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Imaging materials — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation

Matériaux pour image — Méthodes d'évaluation de l'efficacité de la conversion chimique des images argentiques contre l'oxydation

Reference number
ISO 18915:2000(E)

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Foreword

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

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

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

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

International Standard ISO 18915 was prepared by Technical Committee ISO/TC 42, *Photography*.

This first edition cancels and replaces ISO 12206:1995, of which it constitutes a minor 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).

Annex D forms a normative part of this International Standard. Annexes A, B and C are for information only.

Introduction

Silver-gelatin photographs have been used extensively for recording and preserving information of lasting value in all fields of human activity. The long-term stability of these records has become of increasing concern in recent years, because image and support degradation have been found with accelerating frequency in photographic collections and archives.

ISO has published documents on various aspects of the stability and preservation of black-and-white silver-gelatin photographic materials. ISO 18901:—[1] *Imaging materials — Processed silver-gelatin type black-and-white film — Specifications for stability*, provides test methods and criteria for the physical properties, permissible residual processing chemicals, and the image quality of films. ISO 18911:2000, *Imaging materials — Processed safety photographic films — Storage practices*, deals with the conditions required for maintaining and preserving the integrity of photographic films during storage. ISO 18902—[2], *Imaging materials — Processed photographic films, plates and papers — Filing enclosures and storage containers*, pertains to the materials used in contact with stored photographic materials.

If photographic film meets the material and processing specifications of ISO 18901 and is stored in accordance with ISO 18902 and ISO 18911, excellent stability will be obtained. Similarly, photographic paper prints should be stored in accordance with ISO 18920:2000, *Imaging materials — Processed photographic reflection prints — Storage practices*, and processed photographic plates in accordance with ISO 18918:2000, *Imaging materials — Processed photographic plates — Storage practices.*

However, in practical situations it is not always possible to control the storage conditions, particularly with respect to contaminants.

Atmospheric pollutants such as peroxides, sulfur dioxide, ozone and nitrogen dioxide are very detrimental to silver images (see [1] in the bibliography). Such environmental pollutants are of increasing concern in our industrial society. They can cause oxidation of the silver with consequent silver migration. This results in image fading, silver mirroring and redox blemishes (see [2] and [3] in the bibliography). Oxidizing agents that diffuse out of enclosure materials cause similar defects.

Recent studies have shown that silver images can be made resistant to oxidizing pollutants by chemically treating the silver to form silver sulfide (see [4] in the bibliography) or silver selenide (see [5] in the bibliography), or by substitution of the silver by gold (see [6] in the bibliography). Such treatments are recommended when it is not possible to ensure the absence of contaminants, or when the importance of the image justifies the added expense.

This International Standard is an adjunct to the processing requirements and describes methods for evaluating the effectiveness of various treatments which impart greater stability to silver images.

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[1] To be published. (Revision of ISO 10602:1995)

[2] To be published. (Revision of ISO 10214:1991)

Imaging materials — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation

1 Scope

1.1 This International Standard describes methods for evaluating the effectiveness of chemical conversion treatments intended to increase the resistance of wet-processed silver images to oxidation. The treatment may be applied as part of the original processing, or it may be a post-processing treatment.

This International Standard does not recommend general or specific treatments for silver images. Likewise, treatment temperature, times and replenishment rates are outside the scope of this International Standard. Factors to be considered in a stabilizing treatment are discussed in informative annex B.

Two test methods are described: the "dichromate bleach test" and the "hydrogen peroxide incubation test" (see [7] in the bibliography). The significance of each is discussed in informative annex C.

1.2 This International Standard is applicable to silver-gelatin images coated on supports of either plastic, paper or glass.

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:—3), *Photography — Density measurements — Part 2: Geometric conditions for transmission density*.

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

ISO 5-4:1995, *Photography — Density measurements — Part 4: Geometric conditions for reflection density*.

3 Terms and definitions

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

3.1

treated silver images

silver images that have been given a specific treatment, either during or after processing, to increase their stability

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3) To be published. (Revision of ISO 5-2:1991)

3.2
toned silver images
silver images that have been given a specific treatment, either during or after processing, to modify their colour

4 Dichromate bleach test

4.1 Principle

This test consists of dissolving the treated silver image and measuring the retained density. This retained density is proportional to the silver that has been chemically converted to a non-bleachable compound, or has been substituted by a non-bleachable element.

