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WORKING GROUP
CHAIR Chris Czyryca
SUBJECT
CATEGORY Optical Properties
RELATED
METHODS See “Additional Information”

CAUTION:
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Optical measurements terminology (related to
appearance evaluation of paper)

(Five-year review of Standard Glossary T 1500 gl-18: Approval of
T 1500 Draft 2)
(Underscores, notes, and strikethroughs show changes from Draft 1)

1. Scope

1.1 This glossary defines terms used in the pulp and paper industry relating to both visual and instrumental evaluations of appearance. This technical terminology includes such optical assessments such as brightness, whiteness, color, gloss, opacity, scattering, absorption, etc.

2. Significance

2.1 This glossary of terms and definitions has been assembled by the TAPPI Optical Properties Committee. The committee has consulted definitions published by the [ASTM International, formerly known as the](#)

Approved by the Standard Specific Interest Group for this Standard Glossary
TAPPI

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American Society for Testing and Materials, Illuminating Engineering Society, International Commission on Illumination, Inter-Society Color Council, and the Optical Society of America. Many of the terms in this glossary are applicable to both radiometric and photometric quantities, but each term can be restricted to the intended quantity by adding the adjective “radiant” or “luminous,” respectively.

3. Safety precautions

There are no safety precautions required for this Standard Glossary.

4. Definitions

Abridged spectrophotometer - see *Spectrophotometer, abridged*.

Absolute brightness - the reflectance of blue light corresponding to a centroid wavelength of 457 nm in terms of the perfect reflecting diffuser. See TAPPI T 534 “Brightness of Clay and Other Mineral Pigments (Diffuse Blue Reflectance)” and TAPPI T 525 “Diffuse Brightness of Pulp.” Also, see *Perfect reflecting diffuser*.

Absolute reflectance factor - the ratio, which may also be expressed as a percentage, of the radiation reflected by a body to that reflected by the perfect reflecting diffuser under the same conditions of illumination and viewing.

Absorbance - the negative logarithm to the base 10 of the internal transmittance for a transparent material.

Absorptance - the ratio of absorbed flux to incident radiant flux.

Absorption - the process by which light or other electromagnetic radiation is converted into another form of energy such as heat when incident on or passing through material.

Absorption, coefficient of (K) - for a thin layer within an isotropic absorbing and scattering material over a black backing, the limit as the layer thickness approaches zero of the fraction of the incident radiation absorbed by the layer, divided by its thickness. Dimensions are reciprocal grammage (usually m²/kg in this case).

Absorptivity - see *Absorption, coefficient of*.

Adams coordinates - see *Opponent color scales (L,a,b)*.

Additive color mixture - see *Color mixture additive*.

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(related to appearance evaluation of paper)**

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Angle of incidence - the angle between the axis of an impinging light beam and the normal to the specimen surface.

Angle of view - angle between the axis of observation and the normal to the specimen surface.

Angstrom - see *Wavelength units*.

Beer's law - transmittance of a stable solution is the exponential function of the product of concentration (c), absorptivity (k_l), and length of path (x) in solution.

$$T = E^{ck_l x}$$

Black - color name applied to opaque objects that are highly absorbing throughout the visible spectrum.

Bleached specimen - specimen whose absorbance has been decreased by chemical or radiant means.

Blue - hue name applied to light of wavelengths from 455 to 485 nm and to visually similar stimuli.

Brightener: optical - see *Fluorescent whitening agent*.

Brightness (of paper) - reflectance of an infinitely thick stack of material (reflectivity) measured for blue light with centroid wavelength of 457 nm under specified spectral and geometric conditions of measurement [see TAPPI T 452 "Brightness of Pulp, Paper and Paperboard (Directional Reflectance at 457 nm)"].

Brightness, absolute - see *Absolute brightness*.

Brightness reversion - see *Reversion, brightness*.

Bronzy color (or bronzing) - a metallic-like color observed by viewing a surface in the general direction of specular reflection. (Hue observed in the direction of specular reflection is usually quite different from the hue observed for other directions.)

Brown - color name for perception of dark yellow or dark orange.

Candela - the SI unit of luminous intensity; luminous intensity, in the perpendicular direction, of a surface of 1/600,000 m² of a blackbody (full radiator) at the temperature of freezing platinum under a pressure of 101,325 Pa.

Centroid (wavelength) (effective wavelength) - wavelength of center of gravity of area under curve of spectral function.

Chromatic - perceived as having a hue; not white gray, or black.

Chroma, Munsell - see *Munsell chroma*.

Chromaticity - dimensions of color stimulus excluding luminous magnitude, often designated by coordinates of point in rectangular or polar coordinate system.

Chromaticity coordinates - the ratios of each tristimulus value of a color to the sum of the tristimulus values. (Chromaticity coordinates in the CIE system of color specification are designated *x*, *y*, and *z*.)

