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Imaging materials — Processed vesicular photographic film — Specifications for stability

Matériaux pour l'image — Film photographique vésiculaire traité — Spécifications relatives à la stabilité

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Foreword

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

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

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18912 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 18912 cancels and replaces the second edition of ISO 9718:1995, of which it constitutes a technical revision.

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

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

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Introduction

Since 1930, great advances have been made in the use of photographic films for the preservation of records. The preservation of records on film by national, state and municipal governments, by banks, insurance companies, industry and other enterprises has been stimulated by recognition of the resultant economies in storage space, organization, accessibility and ease of reproduction. The safe-keeping of pictorial film records having legal, scientific, industrial, medical, historical, military or other values has also become increasingly important.

The use of film for records having long-term values necessitated the development of International Standards to specify the characteristics of film suitable for this purpose. ISO 18901 specifies the requirements for silver-gelatin films which are suitable for storage. This International Standard (for vesicular film) and ISO 18905 (for diazo film) give the requirements for photographic duplicate films suitable for storage.

The term “archival film” has been discontinued and the new concept of “life expectancy” is introduced. Film life is classified by the LE or life expectancy rating as defined in this International Standard. For example, LE-100 represents film with a life expectancy of 100 years when stored at 21 °C and 50 % RH.

Criteria for properties of LE-10 and LE-100 vesicular films are based upon the dark-ageing stability of D_{min} processed areas. Different dark-incubation tests are specified for LE-10 and LE-100 films. All other properties and processing requirements for medium and long-term vesicular films are identical.

In addition to tests to ensure that the density of D_{min} areas does not increase to unacceptable levels during storage, a test is also specified on high-density areas. This is to guard against the possibility of vesicle (or bubble) collapse during storage. This test has to be carried out at temperatures below the softening point of the image binder, as tests above this temperature have no practical meaning (see [1], [2] in the bibliography). However, to give confidence of acceptable image stability, the permissible density change was set as low as possible, in line with the measurement error of the densitometer. Both LE-10 and LE-100 vesicular films shall meet the same requirement.

It is recognized that vesicular images may show density changes after exposure to light. However, this International Standard covers only films used as storage copies, not as work copies (as defined in annex B). The light-fading requirements specified in this International Standard ensure satisfactory behaviour for storage copies that are not intended to be subjected to frequent light exposure.

In addition to the characterization of films with respect to their expected storage life, vesicular films are also separated into two classes (A and B) which are dependent upon their intended use. Class A films are those which retain density in both the visual and actinic region (printing) after storage. Such films can be viewed directly or reprinted onto ultraviolet (UV)-sensitive materials. However, some vesicular films are not intended to be reprinted onto UV-sensitive materials and require only visual capabilities after storage. Such films are designated as Class B films. Obviously, both Class A and Class B films can fall into the LE-10 and LE-100 categories. The requirements for Class A and Class B films are identical, with the exception of image-stability tests after dark-ageing and after light-fading.

Everyone concerned with the preservation of records on photographic film should realize that specifying the chemical and physical characteristics of the material does not, by itself, assure satisfactory behaviour. It is also essential to provide the correct storage temperature and humidity, as well as protection from the hazards of fire, water, light and certain atmospheric pollutants. Conditions for the storage of record films are specified in ISO 18902 and ISO 18911.

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Imaging materials — Processed vesicular photographic film — Specifications for stability

1 Scope

This International Standard establishes specifications for the stability of polyester-base safety film which has a heat-processed vesicular photographic image formed by nitrogen bubbles. It is applicable only to vesicular photographic film intended and used as LE-10 and LE-100 storage copies, which shall be stored in accordance with ISO 18902 and ISO 18911.

This document characterizes only the inherent keeping behaviour of the film. However, the suitability of a film record after extended storage depends on both the inherent ageing characteristics of the film and the original image quality. The latter is discussed in annex C.

This International Standard is applicable to photographic film in which the image layer is a discrete layer attached to a transparent support, and it applies to roll film and sheet film.

This International Standard is not applicable to vesicular film records intended and used as “work” or “use” copies as discussed in annex B.

The effects of heat and pressure are discussed in annex D and those of high humidity in annex E.

2 Normative references

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

ISO 5-2:2001, *Photography — Density measurements — Part 2: Geometric conditions for transmission density*

ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*

ISO 527-3:1995, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets*

ISO 18902:2001, *Imaging materials — Processed photographic films, plates and papers — Filing enclosures and storage containers*

ISO 18906:2000, *Imaging materials — Photographic films — Specifications for safety film*

ISO 18907:2000, *Imaging materials — Photographic films and papers — Wedge test for brittleness*

ISO 18911:2000, *Imaging materials — Processed safety photographic films — Storage practices*

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3 Terms and definitions

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

3.1
archival medium
recording material that can be expected to retain information forever so such information can be retrieved without significant loss when properly stored

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

3.2
blocking
sticking together of similar or dissimilar materials in physical contact

3.3
Class A films
films which are usable both visually and for printing onto ultraviolet-sensitive materials

3.4
Class B films
films which are usable visually, but do not have any density requirements for printing onto ultraviolet-sensitive materials

3.5
density
⟨optical⟩ degree of light absorption, reflection or scattering characteristics of a photographic image, expressed as the logarithm to the base 10 of the ratio of incident radiant flux to the transmitted, reflected or scattered flux

NOTE See ISO 5-3.

