
**Imaging materials — Photographic
reflection prints — Determination of
abrasion resistance of photographic
images**

*Matériaux pour l'image — Impressions de réflexion
photographiques — Détermination de la résistance à l'abrasion des
images photographiques*



Reference number
ISO 18947:2013(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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 42, *Photography*.

Introduction

This method is one of a series relating to image durability. Others in this family include scratch resistance and water resistance. Compared to image permanence standards that cover ever-present environmental factors such as light, heat, ozone, and humidity, this family of durability standards covers factors that are not necessarily present in the environment. Although the consumer may have less control over the environmental factors in which a print is stored or displayed, they may have more control over durability aspects such as careful handling and good quality storage enclosures. “Accidental” exposures and resulting damage such as water or food spills on a print, as opposed to always-present environmental factors, can, with care on the part of the consumer, be reduced. Obviously, this is not always true and in some cases, such as rubbing caused by turning pages in a photo book or natural disasters caused by flooding, the end user has little control. This International Standard provides standardized requirements to evaluate and quantify the abrasion resistance of photographic images in their various formats such as hard copy prints and photo books.

Abrasion and smudge can include both accidental and repeating factors resulting from handling of the image. The following are some examples of sources of abrasions:

- dirt particles rubbing on printed surface;
- sheet-to-sheet abrasion (sliding motion of sheets relative to each other);
- prints sliding on tables or other flat surfaces;
- interaction with dirt or components inside of printers;
- magnets or other items used in the display of images.

Imaging materials — Photographic reflection prints — Determination of abrasion resistance of photographic images

1 Scope

This International Standard specifies tests to determine the abrasion, scuff, and smudge resistance of photographic images. This International Standard is applicable to photographic prints and photo books prepared by digital and analogue processes.

2 Normative references

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

ISO 2813, *Paints and varnishes — Determination of specular gloss of non-metallic paint films at 20 degrees, 60 degrees and 85 degrees*

ISO 8254-1, *Paper and board — Measurement of specular gloss — Part 1: 75 degree gloss with a converging beam, TAPPI method*

ISO 13655, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

ASTM D 2240, *Standard Test Method for Rubber Property — Durometer Hardness*

3 Terms and definitions

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

3.1

ambient conditions

environmental conditions of the test

3.2

abrasion

process of wearing away or deformation of a surface by friction as a result of rubbing

3.3

scuff

result of abrasion, leading to a change in gloss

3.4

smudge

result of abrasion leading to the displacement of colorants into adjacent areas as a result of the re-deposition of abraded material

3.5

receptor

substrate used to abrade the test specimen and onto which ink or overcoat that is removed from the specimen is transferred during the abrasion test

Note 1 to entry: An example of a receptor is the back side of the printed media being evaluated or a standard reference paper.

4 General test background

4.1 Summary of practice

This method utilizes a reciprocating rubbing device, or its equivalent, as described in ASTM F 2497, ASTM D 5264, and ASTM F 1571. Reciprocating abraders of alternate designs, such as those described in JIS K 5701-1, JIS L 0849, ISO 7784-3, or ASTM F 1319, may also be used as noted below. The test specimen is placed in contact with a receptor surface under a specified load and is rubbed with a back and forth motion at a specified frequency and for a specified number of cycles.

After treatment, the test specimen is removed from the test device and evaluated for degree of degradation by measuring the change in gloss, optical density, colorimetry, and/or change in physical appearance in both printed and unprinted (Dmin) areas. The receptor is analysed for the amount of colorant or coating transferred from the specimen as evidenced by an increase in optical density or change in colorimetry. Results are compared to equivalent, unabraded specimen and receptor.

NOTE It is not the purpose of this International Standard to define limits of acceptability or failure.

4.2 Significance and use

Depending upon their intended use applications, abrasion resistance is a desirable and sometimes critical property of imaging materials. The result of abrasion can be degradation in both image quality and functionality. The amount of abrasion damage to a photograph is dependent on many variables, including the nature of the abrading material, pressure, temperature, and humidity. This practice can be used to evaluate the relative abrasion, smudge, and scuff resistance of printed photographic images and unprinted photographic materials under laboratory conditions.

