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Imaging materials and prints — Abrasion resistance —

Part 1:
General rub testing methods

Matériaux pour l'image et les impressions — Résistance à l'abrasion —

Partie 1: Méthodes d'essai de frottement générales

Member bodies are requested to consult relevant national interests in ISO/IEC JTC 1/SC 28,ISO/TC 130 before casting their ballot to the e-Balloting

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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 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 42, *Photography*, in cooperation with ISO/TC 130, *Graphic Technology* and ISO/IEC JTC 1/SC 28, *Office equipment*.

This second edition cancels and replaces the first edition (ISO 18947:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

— graphic prints and office prints are also covered,

— more test devices have been introduced,

— visual evaluation was added.

A list of all parts in the ISO 18947 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This method is one of a series relating to permanence and durability of image prints, which is the resistance to physical, mechanical, chemical and/or environmental stresses in conditions of use. The permanence of the image under environmental stresses is tested by each stress factor individually: light (ISO 18937[11]), heat (ISO 18936[10]), ozone (ISO 18941[12]), and humidity (ISO 18946[13]). These stress factors are given by the ambient conditions, over which the user often has limited control. The exposure to mechanical and physical stress may often be controlled by the user, unless intense handling is integral to intended use. Tests for rubbing of prints resulting in abrasion or smearing of the image are handled in the series 18947, scratch resistance is addressed in ISO 18922[8] (for film) and in the series ISO 18951 (all parts) (for reflection prints, currently under development), respectively, and durability tests to simulate accidental exposure to water or food spill is described ISO 18935[9].

The process of rubbing a surface may result in different types of degradations, e.g. abrasion, scuffing, smudging, and others. They may be observed as loss of colour intensity, scratches, changes in gloss, coloration of former uncoloured areas, (coloured) material transfer to a receptor and others.

This document provides standardized requirements to evaluate the abrasion resistance of image prints in their various formats.

Abrasion and smudge can include both accidental and repeating stresses 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.

This second edition transforms ISO 18947 into a multipart standard to extend the applicability of this standard to analogue and digital photographic, graphic and office prints. In addition, this second edition allows for the use of additional types of rub testers. The level of abrasion observed in a test depends on the combination of many factors, including factors of the print material under test as well as the test apparatus.

Different test devices show different levels of rub work, depending on the force of the device, relative movement of the samples (direction and speed), test length on the device and the selection of the material and geometry of the abrading receptor.

Material factors that contribute to friction coefficients and therefore influence the susceptibility of printed image to abrasive conditions include surface roughness, surface elasticity, substrate porosity of samples and the chemical formulation, mobility as well as localization of the colorants on the surface or within a receiver layer.

A research project[25] performed to develop content for the expansion of the applicability of this standard to prints of all kinds tried to link the magnitude of abrasion to a combination of surface roughness, surface elasticity, substrate porosity, direction of the paper fibres and ingredients of inks. The samples used were black sheet-fed offset prints. Substrates, prints and tested samples were investigated with respect to the mentioned properties. Receptors were investigated with respect to the degree of material transfer using scanning densitometry, colour measurement using diffuse sample illumination and two different scanner based image analysis systems. Unfortunately, no correlation of the optical measurements to the visual assessments could be established. This is the background that this document also requires visual assessments of rub sample series.

For photographic prints on coated photo-grade papers, a correlation between abrasion results on reciprocating, flat abrasion testers was found in a round robin study (several laboratories tested

samples of the same origin) of TC 42/WG 5, that included imaging technologies such as silver halide, inkjet, electro-photographic and dye diffuse thermal transfer. Together with results from IPI[24] this round robin study serves as background for ISO 18947-2, which is dedicated to (quasi-) linear, reciprocating, flat abrasion testing of photographic prints on photo-grade papers, including resin coated (RC photo-grade), barrier coated (water impermeable) paper and coated (water permeable) paper, as well as photo-grade films. The term (quasi-)linear considers that the test movement on the Sutherland type tester (see A.1) follows an arc segment of a circle with a large diameter, resulting in a mainly linear motion with a small orthogonal component.

Imaging materials and prints — Abrasion resistance —

Part 1:
General rub testing methods

1 Scope

This document specifies test methods to determine the rub resistance of analogue and digital prints. This includes photographic as well as graphic and office prints on all substrates. ISO 18947-1 provides information and general guidance relevant to the selection and operation of abrasion test methods and also describes general performance requirements for abrasion test devices used.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2813, *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 2834 (all parts), *Graphic technology — Laboratory preparation of test prints*

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

ISO 18947-2, *Imaging materials and prints — Abrasion resistance — Part 2: Rub testing of photographic prints*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
abrasion
loss of material from a surface or deformation of a surface, with changes in gloss, colour, or density, due to frictional forces as a result of rubbing

Note 1 to entry: Surface deformations can result in changes in gloss and colour.

