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Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability

Matéruaux pour l'image — Tirages photographiques par réflexion — Méthodes de mesure de la stabilité de la lumière en intérieur

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Contents

Page

Foreword

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

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

Introduction

This International Standard addresses the methods and procedures for measuring the indoor light stability of reflection colour photographs.[6][8][9][18]–[23][30]

The length of time that such photographs are to be kept can vary from a few days to many hundreds of years and the importance of image stability can be correspondingly small or great. Often the ultimate use of a particular photograph might not be known at the outset. Knowledge of the useful life of colour photographs is important to many users, especially since stability requirements can vary depending upon the application.

The images of most modern analog and digitally-printed colour photographs are made up of cyan, magenta, yellow, red, green, blue, orange, black, gray, white or other colourants. Colour photographic images typically fade during storage and display; they will usually also change in colour balance because the various image colourants seldom fade at the same rate. In addition, a yellowish (or occasionally other colour) stain can form and physical degradation might occur, such as embrittlement and cracking of the support and image layers. The rate of fading and staining can vary appreciably and is governed principally by the intrinsic stability of the colour photographic material and by the conditions under which the photograph is stored and displayed. The quality of any chemical processing is another important factor. Post-processing treatments and, in the case of digitally generated photographs, post-production treatments, such as application of lacquers, plastic laminates, and retouching colours, also can affect the stability of colour materials.

The light stability of colour photographs is influenced primarily by the intensity of the illumination, the duration of exposure to light, the spectral distribution of the illumination, and the ambient temperature and humidity conditions. However, the normally slower dark fading and staining reactions also proceed during display periods and will contribute to the total change in image quality. Ultraviolet radiation is particularly harmful to some types of colour photographs and can cause rapid fading as well as degradation of plastic layers such as the pigmented polyethylene layer of RC (resin-coated) paper supports.

Information about the light stability of colour photographs can be obtained from accelerated light stability tests. These require special test units equipped with high-intensity light sources in which test strips can be exposed for days, weeks, months, or even years, to produce the desired amount of image fading (or staining). The temperature of the sample prints and their moisture content needs to be controlled throughout the test period, and the types of light sources need to be chosen to yield data that can be correlated satisfactorily with those obtained under conditions of normal use.

Accelerated light stability tests for predicting the behaviour of photographic colour images under normal display conditions might be complicated by “reciprocity failure”. When applied to light-induced fading and staining of colour images, reciprocity failure refers to the failure of a colourant to fade, or to form stain, equally when irradiated with high-intensity versus low-intensity light, even though the total light exposure (intensity × time) is kept constant through appropriate adjustments in exposure duration. The extent of colourant fading and stain formation can be greater or smaller under accelerated conditions, depending on the photochemical reactions involved in the colourant degradation, on the kind of colourant dispersion, on the nature of the binder material, and on other variables. For example the supply of oxygen, which can diffuse into a photograph’s image-containing layers from the surrounding atmosphere, can be restricted in an accelerated test (dry gelatine, for example, is an excellent oxygen barrier). This can change the rate of colourant fading relative to the fading that would occur under normal display conditions. The magnitude of reciprocity failure can also be influenced by the temperature and moisture content of the test sample prints. Furthermore, light fading can be influenced by the pattern of irradiation (continuous versus intermittent) as well as by light/dark cycling rates (see Annex A).

Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability

1 Scope

This International Standard describes test equipment and procedures for measuring the light stability of images of colour photographic reflection prints designed for display in, for example, houses, apartments, other dwelling places, offices and commercial display, when subjected to certain illuminants at specified temperatures and relative humidities. This International Standard also addresses colour photographic reflection prints designed for display in galleries and museums.

Indoor illumination conditions described in this International Standard include a) simulated indoor daylight typical home display, b) simulated direct sunlight in-window display, c) fluorescent illumination using "cool white", and d) other types of illumination sources, such as other fluorescent lamps, tungsten halogen, LED, OLED and metal halide lamps.

This International Standard is applicable to reflection colour prints made with colour hardcopy materials. Included are inkjet prints, thermal dye diffusion transfer ("dye-sub") prints, liquid- and dry-toner electrophotographic prints, prints made with traditional chromogenic ("silver-halide") photographic colour materials and, in general, all types of colour prints made with direct analog and digital print processes. The recommended evaluation methods can also be applied to black-and-white photographic prints.

This International Standard does not include test procedures for determining the effects of light exposure on the 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 the stability of the image itself, will determine the useful life of a print material.

