
**Information and documentation —
Permanence and durability of writing,
printing and copying on paper —
Requirements and test methods**

*Information et documentation — Permanence et durabilité de
l'écriture, de l'impression et de la reprographie sur des documents
papier — Prescriptions et méthodes d'essai*

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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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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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 46, *Information and documentation*, Subcommittee SC 10, *Requirements for document storage and conditions for preservation*.

This second edition cancels and replaces the first edition (ISO 11798:1999), which has been technically revised.

The main changes are as follows.

- The reference material used for the testing of mechanical properties is defined and shall, prior to testing, be handled according to [4.5](#).
- CIELAB measurements replaces optical density measurements, i.e. evaluation of monocoloured printing shall be performed by CIELAB measurements. Accordingly, microdensitometers or densitometers are no longer needed.
- Testing of colour fastness ([5.2](#) and [6.2](#)) shall be followed to evaluate recording (monocoloured and multicoloured) for lightfastness ([6.4](#)), water resistance ([6.5](#)) and resistance to heat ([6.8](#)).
- [Table 1](#) (see [5.1](#)) presents, for printing devices, elaborated CIELAB lightness and colour shift requirements ΔL^* , Δa^* , Δb^* and, in addition, a new requirement of ΔE_{ab}^* (Euclidean distance between two CIELAB coordinates).
- [Table 2](#) (see [5.1](#)) presents, for pens and stamps, requirement of maximum CIELAB lightness change ΔL^* .
- Abrasion resistance (formerly referred to as *resistance to wear*) shall be evaluated by the degree of abrasion ([6.7](#)) and is determined by CIELAB measurements prior to, and after, abrasion.

- Detailed descriptions of specimen preparation for pens and stamps, three printout templates for specimen preparation from printers and copying machines and reporting forms are given in Annexes.

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.

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Introduction

It is of great importance that recording of images on paper which, during long-term storage in libraries, archives, and other protected environments, undergo little or no change in properties that affects its use. The documents must preserve their information content and, thus, enable information storage and information supply for the future. Accordingly, it is important to study the permanence and durability of recording on paper.

Writing materials and printing equipment meeting the requirements given in this document can be used in the preparation of paper documents intended for long-term storage and recurrent use. Such documents contain permanent and durable images, i.e. images likely to be stable and thus undergo little or no change in properties that influence legibility and the possibility of copying or converting the paper documents to other data carriers.

Permanent paper and archival paper, used in the preparation of documents, may differ widely in properties of importance for the quality and permanence of the image. Some properties of an image, such as abrasion resistance, depend on the combination of the image and the paper. The testing conditions of this document are chosen so that results, representative of most papers on the market to be used for a particular imaging process, shall be obtained.

In this document, the requirements are given in the following attributes:

- visual image colour strength and appearance;
- lightfastness;
- water resistance;
- transfer of recorded image;
- abrasion resistance;
- resistance to heat;
- effect of recording on the mechanical strength of the paper.

Experience has shown that images written with carbon black ink as well as printed images using commercial printing inks have proved to be consistently reliable. There are, however, many documents where acidic inks have affected the paper to such an extent that the paper has degraded. Images produced from dry or liquid toner are also susceptible to ageing problems.

Images printed with modern material and machinery are often completely different from old images with respect to composition and properties. The rapid development of new printing techniques makes this testing very important. One printing technology may be replaced by a newer technology within a few years on the market. Therefore, conclusions based on studies of old documents in libraries and archives are of limited use when discussing the permanence of modern documents.

Strictly speaking, the only way to test the permanence and durability of documents is to handle them and to store them under the relevant conditions for long periods of time. In practice, one can only rely on the observations made on documents kept for a few decades and evaluate the effect of factors known to influence the permanence and durability of the image. Therefore, the testing according to this document does not correlate to lifetime of documents, but rather the documents that satisfy the requirements can be stored for a long time in the future in archives and protected environments, probably for several hundred years.

Information and documentation — Permanence and durability of writing, printing and copying on paper — Requirements and test methods

1 Scope

This document specifies requirements and test methods for evaluation of the permanence and durability of writing, printing and copying on paper stored in libraries, archives, and other protected environments for long periods of time, in which the information recorded on paper must be retained but not necessarily the full artistic quality.

It is applicable to:

- images on white permanent paper according to ISO 9706 or ISO 11108;
- recording obtained from pens, stamps, copying machines and printers (that can produce monocoloured and/or multicoloured images).

It does not apply to:

- documents stored under harmful conditions, such as high humidity that promotes microbiological attack, excessive heat, radiation (e.g. light), high levels of pollutants, or the risk of water damage (or water contact). Since documents might be kept in non-protected environments before being transferred to protected environments, resistance to water and light is, however, of importance;
- legal documents, e.g. banking documents, where the authenticity is of primary interest;
- documents where the information contents are influenced by small colour changes;
- documents within the scope of ISO/TC 42, *Photography*.

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 536, *Paper and board — Determination of grammage*

ISO 1924-2, *Paper and board — Determination of tensile properties — Part 2: Constant rate of elongation method (20 mm/min)*

ISO 2470-1, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 5626, *Paper — Determination of folding endurance*

ISO 9352, *Plastics — Determination of resistance to wear by abrasive wheels*

ISO 9706, *Information and documentation — Paper for documents — Requirements for permanence*

ISO 11108, *Information and documentation — Archival paper — Requirements for permanence and durability*

ISO 12757-1, *Ball point pens and refills — Part 1: General use*

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

ISO 14145-1, *Roller ball pens and refills — Part 1: General use*

ISO 27668-1, *Gel ink ball pens and refills — Part 1: General use*

3 Terms and definitions

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

ISO and IEC maintain terminology 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 resistance rub resistance

characteristic of a document with *recording* (3.14) against losses of image or text from the action of abrasion (i.e. the ability of materials and structures to withstand mechanical wear or rubbing by means of friction)

Note 1 to entry: Abrasion resistance is measured in this standard as the *degree of abrasion resistance*, R_a (3.4).