4.2 Reagents

4.2.1 Bleach solution

A bleach solution shall be prepared by dissolving 90 g of anhydrous potassium dichromate in 1 litre of water. Subsequently, 96 ml of concentrated sulfuric acid shall be slowly added with constant stirring.

WARNING — Avoid contact with the eyes, skin, and clothing. Wash thoroughly after handling. In case of contact, flush eyes and skin with water. Obtain medical attention immediately.

Take care to dispose of dichromate bleach solution in accordance with national and local regulations for hazardous waste disposal.

4.2.2 Clearing solution

The clearing solution shall be prepared by dissolving 100 g of sodium sulfite in 1 litre of water.

4.3 Specimen preparation

Six uniform-density patches shall be prepared on the treated silver material with densities (D) ranging in approximately equal increments from 0,1 above D_{min} to D_{max}.

The exact size of the patches is not critical, provided they cover the aperture of the densitometer and are easy to handle.

4.4 Procedure

Measure the treated silver image on the six uniform-density patches and on the D_{min} for status A blue density. Densities shall be measured on a densitometer having spectral conformance to ISO 5-3. The densitometer shall have geometric conformance to ISO 5-2 for photographic films and plates, and geometric conformance to ISO 5-4 for photographic papers.

Then immerse the specimen in the bleach solution (4.2.1) for 30 s at (20 ± 5) °C, rinse it in water for 2 s, and clear for 30 s in the clearing solution (4.2.2). Then rinse the specimen in water, dry it and remeasure the status A blue density.

4.5 Calculation

The percent density retention is calculated by dividing the blue density after bleaching by the original blue density (after treatment, but before bleaching) and multiplying by 100. Make this calculation for all six uniform-density patches.

With some photographic materials, particularly photographic paper prints, bleaching can cause an increase in the D_{min}. The percent density retention shall be corrected for any D_{min} increase, as shown in normative annex D.

4.6 Significance

The retained density is an approximation of the percentage of silver image that has been converted into substances which are not affected by oxidants or pollutants. A treatment that results in 65 % density retention or more after bleaching for all six density patches is considered a stable image.

NOTE This density retention value is based on the fact that since two-thirds of the image will not be affected by oxidants, there would be no loss of information. Treatments that result in a lower percent density retention may also be very stable, depending upon the image density and type of chemical conversion.

5 Hydrogen peroxide incubation test

5.1 Principle

This test consists of exposing the treated silver images to hydrogen peroxide vapour and measuring the resultant change in density. A small change in density represents an image that is resistant to peroxides.

5.2 Reagents

5.2.1 Hydrogen peroxide, reagent grade, 2 % (*m/m*) solution, freshly prepared from a 30 % stock solution.

WARNING — Hydrogen peroxide is very corrosive. Caution should be used in handling hydrogen peroxide solutions. The stock solutions should be kept refrigerated in vertical vented bottles and kept away from combustibles. Gloves and protective clothing should be worn.

Take care to dispose of hydrogen peroxide solutions according to national and local waste disposal regulations.

5.2.2 Potassium chloride, saturated solution.

5.2.3 Potassium chloride, dry solid.

5.3 Apparatus

5.3.1 Glass desiccator jar, having a nominal inside diameter of 150 mm and a capacity of 2 litres.

5.3.2 Ground plastic desiccator lid[4), fitted with a fan.

The fan motor is attached to the top surface of the desiccator lid with the shaft going through the lid to the fan mounted on the inside surface. There shall be four fan blades, each approximately 25 mm in length. The fan shall rotate at approximately 2 000 r/min.

5.3.3 Plastic collar4), that shall fit snugly inside the desiccator on which the specimens are mounted.

The collar shall be roughly 80 mm in height with an inside diameter of 135 mm and a wall thickness of approximately 7 mm. The collar shall be fitted with three baffles, each approximately 80 mm in length, 20 mm in depth, and 25 mm in width.

NOTE The baffles serve to provide more turbulent air movement and ensure uniform distribution of the hydrogen peroxide vapour. They may be constructed of a hydrogen-peroxide-resistant plastic, such as polycarbonate.

