

INTERNATIONAL
STANDARD

ISO
105-B02

Fourth edition
1994-09-15

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
ISO 105-B02:1994(E)

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.

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.

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

This fourth edition cancels and replaces the third edition (ISO 105-B02:1988), of which it constitutes a technical revision.

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 earlier alphanumeric designations. A complete list of these parts is given in ISO 105-A01.

Annexes A and B form an integral part of this part of ISO 105. Annex C is for information only.

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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 resistance of 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.

NOTE 1 General information on colour fastness to light is given in annex C.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 105. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 105 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 105-A01:1994, *Textiles — Tests for colour fastness — Part A01: General principles of testing*.

ISO 105-A02:1993, *Textiles — Tests for colour fast-*

ness — Part A02: Grey scale for assessing change in colour.

ISO 105-A05:—¹⁾, *Textiles — Tests for colour fastness — Part A05: Method for the instrumental assessment of the change in colour of a test specimen*.

ISO 105-B01:—²⁾, *Textiles — Tests for colour fastness — Part B01: Colour fastness to light: Daylight*.

ISO 105-B05:1993, *Textiles — Tests for colour fastness — Part B05: Detection and assessment of photochromism*.

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*.

CIE 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 prescribed conditions, along with a set of blue wool references. The colour fastness is assessed by comparing the change in colour of the test specimen with that of the references used.

For white (bleached or optically brightened) textiles, the colour fastness is assessed by comparing the change in whiteness of the specimens with that of the reference used.

1) To be published.

2) To be published. (Revision of ISO 105-B01:1989)

4 Reference materials and apparatus

4.1 Reference materials

Either of two sets of blue wool references may be used. The results from the two sets of references are not interchangeable.

The colour fastness ratings mentioned in this part of ISO 105 are obtained by comparison with either blue wool references 1 to 8 (preferable in Europe) or blue wool references L2 to L9 (preferable in America).

4.1.1 References 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 cloths dyed with the dyes listed in table 1. They range from 1 (very low colour fastness) to 8 (very high fastness) so that each higher-numbered reference is approximately twice as fast as the preceding one.

4.1.2 References L2 to L9

Blue wool references developed and produced in the United States are identified by the letter L followed by the numerical designation 2 to 9. These eight references are specially prepared by blending varying

proportions of wool dyed with CI Mordant Blue 1 (Colour Index, third edition, 43830) and wool dyed with CI Solubilized Vat Blue 8 (Colour Index, third edition, 73801), so that each higher-numbered reference is approximately twice as fast as the preceding reference.

4.1.3 Humidity test control

Effective humidity is defined as the combination of air and surface temperatures and air relative humidity which governs the moisture content of the surface of the test specimen during exposure. The effective humidity can be measured only by determining the colour fastness of a specific humidity test control.

For the purposes of this part of ISO 105, the humidity test control is a red azoic dyed cotton cloth.

This control has been calibrated by exposing it facing south in several Western European locations at different times of the year, the exposures being made together with the references in sealed vessels containing air maintained at constant humidities between 0 and 100 %; the results did not vary greatly and the mean values are shown in figure 1.

When this control was exposed under the conditions specified in ISO 105-B01 in temperate zones, its colour fastness was found to be, on average, 5.

Table 1 — Dyes for blue wool references 1 to 8

Reference	Dye (Colour Index designation) ¹⁾
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 Solubilized Vat Blue 5
8	CI Solubilized Vat Blue 8