Chromaticity diagram - plane diagram formed by plotting one of the three chromaticity coordinates against another.

Chromaticity diagram, CIE - formed by plotting two CIE chromaticity coordinates, usually *x* and *y*.

CIE - abbreviation for International Commission on Illumination, which in [French](#) is [Commission Internationale de l'Eclairage](#).

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CIE coordinates - see *Chromaticity coordinates*.

*CIE $L^*a^*b^*$ (CIELAB)* - see *Opponent color scales*.

CIE observer - see *Observer, standard, CIE 1931 and Observer, supplementary, CIE 1964*.

CIE illuminant A - colorimetric illuminant, representing the full radiator at 2856K, defined by the CIE in terms of a relative spectral power distribution.

CIE illuminant C - colorimetric illuminant, representing daylight with a correlated color temperature of approximately 6800K, defined by the CIE in terms of a relative spectral power distribution.

CIE illuminant D 65 - colorimetric illuminant, representing daylight with a correlated color temperature of approximately 6500K, defined by the CIE in terms of a relative spectral power distribution.

Clarity - the characteristic of a material permitting distinct images to be observed through it (see *Transparency*).

Color, perceived - attribute of visual perception that can be described by color names, such as *white, gray, black, yellow, brown, vivid red, deep reddish purple*, or by combinations of such names.

NOTE 1: Color stimuli can under certain conditions produce identical colors, perceived, despite having spectrally different reflectance; their colorimetric specifications are then also identical (see Metameric objects).

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NOTE 2: When the meaning is clear from the context, the term *color* may be used alone.

Color, psychophysical - characteristics of a color stimulus (i.e., light producing a sensation of color) denoted by three values such as three tristimulus values.

NOTE 3: The appearance of a color depends not only on its tristimulus values but also on the conditions under which it is viewed, including the nature of the surround; however, colors having the same tristimulus values appear the same if viewed under the illuminant for which the tristimulus values were determined.

NOTE 4: Spectrally different color stimuli can have the same absolute tristimulus values.

NOTE 5: When the meaning is clear from the context, the term *color* may be used alone.

Color difference -

1. *Color difference (perceived)* - the magnitude and character of the difference between two colors, described by such terms as redder, bluer, lighter, darker, grayer, or more saturated.

2. *Color difference (computed)* - the magnitude of color difference and its components computed from tristimulus values, or chromaticity coordinates and luminance factor, by means of a specified set of color difference equations.

Color difference units - determined by weighting factors of particular color difference equations. For identification of various color-difference scales, see TAPPI T 1215 "The Determination of Instrumental Color Differences."

Color match - one color indistinguishable from another under specified illuminating and viewing conditions.

Color matching - procedure of selecting and adjusting a color mixture until all visually apparent differences are minimized between the mixture and standard.

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Color measurement - the process of deriving numbers which serve to identify a given color. Since color is

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tridimensional, a minimum of three numbers is required for a complete specification. Most widely used for color measurement are the various forms of tristimulus color specification, each of which is traceable to a visually matching mixture of three primary lights.

Color mixture, additive - superposition or other non-destructive combination of lights of different [chromaticity](#).

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Color mixture, subtractive - mixture of absorbing media or superposition of filters so that spectral composition of light passing through combination is determined by simultaneous or successive absorption.

Color notation - the systematic use of symbols or numbers to designate color.

Color of an object - the aspect of object appearance distinct from form, shape, size, position, or gloss that depends upon spectral composition of incident light, spectral reflectance or transmittance of the object, and spectral response of the observer as well as the illuminating and viewing geometry.

Color perception - subjective impressions of color, as modified by conditions of observation and by mental interpretation of stimulus object.

Color scale - series of stimuli perceived as having differences of some attribute of color sensation.

Color solid - same as *color space*.

Color space - A three-dimensional arrangement representing all possible colors with respect to their primary attributes of hue, brightness or lightness, and saturation.

Color specification - tristimulus values, chromaticity coordinates and luminance value, or other color-scale values, used to designate a color numerically in a specified color system. (Practical color specifications should include tolerances as well as target color designations.)

Color staining - discoloration of a material by unintended transfer of ingredients from contact with another material.

Color standard - objects used for making a visual or photo-electric evaluation of the color of a test material. The standard may represent physical example of numerical color specification.

Color tolerance - the permissible color difference between a sample and a specified standard color.

Colorant - substance added to an object to change the color of light reflected from, or transmitted by, an object.

Colorimeter - an instrument designed for direct measurement of color.

Colorimetric purity - see *Purity, colorimetric*.

Colorimetric specification - see *Color specification*.

Colorimetry - science of color measurement.

