INTERNATIONAL STANDARD

ISO 18911

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Imaging materials — Processed safety photographic films — Storage practices

Matériaux pour image — Films photographiques de sécurité traités — Techniques d'archivage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 18911 was prepared by Technical Committee ISO/TC 42, *Photography*.

This first edition cancels and replaces the fourth edition of ISO 5466:1996, of which it constitutes a technical revision.

This International Standard is one of a series of International Standards dealing with the physical properties and stability of imaging materials. To facilitate identification of these International Standards, they are assigned a number within the block from 18900 to 18999 (see annex A).

Annexes A to K of this International Standard are for information only.

Introduction

The value of records used in archives, museums, libraries, government, commerce and universities has focused attention on the care of these records to ensure their longest possible life (see [1, 2, 3] in the bibliography). Photographic film is an important documentary and pictorial material, and there is a recognized need for information on safeguarding photographic film having legal, scientific, industrial, artistic or historical value.

Films are susceptible to degradation from many sources. These factors may be divided into three general categories as follows.

a) Nature of the photographic film

The stability of photographic film records depends on the physical and chemical nature of the film. The specification for safety photographic film which is suitable for storage is described in ISO 18906.

For preservation purposes, processed photographic films are classified according to their life expectancy or LE designation. These are specified in the appropriate International Standards. The term "archival" is no longer specified to express longevity or stability in International Standards on imaging materials, since it has been interpreted to have many meanings that range from "preserving information forever," which is unattainable, to "temporary storage of actively used information."

For optimum preservation of photographic information, a high LE film should be used, and it should be stored under extended-term storage conditions. A film material suitable for preservation is silver-gelatin type film on polyester base that meets the requirements of ISO 10602. However, this International Standard also applies to processed colour, diazo (ISO 8225), vesicular (ISO 9718) and thermally processed silver (ISO 18919) films. Although these film types may not have as high an LE designation, excellent keeping properties have been obtained with many of them.

b) Photographic processing of the film

For black-and-white silver-gelatin type film, ISO 10602 specifies a maximum residual thiosulfate level for different LE classifications and a residual silver compounds level.

For diazo film, ISO 8225 specifies a proper development test. ISO 9718, for vesicular film, includes both a proper development test and a residual diazonium salt test.

c) Storage conditions

The conditions under which safety photographic film records should be stored are extremely important for the preservation of film and are the subject of this International Standard (see ISO 18906). The same environmental conditions are recommended for nitrate-base films, but they shall be stored in a separate storage area having suitable fire protection safeguards (see [4] in the bibliography).

The important elements affecting preservation of processed film are humidity, temperature and air pollutants, as well as the hazards of fire, water, light, fungal growth, insects, microbiological attack, contact with certain chemicals in solid, liquid or gaseous form, and physical damage. Direct contact with other generic types of film can be detrimental to either film.

The extent to which humidity, temperature, and atmospheric contaminants or variations thereof can be permitted to reach beyond recommended limits without producing adverse effects will depend upon the duration of exposure, the biological conditions conducive to fungal growth, and the accessibility of this atmosphere to the emulsion and support surfaces. Exposure to high temperatures, and in particular to high humidities, can lead to degradation of the film support and the photographic emulsion (see [5, 6, 7] in the bibliography). Cellulose ester base films are more subject to base degradation than polyester base films.

There are two levels of storage conditions: medium-term and extended-term. Medium-term storage can be used for films where the information is to be preserved for a minimum of 10 years, while extended-term storage conditions can extend the useful life of a majority of freshly processed films to 500 years. However, extended-term storage conditions will prolong the life of all films, independent of age, type or processing conditions. The storage protection provided by each level will differ in degree, as will the cost of providing and maintaining the storage facility.

Immediate availability of space and cost may need to be considered when selecting storage conditions. It is recognized that many facilities may not be able to obtain the low humidity and low temperature levels specified in this International Standard because of energy considerations, climate conditions or building construction. Such deviation from the specified conditions will reduce the degree of protection offered, and in such cases maintaining a humidity and temperature as low as possible will still provide some benefits.

This International Standard is not designed to provide protection against natural or man-made catastrophes, with the exception of fire and associated hazards which are sufficiently common to warrant inclusion of protection measures.

In addition to the recommendations in this International Standard, good storage practices must consider the filing enclosure. These are covered in ISO 18902.

Imaging materials — Processed safety photographic films — Storage practices

1 Scope

This International Standard provides recommendations concerning the storage conditions, storage facilities, handling and inspection for all processed safety photographic films (hereafter referred to as photographic film) in roll, strip, aperture-card or sheet format, regardless of size.

This International Standard is applicable to extended-term and medium-term storage of photographic film as defined in clause 3.

It is applicable to photographic film records intended as storage copies, which should not be in frequent use. It does not apply to "work" or "use" copies (see annex B).

This International Standard, while intended for materials that are properly processed, should also be of considerable value in prolonging the useful life of photographic film whose processing conditions are unknown, or that have been toned, retouched, or have markings with materials of uncertain or unknown stability.

This International Standard is applicable only to safety photographic film (see ISO 18906). Nitrate-base films are hazardous (see [8] in the bibliography) and are not covered by this International Standard. They require special storage considerations (see [4] in the bibliography), but the environmental conditions specified in this International Standard are applicable.

The storage of photographic prints and photographic plates requires different considerations. They are not covered in this International Standard, but are described respectively in ISO 18920 and ISO 18918.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 18906:—[1)], *Imaging materials — Photographic films — Specifications for safety film.*

ISO 8225:1995, *Photography — Ammonia-processed diazo photographic film — Specifications for stability.*

ISO 9718:1995, *Photography — Processed vesicular photographic film — Specifications for stability.*

ISO 10602:1995, *Photography — Processed silver-gelatin type black-and-white film — Specifications for stability.*

ISO 18915:—[1)], *Imaging materials — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation.*

1) To be published.

ISO 14523:1999, *Photography — Processed photographic materials — Photographic activity test for enclosure materials*.

ISO 18902:2000, *Imaging materials — Processed photographic films, plates and papers — Filing enclosures and storage containers*.

ISO 18919:1999, *Imaging materials — Thermally processed silver microfilm — Specifications for stability*.

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
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

NOTE There is, however, no such material and it is not a term to be used in International Standards or system specifications.

