BS ISO 18920:2011

BSI Standards Publication

Imaging materials — Reflection prints — Storage practices

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National foreword

This British Standard is the UK implementation of ISO 18920:2011. It supersedes BS ISO 18920:2000 which is withdrawn.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.

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Imaging materials — Reflection prints — Storage practices

Matériaux pour l'image — Tirages par réflexion — Directives pour l'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 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 18920 was prepared by Technical Committee ISO/TC 42, Photography.

This second edition cancels and replaces the first edition (ISO 18920:2000), which has been technically revised.

Introduction

This International Standard is one of a series of standards dealing with the physical properties and stability of imaging materials.

Photographic and other reflection prints, including hard-copy output from digital imaging systems, have become increasingly important as documentary and pictorial reference material and art for consumers, as well as in archives, libraries, government, commerce, museums and academia. This has focused attention on the importance of preserving such materials to ensure their longest possible life.

The stability and useful life of reflection prints (hereafter referred to as prints) depend on their physical and chemical properties, as well as on the conditions under which they are stored and used. This International Standard provides recommendations on proper storage conditions and practices.

The important elements affecting the useful life of prints during storage are as follows:

a) relative humidity and temperature of the storage environment;

b) hazards of fire, water and light exposure;

c) fungal growth and other micro-organisms;

d) contact with certain chemicals in solid, liquid or gaseous form;

e) physical damage;

f) proper processing;

g) enclosures and containers in contact with the print material.

The extent to which the relative humidity and temperature of the storage environment, or variations of both, can be permitted to reach beyond recommended limits without producing adverse effects will depend upon the duration of exposure, biological conditions conducive to fungal growth and the accessibility of the atmosphere to the print surfaces.

The term “archival” is no longer used to express longevity or stability in International Standards on imaging materials since it has been interpreted to have many meanings, ranging from preserving documents “forever”, which is unattainable, to temporary storage of actively used materials.

This International Standard defines two levels of recommended storage conditions: medium term and extended term. Medium-term storage conditions can be used to preserve information for a minimum of 10 years. Extended-term storage conditions can be used when it is desired to preserve information for as long as possible; these conditions will prolong the life of all prints, even those not optimized for permanence.

The space requirements and costs for establishing and operating the two levels of storage conditions (medium term and extended term) differ significantly. Furthermore, the ability to maintain specified limits of temperature and relative humidity for both sets of storage conditions can be limited due to budgetary constraints, energy considerations, climatic conditions, building construction, etc. However, any deviation from the specified conditions will reduce the effectiveness of the storage environment. If such deviation is unavoidable, it is advisable to select the lowest possible storage temperature that can be maintained. In any event, the best preservation of prints will be attained with extended-term storage conditions.

This International Standard does not address the various strategies to upgrade substandard environments. However, institutions with substandard environments and restricted budgets can plan for the improvement of these environments as resources allow by judicious use of air conditioning, dehumidifiers (or humidifiers), air circulation and filtration. Although practicalities might force compromises, any improvement in poor conditions will add to the longevity of materials, even if they do not attain the life expectancies possible with the environments recommended in this International Standard. The subject of basic air conditioning principles, the various options and associated costs are outside the scope of this International Standard. There are many references on this subject.

The storage of traditional paper collections is not within the scope of this International Standard. However, many archives containing mixed recording media also include such collections. Archivists are encouraged to review the appropriate standards for those materials specified in ISO 11799 and in the International Standards listed in Clause 2.

The recommendations of this International Standard for the storage of prints encompass the following:

— storage enclosures, housing and rooms;

— atmospheric and environmental conditions;

— fire protection;

— handling and inspection procedures.

With the exception of fire and associated hazards that are sufficiently common to warrant inclusion of protective measures, this International Standard does not pertain to means or methods for protecting photographic reflection prints against natural or man-made catastrophes.

It is understood that the archivist of a multiple media collection might be forced to limit the number of storage environments that can be provided. This compromise might be based on the value, physical size, quantity or legal requirements to maximize life expectancy of some collections relative to others. The issues of mixed media archives and recommendations for their storage are addressed in ISO 18934.

Imaging materials — Reflection prints — Storage practices

1 Scope

This International Standard specifies dark storage conditions, storage facilities and procedures for the handling and inspection of reflection prints of all types and sizes.

This International Standard is applicable to prints on the following opaque supports:

a) fibre-base paper;

b) RC (resin coated) paper;

c) pigmented and other types of plastic supports, e.g. polyester, cellulose acetate;

d) fabric, e.g. canvas, linen.

This International Standard is applicable to the following processed black-and-white silver gelatine prints:

1) wet-processed, including those that have been chemically treated to improve the permanence of the silver image and/or to modify its colour, e.g. with gold, selenium or sulphur formulations;

2) diffusion transfer, e.g. Polaroid and Fuji Photo Film instant prints[1];

3) stabilization-processed (which contain the silver image as well as invisible, chemically stabilized silver halides).

This International Standard is applicable to the following processed multicolour and monochrome colour photographic prints:

i) chromogenic, washed and stabilized;

ii) silver dye bleach;

iii) dye transfer;

iv) diffusion transfer, e.g. Polaroid and Fuji Photo Film instant prints[1], peel-apart or integral;

v) pigmented gelatine, e.g. carbon, carbro.

