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Light sources for evaluating papers including those containing fluorescent whitening agents

1. Scope

1.1 This standard practice covers the significance and application of both instrumental and visual light sources for evaluating papers and related materials including those containing fluorescent whitening agents. The information presented is based on accepted or current proposals of the Inter Society Color Council (ISCC), Commission Internationale d'Eclairage (CIE), International Standards Organization (ISO), American National Standards Institute (ANSI), TAPPI, and TAPPI Optical Properties Committee experience. Also presented is a method for the visual evaluation of a color match under standard conditions of illumination.

2. Significance

2.1 Light sources are commonly described by their color temperature.

2.2 Common tungsten filament lamp color temperature is a very close approximation to the black body color temperature. These sources have a smooth and continuous spectral energy distribution. Non-black body light sources are described by their correlated color temperature which is the color temperature of a black body which they most closely resemble. Such sources are, for example, arc lamps whose spectral energy distributions are not continuous, but rather have concentrated energy in a few very narrow wavelength regions, or fluorescent lamps which do have continuous spectrums but superimposed with a few narrow wavelength regions of concentrated energy. In all cases, the spectral energy distribution for a light source at a given color temperature is defined in the visible portion only and does not include the amount or distribution of energy in the ultraviolet (UV) which excites fluorescent whitening or brightening agents. For these reasons, the description of a light source or an illuminant by giving the color temperature or correlated color temperature alone is not entirely satisfactory.

2.3 When viewing papers or related materials containing fluorescent whitening or brightening agents, the illumination must have a suitable form, must be continuous (not have significant energy located in a few spectral lines only), and must contain a sufficient amount of UV radiation to excite the fluorescent agent. The visual appearance of paper containing such an agent will depend on the relative amount of UV energy present in the illumination.

2.4 If only the presence of a fluorescent whitening agent in a material needs to be determined, then a light source rich in ultraviolet energy with only a very small amount of visible light should be used. A mercury lamp such as Ultraviolet Products Black-Ray UVL-21 which operates on 115 V ac is suitable for this purpose. When a sample is

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viewed in the dark under such illumination, spot fluorescent contaminants can be distinguished from a uniform overall application of a fluorescent material.

3. Definitions

3.1 Definitions of technical terminology used in this standard practice may be found in TAPPI T 1213 "Optical Measurements Terminology (related to appearance evaluation of paper)."

4. Index of light sources

4.1 Table 1 is an index of light sources referred to in this document.

4.2 Specific light sources and illuminants

The applicable light sources are described by their approximate correlated color temperatures as follows:

4.2.1 2300-2854 K

4.2.1.1 The color of off-white papers may vary with the quality of the illuminant. To evaluate this effect, the specimen is viewed alternately under sources of low and high temperatures. Two low temperature illuminants have been in common use. One has a color temperature of 2300 K and is known as horizon light; the other is CIE Illuminant A which has a color temperature of 2854 K.

Table 1. Index of light sources.

<i>Correlated color temperature, K</i>	<i>Name of lamp</i>	<i>Manufacturer</i>	<i>Section</i>
(UV only)	-----	Ultra-violet Products	4.2.1
2300-2854	Tungsten filament	G. E. Sylvania, etc.	4.2.1
3000	ANSI Code CPR	G. E. PH/18AT 10P-6V	4.2.2
3000	No. 38 02 07	Carl Zeiss, Inc.	4.2.2
2800-3400	Tungsten-halogen	G. E. and Sylvania	4.2.2
3800	Avlite	GretagMacbeth	4.2.3
3800	Colorarc	Sylvania	4.2.3
4000-4200	Deluxe cool white fluorescent	Sylvania	4.2.4
5000	Macbeth 5000 fluorescent lamps in Proofite D ₅₀₀₀ System	GretagMacbeth	4.2.6
5000	Metalarc	Sylvania	4.2.6
5900	IXBO Xenon Arc	Osram	4.2.6
6000	Xenon Lamp in Elrepho Photometer	Zeiss	4.2.6
6500	Norlite D ₆₅₀₀ Illumination systems	GretagMacbeth	4.2.7
6500	Osram Xenon XBF + filter	Osram	4.2.7
6500	Xenon lamp + filter in DMC 25 Spectrophotometer	Zeiss	4.2.7
6770	Illuminant C	-----	4.2.8
North Sky 7400	Macbeth Skylight Illumination System	GretagMacbeth	4.2.9
North Sky 7500	Macbeth Skylight Illumination System	GretagMacbeth	4.2.9
7500	Macbeth 7500 Fluorescent Lamps in Norlite D ₇₅₀₀ System	GretagMacbeth	4.2.9

4.2.1.2 Two committees have adopted incandescent light at 2300 K (in conjunction with standard fluorescent light of 4400 K) as a standard for the detection of metamerism by visual viewing. ISCC Subcommittee for Problem 21 is proposing 2300 ± 100 K with a Color Rendering Index (CIE R) = 92-100 in the Standard Practices for Visual Examination of Small Color Differences. ASTM Committee D-1 for the revision of D-1729-64 has also selected 2300 K with CIE R_a = 92-100 for Visual evaluation of Color Differences of Opaque Materials.

