

## Test Methods for Color Measurement

The world governing body for color and appearance measurement is the CIE, Commission Internationale de l'Eclairage, or the International Commission on Illumination. They can be found online at [www.cie.co.at](http://www.cie.co.at). Their fundamental publication is Publication CIE 15:2004, *Colorimetry*, which provides detailed information on standard illuminants and observers, as well as the calculations for color scales.

The primary standards organizations for the colorimetric industry are:

- NIST, National Institute of Standards and Technology, [www.nist.gov](http://www.nist.gov).
- NPL, National Physical Laboratory, [www.npl.co.uk](http://www.npl.co.uk).
- NRC, National Research Council Canada, [www.nrc-cnrc.gc.ca](http://www.nrc-cnrc.gc.ca).
- BAM, Bundesanstalt für Materialforschung und -prüfung, [www.bam.de](http://www.bam.de)

In addition, many test methods have been published by organizational bodies describing how color measurement should be performed in various industries. Brief descriptions of some of them (primarily addressing instrumental—as opposed to visual—assessments) are provided below. This list is not intended to be exhaustive.

### **AATCC Evaluation Procedures - Textiles**

American Association of Textile Chemists and Colorists (AATCC) evaluation procedures may be ordered through [www.aatcc.org](http://www.aatcc.org).

AATCC Evaluation Procedure 1, “Gray Scale for Color Change,” describes the use of a gray scale for visually assessing color changes that occur during color fastness tests.

AATCC Evaluation Procedure 2, “Gray Scale for Staining,” describes the use of a gray scale for visually evaluating staining of adjacent fabrics during color fastness tests.

AATCC Evaluation Procedure 6, “Instrumental Color Measurement,” is a reference document covering instrumental reflectance measurement, transmittance measurement, and related calculations. It also contains an appendix describing sample handling techniques.

AATCC Evaluation Procedure 7, “Instrumental Assessment of the Change in Color of a Test Specimen,” describes how to instrumentally assess color changes that occur during color fastness tests. This procedure is intended as an alternative to Evaluation Procedure 1’s visual method.

## AATCC Test Methods - Textiles

American Association of Textile Chemists and Colorists (AATCC) test methods may be ordered through [www.aatcc.org](http://www.aatcc.org).

AATCC Test Method 110, “Whiteness of Textiles,” lists procedures for instrumentally measuring and calculating whiteness and tint of fabrics.

AATCC Test Method 173, “CMC: Calculation of Small Color Differences for Acceptability,” describes how to calculate and use the dE CMC color difference scale.

AATCC Test Method 182, “Relative Color Strength of Dyes in Solution,” describes determination of color strength of a dye spectrophotometrically by comparing its transmission measurements to those of a reference dye.

## AS/NZS Australian/New Zealand Standards

Australian Standard (AS)/New Zealand Standard (NZS) standards may be obtained through Standards Australia at [www.standards.com.au](http://www.standards.com.au).

AS/NZS 1301.455s, “Colour Measurement with a Diff/0° Geometry Tristimulus Reflectometer,” describes color measurement of non-fluorescent paper and board using a diffuse/0° colorimeter.

AS/NZS 1580.601.2, “Paints and related materials—Methods of test: Colour—Principles of color measurement,” provides an overview of colorimetric terms, illuminants, etc.

AS/NZS 1580.601.3, “Paints and related materials—Methods of test: Colour—Methods of colour measurement,” describes the parameters of instrumental measurement, including geometries and illuminants.

AS/NZS 1580.601.4, “Paints and related materials—Methods of test: Colour—Calculation of colour differences,” describes calculation of color differences using instrumental measurements.

AS/NZS 1580.601.5, “Paints and related materials—Methods of test: Colour—Calculation of small colour differences using the CMC equation,” describes the use of the CMC equations for color tolerancing.

AS 2001.4.A02, “Methods of test for textiles—Colourfastness tests—Grey scale for assessing change in colour,” adopts the ISO 105-A02 method described below for assessing gray scale during colorfastness testing.

AS 2001.4.A03, “Methods of test for textiles—Colourfastness tests—Grey scale for assessing staining,” adopts the ISO 105-A03 method described below for assessing staining of adjacent fabrics during colorfastness testing.