3.2 archival paper

paper of high *permanence* (3.11) and high *durability* (3.6)

[SOURCE: ISO 11108:1996, 3.1]

3.3 CIELAB colour shift

lightness and colour change (ΔL^* , Δa^* , Δb^* and ΔE_{ab}^*) measured between two coordinates in the CIELAB colour space

Note 1 to entry: CIELAB colour space is a three-dimensional, approximately uniform colour space, produced by plotting, in rectangular coordinates L^* , a^* , b^* . It was defined by the International Commission on Illumination (CIE) in 1976 (Synonymously referred to as CIE 1976 $L^*a^*b^*$, CIELAB colour space or CIELAB values.).

Note 2 to entry: The quantity L^* is a measure of the lightness, where $L^* = 0$ corresponds to black and $L^* = 100$ corresponds to the perfect reflecting diffuser. Visually, the quantities a^* and b^* represent respectively the red-green and yellow-blue axes in colour space, such that:

- $+a^*$ is a measure of the degree of redness;
- $-a^*$ is a measure of the degree of greenness;
- $+b^*$ is a measure of the degree of yellowness;
- $-b^*$ is a measure of the degree of blueness.

If both a^* and b^* are equal to zero, the test piece is grey

Note 3 to entry: Synonymously referred to as CIE 1976 $L^*a^*b^*$, CIELAB colour space or CIELAB values.

Note 4 to entry: Adapted from ISO/TS 21331:2020, 3.3.5.

3.4 degree of abrasion resistance

R_a

measure of the magnitude of retain of recorded image (or text) on paper because of abrasion (or wear, or rubbing)

Note 1 to entry: Degree of abrasion resistance is evaluated by measuring the % of changes in L^* of a printed image or text prior to and after the abrasion test, according to ISO 13655, and is calculated according to [Formula \(5\)](#) in [6.7](#).

3.5 document

recorded information which can be treated as a unit in a documentation process

[SOURCE: ISO 5127:2017, 3.1.1.38, modified — "material object" and Notes to entry have been deleted from the definition.]

3.6 durability

ability to resist the effect of physical stress, such as wear and tear, pressure, or damage during recurrent use

3.7 image

visual representation with colourants (such as dyes or pigments) distributed on paper as text characters, lines, colour patches or other visually identifiable patterns

3.8 monochromatic image

image ([3.7](#)) with *recording* ([3.14](#)) uniformly in one colour

Note 1 to entry: Images produced in one colour from a black and white printer, or any colour from a printer that can produce other colours, such as black, cyan, magenta and yellow.

3.9 multicoloured image

image ([3.7](#)) composed of *recording* ([3.14](#)) in more than one colour, where the colours constitute part of the information contents

Note 1 to entry: It can be separated into different base colours (e.g. black, cyan magenta and yellow).

Note 2 to entry: Not to be confused with a coloured image. A coloured image is in this standard referred to as an image recorded in any colour as a *monochromatic image* ([3.8](#)).

3.10 performance testing paper

permanent paper ([3.13](#)) or *archival paper* ([3.2](#)) used for sample preparation

Note 1 to entry: The performance testing paper shall be handled according to [clause 4.1](#) and meet the requirements of [Annex A](#).

3.11 permanence

ability to remain chemically and physically stable over long periods of time

3.12 permanent image

image ([3.7](#)) which, during long-term storage in libraries, archives and other protected environments will undergo little or no change in properties that affect its use

3.13

permanent paper

paper of high *permanence* (3.11) in accordance with ISO 9706

3.14

recording

process of performing writing, printing and copying on paper

3.15

spot colour image

specialized ink mixes to create a specific predetermined uniform colour in commercial printing

3.16

sample

aggregate of all the *specimens* (3.17) taken to be representative of a lot

[SOURCE: ISO 4046-5:2016, 5.100]

3.17

specimen

portion of a paper or board sample (in this context performance testing paper with recording from the tested writing, printing, or copying material) sufficient in size so that *test pieces* (3.18) can be obtained from it

[SOURCE: ISO 4046-5:2016, 5.106, modified — text in brackets has been added.]

3.18

test piece

piece or pieces of paper or board on which the measurement is carried out in accordance with the stipulations of the method of test

[SOURCE: ISO 4046-5:2016, 5.118, modified — Note to entry has been omitted.]

4 Preparation of specimens

4.1 Performance testing paper

Paper used for production of specimens shall meet the requirements of [Annex A](#).

For the use of archival paper (in accordance with ISO 11108) as performance testing paper, watermarks may be present on various spots throughout the specimens. Such imprints are basically attenuations of the paper and indicate authenticity. To avoid misleading testing results, the watermarks shall be avoided for the test piece preparation when tested according to [6.2](#), [6.4](#), [6.5](#), [6.7](#), [6.8](#) and [6.9](#).

4.2 Conditioning of document substrates and recording atmosphere

Preferably, material (including paper) should be conditioned for at least 15 h at $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$ before recording. The recording should be performed in the same atmosphere. If this is not possible, instructions from the manufacturer of the recording equipment to be tested shall be followed.

4.3 Guidance for sample preparation

Specimens for testing purposes shall be prepared as described in an International Standard dealing with the specific type of recording equipment. If no such standard is available, the preparation of specimens shall be performed according to the instructions of the manufacturer of the recording equipment.

The test patterns shall be recorded to conform with [Clause 6](#) using the same printing/writing method, ink, and paper combination, identical to the intended application or user case. Characters, spacing, etc.

shall represent normal use of the recording equipment intended for testing. Specimen preparation shall also meet the requirements of [Annex B](#).

Three printout templates and the number of specimens that shall be used for sample preparation are given in [Table C.1](#) of [Annex C](#).

For printers and other recording devices, in addition to their manufacturer/brand, model number and serial number, note the print adjustment settings (such as paper setting, driver setting, colour mode and printing speed used), if specific print adjustments are to be made.

NOTE Print adjustments and other settings on a printer may have major impact on the permanence of the printed images. Accordingly, the print adjustments and print settings are two very important parameters to report, because different settings can drastically change the quality of the recorded information and thus impact its permanence.

4.4 Conditioning of specimens

Printed specimens shall be dried or cured and conditioned to the level of the intended use prior to testing. The specimens shall be kept at $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$ for at least 24 h (depending on the type of printing method) prior to further test piece preparation and testing. Inks that must evaporate or cure, such as water-based inkjet-printed specimens, shall be conditioned at least 7 days prior to the testing. When testing the mechanical strength of the paper (see [6.9](#)), the preparation of test pieces, conditioning and testing atmosphere shall be in accordance with ISO 1924-2 and ISO 5626.