3.2
analogue print
print, where the image is printed from the analogue domain

Note 1 to entry: In graphic printing, the marking information of an analogue print is generated by means of an off-line produced forme with which the ink is printed on the media. Examples of traditional forme-based printing as defined in ISO 12637-1 are flexographic, letterpress, letterset, (offset) lithographic, gravure, intaglio, pad-transfer printing, screen and stencil printing.

Note 2 to entry: Ambiguous use also for chromogenic (silver-halide) print, where image information is exposed conventionally ("analogue") through a film negative or positive, or actual scene images are exposed through camera lenses.

3.3
digital print
print where the image is printed directly from the digital domain

Note 1 to entry: Digital print is a print made directly from digital data when there is no intermediate image carrier, or when the image carrier is refreshed for each impression and thus each impression can be different in content if desired.

Note 2 to entry: Graphic printing in its various forms as defined in the ISO 12647 (all parts) is typically categorized as "analogue printing" even though data may stem from the digital domain as in the case of computer-to-plate systems.

Note 3 to entry: There is substantial confusion around the definition of this term by users, particularly in the consumer market where it may be taken to mean a print where the original image is produced or manipulated in the digital domain.

3.4
interval scale
<psychophysical> scale established by a psychophysical method, which, in addition to possessing the attributes of *rank order* (3.7), is distinguished by the fact that equal differences between numerical values correspond to equal differences between properties measured (in sensory analysis, perceived intensities)

Note 1 to entry: Larger values correspond to larger perceived intensities and the size of the difference between two values reflects the size of the difference in perceived intensity of the property being measured. However, a numerical value of zero may not indicate a total absence of the property and the ratio of two values cannot be assumed to reflect the ratio of the perceived intensities.

3.5
minimum density
D_{min}
optical density corresponding to the maximum transmittance (film) or reflectance (paper) that a printed product can achieve

Note 1 to entry: The representation of the minimum density level of a print depends on the printing technology and includes (a) non-printed area of the print material, i.e. a substrate with or without a specific image receiving or image forming layer, (b) coated or printed pre-white area (wherein a white layer is applied before the image is printed such that a coloured or transparent substrate is covered) or (c) a printed area of the material, where a transparent and/or white process colour (e.g. ink or toner) is printed image-wise.

Note 2 to entry: In this document, transparent substrates are evaluated in reflection mode by use of a white or black backing, as suitable.

[SOURCE: ISO 12641-2:2019, 3.6, narrowed to prints observed in reflection mode]

3.6
quasi-linear
<materials testing> curvilinear motion with a small component of total displacement orthogonal to its main movement

Note 1 to entry: The Sutherland type abrasion tester provides an arc motion, where the length of the arc is much shorter than the radius of the circle, resulting in a mainly linear motion with a small orthogonal component. The Martindale type tester using a Lissajous-Figure as the rub schema also has a mainly linear motion with a small orthogonal component.

3.7
rank order
result of a psychophysical method involving the arrangement by an observer of a series of stimuli in order of increasing or decreasing image quality or an attribute thereof, in accordance with the set of instructions provided

3.8
ratio scale
<psychophysical> scale established by a psychophysical method, which has the properties of an *interval scale* (3.4) but for which, in addition, the ratio between the values allocated to the two stimuli is equal to the ratio between the perceived intensities of these stimuli

Note 1 to entry: With this scale, a numerical value of zero designates total absence of the property.

Note 2 to entry: The ratio scale is the only case for which it is meaningful to say that one result is, for instance, ten times as great as another.

3.9
receptor
<materials testing> substrate used to rub the test specimen and onto which ink or other material that is removed from the specimen is transferred

Note 1 to entry: An example of a receptor is the back side of the printed media (printed or D_{min} area) being evaluated or a standard reference paper.

3.10
rub resistance
ability and/or degree of a substrate or a print to withstand rubbing, as evidenced by *abrasion* (3.1) effects

3.11
scuff
surface mark caused by rubbing or *abrasion* (3.1)

3.12
smudge
result of rubbing leading to the displacement of colorants into adjacent areas as a result of the re-deposition of abraded material

4 Principle

Depending upon their intended use applications, rub resistance is a desirable and sometimes critical property of prints. The result of rub may be degradation in both image quality and physical properties. This practice can be used to evaluate the abrasion, smudge, and scuff resistance of prints under laboratory conditions.

The key intrinsic property of a print that affects its abrasion resistance is the internal cohesion strength, the loss elastic module, the elastic module, etc. which relates to plastic deformation of the materials that make up the imaging layer of the print. The secondary property in a print that also affects the abrasion resistance is the strength of adhesion between the imaging layer material and its substrate. Finally, the condition of the substrate surface itself (such as sizing, or coating, or porosity) will also impact the abrasion resistance of a print.

This method provides a reasonably simple procedure that can be used to set specifications for prints and determine whether a product meets a predetermined standard for abrasion, smudge, or scuff resistance for a given use application.

NOTE 1 It is not the purpose of this document to define limits of acceptability or failure.