3.2
duplicate
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 and properly processed photographic films for 500 years

3.4
fire-protective storage
facility designed to protect records against excessive temperatures, water and other fire-fighting agents, and steam developed by insulation of safes or caused by the extinguishing of fires and collapsing structures

3.5
life expectancy
LE
length of time that information is predicted to be acceptable in a system at 21 °C and 50 % RH

3.6
LE designation
rating for the **life expectancy** (3.5) 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, e.g., LE-100 indicates that information can be retrieved after at least 100 years storage.

3.7
macroenvironment
atmospheric conditions (temperature, relative humidity and pollutants) in a large area in which records are kept

3.8
medium-term storage conditions
storage conditions suitable for the preservation of recorded information for a minimum of 10 years

3.9
microenvironment
atmospheric conditions (temperature, relative humidity and pollutants) inside a storage enclosure in which records are kept

3.10
open enclosure
enclosure that is intended for physical protection against mechanical damage, but is neither light-tight nor airtight

NOTE Such enclosures may be reels, cores, spools, cassettes, magazines, folders, envelopes, cartons, boxes, sleeves, transparency mounts or aperture cards.

3.11
protective enclosures
impermeable sealed containers, that may also have to be opaque, used for protection from outside factors such as reactive gases and moisture, including changes in relative humidity, and from light for certain kinds of products

NOTE Such enclosures may be taped cans and sealed envelopes.

3.12
safety photographic film
film that meets the flammability specifications defined in ISO 18906

3.13
storage housing
physical structure supporting materials and their enclosures

NOTE It may consist of drawers, racks, shelves or cabinets.

4 Film enclosures

4.1 Requirements

All enclosures used for medium-term and extended-term storage shall meet the requirements of ISO 18902.

4.2 Film in roll format

4.2.1 Medium-term storage enclosures

Aerial film, microfilm, motion-picture film, and some portrait films are wound on reels or cores and stored in roll form. The rolls shall all be wound tightly, but not under extreme tensions. A tension caused by 0,3 N of pull-out force for a 35 mm film width is recommended. Rolls greater than 150 m in length shall be stored so that the radius of the roll is in the horizontal position and the film is supported on its edges. Rolls less than 150 m in length may also be stored with the radius of the roll in the vertical position, if the core itself is supported by a horizontal spindle inserted into the cores so as to avoid pressure on the bottom of the roll. However, if such rolls are on reels or spools which have flanges, a spindle is not required since the flanges support the weight of the roll.

Motion-picture prints shall be wound with the emulsion surface on the inside of the roll, as this improves subsequent projection performance (see [9] in the bibliography).

Rolls of photographic film shall be stored in closed containers to provide protection against dirt and physical damage, unless the film is protected by the storage housing (see clause 5).

Colour, diazo and thermally-processed silver films shall be stored in closed, opaque enclosures or be otherwise protected from light exposure. Suitable enclosures are containers with telescoping, slip-type, or threaded twist-on lids. The materials used shall meet the same requirements as those for cores and reels. Closed enclosures are not necessarily airtight and may provide limited access to ambient air. Therefore, if they are used, the humidity of the ambient air shall not exceed the recommended limits.

Protective enclosures made from impermeable materials shall be used, where needed, to maintain the humidity limits of the film (see clause 7), to protect against gaseous impurities in the atmosphere, or when low-temperature storage is used without humidity control (see annex C). Suitable enclosures are closed containers with friction-type or threaded, twist-on lids having an incorporated seal. Rubber gaskets shall not be used. Cans within heat-sealed foil bags also provide protection from high humidity.

Metal containers provide the best protection against gases from the environment. However, they may corrode from acidic fumes[2)] from within the container unless they are protected with an overcoat. Alternative materials are polystyrene, polyethylene and polypropylene.

4.2.2 Extended-term storage enclosures

For extended-term storage, the requirements of 4.2.1 shall be met. The materials used for reels, cores, and containers shall meet the requirements of ISO 18902 and ISO 14523. Rubber bands shall not be used for confining film on reels or cores. If paper bands are used, the paper shall meet, as a minimum requirement, the specifications described in ISO 18902 and ISO 14523. Films on reels may be confined by tucking the film end between the roll and the flange. Pressure-sensitive tape, if needed for the enclosure, shall be free from peroxide and pass the photographic activity test specified in ISO 14523. Pressure-sensitive tape shall not be used in contact with the film.

Films may have possible interactions with other films that are of a different generic type (for example, diazo and silver-gelatin), as well as with magnetic tapes and optical disks. Films of a different generic type shall not be wound in the same rolls or stored in the same enclosures. Closed containers are required, unless the photographic film is protected from dirt and damage by the storage housing (see clause 5).

4.3 Film in sheet and slide format

4.3.1 Medium-term storage enclosures

Film in sheet form may be stored in envelopes of paper or plastic foil, folding cartons, boxes, file folders, aperture cards, or film strip jackets. Photographic slides may be stored in cardboard, metal or plastic boxes. Colour, diazo, and thermally-processed silver films shall be stored in opaque envelopes or folders, or otherwise protected from light exposure. Films should not be stacked, as this could cause excessive pressure on the lowermost sheets. When in direct contact with the surface of the photographic film, the paper or plastic material used for envelopes, sleeves, jackets, folders, boxes and cartons shall meet, as a minimum requirement, the specifications described in ISO 18902 and ISO 14523.

Suitable plastic enclosure materials are uncoated polyester (polyethylene terephthalate), polystyrene, polyethylene and polypropylene. Glassine envelopes and chlorinated, nitrated or highly plasticized sheeting shall be avoided. Specifically, cellulose nitrate and polyvinyl chloride are not acceptable.

Protective enclosures shall be used, where needed, to maintain humidity within the limits recommended for the specific film type (see clause 7), to protect against gaseous impurities in the atmosphere, or when low-temperature storage is used without humidity control. Heat-sealable envelopes, consisting of aluminum foil extrusion coated with clear polyethylene on the inside and laminated to a suitable paper sheet on the outside, have been successfully used as sealed enclosures. Precautions should be taken in handling these envelopes, so that they are not punctured. To provide greater protection against pinholes, a double bagging technique is recommended.

The adhesive used for seams and joints shall also meet the requirements of ISO 18902 and ISO 14523. The filing enclosure shall be constructed so that any seam or joint will be at the edge of the enclosure and not in contact with the image layer.

Any film that is actively releasing acidic fumes[2)] shall be stored in plastic or acid-neutralizing envelopes.