The specimens shall not be touched with bare hands.

4.5 Reference material used for testing of mechanical properties

Tensile energy absorption (see [6.9.2](#)) and folding endurance (see [6.9.3](#)) are both comparative tests between test specimens (performance testing paper with recording) and reference specimens (performance testing paper without recording). Accordingly, for a reliable comparison, all the performance testing paper used, for both test and reference specimens, shall be ensured to come from the same batch and also from the same section of the paper roll (i.e. sorted paper). In addition, paper is a sensitive material and is strongly affected by the surrounding climate, so the reference specimens shall be handled and stored in a similar manner as the test specimens prior to testing. Due to such unique handling, the reference specimens are restricted to the corresponding test specimens and cannot be used for other comparative tests.

EXAMPLE If test specimens are prepared for, such as a printer outside the laboratory, the reference specimens are brought to all environments where test specimens are produced and are stored together, preferably in the same box, prior to preparation of test pieces in the laboratory.

5 Required characteristics

5.1 General

Paper documents conforming to this document shall meet the following requirements. Specimens for testing shall be prepared as described in [Clause 4](#) and tested according to [Clause 6](#).

5.2 Colour fastness

The colour fastness is evaluated as CIELAB colour shift between before and after each test when tested according to [6.4](#), [6.5](#) and [6.8](#), and measured according to [6.2](#).

The colour change of monochromatic images obtained from printing devices shall not exceed the maximum CIELAB lightness and colour differences specified in [Table 1](#).

For printing equipment that can produce multicoloured images (from e.g. toners or inks), all the base colours such as cyan, magenta, yellow and black (CMYK), shall be tested individually to cover all sets of

chemical compositions of the multicolour. For spot colour images, each spot colour shall individually be tested. The colour change (for each base colour or spot colour) shall not exceed the maximum CIELAB lightness and colour differences specified in [Table 1](#).

The colour tone of the image may change visually but it shall still be recognizable as being of the same colour as before the treatment.

Table 1 — Maximum CIELAB lightness and colour changes for printers and other machines

Test property	ΔL^*	Δa^*	Δb^*	ΔE_{ab}^*
5.4^a , 5.5^b and 5.8^c All colours except yellow	±8	±8	±8	≤10
5.4^a , 5.5^b and 5.8^c Yellow	±8	±8	±15	≤15
<p>^a Lightfastness.</p> <p>^b Water resistance.</p> <p>^c Resistance to heat.</p> <p>NOTE 1 ΔL^* is lightness difference and Δa^*, Δb^* and ΔE_{ab}^* are colour differences.</p> <p>NOTE 2 The presented maximum changes are valid for uniform colours, such as cyan, magenta, yellow and black (CMYK).</p>				

The lightness change of images obtained from pens and stamps shall not exceed the maximum CIELAB lightness changes specified in [Table 2](#). For pen writing with blue ink, the colour may change from blue to green when testing lightfastness and resistance to heat. This is acceptable if the requirement in [Table 2](#) is met.

Table 2 — Maximum CIELAB lightness changes for pens and stamps

Test property	ΔL^*
5.4^a	±15
5.5^b and 5.8^c	±10
<p>^a Lightfastness.</p> <p>^b Water resistance.</p> <p>^c Resistance to heat.</p> <p>NOTE Multicoloured images (where colours constitute parts of the information content) are not possible to produce from pens and stamps, and thus, only lightness difference ΔL^* is required to measure.</p>	

5.3 Visual appearance

5.3.1 Each element of the specimen images shall be clearly defined and easily legible when inspected as described in [6.3](#). The colour strength shall be even, and the print density and colour intensity shall be satisfactory by eye for each colour that is tested. Text characters shall be easily legible. Feathering or strikethrough shall not be visible without magnification.

5.3.2 For printing or copying on paper, if traces of characters are detected outside the intended area on the paper specimens, anywhere on the white sections of the paper, and the assessment is that this appearance can interfere with the information content of the document, those specimens shall be regarded as failed. Such incident is referred to as ghost printing.

5.3.3 For printing devices that can produce multicolours, this visual appearance requirement shall be met for each base colour.

5.4 Lightfastness

After illumination in accordance with [6.4](#), images shall meet the requirements of colour fastness in [5.2](#).

5.5 Water resistance

After treatment with water in accordance with [6.5](#), images shall meet the requirements of colour fastness in [5.2](#).

NOTE Resistance to forgery by chemicals may be important for some types of documents, such as banking documents. ISO 12757-2 and ISO 14145-2 contain requirements on resistance to chemicals other than water.

The image shall also meet the requirements of [5.3.1](#) when inspected visually as described in [6.3](#). However, noticeable traces of characters can occur on the white adjacent paper loaded against the test piece. This is acceptable if the image on the test piece meets the requirements stated in the first sentence of this paragraph.

Only a slight discolouration of the paper is accepted, $\Delta E_{background} < 5$, when determined in accordance with [6.5](#).

5.6 Transfer of recording

Test pieces kept in a stack under pressure as described in [6.6](#) shall show no evidence of blocking (sticking) or damage to the images after separation. No characters, or parts of characters, shall be visible on the adjacent paper, but traces of transfer in the form of small dots are acceptable if the image on the test piece meets the requirements stated in the first sentence.

For printing devices that can produce multicolours, this requirement shall be met for each base colour.

5.7 Abrasion resistance

When testing abrasion resistance, the degree of abrasion resistance of the image shall be $\geq 75\%$ as specified in [6.7](#). The abraded surface will be affected by the abrasion procedure, and when inspected visually, smaller fibres of uniform size can be found, but larger fibres shall not be found.

Flaking of part of the image, causing partial deletions or voids, shall not occur on the test pieces containing alphabetical characters when abraded as specified in [6.7](#), steps 8 to 9.

5.8 Resistance to heat

Images that have been exposed to heat in accordance with [6.8](#) shall meet the requirements of colour fastness in [5.2](#). The image shall also meet the requirements of [5.3.1](#) when inspected visually as described in [6.3](#).

