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Imaging materials — Pictorial colour reflection prints — Methods for evaluating image stability under outdoor conditions

Matériaux pour l'image — Impressions de couleurs de réflexion picturale — Méthodes d'évaluation de la stabilité d'image dans des conditions extérieures

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 18930 was prepared by Technical Committee ISO/TC 42, *Photography*.

This first edition of ISO 18930 cancels and replaces ISO/TR 18930:2001, which has been technically revised.

Introduction

Printed digital images are used in many applications in which they are exposed to outdoor weathering. This International Standard provides standardized test procedures to evaluate image stability both in real-time outdoor weathering tests and in accelerated laboratory simulations of the weathering process.

Accelerated laboratory weathering tests have been developed as a result of the desire to obtain test results faster than would be obtained by actual outdoor exposure. However, accelerated weathering tests only have value if they can be correlated with actual outdoor performance. In outdoor testing, critical factors that cause image degradation include light, water, heat, ozone, and local and diurnal variations in climate. In accelerated testing, it is important that the most critical factors of light, water and heat are included. The use of xenon arc lamps with “daylight” filters has become an industry standard procedure for the most accurate simulation of the spectral power distribution of sunlight. The coupling of the xenon arc lamps and “daylight” filters with a water spray and elevated temperatures forms the basis for testing with accelerated laboratory weathering instruments. The accelerated weathering test procedure described in this test method is intended to provide a means for predicting the behaviour under actual outdoor exposure.

Imaging materials — Pictorial colour reflection prints — Methods for evaluating image stability under outdoor conditions

1 Scope

This International Standard describes test equipment and test procedures for determining the colour stability of photographic colour images when subjected to outdoor conditions. It does not specify limits of acceptability or failure criteria. Instead, it provides means for measuring image changes that take place during the aging of pictorial photographic images and indicates the critical image-change parameters that should be reported. Users of this International Standard should determine which test end-points best simulate the intended display application.

This International Standard is applicable to pictorial images made with digital printing media, for example:

— prints on coated papers, coated and uncoated clear and opaque films, vinyl, polyester, synthetic papers and other plastic substrates, laminated and not laminated;

— dye-based and pigment-based inkjet prints with aqueous, solvent, phase-change, or UV curing inks;

— thermal dye and mass transfer;

— dye sublimation prints;

— digitally-printed dye-diffusion-transfer prints;

— liquid- and dry-toner xerographic prints;

— liquid toner electrostatic prints;

— digitally printed images made with traditional chromogenic and silver dye-bleach photographic materials;

— colour direct thermal prints.

In these digital printing processes, the ink laydown is controlled by means of digital pixel information, and all of the settings and controls of the printing system can be documented and repeated. In contrast, for many analogue printing systems, the control over the ink film thickness can be subject to manual adjustment. Window graphics on the outside of windows are covered by this International Standard. Window graphics on the inside of windows, for which sunlight is filtered by a layer of glass, will be covered by ISO 18937.

This International Standard does not include test procedures for physical stability of images, supports or binder materials. However, it is recognized that in some instances physical degradation such as support embrittlement, image layer cracking, or delamination of an image layer from its support, rather than image stability, will determine the useful life of a print material.

NOTE Image print stability results determined for one printer model, ink set, printing mode, print resolution and media combination are not applicable to image prints produced through another printer model, ink set, printing mode, print resolution and media combination, even if the ink jet cartridges and/or media used in testing are the same.

2 Normative references

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

ISO 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

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

ISO 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* Colour Space*

CIE 85:1989, Solar Spectral Irradiance

3 Terms and definitions

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

3.1
digital printing media
recording elements used by digital printers to receive inks or pre-formed colorants

EXAMPLE The substrate might be paper, plastic, canvas, fabric, or other ink-receptive material; the substrate might, or might not, be coated with an ink-receptive layer. The category of digital printers includes inkjet, electrophotographic and thermal transfer.

3.2
encapsulation
sealing of all edges of a specimen that has been laminated on both front and back surfaces

NOTE This is usually done by laminating with sheets that are larger in dimension than the specimen and then sealing at the overlaps.

3.3
laminate
layer of material that goes over the top or bottom of a specimen

NOTE This is usually to provide water-resistance, physical, and/or ultraviolet (UV) light protection of the specimen during a weathering test. A layer of protective film is applied with a pressure-sensitive or heat-activated adhesive.

3.4
accelerated laboratory weathering

simulated weathering where instruments (weathering devices) are used to obtain very controlled conditions that simulate, to some degree, and generally accelerate, the outdoor weathering results

NOTE The use of such instruments is described in ISO 4892-1 and ASTM G151.