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2) Some vesicular films give off acidic fumes that may interact with silver, diazo or dye-gelatin type films. Decomposing acetate-base films release acetic acid, which further catalyses base degradation.

4.3.2 Extended-term storage enclosures

For extended-term storage, the requirements of 4.3.1 shall be met except that film shall not be stored in cardboard enclosures.

Photographic-quality gelatin, modified and photographically inert starch, some acrylic and polyvinyl acetate adhesives and methyl cellulose are suitable for use with paper storage enclosures. Pressure-sensitive (permanently tacky) adhesives shall meet the specifications of ISO 18902 and ISO 14523.

Films may have possible interactions with other films that are of a different generic type (for example, diazo and silver-gelatin), as well as with magnetic tapes and optical disks. Films of different generic types shall not be interfiled or be in physical contact.

5 Storage housings

Photographic film should be stored in closable housings, such as drawers or cabinets, or on shelves and racks enclosed by tightly fitting doors in order to provide protection from dust and dirt. Alternatively, open shelves and racks may be used if the film is in closed containers. The storage housing materials shall be non-corrosive as described in ISO 18902. They shall also be non-combustible and chemically inert. Wood, pressed-board, particle-board, plywood and other such materials shall be avoided due to their combustible nature and the possibility of producing active deteriorating agents as they age.

The finish on storage housing materials shall be durable and should not contain substances that can have a deleterious effect on stored photographic film. Adverse effects may be produced by finishes containing chlorinated or highly plasticized resins, or by solvents off-gassing from freshly applied finishes. Paints used on cabinets may give off peroxides, solvents and other contaminants for up to three months after being applied. Metal housing materials that have been powder coated (a solvent-free finish process in which electrostatically applied resin particles are fused by heat) or cabinets made from stainless steel or anodized aluminum are recommended.

When air-conditioned individually, storage housings shall be arranged to permit interior circulation of air to all shelves and drawers holding film containers so as to provide uniform humidity conditions. Storage housings, located in rooms conditioned in accordance with 7.1, shall be provided with ventilation openings that permit access of air to the interior. Such openings shall not interfere with the requirements for fire-protective storage or water protection.

Films and other materials that release acidic fumes, magnetic tapes and optical disks shall not be stored in the same storage housing as other photographic products.

6 Storage rooms

6.1 Medium-term storage rooms

Rooms and areas used for film storage should be located in the same area as rooms containing provisions for inspection and viewing of the film. Good housekeeping is essential. Walls and enclosed air-conditioned spaces shall be designed to prevent condensation of moisture on interior surfaces and within walls, especially during periods of low exterior temperatures when the walls can be cooled below the dew-point of the air.

Provisions shall be made against damage of film by water from floods, leaks, sprinklers, and from the steam released from masonry walls during a fire. Storage rooms or vaults should be located above basement levels where possible. A special storage room separated from the work areas, for film records of medium-term interest, generally will not be required, provided that the conditions recommended in 7.1.2 are maintained.

Films that are not essentially free from release of acidic fumes, such as some vesicular films, shall be stored in separate storage rooms. Films showing any sign of chemical degradation, such as the presence of acidic fumes, shall be stored in a separate storage room having a separate circulating-air system.

6.2 Extended-term storage rooms

For extended-term storage, the requirements of 6.1 shall be met.

The value of photographic film kept for long-term purposes makes it advisable to provide a storage room or vault separate from medium-term storage facilities, temporary storage facilities, offices or work areas. Storage rooms for films that are not essentially free from acid release shall have a separate circulating-air system (see annex D).

Storage rooms have been constructed in caves and mines and have proven very satisfactory when requirements are met for environmental conditions (see 7.1) and air purity (see 7.3).

7 Environmental conditions

7.1 Temperature and humidity specifications for storage (see annexes E, F and G)

7.1.1 Recommended temperature and relative humidity

The recommended temperature and relative humidity conditions given in Table 1 shall be maintained either within individual storage housings or within storage rooms containing such housings.

Table 1 — Maximum temperatures and relative humidity ranges for extended-term storage

Image	Base	Maximum temperature[a, b] °C	Relative humidity range[a, c] %
Black-and-white silver-gelatin[d] (see ISO 10602)	Cellulose esters[e]	2 5 7	20-50 20-40 20-30
Black-and-white silver-gelatin[d] (see ISO 10602) Thermally or processed silver (see ISO 18919) Vesicular (see ISO 9718) Silver dye bleach	Polyester	21	20-50
Colour (chromogenic) Diazo (see ISO 8225)	Cellulose esters[e] Polyester	– 10 – 3 2	20-50 20-40 20-30

a See annex H for storage of historic still photographic records.

b Cycling of temperature shall not be greater than ± 2 °C over a 24 h period.

c Cycling of relative humidity shall not be greater than ± 5 % RH over a 24 h period.

d If there is concern about the possibility of silver image oxidation due to atmospheric contaminants, poor quality enclosures, and/or excessively high temperature and humidity levels, a post-process chemical conversion treatment can be used to provide added protection (see ISO 18915).

e This includes cellulose triacetate, cellulose acetate butyrate, and cellulose acetate propionate.

7.1.2 Medium-term storage environment

The average relative humidity (RH) of a medium-term storage environment shall not exceed 50 % RH, and the maximum relative humidity shall not exceed 60 % RH. Ideally, the maximum temperature for extended periods should not exceed 25 °C, and a temperature below 21 °C is preferable. The peak temperature for short time periods shall not exceed 32 °C.

Short-term cycling of temperature shall be avoided. Cycling of relative humidity shall not be greater that ± 10 % RH over a 24 h period. Cycling of temperature shall not be greater than ± 5 °C over a 24 h period.

Protection may be increased by storing film at low temperature and low relative humidity.

7.1.3 Extended-term storage environment (see annex G)

7.1.3.1 Recommended environment for black-and-white films

The rate of most chemical reactions, such as the degradation of film base and the discolouration of the image silver by oxidation, is lowered with decreasing temperature and decreasing relative humidity. Consequently, life expectancy is increased as either storage temperature or storage humidity is lowered. Moreover, a lower storage temperature can compensate for a higher humidity to provide the same life expectancy (see annex G). For this reason, several relative humidity/temperature combinations can be used for an extended-term storage environment as specified in Table 1.

Higher relative humidity ranges can be employed if the average temperature is reduced, but the maximum relative humidity shall not exceed 50 %. Cycling of relative humidity shall be no greater than ± 5 % RH over a 24 h period. Cycling of temperature shall be no greater than ± 2 °C over a 24 h period.

