TRISTIMULUS SPECIFICATION OF THE MUNSELL BOOK OF COLOR FROM SPECTROPHOTOMETRIC MEASUREMENTS

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ABSTRACT

The development of the Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) system of color names, based on the standards in the Munsell Book of Color, made it necessary to specify the master standards of this book in fundamental terms. Accordingly, spectral reflection curves were run for each of the 421 master standards on the General Electric recording spectrophotometer at the National Bureau of Standards, using slit widths of approximately 4 millimicrons. Various corrections were applied to these spectrophotometric data in accordance with methods regularly used for such work at the bureau. Colorimetric computations were then made with these data, resulting in tristimulus specifications according to the 1931 ICI standard observer and coordinate system. Four illuminants were used: ICI illuminants A and C, representative of incandescent-lamp light and average daylight, respectively, illuminant "D" (lightly overcast north sky), and illuminant "S" (extremely blue sky). The colorimetric specifications of the Munsell standards for all four illuminants are thus given.

The trilinear coordinates for the Munsell standards calculated for ICI illuminant C have been plotted on large chromaticity (x, y) diagrams and constant Munsell chroma lines drawn in. (Similar values obtained by Glenn and Killian at the Massachusetts Institute of Technology in 1935 for Munsell color standards bearing the same hue-value-chroma designations have also been plotted on the diagram and differences between the two sets of data are discussed.) These diagrams serve as means for determining the Munsell notation and thereby the ISCC-NBS color name for any color whose trilinear coordinates and apparent reflectance are given.

CONTENTS

I. INTRODUCTION

Two of the official compendia of drugs and medicines, the United States Pharmacopoeia and the National Formulary, specify the purity and quality of drugs by a number of tests for which tolerance limits are set. With a crude drug, for example, these tests refer to ash, acid

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insoluble ash, size, chemical identification tests, taste, color, and so forth, these being indications of purity or quality. All of the tests except color have been under continuous study by committees entrusted with their revision. Color, on the other hand, presented a different type of problem whose solution was not attempted until 1931. Previously the color terms used in the USP and NF had enjoyed no official definition but contained, among others, such confusing terms as "brownish green" or "blackish white," with seldom any reference to a color chart or standard. In the monograph of a drug, the pharmacognocist describes the colors of the outside and the inside, the colors of the various microscopic elements, and finally, the colors of the identification tests. In each instance, no mention is made of the normality of the observer's color vision [1], [3] or of the conditions of lighting or viewing.

Agitation toward research for the development of a suitable system of color terminology was begun in the twenties by E. N. Gathercoal, then a member of the USP Revision Committee [2]. After the founding of the Inter-Society Color Council, of which he was the first chairman, studies were made of the then existing color systems, and in 1933 the report [3] was submitted which became the basis of the system of color names now known as the ISCC-NBS system of color names [4]. Procedures were developed at the same time for the application of these color names to the description of the colors of crude drugs, powdered drugs, chemicals, liquids, precipitates, microscopic structures, and fluorescent materials [5]. The central notations of the color-name blocks were determined for the application of these color names to the description of the colors of soils [6]. Recently these names have also been used to describe the colors of illuminants, and a description of this method of use is in preparation.

In all of this work, the boundaries of the separate color-name blocks have been specified in terms of the Munsell color standards [7, 8]. It was realized early in the project that in order to be placed on a sound basis the individual boundaries must be specified in fundamental terms. The accuracy of the system of color names would then be independent of the existence or stability of the individual system of material color standards, in terms of which the system is used in practice. Since the Munsell color system provided a very satisfactory means of determining which color name best described the color of an object, it was decided to measure the spectral reflectances of all of the color standards in the Munsell Book of Color. The specification of the trilinear coordinates and apparent reflectances of each of the Munsell samples would provide an invariable specification of the color of that sample and thereby of a definite point in the framework of the system by which the relative position of each color name is indicated.

Tristimulus specifications of the Munsell Book of Color have been published by Glenn and Killian [8] and were available for some time before that date. Instead of using the Glenn-Killian data, however, it seemed preferable to define the ISCC-NBS system of color names by way of the Munsell samples actually used in the color-names work. This involved a nominal repetition of the spectrophotometric and colorimetric work carried out by Glenn and Killian, but avoided uncertainties arising out of the possible differences between the respective Munsell samples bearing the same

[3] Figures in brackets indicate the literature references at the end of this paper.

color designation as well as those arising from the unknown history and usage of the Glenn-Killian samples prior to their measurement. Furthermore, the present authors desired to use in the spectrophotometric measurements certain methods of calibration regularly used at the National Bureau of Standards for such work. The measurements and computations described below were accordingly undertaken, and the diagrams and tables included in the present paper provide a means by which a color may be named without reference to a color chart, or by which the boundaries of the color-name blocks may be specified in terms of a fundamental color system. It is now possible to select the appropriate color name for a color when the fundamental specifications for that color are given.