3.5.1
printing density
optical density in which the incident radiant flux has the same spectral energy distribution as the printer light source and the transmitted density is evaluated by a receiver having the same spectral response as the print material

3.5.2
projection density
optical density of a processed photographic image in which the angular distributions of the incident and transmitted radiant flux are equal and specified

NOTE For microfilm applications, the angular distribution is a nominal half-angle of 6,4°, which corresponds to an *f*-number of *f* /4,5 and simulates a microfilm reader.

3.5.3
visual density
optical density of a processed photographic image in which the incident radiant flux has a spectral energy distribution as defined in ISO 5-3, and the transmitted or reflected flux is evaluated by the human eye or by a receiver having the same spectral receiver as the human eye

3.6
emulsion layer(s)
image or image-forming layers(s) of photographic films, papers and plates

3.7
extended-term storage conditions
storage conditions suitable for the preservation of recorded information having permanent value

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3.8
film base
plastic support for the emulsion and backing layers

3.9
LE designation
rating for the “life expectancy” of recording materials and associated retrieval systems

NOTE The number following the LE symbol is a prediction of the minimum life expectancy in years for which information can be retrieved without significant loss when stored at 21 °C and 50 % RH, e.g. LE-100 indicates that information can be retrieved after at least 100 years storage.

3.10
life expectancy
LE
length of time that information is predicted to be acceptable in a system after dark storage at 23 °C and 50 % RH

3.11
medium-term storage conditions
storage conditions suitable for the preservation of recorded information for a minimum of 10 years

3.12
polyester base
base for recording materials composed mainly of a polymer of ethylene glycol and terephthalic acid (also referred to as polyethylene terephthalate), or a polymer of ethylene glycol and 2,6 naphthalene dicarboxylic acid (also referred to as polyethylene naphthalate)

3.13
poly(ethylene terephthalate) base
polyester base for recording materials composed mainly of a polymer of ethylene glycol and terephthalic acid

3.14
safety photographic film
photographic film which passes the ignition-time test and the burning-time test specified in ISO 18906

4 Film base requirements

The base used for record films, as specified in this International Standard, shall be of a safety polyester type and can be identified by the method described in 8.1.

Films can have a maximum LE rating of 500.

5 Processed film requirements

5.1 Safety film

Film shall meet the requirements specified in ISO 18906.

5.2 Tensile properties and loss in tensile properties

Film specimens shall be processed and dried under the conditions used for the film records.

Processed films shall be tested for tensile properties as described in 8.3 and shall have a tensile stress and elongation at break as specified in Table 1 (unheated film). The loss in tensile properties after accelerated ageing as described in 8.2 shall not exceed the percentage specified in Table 1 (heated film).

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Table 1 — Limits for tensile properties and loss in tensile properties on accelerated ageing of polyester-base film

Film type	Tensile stress at break	Elongation at break
Unheated film Minimum permissible tensile properties	140 MPa	75 %
Heated film Maximum permissible loss in tensile properties compared with unheated film	15 %	30 %
NOTE 1 MPa = 10^6 N/m^2		

6 Requirements for the emulsion and backing layers of processed film

6.1 Layer adhesion

6.1.1 Tape-stripping adhesion

Processed film shall not show any removal of the emulsion layer or backing layer when tested as described in 8.4.

6.1.2 Humidity-cycling adhesion

The emulsion layer or backing layer of the processed film shall not show separation or cracking that can impair its intended use when tested as described in 8.5

6.2 Blocking

Processed film shall show no evidence of blocking (sticking), delamination or surface damage when tested as described in 8.6. A slight sticking of the film specimens that does not result in physical damage or a change in gloss of the surface shall be acceptable.

6.3 Binder stability

Processed film shall not exceed a 1 mm increase in brittleness after accelerated ageing as specified in 8.2. Brittleness shall be determined at 50 % RH and shall be tested in accordance with ISO 18907.

Films shall be tested preferably in low-density areas.

6.4 Thermal sticking

Processed film shall show no evidence of blocking (sticking), delamination or surface damage at high temperature when tested before and after accelerated ageing as described in 8.2.

Thermal sticking shall be tested as specified in 8.7. A slight sticking of film to glass that does not result in physical damage shall be acceptable.

7 Image stability requirements

7.1 Proper development

Processed film shall not show a projection density decrease greater than 20 % when tested as specified in 9.2.

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7.2 Residual diazonium-salt test

Processed film shall not show a printing density decrease greater than 0,1 when tested as specified in 9.3.

7.3 Light-fading

Low-density and high-density patches of processed film shall be tested in a light-exposure apparatus as described in 9.4.2.

After testing, patches with low-printing and low-projection densities shall have a density of 0,7 or less. The difference between densities for patches with high and low-printing densities shall be 0,8 or greater and that between patches with high and low-projection densities shall be 1,4 or greater (see Table 2).

These density requirements shall apply to both projection and printing densities for Class A films and to projection densities only for Class B films (see annex E). The same density requirements shall apply for both LE-10 and LE-100 films.