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

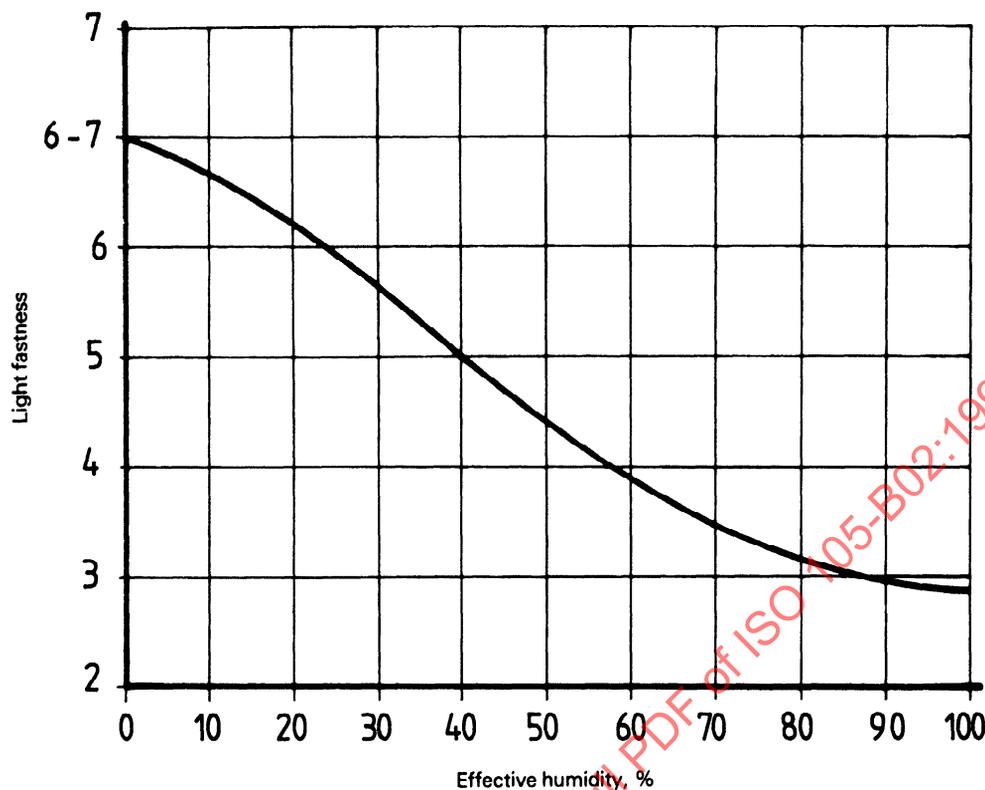


Figure 1 — Mean values obtained from humidity test control exposures

4.2 Apparatus

4.2.1 Xenon arc lamp apparatus, either air-cooled or water-cooled.

The specimens and the references are exposed in one of the two types of apparatus (see 4.2.1.1 and 4.2.1.2). The variation in light intensity over the area covered by the specimens and references shall not exceed $\pm 10\%$ of the mean. The recommended level of irradiance (radiant power per unit area) measured by a radiometer (4.2.6) is $42 \text{ W/m}^2 \times \text{wavelength}$, in nanometres, at 300 nm to 400 nm, equivalent in cases of water-cooled xenon arc apparatus to $1,1 \text{ W/m}^2 \times \text{wavelength}$, in nanometres, at 420 nm.

The distances from the surface of the specimen and from the surfaces of the references to the lamp shall be the same.

4.2.1.1 Air-cooled xenon arc lamp apparatus (see annex A), consisting of the following elements:

NOTE 2 For exposure conditions preferable for use in Europe, see 6.1.

- a) **Light source**, in a well-ventilated exposure chamber.

The light source shall consist of a xenon arc lamp of correlated colour temperature 5 500 K to 6 500 K, the size of which will depend on the type of apparatus used.

- b) **Light filter**, placed between the light source and the specimens and references so that the ultra-violet spectrum is steadily reduced.

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.

- c) **Heat filter**, placed between the light source and the specimens and references so that the amount of infrared (IR) radiation contained in the xenon arc spectrum is steadily reduced (see A.1.1 and A.2.2).

If a glass or water filter is used to eliminate excess infrared radiation so as to meet the temperature conditions specified in 4.2, frequent cleaning shall be carried out to avoid unwanted filtering caused by dirt (see B.1.4).

4.2.1.2 Water-cooled xenon arc lamp apparatus

(see annex B), consisting of the following elements:

- a) **Light source**, in a well-ventilated exposure chamber.

The light source shall consist of a xenon arc lamp of correlated colour temperature 5 500 K to 6 500 K, the size of which will depend on the type of apparatus used.

- b) **Light filter**, consisting of inner and outer filter glass containing and directing the flow of cooling water, placed between the light source and the specimens and references so that the ultraviolet spectrum and a part of the infrared spectrum are steadily reduced.

For exposure conditions preferable for use in Europe [see 6.1 a) and 6.1 b)]: inner and outer IR filter glass and a lantern, equipped with European 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.

For exposure conditions preferable for use in America (see 6.2): an inner filter of Pyrex (borosilicate) glass and an outer filter of clear (soda lime) glass are used so that the irradiation at the specimen has a lower spectral cut-off approximately equal to that of window glass (see B.1.2).

- c) **Heat filter**, comprising grade 3 water (see ISO 3696) circulating through the lamp assembly between the inner and outer filter glass, cooled by passing through a heat-exchange unit (see B.1.4).