Complementary color - the color that when combined additively with another color produces mixture that matches the agreed-upon achromatic color.

Contrast ratio - ratio of the luminous reflectance of a specimen backed with a black material of specified reflectance to the reflectance of the same specimen backed with white material of a specified reflectance. *Contrast gloss* (see *Luster*).

Daylight, artificial - a light source whose spectral distribution of radiant flux is similar to that from natural daylight (combined light from sun and sky).

Densitometer - instrument designed for measuring optical density of a photographic negative or positive or a printed image.

Density, optical - negative logarithm to base 10 of transmittance for transparent material or the reflectance for an opaque material.

Diffuser, perfect - ideal, completely reflecting or transmitting uniform diffuser.

Diffuser, uniform - ideal surface that reflects or transmits in accordance with Lambert's Law.

Diffusion - scattering of the incident radiant flux.

Directional reflectance - see *Reflectance factor*.

Directional transmittance - see *Transmittance factor*.

Dominant wavelength - see *Wavelength, dominant*.

Energy, radiant - energy emitted, transferred, or received as radiation.

Entrance window - see *Stop, field*.

Equal-energy illuminant - see *Illuminant, equal energy*.

Excitation purity - see *Purity excitation*.

Exit window - see *Stop, field*.

Fluorescence - process by which electromagnetic radiation in one spectral region is absorbed and re-emitted at other wavelengths, usually longer.

Fluorescent whitening agent (FWA) - fluorescent dye or pigment that absorbs ultraviolet radiation and re-emits blue light, thereby effecting whiter appearance when added to yellow-white material. Same as *Optical Brightening Agent (OBA)*.

Flux – the rate of transfer of energy across a given surface.

Fractional reflectance - see *Reflectance, fractional*.

Fresnel reflector - plane boundary between two media that specularly reflects a fraction, G , of the incident flux, depending on the angle of incidence, I , and the index of refraction, n , of the more dense medium relative to the less dense according to the following equation:

$$G = \frac{I}{2} \left[\left(\frac{\cos i - \sqrt{n^2 - \sin^2(i)}}{\cos i + \sqrt{n^2 - \sin^2(i)}} \right)^2 + \left(\frac{n^2 \cos i - \sqrt{n^2 - \sin^2(i)}}{n^2 \cos i + \sqrt{n^2 - \sin^2(i)}} \right)^2 \right]$$

Geometric - relating to the geometry or spatial aspects of the illuminating and reflected (and fluorescent) rays collected for measurement.

Gloss - angular selectivity of reflectance of surface-reflected light responsible for degree to which reflected highlights or images of objects may be seen as superimposed on surface.

Gloss, contrast - see *Luster*.

Gloss, distinctness-of-image - aspect of gloss depending on sharpness of images reflected by object surface.

Gloss retention - the percentage of the original gloss retained by the specimen after aging under specified conditions, i.e., the final gloss divided by the initial gloss, multiplied by 100.

Gloss, specular - ratio of flux reflected in the direction to the incident flux for specified source and receptor apertures (usually measured relative to a standard of specified index of refraction).

Goniophotometer - instrument used to obtain a geometric distribution of the reflected or transmitted radiant flux.

Goniophotometer curve - plot of reflectance (transmittance) factor of fractional reflectance (transmittance) as a function of angle of view for a given angle of incidence, or the converse.

Gray - color name applied to achromatic stimuli of moderate relative luminance (not black or white).

Green - hue name applied to light of wavelengths from 495 to 550 nm and to visually similar stimuli.

Haze, reflection - scattering of reflected light in directions near that of specular reflection by a specimen having a glossy surface.

Haze, transmission - scattering of light within or at the surface of a nearly clear specimen which is responsible for the appearance of specimen when viewed by transmission.

Note: Haze, transmission and opacity measure nearly the same property but at the opposite ends of the scale. Haze is generally used when the transmission of light is less than 20%, although higher values may be used. See opacity.

Note: Haze, transmission, is generally used for plastic films, whereas opacity may be used for paper, film, and print.

Hemispherical optical measuring system - an optical measuring system for measuring the reflecting or transmitting properties of specimens, wherein either the specimen is uniformly irradiated from all directions within the hemisphere on one side of the specimen or the flux emanating from the specimen is evaluated uniformly for all directions within a hemisphere.

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Hue - attribute of color perception by means of which an object is judged to be red, yellow, green, blue, or intermediate between some adjacent pair of these.

Hue, Munsell - see *Munsell hue*.

Hunter L,a,b scales - opponent color scale in which L = lightness, $+a$ = redness, $-a$ = greenness, $+b$ = yellowness, $-b$ = blueness (similar to, but numerically different from Adams coordinates and CIELAB L^* , a^* , b^*).

Ideal black - object or material which absorbs all light falling on it.