This practice can provide a reasonably simple procedure that can be used to set specifications for printed photographic materials and determine whether a product meets a predetermined standard for abrasion, smudge, or scuff resistance for a given use application.

4.3 Applicability and usage of alternative test methods

It should be noted that there are several alternative standard test methods that attempt to characterize other degradation aspects of imaging materials due to frictional contact with various surfaces under different loads and geometries. Specifically, the user of this International Standard is directed to ASTM F 1486 (GA-CAT), ASTM D 6037 (Taber), and ASTM F 1478 (Taber). Depending on the specific end-user application, one or more alternative methods may produce a more relevant result.

5 Test device

5.1 Test device description

This International Standard uses a test device¹⁾, such as described in ASTM D 5264, ASTM F 1571, ASTM F 2497, JIS K 5701-1, JIS L 0849, ISO 7784-3, and ASTM F 1319. See [Annex A](#) for a more complete description of the different abrasion testers mentioned in these referenced documents. Equipment that applies a similar reciprocating abrasive force in a similar manner as described in the preceding standards may also be used.

1) Examples of test devices are the Sutherland® Rub Tester (Danilee Co.), the AB-301 Colour Fastness Rubbing Tester (Tester Sangyo Co., Ltd.), the NUS-ISO 3 (Suga Test Instruments Co., Ltd.), the FR-2 (Suga Test Instruments Co., Ltd.), and the TRIBOGEAR TYPE 32 (Shinto Scientific Co., Ltd.) This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

5.2 Test device preparation

The test device shall be set on a sturdy bench, in a room conditioned to the desired test temperature and relative humidity. Conditions of $23\text{ °C} \pm 1\text{ °C}$ and $(50 \pm 5)\%$ relative humidity shall be used for testing, unless specific product end-use requires different conditions.

6 Sample preparation and conditioning

6.1 Test target definition

Test targets consisting of uniform patches sized to fit the test device described above shall be used. The target shall comprise a specified image substrate, with an associated substrate colour as measured in the Dmin patch, as well as the colour(s) of the imaging material utilized by the printing system under test. In the printed image areas, the target shall include neutral patches and print primary colorant patches, typically cyan, magenta, and yellow. Patches corresponding to additional colorants may also be added for such systems. For example, red, green, or blue patches may be added for systems using red, green, or blue colorants. Each colour patch shall be bordered by adjacent unimaged (Dmin) areas, oriented with the abrasive action of the test instrument, such that the smudging of colorant or imaging media into adjacent unprinted (Dmin) areas can be assessed. The optical density of each patch shall aim to be 1,5. If this density target cannot be obtained with the printing system of interest, the maximum density achievable may be used. If the printing system makes use of multiple ink levels for a colorant (e.g. cyan and light cyan ink), then a second set of patches falling between 0,3 and 0,5 density may also be included. Monochrome imaging systems (e.g. silver halide, true monochrome inks) and chromogenic imaging systems (e.g. colour silver halide) shall also use these additional density patches. The size of the patches shall be large enough to accommodate the size of the device mountings and weights. See [Annex B](#) for an example of a test target suitable for use in the test equipment described in ASTM F 2497, ASTM D 5264, and ASTM F 1571. See [Clause 8](#) for instructions on how to measure optical density.

6.2 Test target printing and conditioning

The specimen shall be a flat sample with no surface irregularities, such as scoring or creases.

If testing multiple samples, it is important that each has comparable, if not, identical colorant coverage and colorant density. When testing across different print technologies, select appropriate imaging substrates and minimize substrate differences whenever possible.

The test specimen shall be sized such that the printed colour patches and the adjacent unprinted (Dmin) areas of comparable dimensions are within the area of abrasion as defined by the specific test device being used for the test. If all colour patches and adjacent unprinted (Dmin) areas cannot fit within the area of abrasion, multiple test specimens shall be printed and tested under identical conditions.

Printer settings shall be recorded.

The method of printing and handling of printed samples shall be consistent with the anticipated product end use, including the presence of an image overcoat if integral to the printing process.

Test specimens shall be conditioned uncovered for at least 72 h at $23\text{ °C} \pm 1\text{ °C}$ and $(50 \pm 5)\%$ relative humidity. Inkjet-printed samples should be kept at these conditions for 14 days prior to testing. A shorter conditioning time may be specified when the purpose of the test is to evaluate the abrasion resistance at a shorter time after printing.