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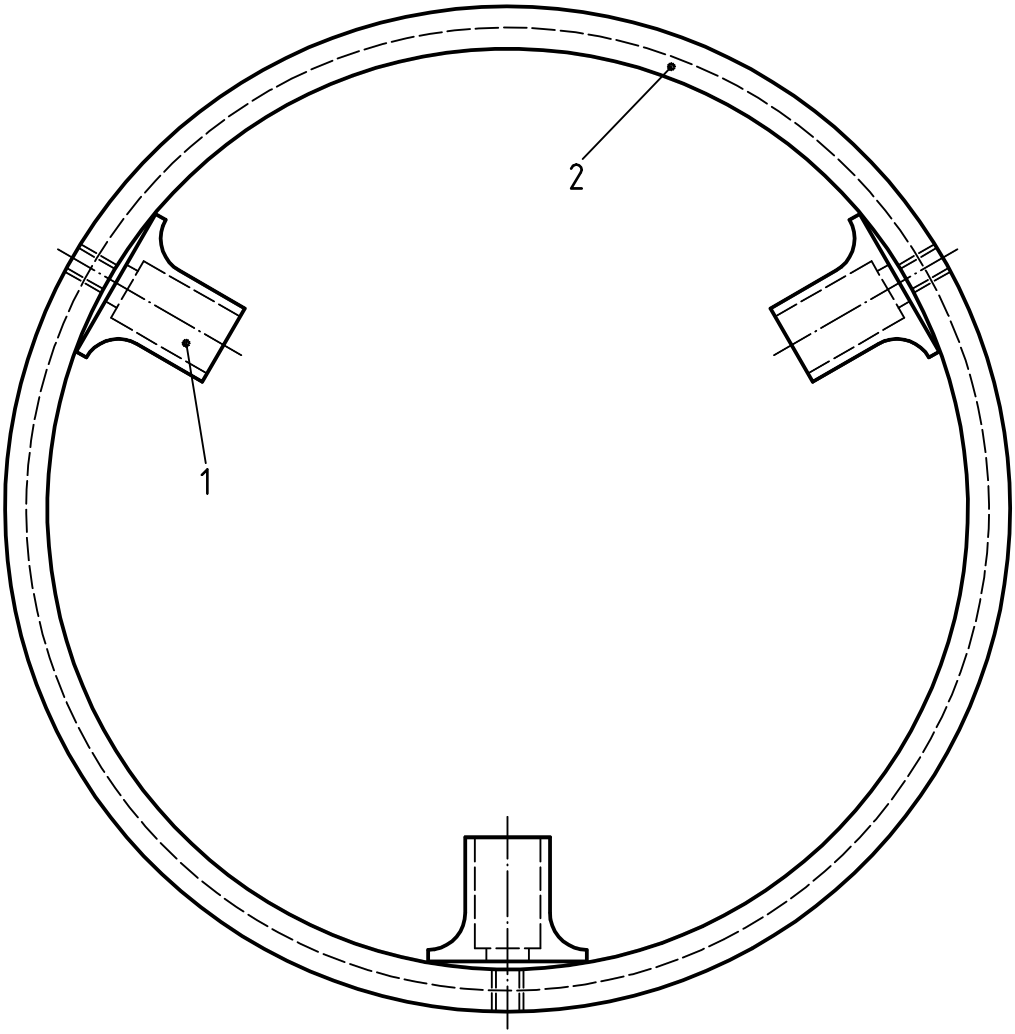
4) Poly(methyl metachrylate) has proven to be an acceptable plastic.

A drawing of the collar and baffles is shown in Figure 1.



Key

1	Baffle
2	Collar

Figure 1 — Drawing of collar and baffles

5.3.4 Perforated porcelain plate, of diameter 140 mm, which fits over the desiccator well.

5.3.5 Petri dish, of capacity 60 ml which fits into the desiccator well and holds a saturated salt solution to regulate the relative humidity.

5.3.6 Circular pad, approximately 40 mm in diameter, made of 0,3 mm chromatography paper or filter paper, with a water flowrate of 100 mm to 150 mm per 30 min, which is wired to the upper side of the perforated porcelain plate with stainless steel wire.

NOTE 1 A suitable chromatography paper is Whatman No. 3 mm CHR paper. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

NOTE 2 The flowrate refers to the capillary rise of water when the paper is partially immersed in water.