4.2.2 Opaque cardboard or other thin opaque material, for example thin sheet aluminium or cardboard covered with aluminium foil, for partial covering of samples and references.

4.2.3 Temperature sensor, either a black-panel thermometer (BPT) or black-standard thermometer (BST).

4.2.3.1 The black-panel thermometer (BPT) shall consist of a metal panel at least 45 mm × 100 mm whose temperature is measured with a thermometer or a thermocouple whose sensitive portion is located in the centre of and in good contact with the panel.

The side of the panel facing the light source shall be black with a reflectance of less than 5 % throughout

the spectrum of light reaching the specimen; the side of the panel not facing the light source shall be thermally insulated (see also B.1.5).

4.2.3.2 The black-standard thermometer (BST) shall consist of a plane of stainless steel plate measuring about 70 mm × 30 mm and with a thickness of about 0,5 mm, whose temperature is measured by a thermal resistor, with good heat-conducting properties, fitted to the reverse side. The metal plate is fixed to a plastics plate so that it is thermally insulated. It is coated with a black layer which has an absorption of at least 95 %, even in the infrared range.

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

4.2.5 Colour-matching lamp, in accordance with CIE Publication No. 51, for assessing change in whiteness.

4.2.6 Radiometer, (when available/specified) for measuring irradiance and radiant exposure in the wavelength range 300 nm to 400 nm or at a specific wavelength (e.g. 420 nm) (see A.1.7 and B.1.8).

Since irradiance at the test specimen face can vary as a function of lamp intensity and lamp-to-specimen distance, a monitoring radiometer may be used to control uniformity of exposure. The radiometer permits exposure to an established level of irradiance (radiant energy flux per unit area) at a point in the plane of the specimen rack.

5 Test specimens

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.

5.1 In apparatus of the air-cooled type (4.2.1.1), an area of the textile not less than 45 mm × 10 mm is usually used when several periods of exposure are made side by side on the same specimen, which is the preferred practice. The specimen may be a strip of cloth, yarn wound close together on a card 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.

5.2 To facilitate handling, the specimen or specimens to be tested and similar strips of the references may be mounted on one or more cards as indicated in figure 2 or 3.

5.3 In apparatus of the water-cooled type, specimen holders are fitted to take specimens of approximately 70 mm × 120 mm. When desired, specimens of different sizes to fit alternative sizes of specimen holder may be used. References shall be exposed on a white cardboard backing. Specimens may also be mounted on white cardboard if desired.

5.4 The covers (4.2.2) 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.

5.5 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 (see 8.4).

5.6 When testing pile fabrics, the references shall be arranged so that they are the same distance from the light source as the surface of the pile fabrics. This can be achieved for example by using pieces of cardboard as underlay. Covers for the unexposed portions shall avoid surface compression.

Pile fabrics, such as carpets, 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.

6 Exposure conditions

6.1 Conditions preferable for use in Europe

- a) **Normal conditions** (temperate zone): moderate effective humidity (see 4.1.3); colour fastness of the humidity test control: 5; maximum black-standard temperature: 50 °C (see 4.2.3.2).
- b) **Extreme conditions:** For testing the sensitivity of specimens to different humidity during irradiation, the following extreme conditions are useful:

- 1) low effective humidity:
 - colour fastness of the humidity test control: 6-7;
 - maximum black-standard temperature: 65 °C;

- 2) high effective humidity:

- colour fastness of the humidity test control: 3;
- maximum black-standard temperature 45 °C.

NOTE 3 Measurements with the black-panel thermometer (BPT) (4.2.3.1) yield a temperature 5 °C lower than the more modern black-standard thermometer (BST) (4.2.3.2).

6.2 Conditions preferable for use in America

Black-panel temperature (63 ± 1) °C (see 4.2.3.1); the controls of the apparatus are adjusted so that the relative humidity of the air in the test chamber is (30 ± 5) %. Effective humidity: low. Colour fastness of the humidity test control: 6-7.

These conditions shall be controlled by continuous operation of a blower, with concomitant measuring and thermostatic control of the temperature of a constant volume of air whose relative humidity is increased by adding moisture to the air as it passes through the conditioning chamber by means of an electrically operated atomizer.

7 Procedure

7.1 Adjustment of the humidity (see clause 6)

7.1.1 Check that the apparatus is in good running order and that it is equipped with a clean xenon burner tube. (Follow the manufacturer's directions and see annexes A and B.)