This International Standard is applicable to black-and-white and colour prints made with the following systems:

— thermal dye transfer (commonly referred to as dye sublimation);

— thermal wax transfer;

— electro-photographic;

— dye and pigmented ink jet;

— swellable and porous-coated media supports;

— diazo.

1) Polaroid and Fuji Photo Film instant prints are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

Recommendations for storage of photographic films and storage of processed photographic plates are given in ISO 18911 and ISO 18918 respectively.

This International Standard is applicable to medium-term and extended-term storage conditions, as defined in Clause 3.

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 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
extended-term storage conditions
storage conditions suitable for the preservation of recorded information which has permanent value

3.2
fire-protective storage
facility designed to protect records against excessive temperatures, water and other fire-fighting agents, and against steam developed by insulation of safes or caused by the extinguishing of fires and collapsing structures

3.3
fire-resistant vaults
fire-resistant vaults as defined in appropriate national standards and regulations

NOTE See References [9] and [17].

3.4
insulated record containers (Class 150)
insulated record containers (Class 150) as defined in appropriate national standards and regulations

NOTE See References [7] and [12].

3.5
life expectancy
LE
length of time that information is predicted to remain in an acceptable state when placed 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.

3.6
medium-term storage conditions
storage conditions suitable for the preservation of recorded information for a minimum of 10 years

3.7
storage container
box or can be used to store prints

3.8
storage enclosure
any item in close or direct contact with recording material, such as folders, envelopes, sleeves, albums and mats

3.9
storage housing
physical structure supporting materials and their enclosures

NOTE This can consist of drawers, racks, shelves or cabinets.

4 Enclosures and containers

All enclosures and containers used for medium-term and extended-term storage shall meet the requirements of ISO 18902 and ISO 18916. This includes enclosures and containers that are in either direct or indirect contact with the prints. Prints may be stored in envelopes or sleeves of paper or plastic, file folders, folding cartons, boxes and albums, or may be matted. Prints shall be protected from unnecessary use and light exposure. Prints that are prone to light-induced fading, especially diazo and some colour processes, shall not be exposed at all.

Generally, prints smaller than 28 cm × 36 cm in size may be stored vertically, but shall be placed between rigid supports to minimize slumping and curling. Prints 28 cm × 36 cm or larger should be stored horizontally, unless mounted on rigid supports. Stacks of horizontal prints should be less than 5 cm high to prevent excessive pressure on prints at the bottom.

Multiple prints, stored within an enclosure or container, shall be oriented with the emulsion sides against back sides, never emulsion against emulsion.

Suitable plastic enclosure materials are uncoated polyester (polyethylene terephthalate), polystyrene, high-density polyethylene and polypropylene. Other plastics may be satisfactory, but there has been no extended experience with such materials. Glassine envelopes and chlorinated, nitrated, or highly plasticized sheeting shall be avoided. Specifically, cellulose nitrate and polyvinyl chloride are not acceptable. Glassine is not dimensionally stable when exposed to high relative humidity, although it may meet the other requirements specified in ISO 18902 and pass the photographic activity test.

Microclimates (sealed enclosures or cabinetry) shall be used where needed in order to maintain the desired moisture content of the prints where humidity control is inadequate in storage rooms or where cold storage vaults and units do not have humidity control, and to protect against gaseous and solid atmospheric contaminants. A variety of sealed vapour-proof housings, containers and cabinetry can provide this protection (as discussed in Table 1, 7.1.3.2 and Annex H).

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 the seam or joint will be at the edge of the enclosure and not in contact with the image layer. Photographic-quality gelatine, modified and photographically inert starch, some acrylic and polyvinyl acetate adhesives and methyl cellulose are suitable adhesives for use with paper.

For maximum life, prints shall be in a clean condition before being placed in storage and shall be inspected periodically thereafter, as outlined in 9.3.

5 Storage housings

Prints shall be stored in closable storage housings such as drawers or cabinets, in storage cabinets with tightly fitting doors, or on open shelves when enclosed inside containers. The storage-housing materials shall be non-combustible, non-corrosive, and chemically inert, e.g. anodized aluminium, stainless steel or steel with a non-plasticized synthetic resin-powder coating. Wood, pressboard, particle-board, plywood and other such materials shall be avoided because of their combustible nature and the possibility of their producing active deteriorating agents as they age.

The finish on the storage housing materials shall be durable and shall not contain substances that can have a deleterious effect on the stored prints. Finishes containing chlorinated or highly plasticized resins, or solvents giving off gas from freshly applied finishes can adversely affect the image and base layers on prints. Paints used on cabinets may give off peroxides, solvents and other contaminants for up to three months after application. Cabinets made of stainless steel or anodized aluminium are recommended. Metal housing materials that have been powder-coated (a layer of resin particles that are applied electro-statically to the surface of the metal and then fused to the surface using heat without the use of chemical solvents) are also recommended.

When air-conditioned individually, storage housings shall be arranged to permit interior circulation of air to all shelves and drawers holding print containers, so as to provide uniform humidity conditions. Storage housing 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.

Different types of prints, films and other media may be stored in the same storage room separately from each other. However, different types of material shall not be stored (interfiled) within the same enclosure or storage container.

6 Storage rooms

6.1 Medium-term storage rooms

Rooms and areas used for print storage should be located in the same area as rooms containing provisions for inspection and viewing of prints. 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 may be cooled below the dew point of the air.