Since the application of this system of color names will be made in the plant or in the field where the illumination used will usually be daylight, all of the techniques and computations, both for the color names and for the Munsell system, have primarily been made on the basis of ICI illuminant *C*. However, colorimetric data on the Munsell standards for other illuminants are also of interest. Accordingly, based on the same spectrophotometric data, tristimulus values have been computed for four illuminants—ICI illuminant *C* [9] (representative of average daylight), ICI illuminant *A* [9] (2,842°K [10], representative of incandescent illuminants), illuminant *"D"* [11, 12] (representative of lightly overcast north sky), and illuminant *"S"* [13, 14] (representative of extremely blue sky).

II. SAMPLES MEASURED

Prior to his death, Walter T. Spry, then manager of the Munsell Color Co., deposited one or more samples of all of the original paintings of the standards in the Munsell Book of Color with the Colorimetry Section of the Bureau. He also deposited repaints of all colors the original paintings of which had become depleted, together with new colors prepared up to 1935. In selecting the samples of each color to be measured, that painting was chosen which matched the color chip of the same designation in the Munsell Book of Color. In most instances the color differences between the originals and their repaints were negligible, but in several cases it was important to specify which painting was used. Therefore, for the purpose of accuracy and as a matter of record, the painting number of each sample measured is given.

The 2-value 2-chroma samples for the intermediate hues (*10R, 10YR, 10Y*, etc.) were painted independently of the other 2-value 2-chroma samples, and the colors and the data are not as congruent with the other samples as they are with each other. These samples, as well as several 8-value 2-chroma samples for the intermediate hues, are not included in the Munsell Book of Color, but they were measured and the data are included in the present paper for the sake of completeness. One new sample, *10YR 8/8*, recently received, is included. The complete list of samples measured is given in table 2.

The samples in the Munsell Book of Color were inspected under a strong source of ultraviolet radiant energy and also under a strong yellowish green light for fluorescence that might vitiate the spectrophotometric measurements [15]. No fluorescence was observed under either illuminant.

III. METHODS OF MEASUREMENT AND COMPUTATION

Spectral reflection curves of all of the samples noted and listed in table 2 were run on the General Electric recording spectrophotometer at the National Bureau of Standards. The samples were run relative to magnesium oxide [16], with approximately 4 mμ slits and over a wavelength range from 400 to 750 mμ. The samples were backed with black paper for these measurements. Calibration curves were run on each sheet, enabling corrections to be applied to the data for wavelength errors, for 100-percent and zero curve deviations, and for aging of the magnesium oxide comparison surface, in accordance with methods regularly used at the National Bureau of Standards [17, 18].

As already noted, the colorimetric computations were made for four different illuminants. ICI illuminants A and C have become well established in colorimetric work. Illuminant A is the Plankian radiator or blackbody at 2,842° K ($C_2 = 14,320$ micron-degrees, or 2,848° K with $C_2 = 14,350$); the color temperatures of common incandescent illuminants vary from about 2,600° to about 3,100° K. Illuminant C is that produced by a source at 2,842° K combined with a certain Davis-Gibson daylight liquid filter [19]. On the "OSA excitations" basis (used in the design of the Davis-Gibson filters) the resulting color matched that of a Plankian radiator at 6,500° K. On the basis of the ICI data the approximate color temperature of this lamp-and-filter combination is 6,800° K. The color and spectral-energy distribution of ICI illuminant C satisfactorily match those of overcast sky or average daylight for colorimetric use. Illuminant "D" is that produced by an illuminant at 3,000° K combined with a Macbeth (Corning) daylight glass filter giving a color temperature of approximately 7,500° K. The color of illuminant "D", found to be the optimum color for cotton grading, is also being widely used for agricultural grading and textile color matching. Its color closely matches that of the lightly overcast north sky most desired for such work. Illuminant "S" was designed as the blue end point for a series of illuminants representing the range from fully overcast to maximally clear sky. It was devised by weighting Abbot's "sun-outside-atmosphere" energy data by the inverse λ^4 scattering relation. Illuminant "S" has been designated as "limit blue sky."