Table 2 — Limits for the change in image density after the light-fading test

Vesicular density levels	Printing density	Projection density
Original		
Low density	$< 0,4$	$< 0,4$
High density – low density	$> 0,8$	$> 1,4$
Final		
Low density	$\leqslant 0,7$	$\leqslant 0,7$
High density – low density	$\geqslant 0,8$	$\geqslant 1,4$

7.4 Dark-ageing of minimum-density area

Minimum-density patches of processed film shall be incubated as specified in 9.5 using the two conditions specified for either LE-10 or LE-100 films. After incubation under each of the two conditions, the density patches with low-printing and low-projection densities shall have a density of 0,6 or less.

These density requirements shall apply to both projection and printing densities for Class A films and to projection density only for Class B films.

7.5 Dark-ageing of vesicular image

A density patch having a projection density of 2,0 shall be incubated as specified in 9.6. After incubation, the projection density shall not show a density change greater than $\pm$ 0,03.

This density requirement shall apply for both LE-10 and LE-100 films.

8 Test methods

8.1 Identification of film base

Remove all emulsion and backing layers from a specimen of the unknown film by scraping and then remove all sublayers by scraping.

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Prepare a specimen of the base material by scuffing the surface with a suitable tool such as a razor blade. The general procedure is to move the scuffing device back and forth over the specimen manually while exerting a very slight pressure. This removes the top layer of the base as a very fine dust. Carefully brush this into a mortar.

Mix the specimen with about 100 times its mass of potassium bromide, previously ground to about 75 µm. Prepare a strip or pellet as described in [3] in the bibliography.

Obtain an infrared (IR) absorption curve from the prepared strip or pellet by means of an infrared absorption spectrometer. By comparing the IR absorption curve for the unknown with curves for known polymers, the identity of the unknown can be established (see [4] in the bibliography).

8.2 Accelerated-ageing conditions

Processed film shall be subjected to accelerated-ageing conditions to meet the requirements for a loss in tensile properties, binder stability and thermal sticking.

Test specimens shall be conditioned at (23 ± 1) °C and (50 ± 2) % RH for at least 15 h. After conditioning, place the specimens in a moisture-proof envelope and heat-seal the envelope.

NOTE 1 A suitable moisture-proof envelope is a metal-foil bag that is coated on the inside with polyethylene for heat-sealing.

To prevent sticking between adjacent specimens, it may be necessary to interleave them with polytetrafluoroethylene or uncoated polyester. Ensure a high ratio of film to air volume by squeezing out excess air prior to heat-sealing. Use a separate envelope for each film specimen. Double bagging is recommended to reduce any effects of pinholes in the envelopes. Heat the envelopes in an oven for 72 h at (100 ± 2) °C.

NOTE 2 Incubation is accomplished in a closed environment to prevent escape of any acid that may be produced during incubation. Such acid may catalyse further film-base degradation.

An alternative method of incubating the specimens in a closed environment is by placing them in 25 mm borosilicate-glass tubes (see [5] in the bibliography). Each tube shall have two flanged sections separated by a gasket to provide a moisture seal and shall be held together by a metal clamp.

NOTE 3 A suitable inert gasket can be made from polytetrafluoroethylene.

Sufficient film specimens shall be used to provide a high ratio of film to air volume.

NOTE 4 In the text, specimens subjected to these accelerated-ageing conditions are designated “heated film”. Comparison specimens kept at room conditions are designated “unheated film”.

8.3 Tensile-property test for processed film

8.3.1 Specimen preparation

Processed film already in 16 mm format may be tested in this width. In the case of perforated 16 mm film, specimens shall be cut from the area between the perforations. Film in other sizes shall be cut into sections 15 mm to 16 mm wide and at least 150 mm long, using a sharp tool that does not nick the edges of the specimen.

Five specimens are required for unheated film and five specimens for heated film. The specimens to be heated and the control specimens shall be cut alternately and contiguously from a single piece of film.

The thickness of each specimen shall be measured with a suitable gauge to the nearest 0,002 mm and the width to the nearest 0,1 mm.

8.3.2 Accelerated ageing

Five specimens shall be subjected to accelerated ageing as described in 8.2.

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8.3.3 Conditioning

All specimens, both unheated and heated, shall be conditioned at (23 ± 1) °C and (50 ± 2) % RH for at least 15 h. This can be accomplished by means of an air-conditoned room or a conditioning-air cabinet.

Specimens shall be supported in such a way as to permit free circulation of air around the film. The linear air velocity shall be at least 150 mm/s.

8.3.4 Procedure

Film specimens shall not be removed from the conditioning atmosphere for testing.

The tensile stress and per cent elongation at break of unheated and heated film specimens shall be tested alternately by means of a tensile machine, as specified in ISO 527-3. The initial grip separation shall be 100 mm and the rate of grip separation shall be 50 mm/min.

The tensile stress and per cent elongation at break shall be calculated separately for unheated and heated film.

8.4 Tape-stripping adhesion test

8.4.1 Specimen preparation

Although the dimensions of the processed film specimen are not critical, one dimension shall be at least 150 mm. Four specimens shall be used for the emulsion surface and four specimens for the backing layer, if present.

8.4.2 Conditioning

Specimens shall be conditioned as described in 8.3.3.

8.4.3 Procedure

Film specimens shall not be removed from the conditioning atmosphere for testing.