Care shall be taken to avoid contaminating the sample with fingerprints during handling, as this can potentially influence the test results.

7 Test procedure

The test shall be conducted under environmental conditions of $23\text{ °C} \pm 1\text{ °C}$ and at a relative humidity of $(50 \pm 5)\%$. The test procedure for each of the test devices referenced in [4.1](#) and [5.1](#), and described in

more detail in [Annex A](#), is slightly different, based on the specific design and capabilities of each of the test devices. The following are the key parameters that need to be controlled and reported relative to the specific test device being used:

- the size of the sample specimen and the dimensions of the printed colour patches;
- the specific receptor material and the dimensions of the receptor;
- the weight or load applied to either the test specimen or receptor;
- the number of rubbing cycles or strokes (one cycle comprises one stroke in each direction);
- the rate of cycling, expressed in cycles/minute; and
- the line speed of abrasion, expressed in mm/sec.

The values of each of these parameters shall be selected in accordance with the specific application and usage that is being evaluated. [Table A.1](#) in [Annex A](#) lists the ranges of load, cycling frequency, and line speed across the test devices referenced in [4.1](#) and [5.1](#), and described in more detail in [Annex A](#).

The minimum test duration shall be 10 cycles. The test may be continued in increments of 10 cycles up to 50 cycles and may be further continued in increments of 50 cycles up to 500 total cycles or until a specified amount of change is achieved or exceeded. In this case, the total number of cycles to reach the specified change shall be reported. If no detectable change is encountered after a total of 500 cycles, stop and report.

NOTE Other test specimens and receptor dimensions and applied loads can optionally be used in cases in which the intended conditions of use are such that the specified parameters and conditions produce results that do not adequately correlate to the abrasion, smudge, or scuff experienced under the intended conditions of use.

8 Evaluation

8.1 Sample measurement

Each specimen shall be examined for degradation using a gloss meter at either a 20°, 60°, 75°, or 85° angle as described in ISO 2813 and ISO 8254-1, as well as with either a densitometer (Status T or Status A filtration) as described in ISO 5-3 and ISO 5-4 or a colorimeter (CIE L*a*b*) as described in ISO 11664-4/CIE S 014-4/E 4 with either 0°/45° or 45°/0° geometry. Both the imaged and adjacent unimaged (Dmin) areas of the specimen shall be measured. The unimaged area(s) to be measured shall be centered in the most visibly evident smudge area adjacent to the imaged area(s). Optionally, each corresponding receptor may be measured for densitometric or colorimetric gain, due to transfer of colorant from the specimen. In cases in which non-uniform wear patterns are observed, at least five separate measurements randomly selected within the treated area shall be made and averaged so as to obtain a representative result. In any event, a minimum of three measurements per sample shall be taken and averaged. Each specimen shall also be inspected visually, and visible degradation not accounted for by changes in gloss or optical density shall also be noted.

It can be difficult to accurately measure the optical density or colorimetry of the abraded target due to non-uniform abrasion or smudge patterns. To reduce the variability of the measurement, use the largest aperture available for the densitometer or colorimeter and use an average of multiple measurements at various locations within the abraded area. Alternately, use an area or scanning array measurement system to improve the accuracy of the measurement.

NOTE 1 Other assessments may be useful in particular applications, e.g. goniophotometric measurement and analysis may be applicable to fine art materials with surfaces for which visible scuffs do not result in significant changes in gloss or density.

NOTE 2 The amount of colorant migration to the receptor does not necessarily represent the magnitude of damage on the image patch since some of the colorant loss can take the form of colorant debris that comes off the image patch during the abrasion test process but does not migrate to the receptor area.

8.2 Calculations

Calculations shall be performed to assess the difference between the treated (abraded) and untreated specimen and receptor for each colour patch and adjacent unprinted (Dmin) area on the specimen. Results shall be expressed in terms of an absolute change in gloss or as absolute or percentage change in optical density relative to the untreated specimen.