ICI - International Commission on Illumination (use international abbreviation CIE).

Illuminant - a luminous flux, specified by its spectral distribution, used, in principle, to illuminate, but may be defined for computational purposes and may not correspond to a real source (see also *source*, *standard illuminant*).

Illuminant, equal energy - hypothetical illuminant whose radiant excitation per unit wavelength interval is constant for specified spectral region.

Incident flux - see *Irradiance*

Index of refraction (of a material) - ratio of sines of angles of incidence and refraction of a ray of light passing obliquely from vacuum into material.

Infinite thickness - a stack of sheets so thick that doubling the thickness does not change its reflectance.

Infrared - referring to radiant flux having wavelengths longer than the wavelengths of light, usually wavelengths from about 760 nm to about 3 μm .

Infrared fluorescence - a usually weak fluorescence in the infrared spectrum exhibited by many papers and other substances, often excited by visible light. If not allowed for in instrumental design, it can result in significant error.

Integrating sphere or cavity - hollow sphere or cavity with a highly-reflecting, highly-diffusing interior coating so that the exit port receives an integrated sample of all light entering or generated within sphere or cavity.

Integration - see *Tristimulus value computation*.

Interference filter - filter constructed of extremely thin alternate layers of material and capable of transmitting narrow spectral bands by constructive interference in the desired waveband and destructive interference at other wavelengths. (Filters of this type reflect rather than absorb the flux not transmitted.)

International Commission on Illumination - English translation of Commission Internationale de l'Eclairage, abbreviated CIE.

Irradiance - Directional or diffuse radiant flux incident upon a unit area of a surface.

ISCC-NBS color designation - two-to-four-word descriptive phrases for surface colors (such as “vivid orange” or “dark grayish reddish brown”) defined by sections of the Munsell color solid. The system was developed cooperatively by the Inter-Society Color Council and the National Bureau of Standards (see NBS Special Publication 440).

Just-perceptible difference - color difference that is just large enough to be perceived. It is quite subjective and observer dependent.

Kubelka-Munk - Kubelka-Munk theory is widely used to explain the effects of pulp properties and the addition of dyes or pigments on the reflectance and opacity of paper. This theory is based on the assumption that if the irradiance on one surface of an infinitesimal layer within the sheet is dX , then the fraction of that irradiance reflected back by the layer is SdX , and the fraction absorbed by the layer is KdX , where S is the scattering coefficient, K is the absorption coefficient, and X is the thickness of the layer. In this formulation S and K have the dimensions of reciprocal length. However, in the paper industry it is common to describe the layer thickness in terms of its grammage, dW , so the respective fractions are SdW and KdW where K and S have the dimensions of reciprocal grammage (usually m^2/kg in this case).

Lambert's law - flux emitted or reflected per unit solid angle is proportional to cosine of angle measured from normal to surface. (Defines uniform diffuser, approximated by mat surface).

Light -

1. Electromagnetic radiation in the spectral range detectable by the normal human eye (approximately 380 to 760 nm).
2. Radiant energy evaluated according to CIE photopic spectral luminous efficiency function.
3. Adjective meaning highly reflecting, as in the term light green.

Lightfastness - the ability to resist color change on exposure to light.

Lightness -

1. The attribute of color perception by which a nonself-luminous body is judged to reflect more or less light.
2. The attribute by which a perceived color is judged to be equivalent to one of a series of grays ranging from black to white.

Linear filter - an optical filter whose transmittance varies linearly with wavelength over a spectral range of interest (see material on standardization techniques developed at IPC: in Wendlandt's *Modern Aspects of Reflectance Spectroscopy*, p. 132-42, New York, Plenum Press, 1968).

Lovibond tintometer - an instrument for evaluating the color of materials by visual comparison with colors of glasses of Lovibond system.

Lumen - units of luminous flux, defined as flux emitted through unit solid angle (one steradian) from directionally uniform point source of one candela.

Luminance - luminous flux in a beam, emanating from a surface, or falling on a surface, in a given direction, per unit of projected area of the surface as viewed from that direction, per unit solid angle.

Luminance (reflectance or transmittance) factor - the luminance of a specimen when illuminated and viewed under specified geometric conditions divided by the luminance of a perfect diffuse ideal white under the same conditions. When reflection is involved, *luminance factor* and *reflectance factor* are synonymous.

Luminous - an adjective indicating that the radiant flux is evaluated by weighting according to the luminous efficiency function of the CIE 1931 standard observer.

Luminous flux - see *Luminance*

Luminous reflectance - see *Reflectance, luminous*.

Luminous transmittance - see *Transmittance, luminous*.

Luster - the appearance characteristic of a specimen resulting from pronounced changes in the amount of light reflected from elemental areas of the specimen when the angle of illumination or viewing is changed.