5.9 Effects of recording on the mechanical strength of the paper

5.9.1 General

The mechanical strength of the paper may be affected by the recording process and by the recorded image. Heat, radiation and chemical agents involved in the recording process may cause degradation of the paper.

For paper documents prepared by recording processes that involves processes which may cause degradation of the paper, the requirements of [5.9.2](#) and [5.9.3](#) shall be met in both machine- and cross-directions of the paper. For paper documents prepared by recording processes where no such processing occurs, only the requirements of [5.9.2](#) shall be met in both machine- and cross-direction of the paper. In the case of, for example, ball-point pens, where specimens in accordance with [6.9.2](#) are normally obtainable in one direction only, testing in one direction is accepted.

5.9.2 Tensile energy absorption

The tensile energy absorption of the test pieces with recorded images shall not be lowered by more than 10 % as compared to the reference pieces (blank paper), when tested as described in [6.9.2](#). This requirement applies to both the unaged test pieces as well as to the aged test pieces in accordance with the accelerated ageing conditions described in [6.8](#).

5.9.3 Folding endurance

The folding endurance of the test pieces with recorded images shall not be lowered by more than 0,1 as compared to the reference pieces (blank paper), when tested as described in [6.9.3](#). This requirement applies to both the unaged test pieces as well as to the aged test pieces in accordance with the accelerated ageing conditions described in [6.8](#).

6 Test method and procedure

6.1 General

To comply with the requirements of document permanence and durability, nine test methods are required in this document. These test methods assess the permanence and durability of recorded information under different types of stresses from the storage or display environment to the ordinary wear and tear during the usages.

For the testing, prepare specimens as described in each test method and in accordance with [Clause 4](#) and [Annex B](#).

6.2 Colour fastness

This test examines the colour fastness of recorded images and is a measure which is used to evaluate the tests of lightfastness (see [6.4](#)), water resistance (see [6.5](#)) and resistance to heat (see [6.8](#)).

To produce specimens for colour fastness from printing devices, use the printout template with colour patches attached in [C.3](#) and use the printout template 2, [Figure C.4](#). Specimens from pens and stamps shall be prepared according to [B.4](#) and [B.5](#).

From the specimens, prepare test pieces with colour patches of uniform colour that are appropriate in size for the intended spectrophotometer. Perform measurements on the colour patches and determine the CIELAB lightness and colour coordinates L^* , a^* , b^* according to ISO 13655 prior to exposure (coordinate L_0^* , a_0^* , b_0^*) and after exposure (coordinate L_1^* , a_1^* , b_1^*) of each test as described in [6.4](#), [6.5](#) and [6.8](#). Measurement condition M1 shall be used with the same paper used for recording as background. For reliable measurement results, multiple test pieces shall be measured according to [6.4](#), [6.5](#) and [6.8](#). Measurement instruments shall be calibrated in accordance with the manufacturer's instructions.

For printing devices that can produce multicoloured images, identify each base colour and perform measurements on each colour individually, such as cyan, magenta, yellow and black (CMYK). If spot colours are used, measurements shall be performed on each spot colour with the same procedure. Process colours shall not be used for the measurements. However, if there are difficulties to produce specimens with completely pure colours for each base colour, exceptions can be made.

For pens and stamps, only the lightness shift ΔL^* shall be calculated using [Formula \(1\)](#). For printing devices and other machines, make calculations of CIELAB lightness and colour differences (colour shifts) ΔL^* , Δa^* , Δb^* and ΔE_{ab}^* as follows:

— Calculate the lightness difference ΔL^* as shown in [Formula \(1\)](#);

$$\Delta L^* = L_1^* - L_0^* \tag{1}$$

where

L_1^* is the lightness coordinate after exposure;

L_0^* is the lightness coordinate prior to exposure.

— Calculate the differences Δa^* and Δb^* as shown in [Formulae \(2\)](#) and [\(3\)](#);

$$\Delta a^* = a_1^* - a_0^* \quad (2)$$

$$\Delta b^* = b_1^* - b_0^* \quad (3)$$

where

a_1^* , b_1^* are the coordinates after exposure;

a_0^* , b_0^* are the coordinates prior to exposure.

— Calculate the CIELAB colour difference ΔE_{ab}^* (Euclidean distance between two points) as shown in [Formula \(4\)](#):

$$\Delta E_{ab}^* = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2} \quad (4)$$

NOTE There are 4 conditions relating illumination spectra specifications in ISO 13655. M0 corresponds to the CIE illuminant A, as specified in ISO 5-3 for density measurements, in which UV spectra are not specified. M1 matches the CIE Illuminant D50, which include UV spectra equivalent to D50. M2 matches the CIE D50 spectra in the visual range but excludes UV spectra to remove the effect of fluorescence caused by UV illumination. M3 is the illumination condition through a polarizer to suppress the influence of surface reflection on the colour coordinates. M1 is used in this document to measure colour coordinates and their changes which correlate well with colour appearance under the D50 illuminant determined by colourants and paper properties, and their changes, i.e. degradation of optical brightener in papers in addition to colourant caused by light exposure.

6.3 Visual appearance

This test examines the appearance of recorded images, i.e., the readability of recorded information on a document.

Prepare at least 5 specimens with recording of lines, alphabetical characters and patches of uniform colour included (for printing devices, use the printout templates in [C.3](#) and [C.4](#), and for pens and stamps, prepare specimens according to [B.4](#) and [B.5](#)).

Inspect each specimen visually for defects, such as voids or broken characters, bad edge definition, uneven colour, and others like traces of image characters outside the intended area using a magnifying glass or an equivalent device at 8X magnification. Evaluate the density, legibility and colour intensity of the recording. Inspect if feathering or strikethrough has occurred. Specimens from each colour shall be inspected individually.

6.4 Lightfastness

This test examines if daylight through a window or strong indoor light has negative impact on recorded images. Lightfastness is a measure of the ability of recorded images to withstand strong light exposure with minimal change in colour tone. The colour change is calculated based on CIELAB measurements performed before and after exposure to light.

Prepare test pieces as strips, so that measurements can be made on three images, according to [6.2](#).

Illuminate the test pieces with a xenon arc lamp through window glass filters in accordance with method B of ISO 4892-2. Expose the test pieces for 60 h to achieve the UV-light dose of 0,108 J/m² using irradiance 50 W/m² at broadband 300 nm to 400 nm. The black panel temperature shall be controlled within (60 ± 3) °C and the humidity shall be controlled within (50 ± 5) % RH.