Percentage change in optical density shall be calculated per Formula (1), where d is the symbol for measured density, X is the colour patch being measured, e.g. C, M, Y, R, G, B, and N, which are the symbols for cyan, magenta, yellow, red, green, blue, and neutral test patches that are to be measured, and (Z) stands for either (R), (G), or (B), which are the symbols for the red, green, and blue Status A or Status T densities of the test patches that are measured by the densitometer.

$$\left[dX(Z)_{\text{untreated}} - dX(Z)_{\text{treated}} \right] / dX(Z)_{\text{untreated}} \times 100 \quad (1)$$

For example, the measured density of a cyan patch is represented by the expression $dC(R)$. For a secondary colour, such as red, the measured density is represented by both the blue and green components, e.g. $dR(B)$ and $dR(G)$, and for the black or neutral patch, all three components are represented, e.g. $dN(B)$, $dN(G)$, and $dN(R)$. For secondary and neutral colour patches, the percentage change in optical density shall be calculated and reported for each component.

Colorimetric changes shall be reported as ΔE^*_{ab} , per Formula (2):

$$\Delta E^*_{ab} = \sqrt{(L_t^* - L_0^*)^2 + (a_t^* - a_0^*)^2 + (b_t^* - b_0^*)^2} \quad (2)$$

where L^* , a^* , and b^* are the colour coordinates of the colour area or the adjacent unprinted (Dmin) area of the untreated sample (0) and the treated sample (t), as defined by ISO 13655.

Abrasion is expressed as the change in optical density or colorimetry of the imaged area of the specimen. Scuff is expressed as the change in gloss of the imaged or unimaged areas. Smudge is expressed as the absolute change in optical density or the change in colorimetry of an adjacent unprinted area. Colorant transfer is the change in optical density or colorimetry of the receptor.

9 Reporting

For each sample tested, the user of this International Standard shall report the following parameters, conditions, and results:

- a) a reference to this part of ISO 18947;
- b) the printer settings and materials used to make the test specimen (in the case of analogue test specimens, the process used to make the print);
- c) the test device used to perform the test, including model number, manufacturer, and any unique modifications that have been made;
- d) the dimensions of the test specimen, the individual colour patches, and the receptor;
- e) a precise description of the receptor material;
- f) the weight or load applied to the receptor and test specimen;
- g) the total number of cycles, the rate of cycling, and the line speed;
- h) the specific instruments and pertinent geometries, illuminants, and filters used to measure densitometry, colorimetry, and gloss;
- i) abrasion resistance in terms of the change in optical density or colorimetry of each of the colour patches;

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- j) smudge resistance in terms of the change in optical density or colorimetry of the Dmin area adjacent to each of the colour patches;
- k) colorant transfer in terms of the change in optical density or colorimetry of the receptor;
- l) scuff in terms of the change in gloss;
- m) any visible change not accounted for by changes in gloss, optical density, or colorimetry;
- n) the place and date of the test; and
- o) the person, institute, and/or organization responsible for the report.

Results obtained under different operating parameters and conditions or with different test devices shall not be directly compared.

Annex A (informative)

Examples of test equipment and corresponding procedures and operating parameters

A.1 ASTM D 5264, ASTM F 2497, and ASTM F 1571

The test device described in ASTM D 5264, ASTM F 2497, and ASTM F 1571 is depicted in [Figure A.1](#).



Figure A.1 — Test device described in ASTM D 5264, ASTM F 2497 and ASTM F 1571

According to the referenced ASTM standards, when this type of instrument is used, the following procedure and key parameters are typical:

A rubber pad, 76 by 152 mm, is mounted on top of the test device base and to the bottom face of the detectable receptor block. The pad face should be uniformly flat (level) with a Shore A durometer of 15 ± 5 as measured according to ASTM D 2240.

NOTE This pad will need periodic replacing as the rubber becomes brittle due to oxidation or if the rubber wears off the pad. This periodic replacing is also true of the pads that come with the test device receptor weight. Failure to replace worn pads could result in distorted test results.

The test specimen is cut to 76 mm \times 152 mm (3 in \times 6 in) and is mounted on top of the rubber pad on the test device base, and the receptor is cut to fit either the 0,91-kg (2-lb) or the 1,81-kg (4-lb) weight (depending on which one is being used). The receptor is mounted to the weight. Receptors cut to a 178-mm length (51-mm width) can be held in place by the clamps on the sides of the block, while shorter receptors (minimum of 102-mm length) can be held in place by pressure-sensitive double-sided tape. The specimen and receptor should be lightly brushed with a camel's hair brush to remove any potentially abrasive contaminants from the surfaces. A vacuum cleaner fitted with a soft nylon brush may also be used to remove contaminants from the surface.