Apply a strip of pressure-sensitive, plastic-base adhesive tape[1)] about 150 mm long to the surface of the processed film. Press the tape down with thumb pressure to ensure adequate contact, leaving enough tape at one end to grasp. No portion of the tape shall extend to the edges of the film specimen or extend to the film perforations.

Hold the specimen firmly on a flat surface and remove the tape rapidly from the film surface. This shall be accomplished by peeling the tape back on itself and pulling the end so that it is removed from the film at an angle of approximately 180°. Removal by the tape of any portion of the surface layer on any of the specimens shall be considered failure.

The results of the tape-stripping test may be very dependent upon the adhesive tape used if the bonding force between it and the particular film surface under test is not sufficiently high. For this reason, a minimum bonding force is specified for this test. This bonding force shall be determined by applying the adhesive tape to the film surface in the same manner as described in the tape-stripping test. The tape shall be rapidly peeled back from the film surface at an angle of approximately 180°.

The peelback force required to separate the tape from the film shall be measured by a suitable device, such as a strain gauge or spring scale capable of reading the maximum force used. A bonding force of at least 0,9 N/mm of tape width is required.

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1) An example of a suitable tape available commercially is 3M tape No. 610. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

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8.5 Humidity-cycling adhesion test

8.5.1 Specimen preparation

Two specimens of processed film shall be selected from an area of high density. The specimens should be 50 mm × 50 mm or 50 mm long × the film width, but the dimensions are not critical provided all specimens are of uniform size.

8.5.2 Procedure

Mount the test specimens in a specimen rack and place them in a glass laboratory-desiccator jar in such a way that they are freely exposed to the required conditioning atmosphere. Place the jar in a forced-air circulating oven for 8 h at (50 ± 2) °C. The atmosphere within the jar shall be maintained at 96 % RH, which can be obtained by keeping a saturated solution of potassium sulfate in water (see [6] in the bibliography) in the bottom of the jar.

NOTE Relative humidity is based on the normal vapour pressure of the salt solution, but RH tolerances cannot be specified.

Take care to ensure that the saturated solution contains an excess of undissolved crystals at 50 °C. Some undissolved crystals shall be above the level of the saturated-salt solution, and the surface area of the solution should be as large as practical. To ensure adequate equilibrium, the jar and salt solution shall be kept at 50 °C for at least 20 h prior to use.

After 8 h, place the specimens and specimen rack for 16 h in a second desiccator jar that is also in the same oven. The atmosphere within the second jar shall be maintained at 11 % RH, which can be obtained by keeping a saturated solution of lithium chloride in water (see [6] in the bibliography) in the bottom of the jar.

Alternatively, the temperature and humidity conditions can be achieved by means of conditioning-air cabinets or air-conditioned rooms.

Time periods of 8 h at the high humidity and 16 h at the low humidity constitute one cycle. This can be most easily accomplished by placing the specimens in the 96 % RH jar in the morning and in the 11 % RH jar in the evening. Each film specimen shall be subjected to 12 humidity cycles. After this, remove the film specimens from the specimen rack and examine the emulsion and any backing layer for evidence of peeling, flaking or cracking produced as a result of the humidity-cycling treatment.

Films may sometimes exhibit what appear to be small pinholes in the image after processing. These can be caused by dirt or dust particles on the emulsion surface at the time that the raw film is exposed and should not be confused with holes or cracks in the emulsion layer. The existence of such pinholes in the image prior to humidity cycling should be noted so that their presence does not lead to a false interpretation of adhesion weakness.

Film shall be examined under magnification and lighting conditions that are normal for the end-use of the product. During an interruption in the cycling procedure, film specimens shall be kept at (50 ± 2) °C and 11 % RH.

8.6 Blocking test

At least five specimens of processed film shall be conditioned at (40 ± 2) °C and 62 % RH. The preferred specimen size is 50 mm × 50 mm, but the dimensions are not critical provided all specimens are of uniform size.

Place the specimens in a glass laboratory-desiccator jar so that they are freely exposed to the required conditioning atmosphere for at least 15 h. Place the jar containing the specimens in a forced-air circulating oven at (40 ± 2) °C. A relative humidity of approximately 62 % can be obtained by keeping a saturated solution of sodium nitrite (see [7] in the bibliography) in water at the bottom of the jar.

Take care to ensure that the saturated solution contains an excess of undissolved crystals at 40 °C. Some undissolved crystals shall be above the level of the saturated-salt solution, and the surface area of the solution should be as large as is practical. To ensure adequate equilibrium, the jar and salt solution shall be kept at 40 °C for at least 20 h prior to use.

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After moisture equilibrium is attained, remove the jar from the oven. Without removing the film specimens from the jar, stack at least five specimens so that the emulsion surface of one specimen is against the back surface of the adjacent specimen. Place the stack under a uniform pressure of 35 kPa. This can be accomplished by placing a weight on the film stack, the dimensions of the weight being greater than those of the film specimens. The jar containing the weighted stack shall be put back into the forced-air circulating oven for 3 d at 40 °C.

Alternatively, the temperature and humidity conditions can be achieved by means of conditioning-air cabinets or air-conditioned rooms.

