BRITISH STANDARD

Instrumental colour measurement of textiles – Method

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Foreword

Publishing information

This British Standard was published by BSI and came into effect on 10 February 2006. It was entrusted by Technical Committee TCI/81, Colour fastness and colour measurement, to Working Group 3 of the Colour Measurement Committee of the Society of Dyers and Colourists. A list of organizations represented on this committee can be obtained on request to its secretary.

Information about this document

Colour measurement of textiles has become increasingly important. Errors in colour measurement are usually caused by either a non-representative specimen being measured or incorrect or inconsistent presentation of the specimen to the measuring instrument.

This standard is intended to provide procedures for the preparation and presentation of all types of textile materials in order to enable their colour to be measured consistently and reproducibly.

The procedures may be used in the determination of:

- a) the absolute colour specification of a single specimen (Notes 1, 2 and 3) or of a number of specimens to be used together in the construction of a match prediction database;
- b) the colour difference between areas of a single specimen (Note 4);
- c) the colour difference between specimens (Note 4)
- d) colour formulations and colour corrections by computer match prediction.

NOTE 1 The method may be used in defining and measuring the colours associated with specifications such as BS 3510, BS 381C, BS 5455, BS 6341 and BS EN 471.

NOTE 2 The recommended method for calculating the absolute colorimetric values of a coloured specimen is the CIE 1976 L*a*b* (CIELAB) equation (see Publication CIE 15).

NOTE 3 The recommended method for calculating the whiteness values of a white specimen is the CIE whiteness equation (see Publication CIE 15).

NOTE 4 The recommended method for calculating the colour difference within a single specimen or between specimens measured under identical conditions is the CMC (I:c) equation given in BS EN ISO 105-J03, which provides a numerical value ΔE [the total colour difference], which quantifies the perceptibility or the acceptability of the colour match. The direction of the colour difference is given by the components ΔL , ΔC and ΔH .

NOTE 5 The symbol Δ (for difference) is often replaced by D, giving DE, DL, DC and DH.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies procedures to be used in preparing representative textile materials for presentation to an instrument appropriate for the measurement of surface colour. It includes procedures for acquiring the data for the determination of a numerical colour specification.

2 Normative references

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

BS EN ISO 105-B05, Textiles – Tests for colour fastness – Part B05: Detection and assessment of photochromism

BS EN ISO 105-J03, Textiles – Tests for colour fastness – Part J03: Calculation of colour differences

BS EN ISO 139, Textiles – Standard atmospheres for conditioning and testing

BS EN ISO 3696, Water for analytical laboratory use – Specification and test methods.

CIE Publication 15:2004. Colorimetry (3rd edition). Vienna: CIE – Commission Internationale de l'Eclairage, 2004¹⁾

IWTO-35-03, Method for the measurement of colour of sliver. International Wool Textile Organisation http://www.iwto.org

IWTO-56-03, Method for the measurement of base and "as is" colour of raw wool. International Wool Textile Organisation http://www.iwto.org

3 Principle

The specimen is prepared and presented to the aperture of the selected instrument and its colour is measured.

4 Apparatus

4.1 Spectrophotometer, using one of the optical geometries specified in CIE Publication 15, for the measurement of reflectance throughout the visible spectrum. The preferred optical geometry of specimen illumination and viewing is diffuse/normal (d/0) as defined in CIE 15.

NOTE The angle between the normal to the specimen and the axis of the viewing beam should not exceed 10° .

4.2 *Tristimulus colorimeter*, which may be used only for colour comparisons of non-metameric materials.

Available from The Secretary, NIC/GB, c/o CIBSE, Delta House, 222 Balham High Road, London SW12 9BS, or The CIE Central Bureau, Kegelgasse 27, A-1030, Vienna, Austria. http://www.cie.co.at/cie

5 Preparation of specific types of specimen

5.1 Fibres

Loose fibre, sliver or tow specimens shall be prepared in accordance with one of the methods described in A.1, A.2 or A.3 respectively.

5.2 Spun and continuous filament yarn specimens

5.2.1 Yarn used for fabric and sewing threads

Yarn used for fabric shall be, either:

- a) wound from the original package onto a former in accordance with A.4, with consistent tension, to provide a flat opaque specimen; or
- b) knitted under controlled conditions on a knitting machine and folded to provide sufficient thickness so as to be opaque (see Clause 7), and then presented directly to the instrument for measurement.

