BS ISO 18911:2010

BSI Standards Publication

Imaging materials — Processed safety photographic films — Storage practices

National foreword

This British Standard is the UK implementation of ISO 18911:2010. It supersedes BS ISO 18911:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CPW/42, Photography.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 59918 7

ICS 37.040.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2010.

Amendments issued since publication

Date	Text affected

BS ISO 18911:2010

INTERNATIONAL STANDARD

ISO 18911

Second edition
2010-09-01

Imaging materials — Processed safety photographic films — Storage practices

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

Reference number
ISO 18911:2010(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword iv

Introduction v
0.1 General v
0.2 Nature of the photographic film v
0.3 Photographic processing of the film v
0.4 Storage conditions v

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Film enclosures 3
4.1 Requirements 3
4.2 Film in roll format 3
4.3 Film in sheet and slide format 4

5 Storage housings 5

6 Storage rooms 5
6.1 Medium-term storage rooms 5
6.2 Extended-term storage rooms 5

7 Environmental conditions 6
7.1 Temperature and humidity specifications for storage 6
7.2 Air-conditioning requirements 9
7.3 Air purity 10
7.4 Light 10

8 Fire-protective storage 10

9 Film identification, handling and inspection 11
9.1 Identification 11
9.2 Handling 11
9.3 Inspection 11

Annex A (informative) **Distinction between storage (record) copies and work (reference) copies** 12

Annex B (informative) **Advantages and disadvantages of protective (sealed) enclosures** 14

Annex C (informative) **Air-entrained and gaseous impurities** 15

Annex D (informative) **Humidity during storage** 16

Annex E (informative) **Temperature during storage** 17

Annex F (informative) **Temperature/relative humidity relationship** 18

Annex G (informative) **Microenvironments** 20

Annex H (informative) **Silver image degradation** 21

Annex I (informative) **Fire protection** 22

Bibliography 23

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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

This second edition cancels and replaces the first edition (ISO 18911:2000), which has been technically revised.

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 ISO 18900 to ISO 18999.

Introduction

0.1 General

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 References [1][2][3]). 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 can be divided into three general categories as described below.

0.2 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 (LE) 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, it is advisable that a high LE film be used and that it be stored under extended-term storage conditions. A film material suitable for preservation is silver-gelatine-type film on polyester base that meets the requirements of ISO 18901. However, this International Standard also applies to processed colour, diazo (see ISO 18905), vesicular (see ISO 18912) and thermally processed silver (see ISO 18919) films. Although these film types sometimes do not have as high an LE designation, excellent keeping properties have been obtained with many of them.

0.3 Photographic processing of the film

For black-and-white silver-gelatine-type film, ISO 18901 specifies a maximum residual thiosulfate level for different LE classifications and a residual silver compounds level.

For diazo film, ISO 18905 specifies a proper development test. ISO 18912, for vesicular film, includes both a proper development test and a residual diazonium salt test.

0.4 Storage conditions

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

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 References [5][6][7]). 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 often need to be considered when selecting storage conditions. It is recognized that many facilities will 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 consider filing enclosures. These are covered in ISO 18902 and ISO 18934.

INTERNATIONAL STANDARD ISO 18911:2010(E)

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 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.

This International Standard is applicable to photographic film records intended as storage copies, which are not in frequent use. It does not apply to “work” or “use” copies (see Annex A).

This International Standard, while intended for materials that are properly processed, is also of considerable value in prolonging the useful life of photographic film whose processing conditions are unknown, or which has been toned or retouched, or has 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 not covered by this International Standard.

NOTE Nitrate-base films are hazardous (see Reference [8]). They require special storage considerations (see Reference [4]), 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18902, *Imaging materials — Processed imaging materials — Albums, framing and storage materials*

ISO 18906, *Imaging materials — Photographic films — Specifications for safety film*

ISO 18916, *Imaging materials — Processed imaging materials — Photographic activity test for enclosure materials*

3 Terms and definitions

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

3.1
duplicate
reproduction of a master, retaining the same polarity and size

3.2
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

3.3
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

3.4
life expectancy
LE
length of time that information is predicted to be acceptable in a system at 21 °C and 50 % RH

NOTE In the past, the term “archival” was used to define material that could be expected to preserve images forever, so that such images could be retrieved without significant loss when properly stored. However, as no such material exists, this is now a deprecated term and is no longer used in International Standards for imaging materials or in systems specifications.