Print image stability results determined for one printer model, software settings, colourant and media combination might not be applicable to image prints produced through another printer model, software settings, colourant and media combination.

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

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

ISO 2471, *Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method*

ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

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

ISO 9370, *Plastics — Instrumental determination of radiant exposure in weathering tests — General guidance and basic test method*

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

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

ISO/TR 18931, *Imaging materials — Recommendations for humidity measurement and control*

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

ISO 18944, *Imaging materials — Reflection colour photographic prints — Test print construction and measurement*

CIE S 023/E:2013, *Characterization of the Performance of Illuminance Meters and Luminance Meters*

ASTM G113, *Standard Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials*

ASTM G151, *Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18913 and the following apply.

NOTE In any case where the terms and definitions are duplicated with ISO 18913, the following terms and definitions take precedence for the use of this International Standard.

3.1
operational control point
set point for equilibrium conditions measured at one or more sensor locations in an exposure device

[SOURCE: ASTM G 113-09, 3.2]

3.2
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

[SOURCE: ASTM G 113-09, 3.3]

Note 1 to entry: Operational fluctuations are the result of unavoidable machine variables and do not include measurement uncertainty. Operational fluctuations apply only at the location of the control sensor and do not imply uniformity of conditions throughout the test chamber.

3.3
operational uniformity
range around the operational control point for measured parameters within the intended exposure area within the limits of the intended operational range

[SOURCE: ASTM G 113-09, 3.6]

Note 1 to entry: Operational uniformity evaluates the measured parameters throughout the volume of a test chamber so that regions of the test chamber volume can be determined to comply within the required stated limits of the measured parameter operating aim.

3.4
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 measurement

Note 1 to entry: The parameter might be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated confidence level.

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

Note 3 to entry: It is understood that the result of the measurement is the best estimate of the value of the measurement, 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.

[SOURCE: ASTM G 113 and ISO Guide 98-3:2008, 2.2.3]

4 Requirements

This International Standard specifies a set of recommended test methods with associated requirements for permitted reporting. Data from these tests shall not be used to make life expectancy claims, such as time-based print lifetime claims, either comparative or absolute. Conversion of data obtained from these methods for the purpose of making public statements regarding product life shall be in accordance with the applicable International Standards for specification of print life.

The test methods in this International Standard may be useful as stand-alone test methods for comparison of the stability of image materials with respect to one specific failure mode. Data from the test methods of this International Standard may be used in stand-alone reporting of the absolute or comparative stability of image materials with respect to the specific failure mode dealt with in this International Standard, when reported in compliance with the reporting requirements of this International Standard. Caution shall be used when comparing test results for different materials. Comparisons shall be limited to test cases using equipment with matching specifications and matching test conditions.

The test procedures contained within this standard allow for the use of a variety of light source and filter combinations. Test results obtained using different test conditions, such as different light sources and filters, shall not be compared. Materials under test can be expected to behave quite differently as a result of different relative spectral power distributions of the flux incident on the specimen.

5 Test methods — General

5.1 Safety precautions

In light stability tests, high intensity illumination is used, often with significant UV content. Special care shall be taken to avoid eye injury or skin erythema. Precautions should be taken to ensure that the light source cannot inadvertently be viewed without suitable eye and skin protection.

5.2 Acceleration and reciprocity issues

The sample prints to be tested are exposed to laboratory light sources under controlled environmental conditions.

Commonly employed accelerated methods of testing light stability, for both photographic digital hardcopy materials and for traditional analog photographic materials, are based on the concept that increasing the light intensity should produce a proportional increase in the photochemical reactions that occur during typical viewing or display conditions, without introducing any undesirable side effects.

However, because of “reciprocity failures” that might be present in high-intensity accelerated light fading tests with imaging materials, this assumption may not always apply (i.e. a material might fade, change colour balance, or stain a different amount when exposed to high-intensity illumination for a short period than it does when exposed to lower-intensity illumination for a longer period, even though the spectral distribution, the total light exposure [intensity × time], the temperature, and the relative humidity are the same in both cases.)[12]–[17][24]

In general, the closer accelerated test conditions are to actual use conditions, the more meaningful the test results become.

For further discussion of approaches to evaluating reciprocity behaviour in the light-induced fading, changes in colour balance, and stain formation in imaging materials, see Annex A.