Determine the CIELAB lightness and colour differences for images as specified in 6.2. Calculate the average values based on measurements of the three test pieces.

6.5 Water resistance

This test examines whether water contact, which might occur in the event of for example a water leakage in an archive, has a negative impact on recorded images. Water resistance is a measure of the ability of recorded images to withstand water damage with minimal change in colour tone. The colour change is calculated based on CIELAB measurements performed before and after exposure to water.

Prepare, from specimens with approximately 10 % image coverage, test pieces as strips so that measurements can be made on two images according to 6.2. Leave an area of the test piece free from image and, if needed, use this area for determination of the colour change of the background.

Completely immerse the test pieces in glass tubes with deionized water for 24 h, with one tube for each test piece. Lift the test pieces carefully onto a performance testing paper (see Annex A). Place a piece of the performance testing paper on top of the test pieces and load with a pressure of 7 kPa. Remove the paper and the load after 10 min. Leave the test pieces to dry.

Inspect the dry test pieces visually as described in 6.3. Determine the CIELAB lightness and colour differences for images as specified in 6.2. Calculate average values based on the measurements of two test pieces.

If a discolouration of the test piece is visually observed on the white parts of the paper, determine the colour change of the paper background ($\Delta E_{background}$) by measuring the colour difference in ΔE_{ab}^* between a performance testing paper and the discoloured area on the test piece.

6.6 Transfer of recording

This test examines if recorded images kept in a stack has negative impact on the ability of recorded images to remain intact on the paper substrate without being transferred to an adjacent paper. Transfer of recording is estimated by separating test pieces kept in a stack and subjected to a load under elevated temperature and humidity.

For preparation of imaged specimens using printing devices, use the images of printout template 2 in Annex C, Figure C.3 (alphabetical characters). For preparation of imaged specimens using pens and stamps, follow the procedure in B.4 and B.5, respectively.

Condition imaged specimens and non-imaged performance testing papers at (23 ± 1) °C and (50 ± 2) % RH for at least 24 h.

Cut the specimen with the recorded images into five smaller test pieces of appropriate size (e.g. squares of 16 cm²). For testing of multicolours or spot colours, five test pieces shall be prepared for each base colour or spot colour. Cut the specimen of a blank performance testing paper into six pieces of similar size.

Place the above five imaged test pieces and the six pieces of blank performance testing paper into a stack in alternate order (i.e. performance testing paper, test piece, performance testing paper, test piece and so on) on a flat plate of an inert material. Then, cover the stack with another plate of inert material. Finally, add a weighting load on the stack to reach a total pressure of 7 kPa.

Keep the above sample stack in a humidity chamber with a temperature of (50 ± 1) °C and (60 ± 2) % RH for 6 days.

Remove the load and allow it to cool down to an ambient temperature of $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$ for at least 15 h before separating the test pieces from the blank performance testing paper.

Inspect the image and the adjacent performance testing papers visually. Record the observation, if the image is intact on the test piece and if characters, or traces of characters, are visible on the adjacent paper.

6.7 Abrasion resistance

This test examines the impact of abrasion on recorded images. Abrasion resistance is a measure of the ability of recorded images to withstand damage due to wear. The colour change is calculated based on CIELAB measurements performed before and after abrasion.

For preparation of imaged specimens using printing devices, use the two images of printout template 1 in [Annex C, Figures C.1](#) and [C.2](#) (print two specimens). For preparation of imaged specimens using pens and stamps, follow the procedure in [B.4](#) and [B.5](#).

Follow these 9 steps for assessment of the “degree of abrasion resistance”, as well as the “partial deletions, flaking and voids”.

— Degree of abrasion resistance

- 1) Cut a test piece containing a colour patch.
- 2) Measure the CIELAB lightness coordinate L^* according to ISO 13655 on the colour patch prior to abrasion and on the performance testing paper. The performance testing paper shall be measured only once before abrasion. Calculate the lightness difference, $\Delta L_P^* (initial)$, for the colour patch and the performance testing paper according to [Formula \(5\)](#):

$$\Delta L_P^* = L_{paper}^* - L_{colour\ patch}^* \quad (5)$$

- 3) Abrade the test piece with a testing machine in accordance with ISO 9352, using abrading wheels with abrasive action very mild to mild (e.g. Taber Abraser CS 10F¹⁾) and load 2,5 N. Prior to abrasion, the abrasive wheels are sanded against sandpaper, with grit size ≥ 150 (e.g. Taber Abraser refacing disc S-11), 25 turns before each new test piece is mounted;

NOTE 1 The durability of the abrasive wheels is limited, and the expiration date must not be exceeded.

- 4) The wheels shall rotate 140 turns in total. Use a soft brush to cleanse the test piece and wheels from dust every 35 turns;
- 5) Measure the CIELAB lightness coordinate L^* according to ISO 13655 on the colour patch after abrasion. Calculate the lightness difference, $\Delta L_P^* (abraded)$, for the colour patch and the performance testing paper according to [Formula \(5\)](#);
- 6) Calculate the degree of abrasion resistance R_a as shown in [Formula \(6\)](#):

$$R_a = \frac{\Delta L_P^* (abraded)}{\Delta L_P^* (initial)} \times 100 \quad (6)$$

where R_a is the degree of abrasion resistance (%).

Calculate the degree of abrasion resistance as an average based on at least three colour patches.

1) Taber Abraser CS 10F and Taber Abraser refacing disc S-11 are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

- 7) Inspect the abraded area visually and note if large fibres are found. If so, reduce the number of total turns by 10 or 20 and repeat the procedure. Note this deviation in the report.
 - Partial deletions, flaking and voids:
- 8) Cut another test piece containing alphabetical characters;
- 9) Abrade that test piece as in step 3) but only for 35 turns in total. Inspect the test piece visually and note partial deletions, flaking and voids on the characters.

NOTE 2 Experience has shown that wearing 25 % of the total number of abrasions in step 3) on alphabetical characters, partial depletion and flaking occur more easily as compared to fields with uniform colour. Since alphabetical characters are information carriers, this step is very important.