The colorimetric data on the Munsell samples for ICI illuminant C, representative of average daylight, are of primary interest and the computations were carried out both at the National Bureau of Standards and in the U. S. Department of Agriculture. Those for the other three illuminants were made in the Department of Agriculture. All of the computations in the Department of Agriculture were done by using Hollerith cards and automatically punching sums obtained by the method of progressive digiting. The authors are indebted to Lila F. Knudsen, mathematical statistician of the Food and Drug Administration, for suggesting this rapid method of computation [20]. All of the computations were made by the weighted ordinate method.

The spectral-energy distributions of the four illuminants are shown in figure 1, and in table 1 are given the tristimulus data for the spectrum of each of the four illuminants used in the computations of X, Y, Z and x, y, z.

TABLE 1.—*ICI tristimulus data for the four illuminants, A, C, "D," and "S," used in deriving the colorimetric data on the Munsell standards*

Wavelength	For illuminant A			For illuminant C			For illuminant "D"			For illuminant "S"		
	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$	$\bar{x}E$	$\bar{y}E$	$\bar{z}E$
$M\mu$												
380	1	------	6	4	------	20	6	------	30	36	------	165
390	5	------	23	19	------	89	27	1	128	99	3	473
400	19	1	93	85	2	404	119	3	567	349	10	1658
410	71	2	340	329	9	1570	446	12	2125	1199	33	5719
420	262	8	1256	1238	37	5949	1504	45	7223	3567	107	17137
430	649	27	3167	2997	122	14628	3373	138	16461	6852	280	33442
440	926	61	4647	3975	262	19938	4202	277	21077	8143	538	40845
450	1031	117	5435	3915	443	20638	4100	463	21613	7652	865	40332
460	1019	210	5851	3362	694	19299	3476	717	19952	6194	1278	35554
470	776	362	5116	2272	1058	14972	2274	1059	14982	3870	1803	25503
480	428	622	3636	1112	1618	9461	1070	1556	9099	1742	2533	14815
490	160	1039	2324	363	2358	5274	347	2258	5049	530	3444	7703
500	27	1792	1509	52	3401	2864	52	3451	2906	74	4871	4102
510	57	3080	969	89	4833	1520	96	5214	1640	127	6870	2160
520	425	4771	525	576	6462	712	626	7023	774	781	8757	965
530	1214	6322	309	1523	7934	388	1533	7986	391	1847	9618	471
540	2313	7600	162	2785	9149	195	2610	8574	182	2958	9717	207
550	3732	8568	75	4282	9832	86	4062	9324	82	4070	9343	81
560	5510	9222	36	5880	9841	39	6072	10162	40	5148	8615	34
570	7571	9457	21	7322	9147	20	8160	10194	22	6092	7610	16
580	9719	9228	18	8417	7992	16	9310	8840	17	6798	6454	13
590	11579	8540	12	8984	6627	10	8946	6599	10	7090	5229	7
600	12704	7547	10	8949	5316	7	8343	4956	6	6798	4038	5
610	12669	6356	4	8325	4176	2	7800	3913	2	5871	2945	2
620	11373	5071	3	7070	3153	2	6372	2841	1	4585	2044	1
630	8980	3704	------	5309	2190	------	4477	1847	------	3160	1303	------
640	6558	2562	------	3693	1443	------	2732	1067	------	2030	793	------
650	4336	1637	------	2349	886	------	1640	619	------	1183	447	------
660	2628	972	------	1361	504	------	988	365	------	636	236	------
670	1448	530	------	708	259	------	603	221	------	313	114	------
680	804	292	------	369	134	------	367	133	------	155	56	------
690	404	146	------	171	62	------	197	71	------	69	25	------
700	209	75	------	82	29	------	102	37	------	32	11	------
710	110	40	------	39	14	------	49	18	------	15	5	------
720	57	19	------	19	6	------	23	8	------	7	3	------
730	28	10	------	8	3	------	11	4	------	3	1	------
740	14	6	------	4	2	------	5	2	------	2	1	------
750	6	2	------	2	1	------	2	1	------	1	------	------
760	4	2	------	1	1	------	1	1	------	------	------	------
770	2	------	------	1	------	------	1	------	------	------	------	------
$\Sigma=$	109828	100000	35547	98041	100000	118103	96124	100000	124379	100078	100000	231410
$x, y, z=$	0.44759	0.40754	0.14487	0.31012	0.31631	0.37357	0.29992	0.31201	0.38807	0.23194	0.23176	0.53630
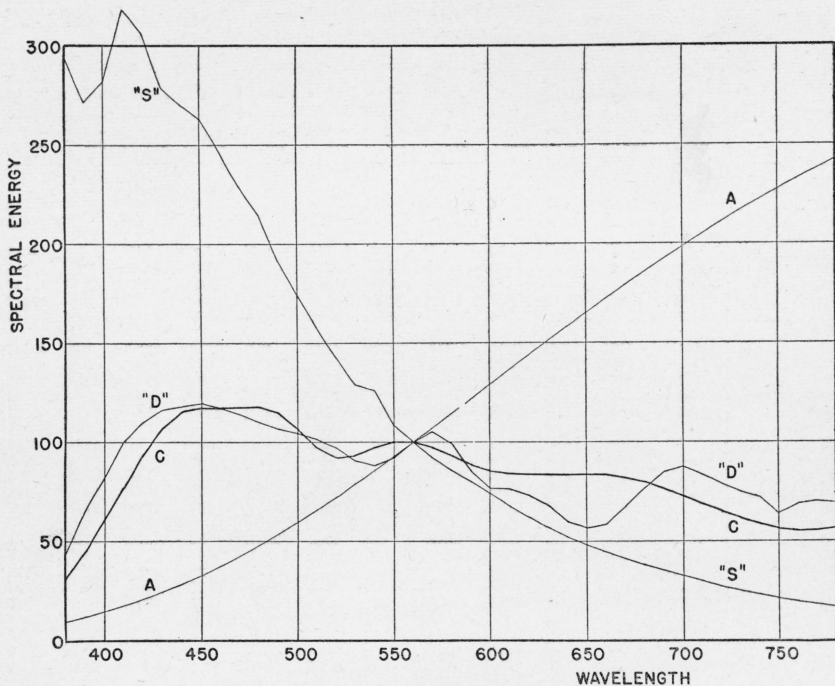
FIGURE 1.—*Spectral energy distributions of the four illuminants used in deriving the colorimetric data on the Munsell standards.*

