed microfilm is essentially unaffected by radiation, even of the intensity encountered in the vicinity of a nuclear explosion. Best protection from blast and fire is afforded by removing security files from potential target areas. Storage in underground vaults, with duplicate copies in different locations, provides the greatest security.

Time-Capsule Storage

Only silver-gelatin films conforming to ANSI/PIMA IT9.1-1996[2] or ISO 18901-1999 should be used for time capsules or sealed in cornerstones of buildings. Film intended for this kind of storage should be conditioned to a low relative humidity (20-30% is recommended for acetate-base films) in a conditioning room or chamber. During conditioning, air should be circulated against both roll surfaces. Conditioning times should be at least two weeks for 16 mm film and four weeks for 35 mm film. This conforms to ANSI/PIMA IT9.11-1998 and ISO 18911-1999.[5]

During conditioning, the film should be in the form intended for final storage (wound on itself or a glass rod, not on a conventional core or reel) because the possibility of rapid moisture change makes it inadvisable to rewind the film after conditioning. The capsule should be loaded in the conditioning chamber, if possible; if not, the film should be transferred immediately to the capsule and sealed tightly.

The capsule should be a stainless steel cylinder gasketed cover. When there is more than one roll of film, it is a good idea to separate rolls with stainless steel disks of the same inside diameter as that of the capsule. Cores, reels, or wrapping of any kind should not be included; only the film itself should be put into the capsule.

Handling and Filing Film Records

Well-planned filing systems and proper handling of film records are important in the storage of records. The custodian should set up safeguards against loss or misplacement of valuable records and also make sure that the methods of filing and handling do not add unnecessary wear to the records. When films must be used, duplicates should be made and originals retained in storage.

Interfiling

Microfilm may be subject to interactions when stored with films of different generic types (e.g., diazo and silver-gelatin). Do not wind different generic film types on the same roll or store them in the same container. Diazo and silver-gelatin microfilms should be stored separately before and after processing. Diazonium salt gases emitted from Diazo microfilm (pre- and post-process) can be detrimental to silver-gelatin microfilm.

Continual handling of film, even under favorable conditions, causes some wear, but wear can be accelerated greatly by certain factors which can be controlled. Scratching occurs when film is dirty or equipment is poorly maintained or wrongly used. “Cinching” causes scratches and occurs when film is made to slide layer on layer (e.g., when the end of a loose roll of film is pulled). Tearing and fingerprinting occur when equipment and handling methods are not suitable.

Remove dirt from film by wiping with a lintless fabric pad moistened with film cleaner or its equivalent. Carry out cleaning operations in an atmosphere of about 50% relative humidity to minimize the possibility that the film will become electrostatically charged and attract dust particles.

Another proven method for removing foreign matter from film is the use of Particle Transfer Roller (PTR) technology. These rollers are a polyurethane material whose tackiness and cushiness pick up dust, hair, and other unwanted material from a continuous moving film surface. These rollers can be mounted in-line with most film operations. They can be cleaned easily with warm water and mild soap.

Cleanliness of the work space is essential to success in these operations. Static discharge devices are available for use when handling film which has been in dry storage. Alternatively, film can be conditioned to a higher relative humidity before cleaning and then reconditioned to the original low relative humidity.

Inspection

The potential life of photographic records depends largely on atmospheric conditions—temperature, humidity, cleanliness—and the manner in which the film is used. If storage conditions are kept within the limits suggested in Table 3, inspection of an adequate number of properly selected lot samples should be made at two-year intervals.[12]

While extended-term records should definitely be kept under the recommended storage conditions, film records of medium-term value may have more leeway in terms of storage humidity and temperature. Where humidity is not controlled closely, film should be inspected more frequently than at two-year intervals; the intervals between inspections should not initially exceed six months and then, if no deterioration is noted, can be extended but should not exceed one year.

Sometimes film inspection is considered too laborious and costly and is neglected for many years—occasionally with unfortunate results. If it is not always possible to open every film can or rewind every roll at the recommended frequency, select a few rolls at random from the film collection each month for examination. This approach provides some protection at a relatively small cost. If there is any indication that film records are not keeping properly, storage conditions should be improved and other protective treatments given the film. Make copies of films that show signs of deterioration because deterioration, once initiated, is an irreversible process that may be restrained, but not terminated, by improving storage conditions. Therefore, extensive and frequent inspections should be made.