Provisions shall be made against damage of prints by fire and by water from floods, leaks and sprinklers, and from the steam released from masonry walls during a fire[7][9][12][17]. Storage rooms or vaults should be located above basement levels where possible. A special storage room separated from the work areas for prints of medium-term interest generally will not be required, provided the conditions recommended in 7.1.2 are maintained.

6.2 Extended-term storage rooms

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

In addition, the value of photographic prints 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.

7 Environmental conditions

7.1 Temperature and humidity specifications for storage

7.1.1 General

See Annexes A, B, C, H and I.

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

Table 1 — Maximum temperature and average relative humidity ranges for storage

Print process[a,g]	Medium term storage		Extended term storage[a]	
	Maximum temperature	Relative humidity range	Maximum temperature[c]	Relative humidity range[b,d]
	°C	% RH	°C	% RH
Black-and-white silver[e] Pigment (carbon, carbro) Dye imbibition (dye transfer) Silver dye bleach Dye/silver diffusion transfer (instant) Diazo Electro-photographic[f]	25	20 to 50	16	30 to 50
Thermal dye transfer (dye sublimation)[f] Chromogenic dye Ink jet (dye or pigment)[f,h]	25	20 to 50	2 5	30 to 50 30 to 40

a The values of Table 1 are the required conditions experienced by the photographic material. When micro-climates (housings or storage containers) are used that establish internal climate conditions, the environment of the exterior room need not necessarily meet the Table 1 conditions. See Annex H.

b As discussed in 7.1.3.3, certain gelatine emulsion photographs can be sensitive to RH levels of less than 30 % and can experience physical changes that can exacerbate existing deterioration such as flaking, cracking and curl. If these materials are present and RH above 30 % cannot be maintained, then microclimate storage housings or cabinetry shall be used to protect photographs from extremes in cycling or prolonged excursions below 30 %. Alternatively, a higher RH set point can be selected, e.g. 35 %, when a 5 % RH fluctuation within any 24-hour period does not exceed the lower RH limit of 30 %.

c Cycling of temperature shall not be greater than ± 2 °C over any 24-hour period. Some prints can become brittle at low temperatures and require careful handling when cold to avoid flexing that could cause cracks and image delamination (refer to 7.1.3.3).

d Cycling of relative humidity shall not be greater than ±5 % RH over any 24-hour period. However, the relative humidity shall not exceed 50 % RH. If RH cycling in the room cannot be controlled to this level, then microclimate storage housings or cabinetry shall be used to protect photographs from extremes in cycling or prolonged excursions to either high or low RH.

e If there is concern about the possibility of silver image deterioration due to atmospheric pollutants, 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).

f The rates of degradation and the potential for physical problems with extremely low temperature and/or low relative humidity storage is not well known for rapidly changing technologies such as thermal dye transfer (dye sublimation), thermal wax transfer, electro-photographic, and the many different ink jet image media (dye, pigment, wax) and base media (porous, swellable, plain paper). Factors such as chemical sensitivity, humidity fastness, and the stability of base materials may have a greater impact on longevity than thermal stability and light-fastness.

g Print life expectancy ratings by process type are not provided in this International Standard. For information on print stability, see Annex I.

h Some current ink jet prints, especially those utilizing inks made from stable pigment or optimized dyes printed onto stable supports as recommended by the manufacturer, may have very good image stability at temperatures warmer (up to 16 °C) than the recommended cold storage temperatures listed for extended-term storage. Where the identification of the type of ink and base cannot be determined, or where stable ink jet prints may have been interfiled with less stable materials, the colder temperatures listed shall be used unless prints can be separated by type for storage at different temperatures. The use of non-permanent paper supports or papers that are not optimized for the particular ink set can also adversely affect the overall stability of the print, requiring storage at cold temperatures.

7.1.2 Medium-term storage environment

The maximum temperature for medium-term storage shall be 25 °C. Cycling of temperature shall not be greater than ±5 °C over any 24-hour period, and the peak temperature shall not exceed 30 °C. Some temperature fluctuation is permitted as long as the relative humidity stays within the specified limits.

The relative humidity of a medium-term storage environment shall be between 20 % and 50 %. Cycling of relative humidity shall not be greater than ±10 % over any 24-hour period within the specified range (relative humidity shall not exceed 50 %). The moisture content in prints shall not be greater than the moisture in equilibrium with these relative humidities. Storing prints at the lower limit of the specified relative humidity range may cause curling of the prints or physical damage during handling (see 7.1.3.3); prints may need to be equilibrated to a higher relative humidity prior to use.

7.1.3 Extended-term storage environment

7.1.3.1 Recommended environments for specific print media

A maximum storage temperature of 16 °C with a set point RH within the given range listed in Table 1 shall be used for black-and-white silver gelatine, silver dye bleach, dye/silver diffusion transfer (instant), dye imbibition (transfer), pigment (carbon, carbro) and diazo.

Cool storage between 2 °C and 5 °C with a set point RH within the range listed in Table 1 shall be used for monochrome and multi-colour chromogenic, thermal dye transfer (dye sublimation) and ink jet (see Annex H for cold storage practices). Excellent keeping behaviour has been obtained by storing colour prints at such low temperatures.