7.1.2 Place a portion of the humidity test control (4.1.3) measuring not less than 45 mm × 10 mm, together with the blue wool references (4.1.1 or 4.1.2), on a card, if possible in the middle area of the specimen holder (see 5.3).

7.1.3 Place the filled specimen holders on the specimen rack of the apparatus, with the holders supported both top and bottom and in proper vertical alignment. Completely fill all remaining spaces in the specimen rack with holders containing white cardboard.

7.1.4 Operate the apparatus with the light on continuously until a test is completed unless the lamp requires cleaning or the burner, outer filter or inner filter requires changing because it has reached the maximum number of hours of recommended usage.

7.1.5 Expose the partially covered strip of the humidity test control and the references simultaneously until a contrast between the exposed and unexposed portions equal to grade 4 on the grey scale is produced on the humidity test control.

7.1.6 Assess the colour fastness of the humidity test control at this stage and, if necessary, adjust the controls on the apparatus to give the selected exposure conditions. Check daily and when necessary readjust the controls to maintain the specified black-panel (black-standard) temperature and humidity.

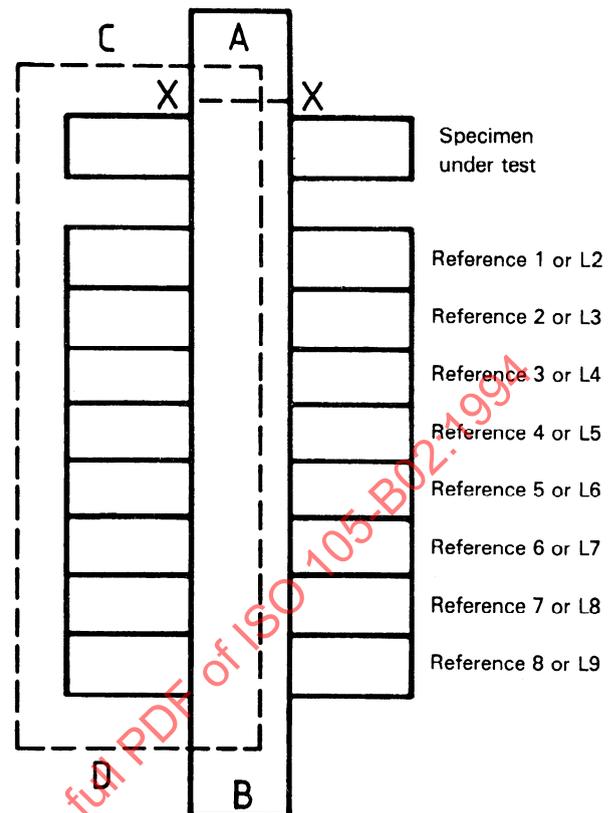
7.2 Exposure methods

Expose the specimen (or group of specimens) and the references simultaneously, under the desired conditions, in such a manner and for such a time as is necessary to evaluate fully the colour fastness of each specimen relative to that of the references, by progressively covering both the specimens and the exposed references during the test (using either method 1 or method 2). Covering arrangements other than those described, for instance covering specimens and references on both ends and exposing the middle third or half, are also allowed.

7.2.1 Method 1

This method is considered most exact 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 therefore only one set of blue wool references is required for each specimen under test.

7.2.1.1 Arrange the test specimen and the references as shown in figure 2 with an opaque cover AB across the middle one-third of the specimen and references. Expose to the xenon arc light under the conditions enumerated in 7.1. Follow the effect of light by removing the cover and inspecting the specimen frequently. When a change in the test specimen can be perceived equal to grey scale 4-5, note the number of the blue wool reference showing a similar change. (This is a preliminary assessment of colour fastness.)



AB: Opaque cover; may be hinged at X-X so that it can be lifted and returned to the same place over the specimen and references

CD: Second cover

Figure 2 — Mounting of specimen and references for exposure method 1

If there is a possibility of the sample being photochromic, then at this stage the test for photochromism shall be applied additionally (see ISO 105-B05).

For all specimens except for white (bleached or optically brightened) specimens, continue the procedure as described in 7.2.1.2 to 7.2.1.4. For optically brightened textiles, continue with the procedure as described in 7.2.1.5.

7.2.1.2 Continue to expose until the contrast between the exposed and the unexposed portions of the specimen is equal to grey scale grade 4. Cover the left-hand one-third of the specimen and references with an additional opaque cover (CD in figure 2).

