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Imaging materials — Processed photographic films — Methods for determining scratch resistance

Matériaux pour image — Films photographiques développés — Méthodes de détermination de la résistance à la rayure

Reference number
ISO 18922:2003(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 2.

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

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

ISO 18922 was prepared by Technical Committee ISO/TC 42, *Photography*.

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 18 900 to 18 999 (see Annex A).

Introduction

Processed photographic film should have sufficient scratch or abrasion resistance to permit satisfactory performance when it is used in equipment for which it is intended and under conditions likely to be encountered. Treatments to enhance the scratch resistance of film are commercially available. Test methods are needed to evaluate the effectiveness of such treatments, as well as to rate the inherent scratch resistance of photographic film.

Scratch resistance is a complex and abstruse characteristic. Processed photographic film is subjected to several varieties of scratch, such as those caused by grit particles or by cinching in rolls. Since each variety has a different physical mechanism, scratch resistance of film is not an absolute, singular property. One film may be rated superior to another in one test, while the opposite ranking may be found in another test. There is not a scratch or abrasion test capable of ranking a variety of film types as they would behave under different practical conditions. The test methods described in this document yield results that correlate rather successfully with practical use in some applications, but not in all.

The scratch resistance of photographic film is affected by relative humidity, processing conditions and surface friction. This means that scratch tests on photographic film are to be carried out in a controlled atmosphere with proper processing and without touching of the film surface or other handling that might unintentionally lubricate the surface. In some cases, such as lacquered or freshly processed film, the scratch resistance may change with age. Lubrication generally increases the scratch resistance of a film surface. Lubrication can be detected by the method described in ISO 18904.

Both the emulsion layer and the base side of processed photographic film are susceptible to scratching or abrasion. However, many film-handling machines are designed to protect the emulsion side as much as possible, so that the base side takes the brunt of the wear. The test methods given in this document are applicable to both sides of the film.

Scratch resistance greatly depends upon the geometry of the stylus used in the test. Styli that are nominally the same may differ widely in scratch characteristics. For this reason, the methods described in this International Standard are good for material comparisons using a single stylus point. However, agreement of scratch levels obtained with different equipment may be poor.

Unprocessed photographic emulsions generally exhibit photographic scratch or abrasion sensitivity (made visible by development) at lower levels than those where physical scratch is apparent. Method A (see Clause 3) can be used to determine photographic abrasion sensitivity, if desired; the test should be performed in the dark, and the specimen should then be processed.

Imaging materials — Processed photographic films — Methods for determining scratch resistance

1 Scope

This International Standard is applicable to evaluating the scratch resistance of dry, processed photographic film. It specifies two test methods for evaluating the scratch resistance on either the emulsion or the base side. The two test methods usually give comparable results. It provides empirical laboratory tests made under controlled conditions, but does not necessarily predict the actual scratch resistance of a film in any particular commercial machine.

Method A (see Clause 3) gives a measure of the minimum load requirement to produce a scratch, requires less elaborate evaluation equipment and is less stringent in its requirements of the optical condition of the specimens. Method B (see Clause 4) provides a measurement of haze produced by various stylus loads, is a more complete measure of scratch characteristics of a material and is the preferred method.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI/ASTM D1003-95, *Test method for haze and luminous transmittance of transparent plastics*

3 Method A

3.1 Apparatus

The apparatus shall consist of a specimen holder that will hold the specimen flat on a smooth glass plate. The specimen holder should permit smooth, linear, horizontal travel of the specimen for a distance of at least 20 mm without sidewise motion, and the holder may be either manually operated or power driven.

A spherical sapphire stylus of either 0,050 mm or 0,075 mm radius shall be used[1)]. It shall be mounted at the end of a pivoted arm, so that it can be lowered onto the specimen and thereby scribe a line on it when the specimen holder travels along under the stylus. The stylus shall make perpendicular contact with the specimen.