3.5
LE designation
rating for the **life expectancy** (3.4) of recording materials and associated retrieval systems

NOTE The number following the LE symbol is a prediction of the minimum life expectancy, in years, during 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.

3.6
macroenvironment
atmospheric conditions (temperature, relative humidity and pollutants) in a large area in which records are kept

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

3.8
microenvironment
atmospheric conditions (temperature, relative humidity and pollutants) inside a storage enclosure in which records are kept

3.9
open enclosure
enclosure that is intended for physical protection against mechanical damage, but is neither light-tight nor airtight

EXAMPLE Reels; cores; spools; cassettes; magazines; folders; envelopes; cartons; boxes; sleeves; transparency mounts; aperture cards.

3.10
protective enclosure
impermeable sealed container 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

EXAMPLE Taped cans; sealed envelopes.

NOTE Protective enclosures sometimes also need to be opaque.

3.11
safety photographic film
photographic film
safety film
film that meets the flammability specifications defined in ISO 18906

3.12
storage housing
physical structure supporting materials and their enclosures

NOTE Storage housing can 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. Safety photographic film shall comply with the flammability specifications defined in ISO 18906.

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 Reference [9]).

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 [1)] 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 18916. 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 18916. 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 18916. 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-gelatine), as well as with magnetic tapes and optical discs. 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 18916.

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 aluminium 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 18916. 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 shall be stored in plastic or acid-neutralizing envelopes.

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.

---

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

Photographic-quality gelatine, 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 18916.

Films may have possible interactions with other films that are of a different generic type (for example, diazo and silver-gelatine), as well as with magnetic tapes and optical discs. 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 aluminium 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 discs 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 D, E and F.

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-gelatine[d] (see ISO 18901)	Cellulose esters[e]	2 5 7	20-50 20-40 20-30
Black-and-white silver-gelatine[d] (see ISO 18901) Thermally or processed silver (see ISO 18919) Vesicular (see ISO 18912) Silver dye bleach	Polyester	21	20-50
Colour (chromogenic)	Cellulose esters[e]	−10 −3	20-50 20-40
Diazo (see ISO 18905)	Polyester	2	20-30

NOTE ISO 18934 covers the storage of multiple types of media in a mixed archive.

[a] See Annex F for storage of historic still photographic records.

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

[c] Cycling of relative humidity shall not be greater than ± 5 % RH (for example 30 % RH to 40 % RH) over any 24 h period, and shall not be less than the lower RH limit or greater than the upper RH limit specified in this table.

[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 than ± 10 % RH (e.g. 25 % RH to 45 % 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

7.1.3.1 General

When considering extended term storage the impact of low relative humidity conditions shall be taken into consideration. Low relative humidities can cause excessive contraction or brittleness, or both, in gelatine emulsions resulting in high curl and an associated risk of handling damage (cracking). Low relative humidities can cause serious problems with gelatine emulsion layers that have existing physical damage such as cracks or flaking emulsion layers. With such damaged emulsions, a low relative humidity condition can exacerbate lifting along cracks and existing areas of flaking and curl. In facilities where such films are stored, care should be exercised when choosing the relative humidity level so that items in poor condition (those that are curled or have cracking or delaminating emulsions) are not physically stressed by low relative humidities in the range of 20 % to 30 %. Cycling between low relative humidity areas and higher relative humidity areas can exacerbate existing problems. If films with the above condition problems are in the collection, the RH set point and RH cycling should be considered to avoid these low humidities. If this cannot be accomplished then microclimate storage housings or cabinetry shall be used to protect films from extremes in cycling or prolonged excursions below 30 %. In general, films stored tightly packed in boxes or albums, or sleeved in plastic, respond slowly to exterior short-term RH cycling. Loose or bare films, or those stored in partially filled permeable containers, may experience RH changes more quickly and respond accordingly by undergoing curl and by contraction or strain on the emulsion (especially along cracks or flaking areas). Storage at low temperature, or at low relative humidity, or at low temperature and low humidity, can embrittle emulsion or image layers, making them more susceptible to physical damage during handling. Flexing or rough handling may damage brittle emulsions, in addition to potentially exacerbating physical problems such as cracking image layers. Because of this, all such films, especially those in poor condition, should be handled carefully when in storage at low temperature, or at low relative humidity, or at low temperature and low humidity. In such cases, it is good practice to restore flexibility prior to use by reconditioning the films up to a relative humidity not exceeding 50 %. After use, reconditioning to the recommended humidity is required before returning the films to their storage environment. Copies should be made for items that require frequent or extended use. This is especially true since the benefits of increased chemical stability of photographic materials gained by storage at low temperature or low relative humidity are quickly mitigated by frequent cycling and prolonged removal to higher temperatures and humidities.