The weight is mounted on the test device and the machine is turned on. The specimen is rubbed in increments of either 10 or 50 cycles (100 strokes) at a rate of 43 cycles/min along a 57-mm path, where one cycle is one back-and-forth stroke. The number of cycles is typically preset on the device control panel.

A.2 JIS K 5701-1 and JIS L 0849

The rubbing tester which is described in JIS K 5701-1 and JIS L 0849 consists of a curved sample stage and rubbing finger in conjunction with a loading arm. (See [Figure A.2](#)). The rubbing finger has a curved surface of 45-mm surface radius, and it is approximately 20-mm long and 20-mm wide, capable of fixing a receptor (e.g. a standard reference paper, the face or back side of an unprinted piece of the sample paper, or a cloth, such as un-dyed cotton cloth). The contact area between the sample and receptor is approximately 100 mm². One end of the loading arm is on a fixed axis, and a load is exerted on the rubbing finger at the other end. The curved specimen stage has a 200-mm surface radius, is capable of reciprocating horizontally at a speed of 30 reciprocations per minute along a 120-mm track, and is capable of reciprocating the rubbing finger in a 100-mm track.

When this type of instrument is used, the following procedure and key parameters are typical:

The test specimen is mounted on the stage, and the abrasive receptor is attached to the tip of the rubbing finger. The rubbing meter is started for 50 cycles at a speed of 30 cycles/min along a 100-mm track on the specimen exerting a load of 2 N (approximately 200 g). The load and number of reciprocations can be varied and will depend on the type of materials and the intended application.

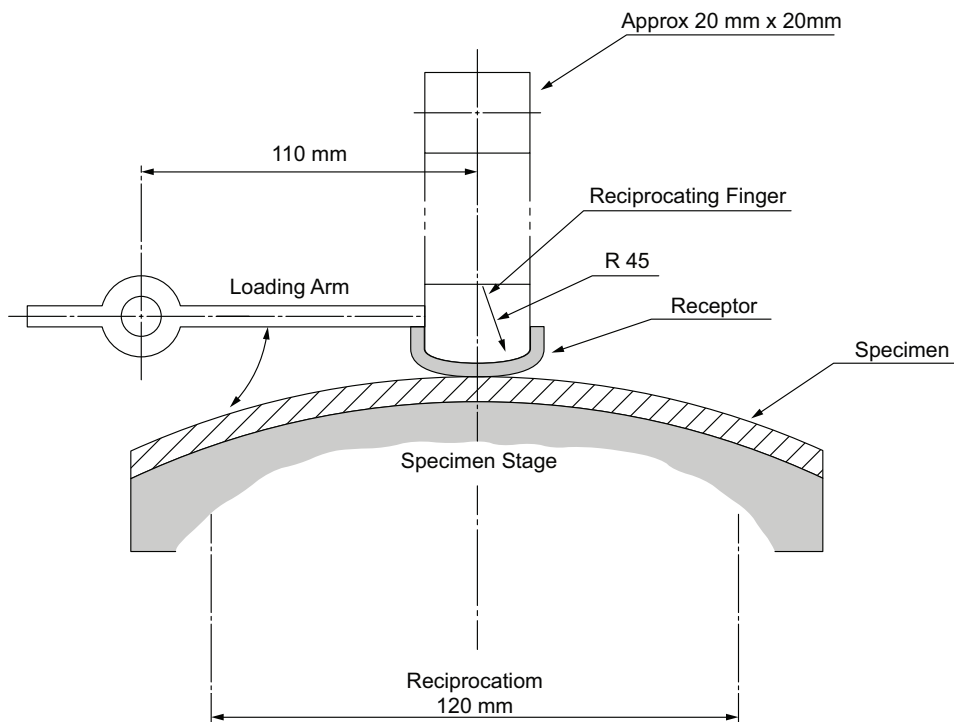


Figure A.2 — Rubbing tester

A.3 ISO 7784-3

The abrasion tester that is described in ISO 7784-3 consists of a clamping device or pressure plate for holding the test specimen level and rigid, and a 50 mm ± 0,05 mm diameter wheel, to the outer circumference of which is attached a 12-mm wide strip of abrasive receptor (e.g. paper). (See [Figure A.3](#).)