An alternative procedure to controlling the macroenvironment is to condition the film to the recommended relative humidity at room temperature, place it in hermetically sealed or taped containers, and then put it in cool storage (see [10] in the bibliography). Roll and sheet films generally are protected adequately against moisture when placed within two heat-sealed foil bags from which as much air as possible has been expelled before sealing. Roll films are provided with greater physical protection if first placed in cans. The double-bag arrangement reduces the possibility of air leakage through pin holes, but does not guarantee it. However, except in rare instances, it does provide the desired moisture conditions inside the inner bag and, therefore, permits the use of cold storage vaults or reasonably-priced deep-freeze units. It is essential to limit, as much as possible, the volume of free air in the sealed film container.

It is difficult to specify in this International Standard what the exact relative humidity and temperature of storage should be, since they depend upon the value of the film, the past storage history, the length of time the film is to be kept, the size of the vault, the cost of various options, and the climate conditions where the facility is to be located. The cost/protection ratio has to be determined by the individual facility. Another very important factor is the exact mix of the photographic objects in the collection, i.e., whether photographic prints and plates are included and whether the materials are new or old.

Low relative humidities can cause excessive strain on the emulsion and result in high curl. Low humidities can also cause serious problems with older historic records (see annex H). The environmental conditions chosen should fall within the guidelines of Table 1.

The recommended humidity and temperature conditions can be maintained either within individual storage housings or within storage rooms containing such housings. When the regulation of the macroenvironment is not possible, the microenvironment shall be controlled by means such as molecular sieves or silica gel, or by conditioning to a lower humidity (see annex I).

Very low humidity conditions may produce brittleness or curl in films having a gelatin emulsion, by extraction of moisture from the emulsion. In such cases, it is good practice to recondition the film to a higher humidity prior to use.

7.1.3.2 Recommended environment for colour films

The storage temperature for colour films shall be 2 °C or below for chromogenic materials (see [11, 12] in the bibliography) and 21 °C or below for silver dye bleach materials. This can be provided by a storage room controlled at the desired temperature and at the recommended relative humidity. Several relative humidity/temperature combinations can be used as specified in Table 1.

As an alternative method, use the procedure described in the third paragraph of 7.1.3.1.

The user should balance the capital and operating cost of cold storage vaults or deep-freeze units with the labour and material cost of bagging film.

7.1.3.3 Moisture-conditioning time

Moisture equilibration requires considerably more time than temperature equilibration. The time needed for films to reach moisture equilibrium with a given atmosphere depends on the following main factors:

— the film format (sheets, rolls);

— the packing density and volume of sheet-film stacks or the number of convolutions of film rolls;

— the moisture permeability of enclosure materials and/or containers;

— the difference between the initial and the desired final moisture content of the films;

— the temperature at which the moisture conditioning occurs.

A combination of these factors can prolong conditioning periods and may compromise the effectiveness of low temperature storage vaults, if the conditioning is expected to take place in storage. For example, a 150-sheet stack will condition in less than two weeks at room temperature but will require six months at sub-zero temperature (see [13] in the bibliography).

For these reasons, preconditioning of films may be necessary before they are placed in their controlled storage place. This can be accomplished with sheet films by exposing them to freely circulating air (see 7.3 for air purity) of suitable temperature and relative humidity for 24 h. Longer periods will be needed if the sheets are in stacks. Moisture equilibration of roll films takes much longer. Here again, free access of air will shorten the required conditioning period, and rolls in moisture-permeable enclosures will require less time than those in closed metal containers. However, even the latter will come to moisture equilibrium within several months at room temperature (see [12, 13] in the bibliography). Film rolls that contain more than the desired quantity of moisture can be dried by keeping them for two to three weeks in taped metal containers that contain suitable amounts of silica gel or a molecular sieve.

If the relative humidity of the use environment is chosen to match that of the storage environment, moisture-conditioning procedures can be reduced or eliminated. Matching the relative humidity levels between use and storage has the added advantage of reducing physical stress on the film caused by relative humidity cycling between storage and use. Unmatched humidity levels will have a strong influence on the time required to reach moisture equilibrium.

7.1.3.4 Warm-up time

Films stored at temperatures significantly below room temperature will require some warm-up time before they can be used, in order to prevent absorption or condensation of moisture on cold film surfaces. This warm-up procedure requires that an adequate vapour barrier be wrapped around the film contents during the warm-up period. Adequate time must be provided to allow the total volume of film to approach room temperature (see annex F). The required warm-up time can vary between 1 h and 1 d, depending on the package size, degree of insulation and temperature differential.

7.2 Air-conditioning requirements

Properly controlled air-conditioning may be necessary for maintaining humidity and temperature within the limits specified, particularly for extended-term storage where the requirements are more stringent than for medium-term storage. Slightly positive air pressure shall be maintained within the storage room or vault. Air-conditioning installations and automatic fire-control dampers in ducts carrying air to or from the storage vault shall be constructed and maintained on the basis of the recommendations contained in appropriate national standards and regulations[3]. They shall also conform with recommendations for fire-resistive file rooms contained in appropriate national standards and regulations[4]. Masonry or concrete walls may release steam from internally bonded water when heated in a fire. A vapour barrier is required for such vaults, or sealed containers shall be used.

Automatic control systems are recommended, and they shall be checked frequently with a reliable hygrometer that has been properly calibrated to determine that the humidity limits specified in Table 1 are not being exceeded. Where air-conditioning is not practical, high humidities may be lowered by electrical refrigeration-type dehumidifiers controlled with a hygrostat. Inert desiccants, such as chemically pure silica gel, may be used, provided the dehumidifier is equipped with filters capable of removing dust particles down to 0,3 μm in size and is controlled to maintain the relative humidity specified in 7.1.

Dehumidification may be required in storage areas, such as basements and caves, that have inherently low temperatures and frequently exceed the upper humidity limit.

Humidification is necessary if the prevailing relative humidity is less than that recommended in 7.1, or if physical troubles such as curl or brittleness are encountered with active files. If humidification is required, a controlled humidifier shall be used. Water trays or saturated chemical solutions shall not be used because of the serious danger of over-humidification.