7.1.3.2 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. 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 Reference [10]). 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 G). 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 G).

Very low humidity conditions may produce brittleness or curl in films having a gelatine 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.

7.1.3.3 Recommended environment for colour films

The storage temperature for colour films shall be 2 °C or below for chromogenic materials (see References [11][12]) 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 7.1.3.2.

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.

7.1.3.4 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 or containers, or both;

— 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 Reference [13]).

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 References [12][13]). 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.

7.1.3.5 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 shall 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 day, 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 (e.g. see References [14][15]). They shall also conform to recommendations for fire-resistive file rooms contained in appropriate national standards and regulations (e.g. see References [16][17]). 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, which 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 C.

Solid particles, which 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 (e.g. see References [18][19]). Filters shall be of a non-combustible type, meeting the construction requirements of appropriate national standards and regulations (e.g. see References [19][20]).

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 H). They can be removed from the air by suitable washers or absorbers. 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 three-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 Reference [21]). 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.

8 Fire-protective storage

See Annex I.

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) (e.g. see References [22][23]). If fire-resistant vaults are used, they shall be constructed in accordance with recommendations contained in appropriate national standards and regulations (e.g. see References [16][17]), 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 (e.g. see References [22][23]). 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 A, G and H.

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 18916.

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 Gelatine 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 two-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 random-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 (e.g. see Reference [24]).

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 E).

Annex A
(informative)

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

The distinction between photographs that are used for purposes of research or display, or for the generation of additional copies, and those kept for long-term safekeeping by institutions and individuals, has not always been clear. Institutions such as archives, records centres, libraries and museums collect, preserve and make available images as part of their mission. Ideally, photographic prints, films and plates would always be kept in dark storage according to the appropriate International Standards. However, the value of these photographs lies in their being available for research and even display. Original photographs having permanent value will always need to be used for some purpose, otherwise the need for keeping these materials would be pointless.

As a result of use, photographs are subject to physical damage, such as tears, creases, breakage, abrasions, fingerprints, contamination with foreign materials, and exposure to excessive light, temperatures and relative humidity. During use, they may become conditioned to the different moisture levels from those found in storage areas that provide environmental conditions for long-term keeping. Physical distortions may result as the photographs are cycled between areas of differing environments. All of these factors directly impinge on long-term photographic preservation.

All photographic prints, films and plates that are frequently used for examination, research or display should have copies, duplicates, or digital scans made for that purpose so that those originals having permanent value can be kept in proper storage to maximize their life expectancy and minimize physical damage. Photographic prints that are used frequently to generate additional copies can suffer excessive and irreversible wear and tear. These items should have a master duplicate made that can be used to generate all future copies. This applies to original negatives, transparencies and prints, whether copies are made using traditional photographic printing methods or via digitization using scanners or digital cameras for image capture. Display can irreversibly harm some types of photographs, either through light exposure that alters the image or when the photograph has physical weakness or existing damage that could worsen. These items should have facsimiles made for display purposes. Photographs that require cold storage for long-term preservation should be removed from that environment as infrequently as possible because time out of storage will decrease their life expectancy.

In general, it is advisable to store duplicates, reference copies and facsimiles separately from originals having permanent value. Historically this serves several functions, including:

a) strategic dispersal of collections so that at least one version will survive in the event of a disaster;

b) storage cost efficiency so that proper environments and enclosures that may be limited due to expense can be reserved for valuable originals;

c) storage of duplicates and reference copies in proximity to the areas where they are used most frequently;

d) security from theft of originals by restricting access; and

e) to avoid confusing irreplaceable originals and duplicates.

Although not the subject of this International Standard, it is worth noting that digital image files require their own special type of preservation actions. These actions include updating the electronic file periodically as software is upgraded or is replaced entirely, and periodically checking the file to verify that it has not become corrupted or suffered loss of information. As with any electronic file, it is advisable to keep a back-up copy of the image file in order to reduce the risk that the file will be lost if the primary electronic copy is damaged or destroyed. This back-up copy can be maintained on a separate hard drive, copied to a CD with fade-resistant imaging dyes, or automatically copied onto back-up tapes commonly used by institutional information technology departments.

