TECHNICAL SPECIFICATION

ISO/TS 21139-1

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Permanence and durability of commercial prints —

Part 1: Definition of use profiles and guiding principles for specifications

Permanence et durabilité des impressions commerciales —

Partie 1: Définition des profils d'utilisation et des principes directeurs pour les spécifications

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Foreword

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

A list of all parts in the ISO/TS 21139 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 Technical Specification ISO/TS 21139 (all parts) defines use profiles and test methods for permanence and durability testing of printed matter for use in the context of commercial applications, which resemble a wide range of product and usage classes (see e.g. ISO/TR 19300). Product classes included are commercial production prints (flyers, brochures), transactional and stationary prints, signage, newspapers and periodical prints, book printing as well as packaging printing. These commercial prints often contain combinations of text, pictorial images and/or artwork. Prints for non-commercial use, including prints used and displayed in consumer home environments and prints exhibited or stored in museum context, are outside the scope of this document.

A use profile describes typical environmental and other stresses characteristic for the conditions under which a printed sheet or object is typically used. Also certain (implicit) expectations for retained print properties under these conditions may be connected to a particular use profile. These need to be explicated and linked to observed failure modes and assessed as measureable changes of image parameters, including the various dimensions of image quality and physical integrity of the print.

For permanence testing either single or combined stress factors are applied in accelerated laboratory tests that aim to simulate the degradation observed in field use. ISO/TS 21139 (all parts) defines test methods that are appropriate to simulate exposure in use profiles of printed matter in a variety of uses. Furthermore, requirements for reporting of permanence test results are given as guidance for translation of test results into use profile performance, also addressing limitations of "year calculations" due to restrictions of accelerated testing and variability in actual display conditions.

In the context of service life testing of identification cards defined in ISO 24789-1 and ISO 24789-2, a matrix of stresses and evaluations has been defined to simulate various application profiles of such plastic cards. ISO/TS 21139 (all parts) may be developed in an analogous way in a future revision.

Permanence and durability of commercial prints —

Part 1:
Definition of use profiles and guiding principles for specifications

1 Scope

This document defines use profiles for commercial prints in terms of typical environmental stress factors and any mechanical and chemical stress factors to be considered additionally in their application.

Methods and principles defined in this document apply to the various product classes of "commercial prints" that, following the terminology of ISO/TS 19300, include commercial production prints (flyers, brochures), transactional and stationary prints, signage, newspapers and periodical prints, book printing as well as packaging printing. These commercial prints often contain combinations of text, pictorial images and/or artwork. Prints for non-commercial use, including prints use and display in consumer home environments and prints exhibited or stored in museum context, are outside the scope of this document.

For each use profile a set of suitable accelerated test methods for the leading environmental and/or mechanical or chemical stress factors is defined for representative testing. Guidance is given for translation of test results into suitable image permanence performance claims considering the variability of actual use in comparison to reference use profiles.

The test methods and guiding principle described in this document apply to both, analogue and digitally printed matter, and the corresponding test targets from the ISO 12647 series are used. Methods and principles apply to both colour and monochrome prints.

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 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*

ISO 2836, *Graphic technology — Prints and printing inks — Assessment of resistance of prints to various agents*

ISO 5626, *Paper — Determination of folding endurance*

ISO 12647-7, *Graphic technology — Process control for the production of halftone colour separations, proof and production prints — Part 7: Proofing processes working directly from digital data*

ISO 12647-8, *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 8: Validation print processes working directly from digital data*

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

ISO 18930, *Imaging materials — Pictorial colour reflection prints — Methods for evaluating image stability under outdoor conditions*

ISO 18936, *Imaging materials — Processed colour photographs — Methods for measuring thermal stability*

ISO 18937, *Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability*

ISO 18941, *Imaging materials — Colour reflection prints — Test method for ozone gas fading stability*

ISO 18946, *Imaging materials — Reflection colour photographic prints — Method for testing humidity fastness*

ISO 18947, *Imaging materials — Photographic reflection prints — Determination of abrasion resistance of photographic images*