AS 2001.4.A04, “Methods of test for textiles—Colourfastness tests—Instrumental assessment of the degree of staining of adjacent fabrics,” allows for gray stain values to be assigned using instrumental color measurements.

AS 2001.4.A05, “Method of test for textiles—Colourfastness tests—Instrumental assessment of the change in colour for determination of grey scale rating,” allows for gray scale values to be assigned using instrumental color measurements.

AS/NZS 2111.19.1, “Textile floor coverings—Tests and measurements: Colourfastness tests—Rubbing,” describes how to evaluate visually or instrumentally the staining of cloths rubbed on floor coverings.

AS/NZS 2633, “Guide to the specification of colours,” provides guidance on specifying colors, selecting a color measurement method, and establishing tolerances.

AS 4459.16, “Methods of sampling and testing ceramic tiles—Determination of small colour differences,” provides a method for quantifying instrumentally color differences between glazed ceramic tiles.

## **ASBC - Beer**

American Society of Brewing Chemists (ASBC) methods may be ordered through [www.asbcnet.org](http://www.asbcnet.org).

ASBC Beer-10, “Color,” describes how to measure beer using a spectrophotometer and defines the ASBC Beer and Turbidity scales.

## **ASTM Standard Specifications**

American Society for Testing and Materials (ASTM) standards may be ordered through [www.astm.org](http://www.astm.org).

ASTM C1510, “Standard Test Method for Color and Color Difference of Whitewares by Abridged Spectrophotometry,” describes how to measure reflectance and color of ceramics using a sphere spectrophotometer.

ASTM C1649, “Standard Practice for Instrumental Transmittance Measurement of Color for Flat Glass, Coated and Uncoated,” provides guidelines for measuring the transmitted color of coated and uncoated flat, transparent glass using an instrument.

ASTM C1650, “Standard Practice for Instrumental Reflectance Measurement of Color for Flat Glass, Coated, and Uncoated,” provides guidelines for measuring the reflected color of coated and uncoated flat glass using an instrument.

ASTM D156, “Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method),” describes evaluating the color of refined oils visually using Saybolt Color Units.

ASTM D985, “Standard Test Method for Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm),” describes how to determine brightness of white paper products (even those that include fluorescent whitening agents) using a 45°/0° instrument.

ASTM D1003, “Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics,” provides a procedure for the instrumental measurement of luminous transmittance and haze of materials with haze values up to 30%.

ASTM D1209, “Standard Test Method for Color of Clear Liquids (Platinum-Cobalt Scale),” describes visual evaluation of light, yellow-colored liquids using the PtCo (APHA) scale.

ASTM D1500, “Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale),” describes visual evaluation of petroleum products using the ASTM Color scale.

ASTM D1544, “Standard Test Method for Color of Transparent Liquids (Gardner Color Scale),” describes visual evaluation of oils and varnishes using the Gardner Color Scale.

ASTM D1746, “Standard Test Method for Transparency of Plastic Sheeting,” covers instrumental measurement of regular transmittance of clear and colorless thin sheeting.

ASTM D2066, “Standard Test Method for Relative Tinting Strength of Paste-Type Printing Ink Dispersions,” describes reflectance instrumental or visual evaluation of the relative tinting strength of ink dispersions.

ASTM D2244, “Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates,” describes the calculation of rectangular and elliptical color differences for opaque samples.

ASTM D2616, “Standard Test Method for Evaluation of Visual Color Difference With a Gray Scale,” describes visual evaluation of small color differences and is based on the AATCC method that discusses the Gray Scale for Color Change.

ASTM D2745, “Standard Test Method for Relative Tinting Strength of White Pigments by Reflectance Measurements,” explains how to determine the relative tinting strength of white pigments by using their reflectance measurements.

ASTM D3134, “Standard Practice for Establishing Color and Gloss Tolerances,” describes a means of establishing color and gloss tolerances from standards for non-fluorescent opaque samples.

ASTM D3210, “Standard Test Method for Comparing Colors of Films from Water-Emulsion Floor Polishes,” describes characterization of luminous reflectance for films treated with floor polishes using a tristimulus colorimeter.

ASTM D3964, “Standard Practice for Selection of Coating Specimens for Appearance Measurements,” discusses selection of appropriate samples for appearance measurement and methods for their preparation and presentation.

ASTM D4086, “Standard Practice for Visual Evaluation of Metamerism,” describes visual methods for detecting metamerism and for establishing the magnitude of such color differences.