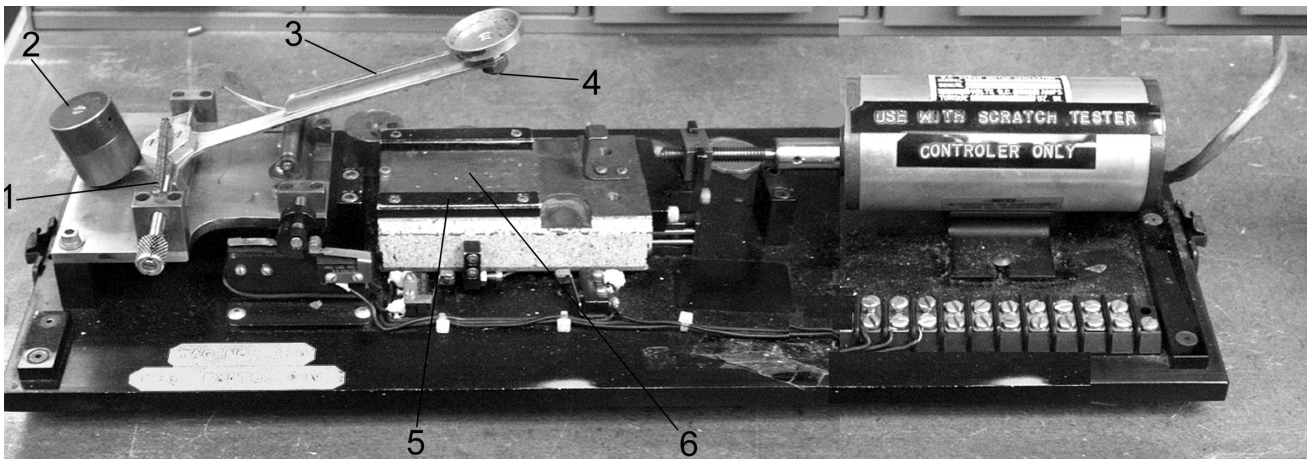
The stylus arm may be pivoted on a threaded hinge with a knurled knob or other provision for positioning the stylus laterally so that many parallel scribe lines can be made on the same specimen. Alternatively, the specimen holder can be provided with lateral positioning and a simple pivot used on the stylus arm.

1) Sapphire styli generally give results that usually reflect trade experience. They may be obtained from the following sources: Stanton, Inc., 101 Sunnyside Blvd., Plainview, NY 11803, USA; Carbide Probes, Inc., 1328 Research Park Dr., Dayton, OH 45432, USA; Sinto Kagaku, Co., Ltd., Nukui 2-16-30, Nerina, Tokyo 176, Japan. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these suppliers. Diamond styli have the advantage of greater durability, but because of their different friction properties they are frequently less sensitive to differences between materials.

The stylus arm shall be counterbalanced so that it produces no load on the stylus. The weights shall be designed so that, when used singly or in combination, the centre of gravity of the mass will be positioned directly over the stylus. Preferably, this should provide for automatic, accurate positioning. These weights should range from 1 g to 100 g, but are not necessarily limited to this range.

An example of a scratch test instrument is shown in Figure 1. Figure 2 shows a mechanical drawing of the same apparatus. Exact dimensions are not critical, except with respect to the stylus.

NOTE The test apparatus for mushiness, described in ISO 18914, may be adapted for this test which is constructed so that the load is continuously increased as the stylus arm is drawn across the specimen. However, it is not as satisfactory since only a single point, rather than a line, is obtained at each load level.



Key

1 hinge
2 knob
3 pivoted arm
4 stylus
5 specimen holder
6 aperture

Figure 1 — Spherical stylus scratch tester

3.2 Specimen preparation

Film specimens should preferably be processed so that there is no significant optical density. Film exposed with an image that contains some clear areas is also usable. Film shall be processed in the normal manner for the specific product, except where the effect of processing variables is being investigated.

