WI 240804.01

T 515

BALLOT NO. 02 - SARG

DRAFT NO. 01

DATE October 22, 2024

WORKING GROUP CHAIR N/A

SUBJECT CATEGORY Optical Properties

RELATED METHODS See "Additional Information"

CAUTION:
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Visual Grading and Color Matching of Paper

(Five-year review of Official Method T 515 om-20)

1. Scope

1.1 This method describes the spectral, photometric, and geometric characteristics of a light source, the illuminating and viewing conditions, and the procedures to be used for the visual evaluation of color differences of paper, including those containing fluorescent whitening agents.

1.2 This method specifies light sources which are selected to accomplish three objectives: (a) simulation of the actual and illuminating conditions of ultimate use, (b) employment of two light sources which are spectrally very different in order to exaggerate observable differences between sample and standard if any difference exists, and (c) employment of a UV radiator to detect the presence of fluorescent whitening agents (FWA) and assess their impact on final appearance.

1.3 This method is applicable when the testers have normal color vision.

2. Significance

2.1 In order to achieve the best possible agreement between customer and supplier on visual color matches, the same set of illuminating and viewing conditions must be employed by both customer and supplier. For example, if the customer will be using the paper in a typical office which is illuminated by cool white fluorescent (CWF) lighting, then the paper supplier should also use CWF as the light source for the visual assessment of the product. If the paper being evaluated contains optical brightening agents which fluoresce when excited by ultraviolet light, it is very important that the customer's light source be matched in the ultraviolet region as well as the visible region of the spectrum. Many observation booths are equipped with a UV light which may be added to any illuminant. Since its intensity is not calibrated, it does not match any standard illuminant distribution but by adding UV light, the trained eye can assess the influence of the fluorescence and its impact on the final color.

2.2 In many instances, colored paper products may be used and viewed in a wide variety of light sources. It is recommended that such papers be visually color matched under two light sources which are spectrally quite different such as A and D65 or A and CWF. Doing so will exaggerate any color differences which may exist. This added discrimination capability allows one to better judge between closely matched specimens.

3. Apparatus

3.1 *Light source.* The light source is defined by the spectral distribution of the light energy incident on the specimen. This spectral power distribution results from a combination of the background, surround and the lamp or lamps employed.

3.1.1 *Spectral power distribution.* Table 1 contains the relative power distribution for the four standard illuminants which are most commonly used in the paper industry, viz, A, C, D65 and F2 (*1, 2, 3*). Standard Illuminant F2 is commonly known as cool white fluorescent (CWF) illumination. It is not possible to exactly duplicate the spectral power distribution of Standard Illuminant D65 in a physically realizable light source. Therefore, it must be understood that any physical D65 light source is an approximation of the actual D65 data shown in Table 1. Light used in observation booths is generally not standardized in the UV region; therefore, assessment of FWA containing papers will provide only an approximation of proper fluorescence excitation.

3.1.2 *Photometric conditions.* For the general evaluation of papers of medium lightness, the illumination at the center of the viewed area is to be 807-1884 lumens/m^2 (75-175 footcandles), but for critical evaluation of such papers it is to be 1076-1345 lumens/m^2 (100-125 footcandles).

NOTE 1: For the evaluation of very light papers, the illumination may be reduced to as low as 538 lumens/m^2 (50 footcandles), and for very dark papers it may be increased to as high as 2153 lumens/m^2 (200 footcandles).

3.1.3 *Geometric conditions.* The specimen is to be illuminated from an overhead extended-area source. The illumination over the viewing area should be diffuse and uniform to within 20%, and abrupt changes in illumination level are not to be visible.

3.1.4 *Background and surround.* The viewing area is to be shielded from extraneous light, preferably by a permanent structure. The background should be matte gray with a maximum reflectance of 65.0% and a minimum reflectance of 50.0% measured at an effective wavelength of 557nm.

3.2 *Illumination meter*[1], suitable for measuring the illumination of the viewing area with a minimum scale of 538-2153 lumens/m^2 (50-200 footcandles).

3.3 Both the specimen and reference papers should be in the form of an opaque pad. The pad should generally be at least 150 × 250 mm (6 × 10 in.) in size and thick enough to be opaque.

4. Sampling and test specimens

Obtain the sample in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product." Select specimens at least 150 × 250 mm (6 × 10 in.) in size, uniform in color and gloss, free from imperfections in surface texture, and free from fingerprints and other blemishes. Curl, cockle or large differences in smoothness may affect the evaluation.

5. Procedure

[1]Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.