ASTM D4265, “Standard Guide for Evaluating Stain Removal Performance in Home Laundering,” describes how to evaluate fabrics that have been involved in laundry tests either visually or instrumentally.

ASTM D4303, “Standard Test Methods for Lightfastness of Colorants Used in Artists’ Materials,” explains how artists’ colorants can be evaluated using a spectrophotometer or colorimeter that can exclude specular reflectance.

ASTM D4838, “Standard Test Method for Determining the Relative Tinting Strength of Chromatic Paints,” explains how to determine absorption tinting strength relative to a standard paint using a spectrophotometer or colorimeter.

ASTM D4877, “Standard Test Method for Polyurethane Raw Materials: Determination of APHA Color in Isocyanates,” provides a test method for measuring the color of clear, yellowish liquids.

ASTM D4960, “Standard Test Method for Evaluation of Color for Thermoplastic Traffic Marking Materials,” describes using a 45°/0° colorimeter or spectrophotometer to measure these materials.

ASTM D5215, “Standard Test Method for Instrumental Evaluation of Staining of Vinyl Flooring by Adhesives,” describes how to instrumentally measure the degree of staining that occurs in vinyl flooring as a result of its contact with adhesives. Color differences are expressed in CIELAB units.

ASTM D5326, “Standard Test Method for Color Development in Tinted Latex Paints,” describes evaluation of paints by comparing a drawdown and a brushout of the same color using a colorimeter or spectrophotometer standardized in reflectance, specular excluded mode.

ASTM D5386, “Standard Test Method for Color of Liquids Using Tristimulus Colorimetry,” gives an instrumental method for obtaining APHA values for near-clear liquid samples.

ASTM D5531, “Standard Guide for Preparation, Maintenance, and Distribution of Physical Product Standards for Color and Geometric Appearance of Coatings,” discusses the types of physical product standards used in the coatings industry and techniques for creating them.

ASTM D6166, “Standard Test Method for Color of Naval Stores and Related Products (Instrumental Determination of Gardner Color),” describes color measurement of clear, yellow/brown liquids using an instrument and reporting of the results in the Gardner color scale.

ASTM D6290, “Standard Test Method for Color Determination of Plastic Pellets,” explains how to measure the degree of yellowness of plastic pellets using a spectrophotometer or colorimeter.

ASTM E179, “Standard Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials,” suggests appropriate instrument types and measurement scales for evaluating appearance characteristics such as color, glossiness, and opacity.

ASTM E259, “Standard Practice for Preparation of Pressed Powder White Reflectance Factor Transfer Standards for Hemispherical and Bi-directional Geometries,” defines preparation of highly-reflective transfer standards for both directional and diffuse instruments.

ASTM E275, “Standard Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near-Infrared Spectrophotometers,” provides the requirements of spectrophotometric performance for ASTM methods and explains how to test an instrument.

ASTM E284, “Standard Terminology of Appearance,” defines terms used in describing appearance, such as color and opacity.

ASTM E308, “Standard Practice for Computing the Colors of Objects by Using the CIE System,” explains how to calculate CIE XYZ and other color scales from spectral reflectance and transmittance values and defines the CIE illuminants and standard observers.

ASTM E313, “Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates,” defines the whiteness and yellowness indices.

ASTM E805, “Standard Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials,” describes how to effectively communicate color values and all the parameters that affect them.

ASTM E808, “Standard Practice for Describing Retroreflection,” describes how to measure retroreflective samples and present the results.

ASTM E809, “Standard Practice for Measuring Photometric Characteristics of Retroreflectors,” explains how to measure the photometric characteristics of retroreflectors.

ASTM E991, “Standard Practice for Color Measurement of Fluorescent Specimens,” describes measurement of fluorescent samples and presenting numerically how they appear in daylight.

ASTM E1164, “Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation,” covers instrumental measurement requirements for spectrophotometers and colorimeters.

ASTM E1247, “Standard Practice for Detecting Fluorescence in Object-Color Specimens by Spectrophotometry,” describes how to use a spectrophotometer to determine whether samples are fluorescent.

ASTM E1331, “Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry,” defines colorimetric measurement using a spectrophotometer with a sphere (diffuse) geometry.

ASTM E1345, “Standard Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements,” describes averaging as a technique for minimizing sample variation.

