INTERNATIONAL STANDARD

ISO 105-B02

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Textiles — Tests for colour fastness —

Part B02: Colour fastness to artificial light: Xenon arc fading lamp test

Textiles — Essais de solidité des teintures —

Partie B02: Solidité des teintures à la lumière artificielle: Lampe à arc au xénon

Reference number
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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 105-B02 was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 1, *Tests for coloured textiles and colorants*.

This fifth edition cancels and replaces the fourth edition (ISO 105-B02:1994), which has been technically revised. It also incorporates ISO 105-B02:1994/Amd 1:1998 and ISO 105-B02:1994/Amd 2:2000.

ISO 105 was previously published in 13 “parts”, each designated by a letter (e.g. “Part A”), with publication dates between 1978 and 1985. Each part contained a series of sections”, each designated by the respective part letter and by a two-digit serial number (e.g. “Section A01”). These sections are now being republished as separate documents, themselves designated “parts” but retaining their alpha-numeric designations. A complete list of these parts is given in ISO 105-A01.

Textiles — Tests for colour fastness —

Part B02:
Colour fastness to artificial light: Xenon arc fading lamp test

1 Scope

This part of ISO 105 specifies a method intended for determining the effect on the colour of textiles of all kinds and in all forms to the action of an artificial light source representative of natural daylight (D65). The method is also applicable to white (bleached or optically brightened) textiles.

This method allows the use of two different sets of blue wool references. The results from the two different sets of references may not be identical.

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 105-A01, *Textiles — Tests for colour fastness — Part A01: General principles of testing*

ISO 105-A02, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour*

ISO 105-A05, *Textiles — Tests for colour fastness — Part A05: Instrumental assessment of change of colour for determination of grey scale rating*

ISO 105-B01:1994, *Textiles — Tests for colour fastness — Part B01: Colour fastness to light: Daylight*

ISO 105-B05, *Textiles — Tests for colour fastness — Part B05: Detection and assessment of photochromism*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

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

CIE[1)] Publication No. 51, *Method for assessing the quality of daylight simulators for colorimetry*

3 Principle

A specimen of the textile to be tested is exposed to artificial light under controlled conditions, together with a set of reference materials. The colour fastness is assessed by comparing the change in colour of the test specimen with that of the reference materials used.

NOTE General information on colour fastness to light is given in Annex D.

4 Terms and definitions

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

1) Commission Internationale de l'Éclairage, CIE Central Bureau, Kegelgasse 27, A-1030, Vienna, Austria www.cie.co.at.

4.1
test specimen
portions of the textile to be tested and which are representative parts of the item to be tested

Note 1 to entry: This is used for comparison between the exposed and the original (untested) state.

4.2
reference specimen
portion of a reference material that is to be exposed simultaneously with the test specimen

Note 1 to entry: Multiple reference specimens may be required to determine the test results.

4.3
blue wool reference material
one of a series of blue dyed wool textile materials with a known reaction to light

4.4
test chamber
area within the apparatus capable of meeting and maintaining the requirements for temperature, light and humidity

4.5
chamber relative humidity
ratio of the actual water vapour pressure in the test chamber to the saturation water vapour pressure of water at the same temperature, expressed as a percentage

4.6
effective humidity
combination of air and surface temperatures and air relative humidity which governs the moisture content at the surface of the test specimen during exposure

4.7
humidity-test control fabric
a red azoic dyed cotton fabric of known sensitivity to humidity and light

Note 1 to entry: This red azoic dyed fabric is used as a reference material to ensure that the effective humidity requirements are met.

4.8
photochromism
change in colour of a substrate after brief exposure to light, which is substantially returned to its original shade after storage in the dark

4.9
flip-flop mode
mode of operation whereby the specimen holders revolve around the central light source and on alternate rotations the specimen holders are automatically rotated 180° about their vertical axis so that the test specimens face towards the light source only every alternate revolution

5 Materials and apparatus

5.1 Reference materials

5.1.1 General

Either of two sets of blue wool reference may be used. The colour fastness ratings mentioned in this part of ISO 105 are obtained by comparison with either blue wool references 1 to 8 (*preferred* in Europe) or blue wool references L2 to L9 (*preferred* in America). The results from the two sets of references are not interchangeable. Information on the relationship between the two sets of blue wool reference materials can be found in ISO 105-B01:1994, 4.1.

5.1.2 Blue wool reference materials 1 to 8

Blue wool references developed and produced in Europe are identified by the numerical designation 1 to 8. These references are blue wool materials dyed with the dyes listed in Table 1. They range from 1 (very low colour fastness to light) to 8 (very high colour fastness to light) so that each higher-numbered reference is approximately twice as fast as the preceding one.

Table 1 — Dyes for blue wool references 1 to 8

Reference	**Dye** (Colour Index designation)[a]
1	CI Acid Blue 104
2	CI Acid Blue 109
3	CI Acid Blue 83
4	CI Acid Blue 121
5	CI Acid Blue 47
6	CI Acid Blue 23
7	CI Solubilised Vat Blue 5
8	CI Solubilised Vat Blue 8

[a] The Colour Index (fourth edition) is published by the Society of Dyers and Colourists, P.O. Box 244, Perkin House, 82 Grattan Road, Bradford BD1 2JB, West Yorkshire, UK, and by the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709-2215, USA.

5.1.3 Blue wool reference materials L2 to L9

Blue wool references developed and produced in America are identified by the letter L followed by the numerical designation 2 to 9. These eight references are prepared by blending varying proportions of wool dyed with CI Mordant Blue 1 (Colour Index, fourth edition, CI Constitution Number 43830) and wool dyed with CI Solubilised Vat Blue 8 (Colour Index, fourth edition, CI Constitution Number 73801), so that each higher-numbered reference is approximately twice as fast as the preceding reference.

Data in Annex C are presented to illustrate the relationship of each of the blue wool references on exposure to fixed amounts of radiant energy.

5.1.4 Humidity-test control

The effective humidity can **only** be measured by determining the colour fastness to light of a specific humidity-test control fabric (see 4.7).

5.2 Laboratory exposure devices

5.2.1 Light source

5.2.1.1 The exposure device shall provide for placement of specimens and any designated sensing devices in positions that allow uniform irradiance from the light source

NOTE The spectral irradiance produced in an artificial accelerated light and weathering device is very important. Ideally, the relative spectral irradiance produced by the device should be a very close match to that of solar radiation, especially in the short wavelength UV region. Annex A provides information about important benchmark solar spectra that can be used for comparing the spectral irradiance produced in the artificial accelerated exposure to that for solar radiation.

5.2.1.2 Exposure devices shall be designed such that the variation in irradiance at any location in the area used for specimen exposure shall not exceed ± 10 % of the mean. Procedures for measuring irradiance uniformity are found in Annex B.

NOTE The irradiance uniformity in exposure devices depends on several factors. The configuration of the lamp with respect to the specimens on exposure, including the differences in distance between the lamp(s) and the samples can affect uniformity of exposure. Deposits which can develop on the optical system and chamber walls, and the type and number of specimens being exposed, can also have an affect on uniformity of exposure.

5.2.1.3 Periodic repositioning of the test specimens in the test chamber is recommended to ensure the most consistent results.

5.2.1.4 Follow the apparatus manufacturer's instructions for lamp and filter replacement.

5.2.1.4.1 Direct radiation from xenon burners contains considerable amounts of short-wavelength ultraviolet radiation not present in daylight. Optical filters shall be fitted to minimize short-wavelength light (less than 310 nm) in accordance with the requirements in Annex A. The xenon arc, when appropriately filtered, produces radiation with a spectral power distribution that is a good simulation of average daylight throughout the UV and visible region.

5.2.1.4.2 Infrared radiation levels can be attenuated by use of filters to allow some control of the sample temperature.

5.2.1.5 It is preferred that the apparatus should be fitted with an irradiance sensing system. The irradiance sensor (if fitted) shall be mounted so that it receives the same radiation as the specimen surface. If it is not positioned in the specimen plane, it shall be calibrated for irradiance at the specimen distance.

5.2.1.5.1 The irradiance sensor (if fitted) shall be capable of measuring irradiance preferably in a specific wavelength range (e.g. 300 nm to 400 nm), or in a narrow bandpass centred around a single wavelength (e.g. 420 nm) and shall be calibrated at the wavelength range or single wavelength, as appropriate. The measured wavelength or wavelength range shall be reported.

5.2.1.5.2 Where irradiance control is available, the irradiance shall be controlled at (42 ± 2) W/m^2 in the wavelength range 300 nm to 400 nm or (1,10 ± 0.02) $W/(m^2.nm)$ at the wavelength 420 nm.

5.2.1.5.3 The irradiance sensor (if fitted) shall be calibrated in the emission region of the light source used. Calibration shall be checked in accordance with the radiation-measuring and instrument manufacturer's instructions with compliance to ISO 9370.

5.2.1.6 The light source shall consist of a xenon arc lamp of correlated colour temperature 5500 K to 6500 K, the size of which will depend on the type of apparatus used.

5.2.1.7 The apparatus shall be fitted with a light filter placed between the light source and the specimens so that the ultraviolet spectrum is steadily reduced. Annex A provides the transmission requirements for the filter system used.

5.2.1.8 The apparatus shall be fitted with a heat filter placed between the light source and the specimens so that the amount of infrared (IR) radiation contained in the xenon arc spectrum is steadily reduced.

5.2.2 Temperature (See A.3)

One of two types of black-coated temperature sensor shall be used, either a *black-standard thermometer* or a *black-panel thermometer* (for more detail see A.3.) and the thermometer shall be mounted in the same plane and orientation as the test specimen(s).

Note The preferred thermometer is the Black Standard Thermometer (BST).

5.2.3 Humidity

The presence of moisture can have a significant effect in accelerated laboratory exposure tests. The apparatus shall have the means for providing and controlling moisture to specimens by humidification of the chamber air. The quality of the water used to create the effective humidity shall be a minimum of Grade 3 in accordance with ISO 3696.

5.2.4 Covers

Covers shall be made from thin opaque material, for example high-grade steel, thin sheet aluminium or cardboard covered with aluminium foil, for partial covering of samples and references. The opaque material shall neither react with the test specimens nor the test conditions and shall not itself produce any change in colour of either the test specimen or the reference materials.

5.2.5 Colour matching lamps, in accordance with CIE Publication No. 51.

5.2.6 Assessment cabinet, complying with ISO 105-A01.

5.2.7 Sample mounting card, free of optical or fluorescent brightening agent.

5.2.8 Assessment mask, complying with ISO 105-A01. In order to obtain reliable test results using ISO 105-A02, the test specimen(s) shall be masked with a material that is identical in colour to the sleeve that is used to mask the grey scale (5.2.9).