7.1.3.2 Impact of environment on media longevity

See Annexes C and H.

The rate of most chemical reactions, such as the degradation of bases and discolouration or fading of image layers, is lowered with decreasing temperature and decreasing relative humidity. Consequently, life expectancy is increased as either storage temperature or storage humidity is lowered. Added protection may be obtained for all print types by storage at temperatures lower than the maximum listed in Table 1. Moreover, a lower storage temperature can compensate for a higher humidity to provide the same life expectancy (see Annex C). 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 levels 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-hour period. Cycling of temperature shall not exceed ±2C over a 24-hour period.

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 prints, the past storage history, the length of time the prints are to be kept, the size of the storage or cold vaults, the cost of various options and the climate conditions where the facility is located. The cost/protection ratio is determined by the individual facility. Another very important factor to consider is the exact mix of photographic materials in the collection, i.e. whether photographic prints, plates or films are included and whether the materials are new or old. ISO 18934 addresses these issues in more detail and recommends storage environments for multiple media archives.

The benefit of low-temperature storage is reduced dramatically when prints are taken out frequently and/or for extended periods of time into higher temperature environments (see Annex C). Prints stored at temperatures significantly below room temperature will require some warm-up time before they can be used, in order to prevent the absorption or condensation of moisture on cold surfaces. This warm-up procedure requires that a vapour barrier be wrapped around the print or its housing prior to removal from the cold temperature area (see Annex H). Adequate time shall be provided to allow the total volume of prints to approach room temperature prior to removal of the vapour barrier and use of the prints. The required warm-up time may vary between 1 hour and 1 day, depending on package size (mass of the contents), degree of package insulation and temperature differential. The materials shall be allowed to slowly warm above the dew point prior to opening the vapour barrier. Insulated containers are useful for slowing the warm-up period when there is a large temperature difference between the cold storage and use conditions, such as with temperatures below 0 °C.

The recommended temperature and relative humidity conditions shall be maintained either within individual storage housings or within storage rooms containing such housings (see Annex H for cold storage practices and micro-environment storage). When the control of relative humidity in the macro-environment is not possible, the micro-environment shall be controlled using an airtight, moisture-proof housing from which as much free air as possible has been excluded. Prints which might have been exposed to relative humidities above 50 % for prolonged periods should be conditioned to a lower relative humidity in order to lower their moisture content prior to being placed in a sealed micro-environment package.

If the relative humidity of the use environment is similar to that of the storage environment, moisture-conditioning procedures can be reduced or eliminated. In addition, a close match between the two environments reduces physical stress caused by cycling between storage and use. The time needed to reach moisture equilibration with a given atmosphere depends on the following factors:

— the hygroscopic nature of the print type (plastic and resin coated paper versus fibre paper);

— the packaging density and volume of material;

— the moisture permeability of enclosure materials and containers;

— the differential between the initial and final moisture content;

— the temperature at which the moisture conditioning occurs.

Free access of air at room temperature will shorten the conditioning time, as will permeable enclosures.

7.1.3.3 Impact of low relative humidity on gelatine emulsion photographs

See Annexes C and D.

Low relative humidities can cause excessive contraction and/or brittleness in gelatine emulsions resulting in high curl and associated risk of handling damage (cracking). Low relative humidities can cause serious problems with gelatine emulsion photographs 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 prints 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 prints with the above condition problems are in the collection, the RH set point and RH cycling should be controlled so that excursions below 30 % are avoided. If this cannot be accomplished using HVAC controls, then microclimate storage housings or cabinetry shall be used to protect photographs from extremes in cycling or prolonged excursions below 30 %. In general, prints stored tightly packed in boxes or albums, or sleeved in plastic, respond slowly to exterior short term RH cycling. Loose prints, bare prints 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 and/or low relative humidity can embrittle emulsion or image layers, making them more susceptible to physical damage during handling. Flexing or rough handling may damage brittle prints, in addition to potentially exacerbating physical problems such as cracking image layers. Because of this, all such prints, especially those in poor condition, should be handled carefully when in storage at low temperature and/or low relative humidity. In such cases, it is good practice to restore flexibility prior to use by reconditioning the prints up to a relative humidity not exceeding 50 %. After use, reconditioning to the recommended humidity is required before returning the prints to their storage environment. Copies should be made for items that require frequent or extended use (Annex D). 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 (Annex C).

7.2 Environmental conditioning requirements

Properly controlled air-conditioning may be necessary for maintaining humidity and temperature within the specified limits, particularly for extended-term storage where the requirements are more stringent than those for medium-term storage. Slightly positive air pressure should be maintained within the storage room or vault. Air-conditioning installations and automatic fire-control dampers in ducts carrying air to or from storage vaults shall be constructed and maintained on the basis of recommendations contained in appropriate national standards and regulations[8][13]. They shall also follow recommendations for fire-resistant file rooms contained in appropriate national standards and regulations[1][9][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 else sealed containers shall be used.

Automatic control systems are recommended. They shall be checked frequently with a reliable hygrometer that has been properly calibrated in order 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 and controlled with a humidistat set at the desired humidity level. Desiccants, such as chemically pure silica gel, may be used provided they are enclosed within units equipped with filters (see 7.3) capable of removing dust particles 0,3 µm in size and larger, and are controlled to maintain the relative humidity specified in 7.1. Dehumidification may be required in storage areas such as basements and caves. Because of their location, these areas 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 prints suffer physical damage, such as curling or delamination of the image layer from the support, due to increased brittleness or dryness at lower relative humidities. If humidification is required, a controlled humidifier should 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 Annexes E and G.