6.8 Resistance to heat

This test examines if elevated temperature, which might occur in the event of for example a fire incident, has a negative impact on the information content of recorded images. Resistance to heat is a measure of the ability of recorded images to withstand such elevated temperatures with minimal change in colour tone. The colour change is calculated based on CIELAB measurements performed before and after exposure to a high temperature condition.

Prepare test pieces as strips, so that measurements can be made on three images, according to [6.2](#).

Keep test pieces in a climate chamber at (90 ± 1) °C and (50 ± 2) % RH for 12 days. Pass air at a rate of (50 ± 25) ml/min through the chamber. Keep test pieces in a sample rack (without any strain) and ensure that the pieces do not contact each other or the wall of the chamber.

Determine the CIELAB lightness and colour differences for images as specified in [6.2](#). Calculate average values based on measurements of the three test pieces.

Inspect the test pieces visually as described in [6.3](#).

6.9 Effects of recording on the mechanical strength of the paper

6.9.1 General

6.9.1.1 For specimen preparation, record lines across ten sheets of the performance testing paper, in machine- and cross-directions. For imaged specimens made from printing devices, use printout template 3 in [Annex C, Figure C.6](#). For imaged specimens made from pens and stamp impressions, follow the procedure in [B.4](#) and [B.5](#).

6.9.1.2 Both test specimens and reference specimens shall be handled in accordance with [4.5](#) prior to testing.

6.9.2 Tensile energy absorption

This test examines if the recorded images have a negative impact on the tensile energy absorption of the paper substrate. Tensile energy absorption is a measure of the ability of paper to absorb energy at the strain rate of the test instrument. This measure indicates the durability of paper when subjected to a repetitive or dynamic stressing or straining. Tensile energy absorption is measured and compared between imaged and non-imaged reference test pieces. The relative % change in average tensile energy absorption is calculated in both machine- and cross-directions, both before and after accelerated ageing.

Cut test pieces as strips according to ISO 1924-2. Cut 20 test pieces from 10 different imaged specimens (see [6.9.1.1](#)), and 20 reference pieces from the blank performance testing papers (see [4.5](#)), in both the machine- and cross-directions of the papers. When cutting the test pieces, make sure that the lines are perpendicular to the length of the strips. The lines shall be placed across the middle of the strips

extending to the edges. For testing of multicolours, each base colour shall be represented on at least one of the ten test pieces.

Separate the 20 test pieces and reference pieces into two sets, with 10 pieces of test and reference samples in each set. Age one set of the test and reference pieces together in a climate chamber of $(90 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$ for 12 days, as specified in 6.8. After ageing, the aged strips shall be allowed to cool for at least 24 h prior to testing.

In parallel to the above ageing group, store another unaged set of test and reference pieces in an ambient condition at $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$.

Determine the tensile energy absorption of both the unaged and the aged set of ten test and reference pieces according to ISO 1924-2, in both the machine- and cross-directions of the paper. The measurements shall be performed in an ambient condition of $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$.

Calculate the average tensile energy absorption for the test and reference pieces, based on 10 measurements of each, and from both the unaged set and the aged set.

Determine, for both aged and unaged set, the change in average tensile energy absorption between the test pieces and the corresponding reference pieces (expressed in %) for both machine- and cross-direction.

NOTE If the paper is affected by the image, the strips will break at the lines.

6.9.3 Folding endurance

This test examines if the recording process has negative impact on the folding endurance of the paper substrate. Folding endurance is a measure of the durability of paper when repeatedly folded under constant load and determines how many times the paper can be folded until it breaks. Folding endurance is measured and compared between recorded and non-recorded test pieces. The change in average folding endurance is calculated in both machine- and cross-directions, both before and after accelerated ageing.

Cut test pieces as strips in the machine- and cross-directions of the papers according to ISO 5626. Cut 20 test pieces from 10 different imaged specimens (see 6.9.1.1), and 20 reference pieces from the blank performance testing papers (see 4.5), in both the machine- and cross-directions of the papers. For testing of multicolour specimens, each primary colour shall be represented on at least one of the test pieces.

Separate the 20 test pieces and reference pieces into two sets, with 10 pieces of test and reference pieces in each set. Age one set of the test and reference pieces together in a climate chamber of $(90 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$ for 12 days, as specified in 6.8. After ageing, the aged strips shall be allowed to cool for at least 24 hours prior to testing.

In parallel to the above ageing group, store another unaged set of test and reference pieces in an ambient condition at $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$.

Determine the folding endurance on 10 test and reference pieces according to ISO 5626 in both machine- and cross-directions of the paper. Since this clause describes a test for evaluating the impact of the recording process on the paper, not the impact of the recorded image on the paper, image lines (characters, dots, etc.) shall not be positioned to overlap with the folding line. The measurements shall be performed in an ambient condition of $(23 \pm 1) ^\circ\text{C}$ and $(50 \pm 2) \% \text{RH}$.

Calculate the average folding endurance for the 10 test and reference samples, from both the control and aged sample sets.

Determine, for both aged and unaged set, the change in folding endurance between the test pieces and the corresponding reference pieces for both machine- and cross-direction.

NOTE For the purposes of this document, any one of the four instruments described in ISO 5626 can be used. The requirement remains the same for all the instruments.

7 Test report

The testing laboratory shall include the following information in its report:

- a) a reference to this document, i.e. ISO 11798:2023;
- b) date and place of testing;
- c) precise identification of the recording equipment and devices used for preparing the test specimens as specified in [6.1](#) to [6.8](#), i.e. product designation, serial number, brand and model;
- d) precise identification of the paper used for testing;
- e) print setting and adjustment (such as paper setting, driver setting, colour mode and printing speed) used for sample preparation, if specific print adjustments have been made;
- f) for each test, the number of test pieces;
- g) description of sample and specimen preparation;
- h) the test results obtained when testing as specified in [6.2](#) to [6.9](#), expressed as stated in the relevant clause and according to the reporting form in [Annex D](#), or in the relevant International Standard referred to;
- i) when reporting colour changes, include data of individual CIE LAB colour coordinates and their average;
- j) any other observations made that may be of importance for the permanence of paper documents;
- k) any deviations from this document and any circumstances that may have affected the results;
- l) a statement that the recording on paper meets or fails the requirements of this document; in the latter case the specific reason shall be stated.