7.2.1.3 Continue to expose until the contrast between the fully exposed and unexposed portions of the test specimen is equal to grey scale grade 3.

7.2.1.4 If reference 7 or L7 fades to a contrast equal to grey scale grade 4 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 L9. Assessments in the region of 7-8 or L7-L8 are made, therefore, when the contrast produced on 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.

7.2.1.5 For white (bleached or optically brightened) textiles, continue to expose until the contrast between the exposed and unexposed portions of the specimen is equal to grey scale grade 4.

7.2.2 Method 2

7.2.2.1 This method should 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 *references*, which allows a number of specimens differing in colour fastness to be tested against a single set of references, thus conserving supplies.

7.2.2.2 Arrange the test specimens and the references as shown in figure 3 with the cover AB covering one-quarter of the total length of each specimen and reference. Expose under the conditions enumerated in 7.1.1 and 7.1.2. Follow the effect of light by lifting the cover AB periodically and inspecting the references. When a change in reference 3 or L2 can be perceived equal to grey scale grade 4-5, inspect the specimens and rate their colour fastness by comparing any change that has occurred with the changes that have occurred in references 1, 2 and 3 or L2. (This is a preliminary assessment of colour fastness.)

If there is a possibility of the sample being photochromic, then at this stage the test for photochromism shall be applied additionally (see ISO 105-B05).

7.2.2.3 Replace the cover AB in exactly the same position and continue to expose the specimens until a change in reference 4 or L3 can be perceived equal to grey scale grade 4-5; at this point fix an additional

cover, CD, in the position shown in figure 3), overlapping the first cover, AB.

7.2.2.4 Continue to expose the specimens until a change in reference 6 or L5 can be perceived equal to grey scale 4-5, then fix the final cover, EF, in the position shown in figure 3, the other two covers remaining in position.

7.2.2.5 Expose until either

- a) a contrast is produced on reference 7 or L7 equal to the contrast illustrated by grey scale grade 4; or
- b) a contrast equal to grey scale grade 3 has been produced on the most resistant specimen; or
- c) for white (bleached or optically brightened) textiles, a contrast equal to grey scale grade 4 has been produced on the most resistant specimen;

whichever occurs first.

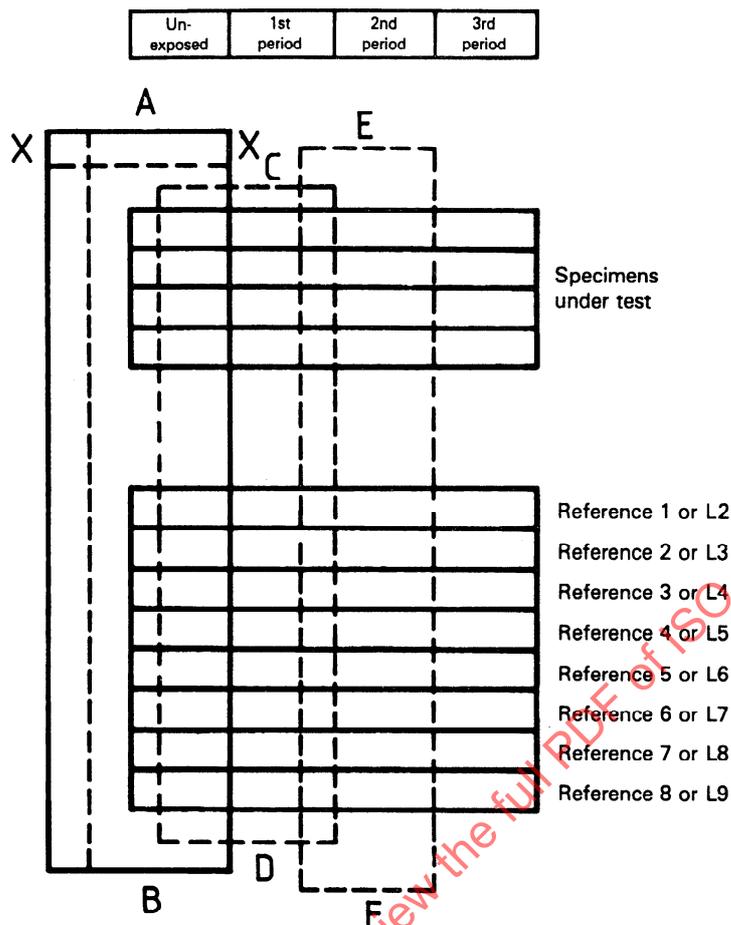
NOTE 4 The contrast referred to in a) and b) may occur before the fading defined in 7.2.2.3 or 7.2.2.4 has taken place.