Remove the film stack from the oven and allow it to cool. Remove the film specimens individually from the stack and observe each for evidence of film blocking (sticking) (see 6.2).

8.7 Thermal sticking test

Measurements shall be made on two unheated specimens of processed film and two heated specimens as specified in 8.2. A specimen 50 mm × 50 mm is convenient, but the dimensions are not critical.

Place the specimen between two smooth uncoated glass plates, that have dimensions slightly larger than the specimen, under a uniform pressure of 35 kPa. This can be accomplished by placing a weight on the upper glass plate, the dimensions of the weight being greater than that of the specimen. Put each glass-plate/film sandwich in a forced-air circulating oven for 1 h at (65 ± 2) °C.

Remove the glass-plate/film sandwich from the oven and allow it to cool. After removal of the glass plates, examine the film for evidence of blocking (sticking), film delamination and surface damage.

9 Image test methods

9.1 Densitometry

Image density shall be measured in accordance with 9.1.1 and 9.1.2.

9.1.1 Projection density

Projection transmission density shall be measured as specified for the f/4,5 type in ISO 5-2 and shall be designated as D_T (6,4 °; S_H: 6,4 °; V_T).

9.1.2 Printing density

Printing transmission density shall be determined as specified for ISO type 1 printing density in ISO 5-3, and shall be designated as D_T (90 ° opal; S_H: $\leqslant$ 10 °; s_1).

9.2 Proper development test

Measurements shall be made on processed vesicular film having a projection density equal to 1,8 or greater. The projection density shall be measured as specified in 9.1.1.

Subject the film to a dark incubation of 3 h at (65 ± 2) °C in an open-air oven. Measure the projection density. Express any density decrease as a percentage of the original projection density.

9.3 Residual diazonium-salt test

A D_{min} area of the processed vesicular film shall be read for printing density as specified in 9.1.2. Place the specimen at a distance of 100 mm from a 100-W clear incandescent lamp without a reflector for a 10-min exposure. The density of the identified area shall be read again for printing density.

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9.4 Light-fading test

9.4.1 Specimens

Measurements shall be made on low-density and high-density areas of two specimens of processed film.

Class A films shall be measured for printing density as specified in 9.1.2, and for projection density as specified in 9.1.1. Class B films shall be measured only for projection density. The density values of the low-density and the high-density areas shall conform to those specified in Table 2.

9.4.2 Light-exposure apparatus

The light-exposure apparatus shall contain a carbon arc of the solenoid-activated type that operates over a range of 120 V to 145 V at 15 A. The arc shall be enclosed in a borosilicate-glass globe that filters out wavelengths below 275 nm.

The film plane surface shall have an irradiance of 1,7 W/mm^2 at 358 nm, 5 W/mm^2 at 386 nm, 2 W/mm^2 at 416 nm, and 0,25 W/mm^2 for the rest of the spectrum[2)].

9.4.3 Procedure

Insert the specimens in the light-exposure apparatus and position the holders so that the emulsion side of the specimens is facing the arc. With the light-exposure apparatus operating between 40 % RH and 50 % RH and at a temperature between 50 °C and 55 °C, expose the film for 7 h.

Measure the density values of the low-density and high-density areas using the appropriate methods specified in 9.1.

9.5 Dark-ageing test for the minimum-density area

9.5.1 Specimens

Measurements shall be made on a minimum-density area of three specimens of processed film.

Class A films shall be tested using a pair of specimens measured for printing density as specified in 9.1.2, and another pair of specimens shall be measured for projection density as specified in 9.1.1. Class B films shall be tested using only specimens measured for projection density.

9.5.2 Procedure

Condition the film at (50 ± 2) % RH as specified in 8.2. One specimen of LE-10 films shall be heated for 30 d at 50 °C and 50 % RH, and a second specimen for 2 d at 70 °C and 50 % RH. One specimen of LE-100 films shall be heated for 40 d at 65 °C and 50 % RH and a second specimen for 6 d at 80 °C and 50 % RH.

Incubation at two temperatures is required in order to verify that the temperature dependence of the D_{min} increase allows predictable extrapolation to room-temperature conditions. However, for films that have been previously tested and do not contain new polymeric binders, a single incubation temperature is sufficient. In such cases, LE-10 films shall be tested for 2 d at 70 °C and 50 % RH, and LE-10 films for 21 d at 70 °C and 50 % RH.

All incubations shall be carried out in a humidity-controlled oven or in a glass desiccator jar containing a salt solution that provides 50 % RH at the incubation temperature. Precautions to be followed in using a desiccator jar are specified in 8.5.2.

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2) Details on the availability of such a carbon-arc light source may be obtained from the Secretariat of ISO/TC 42. Sources with equivalent emission may be used.

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The density of the low-density areas shall be measured using the appropriate methods specified in 9.1. The density increase shall conform to the level specified in 7.4.

9.6 Dark-ageing test for the vesicular image

Measurements shall be made on a projection-density patch of 2,0 and measured as specified in 9.1.1.

Condition the film at (50 ± 2) % RH as specified in 8.2. Both LE-10 and LE-100 films shall be heated for 50 d at 45 °C and 50 % RH in a humidity-controlled oven or in a glass desiccator jar containing a salt solution that provides 50 % RH.