ICI illuminant *A*, 2,842° K, representative of incandescent illuminants.   ICI illuminant *C*, representative of average daylight.   Illuminant "*D*", representative of lightly overcast sky.   Illuminant "*S*", representative of "limit blue sky."

IV. COLORIMETRIC DATA

Values of X, Y, Z, x, and y for all of the samples and for the four illuminants, as explained above, together with the Munsell notations, $H\ V/C$ (hue, value, and chroma), and the Munsell painting number for each sample, are given in table 2.   Values for the neutrals are at the end of the table.   Values of z are omitted, since $z=1-x-y$.

Values of the trilinear coordinates, x and y, for ICI illuminant C, are plotted in figures 2 to 8 for Munsell values 2 to 8, respectively. The x and y values for ICI illuminant C, and therefore for magnesium oxide and for any other spectrally nonselective sample, are given in each diagram at $x=0.3101$, $y=0.3163$.   Values of x and y for the Munsell samples obtained at the National Bureau of Standards are plotted as circled points.   The data obtained by Glenn and Killian [8] at the Massachusetts Institute of Technology in 1935 are plotted as uncircled points for comparison with the present data.   When the two points for a sample coincide, the combination is plotted, as a circled point with a short line attached; in many cases, to avoid confusion, the two points are joined by a fine line.   Lines are drawn connecting all of the NBS points of constant chroma on each diagram, resulting in the spiderweb-like figures shown.