7.2.3 Method 3

Where the test is to be used to check conformity with a performance specification, it is permissible to expose the specimens with two blue wool references only: that specified as minimum and the one below it. Continue exposure until grey scale grade 4 and grey scale grade 3 contrasts have been produced on separate areas of the minimum blue wool reference. For white (bleached or optically brightened) textiles, continue exposure until a grey scale grade 4 contrast has been produced between separate areas of the minimum blue wool reference.

7.2.4 Method 4

Where the test is to be used to check conformity with an agreed-upon reference sample, it is permissible to expose the specimens with the reference sample only. Continue exposure until grey scale grade 4 and/or grey scale grade 3 contrasts have been produced on the reference sample. For white (bleached or optically brightened) textiles, continue exposure until a grey scale grade 4 contrast has been produced on the reference sample.



AB: Opaque cover; may be hinged at X-X so that it can be lifted and returned to the same place over the specimen and references

CD: Second cover

EF: Third cover

Figure 3 — Mounting of specimens and references for exposure method 2

7.2.5 Method 5

Where the test is to be used 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 then removed, together with the blue wool references, and evaluated in accordance with 8.9.

8 Assessment of colour fastness

8.1 The final assessment given as numerical ratings, is based on contrasts equal to grey scale grade 3 between exposed and unexposed portions of the test specimen. For white (bleached or optically brightened) textiles, the final assessment in numerical

ratings is based on a contrast equal to grey scale grade 4 between exposed and unexposed portions of the specimen.

8.2 Remove all the covers, thus revealing on test specimens and references two or three areas, depending on the method used, which have been exposed for different times, together with at least one area which has not been exposed to light. Compare the changes in the specimen with the relevant changes in the references under suitable illumination (see ISO 105-A01:1994, clause 14).

For white (bleached or optically brightened) textiles, the use of artificial daylight produced by a colour-matching lamp (4.2.5) is recommended and is necessary in cases of dispute, unless otherwise agreed.

The colour fastness of the specimen is the number of the 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 nearer to the imaginary reference midway between any two consecutive references, an intermediate rating, for example 3-4 or L2-L3, shall be given.

If different assessments are obtained at the different degrees of contrast, the colour fastness of the specimen is taken as the arithmetic mean of these, expressed to the nearest half or whole grade. When three areas are being rated, take the mean of the contrasts closest to grey scale grades 4 and 3. Assessments, however, shall be confined to whole or midway ratings only. When the arithmetic mean gives a quarter or three-quarters rating, the assessment is defined as the next higher half or whole grade.

However, to avoid a misrating of the colour fastness of the specimen due to its photochromism, the specimen should be allowed to condition in the dark at room temperature for 24 h before assessing the colour fastness (see ISO 105-B05).

8.3 If the colour of the specimens is more fugitive than that of reference 1 or L2, a rating of 1 or L2 is given.

8.4 Comparison of the changes in the test specimen with changes in the references may be facilitated by surrounding the specimen with a mask of neutral grey colour approximately midway between the lighter chips in grades 1 and 2 (approximately Munsell N5), and surrounding the references in turn with a similar mask of equal aperture.

8.5 If the colour fastness is equal to or higher than 4 or L3, preliminary assessment based on the contrast equal to grey scale grade 4-5 (see 7.2.1.2 and 7.2.2.2) becomes significant; if this preliminary assessment is 3 or lower or L2, it shall be included in the rating in brackets. For example, a rating of 6(3) or L5(L2) indicates that the specimen changes very slightly in the test when reference 3 or L2 just begins to fade, but that on continuing the exposure the resistance to light is equal to that of reference 6 or L5.

8.6 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).

8.7 The term "change in colour" includes change in hue, chroma, lightness, or any combination of these characteristics of colour (see ISO 105-A02:1993, sub-clause 2.6).

8.8 Exposures based on a performance reference (see 7.2.3) or together with an agreed-upon reference sample (see 7.2.4) shall be assessed by comparison of the colour changes of the test specimen and the references. If the specimen shows no greater change in colour than the performance reference or the reference sample, the colour fastness shall be classified "satisfactory"; if the specimen shows a greater change in colour than the performance reference or the reference sample, the colour fastness shall be classified "unsatisfactory".