5.2.9 Grey scale for assessing change in colour, complying with ISO 105-A02.

6 Preparation of test specimens

6.1 The size of the test specimen will depend on the number of specimens to be tested and on the shape and dimensions of the specimen holders supplied with the apparatus.

Attention is drawn to the guidelines given in E.4.

6.2 The specimen may be a strip of cloth, yarn wound close together on a sample mounting card (5.2.7) or laid parallel and fastened on a card, or a mat of fibres combed and compressed to give a uniform surface and fastened on a card. Each exposed and unexposed area shall be not less than 10 mm × 8 mm.

6.3 To facilitate handling, the test specimen(s) to be tested and similar strips of the references may be mounted on one or more cards as indicated in Figures 2, 3, 4 or 5.

6.4 The covers (5.2.4) shall make close contact with the surface of the unexposed areas of the specimens and the references, in order to give a sharp line of demarcation between exposed and unexposed areas, but shall not compress the specimen unnecessarily.

6.5 The specimens to be tested and the blue wool references shall be of equal size and shape in order to avoid errors in assessment due to overrating the visual contrast between exposed and unexposed parts on a larger pattern as against a narrower reference.

6.6 When testing specimens of appreciable thickness, the references shall be arranged so that they are the same distance from the light source as the upper surface of the test specimens. Covers for the unexposed portions shall avoid surface compression.

Textiles of appreciable thickness which have fibres that may shift position or texture which may make evaluation of small areas difficult, shall be tested with an exposed area not less than 50 mm × 40 mm and preferably larger.

7 Exposure conditions

To simulate different environments testing can be carried out under different conditions (see Table 2). The type of conditions should be agreed between parties. The chosen conditions shall be reported.

Table 2 — Exposure conditions

	Exposure Cycle A1	Exposure Cycle A2	Exposure Cycle A3	Exposure Cycle B
Condition:	Normal	Extreme low humidity	Extreme high humidity	—
Climatic condition replicated	Temperate zone	Dry	Semi-tropical	—
Blue wool references	Series 1 to 8			Series L2 to L9
Black Standard Temperature[a]	(47 ± 3) °C	(62 ± 3) °C	(42 ± 3) °C	(65 ± 3) °C
Black Panel Temperature[a]	(45 ± 3) °C	(60 ± 3) °C	(40 ± 3) °C	(63 ± 3) °C
Effective humidity (see 8.2)[b]	Approximately 40 % effective humidity. (Note: This is typically achieved when blue wool reference 5 exhibits a contrast equal to grey scale grade 4)	Less than 15 % effective humidity. (Note: This is typically achieved when blue wool reference 6 exhibits a contrast equal to grey scale grade 3-4)	Approximately 85 % effective humidity. (Note: This is typically achieved when blue wool reference 3 exhibits a contrast equal to grey scale grade 4)	Low (Colour fastness of humidity-test control: L6 to L7)
Relative humidity	As determined by effective humidity requirement			(30 ± 5) %
Irradiance[c]	Where irradiance control is available, the irradiance shall be controlled at (42 ± 2) W/m^2 in the wavelength range 300 nm to 400 nm or (1,10 ± 0,02) W/(m^2·nm) at the wavelength 420 nm			

[a] Air chamber temperature control should not be used as air chamber temperature is a different value from Black Standard Temperature and Black panel temperature.

[b] Effective humidity is based on an assessment of the blue wool references after the humidity-test control fabric has been exposed to give a contrast equal to grey scale grade 4 (8.2.5).

Once a contrast equal to grey scale grade 4 on the exposed humidity-test control fabric has been achieved, effective humidity is based on assessment.

[c] The broadband (300 to 400 nm) and narrowband (420 nm) irradiance control values are based on traditional settings and should not be implied as equivalent in all models of test equipment. Consult with the instrument manufacturer for the equivalent irradiance in other controlling wavelengths or bandpasses.

8 Procedure

8.1 Apparatus set-up

8.1.1 Check that the apparatus is in good running order and set up in accordance with the manufacturer's guidelines.

8.1.2 Fill all unused specimen holders with a non-reflective material such as white card stock. For machines employing flip-flop mode, both faces in the unused specimen holders shall be used.

8.1.3 The black panel thermometer (which has an open back) or black standard thermometer (which has an insulated back) shall be positioned in the same plane and orientation as the test specimens.

8.2 Adjustment of the effective humidity (see Clause 7 and Annex E)

8.2.1 When using test conditions in which the use of effective humidity is specified, do not rely on machine readings of relative humidity in the test chamber. The correct adjustment of the effective humidity (for tests using blue wool references 1 to 8) is **critical** to obtaining valid results. Figure 1 shows the relationship between effective humidity and the light fastness of the humidity-test control fabric.

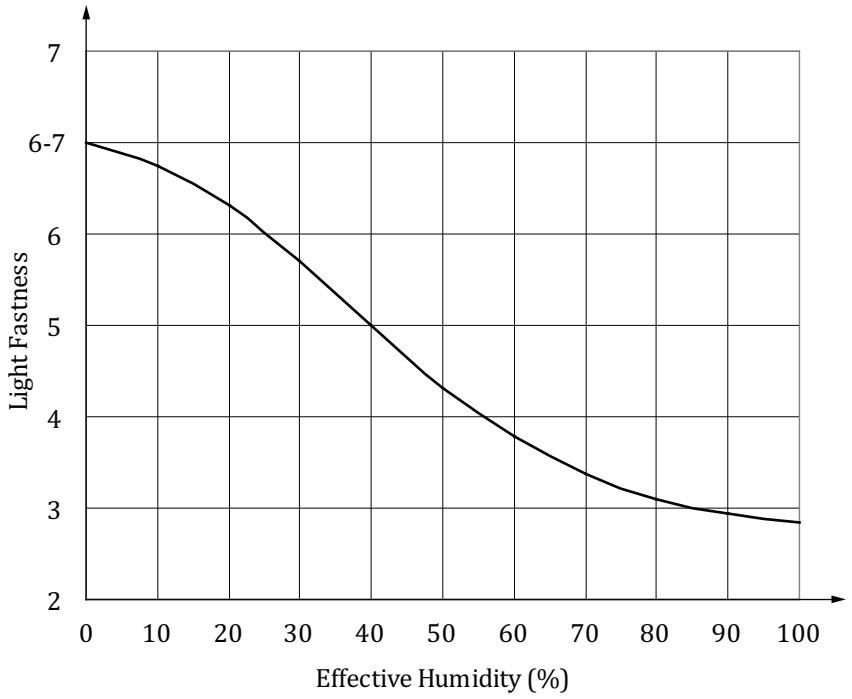


Figure 1 — Mean values obtained from humidity-test control exposures

8.2.2 For the required exposure conditions, determine from Table 2 the required effective humidity then using Figure 1, identify the equivalent light fastness (expressed using blue wool reference series 1 to 8) required to be exhibited by the humidity-test control fabric. (For example, for normal conditions the effective humidity required is 40 % which is equivalent to a light fastness of the humidity-test control fabric of blue wool reference 5).

8.2.3 Place a portion of the humidity-test control fabric (5.1.4) together with the relevant blue wool references (5.1.2 or 5.1.3) on a card. Each of the reference materials (blue wool references and humidity-test control) shall measure not less than 45 mm × 10 mm.

8.2.4 Mask the card prepared in 8.2.3 using an appropriate cover (5.2.4) such that each exposed and unexposed area is not less than 10 mm × 8 mm. Place the masked card in the test chamber.

8.2.5 Expose the masked card until the contrast between the exposed and unexposed portions of the humidity-test control fabric (4.7) is equal to grade 4 on the grey scale (5.2.9).

8.2.6 When the conditions in 8.2.5 have been achieved assess the contrast between the exposed and unexposed portions of the relevant blue wool reference as referenced in Table 2. The contrast should be equal to that specified for the appropriate exposure conditions (see Table 2).

8.2.7 If the necessary contrast in 8.2.5 is not achieved, adjust the controls on the apparatus to give the required selected exposure conditions and repeat 8.2.3 to 8.2.6 using fresh reference materials.

8.3 Exposure methods

8.3.1 General

There are five separate methods given, each of which produce different amounts of information. The user should select the most appropriate method for their application.

For Methods 1 to 4, assessment of fading of test specimens or reference samples is **critical** to obtaining valid results. It is not sufficient to rely on exposure time (hours) to determine the end point of the various stages of each method. For Method 5, the end point is determined by a specified dosage of irradiance and intermediate assessment of fading may not be required.

Attention is drawn to the guidelines given in the annexes in relation to selection of apparatus, test method, and to the recommendations on good testing practice for different types of textile materials.

8.3.2 Method 1

8.3.2.1 This method is considered the most informative and should be used in cases of dispute over the numerical rating. The basic feature is the control of the exposure period by inspection of the *specimen*, and one set of blue wool references is required for each specimen under test. This method is especially suitable for determination of colour fastness to light for test specimens of unknown performance.

For this method, opaque covers (5.2.4) masking approximately one-third and two-thirds of the test specimens and blue wool references are required.

8.3.2.2 Arrange the test specimen and the blue wool references on the sample mounting card (5.2.7) in accordance with Clause 6 and as shown in Figure 2. Cover the middle one-third of the test card using an opaque cover (5.2.4) ABCD.

NOTE The blue wool references and test specimen need not necessarily be mounted on the same card and where applicable test cards should be mounted in suitable specimen holders for the apparatus used.

8.3.2.3 Place the masked card in the test chamber and expose the masked card to light under the selected exposure conditions in Table 2.

8.3.2.4 Follow the effect of exposure by periodically removing the masked card from the test chamber, removing the opaque cover (5.2.4) and inspecting the test specimen by comparison with a grey scale (5.2.9). When a change in blue wool reference 2 equal to grey scale grade 3 (or L2 equal to grey scale grade 4) is achieved, inspect the test specimens and assess their colour fastness by comparing any change that has occurred on the test specimens with the changes that have occurred in blue wool references 1, 2 and 3 or L2. This is a preliminary assessment of colour fastness. If it is required to retain visual evidence of the colour change at this preliminary assessment stage terminate this test at this point and repeat the test using fresh test specimens and blue wool references. There is no need to repeat the preliminary assessment on the new specimen.