ASTM E1347, “Standard Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry,” describes color measurement using tristimulus colorimeters of either 45°/0° or diffuse geometry.

ASTM E1348, “Standard Test Method for Transmittance and Color by Spectrophotometry Using Hemispherical Geometry,” describes color measurement of transparent and translucent samples using a spectrophotometer with a sphere (diffuse) geometry standardized in a transmittance mode.

ASTM E1349, “Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry,” describes color measurement of opaque samples using a spectrophotometer with a 45°/0° or 0°/45° geometry.

ASTM E1477, “Standard Test Method for Luminous Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers,” explains how to measure luminous reflectance (Y) of acoustical materials using a sphere instrument.

ASTM E1767, “Practice for Specifying the Geometries of Observation and Measurement to Characterize the Appearance of Materials,” describes the different geometries of instruments that measure appearance.

ASTM E2022, “Standard Practice for Calculation of Weighting Factors for Tristimulus Integration,” explains how to establish tables of weighting factors that are to be used in calculating tristimulus values from spectral reflectance or transmittance data.

ASTM E2214, “Standard Practice for Specifying and Verifying the Performance of Color-Measuring Instruments,” explains how to characterize the performance of colorimeters and spectrophotometers used for color measurement.

ASTM E2301, “Standard Test Method for Daytime Colorimetric Properties of Fluorescent Retroreflective Sheeting and Marking Materials for High Visibility Traffic Control and Personal Safety Applications Using 45°:Normal Geometry,” describes how to use a 45°/0° instrument to measure the color of fluorescent-retroreflective sheeting such as used for traffic control and safety applications.

ASTM F2109, “Standard Test Method to Determine Color Change and Staining Caused by Aircraft Maintenance Chemicals Upon Aircraft Cabin Interior Hard Surfaces,” Explains how to describe, using the AATCC Gray Scale for Color Change and the AATCC Gray Color Scale for Staining, the effect of chemical cleaning on the color of aircraft interiors.

## DIN

Deutsches Institut für Normung e.V. (DIN) [German Institute for Standardization] industrial test methods may be ordered through [www.en.din.de](http://www.en.din.de).

DIN 5033, “Colorimetry,” has nine parts and covers visual and instrumental color analysis, as well as basic color concepts and terminology.

DIN 6174, “Colorimetric Evaluation of Colour Differences of Surface Colours According to the CIELAB Formula,” describes measuring  $dL^*$ ,  $da^*$ , and  $db^*$  using an instrument.

DIN 6176, “Colorimetric evaluation of colour differences of surface colours according to DIN99-formula,” explains how to measure using the elliptical DIN99 formula.

## ICUMSA Sugar Methods

International Commission for Uniform Methods of Sugar Analysis (ICUMSA) methods may be ordered through [www.bartens.com/shop.html](http://www.bartens.com/shop.html).

ICUMSA Method GS 2/3-9, “The Determination of Sugar Solution Colour at pH 7.0,” describes the preparation and measurement of white sugar solution and the formula for calculating the ICUMSA 420 Sugar Score.

ICUMSA Method GS 2/3-10, “The Determination of White Sugar Solution Color,” describes the preparation and measurement of white sugar solution and the formula for calculating the ICUMSA 420 Sugar Score.

## ISO

International Organization for Standardization (ISO) methods may be ordered through [www.iso.org](http://www.iso.org).

ISO 105-A01, “Textiles—Tests for colour fastness—Part A01: General principles of testing,” provides general information about the various ISO methods for testing color fastness of textiles and dyes. This method may help you select an ISO test method for textiles if none of the ones listed below (not a complete list) is applicable.

ISO 105-A02, “Textiles—Tests for colour fastness—Part A02: Grey scale for assessing change in colour,” describes the gray scale for color changes that occur during color fastness tests. The method includes a colorimetric specification for the scale.

ISO 105-A03, “Textiles—Tests for colour fastness—Part A03: Grey scale for assessing staining,” describes the gray scale for determining staining of adjacent fabrics during color fastness tests. The method includes a colorimetric specification for the scale.

ISO 105-A04, “Textiles—Tests for colour fastness—Part A04: Method for the instrumental assessment of the degree of staining of adjacent fabrics,” describes an instrumental method for assessing color changes that occur during color fastness tests. This method includes the calculations required to convert the instrumental values into a gray scale rating.