7.3 **Air purity** (see annex D)

Solid particles, that may abrade film or react with the image, shall be removed by mechanical filters from air supplied to housings or rooms used for storage. These mechanical filters are preferably a dry-media type having an arrestance rating of not less than 85 %, as determined by tests contained in appropriate national standards and regulations[5]. Filters shall be of a non-combustible type, meeting the construction requirements of appropriate national standards and regulations[6].

For maximum storage life, photographic film shall be in a clean condition before being placed in storage.

Gaseous impurities such as sulfur dioxide, hydrogen sulfide, peroxides, ozone, acid fumes, ammonia and nitrogen oxides can cause deterioration of the film base or image degradation in some films (see annex J). They can be removed from the air by suitable washers or absorbers. An extended-term storage film vault should be located as far as possible from an urban or industrial area, where contaminants can be present in harmful concentrations. Storage of film in sealed containers in accordance with clause 4 will afford adequate protection against outside pollutants.

Since paint fumes may be a source of oxidizing contaminants, film shall be removed from either an extended-term or medium-term storage area for a 3 month period when the area is freshly painted.

Gases given off by decomposing nitrate-base film will damage or destroy the image on safety film records stored in the same area (see [21] in the bibliography). Therefore, safety film shall not be stored with nitrate-base films, either in the same room or in rooms connected by ventilating ducts.

7.4 **Light**

Normally, film is kept under dark conditions. This is recommended practice, as light can be detrimental to some images.

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3) For example, see [14, 15] in the bibliography.

4) For example, see [16, 17] in the bibliography.

5) For example, see [18, 19] in the bibliography.

6) For example, see [19, 20] in the bibliography.

8 Fire-protective storage (see annex K)

Enclosure materials for fire-resistant storage shall be sufficiently fire-resistant that, after heating for 4 h at 150 °C, they will not ignite or release more reactive fumes than the film itself. Many enclosure materials will melt or become badly distorted at this temperature. This melting or distortion shall not cause damage to the film or prevent it from being removed from the enclosure. The materials used in reels or cores shall be neither more flammable nor more decomposable than the film that is stored on them.

For protection against fire and associated hazards, the film shall be placed in closed containers in either fire-resistant vaults or insulated record containers (Class 150)[7]. If fire-resistant vaults are used, they shall be constructed in accordance with recommendations contained in appropriate national standards and regulations[4] with particular care taken for protection from steam.

When the quantity of film is not too great, insulated record containers (Class 150) conforming to appropriate national standards and regulations are suitable[7]. They shall not exceed an interior temperature of 65 °C and an interior relative humidity of 85 % when given a fire-exposure test from 1 h to 4 h depending on the classification of the record container. Insulated record containers shall be situated on a ground-supported floor if the building is not fire resistant.

For the best fire protection, duplicate copies of film records shall be placed in a geographically separate storage area.

9 Film identification, handling, and inspection (see annexes B, H and I)

9.1 Identification

Processed film is frequently inscribed with identification marks using non-photographic means such as ink, crayon, felt marking pens or pressure-sensitive labels. Such identification materials shall pass the photographic activity test described in ISO 14523.

9.2 Handling

Proper handling of film is important. If films are used frequently, this generates damage and necessitates the imposition of critical handling and filing requirements.

NOTE Gelatin emulsion layers can be physically scratched; vesicular images are sensitive to pressure damage causing bubble collapse.

Good housekeeping and cleanliness are essential. Films shall be handled by their edges, and handlers shall wear thin, clean, cotton or plastic gloves.

9.3 Inspection

An adequate number of properly selected lot samples of film shall be inspected at 2 year intervals. If deviations from recommended temperature and relative humidity ranges (see 7.1) have occurred, inspection shall be made at more frequent intervals. A ramdom-sampling plan established in advance shall be used, and a different lot should be inspected each time. Deterioration of either film or enclosure materials shall be noted. Recommended practices have been established by national standardizing bodies for film inspection (for example, see [24] in the bibliography).

7) For example, see [22, 23] in the bibliography.

There may be physical changes in the film (curl, distortion, brittleness, adhesion failure, etc.), visual changes in the film (fading, microblemishes, colour change) or changes in the enclosure material (embrittlement, discolouration). The cause of the problem shall be determined and corrective action taken.

If film has been stored at a temperature below the dew-point of the atmosphere where inspection is to take place, the film in its enclosure shall first be allowed to warm-up, before opening, to a temperature within a few degrees of that of the inspection room. The time required for warm-up increases with the volume of the film and the temperature difference (see annex F).

Annex A
(informative)

Numbering system for related International Standards

The current numbering system for TC 42 documents dealing with the physical properties and stability of imaging materials is confusing since the five digit numbers that are used are not in any consecutive order. To facilitate remembering the numbers, ISO has set aside a block of numbers from ISO 18900 to ISO 18999 and all revisions and new International Standards will be given a number within this block. The last three digits will be identical to the current ANSI/PIMA numbers of published documents. This will be advantageous to the technical experts from Germany, Japan, United Kingdom and the USA who have prepared the standard and who are familiar with the ANSI/PIMA numbers.

As the present International Standards are revised and published, their new numbers will be as given in Table A.1.

Table A.1 — New ISO numbers

Current or former ISO number	Title	New ISO number
10602	*Photography — Processed silver-gelatin type black-and-white film — Specifications for stability*	18901
10214	*Photography — Processed photographic materials — Filing enclosures for storage*	18902
6221	*Photography — Films and papers — Determination of dimensional change*	18903
5769	*Photography — Processed films — Method for determining lubrication*	18904
8225	*Photography — Ammonia-processed diazo photographic film — Specifications for stability*	18905
543	*Photography — Photographic films — Specifications for safety film*	18906
6077	*Photography — Photographic films and papers — Wedge test for brittleness*	18907
8776	*Photography — Photographic film — Determination of folding endurance*	18908
10977	*Photography — Processed photographic colour films and paper prints — Methods for measuring image stability*	18909
4330	*Photography — Determination of the curl of photographic film and paper*	18910
5466	*Photography — Processed safety photographic films — Storage practices*	18911
9718	*Photography — Processed vesicular photographic film — Specifications for stability*	18912
12206	*Photography — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation*	18915
14523	*Photography — Processed photographic materials — Photographic activity test for enclosure materials*	18916
417	*Photography — Determination of residual thiosulfate and other related chemicals in processed photographic materials — Methods using iodine-amylose, methylene blue and silver sulfide*	18917
3897	*Photography — Processed photographic plates — Storage practices*	18918
14806	*Photography — Thermally processed silver (TPS) microfilm — Specifications for stability*	18919
6051	*Photography — Processed reflection prints — Storage practices*	18920
15524	*Photography — Polyester-base magnetic tape — Storage practices*	18923
15640	*Photography — Imaging materials — Test method for Arrhenius-type predictions*	18924