Solid particles can abrade prints or react with the image. They shall be removed by mechanical filters from air supplied to housings or rooms used for extended-term storage. These mechanical filters should preferably be of the dry media type, having an arrestance rating of not less than 85 %, as determined by tests contained in appropriate national standards and regulations[10][14][16]. Filters shall be of a non-combustible type, meeting the construction requirements of appropriate national standards and regulations[10][14].

Gaseous impurities such as sulphur dioxide, hydrogen sulphide, peroxides, ozone, ammonia, acidic fumes, solvent vapours and nitrogen oxides cause deterioration of the print support or degradation of the image in some prints, especially dye-based ink jet printed on porous coated supports. Suitable washers or absorbers can remove them from the air. Because ozone is especially harmful to ink jet images, exposure to it shall be minimized through the use of air filtration and/or layers of enclosures and containers. Where practical, storage of prints in sealed enclosures, containers and storage housings in accordance with Clauses 4 and 5 will afford adequate protection.

Since paint fumes can be a source of oxidizing contaminants, prints should be removed from either an extended-term or medium-term storage area for a 3-month period when the area is freshly painted. The use of zero VOC (Volatile Organic Compound) paints can reduce the wait period to the time needed for the paint to fully dry.

7.4 Light, use, and display

See Annexes D and I.

Normally, extended-term keeping conditions for prints which have enduring and permanent value specify infrequent use and storage under dark conditions. This is recommended practice as light can be detrimental to some images and handling can inflict physical damage.

However, it is realistic to assume that prints will be viewed or displayed at some point in their lifetime, otherwise keeping these materials would be pointless[11][15]. The lifetime of prints on display is beyond the scope of this International Standard due to the many types of historic and modern print technologies, rapidly changing product developments, and the many variables that affect print display life (see Annex I). Long-term display is not recommended for prints since the image material can fade, darken or shift colour balance as a result of exposure to light and air-borne contaminants or due to environmental conditions that do not match those specified in this International Standard. The base material can also undergo degradation in display conditions. Many institutions have developed strict exhibition policies that specify light levels, cumulative light exposure limits and environmental conditions. Institutions also employ micro-environmental display packages to reduce exposure to atmospheric contaminants, relative humidity extremes, and/or cycling humidity. Institutions may also monitor their displayed prints using colorimetry or densitometry in order to intervene before severe image degradation has occurred.

The quality of frame and framing materials can greatly impact the stability of prints. Requirements for these materials are specified in ISO 18902. Annex D discusses in detail the issue of frequent use and display of prints which have permanent value, and recommends the creation of copies or facsimiles for frequently used or displayed prints which have enduring or permanent value so that the original can be maintained in ideal environments appropriate for their long-term preservation.

8 Fire-protective storage

See Annex F.

Enclosure materials for fire-resistant storage shall be sufficiently fire-resistant so that they will not ignite or develop reactive fumes after heating for 4 hours at 150 °C in the package that is to be stored. Many enclosure materials will melt or become badly distorted at this temperature. Do not use enclosures that deform or melt to the extent that the print cannot be removed from the enclosure or is permanently damaged by the enclosure.

For protection against fire and associated hazards, prints shall be placed in closed containers in either fire-resistant vaults or insulated record containers (Class 150)[7][12]. If fire-resistant vaults are used, they shall be constructed in accordance with recommendations contained in appropriate national standards and regulations[9][17], with particular care taken for protection from steam. When the quantity of prints is not too great, insulated record containers (Class 150) conforming to appropriate national standards and regulations may be used. An interior temperature of 66 °C and an interior relative humidity of 85 % shall not be exceeded when carrying out a fire-exposure test lasting from 1 hour to 4 hours, 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 the print records should be placed in another storage area.

9 Print identification, handling and inspection

9.1 Identification

Prints are frequently inscribed with identification marks using non-photographic means such as ink, felt marking pens, or pressure-sensitive labels. Such identification materials shall pass the photographic activity test as described in ISO 18916 and meet the requirements of ISO 18902.

9.2 Handling

See Annex D.

Proper handling of prints is important. If prints are used frequently, this generates damage and necessitates the imposition of critical handling and filing requirements. Many prints frequently have suffered deterioration such as brittleness or disrepair that can result in cracking, breaking or emulsion flaking during handling or by cycling of relative humidity between storage and use areas (see 7.1.3.3). Prints shall be handled by their edges and shall be properly supported during use to prevent flexing, creasing, or sagging. Handlers shall wear thin, clean, cotton or plastic gloves. As discussed in Annex D, copies should be made for frequently used items in order to reduce handling damage of originals that have permanent value. Good housekeeping and cleanliness are essential.

9.3 Inspection

An adequate number of properly selected lot samples of prints should be inspected at intervals of two to three years. If deviations from recommended temperature and relative humidity ranges have occurred, inspection should be made at more frequent intervals. A random sampling plan established in advance of inspection shall be used.