ISO 18948, *Imaging materials — Photo books — Test methods for permanence and durability*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 + 12 h cycle)*

IEC 60068-2-38, *Environmental testing — Part 2-38: Tests — Test Z/AD: Composite temperature/humidity cyclic test*

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 http://www.iso.org/obp

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

3.1
application profile
set of parameters that, in total, define the conditions of use specified for an application

[SOURCE: ISO 24789-1:2012, 3.1.2]

3.2
use profile
total set of environmental, mechanical and/or chemical conditions to which a printed product is subject to during a particular use

3.3
stress factor
element of the environmental, mechanical and/or chemical conditions to which a printed product is exposed

Note 1 to entry: A particular combination of stress factors defines a particular use case and material degradation results from the complex interaction between the processes triggered by the presence of stress factors.

Note 2 to entry: Leading environmental stress factor include light, heat, humidity, and air pollution. Examples of mechanical stress factors are scratching, abrasion, bending, flexing, folding, tearing, and pressure. Example of a chemical stress factor is the contact to a liquid, including water, solvent, sweat, oils and detergents.

3.4
test target
set of colour patches or line elements based on which a change in image quality attributes can be evaluated

EXAMPLE The print control strips described in ISO 12647-8.

3.5
endpoint
defined measurable densitometric, colorimetric, or physical change in a print parameter used to define the point at which a print is no longer usable or acceptable in a particular application

Note 1 to entry: not to be confused with end of test, defined as the point at which a test is terminated after a pre-defined level of physical or chemical stressor has been applied or after an accumulated exposures of the stresses which is determined based on the assumption of the exposure level of the use or the required level of longevity for the product. For example, if the product is expected to be used for 10 years under 250 lx-12 h light level, the test duration in lux-hours should be 250 lx × 12 h per day × 365 days per year × 10 years. A safety factor can be applied to accommodate any experimental errors that may exist.

Note 2 to entry: Limit can for example represent the just visible change or the acceptability of an articulate change in view of the specifications of the use profile.

3.6
permanence
<image> ability to remain chemically and physically stable over long periods of time

3.7
durability
<image print> resistance of an image print to physical, mechanical, chemical and/or environmental stresses in conditions of use, until the end of useful life

Note 1 to entry: In some cases, these stresses can be controlled by the user, like frequency and mode of handling resulting in abrasion of scuff marks. In other cases, stresses are eventually out of control of the user, including strain caused by dimensional changes of the print material arising from repeated humidity and/or thermal cycling in the course of day/night transitions. Other stresses with limited control are exposure to UV and/or reactive airborne pollutants. Those stresses may attack the physical integrity of the material(s) that constitute the printed sheet or object, manifesting themselves for example as cracking, blistering, delamination or brittleness of layers.

3.8
digital print
print where the image is printed directly from the digital domain

Note 1 to entry: Digital printing is a process for text and image reproduction with a colour marker on a medium using a marking device, on which the marking information is generated from digital data directly to the medium. It differs from traditional ink-based printing on which the marking information is generated from a form produced offline prior to imaging on the medium.

Note 2 to entry: Offset printing in its various form as defined in ISO 12647 series is mostly still categorized as “analog printing” even though data stem from digital domain like in case of computer-to-plate systems.

[SOURCE: ISO 18913:2012, 3.52, modified — The word "directly" was added in the definition, Note 1 to entry has changed and Note 2 to entry was added.]

3.9
digital printing system
system that prints one unique iteration at a time for either variable data or classical printing applications including but not limited to electrophotographic and ink jet marking engines

[SOURCE: ISO/TS 15311-2:2018, 3.1]

3.10
transflective print
print on a translucent support that is designed to partially transmit and reflect light, so that print can be viewed both in reflection by means of front illumination or in transmission by means of back illumination

Note 1 to entry: Front and back illumination may be present at the same moment in time.

3.11
product and usage class
category that combines graphic products that have been developed for the same marketing purpose

[SOURCE: ISO/TR 19300:2015, 2.4, modified — The term "use case" was replaced by" product and usage class".]