3.5
outdoor weathering
actual placement of specimens outdoors in specific locations

NOTE This is differentiated from simulated weathering where instruments (weathering devices) are used to obtain very controlled conditions that simulate, to some degree, and generally accelerate, the outdoor weathering results. Use of such instruments is described in ISO 4892-1 and ASTM G151.

3.6
accelerated outdoor weathering
use of mirrors or lenses to focus sunlight onto specimens for increased intensity

NOTE The use of such devices is described in ISO 877-3.

3.7
reciprocity failure
non-equivalence in weathering results between a long exposure/low-intensity experiment and its short exposure/high-intensity counterpart with an equivalent intensity-time product

3.8
total solar UV irradiance
irradiance in the wavelength range from 300 nm to 400 nm integrated over the duration of a test

NOTE This quantity is usually fairly consistent from year to year in a given location, and is usually given in units of MJ/m^2.

3.9
daylight filter
optical filter, or combination of filters, that modifies the spectral power distribution of a light source to better represent some defined daylight spectrum

NOTE 1 These filters are not related to the blue filters used in the photographic industry for the change of correlated colour temperature of light sources.

NOTE 2 Adapted from ISO 18913.

3.10
operational control point
set point for equilibrium conditions measured at sensor location(s) in an exposure device

[ASTM G113]

3.11
operational fluctuations
positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions in a laboratory accelerated weathering device

NOTE The operational fluctuations are the result of unavoidable machine variables and do not include measurement uncertainty. The operational fluctuations apply only at the location of the control sensor and do not imply uniformity of conditions throughout the test chamber.

[ASTM G113]

3.12
operational uniformity
range around the operational control point for measured parameters within the intended exposure area, within the limits of intended operational range

[ASTM G113]

3.13
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could be reasonably attributed to the measurand

NOTE 1 The parameter might be, e.g., a standard deviation (or a given multiple of it), or the half-width of an interval having a stated confidence level.

NOTE 2 Uncertainty of measurement comprises, in general, many components. Some of these components can be evaluated from statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which also can be characterized by standard deviations, are evaluated from assumed probability distributions based upon experience or other information.

NOTE 3 It is understood that the result of the measurement is the best estimate of the value of the measurand and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

[ASTM G113]

4 Summary of test practice

4.1 Accelerated laboratory weathering tests

Accelerated laboratory tests performed in weathering chambers should simulate the outdoor environment for which the display is intended. The test specimens should be subjected to light, water, and elevated temperature. The duration of the test can vary widely, depending on the stability of the imaging materials.

During the course of the test, the colour changes in the printed samples are periodically evaluated instrumentally. Results are compared to the initial values for the same specimen prior to testing, and also to a control sample maintained at ambient conditions with light excluded. A further internal control sample with known weathering behaviour is also recommended for laboratory experiments. The change of the test specimens and the reference samples is reported as optical density and/or L* a* b* (or colour difference, ΔE^*_{ab}) before and after the test.

For an accurate assessment of outdoor performance, an ozone test such as that described in ISO 18941 should also be considered, as many colorants are sensitive to atmospheric pollutants. An ozone test is recommended for media that is unlaminated. However, ozone testing is not a part of this International Standard.

4.2 Outdoor weathering tests

Outdoor exposure conditions can vary by orders of magnitude in irradiance depending on the geographical latitude, altitude, specimen orientation, season and weather conditions. Outdoor weathering services are available for some typical climatic conditions, e.g. South Florida's subtropical hot and humid climate and Arizona's hot and dry desert climate. A list of common outdoor test sites is given in ASTM G7. Due to the annual variations in climate, it is recommended that internal control samples with known behaviour be included in outdoor weathering experiments.

5 Significance and use

5.1 Accelerated laboratory weathering tests

Controlled laboratory tests are often used to provide standardized data and to benchmark materials. Predicting outdoor image display life from controlled laboratory tests without correlation data for the material in question between the laboratory test and natural outdoor exposure is not recommended.

Since the ability of images on digital printing media to withstand colour changes is a function of temperature, humidity, air pollutants, light and diurnal changes of environmental parameters, it is important that print stability be assessed under the conditions appropriate to the end use application.

The laboratory procedure described in this test practice is intended to provide a means for predicting the behaviour under actual outdoor exposure. Test results are useful for specification acceptance between producer and user, for quality control, and for research and product development[20][21].

5.2 Outdoor weathering tests

Real-time outdoor exposure is the most reliable method of assessing outdoor image stability, but the actual exposure of a sample depends on the season and the weather. However, it is not as fast as accelerated laboratory tests. The outdoor test procedure described in this International Standard is intended to provide image stability data for an ink/media combination in a selected outdoor location. Note that the image stability indicated in this test will vary with the weather from year to year[22].