If signs of deterioration of either prints or enclosure materials are noted, corrective action shall be taken, such as improving humidity and temperature controls or replacing poor quality storage enclosures and containers. If these actions are insufficient, high quality duplicates should be made on known stable material. A record of the inspection results should be maintained to monitor changes in the appearance of prints. Periodic inspections shall be performed to ensure that corrective actions are effective.

Care shall be taken during the inspection to prevent abrasion, since prints can be physically scratched. Changes to note during the inspection include:

— physical changes in the print (warping and other planar distortions, emulsion cracking and adhesion failure);

— visual changes (fading, micro-blemishes, colour change);

— changes in the emulsion materials (brittleness, discolouration).

If possible, the cause of the problem should be determined and eliminated.

Annex A
(informative)

Humidity during storage

Relative humidity significantly beyond the limits specified in this International Standard can have a very deleterious effect on prints. The extremes of both low and high humidity should be avoided.

Prolonged exposure to conditions above 60 % RH will tend to damage or destroy the gelatine emulsion layers due to the growth of fungus, and will eventually cause the gelatine emulsion or other image layers to stick to other surfaces such as storage enclosures. Exposure to high humidity will also accelerate any effects of excess residual silver halide and processing chemicals (e.g. thiosulphate) on the stability of silver images, increase yellowing and staining in many print processes, impair the stability of dye images and cause ink jet dyes to migrate. This can alter the appearance of colours, colour balance and image sharpness. High humidities can accelerate degradation of many print bases.

Storage at low humidity not only inhibits fungal growth, but also reduces the rate of chemical degradation. Recent investigations have shown markedly improved stability of film and paper bases and image layers when the storage humidity is reduced below 50 % relative humidity. However, low relative humidity exposure can result in high print curl, which may produce permanent print deformation. Also, low relative humidities can cause brittleness of gelatine emulsions, which makes prints more susceptible to physical damage such as cracking and creasing during handling and can exacerbate existing physical problems such as cracking or delamination. Some ink jet prints made on microporous paper supports may experience increased yellowing at low relative humidity, especially in the 20 % to 30 % range[18].

Annex B
(informative)

Temperature during storage

Continuous storage temperatures above approximately 40 °C can permanently cause brittleness and deteriorate emulsion layers of processed photographic prints, reduce the pliability of some print bases, accelerate the fading of dye images and cause ink migration and blocking in some electro-photographic, ink jet and other pigmented processes. Consistent exposure to dry heat promotes contraction or distortion of the gelatine emulsion and some image layers and reduces the pliability of many base materials.

Although gelatine emulsions, many types of image layers and some base materials (plastic, resin coated) become more brittle at low temperatures (below 0 °C), flexibility is restored upon return to room temperature. Brittle prints are susceptible to physical damage, such as cracking, delamination and creasing during handling; therefore, all print types should be handled carefully at lower temperatures and flexing of the prints should be avoided.

Storage temperatures which are below the dew point of the air in the area for use can cause moisture condensation upon print surfaces, unless the container and contents are brought above the dew point temperature before removal of the prints. The required warm-up time might amount to several hours, depending on the size of the packaged prints and the temperature differential.

An important aspect of temperature is its effect on relative humidity. Low-storage temperatures can raise the relative humidity if the storage area is not humidity controlled. This can cause conditions beyond the range of recommended relative humidities for proper storage. In such a case, sealed containers shall be used.

Annex C
(informative)

Temperature/relative humidity relationship

Degradation of prints is caused by many chemical reactions whose rates are lowered with decreasing temperature and humidity. Consequently, either lowering the storage temperature or storage humidity can increase the useful life of prints. Moreover, a lower storage temperature can compensate for a higher humidity to obtain the same life expectancy. This relationship permits 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 prints from the storage vault. The effect of the time out of storage has been mathematically modelled[19] using data from accelerated ageing studies on the stability of colour dyes and photographic film bases. The illustrative chart in Table C.1 shows the effect of time out of storage.

Table C.1 — Time out of storage relationship

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

a This chart is for illustration purposes only; the actual fading rates or life expectancy for a specific print 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.

Annex D
(informative)

Distinction between originals and copies made for active use

This annex uses the term "photographs" to encompass all types of pictorial materials generated using both silver halide technology and hard copy output from a digital imaging system.

The distinction between photographic documents and artworks that are used for purposes of research, 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 photographs as part of their mission. Many of these photographs have enduring, permanent value. Ideally these photographs always would be kept in dark storage, in accordance with the appropriate ISO standards. However, the value of these photographic documents and artworks lies in their being available for research and even display. Original photographs which have permanent value will always need to be used for some purpose, otherwise there would be no need to keep these materials.

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

All photographs that are frequently used for examination, research or display should have copies or duplicates made for that purpose so that those originals having permanent value can be kept in proper storage in order to maximize their life expectancy and minimize physical damage. Photographs that are used frequently to generate additional copies can suffer excessive and irreversible wear and tear. These items should have a master duplicate made, either a traditional photographic master or digital image file, that can be used to generate all future copies. Display can irreversibly harm some types of photographs, either through light exposure to environmental conditions and contaminants that alters the image, or by exacerbation of an existing physical weakness or damage in the image and/or base layers. 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 (see Annex C). Photographs expected to be used 10 times or more should have copies made for use.