FIGURE 2.—*ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 2/.*

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FIGURE 3.—*ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 3/.*
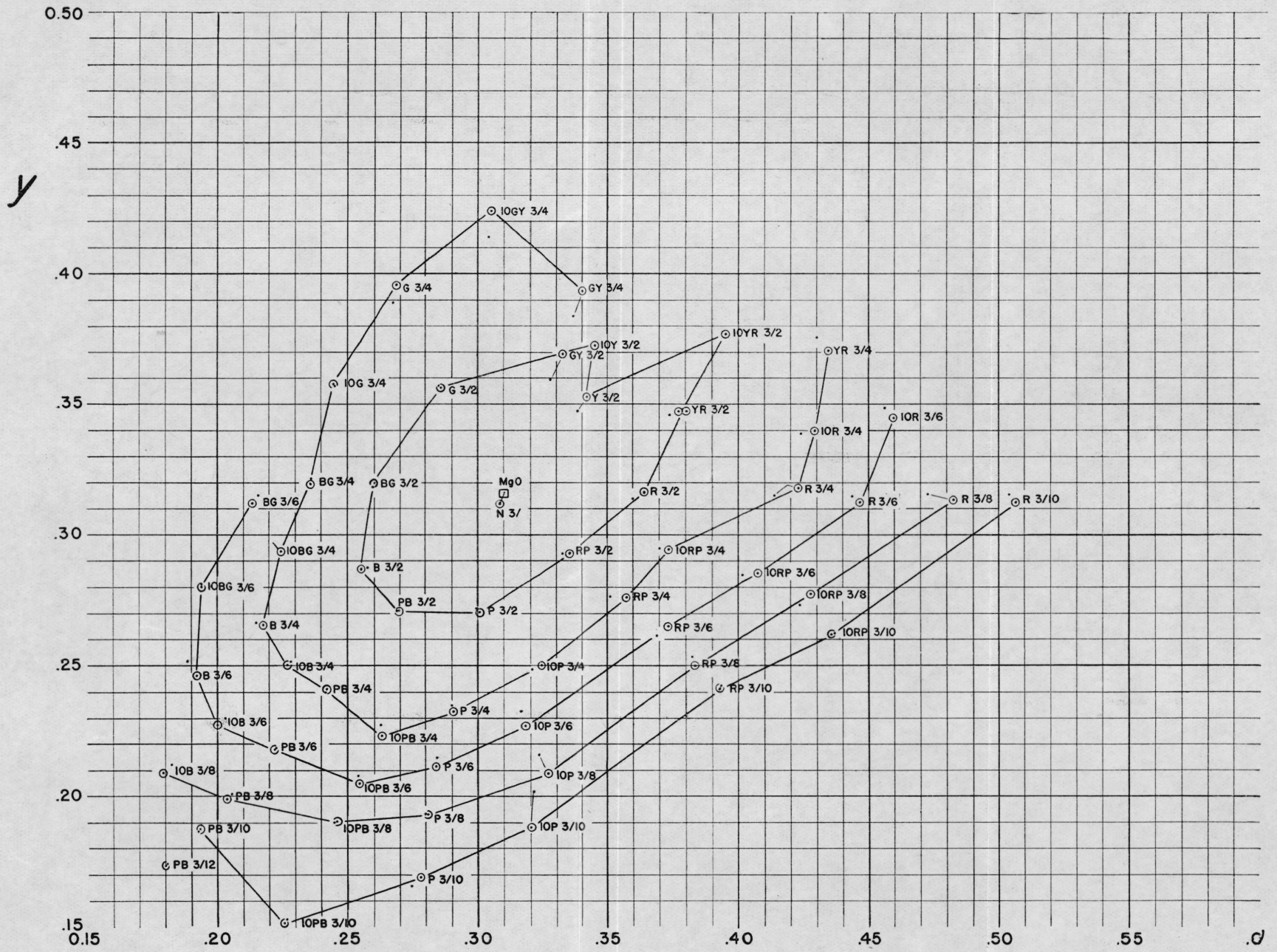
FIGURE 4.—*ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 4/.*

FIGURE 5.—*ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 5/.*

FIGURE 6.—*ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 6/.*

FIGURE 7.— *ICI chromaticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 7/.*

FIGURE 8.—ICI chromiticity diagram showing values of x and y for ICI illuminant C for Munsell standards of value level 8/.