Annex B
(informative)

Distinction between storage (record) copies and work (reference) copies

The distinction between photographic film records that are intended for storage and those intended for use has not always been clear. Work or reference copies, or copies for use, are the predominant photographic records found in archives, record centres, libraries and museum collections. Their value lies in their being available for ready reference. However, as a result of this use, they are subjected to dirt, abrasion, fingerprints, contamination with foreign materials, and exposure to excessive light and temperatures. Such work copies may become moisture-conditioned to the conditions of the working area, which may be quite different from the storage area where they are filed. In fact, physical distortions of work copies can occur if they are not reconditioned to the moisture conditions of the storage area. It is evident that work copies of photographic records are not suitable for long-term preservation; they should not be considered as storage or record copies.

Where there is a need for extended storage of photographic film records having a permanent value, duplicates should be prepared for reference use. These duplicates should be kept in a collection area separate from the one in which original storage copies are stored. Original storage copies should meet the appropriate ISO requirements for the photographic material used and should be stored according to the recommendations of this International Standard. Original storage records will occasionally be looked at, otherwise the need for keeping these records is pointless. However, the use of storage copies should be infrequent.

If the film is expected to be handled more than 10 times during its lifetime, work copies should be produced for use.

Annex C
(informative)

Advantages and disadvantages of protective (sealed) enclosures

Recommended enclosures are very dependent upon the specific conditions of storage. Sealed containers which are impervious to moisture and gases, such as taped metal cans or heat-sealed metallic envelopes, provide protection of the film from high humidities and pollutant gases in the storage environment. Metal cans also offer physical protection from handling damage, dirt and dust, allow easier stacking, and provide some protection from water and fire damage. However, it has been established that decomposing triacetate film base will degrade faster in such a closed environment. A closed environment confines acetic acid (formed by the decomposition) and catalyses further degradation.

Cardboard boxes or paper envelopes offer advantages by absorbing acetic acid vapours, thereby slowing down the degradation reaction. However, they offer only limited protection from outside humidity or pollutants, and no protection from fire and water. These materials can become brittle if the pH of the enclosures drops below 4 as a result of acid absorption. All cardboard and paper enclosures should meet the requirements of ISO 18902 and ISO 14523.

The film archivist should make a qualitative evaluation of the potential risks to the collection. If humidity, pollutants, dirt, water, or fire are major concerns, sealed enclosures should be used. However, if the film collection contains acetate base film that has shown some signs of deterioration, such as an acetic acid or vinegar odour, then the film should be stored in an open environment or in a microenvironment with an acid scavenger that can absorb vapours. If decomposing film is stored in an open environment, consideration should also be given to any effect of acetic acid vapours on other film stored in the same room (see annex I). This will depend upon the air change-over in the storage room, the proximity of other collections, and the type of enclosures used.

Annex D
(informative)

Air-entrained and gaseous impurities

When dust and other air-entrained solid particles are deposited on photographic film, they can interfere with legibility and produce scratches. Reactive types of dust can cause fading or staining of the image layer.

Gaseous impurities such as sulfur compounds, ozone, peroxides, ammonia, paint fumes, solvent vapours and other active compounds may cause deterioration of the base and a chemical degradation of the photographic image. The most frequently encountered impurity, especially in urban and industrial atmospheres, is sulfur dioxide, and small concentrations are likely to produce detrimental effects. Hydrogen sulfide is not a common impurity, but is a very active one even at low concentrations; it can occur in air-conditioners or washers containing decomposed biological slime. Oxidizing gases, such as peroxides, are responsible for the local oxidation of image silver in fine-grain images, which causes formation of minute deposits of coloured colloidal silver (see [25, 26, 27] in the bibliography) and contributes to silver mirroring.

Suitable means for the removal of gaseous impurities are available, such as air washers operating with treated water for elimination of sulfur dioxide and chemical scavengers for the absorption of sulfur dioxide and hydrogen sulfide (see [28] in the bibliography). These methods require consistent control and, in the case of chemical scavengers, expert processing.

Annex E
(informative)

Humidity during storage

Relative humidity appreciably beyond the limits specified in this International Standard can have a very deleterious effect on photographic film. Relative humidities above 60 % and below 20 % should be avoided.

Prolonged exposure to conditions above 60 % relative humidity (RH) will tend to damage or destroy the gelatin emulsion layer due to growth of fungus, and will eventually cause the emulsion to stick to other surfaces such as storage enclosures. Exposure to high humidity will also accelerate any effects of residual silver halide and processing chemicals (for example, thiosulfate) on the stability of silver images and will impair the stability of dye images. In addition, high relative humidities can accelerate the oxidation of image silver and the degradation of the film base.

Storage at low humidities not only avoids fungal growth, but reduces the rate of chemical degradation. Recent investigations (see [7, 29] in the bibliography) have shown markedly improved film base and emulsion stability when the storage humidity is reduced below 50 % RH. When the relative humidity is lowered to 20 %, useful life can be increased by a factor of 4 to 10, depending upon the property measured. Consistent exposure to humidity below 15 % RH can produce a temporary brittleness in gelatin emulsion film, but flexibility can be restored by conditioning the film to 30 % RH or higher.

Film records should be handled carefully while in low relative humidity storage to avoid unnecessary flexing. Film having a low moisture content is apt to develop static charges causing attraction of dust particles, but this difficulty may be avoided by appropriate discharging during handling and printing. Low relative humidity exposure can also result in high film curl, which may produce permanent film deformation in sheet film and "spoking" in motion-picture film. It may also exacerbate existing physical problems, such as emulsion flaking or delamination.

In Table 1 (see 7.1.3), below-freezing temperatures are specified in some situations. Under these conditions, dehumidification devices should be limited to desiccant systems since cooling coils cannot be used.

Annex F
(informative)

Temperature during storage

Continuous storage temperatures above approximately 40 °C may permanently reduce the pliability of some film bases, and may accelerate the fading of dye images and vesicular images. Although gelatin film becomes more brittle at low temperatures (below 0 °C), flexibility is restored upon return to room temperature. To avoid undue flexing, films should be handled carefully when in low temperature storage.