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

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 might 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;

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 to guarantee future availability in case the original file is lost during a computer failure. This back-up copy can be maintained on a separate hard drive, copied to a CD with fade resistant recording dyes (in accordance with ISO 18927), or automatically copied onto back-up tapes (commonly used by institutional IT departments). In addition to preserving the digital files, libraries, archives, museums and consumers should also preserve a print 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 print according to the requirements given in this International Standard.

Annex E
(informative)

Air-entrained and gaseous impurities

When dust and other air-entrained solid particles are deposited on prints, 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 sulphur compounds, ozone, peroxides, ammonia, paint fumes, solvent vapours and other active compounds can cause deterioration of the base and a chemical degradation of the image.

The most frequently encountered impurities, especially in urban and industrial atmospheres, are car exhaust fumes, nitrogen oxides, sulphur dioxide and ozone; small concentrations of these pollutants are likely to produce detrimental effects on print materials. Hydrogen sulphide is a compound that is very reactive with photographic silver images, 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 prints, which causes the formation of minute deposits of coloured colloidal silver and contributes to silver mirroring. Oxidizing gases such as peroxides, ozone and nitrogen oxides can attack colour images such as chromogenic and ink jet prints.

Suitable means for the removal of gaseous impurities are available, such as air washers operating with treated water for the elimination of sulphur dioxide and chemical scavengers for the absorption of sulphur dioxide and hydrogen sulphide. These methods require consistent control and, in the case of chemical scavengers, expert processing.

Annex F
(informative)

Fire protection

Damage to prints by high temperatures can occur even if the prints are not destroyed by fire. Silver-gelatine images can withstand temperatures as high as 150 °C for several hours without significant loss in image quality. However, dye-based images (chromogenic and ink jet), electro-photographic, pigmented and diazo images might show some fading or change in colour balance. In addition to image loss, prints can become so distorted at high temperatures that they can be viewed only with difficulty. Another danger to prints, as a result of exposure to high temperatures, is that of sticking or blocking to adjacent prints.

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. Prints should be protected against steam, as this causes sticking, melting of gelatine-emulsion and other image layers, and severe distortion. 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 fire protection, it is recommended that duplicate copies be stored in another location.

Annex G
(informative)

Silver and colour image degradation

To varying degrees, all images are prone to chemically induced changes when stored under adverse storage conditions or exposed to atmospheric pollutants and chemicals that may release gas from unsuitable enclosures[21]. For example, processed black-and-white silver images are susceptible to discolouration (micro-spots, mirroring or yellowing). The deterioration is caused by local oxidation of the image silver, resulting in ionic silver that is mobile. This mobile silver can migrate from its original site and subsequently be reduced to metallic silver and re-deposited in a new location. When the silver is re-deposited 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 micro-blemishes. Yellowing can be an overall or localized discolouration. Sulphur based compounds such as sulphur dioxide and hydrogen sulphide in particular attack image silver. Colour images also can be susceptible to atmospheric pollutants, especially oxidizing agents.

Possible oxidizing agents that cause image degradation are aerial oxygen, whose action is accelerated by moisture, and atmospheric contaminants such as peroxides, ozone, nitrogen oxides, sulphur dioxide and hydrogen sulphide. Many of these contaminants are common in the modern environment and in institutions and households. Peroxides also are present in most woods and can also be formed as a result of the ageing of paper inserts and cardboard containers commonly used in storing prints in closed containers. Processing of black-and-white silver images plays an important role in the development of discolouration or blemishes. Chemical conversion of the silver image provides excellent resistance to oxidizing gases[3]. 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 silver blemishes and image discolouration, and the colour fading or shifting in colour image materials, especially ink jet.

Various methods may be used to remove atmospheric pollutants using materials such as molecular sieves, chemical scavengers and suitable corrosion inhibitors. Suitable means for the removal of gaseous impurities are addressed in Annex E and 7.3.

Annex H
(informative)

Cold storage practices

Either of the following two methods for cold storage can be used in order to prolong the useful life of prints[20] [21]. All cold storage methods entail the risk of moisture condensation on print surfaces when they are brought into warmer areas where a dew point is crossed. This can be avoided by placing prints in sealed moisture-proof containers or in heavy-gauge self-sealing plastic bags prior to removal from cold storage and allowing them to slowly warm above the dew point prior to opening the vapour barrier. Insulated containers are useful for slowing the warm-up period when there is a large temperature difference between the cold storage and use conditions, such as with temperatures below 0 °C. Photographs that are already housed in moisture-proof enclosures for cold storage [see b)] do not require additional moisture protection when brought out to warmer conditions.

a) The first method is to use a storage room controlled at the desired temperature and maintained within the recommended relative humidity range. Humidity control requires expensive equipment and facilities to maintain the environmental conditions. This method alleviates the need for sealed storage containers, allowing the safe and comfortable review of individual prints kept in humidity controlled cool storage rooms (2 °C to 16 °C). However, many materials become less flexible and more brittle as the storage temperature decreases, increasing the risk of damage during handling, especially below 0 °C. Also, prints removed to warmer conditions where a dew point is crossed still require protection from condensation, as described above.

b) The second method uses a storage room or free-standing freezer or refrigerator that does not provide humidity control and requires the use of microclimate storage to maintain the proper relative humidity[20]. Microclimates employ the use of sealed cabinetry, or airtight moisture-proof containers and/or enclosures to protect the prints from fluctuating or high relative humidity that can exceed the recommended limits. One advantage of this method is that environmental humidity control is not needed, allowing the use of relatively low-cost cold rooms, freezers and refrigerators. When permeable containers and enclosures are used, they shall be sealed within an impermeable vapour-proof material for humidity and moisture protection. Foil-laminate (or metallized) plastic bags are commonly used and double-bagging (one sealed bag within another) can be employed to minimize the problem of air leakage through microscopic holes or pinholes in the bag material or the seal.