Yarn used for sewing threads shall be prepared as in a).

5.2.2 Carpet yarn

Yarns used for cut pile carpets shall be prepared by a cross cutting method in accordance with **A.5**. Where possible, specimens shall be viewed tuft end-on.

5.3 Fabrics

5.3.1 Woven, knitted, non woven and coated fibre structures

The face and orientation of the specimens shall be identified. The specimen shall be folded if necessary to provide sufficient thickness so as to be opaque (see Clause 7).

 ${\it NOTE \,\,\,}$ Most woven fabrics and knitted goods require no special specimen preparation.

5.3.2 Pile fabrics

Before measurement, pile fabrics shall be brushed in the direction of the pile.

5.4 Carpets

Before measurement, cut pile carpets shall be brushed in the direction of the natural pile lay.

6 Conditioning

The atmosphere for preconditioning and conditioning specimens shall be as specified in BS EN ISO 139.

NOTE The colour of specimens can be significantly affected by temperature and humidity.

To ensure stabilization of colour, condition specimens at (20 ± 2) °C and (65 ± 2) % relative humidity for a minimum of 30 min immediately prior to colour measurement. Adjust the conditioning time accordingly for those specimens requiring a longer conditioning time to ensure stabilization of colour. Where there is any doubt about the stability of the colour, check by returning the specimen (after colour measurement) to the conditioning environment for a further 15 min then measure the colour again. If the colour difference between these two measurements is within CMC(2:1) $\Delta E = 0.2$, the prepared specimen is adequately conditioned.

If the colour of the specimen is affected by light, include exposure to a source simulating CIE Standard Illuminant D65 in the conditioning process. To determine whether a sample is affected by light (photochromic), test in accordance with BS EN ISO 105-B05.

In order to avoid significant change in the condition, and regardless of the nature of their conditioning, measure specimens removed from the conditioning environment immediately thereafter.

7 Presentation of specimens

The specimen shall be of a size adequate to completely cover the aperture of the instrument. Measurement shall be with the largest aperture possible. An area of the specimen that is uniform in colour, evenly constructed and clean shall be presented to the aperture of the instrument, avoiding specimen irregularities or spots visible to the eye in the measurement.

The specimen shall be of sufficient thickness so as to be opaque. All specimens shall be measured in the same thickness where the colour difference between specimens is being measured.

NOTE 1 Establishing opacity will depend upon the nature of the specimen, e.g. fabric should be folded and yarn should be wound in multiple layers. If a specimen is not opaque, light passing through it will reflect from the backing material or holder causing an erroneous measurement. The opacity of a specimen may be checked by measuring it over a black background, and separately over a white background. If the colour difference between these two measurements is within CMC(2:1) $\Delta E = 0.2$, the prepared specimen is adequately opaque.

NOTE 2 Care should be taken not to increase the thickness of the specimen beyond that which is necessary to achieve practical opacity in order to avoid intrusion of the specimen beyond the plane of the measurement port of the instrument, which can itself cause error in measurement.

Present the specimen to the instrument in a flat and relaxed state.

NOTE 3 Excessive tension on the mounted specimen can cause distortion, leading to erroneous measurements. If the mounting is too slack, shadows can appear from the attendant wrinkling, giving incorrect measurements.

**

Procedure for colour measurement

Instrument performance and maintenance 8.1

The manufacturer's recommendations for monitoring instrument performance and maintenance shall be followed.

8.2 Standardization of the instrument

NOTE Standardization is often referred to as calibration; the former is the preferred term.

Switch on the instrument and allow sufficient time for stabilization in accordance with the manufacturer's recommendations.

Select the measurement conditions required for standardization of the instrument being used:

- wavelength range and interval (for spectrophotometer);
- size of aperture:
- specular component included or excluded;
- control of ultraviolet content of the light source (see Annex B).

NOTE The sequence to be followed varies from one instrument to another.

Standardize the instrument in accordance with the manufacturer's recommendations.

During the use of the instrument, repeat the standardization at regular intervals in accordance with the manufacturer's recommendations, but avoid re-standardization during related measurements.

8.3 Measuring the specimen(s)

The sequence to be followed varies from one instrument to another, but shall include all the following steps.