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*

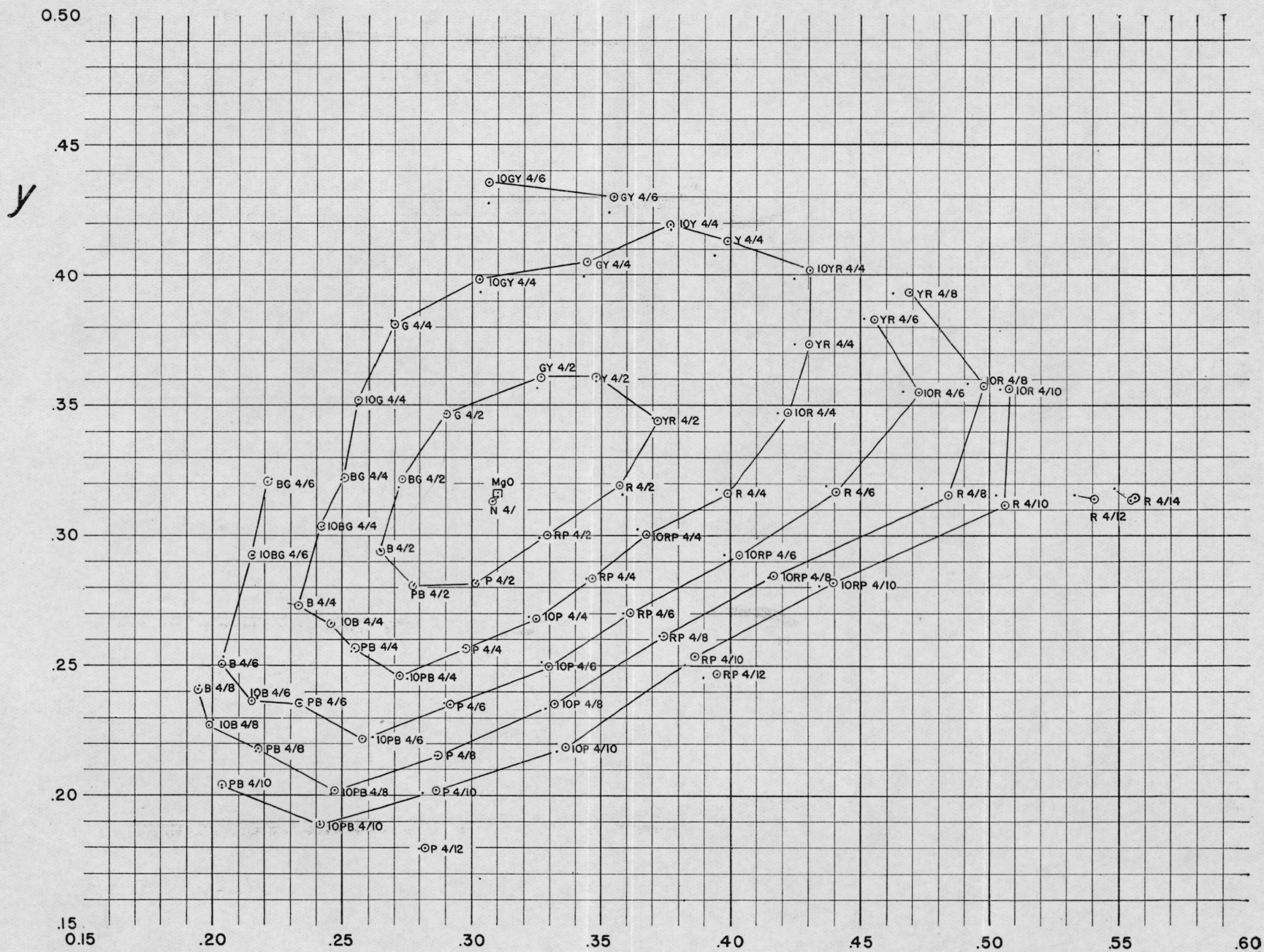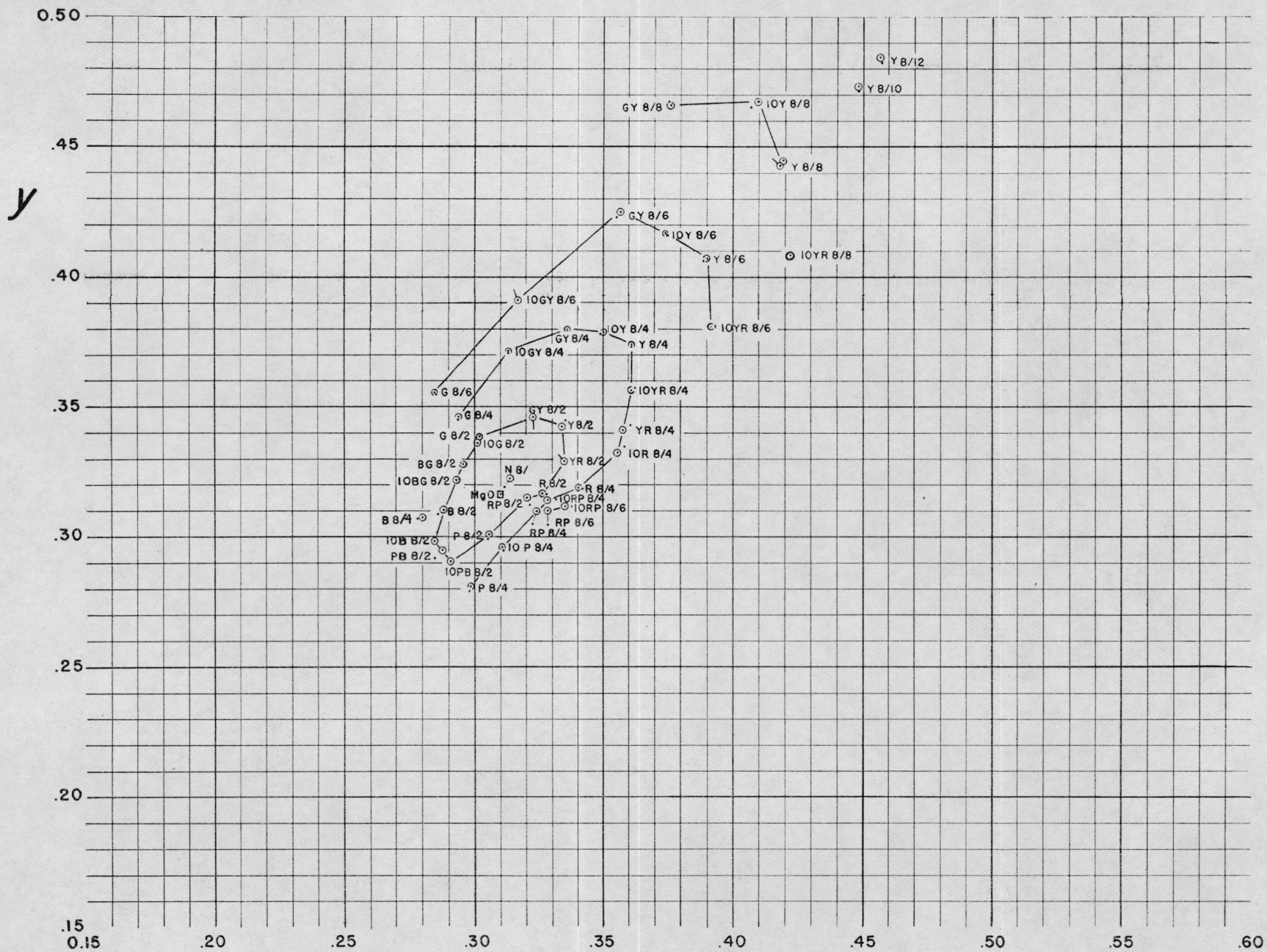| Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
R 8/4	0.7432	0.6147	0.1874	0.4809	0.3978	0.6261	0.5862	0.6264	0.3405	0.3188	0.6075	0.5832	0.6604	0.3282	0.3150	0.6044	0.5667	1.2317	0.2516	0.2358	1168
2	.7160	.6179	.2036	.4657	.4019	.6199	.6021	.6793	.3261	.3167	.6047	.6007	.7158	.3148	.3127	.6147	.5908	1.3338	.2421	.2327	342
7/8	.6564	.4769	.1168	.5251	.3815	.5144	.4244	.3936	.3861	.3185	.4909	.4178	.4159	.3706	.3154	.4614	.3903	0.7794	.2829	.2393	84
6	.6445	.4886	.1276	.5112	.3876	.5157	.4452	.4279	.3713	.3206	.4946	.4400	.4515	.3568	.3174	.4722	.4167	.8437	.2725	.2405	880
4	.6173	.4777	.1324	.5030	.3892	.5020	.4402	.4449	.3619	.3174	.4835	.4361	.4696	.3480	.3139	.4682	.4153	.8784	.2657	.2357	82
2	.5586	.4699	.1485	.4746	.3993	.4763	.4521	.4965	.3343	.3173	.4632	.4503	.5234	.3224	.3134	.4655	.4396	.9765	.2474	.2336	80
6/10	.5912	.3874	.0740	.5616	.3681	.4369	.3236	.2514	.4318	.3198	.4102	.3146	.2662	.4139	.3174	.3666	.2834	.5014	.3184	.2461	1156
8	.5461	.3758	.0804	.5448	.3749	.4142	.3236	.2717	.4103	.3205	.3920	.3167	.2873	.3936	.3180	.3579	.2902	.5396	.3013	.2443	338