3.12
book printing
printing of books and publishing of monographs (reference books, photo-books, comic, paperback, textbooks and directories)

3.13
commercial printing
printing for graphic products for commercial applications such as catalogue, advertisement (flyer, pamphlet, leaflet, direct marketing, free magazines) and other (manuals)

3.14
newspaper and periodical printing
printing for graphic products for newspaper (colour, black and white) and periodical magazines (monthly, weekly)

3.15
package printing
printing for graphic products for packages, including rigid and flexible packaging, such as beverage carton, cardboard container, corrugated box, label, sticker, snack and retort pouch

3.16
sign printing
printing for graphic products for indoor or outdoor display (poster, banner, textile, billboard and wrapping decoration)

3.17
transactional and stationary printing
printing for graphic products for direct mail (direct marketing) and advertisement (flyer, pamphlet, leaflet, free magazine)

4 Guiding principles

4.1 Image stability in view of use profiles

The image permanence and print durability performance of printed sheets and objects depend on two aspects:

a) the kind of level of stresses, which the printed matter undergoes in intended use, and

b) the user expectations on retention of properties. This can often be a matter of dispute when these are not defined in advance.

A use profile for printed matter is thus defined by two aspects, namely

— a set of stresses present in the intended use of the printed product that may result in degradation of the printed image or loss of physical integrity of the printed matter, and

— a certain level of retained image quality and print integrity that is expected to assure intended use.

Examples of use profiles include various types of display situations and/or handling stresses in printed product, including printing products for signage, packaging, newspapers, periodicals, trade books, business forms, flyers, and direct mailings.

4.2 Stresses in use profiles

Typical stresses in use profiles can arise from general environmental conditions of display and storage and/or the presence of particular mechanical and/or chemical stress factors typical for a particular use of printed matter. Leading environmental stress factor include light, heat, humidity, and air pollution. Examples of chemical and mechanical stress factors are scratching, abrasion, bending, flexing, folding, tearing, and pressure as well as eventual exposure to liquids (water, solvent, sweat, oils, detergents, etc.).

In use profiles often combinations of aforementioned stress factors may be present, also including diurnal changes resulting in additional stress fatigue by periodic thermal or moisture related expansion and contraction of layers. Examples of combined stresses are outdoor weathering, wet abrasion and blocking, where the latter is caused by combined effect of pressure and moisture at ambient or elevated temperature. Display use profiles represent a set of environmental stress factors that apply for many product classes.

The actual levels of the various stress factors may span a continuous range, in which suitable "reference points" shall be defined for ease of communication. For guidance, the 95 % percentile values of environmental stress factors, such as temperature, humidity, light intensity or airborne ozone concentration levels, are regarded as reasonable worst case[27] and should therefore be chosen as meaningful reference points. One hour averages of environmental parameters are appropriate for characterizing the 95 percentile in cyclic conditions, one day (24 h) averages are suitable to characterize static conditions. See Annex G for calculation of the 95 percentile. In case of altered conditions, e.g. presence of HVAC (heating, ventilation and air-conditioning) installations in a building or (partial) protection against one of the environmental factors, appropriate other levels are defined.

NOTE In outdoor weathering, e.g., environmental stresses vary due to climate, orientation and inclination of the displayed images, but also just due to seasonal or year-to-year variations of weather. Comparison with exposure to reference climates is recommended.

4.3 Retained print quality in use profiles

Image permanence refers to both retention of certain image quality attributes as well as retention of physical integrity of the print[28]. Examples of attributes representative for real world failure of printed matter include the following changes in image quality and/or print integrity, see Annex F for examples.

a) attributes related to printed colour: colour fade, change of tone reproduction, loss of neutral balance, discoloration, etc.

b) attributes related to detail reproduction: loss of sharpness, e.g. due to (colour) bleeding, etc.

c) attributes related to print uniformity: changes in gloss, introduction of staining or mottle (as function of print density), etc.

d) failure of print layer structure including image (receiving) layer(s), coatings or laminates: cracking on micro- or macro-level, blistering, flaking off, adhesion failure, delamination, chalking, etc.

e) discoloration of the printing substrate: yellowing or carbonization ("browning"), etc.

f) physical disintegration of the printed matter: brittle failure, etc.

g) physical deformation of the print material: cockle, curl, warp, change of dimensions, etc.

h) mechanical damage of the print surface: scratches, dents, scuff marks, wear, etc.