8.3.2.5 Continue to expose the test specimen and blue wool references until the contrast between the exposed and unexposed portions of the test specimen is equal to grey scale grade 4 (5.2.9). Remove the masked card from the test chamber. At this stage attention should be given to the possibility of photochromism (see ISO 105-B05).

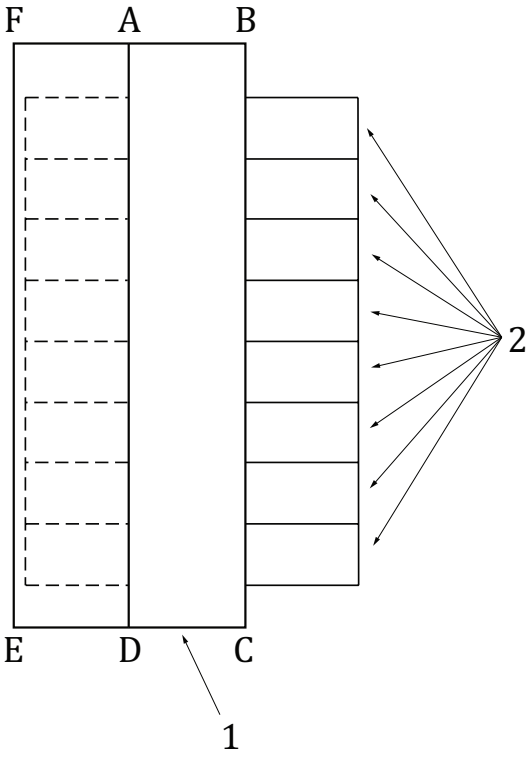
8.3.2.6 For white (bleached or optically brightened) textiles, terminate the exposure of the test specimen at this point and carry out the assessment as described in Clause 9.

8.3.2.7 For all other textiles, apply an opaque cover (5.2.4) FBCE (see Figure 2) such that only the right-hand one-third of the test card(s) remains exposed.

NOTE It is preferable to replace cover ABCD with a new cover FBCE in order to avoid undesired effects from light seepage. If an additional cover is used to cover ADEF then the additional cover should be of sufficient dimensions to overlap the existing cover and prevent any light seepage along the line A–D

8.3.2.8 Replace the masked card in the test chamber and continue to expose the test specimens and blue wool references until the contrast between the exposed and unexposed portions of the test specimen is equal to grey scale grade 3 (5.2.9).

8.3.2.9 If blue wool reference 7 (or L7) fades to a contrast equal to grey scale grade 4 (5.2.9) before the test specimen does, the exposure is terminated at this stage. When a specimen has a colour fastness equal to or greater than 7 (or L7) it would require unduly long exposure to produce a contrast equal to grey scale grade 3; moreover this contrast would be impossible to obtain when the colour fastness is 8 (or L8). Assessments in the region of 7–8 (or L7–L8) are made, therefore, when the contrast produced on blue wool reference 7 (or L7) is equal to grey scale grade 4, the time required to produce this contrast being long enough to eliminate any error which might result from inadequate exposure.



Key

1 masked area

2 blue wool references 1 to 8 or L2 to L9 and/or test specimens

Figure 2 — —Mounting of test specimens and blue wool references for Method 1

8.3.3 Method 2

Flat plane exposure devices (see B.2) cannot be used for method 2 until an ISO ring trial is concluded.

8.3.3.1 This method may be used when a large number of specimens have to be tested simultaneously. The basic feature is the control of the exposure periods by inspection of the *blue wool references*, which allows a number of specimens differing in colour fastness to be tested against a single set of blue wool references, thus conserving supplies. This method is especially suitable for the dyestuff industry.

For this method, opaque covers masking approximately one-quarter, one-half and three-quarters of the test specimens and blue wool references are required (5.2.4).

8.3.3.2 Arrange the test specimens to be tested and the blue wool references as required, in accordance with Clause 6; more than one card may be necessary. As shown in Figure 3, apply opaque cover (5.2.4) ABCD to mask the left-hand most quarter of the total width of each specimen and blue wool references.

8.3.3.3 Place the test card in the test chamber and expose the masked card to light under the selected exposure conditions in Table 2.

8.3.3.4 Follow the effect of exposure by periodically removing cover (5.2.4) ABCD and inspecting the blue wool references. When a change in blue wool reference 2 equal to grey scale grade 3 (or L2 equal to grey scale grade 4) (5.2.9) is achieved, inspect the test specimens and assess their colour fastness by comparing any change that has occurred on the test specimens with the changes that have occurred in blue wool references 1, 2 and 3 or L2. This is a preliminary assessment of colour fastness. At this stage attention shall be given to the possibility of photochromism (see ISO 105-B05).

8.3.3.5 Replace the cover (5.2.4) ABCD in exactly the same position and continue to expose the test specimens and blue wool references until a change in blue wool reference 4 (or L3) equal to grey scale grade 4 (5.2.9) is achieved; at this point replace the cover ABCD with one that masks the area AEFD (see Figure 3).

NOTE It is preferable to replace cover ABCD with a new cover AEFD in order to avoid undesired effects of light seepage. If an additional cover is used to cover BEFC then the additional cover should be of sufficient dimensions to overlap the existing cover and prevent any light seepage along the line B–C

8.3.3.6 Continue to expose the test specimens and blue wool references until a contrast between the exposed (EGHF) and unexposed (ABCD) areas in blue wool reference 6 or L5 equal to grey scale grade 4 (5.2.9) is achieved; then replace the cover (5.2.4) AEFD with one that masks the area AGHD (see Figure 3).

NOTE It is preferable to replace cover AEFD with a new cover AGHD in order to avoid undesired effects of light seepage. If an additional cover is used to cover EGHF then the additional cover should be of sufficient dimensions to overlap the existing cover and prevent any light seepage along the line E–F

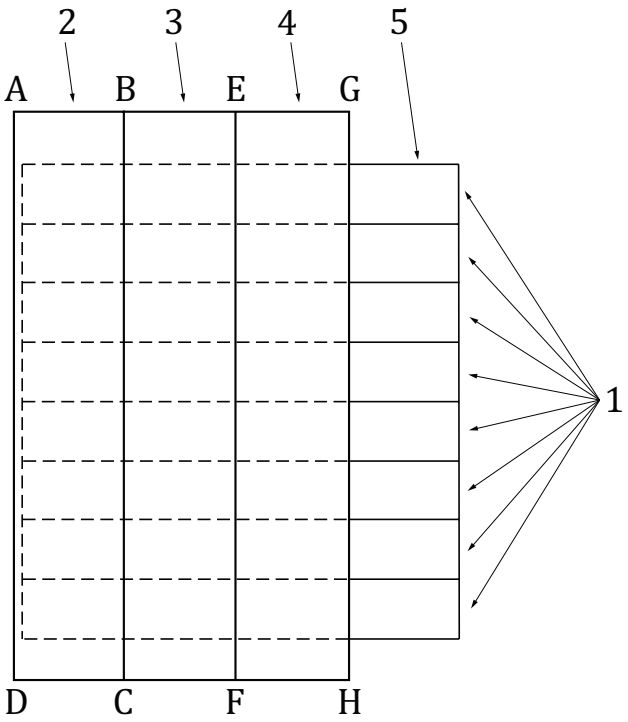
8.3.3.7 Continue to expose the test specimens and blue wool references until whichever of the following conditions occurs first, either:

a) a contrast between the exposed and unexposed areas on blue wool reference 7 or L7 equal to grey scale grade 4 (5.2.9); or

b) a contrast between the exposed and unexposed areas equal to grey scale grade 3 (5.2.9) on the most resistant specimen; or

c) for white (bleached or optically brightened) textiles, a contrast between the exposed and unexposed areas equal to grey scale grade 4 (5.2.9) on the most resistant specimen.

NOTE The contrast referred to in b) and c) may occur before the fading defined in 8.3.3.5 or 8.3.3.6 has taken place and therefore the end point has been achieved.



Key

1 blue wool references 1 to 8 or L2 to L9 and/or test specimens
2 Unexposed
3 First period
4 Second period
5 Third period

Figure 3 — Mounting of test specimens and blue wool references for Method 2

8.3.4 Method 3

8.3.4.1 This test method is similar to Method 1 but is suitable where the test specimen is compared for conformity with a known performance specification. The basic feature is the control of exposure by inspection of the *target blue wool reference*. The method allows multiple test specimens to be tested using a reduced number of blue wool references, typically the target blue wool reference together with the two blue wool references immediately preceding the target blue wool reference. This is to assist in quantifying a specimen which does not conform with the required performance specification.

For this method, opaque covers masking approximately one-third and two-thirds of the test specimens and blue wool references are required (5.2.4).

8.3.4.2 Arrange one or more test specimens together with relevant blue wool references on the sample mounting card (5.2.7) as shown in Figure 4 except that the blue wool references required shall be restricted to the target blue wool reference plus the two preceding blue wool references. Cover the middle one-third of the test card using an opaque cover (5.2.4) ABCD.

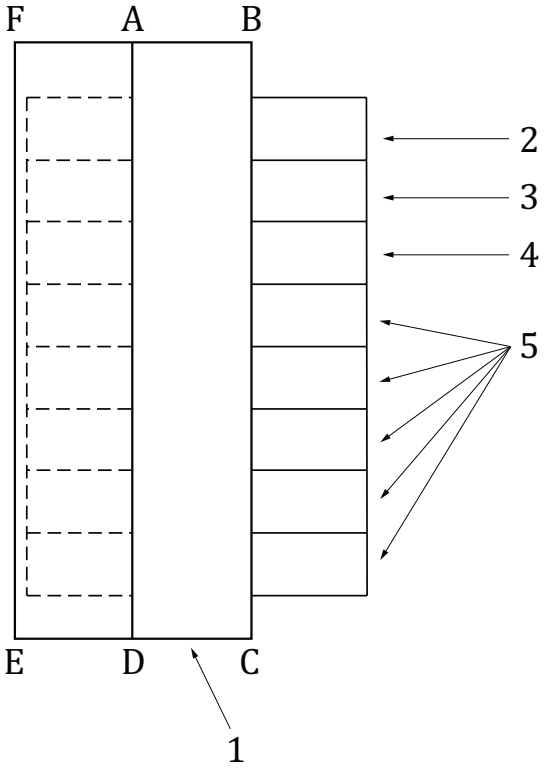
8.3.4.3 Place the masked card in the test chamber and expose the masked card to light under the selected exposure conditions in Table 2 until the contrast between the unexposed and exposed portions of the target blue wool reference is equal to a grey scale grade 4 (5.2.9). At this stage attention should be

given to the possibility of photochromism (see ISO 105-B05). For white (bleached or optically brightened) textiles, terminate the exposure period at this stage and carry out the assessment as described in Clause 9.