ISO 105-A05, “Textiles—Tests for colour fastness—Part A05: Instrumental assessment of change in colour for determination of grey scale rating,” describes an instrumental method for assessing staining of adjacent fabrics during color fastness tests. This method includes the calculations required to convert the instrumental values into a gray scale rating.

ISO 105-J01, “Textiles—Tests for colour fastness—Part J01: General principles for measurement of surface colour,” is a reference document describing general concepts and problems of reflectance color measurement.

ISO 105-J02, “Textiles—Tests for colour fastness—Part J02: Instrumental assessment of relative whiteness,” explains how to quantify whiteness and tint of textiles, including fluorescent textiles.

ISO 105-J03, “Textiles—Tests for colour fastness—Part J03: Calculation of colour differences,” explains how to calculate the color difference between two similar samples and allows for the specification of tolerances.

ISO 2211, “Liquid chemical products—Measurement of colour in Hazen units (platinum-cobalt scale),” describes visual and instrumental means of applying platinum-cobalt (APHA) values to clear, slightly-colored liquids.

ISO 4630-1, “Clear liquids—Estimation of colour by the Gardner colour scale—Part 1: Visual method,” describes how to estimate the color of clear, yellow-brown liquids visually using the Gardner scale.

ISO 4630-2, “Clear liquids—Estimation of colour by the Gardner colour scale—Part 2: Spectrophotometric method,” describes how to estimate the color of clear, yellow-brown liquids instrumentally using the Gardner scale.

ISO 5631, “Paper and board—Determination of colour (C/2 degrees)—Diffuse reflectance method,” describes measurement of paper and paper board using a diffuse spectrophotometer or colorimeter.

ISO 6271-1, “Clear liquids—Estimation of colour by the platinum-cobalt scale—Part 1: Visual method,” defines how to visually assign Pt-Co (APHA) values to clear liquids.

ISO 6271-2, “Clear liquids—Estimation of colour by the platinum-cobalt scale—Part 2: Spectrophotometric method,” defines how to determine the color of clear liquids instrumentally using the Pt-Co (APHA) scale.

ISO 7724-1, “Paints and varnishes—Colorimetry—Part 1: Principles,” describes color scales and requirements for determining color values for paint films (including specifying instrument geometry).

ISO 7724-2, “Paints and varnishes—Colorimetry—Part 2: Colour measurement,” describes how to determine color values for uniform paint films using a spectrophotometer or colorimeter.

ISO 7724-3, “Paints and varnishes—Colorimetry—Part 3: Calculation of colour differences,” explains how to quantify small color differences between paint films using a color measuring instrument.

ISO 8112, “Caprolactam for industrial use—Determination of colour of 50% aqueous caprolactam solution, expressed in Hazen units (platinum-cobalt scale)—Spectrometric method,” describes assignment of Hazen (APHA) values to specific water solutions after measuring their wavelengths at 390 nm with a path length of 50 mm.

ISO/CIE 10526, “CIE standard illuminants for colorimetry,” defines the CIE standard illuminants.

ISO/CIE 10527, “CIE standard colorimetric observers,” defines the CIE standard observers.

ISO 11475, “Paper and board—Determination of CIE whiteness, D65/10 degrees (outdoor daylight),” explains how to instrumentally determine the whiteness of papers and boards with or without fluorescent whitening agents under outdoor lighting conditions.

ISO 11476, “Paper and board—Determination of CIE-whiteness, C/2 degree (indoor illumination conditions),” explains how to instrumentally determine the whiteness of papers and boards with or without fluorescent whitening agents under indoor lighting conditions.

ISO 13468-2, “Plastics—Determination of the total luminous transmittance of transparent materials—Part 2: Double-beam instrument,” describes measurement in transmittance of transparent and colorless plastics using a double-beam spectrophotometer. It does not apply to plastics that contain fluorescent components.

## JIS

Japanese Industrial Standards may be obtained through [www.jsa.or.jp](http://www.jsa.or.jp).

JIS K 5101-2-2:2004, “Test methods for pigments -- Part 2: Comparison of colour -- Section 2: Colorimetric method,” describes how to compare the colors of pigments using an instrument.