5.1 Ensure no foreign material is in the viewing area when color comparisons are being made. Cover half of the top area of the reference pad with a specimen and place both at the distance from the light source needed to obtain the required illumination. The orientation (MD vs. CD, felt side vs. wire side) will be consistent for each specimen and evaluation. Use the illumination meter to determine the proper distance. Avoid any perceptible specular (gloss) reflection of the light source by the specimen. If the source is directly overhead (preferred), place the specimen and pad horizontally and view them at an approximate angle of 45° from the perpendicular. Interchange the positions of the specimen and the reference pad and reevaluate the difference. It is usually desirable to match the specimens under multiple sources as indicated in section 1.2, 2.1 and 2.2.

Table 1. Relative Spectral Power Distributions of CIE Standard Illuminants A, C, D65 and F2.

λ (nm)	*A*	*C*	*D65*	*F2*
300	0.93		0.03	
305	1.13		1.70	
310	1.36		3.30	
315	1.62		11.80	
320	1.93	0.01	20.20	
325	2.27	0.20	28.60	
330	2.66	0.40	37.10	
335	3.10	1.55	38.50	
340	3.59	2.70	39.90	
345	4.14	4.85	42.40	
350	4.74	7.00	44.90	
355	5.41	9.55	45.80	
360	6.14	12.90	46.60	
365	6.95	17.20	49.40	
370	7.82	21.40	52.10	
375	8.77	27.50	51.00	
380	9.80	33.00	49.98	1.18
385	10.90	39.92	52.31	1.48
390	12.09	47.40	54.65	1.84
395	13.35	55.17	68.70	2.15
400	14.71	63.30	82.75	3.44
405	16.15	71.81	87.12	15.69
410	17.68	80.60	91.49	3.85
415	19.29	89.53	92.46	3.74
420	20.99	98.10	93.43	4.19
425	22.79	105.80	90.06	4.62
430	24.67	112.40	86.68	5.06
435	26.64	117.75	95.77	34.98
440	28.70	121.50	104.86	11.81
445	30.85	123.45	110.94	6.27
450	33.09	124.00	117.01	6.63
455	35.41	123.60	117.41	6.93
460	37.81	123.10	117.81	7.19
465	40.30	123.30	116.34	7.40
470	42.87	123.80	114.86	7.54
475	45.52	124.09	115.39	7.62
480	48.24	123.90	115.92	7.65
485	51.04	122.92	112.37	7.62
490	53.91	120.70	108.81	7.62
495	56.85	116.90	109.08	7.45
500	59.86	112.10	109.35	7.28
505	62.93	106.98	108.58	7.15
510	66.06	102.30	107.80	7.05
515	69.25	98.81	106.30	7.04
520	72.50	96.90	104.79	7.16
525	75.79	96.78	106.24	7.47
530	79.13	98.00	107.69	8.04
535	82.52	99.94	106.05	8.88
540	85.95	102.10	104.41	10.01
545	89.41	103.95	104.23	24.88
550	92.91	105.20	104.05	16.64
555	96.44	105.67	102.02	14.59
560	100.00	105.30	100.00	16.16
565	103.58	104.11	98.17	17.56
570	107.18	102.30	96.33	18.62
575	110.80	100.15	96.06	21.47
580	114.44	97.80	95.79	22.79
585	118.08	95.43	92.24	19.29
590	121.73	93.20	88.69	18.66
595	125.39	91.22	89.35	17.73

Table continued next page

λ (nm)	*A*	*C*	*D65*	*F2*
600	129.04	89.70	90.01	16.54
605	132.70	88.83	89.80	15.21
610	136.35	88.40	89.60	13.80
615	139.99	88.19	88.65	12.36
620	143.62	88.10	87.70	10.95
625	147.24	88.06	85.49	9.65
630	150.84	88.00	83.29	8.40
635	154.42	87.86	83.49	7.32
640	157.98	87.80	83.70	6.31
645	161.52	87.99	81.86	5.43
650	165.03	88.20	80.03	4.68
655	168.51	88.20	80.12	4.02
660	171.96	87.90	80.21	3.45
665	175.38	87.22	81.28	2.96
670	178.77	86.30	82.28	2.55
675	182.12	85.30	80.28	2.19
680	185.43	84.00	78.28	1.89
685	188.70	82.21	74.00	1.64
690	191.93	80.20	69.72	1.53
695	195.12	78.24	70.67	1.27
700	198.26	76.30	71.61	1.10
705	201.36	74.36	72.98	0.99
710	204.41	72.40	74.35	0.88
715	207.41	70.40	67.98	0.76
720	210.36	68.30	61.60	0.68
725	213.27	66.30	65.74	0.61
730	216.12	64.40	69.89	0.56
735	218.92	62.80	72.49	0.54
740	221.67	61.50	75.09	0.51
745	224.36	60.20	69.34	0.47
750	227.00	59.20	63.59	0.47
755	229.59	58.50	55.01	0.43
760	232.12	58.10	46.42	0.46
765	234.59	58.00	56.61	0.47
770	237.01	58.20	66.81	0.40
775	239.37	58.50	65.09	0.33
780	241.68	59.10	63.38	0.27

5.2 Observe the degree of color difference between each specimen and the reference pad in terms of hue, lightness, saturation, and overall match as follows:

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

5.2.2 *Lightness*, an attribute of color perception by which an object is graded on its reflected intensity from black to white.