8.3.4.4 Remove the masked card and mask area FBCE (see Figure 4) using an opaque cover (5.2.4) such that only the right-hand one-third of the card remains exposed.

NOTE It is preferable to replace cover ABCD with a new cover FBCE in order to avoid undesired effects from light seepage. If an additional cover is used to cover ADEF then the additional cover should be of sufficient dimensions to overlap the existing cover and prevent any light seepage along the line A–D

8.3.4.5 Replace the masked card in the test chamber and continue to expose the masked card until the contrast between the exposed and unexposed portions of the target blue wool reference is equal to grey scale grade 3 (5.2.9).



Key

1 masked area
2 blue wool reference (*n*–2)
3 blue wool reference (*n*–1)
4 target blue wool reference (*n*)
5 test specimens

Figure 4 — Mounting of test specimens and blue wool references for Method 3

8.3.5 Method 4

8.3.5.1 This method is similar to Method 1 but is intended to check conformity with an agreed-upon reference sample. The basic feature is the control of the exposure period by inspection of the *agreed-upon reference sample*. It is permissible to expose the specimens with the reference sample only and without

the presence of blue wool references. This method is particularly suited as a quality control method and permits many test specimens to be compared with the same reference specimen.

For this method, opaque covers masking approximately one-third and two-thirds of the test specimens and agreed-upon reference sample are required (5.2.4).

8.3.5.2 Arrange one or more test specimens together with the relevant agreed-upon reference sample on the sample mounting card (5.2.7) as shown in Figure 5. Cover the middle one-third of the test card using opaque cover (5.2.4) ABCD.

8.3.5.3 Place the masked card in the test chamber and expose the masked card to light under the selected exposure conditions in Table 2 until the contrast between the unexposed and exposed portions of the agreed-upon reference sample is equal to a grey scale grade 4 (5.2.9). For white (bleached or optically brightened) textiles, terminate the exposure of the test specimen at this point and carry out the assessment as described in Clause 9.

8.3.5.4 Remove the masked card and mask area FBCE (see Figure 5) using an opaque cover (5.2.4) such that only the right-hand one-third of the test card remains exposed.

NOTE It is preferable to replace cover ABCD with a new cover FBCE in order to avoid undesired effects from light seepage. If an additional cover is used to cover ADEF then the additional cover should be of sufficient dimensions to overlap the existing cover and prevent any light seepage along the line A–D

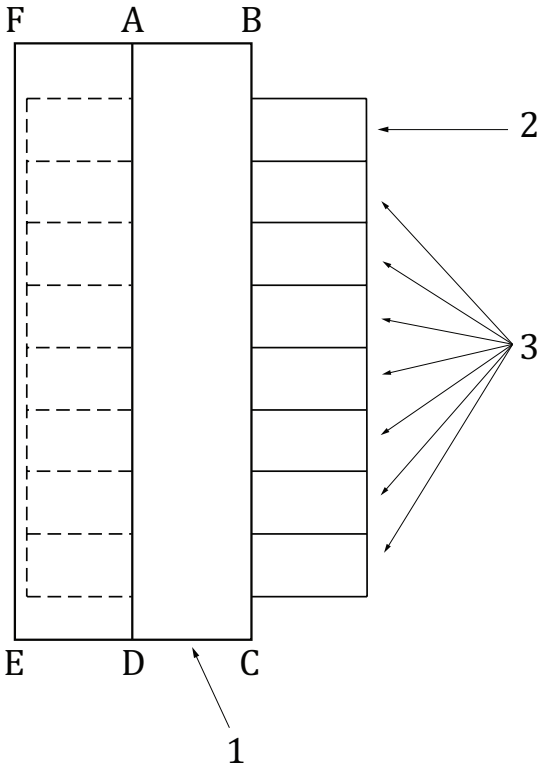
8.3.5.5 Replace the masked card in the test chamber and continue to expose the masked card until the contrast between the exposed and unexposed portions of the agreed-upon reference is equal to grey scale grade 3 (5.2.9).

8.3.6 Method 5

8.3.6.1 This method is suitable to check conformity to agreed-upon radiant energy levels. It is permissible to expose the specimens alone or with blue wool references. The specimens should be exposed until the specified amount of radiant energy is reached.

For this method, opaque covers masking approximately one-half of the test specimens and blue wool references are required (5.2.4).

8.3.6.2 Arrange one or more test specimens together with any blue wool references on the sample mounting card (5.2.7) as shown in Figure 6. Cover one-half of the test card using opaque cover (5.2.4) ABCD.



Key

1 masked area

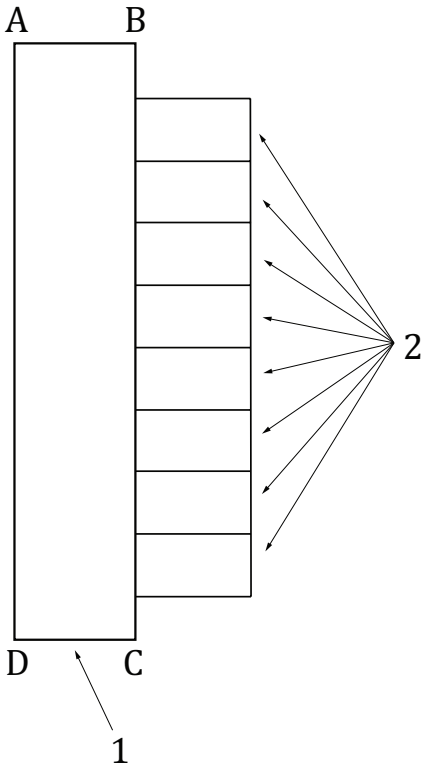
2 agreed-upon reference

3 test specimens

Figure 5 — Mounting of test specimens and blue wool references for Method 4

8.3.6.3 Set the apparatus according to the manufacturer's instructions to provide the desired level of irradiance (see 5.2.1.5.2).

8.3.6.4 Place the masked card in the test chamber and expose the masked card to light under the selected exposure conditions in Table 2 until the desired level of radiant energy normally expressed in Joules has been achieved.



Key

1 masked area

2 test specimens or blue wool references as applicable

Figure 6 — Mounting of test specimens and/or blue wool references for method 5

9 Assessment of colour fastness

9.1 To avoid a mis-rating of the colour fastness of the specimen due to its photochromism (4.8), the tested specimen cards should be allowed to condition in the dark at ambient indoor conditions for a minimum of 24 h before assessing the colour fastness (see ISO 105-B05).

The final assessment (reported grade) given as a numerical rating, is based on the contrasts equal to grey scale grade 4 and grey scale grade 3 (5.2.9) between exposed and unexposed portions of the test specimen. For white (bleached or optically brightened) textiles, the final assessment in numerical ratings is based only on a contrast equal to grey scale grade 4 between exposed and unexposed portions of the test specimen or reference material.

9.2 Remove all the covers (5.2.4), thus revealing on the test specimens and references the various areas, which have been exposed for different times, which will depend on the method used, together with the area which has not been exposed to light.

Comparison of the changes in the test specimen with changes in the blue wool references shall be facilitated by surrounding the specimen with a mask (5.2.8).

Compare the change in colour of the specimen with the corresponding changes in the references using the assessment cabinet (5.2.6) under D65 (artificial daylight) illuminant (see ISO 105-A01). The use of alternative illuminants shall be agreed between the parties and shall be reported.

For all methods using blue wool references, the colour fastness of the specimen is the number of the blue wool reference which shows similar changes in colour (visual contrast between exposed and unexposed parts of the specimen). If the specimen shows changes in colour which are near to the imaginary reference midway between any two consecutive blue wool references, an intermediate rating, for example 3–4 or L2–L3, shall be given. Assessments shall be confined to whole or midway ratings only.

Assessments of change in colour are made at the contrast points as defined in the relevant method. For Methods 1, 3 and 4 this will give two assessments, for Method 2 up to three assessments and for Method 5 a single assessment.

The colour fastness of the test specimen is taken as the individual assessment for Method 5 or the mean of the individual assessments for Methods 1 to 4. Where the arithmetic mean of the individual assessments is not equal to a whole or half grade then the assessment is rounded up to the next half or whole grade.

9.3 If the assessment of the specimen is worse than that of blue wool reference 1 (or L2) a rating of "less than 1" (or "less than L2") is given.

9.4 For Method 1 and Method 2, if the colour fastness is equal to or higher than 4 or L3, any preliminary assessment (see 8.3.2.4 and 8.3.3.4, respectively) becomes significant; if this preliminary assessment is 3 or L2, it shall be included in the rating in brackets. For example, a rating of 6(3) indicates that the specimen changes very slightly in the test when reference 3 just begins to fade, but that on continuing the exposure the resistance to light is equal to that of reference 6.

9.5 If the specimen is photochromic, the colour fastness rating shall include a P bracketed with the rating obtained from the test for photochromism, for example 6(P3–4) (see ISO 105-B05).

9.6 The term "change in colour" includes change in hue, chroma, lightness, or any combination of these characteristics of colour (see ISO 105-A02).

9.7 Exposures based on a performance specification (see Method 3) shall be assessed by comparison of the change in colour of the test specimen and the target blue wool reference. If the specimen shows no greater change in colour than the target blue wool reference, the colour fastness shall be assessed and calculated as in 9.2 and additionally classified as "satisfactory". If the specimen shows a greater change in colour than the target blue wool reference, the colour fastness shall be assessed and calculated as in 9.2 and additionally classified as "unsatisfactory". If the specimen shows a greater change in colour than the lowest numbered blue wool reference used the colour fastness shall be reported as that numbered blue wool reference preceded by the text "less than" and additionally classified as "unsatisfactory".

9.8 Exposures based on an agreed-upon reference sample (see Method 4) shall be assessed by comparison of the change in colour of the test specimen and the reference sample i.e. as blue wool references are not used the colour fastness cannot be quantified. If the specimen shows no greater change in colour than the reference sample, the colour fastness shall be classified "satisfactory"; if the specimen shows a greater change in colour than the reference sample, the colour fastness shall be classified "unsatisfactory".

9.9 Exposures based on an agreed-upon radiant energy level (see Method 5) are assessed either by numerical quantification against the grey scale (5.2.9) for assessing change in colour, in accordance with ISO 105-A02, or by comparison of the change in colour of the sample with that of the blue wool references similar to 9.2.

