

Test Method for Whiteness of Textiles

1. Purpose and Scope

1.1 This test method provides procedures for measuring the whiteness and tint of textiles using formulas recommended by the CIE (see 12.1). The method describes the procedures to be used and also the limitations and restrictions that apply.

2. Principle

2.1 The CIE tristimulus values are measured using a reflectance spectrophotometer or colorimeter, and the whiteness and tint calculated from formulas based on the CIE chromaticity coordinates.

2.2 Many impurities in textiles absorb short wavelength light, resulting in a yellowish appearance to observers. Therefore, a measurement of whiteness may be an indication of the degree to which a textile is free from impurities.

2.3 The presence of bluing components or fluorescent whitening agents (FWAs) in textiles may also be determined using the whiteness measurement.

3. Terminology

3.1 **CIE chromaticity coordinates**, *n.*—the ratio of each of the tristimulus values of a psychophysical color to the sum of the tristimulus values (see 12.1) [ASTM E284].

3.2 **CIE tristimulus values**, *n.*—amounts of three non-real reference color stimuli required to give a color match with the color stimulus considered and defined by the CIE for the CIE 1931 standard colorimetric observer and the CIE 1964 standard colorimetric observer and for a particular illumination condition (see 12.1).

3.3 **fluorescent whitening agent (FWA)**, *n.*—colorant that absorbs near ultraviolet (UV) radiation and re-emits visible longer wavelength radiation. This enhances the whiteness appearance of yellowish materials to which it has been applied. [ASTM E284].

3.4 **perfect reflecting diffuser**, *n.*—ideal reflecting surface that neither absorbs nor transmits light, but reflects diffusely, with the radiance of the reflecting surface being the same for all reflecting angles, regardless of the angular distribution of the incident light. [ASTM E284].

NOTE: The perfect reflecting diffuser is the basis of calibration of reflectance measuring instruments. The equations for whiteness and tint are formulated so that the CIE concept of the perfect reflecting

diffuser has a whiteness index of 100.0 and a tint value of 0.0.

3.5 **tint**, *n.*—*in whiteness measurement*, the hue of a white material as influenced by the wavelength of peak emission or reflectance. [CIE 15.2].

NOTE: Tint, if other than zero, is an indication of a reddish or greenish hue having shifted away from a bluish hue with dominant wavelength of 466 nm.

3.6 **whiteness**, *n.*—whiteness is the attribute by which an object color is judged to approach a preferred white. [ASTM E284].

NOTE: Whiteness as measured by this test method is an indication of how white the textile appears to an average viewer.

4. Safety Precautions

NOTE: These safety precautions are for information purposes only. The safety precautions are ancillary to the testing procedures and are not intended to be all inclusive. It is the user's responsibility to use safe and proper techniques in handling materials in this test method. Manufacturers MUST be consulted for specific details such as material safety data sheets and other manufacturer's recommendations. All OSHA standards and rules must also be consulted and followed.

4.1 Good laboratory practices should be followed. Wear safety glasses in all laboratory areas.

4.2 CAUTION: Protect the eyes from UV light. The safety recommendations provided by the UV light manufacturer should be followed.

4.3 Manufacturer's safety recommendations should be followed when operating laboratory testing equipment.

5. Uses and Limitations

5.1 Because reflectance is affected by the nature of the surface of the textile, comparisons can be made only between samples of the same type of textile.

5.2 The application of the formulas is restricted to specimens that are called "white" commercially, and that do not differ much in color and fluorescence.

5.3 When employing measuring instruments that are not equipped with capabilities for calibrating the UV content of the specimen illumination, the formulas provide for relative evaluations of whiteness that are restricted to specimens measured on the same instrument at nearly the same time. When employing measuring instruments that are equipped with capabilities for calibrating the UV content of the specimen illumination, the formulas pro-

vide evaluations of whiteness that can be directly compared to results from similarly calibrated instruments and that are adequate for commercial use.