   Sealing can be accomplished through pressure sensitive plastic tape, heat-sealing or the use of self-sealing (double groove closure) type bags. Potential air leakage at the closure mechanism of self-sealing bags can be minimized by taping over the sealed end. Because of the availability of different moisture-proof bag sizes, this bag method can be used for packaging either small groups of prints housed in their enclosures, or prints stored in boxes. Excess air in the bag should be squeezed out to minimize the volume of free air inside which reduces the bulkiness of the package and excessive pressure on package seals and seams. When airtight plastic and metal containers are used, the lid closure should be taped over to eliminate air leakage. The airtight vapour-proof containers or bags also serve to protect the item(s) from moisture condensation when removed to warmer conditions. Airtight, moisture-proof cabinets with door and window gaskets also can be used to store large quantities or bulky items in lieu of individual vapour-proof enclosures. When sealed cabinets are used, especially with partially filled cabinets, the interior relative humidity of the cabinet shall be buffered with a hygroscopic material, such as silica gel or paperboard, that is pre-conditioned to not exceed 50 %. Because sealed cabinetry is expensive, this method is most useful where the cabinets are already available or would be used anyway, and for low use collections where the buffering capacity of the moisture conditioning material would not be depleted by frequent opening of the cabinets for retrieval and filing.

Annex I
(informative)

Print stability

Print stability is dependent on many factors (see Annexes A, B, E, G)[21]. This International Standard addresses the overall environmental conditions needed to maximize print life in dark storage and does not attempt to provide estimated life expectancies for the numerous print types at those conditions. Experience has shown that many historic 19th century print processes (silver halide, platinum, and pigmented) have survived more than 100 years. Those that received cool, dry storage and little display have had excellent image quality and base stability. Even those that received substandard storage and display, compared to modern standards, have survived, albeit with varying degrees of image or base degradation. Arrhenius predictions for chromogenic colour processes developed in the 20th century indicate that these materials can survive hundreds of years, if kept in cold storage.

Dark storage, lack of atmospheric pollutants and environmental conditions that decrease thermal and moisture-related degradation are just four variables influencing print life. In actuality, there are other variables that affect print life and one or more of these factors may be the “weak link”. This has been the case throughout the history of photography as new technologies were developed and adopted for use, sometimes for innovative uses that were not the original intent of the product. For example, it became clear shortly after the introduction of silver image printing processes that images faded excessively in tropical climates or where pollution was heaviest. Proper washing and post-processing treatments that converted the silver to more stable forms were successful in combatting this problem, as was storage in cool dry conditions where possible (as in temperate climates). Many photographic images or binders also have had stability problems including:

a) yellow staining of albumen and paper yellowing;

b) abrasion sensitivity of collodion;

c) moisture and water sensitivity of pigmented processes such as carbon and gum bi-chromate;

d) moisture sensitivity of gelatine binders resulting in tackiness or blocking at high humidities;

e) cracking of albumen and thick carbon layers;

f) curling of gelatine and albumen papers due to emulsion contraction relative to the paper support;

g) catalytic degradation of the paper base by platinum image material.

Base problems have included:

1) deterioration of plastic films;

2) RC print cracking;

3) susceptibility of paper to tears, and other physical damage.

The multi-layered structure of photographs (image layers, base, coatings and intermediate layers) creates sources for failure between layers, inherent incompatibility of different component layers and differing deterioration rates. Modern digital imaging and desktop printing have expanded this cornucopia. Manufacturers can optimize their inks and base materials for stability but creators of prints might choose to select their own papers (or films, fabrics, etc.) and use a variety of ink combinations. Some of these newer technologies share the same problems as earlier technologies, such as sensitivity to oxidizing agents and moisture.

Environmental conditions during display and exposure to light frequently exacerbate many of these “weak links” mentioned above by accelerating chemical reactions that cause image or base degradation. Many institutions have strict exhibition guidelines addressing display conditions and environments to reduce display-related damage to valuable photographs. However, these conditions are rarely replicated by consumers or are difficult to achieve in a home or office setting. Finally, careless or frequent handling also inflicts physical wear and tear.

Because of the diversity of print processes, the variety of component materials in these processes, the rapid product development in recent years, the different “weak links” and the need for display and use (versus dark storage), it is difficult to establish a life expectancy rating for each print process. However, the history of photography has shown that good environmental storage, high quality enclosures, careful handling and limited display are essential to maximizing long-term keeping of photographs, as is specified in this International Standard for photographs that have enduring or permanent value.

Lastly, the preservation of prints includes protection from disasters including floods and fires (which usually entails water damage as a result of fire suppression). Specialized recovery techniques are required for many processes that have become wet and should be implemented shortly after the damage occurs in order to prevent loss due to mould, adhesion of materials to themselves or enclosures, or dissolution of media and binders[22].

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