10 Test report

The test report shall include the information:

a) the number and year of publication of this part of ISO 105, i.e. ISO 105-B02:2013;

b) all details necessary for the identification of the specimens tested;

c) for Methods 1 and 2:

report the numerical rating for the colour fastness to light. The colour fastness rating shall be expressed either:

1) by the numerical mean of the individual assessments provided that the difference between the individual assessments does not exceed one half grade (together with the prefix L when using the blue wool references designated L2 to L9); or

2) by the individual assessments reported together with the grey scale grade to which they relate where the difference between the individual assessments exceeds one half grade (together with the prefix L when using the blue wool references designated L2 to L9).

If this rating is equal to or higher than 4 or L3 and the preliminary assessment is equal to or lower than 3 or L2, report the latter figure in brackets.

d) for Method 3:

report the numerical rating for the colour fastness to light. The colour fastness rating shall be expressed either:

1) by the numerical mean of the individual assessments provided that the difference between the individual assessments does not exceed one half grade (together with the prefix L when using the blue wool references designated L2 to L9); or

2) by the individual assessments reported together with the grey scale grade to which they relate where the difference between the individual assessments exceeds one half grade (together with the prefix L when using the blue wool references designated L2 to L9).

If required, report the classification "satisfactory" or "unsatisfactory", together with the performance reference or the reference sample used.

e) for Method 4:

report the classification "satisfactory" or "unsatisfactory", together with the performance reference or the reference sample used.

f) for Method 5:

report the numerical rating for colour fastness to light together with the specified amount of radiant energy. The rating shall be expressed either:

1) by the figure alone (together with the prefix L when using the blue wool references designated L2 to L9); or

2) if no blue wool references are used, by the rating of the colour change assessed by comparison with the grey scale in accordance with ISO 105-A02 or by colour measurement in accordance with ISO 105-A05 and prefixed by the text "grey scale grade".

g) If the specimen exhibits photochromism (see D.5), the colour fastness rating shall be followed by a P bracketed together with the grey scale rating obtained from the test for photochromism, for example 6(P3–4).

h) If the assessment of change in colour of a test specimen includes significant changes in hue and/or chroma, the use of appropriate descriptors shall be included with the numerical rating (see D.6 and ISO 105-A02).

i) for all test methods report:

1) the apparatus used;

2) the method (8.3),

3) the exposure conditions (Table 2)

4) the specified amount of radiant energy, if applicable

5) whether or not flip-flop mode was used

6) the illuminant used for assessment if not D65

7) any deviations from this test method.

Annex A
(normative)

Requirements for xenon arc exposure devices

A.1 General requirements

The xenon arc exposure device uses one or more water or air cooled xenon arc lamps. The lamps may differ in size and wattage, depending on the design or capacity of the exposure area. The device shall be equipped with filters that remove unrealistic short wavelength ultraviolet radiation and optionally filters that remove or reduce long wavelength radiation that could contribute to high specimen temperatures. In addition, the device shall provide for placement of specimens and any designated sensing devices in positions that allow uniform irradiance from the light source.

The xenon arc exposure device shall include means to place specimen holders in an area of uniform irradiance. This may be a revolving rack that rotates around a vertically mounted xenon arc lamp or lamps. The revolving rack may include means to turn the specimen holders about their vertical axis with each revolution of the rotating specimen rack and this is referred to as "flip-flop" mode (4.9). Regardless of the use of flip-flop mode, the exposure of the test specimens to the light source is considered to be continuous. The device may also use a flat tray on which the specimen holders are mounted. This flat tray shall be located parallel to the xenon arc lamp or lamps.

The xenon arc exposure device shall be equipped with an enclosed cabinet to prevent operators from being exposed to UV radiation while the device is in operation. In addition, the device is typically an enclosed insulated cabinet to minimize the effects of variation in room temperature.

A.2 Light source

The light source shall consist of a xenon arc lamp of correlated colour temperature 5500 K to 6500 K, the size of which will depend on the type of apparatus used. The xenon arc lamp shall use filters that provide a reasonable simulation of solar radiation filtered by typical window glass. The transmission of the filter system used shall be at least 90 % between 380 nm and 750 nm, falling to 0 between 310 nm and 320 nm. Infrared radiation from the xenon arc may be attenuated by use of filters to allow better control of the sample temperature.

NOTE The irradiance uniformity in exposure devices depends on several factors such as deposits which can develop on the optical system and chamber walls. In addition, irradiance uniformity can be affected by the type and number of specimens being exposed.

All xenon arc exposure devices used for this standard shall be equipped with suitable starters and control equipment for either manually or automatically controlling the wattage of the lamp. In manually controlled units, the wattage of the lamp is adjusted at regular intervals to maintain the required irradiance. Follow the device manufacturer's instructions for manual wattage control.

For automatic control of the wattage applied to the lamp in order to maintain a constant irradiance, devices may use single or multiple radiometers coupled to an appropriate feedback control system. If a radiometer is used, it shall be mounted so that it receives the same radiation as the specimen surface. If it is not positioned in the specimen plane, it shall have a sufficient field of view and be calibrated for irradiance at the specimen distance. The radiometers used shall meet the requirements given in ISO 9370. The radiometers used shall be capable of measuring irradiance either in a specific wavelength range (e.g. 300 nm to 400 nm), or in a narrow bandpass centred around a single wavelength (e.g. 420 nm). The radiometers shall be calibrated at the wavelength range or single wavelength, as appropriate. Follow the exposure device manufacturer's instructions for calibration of the radiometers with compliance to

ISO 9370. If a radiometer is used to control irradiance, the measured wavelength or wavelength range shall be reported.

The intensity of light emission will drop with continued use. Follow the device manufacturer's instructions for replacement of lamps and filters. Keep a record of when lamps and filters are replaced in each device used for conducting the exposures described in this standard.

For devices designed to automatically maintain a constant level of irradiance, exposures of equal time provide equivalent radiant exposure, which may be calculated by the following formula:

$$H = E \times 3{,}6t$$

where

H is the radiant exposure, expressed in kilojoules per square metre

E is the irradiance, expressed in watts per square metre (or joules per square metre and second)

t is the time, expressed in hours

3,6 is a conversion factor

Devices that use automatic irradiance control may be equipped with a presettable countdown integrator calibrated in kilojoules per square metre that can be used to terminate the test when the specimens have received the required level of radiant exposure.

A.3 Temperature

The surface temperature of exposed materials depends primarily on the amount of radiation absorbed, the emissivity of the specimen, the amount of thermal conduction within the specimen and the amount of heat transmission between the specimen and the air or between the specimen and the specimen holder. Since it is not practical to monitor the surface temperature of individual test specimens, a specified black-coated sensor is used to measure and control the temperature within the test chamber. The temperature sensor fixed to a black plate shall be mounted within the specimen exposure area so that it receives the same radiation and experiences the same cooling conditions as a flat test panel surface.

Two types of black-coated temperature sensor may be used:

Black-standard thermometers consist of a plane (flat) stainless-steel plate with a thickness of 0,5 to 1,2 mm. A typical length and width is about 70 mm by 40 mm. The surface of this plate facing the light source shall be coated with a black layer which has good resistance to ageing. The coated black plate shall absorb at least 90 % of all incident flux to 2500 nm. A thermally sensitive element such as a platinum resistance sensor shall be attached in good thermal contact to the centre of the plate on the side opposite the radiation source. This side of the metal plate shall be attached to a 5 mm thick baseplate made of unfilled poly(vinylidene fluoride) (PVDF). A small space sufficient to hold the platinum resistance sensor shall be machined in the PVDF baseplate. The distance between the sensor and this recess in the PVDF plate shall be about 1 mm. The length and width of the PVDF plate shall be sufficient so that no metal-to-metal thermal contact exists between the black-coated metal plate and the mounting holder into which it is fitted. The metal mounts of the holder of the insulated black panel shall be at least 4 mm from the edges of the metal plate.

Black-panel thermometers, consist of a plane (flat) metal plate that is resistant to corrosion. Typical dimensions are about 150 mm long, 70 mm wide and 1 mm thick. The surface of this plate that faces the light source shall be coated with a black layer which has good resistance to ageing. The coated black plate shall absorb at least 90 % of all incident flux to 2500 nm. A thermally sensitive element shall be firmly attached to the centre of the exposed surface. This thermal sensitive element can be a black-coated stem-type bimetallic dial sensor, a resistance based sensor, a thermistor, or thermocouple. The back of the black panel thermometer shall be open to the atmosphere within the exposure chamber.

The temperature indicated by the black-panel or black-standard thermometer depends on the irradiance produced by the apparatus light source and the temperature and speed of the air moving in the test chamber. Black-panel temperatures generally correspond to those for dark coatings on metal panels. Black-standard thermometer temperatures generally correspond to those for the exposed surface of dark samples with poor thermal conductivity. At conditions used in typical exposure tests, the temperature indicated by a black-standard thermometer will be higher than that indicated by a black-panel thermometer. Because black-standard thermometers are insulated, their response time for temperature changes is slightly slower than for a black-panel thermometer.

Exposure devices shall be able to control the temperature of the black sensor to within ± 3 °C of the required temperature. If the temperature indicated by the black sensor used varies by more than ± 3 °C from the required temperature during equilibrium operation, terminate the test, make any necessary repairs, and verify that the device is able to control the black sensor temperature within the required limits before continuing.

The exposure device shall be designed such that the temperature of a black panel or black standard temperature sensor placed anywhere within the specimen exposure area is within ± 5 °C of the required temperature. Upon request, the supplier of the exposure device shall provide documentation that their device meets this performance requirement.

A ventilating system is used to provide a volume of air flow through the test chamber and over the test specimens. If agreed upon by all parties, the temperature of the air within the chamber may be controlled by using a temperature sensing device that is shielded from the light and from any water spray.

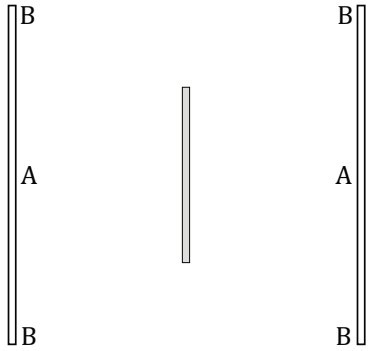
A.4 Humidity

The presence of moisture can have a significant effect in accelerated laboratory exposure tests. Equipment shall have the necessary means to control relative humidity (RH) by humidification of the chamber air. This is a requirement for exposure in Table 2.