Annex A (normative)

Performance testing paper

A.1 Choice of paper

The choice of paper for preparation of specimens and reference material to be tested is very important since some properties of the image differ between different papers. Results when testing paper documents prepared by a particular imaging process on one type of paper may not be valid for other papers.

The same type of paper is not used all over the world. Paper properties such as surface smoothness, grammage and sizing, may vary considerably. In some countries, the same type of paper is used for recording, in others, the difference between so called photo-copying paper and writing and printing paper is substantial.

These requirements shall not be considered as recommendations to manufacturers and users of paper. Their only purpose is to make the test results representative of papers on the market and to make it possible to obtain reproducible results when testing at different laboratories.

A.2 Specifications for performance testing papers

Performance testing paper for use in the preparation of specimens shall be suitable for use with the type of recording equipment to be tested.

All performance testing papers shall meet the following requirements:

- the paper shall meet the requirements of ISO 9706 or ISO 11108;
- the ISO brightness, measured in accordance with ISO 2470-1, shall be > 85 %;
- when testing the wear resistance in accordance with this document, no visually perceptible fibre loss shall occur;
- the grammage shall not be less than 70 g/m² in accordance with ISO 536

The folding endurance should be at least 1,7 (Köhler-Molin, MIT, or Lhomargy testers²⁾) or 1,9 (Schopper testers²⁾) in any direction. The intention of this recommendation is to provide for adequate accuracy when testing the effects of recording on the mechanical strength of the paper.

NOTE Folding endurance is the mean of the logarithms (to the base 10) of each of the individual readings. A folding endurance of 1,7 corresponds to a fold number of 50 and a folding endurance of 1,9 corresponds to a fold number of 80.

Performance testing paper to be used with ball pens shall, in addition, meet the roughness/smoothness requirement of ISO 12757-1 when testing images made by ballpoint pens, that of ISO 14145-1 when testing images made by roller ball pens and that of ISO 27668-1 when testing gel ink ball pens.

2) Köhler-Molin, MIT, Lhomargy and Schopper testers are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

Annex B (normative)

Specimen preparation

B.1 General

Specimens are referred to as the paper substrate (performance testing paper) with recording from the tested writing, printing, or copying material. Specimens can be produced at various locations, i.e. the location where the recording equipment exists, but preferably in a constant room with controlled climate (23 ± 1 °C and (50 ± 2) % RH).

The method of specimen preparation and the appearance of the image are of great importance when testing many properties. In this document, reference is made to other standards or to instructions from the manufacturer. Some further specifications are necessary to obtain reproducible results and to get a relationship to the requirements given in this document.

No standardized procedure for specimen preparation is available at the time of publication. The following provisions shall be considered.

B.2 Ribbons for typewriters, matrix printers, etc.

- Recording with a fabric ribbon shall be performed with equipment for which the ribbon is intended.
- The properties of images prepared with other ribbons in equipment with different printing pressures, rolls of different hardness, etc., may differ considerably. To obtain representative results, recording with such a ribbon shall be performed with the type of equipment in which the ribbon will be used.
- The equipment shall be in good condition (e.g. clean, no aged rolls).
- The equipment shall be adjusted for normal writing.
- The writing pressure shall not be so high as to cause the reverse side of the paper to feel uneven when touched with the fingertip.

Recording with fabric ribbons and similar ribbons shall be performed to represent ribbons which have been in use.

B.3 Digital printers, computer printers and copying machines

Printers can refer to such as laser printers, multifunction printers and inkjet printers, etc.

- The equipment shall be in good condition.
- Product designation, machine serial number and print setting or print adjustment (paper setting, driver setting, colour mode and printing speed if specific print adjustments applied) used for production of test specimen should be noted.
- Produce specimens using the printout templates as presented in [Annex C](#) and number of specimens according to [Table C.1](#).

B.4 Ballpoint pens, roller ball pens, gel ink ball pens, etc.

For [6.3](#), [6.6](#), [6.7](#) and [6.9](#), generate specimens with images as lines by a write test machine set according to the conditions specified in ISO 12757-1 for ballpoint pens, ISO 14145-1 for roller ball pens and ISO 27668-1 for gel ink ball pens. For other pens, generate images in accordance with the instructions of the manufacturer. This preparation represents normal use of the pens.

Since L^* , a^* , b^* measurements are also required in [6.2](#), [6.4](#), [6.5](#) and [6.8](#), specimens with images of large enough areas with uniform colour shall also be prepared. Produce such images according to the conditions specified in ISO 12757-1 for ballpoint pens, ISO 14145-1 for roller ball pens and ISO 27668-1 for gel ink ball pens, but programming the write test machine so that lines are written close together with a paper movement 10 mm/min and writing speed 4,5 m/min \pm 0,5 m/min.

Make sure that images of uniform colours with even colour strength are obtained and that strike-through and floating does not occur.

NOTE The paper roll has one movement speed and the pens has one writing speed. By lowering the paper movement speed, and keeping the same writing speed, the result is that images are written so close to each other that a field of uniform colour is obtained.

B.5 Stamps

For stamp impressions from stamps, use performance testing paper and generate specimens with images of normal use with the stamp in accordance with the instructions of the manufacturer (used in [6.3](#), [6.6](#), [6.7](#) and [6.9](#)). For the testing of mechanical properties according to [6.9](#), if specimens with lines are not possible to obtain with the recording from stamps, prepare specimens so that test pieces with only one image per strip can be obtained.

Since L^* , a^* , b^* measurements are also required in [6.2](#), [6.4](#), [6.5](#) and [6.8](#), specimens with images of large enough coloured areas shall be prepared. Produce such images by a custom-made stamp produced by the manufacturer.

Make sure that images with uniform colours with even colour strength are obtained and that strike-through and floating does not occur.

Annex C (normative)

Printout templates for sample preparation of printers and copying machines

C.1 Sample preparation for testing of printers

The templates are only represented in black colour, but for testing of printers that produce multicolours, printouts shall be produced of each base colour as pure as possible (i.e. 100 % of e.g. CMYK).

For sample preparation when testing printers and other machines, a suggestion of appropriate number of specimens to produce is presented in [Table C.1](#). For testing of printers that produce multicolours, the presented number is valid for each base colour. Watermarks are present on archival papers and often interfere with the fields for measurements, and that is considered for the presented numbers.