6 Apparatus

6.1 Accelerated laboratory weathering test equipment

The exposure equipment shall consist of a light source with simulated direct outdoor daylight with a spectral power distribution as defined in CIE 85:1989, Table 4, and the operating limits defined in Annex A. A recommended match for direct outdoor daylight that is equivalent to CIE 85:1989, Table 4, is a cooled, filtered xenon high-pressure arc lamp. A "daylight filter" that gives the best match to the spectral power distribution of CIE 85:1989, Table 4, should be used. Matching the solar spectral power distribution, especially in the UV region, is extremely important. Irradiance, reference black panel temperature (BPT or BST), chamber (ambient) air temperature, and relative humidity need to be regulated to allow test conditions in the range specified in Clause 12. The apparatus should allow cycling between dark and light phases as well as water spray cycles and dry phases. Annex A shows appropriate operating limits for the spectral power distribution of xenon arc accelerated weathering instruments.

6.2 Outdoor weathering tests

Real-time outdoor weathering may be conducted at test sites that have the ability to mount samples onto racks with fixed or variable angles of inclination. Most testing is performed with the samples facing south (for the northern hemisphere) at a 45° angle of inclination. Advantages of testing at 45° rather than 90° are that seasonal variations in radiant exposure are minimized[22], space requirements are minimized because neighbouring sample racks are less likely to shade each other, and the average annual radiant exposure can be as much as twice as large (e.g. approximately 1,6 to 1,7 times as large for South Florida or Arizona). In some cases where a product is utilized on a vertical surface, such as vehicle graphics, testing is conducted at an angle of inclination of 90° facing either north or south.

Seasonal differences, such as temperature and relative humidity, will occur when tests are run at different times of year. It is critical that the outdoor tests be run for multiples of a calendar year so that separate tests have a basis for comparison. The testing service should provide information on the total solar UV irradiance at 45° for the samples tested, as well as tabulation on a day-to-day basis of the temperature and relative humidity highs, lows, and means[7]. Often, this is published as a newsletter that is routinely sent to customers of the testing service. It is also recommended that the testing service provide ozone level data as well, if possible. Several manufacturers of accelerated weathering equipment offer testing services and outdoor exposure facilities.

7 Interferences

It is recognized that the fade of images on digital printing media will vary significantly because of factors such as initial colour density, the area printed (solid versus half-tone), the substrate, the colorant type (dye versus pigment inks), the number of passes (in multipass printing modes), ink load, print resolution, and the receiver coating type and thickness. Consequently, test results shall be determined individually for each print.

The rate of colorant degradation with light is often strongly dependent on humidity and air pollutants. Separating the environmental factors will not be possible in a real environment. This has to be taken into consideration when extrapolating to other display conditions. Guidance on the interference of environmental factors other than light, their importance in image degradation, and references to methods for measurement can be found in Reference [23].

Some outdoor environments are characterized by strong temperature and humidity fluctuations between day and night or sunny and overcast conditions. In cold weather, the presence of the sunlight creates strong temperature differences, especially in dark colours, that can lead to cracking and mechanical distortions. When samples are set out in the weather, another component for consideration is environmental materials: both polluting gases and materials left by fauna and flora. Information about the levels of common pollutants is available, e.g. on the web sites of local environmental offices, meteorological or climatological web sites, or from the testing services. Unless measurement of resistance to these environmental effects is desired, many of these materials can be removed from samples by request, thus assuring a more controlled test. Effects of polluting gases can be examined or eliminated based on the weathering site location. Other possible sources of degradation to consider are acid rain, salt corrosion from the sea, haze due to pollution or fires, and bird droppings. For removal of unwanted environmental materials, a gentle water rinse is recommended, but without scrubbing that can mar or abrade the surface. The use of mild soap solutions is permitted for laminated samples and for other materials that will not be damaged by this exposure.

Accelerated image stability tests for predicting the behaviour of colour images under normal outdoor conditions can be complicated by “reciprocity failure”. When applied to digital printing media, reciprocity failure refers to the failure of many types of colour images to degrade equally when irradiated to the same total light exposure (intensity × time) by both high-intensity light for a short period and low-intensity light for a long period. The magnitude of any reciprocity failure can also be influenced by the test temperature, the moisture content of the test specimen, and light/dark cycling rates. Also note that apparent reciprocity failures have been observed in some materials due to the presence of ozone or other pollutants in accelerated weathering test chambers[24].