Storage temperatures which are below the dew-point of the air in the area for use may cause moisture condensation upon film surfaces, unless the container and contents are brought above the dew-point temperature before removal of the film. The required warm-up time may vary from 1 h to 1 d, depending on the size and type of the package and the temperature differential.

An important aspect of temperature is its effect on relative humidity. Low storage temperatures may raise the relative humidity if the storage area is not humidity controlled. This may cause conditions beyond the range of recommended humidities for proper storage; in such a case, sealed containers should be used. If sealed enclosures are used, either the container size should be chosen so that the film occupies as much of the volume as possible, or excess air should be squeezed from the foil bags prior to sealing. Otherwise, the relative humidity may increase above the recommended range when the container is cooled.

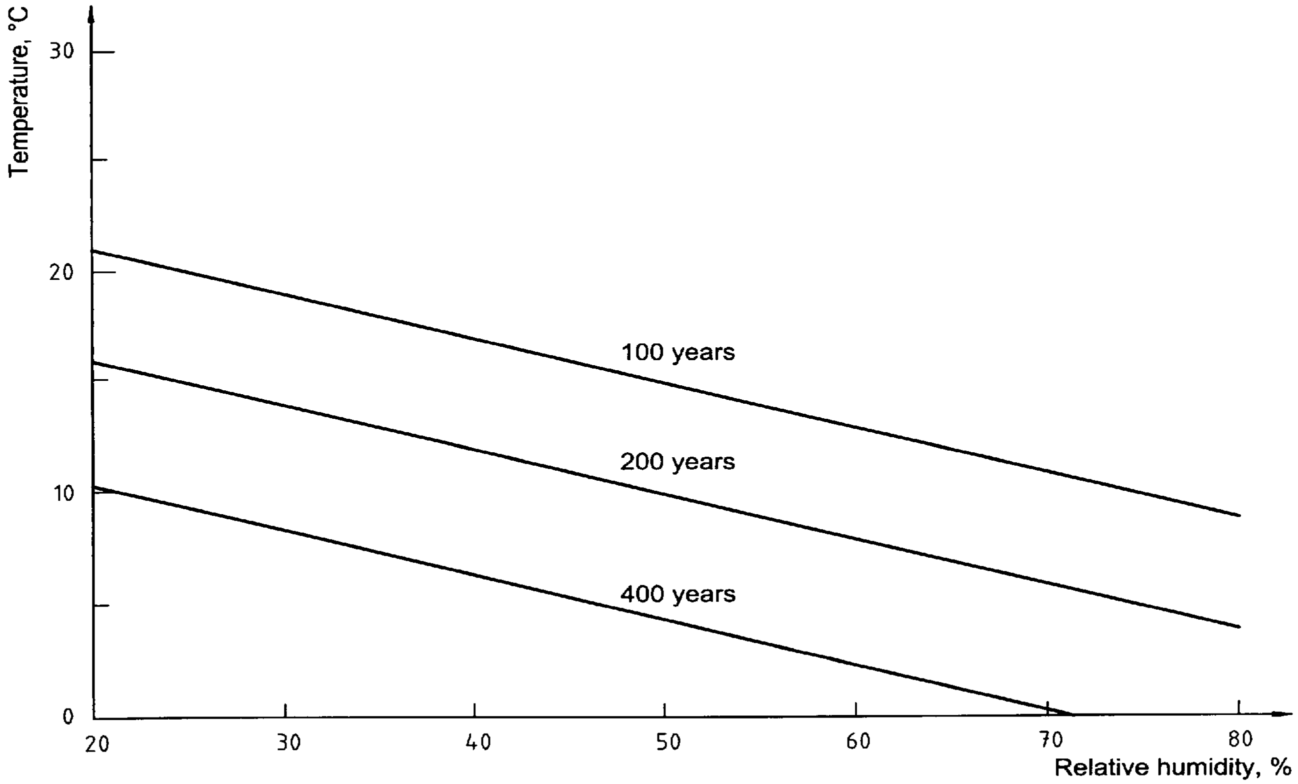
Annex G
(informative)

Temperature/relative humidity relationship

Degradation of photographic film is caused by chemical reactions whose rates are lowered with decreasing temperature and humidity. Consequently, the useful life of film can be increased by lowering either the storage temperature or storage humidity. Moreover, a lower storage temperature can compensate for a higher humidity to obtain the same life expectancy. This is illustrated in Figure G.1 for the acidity increase caused by degradation of cellulose triacetate base (see [29] in the bibliography).

Similar behaviour exists for the degradation of polyester base and the fading rates of chromogenic dyes. These relationships permit several temperature/relative humidity combinations to be acceptable for extended-term storage conditions as specified in Table 1. This gives the storage vault designer a range of options.

The beneficial effect of cool/cold storage and/or storage at lower relative humidities can be mitigated by frequent or prolonged removal of film from the storage vault. The effect of the time out of storage has been mathematically modeled (see [30] in the bibliography) using data from accelerated aging studies on the stability of colour dyes and photographic film bases. The illustrative chart in Table G.1 shows the effect of time out of storage.



NOTE Curves are based on accelerated tests on freshly processed films.

Figure G.1 — Temperature/relative humidity relationship for cellulose triacetate film to attain a fixed acidity level

Table G.1 — Time out of storage relationship

Storage conditions		Days per year at room temperature [a]				
		0	5	10	30	60
Temp °C	RH %	Relative longevity [b]				
20	50 30	1 2	1 2	1 2	1 2	1 2
10	50 30	5 9	4 8	4 7	4 5	3 4
0	50 30	18 33	14 23	12 18	7 9	5 5
− 10	50 30	71 132	36 47	24 29	11 11	6 6
− 20	50 30	288 538	58 64	32 34	12 12	6 6

[a] This chart is for illustration purposes only; the actual fading rates or life expectancy for a specific film material will be different.

[b] The values in this table are the reciprocal of the average dark fading rates for chromogenic colour dyes relative to a steady state environment of 24 °C and 40 % RH; a relative fading rate equal to 1 is assumed during the time that the material is in use and not in storage. The values given in this table are the multipliers for film life expectancy for the indicated storage conditions and for the days at room temperature.

Annex H
(informative)

Historic photographic records

In facilities where historic photographic records are stored, care should be exercised when choosing the relative humidity level so that items in poor condition (those with flaking, delaminating emulsion, or film curl) are not physically stressed by low relative humidities in the range of 20 % to 30 %. If historic film record copies in poor condition are stored in low relative humidity vaults, they should be monitored for damage. Cycling between low relative humidity storage areas and higher relative humidity use areas can exacerbate existing problems.