JIS K 5600-4-4:1999, “Testing methods for paints—Part 4: Visual characteristics of film—Section 4: Colorimetry (Principles),” defines terms used in color measurement of paint films and related materials.



JIS K 5600-4-5:1999, “Testing methods for paints -- Part 4: Visual characteristics of film -- Section 5: Colorimetry (Measurement),” describes color measurement of opaque monochromatic (nonmetallic) paint films.

JIS K 5600-4-6:1999, “Testing methods for paints -- Part 4: Visual characteristics of film -- Section 6: Colorimetry (Calculation of colour differences),” explains how to instrumentally evaluate color differences between paint films.

JIS K 7105:1981, “Testing methods for optical properties of plastics,” describes how to measure attributes of plastics such as light transmittance, color, and color difference.

JIS L 0809:2001, “Instrumental determination of colour fastness—Change in colour and staining,” describes how to determine gray scale values instrumentally.

JIS P 8148:2001, “Paper, board and pulps -- Measurement of diffuse blue reflectance factor (ISO brightness),” gives a method for instrumentally determining ISO brightness of pulps, paper, and boards.

JIS P 8150:2004, “Paper and board -- Determination of colour(C/2 degree) -- Diffuse reflectance method,” explains how to instrumentally measure the color of white paper and board.

JIS Z 8105:2000, “Glossary of colour terms,” defines terms used in communicating color.

JIS Z 8701:1999, “Colour specification -- The CIE 1931 standard colorimetric system and the CIE 1964 supplementary standard colorimetric system,” defines the CIE 2-degree and 10-degree standard observers.

JIS Z 8720:2000, “Standard illuminants and sources for Colorimetry,” defines standard illuminants.

JIS Z 8722:2000, “Methods of colour measurement -- Reflecting and transmitting objects,” gives specifications for measuring color using spectrophotometers and colorimeters.

JIS Z 8729:2004, “Colour specification -- CIELAB and CIELUV colour spaces,” defines the CIELAB and CIELUV color scales.

JIS Z 8781:1999, “CIE standard colorimetric illuminants,” defines the CIE standard illuminants.

JIS Z 8782:1999, “CIE standard colorimetric observers,” defines the CIE standard observers.

## **SAE J1545**

This Society of Automotive Engineers (SAE) publication may be obtained through [www.sae.org](http://www.sae.org).

SAE J1545, “Instrumental Color Difference Measurement for Exterior Finishes, Textiles, and Colored Trim,” specifies how to measure and communicate color difference information for opaque materials used in the manufacture of vehicles.

## **TAPPI Test Methods - Pulp and Paper**

Technical Association of the Pulp and Paper Industry (TAPPI) test methods may be obtained through [www.tappi.org](http://www.tappi.org).

TAPPI T452, “Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm),” describes a method for determining, using a 45°/0° instrument, the brightness of white, near-white, and naturally-colored pulp, paper, and paperboard.

TAPPI T515, “Visual Grading and Color Matching of Paper,” describes the conditions to be used when visually evaluating paper, including those that contain fluorescent whitening agents.

TAPPI T524, “Color of Paper and Paperboard (45/0, C/2),” describes how to measure the color of paper and paperboard using a colorimeter or spectrophotometer with 45°/0° geometry.

TAPPI T527, “Color of Paper and Paperboard (d/0, C/2),” describes how to measure the color of paper and paperboard using a colorimeter or spectrophotometer with diffuse geometry.

TAPPI T646, “Brightness of Clay and Other Mineral Pigments (45°/0°),” gives a procedure for measuring, using a 45°/0° instrument, the brightness of clay and pigments compacted into a plaque.

TAPPI T1213, “Optical Measurements Terminology (Related to Appearance Evaluation of Paper),” defines terms such as brightness, whiteness, color, gloss, and opacity.

TAPPI T1215, “The Determination of Instrumental Color Differences,” introduces color differences and color difference formulas.

## USP - Pharmaceuticals

U.S. Pharmacopeia (USP) monographs may be purchased through [www.usp.org](http://www.usp.org).

USP Monograph 631, “Color and Achromicity,” defines color and colorlessness, the visual observing situation, and how color should be evaluated visually.

USP Monograph 1061, “Color—Instrumental Measurement,” gives a synopsis of color measurement, provides formulas for the calculation of various color scales, and describes how to instrumentally measure the color of opaque solids and transparent liquids.

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