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Macadam unit - see *Color difference units*.

Mass color - color, when viewed by reflected light, of a mixture of colored pigment and vehicle without light-scattering diluent, and of such thickness as to obscure background completely.

Match - appearance of visual identity.

Mat - lusterless surface, uniform surface lacking gloss.

Memory color - color of an object that, according to the judgment of the observer, would match the color of another object previously seen by that person.

Metameric objects - objects having different spectrophotometric curves that nevertheless match when illuminated with light of one particular spectral composition and viewed by one particular observer.

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Metamers - specimens differing in spectral reflectance but having colors that match in a light source of one spectral composition, when viewed by one observer, but may not match in a light source of other spectral compositions or when viewed by another observer.

Micrometer - see *Wavelength units*.

Millimicron - obsolete wavelength unit. Nanometer is now preferred. See *Wavelength units*.

Minus-blue - a yellow substance that absorbs principally blue light.

Minus-green - a magenta substance that absorbs principally green light.

Minus-red - a blue-green substance that absorbs principally red light.

Modes of appearance - various manners in which colors can be perceived:

Object mode - the color is ascribed to an object.

Illuminant mode - the color is ascribed to a light source.

Aperture mode - the color appears through an aperture which prevents its association with a specific object.

Monochromator - dispersive device for providing a narrow portion of the spectrum, usually continuously variable.

Mottle - visual non-uniformity of a sheet usually caused by agglomerations of fiber or by non-uniform application of coatings.

Munsell chroma - the departure of a color from gray having the same Munsell value, expressed on a scale extending from zero, by steps of approximately equal visual importance, to a maximum of about 20.

Munsell color system - a system for color specification of surfaces illuminated by daylight and viewed by an observer adapted to daylight. The System yields approximations to scales of variables of hue, saturation, and lightness, with uniform perceptual spacing. In this system these scales are designated hue, chroma, and value, respectively. (See Fig. 1, from Hunter, *The Measurement of Appearance*, Wiley, New York, 1975.)

Munsell hue - the attribute of a specimen, in Munsell terms, which correlates with the perceived hue of a specimen.

Munsell notation -

1. The Munsell hue, value, and chroma assigned to the color of a specimen by visually comparing the specimen to the chips in the *Munsell Book of Color*.
2. A notation in the Munsell color system, derived from daylight luminous reflectance factor Y and chromaticity coordinates x and y , in the CIE system, by the use of scales defined by the Optical Society of America Subcommittee on the Spacing of the Munsell Colors (previously termed "Munsell renotation").

Munsell scales - scales of attributes of color defined and illustrated by Munsell color standards.

Munsell value - an attribute of color used in the Munsell color system to indicate the lightness of a specimen viewed in daylight on a scale extending from 0 for ideal black to 10 for the perfect diffuser, in steps that are visually approximately equal in magnitude.

NBS unit of color difference - National bureau of Standards, unit of color difference; see *Color difference units*.

Nanometer - see *Wavelength units*.

Neutral - hueless or achromatic color.

Observer, standard, CIE 1931 - hypothetical observer based on color mixture data obtained for 2° field of view adopted by CIE in 1931.

Observer, supplementary, CIE 1964 - hypothetical observer based on color mixture data obtained for 10° field of view adopted by CIE in 1964.

Opacity - degree of obstruction to transmission of light. (Property of paper sheet which restricts transmission of images from one side to the other.)

Opacity (89% reflectance backing) - sometimes called contrast ratio, $C_{0.89}=100 (Y_B/Y_W)$. Accordingly, the contrast ratio is 100% for perfectly opaque paper and is only a few percent for a perfectly transparent sheet [see TAPPI T 425 “Opacity of Paper (15°/Diffuse Illuminant A, 89% reflectance Backing)”].

Opacity (paper backing) - sometimes called “printing opacity,” Y_0/Y_∞ is defined as the ratio of the light reflected by a paper specimen when the specimen is backed by a perfectly black body, Y_0 , to that when the specimen is backed by a thick stack of the same kind of paper Y_∞ for illuminant C, 2° observer. [See T 519].

Opponent colors scales (L,a,b) - symbols L,a,b are used to designate measured values of three attributes of surface-color appearance as follows:

- L represents lightness, increasing from zero for black to 100 for a perfect white.
- a represents redness when positive, greenness when negative, and zero for gray.
- b represents yellowness when positive, blueness when negative and zero for gray (see TAPPI T 524 “Color of White and Near-White Paper and paperboard by L,a,b 45° 0° Colorimetry”).

NOTE 6: The concept of opponent colors was proposed by Hering in 1878. Starting in the 1940s, a number of measurable L,a,b dimensions have been defined by equations relating them to the basic CIE XYZ tristimulus quantities defined in CIE Document No. 15. Measured values for a given color will depend on color space in which they are expressed.