Quantitative assessment of these various dimensions of image permanence requires instrument measurements in addition to visual assessment. Measurement of the change of an image parameter requires the measurement of the corresponding image quality parameter after and before the stability test. Methods for measurement of image quality parameters of digital prints have been described in ISO/TS 15311-1 and ISO/IEC 24790 or are under development.

Judgement of changes of the various dimensions describing initial image quality and print integrity may involve evaluation of many different image parameters. For each image parameter, endpoints may be defined that express the retention of a certain level of quality (either absolute or relative to the initial state) as quality expectation typical in the use profile.

However, an over-coupling, generic metric of visual judgement of multi-dimensional image quality by human observers, including non-linear judgement effects known as “peak picking” (i.e. observers tend to focus on the particular dimension of image quality they perceive worst) does not yet exist. Also, quality expectations depend on the individual purpose that a printed product may have within a usage class, including other aspects such as performance of benchmark materials, market share, industry standards, certification and also commercial aspects[29].

Furthermore, perception of retained image quality strongly depends on the mode of assessment, namely via single stimulus evaluation or via side-by-side comparison. In addition, the initial level of print quality plays a role in the judgement. Last but not least, viewing distance in the use situation has a direct impact of visibility of image quality degradation and artefacts, e.g. micro cracks.

NOTE ISO/TS 15311-2 applies for all press output that is typically held at a viewing distance of 30 cm to 50 cm such as publishing, transactional and stationary printing, brochures, leaflets, stationery, corporate accounts, catalogues, newspapers, magazines and books.

4.4 Measurements of colour changes

4.4.1 Colour fading

One of the most frequently discussed and reported image parameters in permanence studies is colour retention. The measurement of colour retention requires a printed test target with a defined set of test colour patches. Layout and dimensions of test patches are designed to make test targets suitable for exposure in the test chamber and colour measurements with automated chart readers. Target colour patches are typically printed including printer characterization (Colour Management System) as in actual use. Drying down or curing times typical for the printing process shall be applied and reported, as these typically differ across the various digital and analogue printing processes.

Colour retention measurement is based on comparison of colour measurements after exposure vs. before. All colour measurements shall be made in accordance with ISO 13655. The measurement conditions (M0, M1, M2 or M3) and the backing to be used (white backing, self-backing or black backing) shall be in accordance with those specified for the characterization data set being used.

Sampling of test colours in colour space is defined by the selection of colour patches in the test target. To assess colour stability of commercial prints the test target shall include the set of control strip patches specified in the corresponding series ISO 12647 (all parts) depending on the printing technology under test, including offset lithographic, letterpress, gravure, screen printing, flexographic as well as all kind of digital printing, including inkjet and electrophotography printing.

The test patches shall be arranged in a test target layout, such that the patches fit on the exposed area of the specimen holders in the tests. The size of each colour patch area shall be large enough to cover measured area plus positioning error. The appropriate size depends on the patch reading equipment used. Aperture size requirement shall comply with the geometric conditions given in ISO 5-4.

For digitally produced commercial prints, test targets with colour patches following ISO 12647-7 and ISO 12647-8, shall be used (see Annex B). An example of colour analysis after light fading is shown in Annex E.

Evaluation metrics shall be assumed to apply to the assessment of a single printed sheet with measurements after and before exposure unless otherwise specified. In case of multiple sheets, the sheet-to-sheet variability shall be accounted for in the assessment of the effective colour change in addition to the variability of consecutive colour measurements (see ISO/TS 15311-1 for details).