- Select the method of preparation and presentation of the specimens. If required, select the number of repeat measurements.
- If the instrument conditions required to measure the specimen are not those used during standardization, adjust as required.
- Measure the colour of the specimen(s).
- Select the requirements for calculation of the data:
 - illuminant(s);
 - 2) observer(s).

NOTE 1 The preferred illuminant/observer weights are listed in ASTM E308-01.

NOTE 2 The preferred observer, in most applications, is the CIE 1964 standard colorimetric observer (10°).

- e) Select the parameters to be output:
 - 1) absolute colour co-ordinates;
 - colour difference equation(s) and results.
- Output and record the data as required.

8.4 Specular component of measurements

The specular component of measurement shall be taken into account as follows.

- Measure non-glossy specimens with the specular component included.
- b) When making comparisons between two specimens which show different levels of gloss, measure both specimens with the specular component excluded.
- c) Measure glossy specimens with the specular component excluded.

NOTE 1 Glossy specimens are those for which there is a significant difference between measurements made with the specular component included and excluded.

NOTE 2 The practice of measuring the reflectance of specimens behind glass alters the measurements significantly and should be avoided if possible. For certain types of specimen, such as some loose fibre samples, measurement behind glass is necessary and the requirements specified in A.1.2 should be followed. If a specimen has to be measured behind glass, an appropriate correction should be made, e.g. as in IWTO-56-03.

8.5 Consistency

Specimens shall be measured to within CMC(2:1) $\Delta E = 0.2$ between replicate measurements in order to achieve consistency in accordance with BS EN ISO 105-J03.

NOTE This may be accomplished by taking multiple measurements, moving the specimen between measurements without changing its orientation, and obtaining average values.

8.6 Fluorescent specimens

Advice on colour measurement of fluorescent specimens is given in Annex B. Measurement of fluorescent white specimens is discussed in **B.1** and coloured fluorescent specimens in **B.2**.

8.7 Measurement of colour difference

Where the colour difference between specimens is required:

- a) instrument settings shall be the same for each measurement,
 i.e. specular component included/excluded, ultraviolet component included/excluded and aperture size;
- specimens shall be prepared and presented to the instrument selected by identical procedures;
- wherever practicable and the surface direction can be specified, specimens shall be measured in the same orientation.

9 Test report

The test report shall contain at least the following information:

- a) the number and date of this British Standard, i.e. BS 8475:2006;
- b) the date when the test was carried out;
- c) the specimen identification details;
- d) the type of specimen (e.g. fibre, yarn, pile or woven fabric);
- e) the method of specimen preparation used;
- f) identification of the instrument used including, where appropriate, manufacturer, model, spectrophotometer/tristimulus colorimeter, serial number, optical geometry etc.;
- g) details of the conditions of measurement and requirements for output (as specified in 8.2 and 8.3);
- h) methods of handling and presentation of the specimens (number of layers, orientation, etc.);
- i) for an individual specimen, the output colour co-ordinates;
- j) for a colour difference measurement, the output colour difference;
- k) any deviations from the specified procedures.

Annex A (normative) Specific methods of specimen preparation

A.1 Loose fibre

A.1.1 General

Prepare loose fibre to give a homogeneous surface appearance, with any extraneous material such as burrs removed where possible.

Some types of loose fibre specimen might be able to be consolidated into a form suitable for presentation to an instrument without the use of a specimen holder; for these specimens, use one of the methods detailed in **A.1.2**. Mount all other loose fibre specimens in a specimen holder in accordance with **A.1.3**.

NOTE For raw wool, a cleansing method can be used such as one of those described in NZS 8707:1984 or AS 3546:1996 and AS/NZS 1133:1996.

A.1.2 Consolidation of loose fibre specimens

A.1.2.1 General

This may be achieved either by carding (A.1.2.2) or by consolidating the loose fibre into a pad by felting (A.1.2.3).

A.1.2.2 Carding

Carding removes extraneous matter and produces a homogeneous specimen. A specimen carding machine is preferred to improve reproducibility. It is essential that all fibres from previous specimens are removed from the card wires before processing the specimen. When removed from the cards, roll the specimen into a smooth pad for presentation to the measuring instrument.