NOTE Some optical density, up to 0,7, can be tolerated with only a minor effect on the results. However, it is best to avoid density entirely when possible.

Care shall be taken in handling specimens to avoid fingerprints. Use of “medicated” cotton gloves, or any other practice that might contaminate the film surface shall be avoided.

Film shall be conditioned in individual strip format for at least 2 h at the relative humidity (RH) at which the test will be conducted. During the conditioning operation, there shall be no handling of the test surface.

3.3 Procedure

A temperature of 23 °C and a relative humidity of 50 % are suggested test conditions. However, other relative humidities, such as 15 % RH and 70 % RH, may prove useful.

Key

1 hinge
2 knob
3 pivoted arm
4 stylus
5 specimen holder
6 aperture

Figure 2 — Construction of spherical stylus scratch tester

The scratch test shall be performed as follows:

— the film specimen is placed in the specimen holder, and the stylus is laterally positioned toward one side of the specimen;

— a 1 g weight is then positioned above the stylus, and the specimen holder is drawn forward with the stylus riding in contact with the surface of the specimen. A speed of 10 mm/s to 50 mm/s/s is desirable;

— two scratch lines, at least 20 mm long, are made at each load, spaced approximately 1 mm apart. The line pairs may be separated by a 3 mm spacing or more. A set of triple lines may be used occasionally to index the lines according to the load;

— after each line is made, the stylus shall be cleaned of any residual particles from the film surface. This can be accomplished by gently rotating the stylus into the grainy surface of soft balsa wood.

NOTE The effect of lubricant carry-over on the stylus after testing a lubricated specimen is usually negligible. The rate of scratching is unimportant within the range that can reasonably be obtained manually.

The load range may be varied to suit the material being tested. A recommended set of loads in grams for this test is 1 g, 2 g, 4 g, 6 g, 8 g, 10 g, 15 g, 20 g, 25 g, 30 g, 35 g, 40 g, 50 g, 60 g, 70 g, 80 g, 90 g, and 100 g. This range may be extended if required. A preliminary spot check of specific specimens may be used to determine the approximate load level required so that only the appropriate portion of the load range need be tried.

3.4 Rating

The rating of the scratch specimen is taken as the load in grams that produces the first visible scratch. The specimen shall be viewed by the means that corresponds most closely to the actual use of the film. Three methods are suggested:

— viewing the specimen using transmitted light;

— viewing the specimen in a microfilm reader;

— viewing the specimen in a 35 mm slide projector.

In the projection method, the specimen is held in a 50 mm × 50 mm slide mount. The screen shall be flat-white (not beaded) and located at a distance from the projector that will produce an image approximately 6 m in length (approximately 15 × magnification). In order to fully characterize a specimen, two ratings should be obtained. One rating may be made with the observer at a distance of 1 m from the screen. The second may be made with the observer at a distance of 5 m from the screen.

CAUTION — It is essential that the observer has normal vision when testing at these distances.

3.5 Evaluation

The evaluation is made by comparing the load ratings with the ratings of a control experiment that is run at the same time. A higher load rating indicates greater scratch resistance.

With continued use, even sapphire styli wear sufficiently to change the ratings obtained. Furthermore, it is difficult to obtain a supply of styli that are all alike. For this reason, it is desirable to use an additional control, preferably the base side of a clear unbacked film. This control is the best way of ensuring that the stylus is unchanged, undamaged, or similar to a previous stylus. When a stylus begins to give results that differ by more than 10 % from previously obtained control values, it should be replaced. In that connection, it is helpful to have a number of styli on hand that have already been checked for their control specimen ratings.

Because the first visible scratch occurs at only one stylus load for a given rating condition, no information is gained concerning the scratch severity at higher loads. For this reason, the two rating conditions (at 1 m and 5 m) specified in the “35 mm projector viewing method” offer an advantage.