5.3.7 Oven, fan-assisted, capable of being maintained at 50 °C ± 2 °C.

The components of the desiccator jar used to expose the test specimens to hydrogen peroxide vapour are given in Figure 2 and the assembled apparatus is shown in Figure 3.

Figure 2 — Desiccator jar components

Figure 3 — Assembled desiccator jar

5.4 Specimen preparation

Six uniform-density patches shall be prepared with densities (D) ranging in approximately equal increments from 0,1 above D_{min} to D_{max}. The exact size of the patches is not critical, provided they cover the aperture of the densitometer and are easy to handle.

5.5 Procedure

5.5.1 Measure the status A blue density on the six uniform-density patches and on D_{min} before treatment. Densities shall be measured on a densitometer having spectral conformance to ISO 5-3. The densitometer shall have geometric conformance to ISO 5-2 for photographic films and plates and geometric conformance to ISO 5-4 for photographic papers.

5.5.2 Attach the specimens with the base side against the inside surface of the cylindrical collar. Take care to ensure that the specimens are snug against the collar surface.

5.5.3 Place 5 ml of a saturated solution of potassium chloride (5.2.2) in the Petri dish (5.3.5) to achieve a relative humidity of 82 %. To maintain solution saturation, add 10 g of dry potassium chloride (5.2.3) to the Petri dish.

5.5.4 Charge the desiccator by the addition of 0,12 ml of hydrogen peroxide solution (5.2.1) to the pad of chromatography paper (5.3.6). This gives a peroxide concentration of approximately 1 000 ppm.

5.5.5 Seal the desiccator jar (5.3.1) with its cover and place it in the oven (5.3.7) set at 50 °C. The fan shall be turned on for the first 30 min to uniformily distribute the peroxide vapour.

5.5.6 Remove the jar from the oven, quickly charge it with a second addition of 0,12 ml of freshly prepared hydrogen peroxide solution (5.2.1) without allowing the desiccator jar to cool to room temperature. Replace it in the oven set at 50 °C. Turn on the fan for a second 30 min. The desiccator jar shall then be incubated with the fan turned off for 17 h at 50 °C, resulting in a total incubation of 18 h.

5.5.7 Remove the specimens from the desiccator jar and redevelop them to reduce the silver that has been ionized during the test. Then wash and dry the specimens.

Redevelopment for 2 min at 25 °C in Kodak Prostar developer[5)] was found to be satisfactory for microfilms, and 30 s in Kodak Dektol developer for photographic paper prints. Developers should be at full strength.

5.5.8 Examine the specimens visually under a × 10 magnification for any evidence of red spots or redox blemishes. If there are no red spots, remeasure the specimens for status A blue density as specified in 5.5.1.

5.5.9 The change in density of the six uniform-density patches shall be corrected for the change in the D_{min} values by subtracting the change in D_{min} due to the treatment, as shown in normative annex D.

5.6 Significance

The extent to which the silver is attacked by hydrogen peroxide is evaluated by the magnitude of the change in blue density after the peroxide incubation. This is most easily shown by a plot of the change in blue density, corrected for the change in D_{min}, on the y-axis against the original blue density on the x-axis.

The effectiveness of stabilizing treatments can be quantitatively measured by the deviation of this plot from the x-axis. A stabilizing solution which results in less than a 0,05 density change for all six uniform-density patches shall be considered to be an effective treatment against peroxides.

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5) Kodak Prostar developer is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

If the peroxide incubation results in the appearance of red spots on any of the specimens, a quantitative evaluation of the effect of the stabilizing treatment cannot be made. Therefore, such a treatment shall be considered to be not effective.

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

Table A.1 — New ISO numbers

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

Table A.1 — *(continued)*

Current or former ISO number	Title	New ISO number
6051	Photography — Processed reflection prints — Storage practices	18920
15524	Photography — Polyester-base magnetic tape — Storage practices	18923
15640	Photography — Imaging materials — Test method for Arrhenius-type predictions	18924

Annex B
(informative)

Variable in silver stabilizing treatments

The stabilizing treatments that are effective for silver images are also those that have been used for toning. In fact, the enhanced image stability resulting from chemical treatment of the silver has been known for over a century (see [8] and [9] in the bibliography).