In addition to preserving the digital files, libraries, archives, museums and consumers should also preserve a hardcopy version in case the digital file is no longer accessible at some point in the future. It is highly advisable to print out the file onto the most stable imaging medium available and to store the photograph using materials that comply with the requirements listed in this International Standard.

Annex B
(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 18916.

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 H). This will depend upon the air change-over in the storage room, the proximity of other collections and the type of enclosures used.

Annex C
(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 References [25][26][27]) 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 Reference [28]). These methods require consistent control and, in the case of chemical scavengers, expert processing.

Annex D
(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 gelatine 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. Investigations (see References [7][29]) 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 gelatine 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 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 also 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 E
(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 gelatine 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 day, 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.

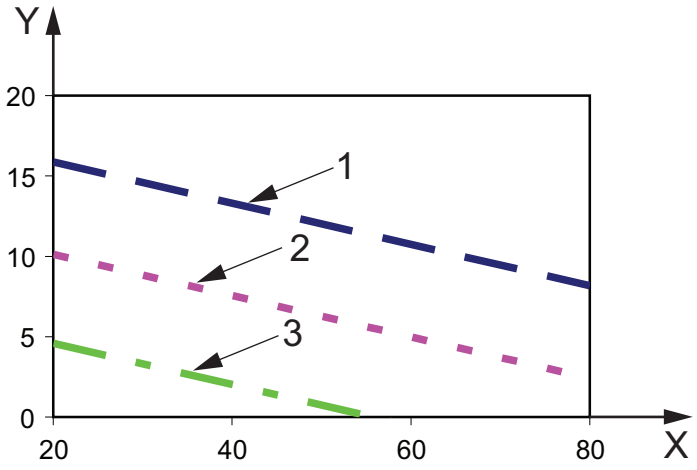
Annex F
(informative)

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 F.1 for the acidity increase caused by degradation of cellulose triacetate base (see Reference [29]).

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, or storage at lower relative humidities, or both, 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 modelled (see Reference [30]) using data from accelerated aging studies on the stability of colour dyes and photographic film bases. The illustrative chart in Table F.1 shows the effect of time out of storage.



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

Key

X relative humidity, %

Y temperature, °C

1 100 years

2 200 years

3 400 years

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

Table F.1 — Time out of storage relationship

Storage conditions		Days per year at room temperature [a]				
		0	**5**	**10**	**30**	**60**
Temperature °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 G
(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 favourable 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 Reference [31]). In 1981, the Swedish Film Institute introduced a film conditioning apparatus (known as FICA) to control the microenvironment of motion-picture films (see Reference [10]). 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 Reference [32]).

Recently, microenvironment control in sealed motion-picture containers was given renewed interest with the use of zeolites, commonly called molecular sieves (see Reference [33]). 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 Reference [34]), 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 H).

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 H
(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 References [25][27]).

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 References [17][35][36]).

Peroxides may be present in most woods and may also be formed as a result of the aging 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 References [25][37][38]). Chemical conversion of the silver image provides excellent resistance to oxidizing gases (see ISO 18915).

Annex I
(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-gelatine 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 gelatine 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, gelatine 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.

Bibliography

[1] BROWN, H.G. Problems of storing film for archival purposes. *British Kinematography*, vol. 20, May 1952, pp. 150-162.

[2] VIVIE, J. The French National Archives. *Journal of the Society of Motion Picture and Television Engineers*, vol. 79, Dec. 1970, pp. 1075-1077.

[3] WILHELM, H. and BROWER, C. (contributing author). *The permanence and care of color photographs: traditional and digital color prints, color negatives, slides, and motion pictures*. Preservation Publishing Company, Grinnell, Iowa, 1993, pp. 493-501.

[4] ANSI/NFPA 40-2006, *Storage and handling of cellulose nitrate film*. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

[5] ADELSTEIN, P.Z. and MCCREA, J.L. Permanence of processed Estar polyester base photographic films. *Photographic Science and Engineering,* vol. 9, 1965, pp. 305-313.

[6] ADELSTEIN, P.Z. and MCCREA, J.L. Stability of processed polyester base photographic films. *Journal of Applied Photographic Engineering*, vol. 7, 1981, pp. 160-167.