This method utilizes either a reciprocating, a rotating, a combined reciprocating and rotating, or a swing arm rubbing device. The test specimen is placed in contact with a receptor surface under a

specified load and is rubbed with a defined motion at a specified frequency and for a specified number of cycles. In case of a reciprocating device, a cycle consists of 2 strokes, namely forth stroke and back stroke.

The test results are significantly influenced by the pressure applied and the number of rub movements. They may also be influenced by the speed of rubbing. The pressure results from the force applied and the effective contact area determined both by the geometry of the instrument and on the roughness/smoothness of both the print or substrate and receptor, which may change during the test.

During tests particulates may be separated from the print/substrate or from the receptor. If these are trapped between print/substrate and receptor, severe damages to the print/substrate may result.

While test results of devices using the same pressure are comparable, the commercial devices described in A.1, A.4, A.5, and A.6 use different pressures and different rub movements. Test results between test devices with different pressures and different rub movements will not necessarily be the same.

NOTE 2 Different instruments are described in ASTM F 2497[22], ASTM D 5264[17], ASTM F 1571[21], ISO 105-X19, ISO 7784-3, ASTM F 1319[18], BS 3110[23], ISO 12947-1 or in A.6.

Results are compared to equivalent, unabraded specimen and receptor. After the test the specimen is removed from the test device and evaluated for degree of degradation by visual assessment, and if appropriate by measuring the change in gloss, optical density, colorimetry, and/or change in physical appearance in both printed and D_{min} 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. For more severe tests, mass differences may also be considered.

NOTE 3 Measuring optical density or colour or using image analysis based on scanner systems is usually insufficient to meet visual rank orders of sample series.

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 document is directed to ASTM F 1486[20] (GA-CAT), ASTM D 6037[17] (Taber), and ASTM F 1478[19] (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 document uses test devices1), such as described in ASTM D 5264, ASTM F 1571, ASTM F 2497, ISO 105 X19, ISO 7784-3, and ASTM F 1319 or in BS 3110, or in ISO 12947-1 or A.6. 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.

5.2 Test device preparation

The test device shall be set on a stable laboratory bench, in a room conditioned to the desired test temperature and relative humidity. Conditions of (23 ± 3) °C and (50 ± 10) % relative humidity shall be used for testing, unless specific product end-use requires different conditions.

1) Examples of test devices are the Sutherland® Rub Tester (Danilee Co.], the AB-3D1 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.], the TRIBOGEAR TYPE 32 (Shinto Scientific Co., Ltd.), Martindale (James Heal), RT 4 (IGT or Hanatek), and Quartant (prüfbau). This information is given for the convenience of users of this Document and does not constitute an endorsement by ISO of these products.

6 Samples

6.1 General

Photographic images printed on “photo-grade” media, including coated or surface treated papers shall be tested in accordance with ISO 18947-2.

Samples to be tested may be prints from regular print runs or test prints. Samples may also be prints treated at either side (varnished, laminated, bonded, backed, etc.). Samples shall be of a size appropriate for the test device to be used.

The evaluation of rub on printed receptor surfaces may be difficult. Therefore, standard (unprinted) receptor substrates (recommended for third party evaluation) or backsides of front side printed substrates (to simulate rubbing resistance for real production runs) are recommended.

Samples shall be tested in two directions perpendicular to each other. If there is proof of non-directional rub testing, then testing in one direction is sufficient.

NOTE Samples can show different properties depending on the rub direction. These differences in rub test directions can be caused by fibre orientation, texture or other. Rub resistance tests perpendicular to the fibre direction of graphic prints result in higher rub-off and therefore more reliable evaluation for offset printed samples.

Both the test specimen and the receptor 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. If the purpose of the test is to compare the print technologies, select appropriate substrates and minimize substrate differences whenever possible.

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

6.2 Preparation of samples and selection of the receptor material

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 or laminate if the print will generally be supplied with an overcoat or laminate.

Test prints for conventional printing processes shall be uniform and shall be prepared in accordance with the ISO 2834 (all parts) with agreed upon density or colour coordinates. Test prints for digital printing processes including photographic prints may contain special test targets.

Printed samples shall be dried or cured and conditioned to the level of the intended use prior to rub testing. Water based inkjet-printed samples shall be left face-open under the standard environmental condition at least 14 days prior to rub testing. A shorter conditioning time may be agreed upon when the purpose of the test is to evaluate the abrasion resistance at a shorter time after printing. During drying, curing and conditioning dust deposition on the surface to be tested shall be avoided.

Samples and receptor material shall be conditioned at (23 ± 3) °C and (50 ± 10) % relative humidity for 24 h or longer. A shorter conditioning time may be agreed upon when the purpose of the test is to evaluate the abrasion resistance at a shorter time after printing.

If tests need to be performed under different climatic conditions, samples also shall be conditioned in this climate and the conditions shall be recorded.

7 Test procedure

The test shall be conducted under environmental conditions of (23 ± 3) °C and at a relative humidity of (50 ± 10) %. The test procedure for each of the test devices referenced in 5.1, and described in more