Storage at low temperature and/or low relative humidity can embrittle the emulsion or film layers making them more susceptible to physical damage during handling. Because of this, all historic film records, especially those in poor condition, should be handled carefully when in low temperature and/or low relative humidity storage to avoid unnecessary flexing. Flexing or rough handling may damage embrittled film in addition to potentially exacerbating physical problems, such as delaminating and flaking emulsions.

Copies should be made for items that require frequent or extended use. This is especially true since the benefits of increased chemical stability of the film base and colour dyes gained by storage at low temperature or low relative humidity are quickly mitigated by frequent cycling and prolonged removal to higher humidities and temperatures (see annex G).

Since the colour images of most types of older colour films (for example, incorporated coupler transparency films manufactured prior to around 1980) are intrinsically less stable than the films being manufactured at this time and because of changes as a result of storage over the years, storage temperatures significantly lower than the maximum temperatures specified in Table 1 (see 7.1.3) should be provided to prolong their life. This is also true for older black-and-white films on acetate film base that may be showing evidence of degradation.

Annex I
(informative)

Microenvironments

This International Standard is primarily concerned with the regulation of the complete film storage area or macroenvironment. This is the preferred approach to environmental control in film storage. Such control often involves a high initial installation cost, in addition to the operating expense of maintaining the temperature and relative humidity. Experience has shown that macroenvironmental control is cost effective, particularly when compared to the cost of film restoration or duplication. Nevertheless, it should be recognized that there are many situations where the installation of air-conditioning equipment is completely impractical because of the up-front cost, unavailability of equipment, or lack of power facilities. In such situations, the control of the microenvironment is a viable alternative. Microenvironment refers to the temperature and relative humidity inside a sealed package or enclosure.

The permanence of photographic film is strongly influenced by the environment in immediate contact with the film. Consequently, microenvironmental control is a technically sound approach. It is applicable when film is in an impermeable container such as a sealed motion-picture can, but not when it is in permeable enclosures such as envelopes or folders because these enclosures are not sufficiently sealed to maintain a separate microenvironment.

A favorable microenvironment can be obtained by conditioning film to a low relative humidity and subsequently sealing the material in a closed container. Over 50 years ago, an alternate approach using activated silica gel to reduce the moisture content of film was recommended (see [31] in the bibliography). In 1981, the Swedish Film Institute introduced a film conditioning apparatus (known as FICA) to control the microenvironment of motion-picture films (see [10] in the bibliography). This found some application although it was labour intensive. Several years later, a study was completed by the USA National Bureau of Standards that analysed the factors involved in controlling microenvironments, with attention being given to pollutant control as well as temperature and humidity (see [32] in the bibliography).

Recently, microenvironment control in sealed motion-picture containers was given renewed interest with the use of zeolites, commonly called molecular sieves (see [33] in the bibliography). While many types of zeolites exist, those most useful in film storage microenvironments have a twofold function: they reduce the moisture content of objects inside the container (see [34] in the bibliography), which increases film stability; and they also adsorb acetic acid generated by degrading cellulose triacetate film base. Since the acid acts as a catalyst and accelerates the degradation rate, its adsorption contributes to a longer storage life for film on cellulose acetate base. Molecular sieves may also remove some atmospheric pollutants that can cause degradation of a silver image (see annex J).

The prime disadvantages of using microenvironmental approaches in film storage are that they require considerable labour to implement and make access to the film more difficult. Each time the film is accessed, repackaging is necessary and periodic replacement of molecular sieves or silica gel is required. However, where regulation of the macroenvironment is not possible, control of the microenvironment is recommended.

Annex J
(informative)

Silver image degradation

Processed black-and-white silver images are susceptible to discolouration (microspots, mirroring or yellowing) when stored under adverse storage conditions or in unsuitable enclosures. The deterioration is caused by local oxidation of the image silver, resulting in ionic silver which is mobile. This mobile silver can migrate from its original site and be subsequently reduced to metallic silver and redeposited in a new location. When the silver is redeposited on the surface of the image layer, it results in a silver mirror. This appears as a metallic sheen when viewed by low-angle reflected light. When migration is confined to a localized area, this defect can appear as small reddish spots or microblemishes which have been found in microfilm collections. Yellowing can be an overall or localized discolouration. These have appeared in the fogged leader at the outside of the roll, but occasionally appear further into the roll in image areas (see [25, 27] in the bibliography).

Possible oxidizing agents that cause this degradation are aerial oxygen, whose action is accelerated by moisture, and atmospheric contaminants such as peroxides, ozone, sulfur dioxide, hydrogen sulfide, or others that occur in industrial atmospheres (see [17, 35, 36] in the bibliography).

Peroxides may be present in most woods and may also be formed as a result of the ageing of paper inserts and cardboard containers commonly used in storing films. In closed containers, various methods may be used to remove atmospheric pollutants using materials such as molecular sieves, chemical scavengers and suitable corrosion inhibitors.

Processing and storage conditions play an important role in the development of discolouration or blemishes. Storage in cool, dry air that is free of oxidizing gases or vapours is usually an effective method of arresting or retarding the formation of discolouration or blemishes (see [25, 37, 38] in the bibliography). Chemical conversion of the silver image provides excellent resistance to oxidizing gases (see ISO 18915).

Annex K
(informative)

Fire protection

Damage to photographic film records by high temperature can occur even if the film is not destroyed by fire. Photographic films show some physical distortion at 150 °C, but the silver-gelatin image can withstand this temperature for several hours without significant loss in image quality. However, dye and diazo images can show some fading or change in colour balance. Vesicular and thermally processed silver images are generally destroyed at this severe condition. In addition to image loss, photographic films may become severely distorted at high temperatures so that they can only be viewed, projected or printed with difficulty.

One danger to film, as a result of high temperature exposure, is that of sticking or blocking of adjacent sheets or laps, particularly with films having gelatin or special backings.

Steam generation and the resultant cooling effect is a design characteristic for the insulation of certain types of fire-resistant safes, insulated record containers and vault doors. Film should be protected against steam; otherwise, sticking, gelatin emulsion melting, and severe distortion will result. For this reason, insulated record containers (Class 150) designed to seal the contents against steam are recommended (see clause 8).

For very critical records and for greater protection, it is recommended that duplicate copies be stored in another location.

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