Optical Brightening Agent (OBA) - fluorescent dye or pigment that absorbs ultraviolet radiation and reradiates blue light, thereby effecting a whiter appearance when added to yellow-white material.

Orange peel - uneven glossy surface resembling that of an orange skin.

Ostwald color system - a system of surface color specification based upon a color match with theoretical

variables of hue, white content, and black content.

Perfect diffuse reflector - ideal uniform diffuser with zero absorptance and zero transmittance.

Perfect diffuse transmitter - imaginary ideal uniform diffuser with zero absorptance and zero reflectance (unattainable in practice since any diffuse material that transmits light must also reflect some light).

Photodetector or photocell - device which converts light signals into electrical signals.

Photoelectric colorimeter - color-stimulus-measuring instrument using photoelectric detectors in which source-filter-detector response characteristics are adjusted so that the instrument reads directly the tristimulus values or related quantities.

Photoelectric spectrophotometer - spectrophotometer employing a photoelectric detector for measurement.

Preferred white - the white color, usually bluish, which is judged by a given group of observers looking at a given series of specimens to be the shade most liked for those specimens.

Primary color stimuli, additive - any three-color stimuli used to specify amounts required to match unknown stimulus. (Any three color stimuli may serve as primaries provided not one of them can be matched by additive mixture of other two. The most common choice of additive primary color stimuli to achieve maximum color gamut are those having red, green, and blue colors.)

Primaries, CIE - the additive primary color stimuli of the CIE system of colorimetry (they are imaginary, not physically realizable).

Primary colorants, subtractive - colorants (dyes or pigments) which, when mixed, produce a large variety of color stimuli (most common subtractive colorants are those having yellow, magenta, and cyan colors) (see *Minus...*).

Purity - generic term implying either excitation or colorimetric purity, usually excitation purity.

Purity, colorimetric - ratio of luminance of spectrally pure light that is mixed with reference achromatic (white) light to produce a color match for specimen light to the luminance of specimen light.

Purity, excitation - ratio of the distance on the CIE chromaticity diagram between achromatic point and specimen point to the distance along a straight line from the achromatic point through the specimen-light point to the spectrum locus.

Purple - color name applied to light composed of a mixture of red and blue and to visually similar colors.

Red - hue name applied to light of wavelengths greater than about 620 nm and to visually similar stimuli.

Reflectance (reflectance, hemispherical) - ratio of reflected flux to incident flux. Practical definition requires that the basic term be modified by adjectives to indicate spectral and geometric weighting of incident and reflected radiation.

Reflectance, apparent - obsolete term; use *Luminance (reflectance) factor*.

Reflectance, directional - obsolete term: use *Reflectance factor* or *Luminance factor*.

Reflectance factor - the ratio, for the same spectral conditions and geometry of illuminating and viewing, of the flux reflected from the specimen to that from an ideal diffuser having an absolute reflectance of unity (see T 442).

R_0 - the reflectance factor of a single sheet backed by a black body (see T 442).

R_∞ - the reflectance factor of a single sheet backed by a pad of sheets from the same sample and of such thickness that when the number of backing sheets is doubled, there is not detectable change in the indicated reflectance (see T 442).

Reflectance, fractional - ratio of flux reflected from specimen in a specified solid angle and direction to that incident on the specimen.

Reflectance, luminous - ratio of luminous flux reflected by specimen to that incident on it.

Reflectance, specular - ratio of flux reflected without diffusion to incident flux. (Reflectance of a surface for image-forming rays only.) See *Gloss, specular*.

Reflection - processes by which incident flux leaves a surface or medium from the incident side.

Reflection, diffuse - process by which incident flux is distributed by reflection over wide range of angles.

Reflectivity - reflectance of a material so thick that an increase in thickness does not alter the reflectance. (Practical test for adequacy of thickness is made by observing no measurable change in reflectance with the black backing when thickness is doubled.)

Reflectometry - technique for measurement of reflectance or reflectance factor.

Refraction - the deflection of radiant flux from a straight path in passing from a region of one index of refraction to another region with a different index.

Refractive index - see *Index of refraction*.

Regular - adjective used to indicate flux transmitted or reflected without diffusion (the adjective *specular* is usually used to indicate regular mirror-reflected flux).

Reversion, brightness - reduction in brightness due to degradation of pulp or paper over some period of time.

Saturation - quality of color sensation by which an observer is aware of the degree of difference from gray.

Scattering - process by which light passing through matter is redirected.

Scattering, coefficient of (S) - for a thin layer within an isotropic absorbing and scattering material over a black backing, the limit as the layer thickness approaches zero of the fraction of the incident radiation scattered (reflected) by the layer, divided by its thickness. Dimensions are reciprocal grammage (usually m^2/kg in this case).