[7] RAM, A.T. and MCCREA, J.L. Stability of processed cellulose ester photographic films. *Journal of Society of Motion Picture and Television Engineers,* vol. 97, June 1988, pp. 474-483.

[8] CALHOUN, J.M. Storage of nitrate amateur still-camera film negatives. *Journal of the Biological Photographic Association,* vol. 21, No. 3, Aug. 1953, pp. 1-11.

[9] SMPTE RP39-1993, *Specifications for maintaining an emulsion-in orientation on theatrical release prints*. Society of Motion Picture and Television Engineers, 595 W. Hartsdale Ave., White Plains, NY 10607, USA.

[10] GOOES, R. and BLOMAN, H.E. An inexpensive method for preservation and long-term storage of color film. *Journal of the Society of Motion Picture and Television Engineers*, vol 92, Dec. 1983, pp. 1314-1316.

[11] LINDGREN, E.H. Preservation of cinematography film in the National Film Archive. *British Kinematography Sound and Television*, vol. 50, Oct. 1968, pp. 290-292.

[12] ADELSTEIN, P.Z., GRAHAM, C.L. and WEST, L.E. "Preservation of motion-picture color films having permanent value". *Journal of the Society of Motion Picture and Television Engineers,* vol. 79, Nov. 1970, pp. 1011-1018.

[13] ADELSTEIN, P.Z., BIGOURDAN, J.L. and REILLY, J.M. Moisture relationships of photographic film. *Journal of the American Institute for Conservation*, 1997.

[14] ANSI/NFPA 90A-2002, *Installation of air conditioning and ventilating systems.* National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

[15] JIS A 1304:1994, *Method of fire resistance test for structural parts of buildings*. Japanese International Standards Association, Minato-ku, Akasaka 4-1-24, Tokyo 107-8440, Japan.

[16] ANSI/NFPA 232-2007, *Protection of records.* National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

[17] Japanese Ordinance No. 306, *Regulation on fire-hazard materials under Fire Protection Law*. Center for Governmental Issues Services, Building No. 2 of Ohtemachi-Godo-Chosha Governmental Offices, Chiyoda-ku, Ohtemachi 1-3-2, Tokyo 100, Japan.

[18] ASHRAE Standard 52-76, *Method of testing air cleaning devices used in general ventilation for removing particulate matter.* American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329, USA.

[19] JIS B 9908:2001, *Test method of air filter units for ventilation and electric air cleaners for ventilation*. Japanese International Standards Association, Minato-ku, Akasaka 4-1-24, Tokyo 107-8440, Japan.

[20] ANSI/UL 900-1995, *Test performance of air filter units*. Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062, USA.

[21] CARROLL, J.F. and CALHOUN, J.M. Effect of nitrogen oxide gases on processed acetate film. *Journal of the Society of Motion Picture and Television Engineers*, vol. 64, Sept. 1955, pp. 501-507.

[22] ANSI/UL 72-1990, *Tests for fire resistance of record protection equipment.* Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062, USA.

[23] JIS S 1037:2006, *Fire resistive containers*. Japanese International Standards Association, Minato-ku, Akasaka 4-1-24, Tokyo 107-8440, Japan.

[24] ANSI/AIIM MS45-1990, *Recommended practice for inspection of stored silver-gelatin microforms for evidence of deterioration*. AIIM, 1100 Wayne Avenue, Suite 1100, Silver Spring, MD 20910, USA.

[25] HENN, R.W. and WEIST, D.G. Microscopic spots in processed microfilm, their nature and prevention. *Photographic Science and Engineering,* vol. 7, Sept.-Oct. 1963, pp. 253-261.

[26] POPE, C.I. Blemish formation in processed microfilm. *Journal of Research of the National Bureau of International Standards: A. Physics and Chemistry*, vol. 72A, No. 3, May-June 1968.

[27] AIIM Special Interest Publication 34. *Microspots and aging blemishes.* AIIM, 1100 Wayne Avenue, Suite 1100, Silver Spring, MD 20910, USA.

[28] KIMBERLY, A.E. and EMLEY, A.L. *A study of the removal of sulphur dioxide from the library air*. NBS Miscellaneous Publication No. 142, Washington, D.C., National Bureau of International Standards, Oct. 17, 1933.