8.9 The assessment of the colour fastness according to method 5 (see 7.2.5) is performed either by comparison with the grey scale 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 references.

9 Test report

The test report shall include the information:

- the number and year of publication of this part of ISO 105, i.e ISO 105-B02:1994;
- all details necessary for the identification of the sample tested;
- for method 1 or method 2:

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

- by the figure alone (when using the blue wool references designated 1 to 8); or
- 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.

If the specimen is photochromic, the colour fastness shall be followed by a P bracketed together with the grey scale rating obtained from the test for photochromism, for example 6(P3-4).

d) for method 3 or method 4:

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

e) for method 5:

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

1) by the figure alone (when using the blue wool references designated 1 to 8); or

2) together with the prefix L (when using the blue wool references L2 to L9);

3) 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.

f) The apparatus used, the method, the exposure conditions and the assessment conditions.

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Annex A (normative)

Apparatus for determining colour fastness with air-cooled xenon arc lamps

A.1 Description and conditions of use

A.1.1 The test apparatus (see also A.2) is equipped with an air-cooled xenon arc lamp as the source of radiation. The two models of apparatus use xenon arc lamps with a wattage of 1 500 W or 4 500 W. The xenon arc lamp is surrounded by a filter system consisting of a quartz inner cylinder, an additional lamp-chimney of seven heat filters and an outer cylinder of ultraviolet filter glass. With this filtering device the requirements given in 4.2.1 are satisfied.

A.1.2 The space between the xenon arc lamp and the filtering device is cooled by a current of air. This cooling air should be discharged into the open atmosphere.

A.1.3 The decrease in intensity of air-cooled xenon arc lamps due to ageing is small. After 1 500 h of use, the radiation flux drops to approximately 90 % and replacement of the lamps is recommended.

The change in the transmission properties of the heat filter due to ageing can be eliminated almost entirely by replacing the oldest filter in rotation after 500 h.

A.1.4 Slot-in specimen holders are mounted on a revolving rack and at a given distance in circular fashion around the vertical lamp unit. The rack rotates at 500 r/min. After each revolution of the rack, the specimen holders are turned 180° about their longitudinal axis.

The surface area of specimen radiated at any one time is 450 cm² in the case of the test apparatus with a 1 500 W xenon arc lamp and 1 800 cm² with a 4 500 W xenon arc lamp.

A.1.5 An air current generated with a blower is directed through the test chamber and over the surface of the specimen. In the case of the apparatus with a 1 500 W xenon arc lamp, the test chamber is air-conditioned by adding moisture to the air via spray jets or by means of an ultrasonic humidification device, while in the case of the apparatus with a 4 500 W

xenon arc lamp, water is atomized very finely via an aerosol device and added to the air current. Measurement and control of the relative humidity in the test chamber is carried out either by a contact hygrometer or by electronic means.

A.1.6 The exposure conditions, relative to effective humidity, specified in this part of ISO 105 are achieved in the test apparatus by regulating the relative humidity of the air within certain values, which are given in the instructions for using the apparatus.

The test chamber temperature and black-panel temperature can be influenced by appropriately throttling the air supply. In the case of the apparatus with a 4 500 W xenon arc lamp, it is possible, by connecting to a heating and/or cooling device, to control the test chamber temperature over a wide range.

A.1.7 A monitoring radiometer mounted on the test specimen area can be useful in this method. A radiometer employing a broad bandpass filter restricting measurement to the ultraviolet spectral region between 300 nm and 400 nm has been used satisfactorily.

Filter radiometers capable of integrating irradiance with respect to time are satisfactory.

The calibration of the radiometer shall be certified by the manufacturer for a specified time interval when used in accordance with this part of ISO 105.

A.2 Use of an alternative apparatus

A.2.1 The description and conditions of use of this alternative apparatus are similar to those given in A.1, except for the changes given in A.2.2 and A.2.3.

A.2.2 There are three different models of this alternative apparatus, with a wattage of 1 500 W, 2 500 W or 4 500 W. The xenon arc lamp is surrounded by a filter system consisting of an outer cylinder of ultraviolet-filter glass and a lamp-chimney of six heat filters.

A.2.3 After each revolution of the rack, the specimen holders are either turned 180° around their longitudinal axis or maintained facing the xenon arc

lamp for the 1 500 W and 4 500 W models. The specimen holders always face the xenon arc lamp for the 2 500 W model.