Selected ordinate method - see *Tristimulus value computation*.

Shade - lightness difference between surface colors whose other attributes are essentially the same. (Shade is derived from shadow and so should theoretically apply only to change toward darker color; in practice, reference is made to lighter as well as darker shades.)

Shade sorting - to examine similar specimens and separate them into groups of essentially identical color.

Sheen - specular gloss at a large angle of incidence for an otherwise mat specimen (usual angle of measurement is 85°).

Snell's law - ratio of sines of angles of incidence and refraction is the reciprocal of the ratio of refractive indices of initial and final media.

Source - that which furnishes light or other radiation; real device by which radiant flux is produced (see *Illuminant*).

Source, equal energy - see *Illuminant, equal energy*.

Source, CIE standard - see *Standard source*.

Specification of color - see *Color specification*.

Spectral - adjective used to indicate either a *function of wavelength* as in spectral transmittance, or spectral reflectance.

Spectral power distribution – specification of an illuminant by the spectral composition of a radiometric quantity, such as radiance or radiant flux, as a function of wavelength.

Spectral sensitivity - reciprocal of spectral energy necessary to produce response of unit magnitude.

Spectrophotometer - instrument for measuring spectral radiance, reflectance, transmittance, fluorescence, or phosphorescence.

Spectrophotometer, abridged - photometer for measuring spectral reflectance or transmittance at a limited number of preselected wavelengths, usually by using narrow-band filters or a combination of a grating and diode array for spectrum separation.

Spectrophotometric curve - graph of reflectance or transmittance as a function of wavelength.

Spectrophotometry - measurement of reflectance or transmittance as a function of wavelength using a spectrophotometer.

Spectroradiometer - an instrument for measuring spectral distribution of irradiance.

Spectroscope - an instrument in which the spectrum is formed for direct visual examination.

Spectrum - a plot of a spectral property i.e. reflectance, transmission, etc., against some measure of photon energy i.e. wavelength or wavenumber.

Spectrum color - color found in spectrum of light.

Spectrum locus - curve connecting points in chromaticity diagram that represent chromaticities of lights of various wavelengths.

Specular - same as Regular when applied to reflection.

Specular angle - angle of regular reflection, which is equal and opposite to angle of incidence.

Specular gloss - see *Gloss, specular*.

Standard illuminant - a luminous flux, specified by its spectral distribution, meeting specifications adopted by a standardizing organization. (See, for example, *CIE standard illuminant A*, *CIE standard illuminant C*, *CIE standard illuminant D₆₅*.)

Standard, instrument - physical standard calibrated for use with a particular instrument, usually not suitable for use with an instrument of a different type.

Standard, laboratory - physical standard to which calibration of a group of instruments is referred.

Standard observer - see *Observer, standard*.

Standard, primary - standard whose calibration is determined by measurement according to specified parameters.

Standard, reference - standard to which calibration of a group of laboratory standards is related.

Standard, secondary - standard calibrated by reference to another standard such as a primary, reference, or a laboratory standard.

Standard source - a source of radiant flux meeting specifications adopted by a standardizing organization. (See also *CIE standard source C*.)

Standard, working - Same as *Standard, instrument*.

Steradian - unit of solid angular measure; solid angle subtended at the center of a sphere by a portion of the surface whose area is the square of the radius.

Stop - any window or diaphragm which restricts passage of light rays in an optical device.

Stop, aperture - diaphragm used to control the amount and direction of light passing through an optical system.

Stop, field - window or diaphragm used to restrict the angular subtense of a source or receptor.

Strength, Dyer's - that color quality, an increase in which is normally associated with an increase in the quantity of dyestuff present, all other conditions remaining constant.

Subtractive color mixture - see *Color mixture, subtractive*.

Surface mode of appearance - see *Modes of appearance*.

Surround - portion of the visual field immediately surrounding the central field or pattern of interest.

Texture - structural quality of a surface determined by the topography of its elements.

Tint - color produced by a mixture of white in a predominating amount with the coloring material (tint of color is, therefore, much lighter and much less saturated than coloring material).

Tinting strength - index of effectiveness with which a chromatic pigment imparts color to a standard white pigment.

Total reflectance - see *Reflectance, hemispherical*.

Total transmittance - see *Transmittance, hemispherical*.

Translucency - property of a material by which the major portion of transmitted flux undergoes scattering.

Translucency error - instrumental error owing to the fact that the areas of illuminating and viewing of a specimen are not of infinite size; the effect may be negligible in measuring the reflectance factor of materials having very high scattering coefficient, but can be very appreciable in measurements of paper and other substances having a low scattering coefficient.

Translucent - allowing passage of light but not clear view of an object.