Remeasure the projection density. The projection density change shall conform to the value specified in 7.5.

10 Classification for reporting

Vesicular films shall be classified as LE-10 or LE-100 film, depending upon their useful life. This is determined by conformance to the test requirements specified in 7.4 for the dark-ageing of the minimum-density area. All other property requirements are the same for both classes.

Vesicular films shall be classified as Class A films if they meet projection and printing density requirements at the end of their projected useful life. They shall be classified as Class B films if they meet projection requirements only. This is determined by conformance to the light-fading test requirements specified in 7.3 and to the dark-ageing test requirements specified in 7.4. Other property requirements are the same for both classes.

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Annex A
(informative)

Numbering system for related International Standards

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

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

Table A.1 — New ISO numbers

Current ISO number	Title	New ISO number
10602*	*Photography — Processed silver-gelatin type black-and-white film — Specifications for stability*	18901
10214*	*Photography — Processed photographic materials — Filing enclosures for storage*	18902
6221*	*Photography — Films and paper — Determination of dimensional change*	18903
5769*	*Imaging materials — Processed films — Method for determining lubrication*	18904
8225	*Photography — Ammonia-processed diazo photographic film — Specifications for stability*	18905
543*	*Imaging materials — Photographic films — Specifications for safety film*	18906
6077*	*Imaging materials — Photographic films and papers — Wedge test for brittleness*	18907
8776*	*Imaging materials — Photographic film — Determination of folding endurance*	18908
10977	*Photography — Processed photographic colour films and paper prints — Methods for measuring image stability*	18909
4330*	*Imaging materials — Photographic film and paper — Determination of curl*	18910
5466*	*Imaging materials — Processed safety photographic films — Storage practices*	18911
9718	*Photography — Processed vesicular photographic film — Specifications for stability*	18912
	Imaging materials — Stability — Vocabulary	18913
	Imaging materials — Photographic film and papers — Method for determining the resistance of photographic emulsions to wet abrasion	18914
12206*	*Imaging materials — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation*	18915
14523	*Photography — Processed photographic materials — Photographic activity test for enclosure materials*	18916
417*	*Photography — Determination of residual thiosulfate and other related chemicals in processed photographic materials — Methods using iodine-amylose, methylene blue and silver sulfide*	18917
3897*	*Imaging materials — Processed photographic plates — Storage practices*	18918
14806*	*Imaging materials — Thermally processed silver microfilm — Specifications for stability*	18919
6051*	*Imaging materials — Processed photographic reflection prints — Storage practices*	18920

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Table A.1 — New ISO numbers (*continued*)

Current ISO number	Title	New ISO number
15525*	*Imaging materials — Compact discs (CD-ROM) — Method for estimating the life expectancy based on the effects of temperature and relative humidity*	18921
	Imaging materials — Processed photographic films — Methods for determining scratch resistance	18922
15524*	*Imaging materials — Polyester-base magnetic tape — Storage practices*	18923
15640*	*Imaging materials — Test method for Arrhenius-type predictions*	18924
16111*	*Imaging materials — Optical disc media — Storage practices*	18925
16112*	*Imaging materials — Life expectancy of information stored on magneto-optical (MO) discs — Method for estimating, based on effects of temperature and relative humidity*	18926
	Imaging materials — Life expectancy of information stored on recordable compact disc systems — Method for estimating, based on effects of temperature and relative humidity	18927
10331*	*Imaging materials — Unprocessed photographic films and papers — Storage practices*	18928
	Imaging materials — Wet-processed silver — Gelatin type black-and-white photographic reflection prints — Specifications for dark storage	18929
	Imaging materials — Protocols for outdoor weathering experiments	18930
	Imaging materials — Recommendations for humidity measurement and control	18931

* This document has already been replaced by an International Standard with the new ISO number.

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Annex B
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Distinction between film storage (record) copies and work (reference) copies

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

Vesicular film is generally used for the work copy of daily information management systems, although it also has found application for storage purposes. The useful life of work copies can be prolonged even in frequent usage by following the recommendations for material selection and handling given in this International Standard.

Where there is a need for extended storage of photographic film records having a permanent value, duplicates should be prepared for reference use. These duplicates should be kept in a collection area separate from the one in which original storage copies are stored.

Original storage copies should meet the appropriate ISO requirements for the photographic material used as outlined in this International Standard and its companion documents, ISO 18901 and ISO 18905. It is equally important that storage copies be stored according to the recommendations of ISO 18902 and ISO 18911. Of vital importance is the control of temperature and humidity and the protection of the film from dirt and impurities. Unless the appropriate film materials are stored according to recommended procedures, satisfactory preservation will not be obtained.

Original storage records will occasionally be looked at, otherwise there is no need to keep these records. However, the use of storage copies should be infrequent. If more than infrequent use is required, duplicate work copies should be printed from the storage copies.

In conclusion, there are two types of film records: those intended for use and those intended for the preservation of information. This International Standard pertains to the latter only.

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Annex C
(informative)

Microfilm image quality

C.1 General

If satisfactory image quality is to be retained after storage, the quality of the image to be stored is as important as the keeping characteristics of the stored film. Considerable attention and care should be taken to ensure that the original camera film is properly exposed and is then properly printed onto the duplicate film.