6. Apparatus and Materials

6.1 Color Measuring Instrument. A reflectance spectrophotometer or colorimeter capable of measuring or calculating CIE tristimulus values with at least one of the CIE specified geometries (45°:0°, 0°:45°, d:8°, 8°:d). When integrating spheres are used for measuring fluorescent specimens, the spectral power distribution of the illuminating system is altered by the reflected and emitted power from the specimen. The use of the 45°:0°, or 0°:45° condition is therefore preferable (see 12.1). To be able to make direct comparisons between results from different instruments, identical measuring geometries should be used and all instruments should have the capability of adjusting the amount of ultraviolet energy in the illumination source.

6.2 Reference Standard. The primary standard is the perfect reflecting diffuser (see 3.4). Secondary Reference Standards are standards that are calibrated in terms of the perfect reflecting diffuser and are used in the standardization of the instrument.

6.3 UV Lamp. Used for visual determination of presence of FWA on textile specimens.

7. Test Specimen

7.1 Condition each specimen for several hours in an atmosphere of $21 \pm 2^\circ\text{C}$ ($70 \pm 4^\circ\text{F}$) and $65 \pm 5\%$ RH by layering each test specimen separately on a screen or perforated shelf of a conditioning rack (see ASTM D1776, Standard Practice for Conditioning and Testing Textiles, and 12.5). Keep the samples free of dirt and stains. The exact size necessary will depend on the aperture of the reflectance measuring instrument used and on the translucency of the textile material.

8. Procedure

8.1 Before proceeding with color measurements, determine whether or not a fabric contains FWA by viewing a specimen in a dark room under ultraviolet light. A fabric that contains FWA will fluoresce under the UV light.

8.1.1 If fluorescent whitening agents (FWA) are present on the textile material, the measurement must be made with an

instrument that illuminates the specimen with polychromatic light (full spectrum) and has a relative spectral power distribution approximating CIE illuminant D₆₅ from 360-700 nm. Consult instrument manufacturers for suitable equipment. The user should also verify the suitability of the instrument if flash illumination is being used.

8.1.2 For the determination of an approximate relative efficiency of an FWA, an instrument which permits the insertion of an ultraviolet cut-off filter into the incident light beam may be used. The difference between the measurements taken before and after the insertion of the ultraviolet cut-off filter can provide an indication of the enhancement of the apparent whiteness due to the addition of an FWA. Because of possible variations in light sources and/or ultraviolet cut-off filters, the user is cautioned to use this procedure only for “relative in-house” determination.

8.2 Operate the color measuring instrument according to the manufacturer’s instructions for standardization and measurement, in accordance with AATCC EP6, Instrumental Color Measurement.

8.2.1 If the spectrophotometer is equipped with adjustable ultraviolet energy, standardize the amount of ultraviolet energy in the spectrophotometer light source (see 12.2).

9. Calculations, Interpretation and Limitations

9.1 Average the measurement values taken for each test sample.

9.2 For each averaged measurement, determine the CIE tristimulus values X_{10} , Y_{10} and Z_{10} for CIE standard illuminant CIE D₆₅ and 1964 10° observer (see ASTM E308 for details on calculation of tristimulus values from reflectance data). Determine the chromaticity coordinates x_{10} , y_{10} .

9.3 The whiteness index (W_{10}) for any sample shall be calculated by the equation in 9.4 and the tint ($T_{W,10}$) by the equation in 9.5. Direct comparisons of whiteness and tint values should only be made for similar samples. Whiteness values are suitable for direct comparison to results from similarly calibrated instruments only when the ultraviolet energy in the spectrophotometer light source has been standardized and measuring geometries are identical. Tint values are not suitable for direct comparison between instruments. The degree of difference that will be accepted or rejected is the sole responsibility of the user, as the requirements

are extremely dependent on the particular use and material being measured. The higher the value of W_{10} , the greater the whiteness. Equal differences in W_{10} value do not necessarily indicate equal differences in perceived whiteness nor equal concentration differences of FWA. Similarly, equal differences in $T_{W,10}$ value do not always represent equal perceptual differences in greenness or redness of whites.