Table C.1 — Printout templates and number of specimens to produce from each template

Clause(s)	Printout template	Number of specimens for recording equipment producing monochromatic images in black and white printing	Number of specimens (for each base colour) for recording equipment that produce multicoloured images
6.6	Template 1 C.2	10	10
6.1, 6.2, 6.3, 6.4, 6.5, 6.7	Template 2 C.3	5	5
6.2, 6.8	Template 3 C.4	30	8

NOTE For [6.8](#), additionally 30 reference specimens are needed for testing (see [5.6](#)).

C.2 Printout template 1

- Degree of abrasion (Colour patch dimensions: 1,1 cm × 1,1 cm)

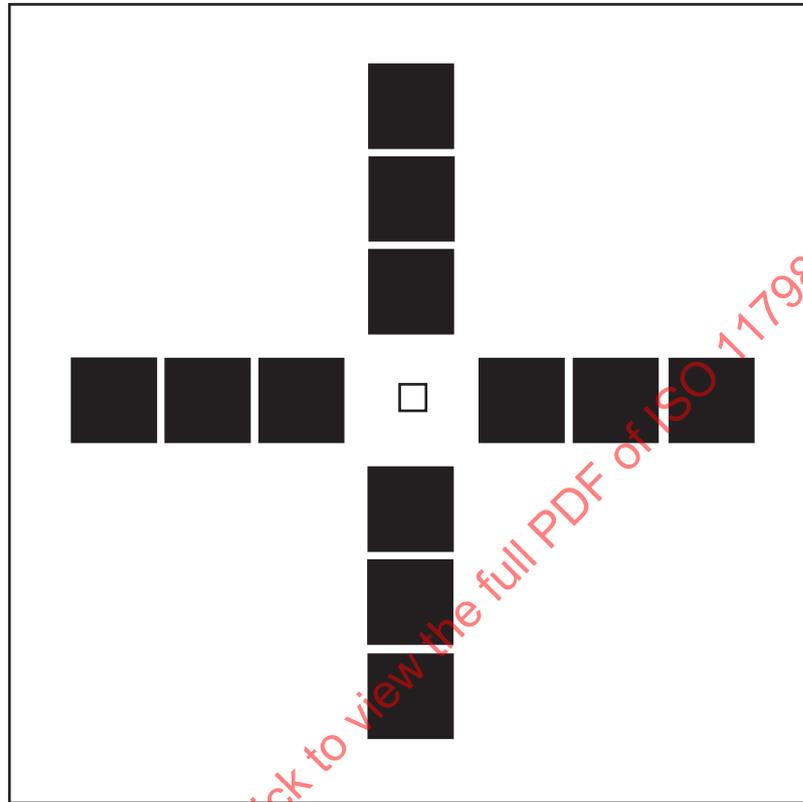


Figure C.1 — Degree of abrasion

- Partial deletions, flaking and voids (Font: Times New Roman, Size: 16)

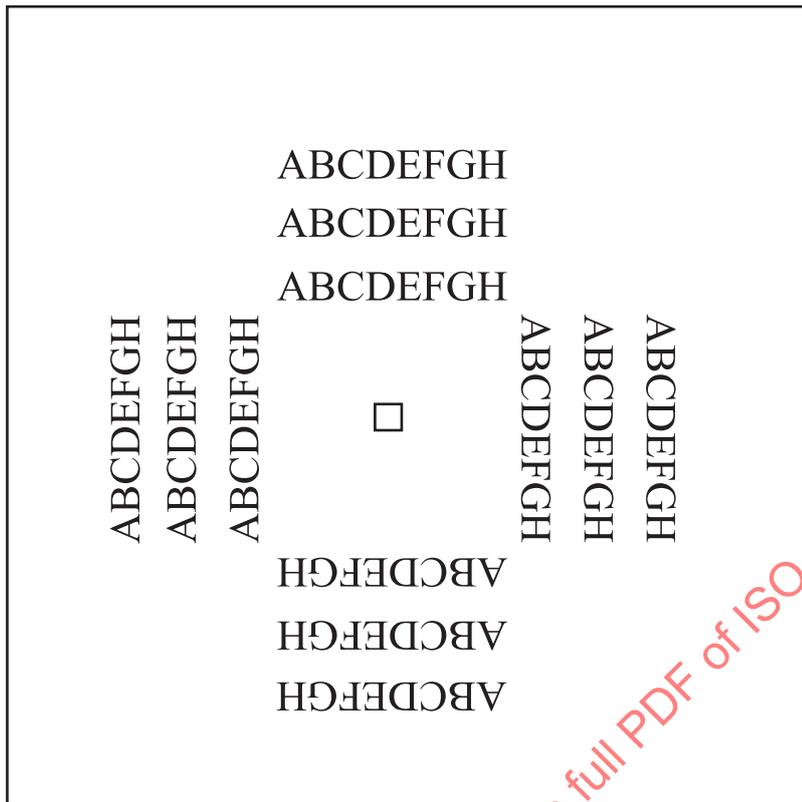


Figure C.2 — Partial deletions, flaking and voids

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C.3 Printout template 2

— Appearance and transfer of recording (Font: Times New Roman, Size: 11)



Figure C.3 — Appearance and transfer of recording

— Appearance, lightfastness and resistance to heat (Colour patch dimensions: 1,1 cm × 1,1 cm)

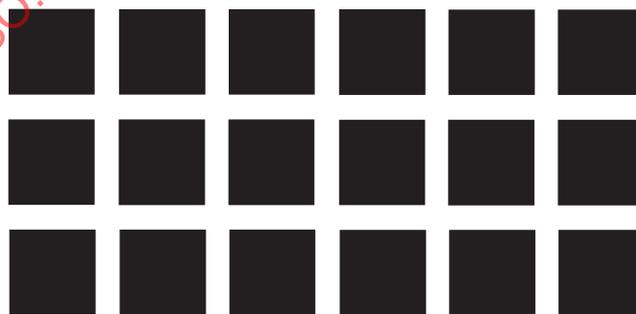


Figure C.4 — Appearance, lightfastness and resistance to heat

— Water resistance (Colour patch dimensions: 1,1 cm × 1,1 cm), see Figure C.5