In establishing a microfilm system, three factors should be considered:

— quality of the original document;

— exposure of the document;

— image contrast (see [8] in the bibliography).

C.2 Quality of original document

C.2.1 General

The three most important qualities of the original document related to image quality are:

— height of the characters;

— stroke width forming the smallest significant character or line;

— for non-computer output microfilm, the contrast between the paper and ink.

C.2.2 Character height

The quality requirements needed to enable a micro-recording system to record a character of a specific size in a document can be estimated by use of a "quality index".

The quality index (QI) relates the reduction ratio and the resolving power of the system to the height of the smallest significant characters in the document in such a way that the level of legibility in the resulting images can be predetermined. The QI is described in [9] in the bibliography.

In most duplicating processes, there is a loss of information with each succeeding generation. It is, therefore, essential that the QI of the camera film be high enough so that the QI of the next generation or generations, including hard-copy printouts, will be sufficient to provide images with adequate legibility for storage (see [10], [11] in the bibliography).

C.2.3 Line or stroke width

Due to optical limitations in most photographic systems, film images of thin lines appearing in the original document will tend to fill in as a function of their width and density. Therefore, as the reduction ratio of a given system is increased, it may be necessary to reduce the background density to achieve an image with relatively low line density so that the copies produced will contain legible characters. No firm rule can, at this time, be written for this relationship.

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C.2.4 Ink/paper contrast

With good clear-black type on a white background, an image with a high QI and high contrast can be achieved at a high reduction ratio. As the original print quality and contrast decrease, the reduction ratio or background density, or both, should be decreased to achieve the same quality image unless the resolving power of the system is increased. Reference [10] in the bibliography gives recommended background densities for achieving satisfactory images.

C.3 Exposure of the document

C.3.1 General

The second important factor to be considered when photographing documents is exposure control (see [12], [13] in the bibliography).

It is desirable that the contrast of all images in a single roll or microfiche have the same value to facilitate duplicating, i.e. to permit constant printing exposure and speed. Due to the wide variety of documents and the various methods by which they are filmed, trade-offs will need to be made in controlling the exposure.

Reference [10] in the bibliography gives recommended background densities for camera films based on the contrast of the original documents when using planetary cameras. The same recommendations also apply to rotary cameras. However, even with automatic exposure controls, the image densities from rotary cameras cannot be as well controlled.

Computer-output microfilmers use higher contrast films, resulting in more uniform and higher contrast images that facilitate duplicating (see [11], [14-19] in the bibliography).

C.4 Image contrast

The third factor to be considered when photographing documents, the contrast of the micro-reproduction system (see [14] in the bibliography), is dependent upon the selection of proper photographic materials for use in each generation. This applies both to the exposure of camera film and to subsequent printing onto duplicating film.

The average individual that uses microfilm thinks of contrast as the magnitude of the difference in density between the light and dark areas in a microfilm image. From the user’s point of view, this is a logical interpretation of contrast. However, the quality of a microfilm depends on more than the two ends of the scale; it also depends on the ability of the photographic materials to differentiate between small differences in tones in the document.

The characteristic curves of the photographic film define the contrast of the reproduction. Cascading of the characteristic curves of all films used in the system produces its tone-reproduction curve.

In a microfilm system, the contrast of the tone-reproduction curve affects the quality of the microfilm reproduction. If the contrast in the image is too high, fine lines and light lines from the original document will tend to fill in and bold black lines from the same original will spread. Open areas in certain characters will also fill in. On the other hand, if the contrast is too low, all the graphic information will be reproduced but the lines will appear unsharp and the reproduction will have a flat, muddy appearance.

Film manufacturers have made camera and print films with contrast designed to work effectively together. However, it is up to the user to select the proper films for use in a particular system.

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Annex D
(normative)

Effects of heat and pressure

D.1 Heat effects

Vesicular images are formed by the presence of bubbles or vesicles in a plastic binder. At elevated temperatures, this plastic binder will soften, causing collapse of the bubbles with a resultant loss of image.

The temperature at which the plastic binder starts to soften depends on the type of polymer used in the binder and varies for different products. However, some vesicular films have shown bubble collapse after 15 min at 70 °C, 1 h at 65 °C, or 1 d at 60 °C. Consequently, particular care should be taken to ensure that vesicular films are not heated to excessive temperatures in readers or printers. Some commercial readers which meet temperature requirements (see [20] in the bibliography) will heat vesicular films to these levels (see annex F).

D.2 Pressure effects

The nature of the vesicular image also causes film to be sensitive to pressure damage. Pressure will cause the bubbles to be physically and irreversibly compressed, with a resultant loss of density.

In ordinary cases, storage copies should not be subject to physical scratches or abrasions that can occur during the infrequent viewing or printing of such records. Highly local pressure points should also be avoided during film storage. For example, roll film should not be wound tightly onto cores or reels. Sheet film, such as microfiche, should not be stacked horizontally under pressure, nor should it be stored vertically in tightly packed film drawers.

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Annex E
(informative)

Effects of high humidity

Most of the binders used in vesicular films, which do not contain chlorine, can be adversely affected by very high humidity.