As a measure of colour change the mean, maximum and 95 % percentile colour difference (CIE DE2000) between the measurements of these patches before and after the test shall be calculated according to

the corresponding part of ISO 12647. The 95 % percentile is obtained from an ascending sort of the results of all the patches on the target, and the 95th quantile is picked. See Annex G for analysis of targets having number of patches different from multiples of 100, where the 95 % percentile falls in between discrete positions of the histogram. Measurements shall be corrected for the contribution of measurement repeatability to overall colour difference. If the change in colour affects one set of colours significantly more this should be noted for report.

4.4.2 Colour bleeding

For testing of humidity induced colour changes by "bleeding" (diffusion of colorants) the checkerboard test target of ISO 18946 shall be used. It is important not to alter (resize, interpolate) the physical size of the checkerboard patterns, as this will influence the effect of humidity bleeding. Here, CIE ΔE76 metrics applies, for which best correlation with psychophysical judgements of image quality degradation has been obtained (see ISO 18946).

4.5 Other evaluations

For measurement of other image quality attributes (gloss, homogeneity, detail reproduction, visual assessment) the reader is referred to the requirements of the corresponding evaluation methods, e.g. as referenced in ISO 15311-1.

For non-destructive post evaluation of prints after stability testing (visual inspection and optical measurements such as colour, gloss, sharpness etc.) intermediate sampling and placing back of specimen can be considered. For destructive post evaluation (e.g. mechanical testing) a suitable number of replicates shall be provided after stability test (light, heat, humidity, ozone, weathering), which may result in a substantial amount of specimen.

A suitable example for a brittleness test of strips of printed matter is given in Reference [30]. Otherwise a tensile test may be suitable as described in ISO 527-1 and ISO 527-3.

5 Definition of use profiles based on stresses

5.1 General

As mentioned in 4.2, a particular use profile typical for a printed product and usage class is defined by a range of environmental stress factors as well as some typical mechanical/chemical stresses.

One common usage of printed products is their display. Therefore, a limited number of display use profiles is defined that are significantly different from each other. Still, the actual levels of the various stress factors in a use profile may span a continuous range, in which preferably one - or if needed a small number of - reference levels typical for that use profile are defined.

Table 1 provides a general overview of display profiles that define typical combinations of environmental stress factors, whereas generic mechanical and chemical stress factors are treated separately. The organization of ISO 21139 series follows this approach: The number block of parts 21, 22 and 23 define stress factors typical for various instances of indoor display as defined by 1.1, 1.2 and 1.3 of Table 1. Likewise, the number block of parts 31 and 32 define typical instances of outdoor display as defined by 2.1 and 2.2 of Table 1. Table 3 provides an overview of environmental stresses in display use profiles.

The parts of ISO 21139 with number block 41, 42 etc. define mechanical and chemical stresses typical for processing, conversion and handling of the printed products and/or typical for their intended usage. Depending on product and usage class various of these factors may apply as shown in Table 4 indicating their typical and eventual occurrence for the product and usage classes defined by ISO/TR 19300 (see Annex C). Some examples of product and usage classes and related stresses are shown in Annex A (Table A.1).

Table 1 — Overview of use profiles, stress factors and related test methods

Groups of stress factors	Environmental stresses						Processing and conversion stresses			Mechanical & chemical stresses (handling or functional)							Product test
				Storage related stresses													
Stress factor	Weathering[a]: light (outdoor), heat, humidity and spray	Elevated heat & humidity cycles, e.g. In enclosures [b]	Light (indoor)	Heat	Ozone	Humidity	Pressure: stack or wind	Folding	Cutting	Wear: abrasion, scratch or rub	Spill & wipe: water or other liquids [c]	Condensation	High pressure water jet[11]	Freeze/thaw	Steam[d]	Fingerprints	Specific system test
Test method	ISO 18930	ISO 18948	ISO 18937	ISO 18936	ISO 18941	ISO 18946	ISO 18948	ISO 5626	—	ISO 18947	ISO 18935	IEC 60068-2-30	ISO 16925	IEC 60068-2-38	food context	ISO 2836	other
1. Indoor display use profiles																	
1.1 In-window display			x		x												
1.2 General indoor display (w/o partial protection)			x	x	x	x											
1.3 Indoor display on light boxes		x	x	x	x	x											
2. Outdoor display use profiles																	
2.1 Outdoor display (w/o partial protection)	x			x	x	x						x		x			
2.2 Outdoor display light boxes	x	x	x	x	x	x								x			
3. Use profiles including processing, conversion, handling and usage related stresses							x	x	x	x	x	x	x	x	x	x	x