5.3 Catalytic fade issues

Catalytic fade is the process by which a given colourant can fade faster (or slower) when in contact with another colourant as a result of an image area containing more than just one of the colourants. It can also occur when other components in the imaging system act as catalysts. Because this process often involves photocatalysis, it can show a dependency on the nature of the light source as well as the light absorption characteristics of the additional colourant, UV absorbing materials, intentionally-added radical quenchers and other components.[31]

Because of these complex interactions, catalytic fade and the resulting nonlinearities can confound predictions of colour fading rates for real-world images.

5.4 Light intensity control

The light intensity shall be maintained and controlled throughout testing with an operational fluctuation within ± 7 % of aim. The 24 h running average of the operational fluctuation, sampled at least every 15 min, shall be within ±4 % of aim. The running average shall not include the test condition transition time which occurs when the test condition is initiated. This transition time shall be at most 1 h.

5.5 Spectral power distribution

This International Standard references the use of different light sources for accelerated tests with the intention of reproducing as closely as possible different end-use lighting conditions.[25][26] However, no accelerated laboratory exposure test can be specified as a total simulation of actual use conditions. Results obtained from these laboratory accelerated exposures may be considered as representative of actual use exposures only when the degree of correlation has been established for the specific materials being tested and when the type of degradation is the same. The relative durability of materials in actual use conditions can be very different in different locations because of differences in radiant energy (both in spectra power distribution and intensity), relative humidity, temperature, pollutants, such as ozone, and other factors.

Light sources referenced in this International Standard include filtered xenon-arc, fluorescent, tungsten halogen, LED or OLED (and others). Each of these can be useful to simulate the various existing lighting conditions found in different environments. It shall be recognized that these different light sources emit different spectral power distributions (SPDs). The combination of different SPDs from these light sources and associated material sensitivities will significantly impact test results. As a result, test results of replicate sample prints using different light sources shall not be compared to each other.

It is essential to consider the effects of variability in accelerated tests when conducting exposure experiments and when interpreting the results from these tests. Sources of variability include sample-to-sample, measurement instrument repeatability/reproducibility, and exposure zone uniformity. It is recommended the user expose replicate sample prints to understand and mitigate the variability of exposures.

5.6 Humidity control

5.6.1 Humidity control calibration

The test chamber relative humidity control shall be calibrated for measurement accuracy and control by using a chilled mirror hygrometer or other type of measurement device calibrated and traceable to a national standards bureau suitably responsible for certifying reference weights and measures. The calibration shall include the full temperature and relative humidity ranges that are to be used in the ensuing test processes. A check of the calibration shall be performed when there is any indication of sensor failure. Ongoing use of redundant sensors is recommended so that sensor integrity can be ascertained. Details of humidity calibration and control methods are described in ISO/TR 18931.

5.6.2 Humidity control

The preferred relative humidity of the air circulating the test chamber shall be 50 % relative humidity (RH). Other levels may be used, such as 30 % and 70 %, where such levels reflect actual product use conditions. In all cases the relative humidity test conditions shall be reported.[29]

NOTE 1 The relative humidity of the sample surface is essentially controlled at the aim value; however, it is not practicable to measure the humidity of the air of the sample surface. It is estimated that the relative humidity difference between the sample surface and the circulating air is not significant, even if the temperature of the sample surface is higher than that of circulating air, according to estimation supposing that the chemical potential of water molecules are equal at the sample surface and the circulating air at the equilibrium state. Water chemical potential of vapour is an increasing function of the partial vapour pressure. On the other hand, it is a decreasing function of temperature at a constant pressure, due to the fact that the derivative of the chemical potential is equal to a negative value (i.e. molar entropy with the opposite sign). Therefore it is qualitatively clear that the increase in the water chemical potential in the blowing air as caused by the decreased air temperature compared to the sample temperature can be compensated by the lower relative humidity of the circulating air. To get numerical predictions, one can utilize the tabulated values of thermophysical properties of water available from NIST.[27]

The specified aim of the relative humidity of the air shall be established for the air temperature of the bulk air in the region of the sample. One approach is to locate the sensor in the region of the sample, however the sensor shall not be directly in the light. Alternatively, based on the temperature offset between the air temperature in the region of the sample and the air temperature next to the humidity sensor, calculate the control percentage RH to achieve the required aim percentage RH at the sample.

NOTE 2 In rotating rack chamber designs, the humidity sensor can be placed behind samples and near the temperature sensor. In flat panel chambers, a small shade can be used in front of the sensor to block the light while not hindering the airflow.