Exposure of processed vesicular film to relative humidities greater than 90 % for several hours can produce tiny fissures in the binder layer. This is evidenced by a high haze and a high increase in D_{min} which can obliterate the image. While this condition should never be encountered during normal storage, it might occur during shipment of processed film, use of film in a non-conditioned area, or if the air conditioner for the storage area malfunctions. This high D_{min} value can generally be lowered by subsequent redevelopment of the film at its normal development temperature, with consequent recovery of the image.

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Annex F
(informative)

Light-fading of vesicular images

The light-fading test condition of 8 h in a fadeometer, specified in 9.4, is based on experimental comparisons with practical reader tests. These comparisons were made using both diazo and vesicular films. However, vesicular images proved to be very stable to light radiation. Consequently, the relationship between the fadeometer test and commercial reader-printers was of necessity based on the behaviour of a variety of diazo films.

The 8 h exposure in the fadeometer showed similar image-density changes as found after 3 h of exposure in a commercial reader-printer whose gate temperature corresponded to the specified maximum (see [20] in the bibliography) in some national standards and caused the film to be heated to approximately 65 °C. A maximum use of 3 h in a reader or printer seems reasonable over the 10-year life of an LE-10 film or the 100-year life of an LE-100 film.

This International Standard applies only to storage copies and not to work copies as described in clause 1 and annex B. While work copies may be subjected to substantial use during their useful life, storage copies should only be used infrequently.

Vesicular images are very stable to light and are not greatly affected by 3 h of light radiation. In fact, practical reader tests have shown density changes well within those specified after as many as 50 h of continuous projection.

Since vesicular images are more sensitive to heat than to light radiation (see annex D), it is the former which is of concern in readers and printers. Some vesicular films will show bubble collapse even if the reader meets the temperature requirements (see [20] in the bibliography). Consequently, particular attention should be given to the temperatures of readers or printers used for vesicular films.

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Annex G
(informative)

Corrosiveness

There have been some commercial vesicular films that released hydrogen chloride during storage. This behaviour did not have any known detrimental effect on the stability of the film itself. However, it did have a very corrosive effect on the film enclosure materials, particularly on metal film cans and storage cabinets. Accordingly, the following steel chip corrosion test was developed to give a measure of the potential corrosiveness of a film.

Corrosiveness is determined by the gain in mass of steel chips. Use basic open-hearth chips[3)] containing 0,1 % carbon. Degrease the steel chips by rinsing with acetone. Then carry out a 5 min cleaning treatment in a 1 % hydrochloric acid solution, followed by 10 rinses with distilled water, a methanol rinse, and a final acetone rinse. (As a guideline, approximately 250 ml of degreasing, cleaning or washing solutions are used for each 50 g of chips.) Dry the steel chips for 5 min at approximately 100 °C, then cool and condition them at 50 % RH for 30 min. Weigh approximately 3 g of the steel chips to the nearest 0,000 1 g at 50 % RH in the ground glass cap-style stopper of a 30 mm × 60 mm glass weighing bottle.

Make measurements on processed film, each specimen being 270 mm × 16 mm or equivalent in area. Condition the processed film specimen for a minimum of 4 h at 21 °C and 50 % RH. Then, coil the conditioned specimen and place it in the bottom half of the weighing bottle containing the steel chips. Close the bottle in an inverted position, so that the cap containing the steel chips is at the bottom and the film is at the top. Heat the bottle for 7 d at 70 °C. Then, remove the bottle from the oven and cool it. Leave the cap portion containing the steel chips in an atmosphere of 21 °C and 75 % RH for 24 h. This relative humidity can be obtained by keeping a saturated solution of sodium chloride in water in the bottom of a glass laboratory-desiccator jar. The precautions described in 8.5.2 should be taken to ensure that the proper humidity is obtained.

Then, dry the cap and steel chips for 5 min at 70 °C. Cool the steel chips to room temperature, and weigh them at 50 % RH after a 30-min conditioning time. The percentage increase in the mass of the steel chips is a measure of the film corrosiveness. Run the test in duplicate and calculate the average.

The early vesicular films that produced corrosion of the metal filing enclosures caused a mass increase in excess of 1 %. To date, no adverse trade effects on film enclosure materials have been reported for film causing a mass increase of 0,25 %. However, the long-term effects of such films are not known.

3) National Institute of Standards and Technology Reference Materials No. 15h (0,1 % °C) can be obtained from the National Institute of Standards and Technology, Gaithersberg, MD 20899, USA.

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[10] ANSI/AIIM MS23-1998, *Microfilm of documents, operational procedures/inspection and quality control of first-generation silver-gelatin*[4)]

[11] ANSI/AIIM MS1-1996, *Recommended practice for alphanumeric computer-output microforms — Operational practice for inspection and quality control*[4)]

[12] ISO 6200:1999, *Micrographics — First generation silver-gelatin microforms of source documents — Density specifications and method of measurement*

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[19] ISO 8514-2:2000, *Micrographics — Alphanumeric computer output microforms — Quality control — Part 2: Method*

[20] ISO 6198:1993, *Micrographics — Readers for transparent microforms — Performance characteristics*

[21] ISO 18901:2002, *Imaging materials — Processed silver-gelatin type black-and-white films — Specifications for stability*

[22] ISO 18905:—[5], *Imaging materials — Ammonia-processed diazo photographic film — Specifications for stability*

5) To be published.

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