The difference between the 1 m and 5 m ratings is an indication of the rate of increasing scratch severity with increasing stylus load. A large difference indicates that the specimen scratch resistance slowly becomes poorer with increasing load. If the two values are about the same, the specimen has a threshold load, below which it does not scratch and above which it scratches severely.

3.6 Interpretation

The significance of differences in rating varies with the range in which these differences lie. Below 10 g, a difference of only a few grams is usually found to be a consistent, reproducible difference. Between 10 g and 40 g, a difference of 5 g is barely significant. Above 40 g, a difference of 10 g may be significant.

NOTE 1 Significance is used here to mean a real, measurable difference in the test results; there is no implication regarding its meaning in a practical application.

In general, a difference of two or three times the significant difference shall be obtained in order to be of practical value. However, it is difficult to state this as a generalization, since evaluation depends on the nature of the practical application of the film being tested.

NOTE 2 The foregoing estimation of the magnitude of practical differences assumes that the practical application of the material under test is simulated in this test. However, there are some treatments (for example, lubrication) that, although they generally improve performance in this test and in many practical applications, have been found to produce adverse effects or no change in some other practical applications.

For certain applications, it may prove useful to determine the load required to penetrate or plough through the photographic emulsion to the extent that silver or dye is removed from the image. In this case, the film would

require exposure to give an image that is pertinent to the problem under study. The rating is then done in the same manner as described in 3.4, except that the minimum load required to plough out the image is recorded as the rating. This rating may rank films differently from the "first visible scratch" ratings.

3.7 Test report

The following information should be reported:

— name and number of the film specimen;

— film type;

— temperature and relative humidity at which the test was conducted;

— the method of viewing the specimen and the distance from the screen when using 35 mm projection viewing;

— the load, in grams, producing the first visible scratch;

— the radius of the sapphire stylus used.

4 Method B

4.1 Apparatus

The scratch test instrument for this method is essentially the same as that used for Method A. However, the specimen holder is somewhat different from the one pictured in Figure 1. Although the overall dimensions are identical, the aperture is 12 mm in width (the direction transverse to the direction of scratching).

A polished metal insert, that fits snugly into the aperture from below, is used as a backing plate for the specimen during the scratching operation. This insert can be dropped out during the evaluation operation without removing the specimen from the holder.

The aperture in the springmetal strip that secures the specimen in place has a width of about 8 mm. This acts as a mask for any perforations in the case of 16 mm film. The holder as described also readily accommodates 35 mm film. The surfaces of the holder are finished in a dull black.

In addition to the scratch tester, Method B requires a means of rating the haze of the specimen, as defined in ANSI/ASTM D1003. For this purpose, a Gardner hazemeter AUX 10A, or its equivalent, is satisfactory[2)]. It is essential to be able to measure very low levels of haze to a precision of about 0,02 % haze.

NOTE This can be accomplished by the method described, even though ANSI/ASTM D1003 states that haze shall be reported "to the nearest 0,1 %."

4.2 Specimen preparation

Film specimens should be processed to as low a level of density and haze as possible. Where hard water is used in the final wash, a distilled water rinse is advisable. Film exposed with an image is not usable. The film should be processed in the normal manner for the specific product, except where the effect of processing variables is being investigated.

The handling and conditioning specified in 3.2 apply also to Method B.

2) A Gardner hazemeter AUX 10A is an example of a suitable product available commercially. This information is given for the convenience of the users of this International Standard and does not constitute an endorsement by ISO of this product.