4.2.1.3 ASTM D-1729-60t specified a light source of 2854 K with tolerances of ± 100 K for an AA match or ± 75 K for an AAA match. In this method, the 2854 K source is augmented with a higher color temperature source, 7500 K and 7400 K respectively, for determining if a metameric match has been made.

4.2.1.4 The CIE official recommendations on colorimetry states that CIE Illuminant A represents the Planckian radiator (black body) at 2854 K and gives relative spectral power distribution from 380 to 780 nm. It is a standard source for instrumental determinations as well as visual viewing. Sources for 2300 K and 2854 K are calibrated gas-filled

tungsten filament lamps operated at the proper conditions to give the specified color temperature.

4.2.2 3000 K

4.2.2.1 An incandescent source is used for most instrumental colorimetric work. The highest available color temperature is used in order to obtain the maximum available ultraviolet energy.

4.2.2.2 The relative spectral energy distributions of several nominal 3000 K sources used in instrumental work for the light incident on the specimen are shown in Fig. 1. The curves have been normalized to be equal to 100 at 500 nm. Many Technidyne brightness and color testers use a quartz tungsten halogen (QTH) lamp, but with a heat absorbing filter. Many Hunter Color-Difference Meters likewise use a QTH lamp, a 6.9 mm (0.27 in.) thick Pittsburgh Plate Glass 2043 heat absorbing filter, and silicate-coated aluminum mirror which further reduces the relative amount of radiation above 600 nm. All of these sources provide essentially the same spectral energy distribution incident upon the specimen from 320 to 500 nm, but beyond this it varies as shown in Fig. 1.

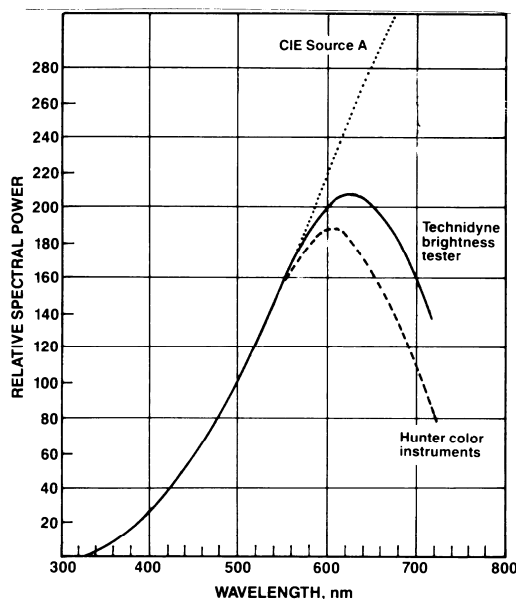


Fig. 1. Relative spectral energy distributions.

4.2.2.3 Quartz tungsten halogen (QTH) lamps contain a tungsten filament and halogen in a fused quartz envelope. In the higher wattages, they can be operated at color temperatures as high as 3400 K and consequently emit slightly more ultraviolet radiation than standard glass envelope incandescent lamps, particularly since the quartz envelope will pass radiation down to 250 nm. The principal advantage of tungsten-halogen lamps is that the halogen combines with evaporated tungsten (vapor) and prevents it from being deposited on the inside of the lamp envelope, thereby eliminating blackening. This keeps the lamp clean, greatly increases its efficiency, and reduces changes in the intensity and spectral distribution of the radiation due to bulb blackening, thus permitting the use of the lamp until it burns out.

4.2.3 3800 K

4.2.3.1 This color temperature is used for visual viewing only. ANSI PH 2.23-1961, "American Standard Lighting Conditions for Viewing Photographic Color Prints and Transparencies," presently specifies 3800 K.

4.2.3.2 Two light sources which approach the 3800 K source are the Macbeth Avlite and Sylvania Colorarc. The Avlite is a bipin fluorescent lamp available in several wattages. The Colorarc is a mogul screw base iodide arc lamp available in several wattages.

4.2.4 4000 to 4200 K

The fluorescent lamps used in many color laboratories, office areas, and commercial establishments selected as a close quality match to natural daylight are the deluxe cool white lamps. The color rendering index for most manufacturer's lamps for a correlated color temperature of 4000 to 4200 K is approximately 86.

4.2.5 4400 K

The ISCC selected a color temperature of 4400 K for their standard fluorescent illumination in conjunction with 2854 K for detection of metamerism. See material included under light source 2300-2854 K for specific references to methods.