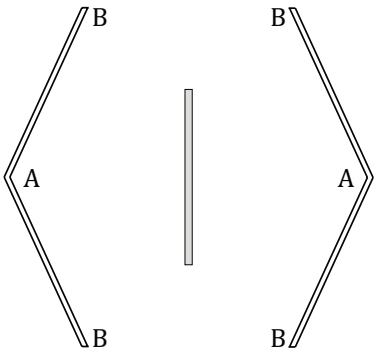
Annex B
(normative)

Procedures for measuring the irradiance uniformity in the specimen exposure area (for apparatus manufacturers only)

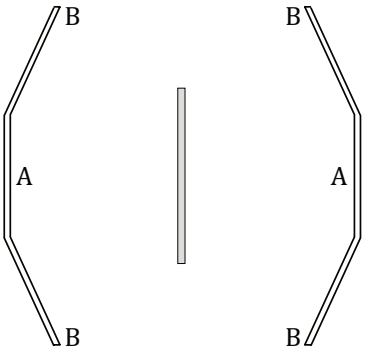
B.1 In devices that use a rack to hold the specimens and rotate them around a light source, measure irradiance at a position in the specimen rack that is closest to the light source (position A in Figure B.1) and at two positions within the specimen rack that are farthest from the light source (position B) in Figure B.1. Measurements made with a radiometer that is placed on the rack as it rotates around the light source will give the most realistic indication of irradiance uniformity. Calculate the mean of all measurements taken. No measurement point on the sample plane shall exceed ± 10 % of the mean.



Vertical specimen rack



Two-tier inclined specimen rack

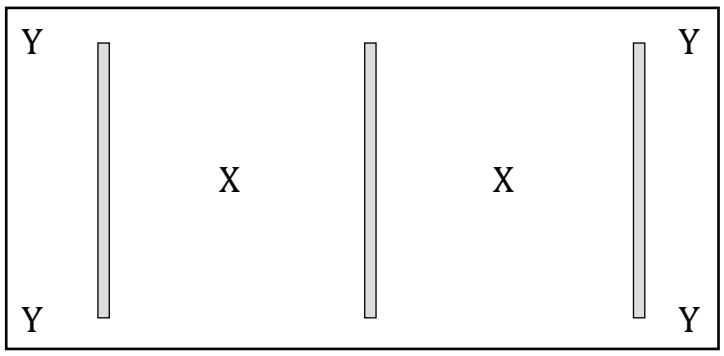


Three-tier inclined specimen rack

Figure B.1 — Determining irradiance uniformity in devices using a rotating specimen rack for specimen exposure

Alternative specimen rack configurations are acceptable provided that they comply with the above irradiance uniformity relationship.

B.2 In devices where specimens are positioned in a flat plane in front of a light source, measure irradiance at a position in the specimen plane that is closest to the light source (position X in Figure B.2) and in two opposite corners of the plane where test specimens are placed (position Y in Figure B.2). Calculate the mean of all measurements taken. No measurement point on the sample plane shall exceed ± 10 % of the mean.



Flat specimen plane with multiple light sources

Figure B.2 — Determining irradiance uniformity in devices using a flat plane for specimen exposure

B.3 If the design of the device is such that the maximum irradiance may not be at the centre of the exposure area, or that the minimum irradiance may not be at the position farthest from the centre, the actual maximum irradiance shall be used and the actual minimum irradiance shall be used to calculate the mean in B.1 and B.2. Additional measurements of the irradiance at other positions within the exposure area may also be made. In all cases, however, the irradiance measured at these positions shall not exceed ± 10 % of the mean.

Annex C
(informative)

Light exposure equivalents for blue wool lightfastness references L2 to L9

Note For colour change of grade 4 on the grey scale for colour change.

Table C.1 — Light exposure equivalents for blue wool lightfastness references L2 to L9

Blue wool reference	Xenon only	
	420 nm kJ/m^2	300 nm to 400 nm kJ/m^2
L2	**21**[a]	**864**
L3	**43**	**1728**
L4	**85**[a]	**3456**
L5	**170**	**6912**
L6	**340**[a]	**13824**
L7	**680**	**27648**
L8	**1 360**	**55296**
L9	**2 720**	**110592**

[a] Verified by experiment; all other values are calculated.

Annex D
(informative)

General Information on colour fastness to Light

D.1 When in use, textiles are usually exposed to light. Light tends to destroy colouring matters and the result is the well known defect of "fading", whereby coloured materials change colour – usually becoming paler and duller. Dyes used in the textile industry vary enormously in their reaction to light and it is obvious that there must be some method of measuring their fastness. The substrate also influences the colour fastness of a dye to light.

This part of ISO 105 cannot satisfy completely all the interested parties (who range from dye manufacturers and the textile industry to wholesale and retail traders and the general public) without becoming technically involved and possibly difficult to understand by many who have a direct interest in its application.

D.2 The following non-technical description of a test for colour fastness to light has been prepared for the benefit of those who find the detailed technicalities of this part of ISO 105 difficult to understand. The method is to expose the specimen being tested and to expose also, at the same time and under the same conditions, a series of colour fastness references which are pieces of wool cloth dyed with blue dyes of different degrees of fastness. When the specimen has faded sufficiently, it is compared with the references and if it has behaved, for instance, like reference 4[2)] then its colour fastness is said to be 4.

D.3 The colour fastness references should cover a wide range, since some specimens fade noticeably after exposure for 2 h or 3 h to bright summer sunshine, although others may withstand long exposure without change, the dyes in fact outliving the material to which they have been applied. Eight references have been chosen, reference 1 being the most fugitive and reference 8 the most resistant. If it takes a certain length of time for reference 4 to fade under certain conditions, then the same amount of fading will occur on reference 3 in approximately half the time, or on reference 5 in approximately twice that time, provided that the conditions are the same.

D.4 It is necessary to ensure that different people testing the same material will fade it to the same extent before assessment against the simultaneously faded reference. The ultimate users of dyed materials differ widely in what they consider to be "faded articles" and therefore specimens under test are faded to two different degrees which adequately cover most opinions and make assessment more reliable. These required degrees of fading are defined by reference to a collection of "grey scale" reference contrasts (grey scale 5 equals no contrast, grey scale 1 equals large contrast). Thus the use of the grey scale enables fading to be taken to defined extents, and the blue wool cloths enable the colour fastness to be rated.

The general principle of assessing on the basis of moderate and severe fading is complicated by the fact that some specimens on exposure undergo a slight change very rapidly indeed but do not change further for a long time. These slight changes are such that under normal conditions of use they would become important, as the following example shows.

A retailer has a length of curtain fabric in his window and on it is a cardboard ticket indicating the price. After a few days the ticket is removed and careful examination reveals the place where it has been resting because the surrounding cloth has changed shade slightly on exposure to light. Some of this curtain material is exposed so as to produce a moderate degree of fading and it is found that reference 7 has faded to the same extent; the general colour fastness of the fabric is therefore 7.

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2) The designations of the colour fastness references referred to here are those of the European set (see 5.1.2). The principles explained are equally valid for the American set (see 5.1.3).

The important factor about this change in shade is that it can only be detected when there is a sharp boundary between the exposed and unexposed areas, and these conditions rarely occur during normal use. The magnitude of this slight change would be given as an additional assessment in brackets. Thus a rating for a test could be 7(2), indicating a slight initial change equivalent to the first perceptible fade of reference 2, but otherwise a high colour fastness of 7.

D.5 A further unusual colour change is also catered for, namely photochromism. This effect is shown when a dye changes colour rapidly on exposure to strong light but on removal to a dark place the original colour returns more or less completely. The extent of photochromism is determined by the special test described in ISO 105-B05, and is shown in the rating by a number following the letter P within brackets; for example 6(P2) means a photochromic effect equal to a grey scale 2 contrast but permanent fading equal to that of reference 6.

D.6 Finally, there are many specimens which change hue on prolonged exposure to light; for example, a yellow may become brown, or a purple may become blue. In the past there have been many arguments as to whether such specimens could be said to have faded or not. The techniques used in ISO 105-B01 to ISO 105-B05 are unambiguous on this point; it is visual contrast on exposure which is being measured, whether it be loss of colour or change in hue; in the latter case, however, the kind of change is included in the assessments. For example, consider two green specimens which, on exposure, change in appearance at the same rate as reference 5; one becomes increasingly pale while the other becomes first a greenish blue and finally a pure blue. The former would be rated “5” and the latter “5 bluer”. In this instance also, the techniques used in ISO 105-B01 to ISO 105-B05 try to present as complete a picture of the behaviour of a specimen on exposure as is possible without becoming excessively complicated.

Annex E
(informative)

Guidelines for Conducting Testing

E.1 Selection of apparatus

This test method permits the use of a wide variety of testing machines including carousel-type machines and flat-bed machines. In addition individual machines may have further options such as the use of alternate cycle rotation of test specimens ("flip-flop" mode).

The choice of testing machine will in part depend upon the size, type, volume of test specimens and desired throughput of the testing machine. For example, a carousel type machine without irradiance control in which test specimens are constantly exposed to the light source will have half the potential capacity of the same machines with double sided specimen holders and using flip-flop mode. However, conversely the same machines using flip-flop mode will typically take double the time to complete the testing as the test specimens are only exposed to the light source on every alternate cycle.

By contrast, a flat-bed machine typically does not have a flip-flop mode but is limited by the area of the test chamber.

Similarly, samples such as carpets which can be heavily patterned and contain up to 30 colours may be more easily tested using a flat bed machine as this will permit the use of larger test specimens and thereby give a more accurate overall assessment of the behaviour of the whole of the pattern when exposed to light. This is because the tested specimen can be re-inserted in to the carpet from which it was taken to provide the area of contrast rather than working with relatively small areas of exposure as would be more common on a carousel-type machine (see E.4 and E.8).

E.2 Using the humidity-test control fabric to "verify" the effective humidity of the apparatus

E.2.1 Whenever the testing machine has been adjusted, serviced, repaired or otherwise modified, then the effective humidity should be re-set following the procedure given in 8.2. This process can sometimes be called "verification" of the testing machine.

E.2.2 The number of cards required containing the blue wool references and humidity-test control fabric will depend upon the individual testing apparatus. The number of cards is dependent upon the extent to which the apparatus is capable of maintaining homogeneity of irradiance, temperature and effective humidity within the test chamber. When setting up the apparatus for the first time it is advisable to use more than one test card to establish the extent of the homogeneity in the test chamber. The test cards should be positioned to assess variability arising from different locations in the apparatus especially in larger apparatus, whether canted carousel or flat plane apparatus.