Transmission - process by which radiant flux is transmitted through an object.

Transmissivity - internal transmittance for unit thickness of nondiffusing substance.

Transmittance - ratio of transmitted to incident flux (practical definition requires basic term to be modified by adjectives to indicate spectral and geometric weighting of incident and transmitted flux).

Transmittance, internal - ratio of flux reaching the exit surface of object to the flux penetrating the entry surface.

Transmittance, diffuse - ratio of flux transmitted in all forward directions except that of regularly transmitted beam to the incident flux.

Transmittance factor - ratio of the luminous flux transmitted in the directions specified to that transmitted in the same directions by a perfect transmitting diffuser identically illuminated.

Transmittance, hemispherical - ratio of the radiant flux transmitted in all directions to the incident flux.

Transmittance, luminous - ratio of the luminous flux transmitted by object to the incident luminous flux.

Transmittancy - ratio of the transmittance of a solution to that of a solvent in equivalent thickness.

Transparency - that property of a material by which a negligible portion of the light rays undergo scattering and through which details of objects can be distinctly seen.

Transparency ratio - ratio of regular transmittance to hemispherical transmittance (usually expressed as a percentage).

Transparent values - amount of three specified light stimuli required to match a color by additive mixture. (X, Y, Z in CIE system).

Tristimulus value computation, selected-ordinate method - numerical integration using unequal intervals of integration variable so as to eliminate multiplications in determination of contribution of each interval. Addition of values of spectral reflectance (transmittance) at wavelengths so selected as to make the product of spectral concentration of source irradiance by each spectral tristimulus value and by wavelength interval a constant.

Tristimulus value computation, weighted ordinate method - multiplication, at equal wavelength intervals, of values of spectral reflectance (or transmittance) by weighting factors that are products of spectral concentration of source irradiance and spectral tristimulus values, followed by addition of these products.

Tristimulus values of spectrum of unit irradiance per unit wavelength (x,y,z) - functions of wavelength which serve to define X,Y,Z scales in CIE system.

Turbidity - loss of transparency due to diffusion of light (normally applied to liquids in which diffusion is due to the presence of particulate matter).

Ultraviolet - invisible region of the spectrum lying between wavelengths of about 10 and 400 nm.

Uniform chromaticity - scale diagram - chromaticity diagram on which all pairs of just-noticeably different colors of equal luminance are represented by pairs of points separated by nearly equal distances.

Uniform color solid - schematic arrangement of colors in space in which spatial intervals between points correspond to visual differences between colors represented by those points.

Uniform diffuser - see *Diffuser, uniform*.

Value - see *Munsell value*.

Viewing conditions - the conditions under which a visual observation is made, including the angular subtense of the specimen at the eye: the geometric relationship of source, specimen, and eye: the photometric and spectral character of the field of view surrounding the specimen: and the state of adaptation of the eye.

Wavelength - distance from a point on one wave to the corresponding point on the next wave (wavelengths of visible light extend from about 380 to 760 nm).

WAVELENGTH UNITS:

Name	Symbol	Length, m	Remarks
Nanometer	nm	10^{-9}	Recommended for visible
Micrometer	μm	10^{-6}	Recommended for infrared
Angstrom	Å	10^{-10}	Use discouraged
Millimicron	m μ	10^{-9}	Use discouraged
Micron	μ	10^{-6}	Use discouraged

Wavelength, complementary (of an illuminate object) - wavelength of spectrally pure energy that when mixed with the color of an object in suitable proportions will match the illuminant.

Wavelength, dominant (of an illuminated object) - wavelength of spectrally pure energy that when mixed with an illuminant in suitable proportions will match the color of the specimen.

Weber's law - just noticeable increment of stimulus is constant fraction of stimulus.

Weighted-ordinate method - see *Tristimulus value computation*.

White - color name most usually applied to opaque, highly reflecting, highly diffusing, visually hueless specimens.

Whiteness - attribute of color perception by which an object color is judged to approach the preferred white.

Whiteness index - a number, computed by a given procedure from colorimetric data, that indicates the degree of departure of an object color from a preferred white.

Yellow - hue name applied to light of wavelengths from 572 to 583 nm and to visually similar stimuli.

Yellowness - attribute by which an object color is judged to depart from the preferred white toward yellow.

5. Keywords

Optical measurement, Nomenclature, Terminology

6. Additional information

6.1 Effective date of issue: To Be Assigned.

6.2 This standard glossary formerly was TIP 0804-02 and was revised in 1998 to become Standard Practice T 1213. It was revised in 2008 as a Standard Glossary with a new number, T 1500. The 2012 revision corrected the subscript on the term R_z .

[6.3 The 2024 revision of the T 1500 gl-18 standard made editorial corrections and technical changes to the definitions of Haze.](#)

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.