ANSI/AIIM standards and technical reports are available related to the inspection of silver gelatin microforms. An example can be found in American National Standard: “Imaging Materials–Processed Silver-Gelatin Type–Black and White Film–Specifications for Stability.”[2]

Table 1: Applicable Standards for Microfilm

*LE is for polyester-based **LE is for acetate-based	**Silver-Gelatin**	**Thermally Processed Silver (TPS)**	**Diazo**	**Vesicular**
	Long Term LE 500* LE 100**	**Long Term LE 100***	**Medium, Long LE 100***	**Medium, Long LE 100***
“Safety Film Specifications”	IT9.6/ ISO 18906	IT9.6/ ISO 18906	IT9.6/ ISO 18906	IT9.6/ ISO 18906
“Specifications for Microfilms on Polyester Base” and “... on Acetate Base”	IT9.1/ ISO 18901			
“Methylene Blue Method ...”	IT9.17/ ISO 18917			
“Specifications for Thermally Processed Silver Microfilms”		IT9.19/ ISO 18919		
“Specifications for Stability of Diazo Films ...”			IT9.5/ ISO 18905	
“Specifications for Stability of Vesicular Films”				IT9.12/ ISO 18912
“Practice for Storage of Photographic Film”	IT9.11/ ISO 18911	IT9.11/ ISO 18911	IT9.11/ ISO 18911	IT9.11/ ISO 18911

Table 2: Storage Life of Microfilms

Film/Type/Parameter	Anticipated Storage Life		
	Medium Term (Minimum of 10 Years)	**Extended Term (Minimum of 100 Years)**	**Long Term (Indefinitely)**
Silver-Gelatin Films Residual Hypo	(1), (2)	Not above 0.030 grams per square meter (1)	Not above 0.014 grams per square meter (1)
Residual Silver Salts	—	No more than perceptible tint by spot stain test.	
All Films— Storage Conditions Temperature and Relative Humidity	See Table 3		
Air Conditioning	Not necessary unless film records are subjected to frequent or sustained high humidity (3)	Essential—including slightly positive air pressure.	
Air Purification	Normal	Must be free from airborne gases, dirt particles, and other contaminants.	
Enclosures	Not necessary with moisture control and/or air conditioning	If proper humidity control is provided, plastic or metal, unsealed, can be used. If adequate humidity control is not available, only metal or glass sealed containers are acceptable.	

NOTES:

(1) Expressed as thiosulfate ion.

(2) Specific limits have not been set—the recommended washing should be satisfactory.

(3) Dehumidification may be necessary even though automatic air conditioning is not practical.

Summary of Requirements for Storage and Preservation of Records on IMAGELINK Microfilm

Storage Facilities

The type of storage vault, safe, cabinet, or area selected must be based on the value of the film records and their intended storage life. In general, one roll per container is recommended. Containers should be stored in metal cabinets. Cabinets should be spaced in the room so there are no stagnant air pockets or localized areas where temperature and humidity may reach higher levels than the general condition. If humidity is not controlled, sealed metal or glass containers are required.

Although the same general storage principles apply to medium-term and long-term storage records, much greater care must be taken to obtain maximum protection for long-term storage records; makeshift or temporary arrangements should not be considered.

In summary, Table 3 indicates the conditions that are considered suitable for black-and-white silver- gelatin, thermally processed silver, diazo, and vesicular IMAGELINK Microfilms.

Table 3: Storage Temperature and Relative Humidity

Film Type	Base	Extended and Long Term			Medium Term		
		Relative Humidity	Temperature (Max.)		Relative Humidity	Temperature (Max.)	
			°C	°F		°C	°F
Silver-Gelatin	Cellulose ester (Acetate)	20–50% 20–40% 20–30%	2 5 7	35.6 41.0 44.6	20–60%	25	77
Silver-Gelatin	Polyester	30–40%	21	69.8	20–60%	25	77
Thermally Processed Silver	Polyester	15–30%	21	69.8	20–60%	25	77
Diazo	Polyester	20–50% 20–50% 20–50%	-10 -3 2	14 26.6 35.6	20–60%	25	77
Vesicular	Polyester	15–50%	20	70	20–60%	25	77
Electro-Photographic	Polyester	15–50%	20	70	20–60%	25	77
Photo-Plastic	Polyester	15–50%	20	70	20–60%	25	77
Color	Cellulose ester (Acetate)	20-30% 20–40%	-10 -3	14 26.6	20–60% 20–60%	25 25	77 77
Color	Polyester	25–30%	2	35.6	20–60%	25	77

NOTE: If the storage temperature is sufficiently low or if the air where the film is to be handled is quite moist, leave the film in its closed container until it warms up to approximate room temperature. Otherwise, condensation of moisture will occur on the cold film surfaces.

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† Available from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1791 Tullie Circle NE, Atlanta, GA 30329-2305.

All ANSI Specifications are available from American National Standards Institute, Inc., 11 W. 42nd St., New York, NY 10036 or http://www.ansi.org.

All AIIM Standards are available from AIIM, 1100 Wayne Avenue, Suite 1100, Silver Spring, MD 20910 or http://www.aiim.org.

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