E.2.3 When carrying out the "verification", it is essential that any surface within the test chamber which may reflect light from the xenon arc lamp(s) onto the test specimens should be masked using non-reflective material such as the card used to mount the test specimens.

For carousel-type machines, typically it is only the specimen holders which need masking. For machines employing flip-flop mode, both faces in the unused specimen holders should be filled.

E.3 Periodic verification of effective humidity

E.3.1 While E.2 deals with setting the effective humidity after adjustment or modification of the testing machine, it cannot be presumed that the effective humidity is maintained as a constant factor. It is therefore good practice to periodically verify that the effective humidity is being maintained at the desired level.

E.3.2 When verifying the effective humidity, it is not necessary to use a full set of blue wool references. It is normal to use a card comprising the humidity-test control fabric plus blue wool references 4, 5 and 6 (or L5, L6 or L7) for normal conditions or the relevant corresponding blue wool references for other conditions. This is sufficient to assess whether the contrast between the exposed and unexposed areas on the humidity-test control fabric is equal to that found on the target blue wool reference (for normal conditions this is blue wool reference 5).

E.3.3 The method of test is as given in 8.2

E.3.4 The frequency of verification is likely to vary according to the volume of testing and frequency of testing. Constant use or infrequent use interrupted by periods of disuse can both lead to potential changes in the effective humidity and, if allowed to go unchecked, would cast doubt on the validity of the test results produced.

It is recommended that verification should be carried out at least every three months. For machines which have not been used or verified within the last three months, it is strongly recommended that this is carried out prior to using the machine or at the same time as the testing is performed. Test results obtained at the same time as verification will be invalid if the verification does not meet the required conditions (see Table 2).

Irrespective of the frequency of verification, it is recommended that the test cards are retained for later reference and to allow visual comparison of different test cards over a prolonged period of time. This can act as a useful tool in detecting any drift in control of the effective humidity over time. All test cards should be stored in the dark.

E.4 Mounting of test specimens

E.4.1 Mounting of specimens to be tested, whether reference material or other textile, can affect the quality of the results. Ideally all samples on any given test card should be of nominally the same thickness. It is not recommended to mix thick samples with thin samples or samples with variable thickness as it will make the use of opaque covers (5.2.4) more difficult and prevent the clear demarcation of the exposed and unexposed areas.

E.4.2 The method of mounting should be appropriate to the textile being tested. For most fabrics, the use of metal staples is appropriate although copper staples are not recommended due to their conductivity of heat absorbed from the light source. Alternatively adhesive tape may be used provided that the adhesive tape used is not exposed to the light source and the adhesive does not migrate or otherwise affect the sample under test. For this reason it is not recommended to use double sided adhesive tape on most samples. Specific guidance on the mounting of particular types of textile is given in the following sections.

E.4.3 For samples comprising loose fibre, sliver, roving or tops, it is recommended that the fibres are brushed to align them to form a loose pad of sufficient thickness and density to provide a uniform and solid colour over the full width of the test card.

It can be difficult to mount staple fibre samples using metal staples and the use of double sided adhesive or spray adhesive may be the only alternative. In such cases, consideration should be given throughout the test to ensuring that the samples remains firmly affixed to the test card while not altering which fibres (on the uppermost surface) are exposed to the light source.

E.4.4 Yarns are less problematical than fibre but not as easy as fabrics to mount. For yarns, the easiest methods of mounting are to either wrap the yarn around a card to provide a dense parallel winding or to place several lengths of yarn parallel on the test card and to secure the yarn using metal staples or adhesive tape on the rear of the test card.

E.4.5 For most fabrics which have a relatively level surface, the recommended method of mounting is by the use of non-copper metal staples. Alternatively the width of the test specimen can be extended so that it can be wrapped around the edge of the test card and secured using adhesive tape on the reverse of the test card.

E.4.6 Three-dimensional fabrics such as chenille, brushed or raised fabrics such as fleeces, pile fabrics and figured jacquard fabrics pose particular problems. For fabrics of irregular or uneven thickness, such as fleece, chenille or embossed fabrics, there is no easy solution and when selecting opaque masks consideration needs to be given to the need to avoid compression of the fabric surface while at the same time ensuring that a clear demarcation between the exposed and unexposed portions of the test specimen can be achieved.

For pile fabrics, the need to avoid compression is critical and is compounded by the need to maintain the pile in the same orientation as it appears in the unexposed area of the test specimens. If compression of the sample cannot be avoided then this should be reported in the test report.

For fabrics which have uneven surfaces such as figured jacquard fabrics or some pile fabrics which may have ground and patterned areas, consideration should be given to testing each of these areas separately and using separate test cards so as to avoid mixing of samples of different thickness on the same test card. As an alternative, it is possible to use a larger test specimen and to expose the test specimen to the light source without the use of an opaque mask and when assessing the contrast to place the exposed test specimen back into the original fabric from which it was taken. One disadvantage of this alternative procedure is the need for larger quantities of substrate and the need to expose multiple test specimens if it is desired to retain the visual evidence of exposure on completion of the test.

E.4.7 Multi-coloured materials or materials with a very detailed or small design such as many printed textiles may also present particular problems. In particular how to ensure that the same area of the design appears in all the exposed areas and also in the unexposed area. Similarly for multi-coloured samples, it is necessary to ensure that all the different colours are tested and this may necessitate the use of multiple test specimens.

E.4.8 Textile floor-coverings can pose similar problems to multi-coloured and heavily patterned textiles. Textile floor coverings can contain numerous different colours, some carpets containing more than 30 separate colours within the same design. While it is possible to extract and test each colour yarn individually, it is not always practical to do so and in addition it will not provide any information about how the overall design may be affected when exposed to light. Consequently it may be more suitable to expose a larger test specimen (or multiple samples) containing all of the various colours and to replace the exposed test specimen back in to the floor-covering from which it was taken in order to assess the overall contrast.

The untested textile floor covering should be stored in conditions where it will not be exposed to ambient lighting or to variations in temperature

In addition there can be an issue with the thickness and textile of the floor-covering and the difficulty in exposing and masking the test specimen without compressing the surface. Again one solution is not to use opaque covers (5.2.4) but to expose multiple specimens and to re-insert them into the substrate from which they were taken when assessing the contrast between the exposed and unexposed areas.

The tested specimen should be reinserted into its original position within the untested portion of textile floor-covering and maintaining the original plane and orientation. This is particularly important to ensure that the direction of pile lay is the same in both the tested and untested specimens.

E.4.9 For all types of textile, while it is not always necessary to mount the test cards into specimen holders, for some type of testing machine this is necessary. When specimen holders are used they should be appropriate to the type of textile being tested and attention should be given to ensuring that the distance between the surface of the test specimens and the light source is identical to that between the surface of the blue wool references or other reference materials and the light source.

In order to achieve this, it is sometimes necessary to adjust the distance by the use of padding materials to raise the surface of the test card furthest from the light source, using specimen holders of different depths to accommodate thicker test specimens, or to use specimen holders where the samples are mounted from the rear.

E.5 Covers

E.5.1 The opaque covers described in 5.2.4 are intended to protect either part of the test specimen from exposure to light or to protect previously exposed areas from further exposure.

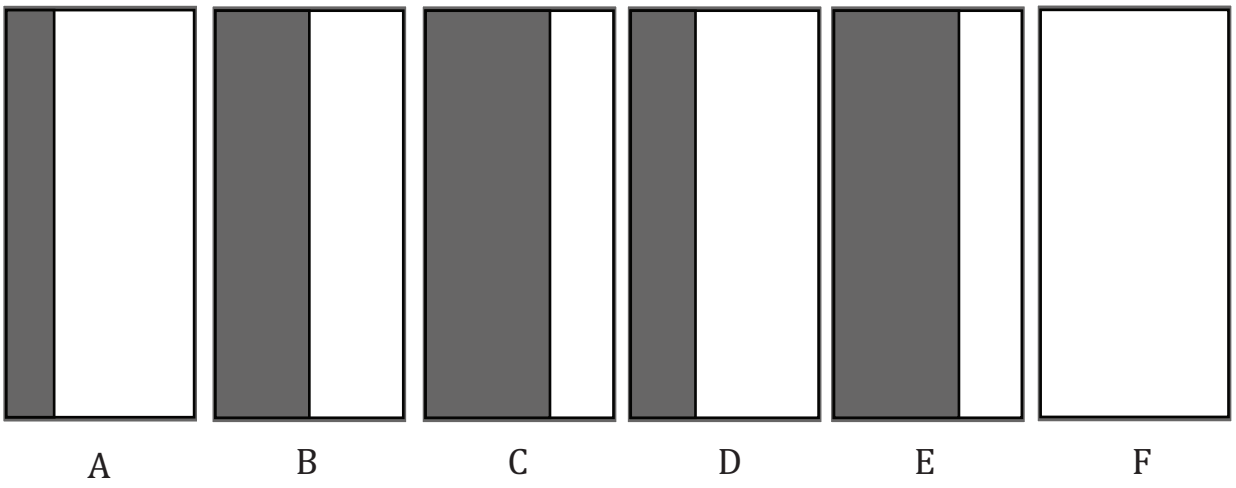
It is therefore necessary to ensure that the opaque covers are close fitting to any specimen holder or, where no specimen holders are used, overlap the edges of the test card sufficiently to prevent any light leakage around the outside edges of the test card.

E.5.2 As discussed in E.4 it is also necessary to ensure that the covers are appropriate to the type of textile being tested and that the cover does not cause compression of the textile nor permits light to leak under the edges.

During the test it is vital that when inspecting the test card during the various stages of the test considerable care is taken to ensure that the covers are replaced in exactly the same position as they were before removal. If care is not taken then this can lead to an indistinct edge between the exposed and unexposed areas thereby making assessment of the contrast more difficult.

Similar problems can also occur when changing covers between the various stages of the test.

E.5.3 Depending upon the option of which method of test is being used, the type of cover required will vary although Figure E.1 indicates covers which will satisfy most options.



Key

A one-quarter cover
B half cover
C three-quarters cover
D one-third cover
E two-thirds cover
F zero cover

Figure E.1 — Showing examples of various covers required for testing

E.6 Selecting the most appropriate method

E.6.1 The choice of which of the five methods included in this standard may depend upon many factors including the type of apparatus to be used, the volume of testing involved and the information required from the test.

E.6.2 Method 1 provides the most detailed information for any individual textile but it requires the test card to contain a full set of blue wool references for each test specimen. However, if the performance behaviour on exposure to light of the textile under test is not known and there is no known target performance requirement then this test method may be the most suitable.