A.1.2.3 Felt pads

Prepare felt pads from carded wool fibre by consolidation using a wetting agent. It is essential to carry out the procedure in a reproducible manner. Wet out the carded specimen using a wetting agent at about 40 °C, then place sufficient pressure on the fibres to ensure that a flat pad is produced, preferably by using suitable apparatus. Thoroughly rinse the pad in grade 3 water conforming to BS EN ISO 3696 to remove wetting agent, etc. Apply compression to ensure that the pad remains flat and that there is no surface distortion during this rinsing process. Dry the pad at a maximum temperature of 60 °C and allow to condition to normal moisture regain (see Clause 6) before measurement.

Fibre specimens requiring a specimen holder A.1.3

If a fibre specimen cannot be prepared in accordance with A.1.2, a specimen holder shall be used. The methodology for this procedure is given in IWTO-56-03.

NOTE 1 A typical specimen holder is cylindrical with a glass window at one end and a means of compressing the fibre behind the glass. The glass should be of high transmittance, colourless and polished on both sides. Keep the thickness of the glass and the distance between the glass and the aperture of the instrument small, preferably less than 3 mm each. The diameter of the glass window should be at least 10 mm greater than the diameter of the aperture of the instrument.

Exclude the specular component when measuring specimens behind glass (as in a specimen holder); see 8.4.

The packing density is important, and optimum conditions shall be determined and maintained for each individual fibre type to ensure consistency of measurement.

NOTE For most wools, a packing density of (160 \pm 5) kg·m⁻³ has been found to be suitable.

Sliver **A.2**

Present sliver to the measuring instrument in a consistent form. No preliminary preparation is normally necessary. Sliver shall be wound round a rigid former (see A.4) at consistent tension or presented to the instrument in a specimen holder as described in A.1.3 (see reference IWTO-35-03).

Tow A.3

Tow shall be wound on a former in accordance with A.4, with consistent tension, ensuring fibres are arranged in a parallel fashion.

Formers for sliver, tow, yarn or thread **A.4**

Formers shall be rigid, parallel sided and larger than the specimen aperture. Wind such that the yarns/threads/sliver/tow are laid as closely together as possible, without overlapping. Wind with tension consistent within a single specimen and between related specimens. Machines are available commercially for winding specimens automatically.

Formers that are white on one side and black on the other may be used to check the opacity of a winding (see Clause 7). Formers that have a central hole (which shall be significantly larger than the aperture used for measurement) allow the winding of only half the length of yarn necessary to achieve opacity on an opaque former.

NOTE The use of transparent formers which are solid (i.e. do not have a central hole) should not be used because of the difficulty of ensuring that the former is overlaid by a sufficiently opaque winding.

Tuft end measurement A.5

NOTE 1 See 5.2.2.

Prepare yarn specimens for tuft end measurement by pulling a skein (small hank) or a bundle of parallel yarns through a tube and cutting the ends to produce a flat surface suitable for colour measurement. The tube shall be cylindrical, of a diameter greater than the size of the aperture of the colour measuring instrument, and made of a rigid material. Cut and/or trim the loop ends of the yarns to produce a flat surface, using e.g. animal clippers, or cut the varn with an electric knife or a guillotine and trim with electric human hair clippers or an electric shaver.

NOTE 2 Unless the apparatus for the finishing cut is kept consistently sharp, errors in measurement will result.

Determine the packing density of the yarns by experiment, ensuring it is dense enough to obtain a good cut surface and achieve consistency of colour measurement. Prepare and present all specimens by identical procedures.

NOTE 3 For a typical carpet yarn with a linear density of 550 tex, a suitable minimum packing density is approximately 50 ends cm⁻²

NOTE 4 "Tex" is not a unit in the SI although it remains in common use in the textile industry.

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Annex B (informative) Colour measurement of fluorescent specimens

B.1 Specimens treated with fluorescent whitening agents

Colour measurement of specimens treated with a fluorescent whitening agent (FWA) requires a particular type of instrument, set up as described. Correct results will be obtained only if the spectral distribution of the light source of the instrument simulates closely the spectral distribution of illuminant D65 over the range of wavelengths 320 nm to 700 nm. Many modern instruments achieve a good approximation to this requirement in the visible region from 400 nm to 700 nm but do not give the correct response to fluorescent specimens because of variation in output in the ultraviolet region of 320 nm to 400 nm.