The relative humidity shall be maintained and controlled throughout testing with an operational fluctuation within ± 6 %RH of aim during test periods when the light is on and ± 3 %RH of aim during test periods when the light is off. The 24 h running average of the operational fluctuation, sampled at least every 15 min, shall be within ± 2 %RH of aim. The running average shall not include the test condition transition time which occurs when the test condition is initiated. This transition time shall be at most 1 h. Operational uniformity of the equipment at the test conditions shall be evaluated prior to test start and shall be within ± 6 %RH of aim during test periods when the light is on and ± 3 %RH of aim during test periods when the light is off, at a constant air temperature. Regions of the test chamber shall be selected for use to comply with the required operational uniformity conditions. If the running average of the operational fluctuation does not meet the requirement it shall be documented and explained.

5.7 Temperature control

The sample aim temperature shall be within the range of 25°C to 30°C and shall be controlled by configuring the light exposure equipment and its environment to achieve the appropriate black panel temperature (BPT) (uninsulated) or white panel temperature (WPT) according to the procedure described below. The air temperature shall be maintained no lower than 5,0°C below sample temperature. These temperature conditions shall be maintained and controlled throughout testing with an operational fluctuation within ± 2,0°C of aim, and with not more than 3 % of temperature measurements in any 24-h period to exceed this operational fluctuation limit. For the sample temperature as represented by the calibrated BPT (uninsulated) or WPT, the 24-h running average of the operational fluctuation, sampled at least once every 15 min, shall be within ± 1,0°C of the aim value. The running average shall not include the test condition transition time which occurs when the test condition is initiated. This transition time shall be at most 1 h. Operational uniformity of the equipment at the test conditions shall be evaluated prior to test start and shall be within ± 5,0°C of aim during test periods when the light is on and ±2,0°C of the aim value during periods when the light is off. Regions of the test chamber shall be selected such that they comply with the required operational uniformity conditions. If the running average of the operational fluctuation does not meet these requirements, it shall be documented and explained.

NOTE Considerations for the actual choice of the test temperature are dependent on the non-accelerated use case and the capability of the equipment as follows: 25°C might be closer to the non-accelerated use case. However, some test equipment might not be able to meet the temperature and humidity operational requirements at temperatures below 30°C.

BPT (uninsulated) and WPT, whichever is used, shall be constructed in accordance with ISO 4892-1 and ASTM G151, as follows:

— The WPT or BPT (uninsulated) should be mounted on a support within the sample print's exposure area so that it receives the same radiation and experiences the same cooling conditions on all sides as do the test samples.

— The sensor accuracy shall be better than or equal to ±1,0°C throughout the measuring range. The sensor shall be small enough to attach to the panel and shall have a known response throughout the expected temperature range.

— In the case of a black panel, the top (exposed) surface of the panel shall absorb 90 % or greater at all wavelengths from 300 nm to 2500 nm.

— In the case of a white panel, the top (exposed) surface of the panel shall exhibit reflectance of 90 % or greater at all wavelengths between 300 nm and 1 000 nm and 60 % or greater at all wavelengths between 1000 nm and 2500 nm.

The control value of the BPT (uninsulated) or the WPT shall be determined prior to actual use (see Annex C for the temperature calibration procedure) in order to control the sample temperature at the selected sample temperature aim. The actual sample patch temperatures depend on the print materials, the colourant materials and each patch's colour, in addition to the equipment environmental conditions.

For the purpose of calibrating the BPT (uninsulated) or WPT to the sample temperature for use in a light fade test, the average sample temperature shall be the average temperature of a set of 0,75 status A or status T density neutral patches from a set of samples that are printed with print materials and colourant materials representative of the materials that will be tested.

The following temperature calibration procedure shall be used, prior to conducting a light fade test, to determine the control value of the BPT (uninsulated) or WPT, whichever is used, and to verify that sample temperature and air temperature meet the requirements of this International Standard. Additional guidance for sample temperature calibration, calculation, and control is provided in Annex C.

a) Printed temperature calibration test samples that each contain one or more neutral patches with status A or status T density, as appropriate for the material under test, of 0,75 ± 0,10 status A or status T shall be prepared. The neutral patches shall be large enough for the precise temperature measurement; for example 20 mm × 20 mm. A number of temperature calibration test samples shall be printed so that the temperature calibration test samples can be distributed over the volume of the light fade test chamber. When more than one type of print material is planned to be light fade tested, the printed temperature calibration test sample set should include a representative variety of such samples.