For example, a textile manufacturer is producing a new textile and has no information about how it might behave when exposed to light. As the textile may be suitable for many different end-uses, so there is no associated performance requirement and the manufacturer needs to know how resistant to exposure to light the textile material is. Having this information will enable the manufacturer to avoid selling the textile for end-uses for which it is not suitable. Conducting Method 1 allows the manufacturer to determine the maximum fastness to light of the textile under the chosen conditions of test.

E.6.3 Method 2, in contrast to Method 1, is more suitable when there are many textiles to be tested but the behaviour of all of them is unknown. Unlike Method 1, it is only necessary to include one full set of blue wool references per machine run and these blue wool references are used for multiple test specimens. This method is more suited to situations such as a dyehouse where there may be many different batches

of the same colour being tested simultaneously for comparison purposes and to ensure constancy of the light fastness behaviour.

For example, a dyehouse has a large order to fulfil but the dye processes used utilize small batches. How can the dyehouse be sure that the light fastness of each dyeing batch is consistent with that of the other batches in the order? Method 2 permits a test specimen from each batch to be tested simultaneously against a single set of blue wool references. Not only does Method 2 allow the dyehouse to determine the maximum light fastness of the dyeing, but it also allows easy visual comparison of the different dye batches. Any batch which is not consistent with the other dye batches will be quickly identified and the batch can be rejected or reworked (re-dyed) as appropriate.

E.6.4 Methods 3 and 4 are very similar to one another as they compare the test specimens against either a known blue wool reference or another reference material. Both Method 3 and Method 4 are most commonly used in situations where the laboratory knows what the textile is expected to achieve, either by comparison with a previously tested material or because there is an applicable performance specification which states the minimum requirements.

For Method 3, if a sample is required to achieve performance at least equal to that of blue wool reference 4, then it is sufficient to include blue wool reference 4 together with blue wool references 3 and 2 on the test card with one or more test specimens. Unlike Method 1, the test is continued until the target blue wool reference exhibits the required contrasts and the test specimens are assessed by comparison with the target blue wool reference. This means that if the test specimen has faded by less than the target blue wool reference then a result of "Better than 4" may be given, using the example cited.

The inclusion of the two lower blue wool references arises from common laboratory practice and at the request of many customers who want to know by how much the test specimen might fail to achieve the target performance. Again using the same example, if the test specimen exhibits a greater contrast than blue wool reference 4, then by including blue wool references 2 and 3 on the same test card, it is possible for the laboratory to provide a more detailed result than merely stating "Less than 4". In the above example, a laboratory may be able to indicate that the test specimen was only marginally worse at say 3-4 or that it was substantially worse at 2. This allows the reader of the test report to make an informed commercial judgement based on other factors unconnected with the testing.

Method 4 replaces blue wool references with another reference fabric. This might be a master dye batch or a previous production run or even a competitor's fabric. The test specimen is compared to this reference but unlike method 3, it is only possible to state "better than", "worse than" or "equal to". However some laboratories may still choose to include blue wool references as well as the reference material so that they are also able to provide additional information about the light fastness of the test specimen.

E.6.5 Method 5 differs from Methods 1 to 4 in that it does not need any reference material to be used. Method 5 relies upon controlling the irradiance (dosage of light) to which the test specimen is exposed. However, many laboratories will include blue wool references so as to be able to maximize the information obtained from this test method.

When using Method 5, it is vital that the laboratory is clear about how the results are to be expressed as the exposure is not controlled by the contrast on either the test specimen or the reference material. It is therefore vital that when reporting results using Method 5 that the assessed grade is clearly stated as being "Grey scale grade" when the assessment is **not** made against blue wool references so as to avoid any confusion by the reader. The two designations are not interchangeable and it is not possible to extrapolate behaviour from one type of grading to the other.

For example, a test specimen when exposed to a particular dosage of irradiance may produce a contrast between the exposed and unexposed areas equal to grey scale grade 4 but this contrast may be similar to that exhibited by blue wool reference 2. This fading may therefore be expressed as "grey scale grade 4" or as "2". In this instance, simply reporting a result of either "4" would be misleading as the result would imply that the test specimen gave results comparable to blue wool reference 4 whereas, in fact, it was only equal to blue wool reference 2.

E.7 Inspection during testing

E.7.1 All of the methods, with the exception of Method 5, rely upon periodic inspection of the test cards to determine when the various contrast points have been reached. E.5 gave information relating to the covers used to mask different areas of the test card.

E.7.2 It is not possible to provide definitive guidelines on the frequency of inspection as this will vary from machine to machine and between different laboratories as well as being influenced by factors such as the ambient laboratory conditions, usage of the test apparatus, etc.

However, evidence obtained from ring trials (repeatability and reproducibility studies) would indicate that for samples which are expected to have low fastness to light (less than blue wool reference 2) short intervals between inspections are necessary. In such cases intervals as short as 1 h may be necessary to avoid over-exposing test specimens or reference materials and thereby having to repeat the test.

For textiles expected to exceed a fastness to light of blue wool reference 4, intervals of 24 h may be used in the initial stages, progressively reducing the interval between inspections as the end-point is reached.

In deciding upon a suitable inspection interval, laboratories may rely on past experience with similar textiles. However, consideration should be given to any periods of exposure when the laboratory may not be manned by personnel qualified to carry out the inspection. For example, many laboratories do not operate 24 h a day or at weekends and a sample which was approaching end point should not be left exposed and in the apparatus without provision of periodic inspection. This may mean removing test cards from the apparatus overnight or at weekends. Where this practice is used, it is strongly advised that the test cards are placed in a darkened environment such as a dark room or an opaque container to avoid uncontrolled exposure to ambient daylight through windows or other light sources such as indoor electric lighting.

Good laboratory practice also dictates that it is better to inspect a sample more frequently and therefore ensure that detection of the various contrast phases is observed rather than not frequently enough and run the risk that the test specimens may become over-exposed and the test would need to be repeated.

E.8 Assessment related issues

E.8.1 The procedure for assessment of light fastness is clearly described in Clause 9. However, there can be issues arising from the nature of the textile material under test which can create specific difficulties in following the assessment procedure as described in D.4.

E.8.2 Test specimens that have small areas of design such as some printed textiles can be difficult to assess for contrast. In such instances, where the design is such that it is not possible to obtain sufficient area on both sides of the contrast line, the assessor will have to make a judgement based on non-contiguous areas.

For some textiles such as pile floor-coverings, it may not be possible to assess each colour in the design individually. In this instance, again it is more appropriate to provide an overall assessment but with particular attention given to whether one or more colours appear to have faded more significantly with the design than the remainder. It is not unusual for some pastel colours in carpets to react more than some darker colours and for the fading of these pastel colours to actually be more noticeable in the overall design effect.

When assessing colours which are non-contiguous it is also necessary to take into account any impact adjacent colours may have on the assessment. For example, if a particular colour occurs at several points in a design but is bordered by a dark colour in one area and by a lighter colour in another area, assessing the target colour by comparison of two non-identically bordered areas may produce undesirable effects in the perceived target colour and thus affect the resultant assessment of contrast.

Assessment of non-contiguous areas may be improved by the masking of smaller identical areas in the exposed and unexposed specimens. This may necessitate the use of a variety of mask shapes and/or

sizes dependent upon the samples being assessed and attention is drawn to 9.2 and the guidance in ISO 105-A02 regarding the colour of opaque masks.

E.8.3 For some textiles, colour change due to heat is particularly relevant for thermochromic colours such as reds and oranges but can affect any colour or textile material.

Similarly, texture effects due to heat or humidity can occur in pile textiles or textiles of synthetic origin such as polyesters, polyamides, etc. It is not uncommon for the effect of heat and humidity to cause pile fabrics to incline in one direction thereby resulting in a perceived colour change caused not by any actual colour change but by the fact that one area is being viewed at a different pile orientation to another. This is best explained by reference to the perceived colour change which occurs when a hand is rubbed over the surface of a pile fabric.

E.8.4 For some textiles, whether by the nature of their design or their construction, assessment of small areas may not be the most appropriate way of assessing the overall effect of exposure to light. In such cases, it may be more appropriate to retain the area of the textile from within which the test specimen was taken and to reinsert the exposed test specimen back into the original textile before assessing the effect of exposure to light. This practice is perhaps most common on textiles such as pile floor coverings and jacquard fabrics.

E.8.5 When assessing colour fastness generally, it is good practice to employ at least two trained assessors so that each assessment can be verified by a second person. In the event of any disagreement, reference to further trained assessors can then be made with the result being the mode result at each contrast point.

When using multiple assessors within a laboratory, it is essential that the assessors participate periodically in intra- and inter- laboratory correlation exercises in order that they can validate that their assessments are within the acceptable limits for uncertainty of measurement.

For colour fastness tests based on the subjective assessment of colour change, the within-laboratory uncertainty of measurement is typically accepted as being ± 0,5 grade. The between laboratory uncertainty of measurement may be higher but it is not possible to quantify this through the use of statistical analysis as there are too many factors involved, any one of which could cause anomalies to occur. However the ring trial carried out in 2006 as part of the development of this revision of B02 indicated that ± 1,0 grade is achievable between laboratories in approximately 85 % of the samples tested.

E.8.6 Although the use of instrumental assessment is permitted, it is not recommended for a number of different reasons. Primarily the use of instrumental assessment is discouraged due to known anomalies with colour measurement equations in the blue region of the spectrum. Although this is being investigated by CMC (Colour Measurement Committee of the Society of Dyers and Colourists), the use of instrumental assessment can give rise to errors of one or more grades when compared to visual assessment of the same test specimens. The 2006 ring trial identified that 24 % of results showed differences from the visual assessment of one grade or more with some errors as great as 2,0 grades being found.

When using instrumental assessment, it is essential that the aperture used is appropriate to both the design or pattern of the test specimen and to the area of exposure.

For some types of textile, for example textile floor coverings, the use of instrumental assessment may be inappropriate due to the problems of compression of the surface of the specimen, the difficulty of measuring light reflected from a surface which will absorb or refract a significantly higher proportion of the illuminant light, and the difficulties in isolating individual colours with the design.

While the use of instrumental assessment is not discouraged, it should only be used after giving due consideration to the above issues. If instrumental assessment is used, it shall be included on the test report.

Bibliography

[1] ASTM G177-03, *Standard tables for reference solar ultraviolet spectral distributions: hemispherical on 37° tilted surface*

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