The force between the wheel and the test surface is capable of being varied from zero to at least 6,9 N ± 0,05 N. The abrasive action is produced by rubbing a test panel in a reciprocating manner (stroke length 30 mm) against a stationary wheel. After each double stroke (one cycle), the wheel is advanced through

a small angle to bring a fresh area of the abrasive receptor into contact with the test surface before making the next double stroke. The angle of rotation is such that, after 200 cycles (400 strokes), the wheel will have made one complete revolution. On completion of this cycle, the abrasive receptor should be replaced. The frequency of motion of the test panel is typically 40 cycles/min. The number of cycles may be registered by means of a counter, and provision is normally made for the apparatus to switch off automatically after a preset number of cycles has been reached (200 cycles maximum).

When this type of instrument is used, the following procedure and key parameters are typical:

The test specimen is mounted on the specimen stage. The receptor is 12-mm wide, and the length is such that it covers the circumference of the abrasive wheel without any overlap or gap at the ends (a strip length of 157 mm should be sufficient). The receptor is attached to the circumference of the wheel with double-sided adhesive tape. The specimen stage is reciprocated 50 times at a frequency of 40 cycles/min along a 30-mm track. The pressure applied to the specimen by the wheel is set between 0,98 N and 29,42 N.

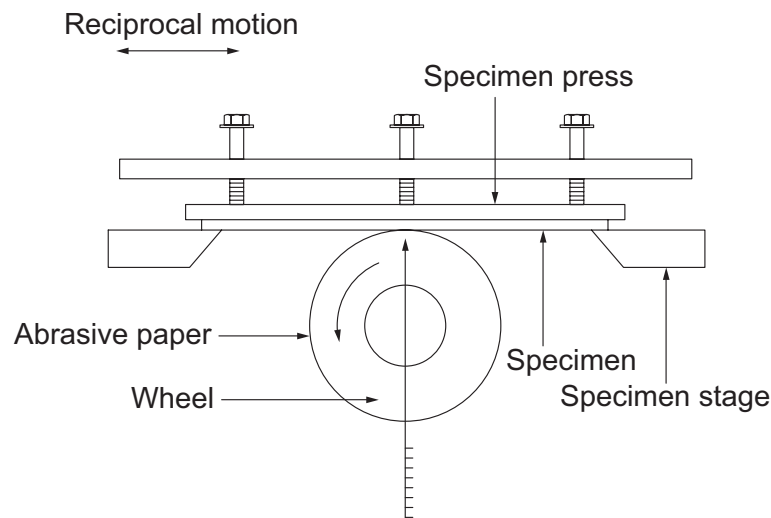


Figure A.3 — Abrasion tester

A.4 Comparison of representative operating parameters for the different test equipment described in A.1, A.2, and A.3

Table A.1 — Comparison of representative operating parameters for different test equipment

Equipment	Load (newton/cm ²)	Cycling frequency (cycles/min)	Line speed (cm/sec)
Sutherland Rub Tester	0,69	43	8,2
FR2	0,98	30	12,0
NUS-ISO-3	16,3 – 49,0	40	4,0

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Annex B (informative)

An example of a test target suitable for use in the test equipment described in A.1

[Figure B.1](#) shows a representative test target that can be used in the test equipment described in A.1. In this example, each colour patch is approximately 51 mm × 76 mm (2 in × 3 in). Each patch is tested separately by cutting into rectangular sections that measure approximately 76 mm × 152 mm (3 in × 6 in), including a sufficient area of unprinted adjacent area to assess smudge. For simplicity, [Figure B.1](#) shows only yellow, cyan, and magenta patches. As stated in the body of this International Standard, neutral and additional colour patches are prepared in a similar fashion.