Chemical modification by noble metals such as gold can produce a cold or blue tone caused by some of the image silver being replaced by gold, forming an alloy of the two metals (see [6] in the bibliography). Another type of stabilizing treatment is toning with compounds of sulfur or selenium which produce silver sulfide or silver selenide (see [4], [5] and [9] in the bibliography). Such treatments often cause a brown or sepia tone. It is, therefore, important to consider whether any stabilizing treatment produces an unwanted colour change in the silver image. Such changes can be evaluated by visual, red, green and blue density measurements.

A satisfactory stabilizing treatment must strike a balance between the tone change of the original image, the degree of chemical conversion, unwanted stains, and solution stability. Other factors to be considered are raw material costs, conversion speed, replenishment rates, toxicity, odour, and the nature of effluents introduced into the waste water.

Annex C
(informative)

Significance of the test methods

C.1 General

Deteriorative changes in the nature and appearance of metallic silver images over time are the result of chemical reactions that take place between silver and a variety of contaminants. Such contaminants may be intrinsic to the photograph (for example, residual processing chemicals), or extrinsic (absorbed from the atmosphere or from storage enclosures).

Although the specific reactive species, chemical mechanisms and environmental circumstances may vary, protection of silver images against oxidation can be achieved in practice in different ways. The hydrogen peroxide fuming test and the dichromate bleach test indicate whether or not protection has been attained, by providing surface passivation against attack by peroxides or by substantial chemical conversion of the image silver into a less easily oxidized substance.

C.2 Hydrogen peroxide fuming test

Peroxides may originate from a number of sources in the storage environment and have been identified as a major practical cause of silver-image deterioration. Attack on metallic silver by peroxides proceeds by a multistep mechanism, beginning with the catalytic decomposition of peroxide on the silver surface and the simultaneous oxidation of silver itself.

The presence of adsorbed sulfide or iodide on the surface of the silver has been shown to inhibit or “poison” the initial catalytic step of the mechanism (see [10], [11], [12], [13] and [14] in the bibliography). Thus, significant protection against peroxide attack can be achieved by a variety of stabilizing treatments which impart a superficial covering of silver sulfide to the image silver. Polysulfide and acidified thiourea solutions are examples of treatments which have this effect.

The hydrogen peroxide fuming test in this International Standard uses a relatively high concentration of peroxide, and images which do not discolour during this test have a high degree of resistance to peroxide attack. However, the resistance to attack demonstrated in the hydrogen peroxide fuming test is applicable only to peroxides.

C.3 Importance of the chemical conversion of silver

Good performance during the hydrogen peroxide fuming test does not necessarily indicate that a silver image will not deteriorate. Protection must also be secured against reactive species which directly oxidize metallic silver.

Atmospheric ozone, nitrogen dioxide and other strong oxidants have been shown to affect silver images in spite of adsorbed surface coatings of silver sulfide (see [4] in the bibliography). Apart from direct oxidation by ozone, other pathways for corrosion exist which involve slow solubilization, migration and possible reduction of silver ions in another part of the gelatin layer (see [13] in the bibliography). In such cases, contaminants of a reducing nature or species which form complexes with silver ions can play a major role in the deterioration.

The equilibrium between metallic silver and silver ions which always exists in close proximity to image grains is disrupted when silver ions diffuse away from the grain. They may subsequently be reduced at another site or react with other species (see [14] in the bibliography). The cumulative effect of slow solubilization in this way is a gradual withering away of the original grains.

Regardless of the mechanism of oxidation, the fundamental issue is simply that the oxidation potential of silver itself is not high enough to forestall attack from real-world contaminants. Metallic silver images are not able to withstand adverse environments for long periods of time.

Stabilizing treatments to prevent oxidation of silver images by non-peroxide contaminants can therefore only be effective when they change the fundamental chemical behaviour of the image substance itself. In other words, it is necessary to convert silver chemically to a substance having a higher oxidation potential. Gold, silver sulfide and silver selenide all fit this requirement, and stabilizing treatments which achieve conversion to these substances are widely used in practice.

A critical factor in the evaluation of any such treatment is the degree to which the image is converted from silver to a less easily oxidized substance such as silver sulfide. Experiments with ozone and nitrogen dioxide atmospheres have shown that the unconverted portion of gold and polysulfide toned images is still vulnerable to attack. The extent of the conversion determines the extent of the protection in such atmospheres; the greater the conversion, the greater the resistance.