5.2.3 *Saturation*, an attribute of color perception used to indicate the degree of departure of a color from a gray of the same lightness.

5.2.4 *Overall match*, expressed as "excellent," if much better than tolerance; "good," if definitely better than tolerance; "fair," if about as close as tolerance, and "poor," if worse than tolerance. For example, the difference between two red colors might be given as "moderately yellower (hue), slightly darker (lightness), very slightly less saturated, overall match, fair."

5.2.5 Before assessment, observe samples under light from a UV radiator only. A blue fluorescence from the samples indicates clearly the presence of FWA. This is readily seen with white samples. Many yellow samples also show fluorescence to some degree.

5.2.6 If fluorescence has been detected, color attributes must be assessed also in the presence and the absence of UV radiation. Since the amount of UV coming from the radiator is not standardized, the impact of fluorescence on final appearance can only be estimated. A good practice is to observe samples under two pieces of flat, transparent plastic; one totally transparent in the UV and the other containing a UV absorber. First look for metamerism of the samples under normal illumination without UV radiation. Assess fluorescence as:

Intensity - compare and estimate the amount of fluorescence on both samples.

Shade - characterize the shade of the outgoing fluorescence as redder, equal or greener than standard.

Assess the final perceived whiteness of the samples in terms of:

Whiteness - the attribute of color perception by means of which an object appears more or less white than standard.

Shade - the attribute of color perception by means of which the perceived white object appears redder, equal or greener than standard.

Blueness - the attribute of color perception by means of which an object appears whiter because of higher blue saturation but less light intensity.

Overall match, expressed similar to 5.2.4. For example, the difference between two white samples might be given as "slightly less white (whiteness), moderately redder (shade), slightly bluer or duller (blueness)."

6. Report

6.1 Include the following information as required:
6.1.1 *Type of evaluation*, approximate, general, or critical.
6.1.2 Description of the reference paper and the specimen, including their gloss and surface characteristics.
6.1.3 Orientation of the specimen (CD vs. MD, felt side vs. wire side).
6.1.4 Intensity of illumination, direction of illumination and viewing, and source identification.
6.1.5 Degree of color difference observed.
6.1.6 Any departures from the recommendations in this method.
6.1.7 Identity of the observer or a note as to the observer's ability and experience.

7. Precision

This method returns a subjective result that describes in text the differences that can occur between color samples. These differences are difficult to quantify and can vary significantly depending on the experience of the user and the color match tolerance required for a given situation. The determination of repeatability and reproducibility is therefore not possible for this method.

8. Keywords

Vision, Color, Light sources, Paper, Fluorescent dyes, Illumination, Color matching, Colorimetry, Visual grading

9. Additional information

9.1 Effective date of issue: To Be Assigned.

9.2 Related methods: ASTM D1729 "Visual Evaluation of Color Differences of Opaque Materials," American Society for Testing and Materials, Philadelphia, PA; BS 950, Part 1, British Standards Institution, London, England; "Colorimetry," Official Recommendations of the International Commission on Illumination, Publication CIE No. 15 (1971), and "Method of Measuring and Specifying Colour Rendering of Light Sources," Publication CIE No. 13.3 (1995), Bureau Central de la CIE, Paris, France.

9.3 This method was reclassified from an Official Method to a Standard Practice in 1999.

9.4 This method was reclassified from a Standard Practice to an Official Method in 2004. Only minor editorial changes were made in 2013.

Literature cited

1. ASTM Standard Method E308 for Computing the Colors of Objects by Using the CIE System. American Society for Testing and Materials, Philadelphia, PA.
2. Judd, D. B., MacAdam, D. L., Wyszecki, G., "Spectral Distribution of Typical Daylight as a function of Correlated Color Temperature," *J. Opt. Soc. Am.* **54**:1031 (1964).
3. Wyszecki, G., "Development of New CIE Standard Sources for Colorimetry," *Die Farbe* **19**: (1970 N.R. 1/6).

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