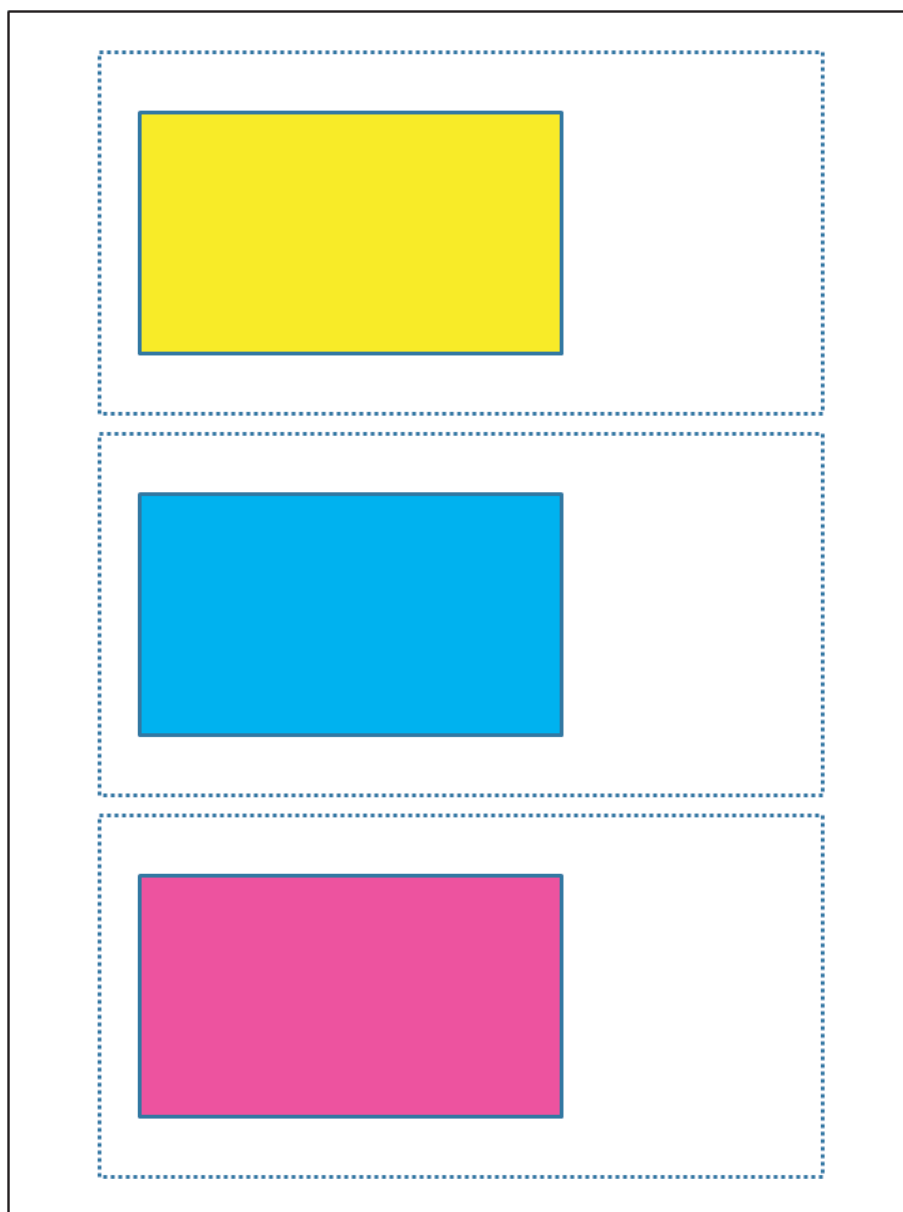


Figure B.1 — Representative test target

Bibliography

- [1] ISO 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*
- [2] ISO 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*
- [3] ISO 7784-3, *Paints and varnishes — Determination of resistance to abrasion — Part 3: Reciprocating test panel method*
- [4] ASTM D 5264, *Standard Practice for Abrasion Resistance of Printed Materials by the Sutherland Rub Tester*
- [5] ASTM F 1571, *Standard Test Method for Determination of Abrasion and Smudge Resistance of Images Produced from Business Copy Products (Sutherland Method)*
- [6] ASTM F 2497, *Standard Practice for Abrasion and Scuff Resistance of Inkjet Media by the Sutherland Rub Tester*
- [7] ASTM F 1319, *Standard Test Method for Determination of Abrasion and Smudge Resistance of Images Produced from Business Copy Products (Crockmeter Method)*
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