Because peroxides are of practical importance as a cause of deterioration, it is useful to have a reliable test method which determines the degree of peroxide resistance imparted to silver images by a stabilizing treatment.

C.4 Dichromate bleach test

The dichromate bleach test specified in this International Standard is a convenient way to determine approximately the extent to which an image has been converted to a chemical form which is resistant to contaminants or slow solubilization.

When little or no loss of density occurs after bleaching, the conversion of silver is nearly total. Intermediate levels of conversion can be estimated and expressed as a percentage of the original (after-treatment) density. Conversion levels of less than 100

% mean that some of the image remains as metallic silver, and thus the unconverted portion can be vulnerable to peroxide or other oxidants. Because 100 % conversion is not always practical or aesthetically desirable (significant colour changes may result when images are converted), intermediate conversion levels are often used in practice.

This explains why the two tests do not necessarily correlate. For example, an image with a high conversion to silver selenide, as determined in the bleach test, may still discolour in the peroxide test due to oxidation of the unconverted silver. Likewise, an image with a lower conversion to silver sulfide during the bleach test may show complete protection during the peroxide test due to surface passivation.

The question as to what intermediate degree of conversion constitutes a stable image is a matter of individual judgement. Experience indicates that a satisfactory print or duplicate microfilm can be made from a treated and bleached film that has approximately 65 % residual blue density after bleaching. This represents an “insurance image” which is resistant to all oxidants. Images meeting this requirement can be considered to be stable, though the unconverted silver may still deteriorate to some extent in adverse environments. In applications where no loss of the information content of images is desired (i.e. where the highest achievable stability is the objective), conversion levels as high as possible are advised.

C.5 Conclusions

The two test methods in this International Standard measure different and complementary aspects of silver-image stability.

The hydrogen peroxide fuming test relates to one specific oxidant type (peroxides) and is a yes/no determination of protection against that species of atmospheric contaminant only. Treated images which discolour during the peroxide test cannot be considered stable in an oxidizing environment. However, lack of discoloration during the peroxide test does not guarantee stability against a variety of other oxidizing contaminants. This can only be achieved by chemical conversion of image silver to a less easily oxidized substance.

When a treated image retains 65 % or more of its original density after the dichromate bleach test and does not discolour during the peroxide test, it is considered to be stable.

Stabilizing treatments have been formulated which are completely successful in preventing peroxide attack on silver images. This is of great practical benefit, not only because of the existence of peroxides in the atmosphere, but also because of their slow release from enclosure materials such as cardboard, paper and wood.

A high degree of conversion, as indicated by a high residual density during the dichromate bleach test together with complete resistance to peroxide vapour during the hydrogen peroxide incubation test, indicates that the image can withstand any plausible degree of exposure to oxidizing contaminants.

Annex D
(normative)

Correction of density values

D.1 General

The purpose of the dichromate bleach test and the hydrogen peroxide incubation test is to determine density changes in a silver image. However, changes in the D_{min} areas caused by gelatin stain or base discoloration are outside the interest of these tests. Consequently, changes in density of the silver patches shall be corrected for changes in the D_{min} area. This is illustrated by the examples in Tables D.1 and D.2 for each test.

D.2 Dichromate bleach test

In the dichromate bleach test example shown in Table D.1, the density of the 1,02 density patch decreased to 0,81 as a result of bleaching. However, there was a stain increase from 0,05 to 0,11.

The net result of bleaching is different for transmission and reflection materials. For transmission, the density of the patch due to the silver is obtained by simple subtraction of the D_{min} values. For reflection, the density of the patch due to the silver is identical to that for transmission density, except that it includes a back correction equal to one-half of the increase in the D_{min} values. The following formula is used:

$$D_{\text{patch}} \text{ (corrected)} = D_{\text{patch}} \text{ (after bleach)} - D_{\text{min}} \text{ (after bleach)} + 0{,}5[D_{\text{min}} \text{ (after bleach)} - D_{\text{min}} \text{ (original)}]$$

$$= 0{,}81 - 0{,}11 + 0{,}5(0{,}11 - 0{,}05)$$

$$= 0{,}73$$

Table D.1 — Dichromate bleach test

	D_{min}	D_{patch}	D_{patch} (corrected)	
			Transmission	**Reflection**
Original	0,05	1,02	0,97	0,97
After bleaching	0,11	0,81	0,70	0,73
% Density retention	—	—	72	75

D.3 Hydrogen peroxide incubation test

As illustrated in Table D.2, the value for the 0,40 density patch increased by 0,08 due to the hydrogen peroxide incubation and the D_{min} value increased by 0,06.