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Annex B (normative)

Apparatus for determining colour fastness with water-cooled xenon arc lamps

B.1 Description and conditions of use

B.1.1 The test apparatus incorporates a 6 500 W water-cooled xenon long-arc lamp as the source of radiation. While all of the xenon arc lamps employed are of the same general type, different-sized lamps operating in different wattage ranges are employed in several sizes and types of apparatus. In each of the various models, the diameter of the specimen rack, lamp size and lamp wattage can be varied so that, when the specimens are exposed in the holders, the irradiance at the face of the specimens is at the appropriate level.

B.1.2 The xenon lamp consists of a xenon burner tube, inner glass filter, outer glass filter, and the necessary accessories. In some cases, additional glass filters may be installed to reduce infrared radiation. For colour fastness tests according to 6.2, a borosilicate glass inner filter and a soda lime glass outer filter are used so that the irradiation at the specimen has a lower spectral cutoff value approximately equal to that of window glass. When operating the apparatus according to 6.2, outer filters shall be discarded after 2 000 h of use and inner filters after 400 h of use. For colour fastness tests according to 6.1 a) and 6.1 b), a lantern equipped with European window glass is used in addition to an infrared inner and outer filter combination. Because of the drop in intensity with continued use, xenon burners shall be discarded when $1,1 \text{ W}/(\text{m}^2 \cdot \text{nm})$ at 420 nm is no longer achievable by automatic control.

B.1.3 All xenon arc exposure apparatus is equipped with suitable starters, reactance transformers and indicating and control equipment for either manually or automatically controlling the wattage of the lamp. In manually controlled units, the wattage of the lamp may require periodic adjustment to maintain $1,1 \text{ W}/(\text{m}^2 \cdot \text{nm})$ at 420 nm.

B.1.4 To cool the lamp, grade 3 water is circulated through the lamp assembly at an approximate minimum flow rate of 380 l/h, and is purified further by

the use of a mixed bed deionizer just ahead of the lamp. The recirculated lamp water is cooled without contamination by the use of a heat exchanger unit employing either tap water or a refrigerant as the heat transfer medium.

B.1.5 The exposure apparatus is enclosed in an insulated cabinet to minimize the effects of variation in room temperature. A ventilating system provides a varying volume of air through the test chamber and over the test specimens. The temperature of the air and the black standard thermometer are automatically controlled by varying the volumes of warm air circulated from the test chamber mixed with cooler room air. Moisture in the amount required to maintain the specified relative humidity of the exit air from the test chamber as measured by wet-and-dry bulb temperatures may be added to the air system as it passes through the air-conditioning chamber in the base of the instrument.

B.1.6 A cylindrical vertical or inclined frame or rack supporting the specimen holders is rotated at 1 r/min around the lamp, which is located centrally with respect to the specimen rack so that the effective arc is centred both horizontally and vertically relative to the exposure area of the specimen holders.

B.1.7 Apparatus for use in this method are equipped with timing units for controlling the length of exposure. Some apparatus are also equipped with a light monitor designed to switch off the apparatus as soon as a given radiant exposure has been achieved.

B.1.8 Apparatus for use in this method may be equipped with a monitoring/controlling radiometer for controlling the length of exposure. A radiometer employing a narrow bandpass interference filter restricting measurement to the UV spectral region has been used satisfactorily. It consists of a sensor employing a photodetector and interference filter with central wavelength tolerance no greater than 2 nm, half-bandwidth no greater than 20 nm.

Single or multiple filter radiometers capable of measuring, recording, controlling and/or integrating irradiance with respect to time are satisfactory.

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

$$H = E3,6t$$

where

- H* is the radiance exposure, expressed in kilojoules per square metre;
- E* is the irradiance, expressed in watts per square metre (joules per square metre per second);
- t* is the time passed, in hours;
- 3,6 is a conversion constant (kiloseconds to hours).

Single filter radiometers equipped with a presettable countdown integrator, calibrated in kilojoules per square metre, designed for use with the exposure apparatus, can terminate the test when the specimens have received the preset level of radiance exposure.

The radiometer shall have means for checking the calibration provided by the manufacturer, or calibration shall be certified by the manufacturer for a specified time interval when used in the manner described herein.

B.2 Use of an alternative apparatus

B.2.1 The description and conditions of use of this alternative apparatus are similar to those given in B.1, except for the different sizes in operating lamps listed in B.2.2.

B.2.2 In addition to the model listed in B.1.1, alternative models of the apparatus are available with lamps of 2 500 W, 4 500 W and 6 500 W.