   NOTE 1 If the neutral patches of the temperature calibration test samples contain carbon black, the difference in temperature between such neutral patches and other colour patches can be accentuated, with the carbon black being warmer.

b) Temperature calibration test samples shall be placed in the light fade test chamber in accordance with the planned manner of placement to be used in light fade testing. As necessary to approximate the planned distribution of light fade sample materials over the volume of the light fade test chamber, the sample positions not occupied by printed temperature calibration test samples shall be populated with a representative range of materials normally tested.

c) The equipment and its environment shall be configured in an initial configuration according to the planned light fade test process. This may include setting up to achieve a preset BPT (uninsulated) or WPT. The light fade test equipment shall be operated in accordance with the planned light fade test process to expose the temperature calibration test samples.

   NOTE 2 The light exposure equipment is configured and operated in the same manner that will be used for the intended light fade tests. The test unit is warmed up and operationally stabilized according to the manufacturer's recommendations.

d) For the equipment and environment configuration, the temperatures of the one or more 0,75 ± 0,10 status A or status T density patches on each of the samples used for calibration shall be measured under the actual planned light fade test conditions using a flat thin thermometer, such as thermocouple or PT-100 type sensor, attached with removable non-conductive adhesive to the back of the sample patch, a radiation thermometer, or a flat thin thermometer inserted between the colourant layer and the substrate layer of the sample patch.

NOTE 3 The radiation thermometer is incapable of being used with intervening material between the instrument and the samples.

NOTE 4 If a sample print has a sample backing, temperature measurement using a thermocouple type sensor attached with removable non-conductive adhesive to the backing layer behind a sample patch will likely be similar to the air temperature rather than the sample face temperature. Alternatively, insert the thermocouple sensor between the sample and the backing.

e) The average sample temperature for the current configuration shall be computed.

f) If the objective is to record the average sample temperature that corresponds to the preset BPT (uninsulated) or WPT and confirm that the temperatures obtained meet the sample temperature and air temperature requirements of this International Standard, then the obtained average sample temperature and air temperature shall be recorded and the temperature calibration procedure ended.

g) If the objective is to obtain a particular average sample temperature and this result was not obtained in the initial configuration, then the equipment and room configuration shall be adjusted as needed to obtain the average sample temperature. The room configuration refers to the configurable components of the chamber and the room environment (the temperature of the air inside or outside of the equipment chamber, the airflow rate inside and outside of the equipment chamber, addition of an IR filter, the irradiance level, etc.) shall be incrementally adjusted to obtain the aim average sample temperature and to ensure that the air temperature and sample temperature are within 5°C of each other.

h) After adjusting the configuration, the manufacturer's recommendation for equipment stabilization shall be followed before repeating sample temperature measurements. The sample temperature measurements shall be repeated at least once again after the aim sample temperature and required air temperature are achieved.

NOTE 5 When the light fade chamber is properly controlled, and taking multiple sample measurements, the standard deviation of the sample measurements is expected to be less than 2°C. When the standard deviation of the sample measurement is larger than 2°C, more measurements with more samples can reduce measurement error. If the standard deviation of the sample temperatures cannot be reduced sufficiently, then the chamber does not meet requirements of this International Standard. One mitigation approach is to avoid using certain volume regions of the chamber.

i) The BPT (uninsulated) or the WPT that corresponds to the verified aim average sample temperature and air temperature shall be the control value of the BPT (uninsulated) or the WPT used in actual light exposure tests.

The air temperature test conditions shall be reported. For the measurement of air temperature when the illumination source is in operation, air temperature-sensing equipment shall be shielded from the light source as stipulated in ISO 4892-1 and ISO 4892-2. A practical method for determining the air temperature may be to measure the temperature at the exit of the test chamber, depending on chamber design.

Sample surface temperature should be measured according to the procedures described in Annex C.

5.8 Air quality in the test environment

Some types of print materials can be highly sensitive to degradation caused by ozone or other airborne pollutants. Therefore, the test facility where print samples are made, dried, and measured, should be sufficiently free of these pollutants. In particular, for materials sensitive to ozone, levels of that gas shall be less than 2 nl/l average ozone concentration over any 24 h period. Ozone sensitivity of materials shall be determined in accordance with ISO 18941. A material that is not sensitive to ozone shall have demonstrated no measurable D_{min} or printed patch colour change at ambient ozone exposure levels and test condition temperature and humidity, over time periods consistent with test time duration.