The effect of the peroxide vapour on the silver is corrected in the same manner as for the dichromate bleach test. The corrected density of transmission samples is obtained by simple subtraction of the D_{min} values. For reflection samples, the following formula is used:

$$D_{\text{patch}}\text{ (corrected)} = D_{\text{patch}}\text{ (after test)} - D_{\text{min}}\text{ (after test)} + 0{,}5[D_{\text{min}}\text{ (after test)} - D_{\text{min}}\text{ (original)}]$$

$$= 0{,}48 - 0{,}11 + 0{,}5(0{,}11 - 0{,}05)$$

$$= 0{,}40$$

Table D.2 — Hydrogen peroxide test

	D_{min}	D_{patch}	D_{patch} (corrected)	
			Transmission	**Reflection**
Original	0,05	0,40	0,35	0,35
After peroxide incubation	0,11	0,48	0,37	0,40
Change due to peroxide incubation	—	—	+ 0,02	+ 0,05

Bibliography

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

[2] HENN, R.W. and WIEST, D.G. Microscopic spots in processed microfilm: Their nature and prevention. *Photographic Science and Engineering,* **7,** September 1963, pp. 253-261.

[3] POPE, C.I. Blemish formation in processed microfilm. *Journal of Research of the National Bureau of Standards (A),* **72A,** May 1968, pp. 251-259.

[4] REILLY, J.M., NISHIMURA, D.W., CUPRIKS, K.M. and ADELSTEIN, P.Z. Polysulfide treatment for microfilm. *Imaging Technology,* **17,** June/July 1991, pp. 99-107.

[5] LEE, W.E., WOOD, B. and DRAGO, F.J. Toner treatments for photographic images to enhance image stability. *Journal of Imaging Technology,* **10,** June 1984, pp. 119-126.

[6] HENN, R.W. and WIEST, D.G. Properties of gold-treated microfilm images. *Photographic Science and Engineering,* **10,** January/February 1966, pp. 15-22.

[7] ADELSTEIN, P.Z., REILLY, J.M., NISHIMURa, D.W. and CUPRIKS, K.M. Hydrogen peroxide test to evaluate redox blemish formation on processed microfilm. *Journal of Imaging Technology* **17,** June/July 1991, pp. 91-98.

[8] HARDWICH, T.F. *A manual of photographic chemistry.* 2nd edition, London, 1855, pp. 227-228.

[9] HAIST, G. *Modern photographic processing.* Vol. 2, John Wiley, New York, 1979, pp. 95-154.

[10] BRANDT, E.S. Mechanistic studies of silver stability. 1: Redox chemistry of oxygen and hydrogen peroxide at clean and adsorbate-covered silver electrodes. *Photographic Science and Engineering,* **28,** Jan/Feb 1984, pp. 1-12.

[11] BRANDT, E.S. Mechanistic studies of silver stability. 2: Iodide adsorption on silver in the presence of thiosulfate and the influence of adsorbed iodide on the catalytic properties of silver toward hydrogen peroxide. *Photographic Science and Engineering,* **28,** Jan/Feb 1984, pp. 13-19.

[12] BRANDT, E.S. Mechanistic studies of silver stability. 3: Oxidation of silver from the vantage point of corrosion theory. *Journal of Imaging Science,* **31,** Sept/Oct 1987, pp. 199-217.

[13] HENDRIKS, K.B. The stability and preservation of recorded images. In: Sturge, Walworth and Shepp (eds.). *Imaging Processes and Materials,* 8th edition, Van Nostrand Reinhold, New York, 1989, pp. 637-684.

[14] TORIGOE, M., OHMURA, K., YAGAMI, S. and IWANO, H. *Kuroshiro shashin no choki hozonho* (A challenge in preservation of black-and-white photographic images). Scientific Publications of the Fuji Photo Film Co., 1984, pp. 31-36.

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