[29] ADELSTEIN, P.Z., REILLY, J.M., NISHIMURA, D.W. and ERBLAND, C.J. Stability of cellulose ester base photographic film; I Laboratory testing procedures; II Practical storage considerations. *Journal of the Society of Motion Picture and Television Engineers*, vol. 101, No. 5, May 1992, pp. 336-353.

[30] MCCORMICK-GOODHART, M.H. and MACKLENBURG, M.F. *Cold storage environments for photographic materials*, IS&T Final Program and Advance Printing of Paper Summaries, IS&T's 46th Annual Conference, pp. 277-280, 1993. The Society for Imaging Science and Technology, Springfield, VA, USA.

[31] KUNZ, C.J. and IVES, C.E. The use of desiccants with undeveloped photographic film. *Journal of the Society of Motion Picture Engineers,* vol. 46, June 1946, pp. 475-510.

[32] PASSAGLIA, E. The characterization of microenvironments and the degradation of archival records: A research program, *National Bureau of International Standards Report* NBS 1R 87-3635, Oct. 1987. National Institute of International Standards Technology, Gaithersburg, MD 20899, USA.

[33] RAM, A.T., KOPPERL, D.F., SEHLIN, R.C., MASARYK-MORRIS, S., VINCENT, J.L. and MILLER, P. The effects and prevention of the vinegar syndrome, *Journal of Imaging Science and Technology,* vol. 38, May/June 1994, pp. 249-261.

[34] BIGOURDAN, J.L., ADELSTEIN, P.Z. and REILLY, J.M. Use of micro-environments for the preservation of cellulose triacetate photographic film, *Proceedings of the Society for Imaging Science and Technology*, May 1997, Boston, MA.

[35] WEYDE, E. A simple test to identify gases which destroy silver images. *Photographic Science and Engineering*, vol. 16, July-Aug. 1972, pp. 283-286.

[36] REILLY, J.M., NISHIMURA, D.W., CUPRIKS, K.M. and ADELSTEIN, P.Z. Stability of black-and-white photographic images, with special references to microfilm. *Proceedings of Conservation in Archives*. May 1988, pp 117-127.

[37] HENN, R.W., WEIST, D.G. and MACK, B.G. Microscopic spots in processed microfilm: The effect of iodides. *Photographic Science and Engineering*, vol. 9, 1965, pp. 167-173.

[38] MCCAMY, C.S. and POPE, C.I., Redox blemishes — Their cause and prevention. *Journal of Micrographics*, vol. 3, No. 4, June 1970, pp. 165-170.

[39] ISO 18901, *Imaging materials — Processed silver-gelatin-type black-and-white films — Specifications for stability*

[40] ISO 18905, *Imaging materials — Ammonia-processed diazo photographic film — Specifications for stability*

[41] ISO 18912, *Imaging materials — Processed vesicular photographic film — Specifications for stability*

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

[43] ISO 18918, *Imaging materials — Processed photographic plates — Storage practices*

[44] ISO 18919, *Imaging materials — Thermally processed silver microfilm — Specifications for stability*

[45] ISO 18920, *Imaging materials — Reflection prints — Storage practices*

[46] ISO 18934, *Imaging materials — Multiple media archives — Storage environment*

ICS 37.040.20

Price based on 25 pages

This page deliberately left blank

British Standards Institution (BSI)

BSI is the independent national body responsible for preparing British Standards and other standards-related publications, information and services.
It presents the UK view on standards in Europe and at the international level.

It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001

BSI offers Members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Tel: +44 (0)20 8996 7669 Fax: +44 (0)20 8996 7001
Email: plus@bsigroup.com

Buying standards

You may buy PDF and hard copy versions of standards directly using a credit card from the BSI Shop on the website **www.bsigroup.com/shop.** In addition all orders for BSI, international and foreign standards publications can be addressed to BSI Customer Services.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001
Email: orders@bsigroup.com

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Knowledge Centre.

Tel: +44 (0)20 8996 7004 Fax: +44 (0)20 8996 7005
Email: knowledgecentre@bsigroup.com

Various BSI electronic information services are also available which give details on all its products and services.

Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048
Email: info@bsigroup.com

BSI Subscribing Members are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration.

Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001
Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at **www.bsigroup.com/BSOL**

Further information about BSI is available on the BSI website at **www.bsigroup.com/standards**

Copyright

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards

raising standards worldwide™