4.3 Procedure

In Method B, the scratching operation and rating operation are inseparable. The scratch test is performed as follows:

— a specimen is inserted in the holder of the scratch tester;

— the holder, minus its metal insert, is placed in position in the hazemeter, which is then balanced to a reading of 100. If a Gardner hazemeter is used, the instrument is first balanced to read 100 with no specimen in it. The instrument is then zeroed at this balance to compensate for stray light. A simple jig can be made to ensure reproducible positioning;

— a haze measurement is taken and is recorded as the original haze of the specimen;

— the specimen holder is then placed in the scratch tester, with the metal insert in place, and a set of ten lines is scribed at a load of 10 g with a lateral spacing between the lines of about 0,5 mm;

— the stylus is cleaned with crocus cloth, under a 1 g load, after each line is made;

— the holder is again placed in the hazemeter and a haze measurement made as before; no zeroing of the Gardner hazemeter is required in this case.

The difference between this reading and the original reading constitutes a measure of the differential haze due to the 10 scratched lines. This operation is repeated for at least two additional load levels, using a different specimen at each load. The loads chosen will depend on the film in question, but 10 g, 30 g, and 50 g ought to prove satisfactory in most cases.

In the event that there is any chatter, skipping, or otherwise nonuniform line formation, the value obtained may be in error. Care shall be taken to avoid specimens exhibiting these characteristics. The tendency for these to occur can be curtailed somewhat by avoiding high rates of scratching. If a film specimen inherently and unavoidably produces erratic line formation, Method A only shall be used.

4.4 Test report

The following information should be reported:

— name and number of the film specimen;

— film type;

— temperature and relative humidity at which the test was conducted;

— a graph of the differential haze against the load on the stylus that produced it (three load points will usually prove adequate);

— the radius of the sapphire stylus used.

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*	Imaging materials — Processed photographic films, plates and papers — Filing enclosures and storage containers	18902
6221	Photography — Films and papers — 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 — Glossary of terms pertaining to stability	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
—	Imaging materials — Thermally processed silver microfilm — Specifications for stability	18919

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

Current ISO number	Title	New ISO number
6051*	Imaging materials — Processed photographic reflection prints — Storage practices	18920
—	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
—	Imaging materials — Polyester-base magnetic tape — Storage practices	18923
—	Imaging materials — Test method for Arrhenius-type predictions	18924
—	Imaging materials — Optical disc media — Storage practices	18925
—	Imaging materials — Magneto-optical (MO) discs — Method for estimating the life expectancy based on the effects of temperature and relative humidity	18926
—	Imaging materials — Recordable compact disc systems — Method for estimating the life expectancy based on the 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.		

Annex B
(informative)

Validity of test methods

Test Method A is rather subjective. Furthermore, it is difficult to achieve absolute standardization of styli for either method. Consequently, both test methods are more valid for relative intercomparison of materials within one laboratory at any one time. Caution should be exercised in any attempts to intercompare test results from different laboratories or results obtained at widely separated times.

The results obtained by Method B regularly agree with the results of tests run by Method A. Usually 0,5 % haze in Method B is the level of severity at which scratches first become visible at 1 m as described in Method A. Quite consistently, the curves obtained by Method B will be found to cross the 0,5 % haze level at or near the load that was rated as the “first visible scratch” in Method A. This is usually a relatively low load.

Method B has an advantage over Method A in that it gives an indication of the degree of abrasion to be expected over a range of loads. While the limited information obtained from the relatively simpler Method A usually allows a correct interpretation, in some circumstances it can be misleading. Such circumstances arise in situations where the “first visible scratch” data do not give a reasonable indication of the abrasion at higher loads.

Figure B.1 shows three examples of curves (A, B and C) obtained by Method B, in each of which the “first visible scratch” occurred at 1 g; yet each of the curves is significantly different. Curves C and D show the similarity between two films that have grossly different “first visible scratch” ratings. These examples are the exception rather than the rule, but they are examples of actual tests.

[a] First visible scratch level from Method A

Figure B.1 — Haze and stylus load relationships obtained with Method B

Bibliography

[1] ISO 18904:2000, *Imaging materials — Processed films — Method for determining lubrication*

[2] ISO 18914:2002, *Imaging materials — Photographic film and papers — Method for determining the resistance of photographic emulsions to wet abrasion*

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