9.4 Whiteness (see 12.2 and 12.3). (For illuminant D₆₅ and 1964 10° observer):

$$W_{10} = Y_{10} + 800(0.3138 - x_{10}) + 1700(0.3310 - y_{10})$$

where W_{10} is the whiteness value or index; Y_{10} , x_{10} , y_{10} are the chromaticity coordinates of the specimen, and 0.3138 and 0.3310 are, respectively, the x_{10} , y_{10} chromaticity coordinates for the perfect diffuser.

Limited to: $40 < W_{10} < 5Y_{10} - 280$.

9.5 Tint (for illuminant D₆₅ and 1964 10° observer):

$$T_{W,10} = 900(0.3138 - x_{10}) - 650(0.3310 - y_{10})$$

where $T_{W,10}$ is the tint value; x_{10} , y_{10} are the chromaticity coordinates of the sample, and 0.3138 and 0.3310 are, respectively, the x_{10} , y_{10} chromaticity coordinates for the perfect diffuser.

Limited to: $-4 < T_{W,10} < +2$.

Values of $T_{W,10}$, when positive, indicate a greenish hue; when negative, indicate a reddish hue; and when zero, indicate a bluish hue with a dominant wavelength of 466 nm.

10. Report

10.1 Report the numerical whiteness value, the tint value if required, the illuminant and the CIE standard colorimetric observer used in the calculations, the instrument and its measuring geometry used, and whether or not the ultraviolet energy of the spectrophotometer light source has been standardized using EP11, Spectrophotometer UV Energy Calibration Procedure for Optically Brightened Textiles (see 12.2).

11. Precision and Bias

11.1 *Precision*. Precision for this test method has not been established. Until a precision statement is generated for this test method, use standard statistical techniques in making any comparisons of test results for either *within-laboratory* or *between-laboratory* averages.

11.2 *Bias*. The whiteness and tint of textiles can be defined only in terms of a

test method. There is no independent method for determining the true values. As a means of estimating these properties, the method has no known bias.

12. Notes and References

12.1 For a description of the CIE colorimetric system, instrument geometry and a complete description of the whiteness and tint formulas used above, see CIE Publication 15:2018, *Colorimetry, 4th Edition*. Available through US National Committee of the CIE or via the CIE webstore (www.techstreet.com/cie/).

12.2 See EP11, Spectrometer UV Energy Calibration Procedure for Optically Brightened Textiles, as included in the AATCC *Manual of International Test Methods and Procedures*, for details regarding ultraviolet energy standardization of spectrophotometer light sources. The Procedure can also be purchased separately from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: 919/549-8141; fax: 919/549-8933; e-mail: ordering@aatcc.org; web site: www.aatcc.org.

12.3 The equation used in prior versions of this test method was:

$$W = 4B - 3G \text{ (AATCC TM 110-1979)}$$

where W = Whiteness, B = Blue reflectance and G = Green reflectance for CIE illuminant C and CIE 1931 2° standard observer.

12.4 Users who wish to explore the prediction of data under true D₆₅ illuminant for samples containing FWAs can refer to the following: F. W. Billmeyer Jr., *Metrology, Documentary Standards, and Color Specifications for Fluorescent Materials*, *Color Research and Application*, Vol. 19, 1994, pp413-425, and Publication ISO 23603 (CIE S 012/E) “Standard method of assessing the spectral quality of daylight simulators for visual appraisal and measurement of colour.”

12.5 ASTM Standard Test Methods and Practices are available from ASTM, 100 Barr Harbor Dr., W. Conshohocken PA 19428; tel: +1.610.832.9500; fax: +1.610.832.9555; web site: www.astm.org.

12.6 For a more complete description of the proper procedures in color measurement, refer to AATCC EP6, Evaluation Procedure for Instrumental Color Measurement.

13. History

13.1 Revised in 2021 for clarity and to add history section to align with AATCC Style Guide.

13.2 Editorially revised 2019 and 2016; revised 2015; reaffirmed 2011, 2005 and 2000; revised 1995; editorially revised and reaffirmed 1994; revised 1989 (title change); editorially revised 1980 and 1979; reaffirmed 1979, 1975, and 1972; reaffirmed 1968.

13.3 Developed in 1964 by AATCC Committee RA34; jurisdiction transferred in 1983 to AATCC Committee RA36. Adopted as ISO 105-J02 in 1987.