x: Stress factor(s) included in use profile.

[a] Weathering represents a cyclic test including sequences of combined exposure to light, heat and humidity and water spray, but excluding ozone. Spectral power distribution is different for indoor and outdoor daylight exposure.

[b] Examples: print display in outdoor light boxes, transport episodes inside a closed vehicle, shipping container etc. – see D.4. Temperature increase can be based on the greenhouse effect within an enclosure that is exposed to sunlight or other illumination.

[c] Test method includes some form of wet abrasion test that may also be used with detergents; these can be used to test resistance to periodic cleaning.

[d] For some applications resistance of printed matter to micro-wave radiation may also be of interest, either in combination with steam or alone.

5.2 Daylight and its variations as source of illumination in indoor and outdoor display

(Terrestrial) daylight is a natural source of illumination for display of printed matter, both indoor and outdoor. However, intensity and spectral power distribution of the effective illumination strongly depends on the details of the display use profile (location, orientation, shading) and varies with season and atmospheric conditions. The following differentiation needs to be considered.

"Direct" daylight includes sunlight and diffuse skylight, which together define the global irradiance. Their spectral components are defined for specific atmospheric conditions and air mass, in ASTM G177 and CIE 85:1989[1)] using the SMARTS2 code. ISO 18930 provides a test method for digital prints under direct daylight in outdoor conditions, either as

— exposure to natural daylight, or as

— exposure to laboratory Xenon-arc lamps with daylight filters.

The so-called "UV cut-on" represents the lowest wavelength, at which the spectral power distribution of terrestrial daylight radiation introduces degradation in matter. At wavelengths below, the intensity is sufficiently reduced by the atmosphere, so that degradation cannot be observed even for long term exposure. The typical UV-cut on of natural daylight varies in the range 295 nm to 300 nm depending on season and atmospheric conditions.

"Indirect" daylight refers to exposure situations, where intensity and/or the effective UV component of direct daylight has been reduced. Typical examples of indirect daylight are:

a) daylight filtered through window glass,

b) daylight in rooms, and

c) daylight in extended shadow zones outdoors.

In case of display "self-shadowing" can simply be introduced by orientation of display essentially away from the overhead direction of the sun at noon. Blocking of direct sunlight by shading in b) and c) also avoids radiative heating of the displayed print. Since most natural and man-made materials have considerable UV absorption, the process of indirect illumination of a display dominated by reflections from its environment effectively represents "UV filtering by reflection". In all instances of indirect daylight, the effective "UV cut-on" wavelength increases in comparison to direct daylight.

Typical "window glass filtered daylight" represents indirect daylight with a spectral distribution as defined in ISO 18937. Window glass acts as UV filter with a 50 % transmission around 340 nm to 345 nm, which is representative for double glazing (6 mm total glass thickness represent e.g. 2 sheets of 3 mm thick glass sheets in double glazing). The corresponding UV cut-on is around 320 nm.

An even more indirect mode of daylight illumination is encountered for indoor display further away from a window, when large part of the window-glass filtered daylight has undergone reflection off the interior of the room before hitting the displayed print. This reflection process results in further reduction of UV component. ISO 18937 defines this "more indirect" daylight situation as "general indoor" and stipulates a filter with 50 % transmission around 370 nm to 375 nm for use with a Xenon arc light source. The corresponding UV cut-on is around 345 nm to 350 nm.

1) Under revision.