NOTE 1 nl/l = 1ppb (10^{-9}). Although the notation "ppb" (parts per billion) is widely used in the measurement and reporting of trace amounts of pollutants in the atmosphere, it is not used in International Standards because it is language-dependent.

To ensure that ozone levels meet this requirement either active or passive monitoring can be used. Active monitoring includes real-time measuring and logging of ozone levels in the test facility. Passive monitoring measures long-term cumulative ozone levels yielding a final verification that pollutant levels were at or below the minimum during the test. Active monitoring is to be preferred as passive monitoring cannot indicate whether test conditions were valid until the test is completed.

5.9 Duration of exposures

The duration of exposures shall be determined with the following considerations:

a) Total exposure required, for example:

   1) total exposure expected in the usage;

   2) total exposure required for the warranty;

   3) total exposure stipulated as end point criteria in the applicable International Standards for specification of print life, when such a specification document is available.

b) Total exposure that will cause an aim change, for example:

   1) total exposure that will cause expected change;

   2) total exposure that will reach end point criteria specified in the applicable International Standards for specification of print life.

This test method does not include test end points to establish test duration. When the end point requirements of a print life specification standard are not applicable to a test and the materials under test are highly stable, such that the materials require a long test period to show a light fade change, it is acceptable to halt the test when a change is reliably detected. A reliable change is considered detected when the test result has progressed beyond the noise of the test system. The smaller of the test result changes: percentage colourant loss, change in colour balance, or change in D_{min}, may be assessed for highly stable materials to determine that a signal can be distinguished from test system noise.

6 Test equipment

6.1 Light source measurements

Light sources shall be measured at the sample plane in terms of illuminance or irradiance. Illuminance (lx) shall be measured with an illuminance meter as specified in CIE S 023. Irradiance (W/m^2) shall be measured with a radiometer as specified in ISO 9370 over a wavelength range from 300 nm to 400 nm, which is effective to monitor the overall light intensity when used with a defined spectral power distribution of this standard."

NOTE Measurement of irradiance is used as an integral part of the control system in light test equipment. The control system can then compensate for reduced UV transmission due to solarisation of the lamp and filters.

6.2 Light exposure equipment

6.2.1 Xenon arc light exposure equipment

Xenon arc lamp equipment that can achieve the test conditions and the tolerances stipulated in Clause 5 shall be used.[10] Temperature and humidity control equipment shall be used to attain the sample temperatures and the air relative humidity stipulated in this International Standard.

Any configuration of xenon arc light exposure equipment can be used while it achieves the required test conditions and the tolerances. One illustrative configuration with vertical sample holders rotating around a xenon arc lamp is shown in Figure E.1. Other configurations may have fixed horizontal sample holders placed below horizontal xenon arc lamps, or may be constructed using a stand-alone xenon arc unit designed to be placed in a temperature and humidity controlled room.

6.2.2 Fluorescent light exposure equipment

Fluorescent light exposure equipment that can achieve the test conditions and the tolerances stipulated in Clause 5 shall be used. Temperature and humidity control equipment shall be used to attain the sample temperature and the air relative humidity stipulated in this International Standard.

An illustrative example of a fluorescent light fading test unit is shown in Figure E.2.

6.2.3 Equipment with other light sources

Equipment with other light sources shall meet the requirements stipulated in Clause 5. Temperature and humidity control equipment shall be used to attain the sample temperature and the air relative humidity stipulated in this International Standard.

6.3 Specifications for optical filters

6.3.1 General

The spectral power distribution of the test illumination source can be modified by the use of optical filters in order to simulate a particular usage condition. UV filters with cut-off wavelengths below 400 nm are especially important in that context.

To control the sample surface temperature at the desired aim value, it may be required to employ one or more IR filters in order to reduce infrared energy above 800 nm.

Suitable UV cut-off filters and IR filters are described in the following subclauses.

NOTE Ultraviolet radiation is considerably more harmful to some types of pictorial colour hard copy images than it is to others and, therefore, variations in the level (and spectral power distribution) of the ultraviolet radiation in the illumination will affect some materials more than others.

6.3.2 Specifications for “standard” window glass

The window glass specified in some of these tests shall be a soda lime float glass. Spectral transmission characteristics shall conform to the tolerance of Table 1. The typical spectral transmission characteristics of the “standard” window glass are shown in Table D.1.

In order to maintain conformance, the glass shall be cleaned or replaced when it is stained or damaged and it does not conform to the values given in Table 1.