6	.5121	.3721	.0903	.5255	.3818	.4013	.3308	.3053	.3868	.3189	.3831	.3259	.3229	.3713	.3158	.3598	.3036	.6064	.2834	.2391	728
4	.4673	.3611	.0958	.5056	.3907	.3787	.3313	.3228	.3667	.3208	.3649	.3284	.3411	.3528	.3175	.3510	.3106	.6393	.2698	.2388	726
2	.4007	.3345	.1037	.4776	.3987	.3396	.3205	.3464	.3374	.3184	.3298	.3190	.3651	.3253	.3146	.3295	.3108	.6805	.2496	.2353	332
5/12	.4675	.2596	.0293	.6181	.3432	.3149	.1938	.0995	.5177	.3187	.2858	.1825	.1055	.4981	.3181	.2346	.1545	.1989	.3990	.2628	894
10	.4651	.2732	.0381	.5990	.3519	.3226	.2128	.1291	.4855	.3202	.2962	.2030	.1367	.4659	.3192	.2501	.1760	.2572	.3660	.2576	729
8	.4099	.2477	.0388	.5886	.3557	.2900	.1963	.1315	.4694	.3178	.2684	.1884	.1391	.4504	.3162	.2306	.1650	.2612	.3511	.2512	18
6	.3713	.2407	.0465	.5639	.3656	.2736	.1998	.1574	.4338	.3167	.2567	.1940	.1663	.4161	.3144	.2289	.1744	.3120	.3200	.2438	16
4	.3074	.2183	.0510	.5331	.3785	.2379	.1915	.1715	.3959	.3187	.2264	.1881	.1810	.3801	.3159	.2100	.1743	.3386	.2905	.2411	14
2	.2604	.2084	.0610	.4915	.3934	.2158	.1954	.2041	.3507	.3176	.2087	.1941	.2150	.3378	.3141	.2047	.1865	.4007	.2585	.2356	12
4/14	.3644	.1881	.0163	.6406	.3308	.2360	.1334	.0550	.5561	.3143	.2104	.1231	.0581	.5373	.3144	.1666	.1015	.1089	.4420	.2692	42R