Instruments fitted with tungsten lamps tend to be deficient in ultraviolet light. Instruments fitted with xenon lamps tend to have an excess of ultraviolet light and require correction by fitting adjustable ultraviolet filtration. The spectral distribution of output of sources can gradually change with ageing, so it is necessary to control the ultraviolet intensity using a fluorescent material as reference standard. Attempts have been made by committees in Europe and in the United States of America to agree fluorescent standards, so far without success.

At present, the alternative is to obtain the reflectance values (strictly the total radiance factors) of a stable fluorescent white material from a reference instrument for which the spectral distribution of the light-source is known to correspond closely to that of illuminant D65. These reflectance data can then be used to set up another instrument which has adjustable ultraviolet filtration. The reference white standard should be measured on this instrument at the start of each period of measurement and the proportion of ultraviolet adjusted until the readings of the reference white standard correspond closely to those obtained with the reference instrument. The fluorescent white material could be a white tile supplied with an instrument suitable for this type of measurement.

Measurements of specimens containing fluorescent whitening agents should be converted to values of whiteness and tint using the CIE Whiteness Equation (see Publication CIE 15), and results reported for illuminant D65 only.

B.2 Coloured specimens containing fluorescent species

Many coloured specimens contain fluorescent species. The substrate itself might be fluorescent, it might have been treated with fluorescent whitening agent, or it might have been coloured with fluorescent dyes or pigments.

In some specimens, the presence of fluorescent colorants is obvious even by casual visual inspection but fluorescent colorants are present in many others, too. Although it is not apparent by inspection, many anthraquinone-based dyes, for example, are fluorescent. These include C.I. Disperse Red 60 and Blue 56, still widely used in dyeing polyester to, *inter alia*, dull ternary shades such as greys and browns, in which their fluorescence is masked.

Wherever fluorescent species are present, there is potential for errors to occur in colour measurement. They may be eliminated only by using an instrument with fully reversible optics in combination with software capable of dealing with the two-dimensional array of data that it yields. (In fully reversible optics, illumination of the specimen is monochromatic throughout the UV and visible regions of the spectrum, and viewing is analysed at each wavelength throughout the visible region.) Such systems are rare in commercial applications.

For conventional instruments, provided they use polychromatic illumination and software, the problem is parallel with that discussed in **B.1**. It is, however, complicated by the need for the equality of the distribution by incident wavelength of the instrument's source and the illuminant under which results are required to extend from the UV well into the visible spectrum. Such systems are equally rare in commerce and, in practice, the problem is compounded by the desire, in most cases, to obtain results under more than one illuminant, requiring the distribution of the source to change with change in illuminant.

Fortunately the impact of the problem is reduced, for many specimens, by interaction between the fluorescent species and other species, which might or might not themselves be fluorescent, in the specimen. Thus, for examples:

- the effect of the presence of fluorescent whitening agent in a specimen is progressively reduced with increase in the concentrations of colorants, especially yellows and reds, present;
- b) the considerable fluorescence of C.I. Disperse Red 60 in self shades is reduced if it is used in combination with yellow and blue dyes to produce greys, browns, etc. The extent of the reduction depends on the nature of the reflectance curves of the yellow and blue dyes. The reduction of the fluorescence of C.I. Disperse Red 60 is greater the higher the total quantity of dye present. The higher the ratio of the amounts of yellow and blue relative to that of C.I. Disperse Red 60, the greater the reduction of the fluorescence.

In consequence, useful results can be obtained in many cases but users of this standard are cautioned to take care in the interpretation of any result obtained by measuring a specimen in which fluorescent species are present.

Bibliography

Standards publications

BS 381C:1996, Specification for colours for identification, coding and special purposes

BS 3510:1968, Specification for a basic symbol to denote the actual or potential presence of ionizing radiation

BS 5455:1977, Specification for polyurethane coated nylon fabric for mattress covers

BS 6341:1983, Specification for fabrics for camping tents

BS EN 471:1994, Specification for high-visibility warning clothing

AS 3546:1996, Wool - Method for measuring average yellowness of raw wool

AS/NZS 1133:1996, Wool - Determination by the airflow method of the mean fibre diameter of core samples of raw wool

ASTM E308-01, Standard practice for computing the colors of objects by using the CIE system

NZS 8707:1984, Method for the measurement of the colour of wool

ASTM - American Society for Testing and Materials. http://www.astm.org

100 Barr Harbor Drive, West Conshohocken, Pennsylvania, USA, 19428-2959

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