14	.3653	.1882	.0166	.6408	.3301	.2361	.1335	.0563	.5544	.3135	.2100	.1231	.0595	.5348	.3135	.1664	.1015	.1119	.4382	.2673	1151
12	.3580	.1884	.0187	.6336	.3333	.2341	.1360	.0631	.5404	.3139	.2094	.1262	.0667	.5207	.3136	.1680	.1055	.1250	.4216	.2647	40
10	.3166	.1736	.0226	.6173	.3386	.2116	.1303	.0762	.5061	.3117	.1905	.1221	.0805	.4847	.3106	.1574	.1050	.1510	.3807	.2540	730
8	.2890	.1683	.0245	.5997	.3493	.2004	.1306	.0831	.4839	.3155	.1837	.1243	.0878	.4642	.3140	.1557	.1082	.1648	.3632	.2524	38 R
6	.2374	.1516	.0282	.5691	.3634	.1734	.1247	.0955	.4406	.3167	.1622	.1207	.1010	.4225	.3144	.1437	.1080	.1897	.3255	.2447	36R
4	.2023	.1418	.0330	.5365	.3760	.1559	.1236	.1115	.3987	.3161	.1481	.1212	.1178	.3825	.3131	.1373	.1119	.2210	.2920	.2381	34
2	.1748	.1377	.0388	.4976	.3920	.1433	.1280	.1299	.3572	.3190	.1383	.1269	.1369	.3439	.3156	.1345	.1213	.2555	.2630	.2373	32
3/10	.1799	.0991	.0126	.6168	.3400	.1206	.0744	.0431	.5065	.3124	.1088	.0698	.0457	.4851	.3113	.0900	.0596	.0862	.3818	.2528	732
8	.1662	.0958	.0142	.6017	.3468	.1143	.0743	.0484	.4824	.3135	.1041	.0704	.0512	.4613	.3120	.0882	.0613	.0963	.3588	.2495	731
6	.1653	.1021	.0188	.5776	.3569	.1185	.0829	.0639	.4466	.3125	.1098	.0797	.0677	.4268	.3100	.0967	.0712	.1276	.3272	.2411	738
4	.1320	.0870	.0178	.5576	.3673	.0977	.0734	.0599	.4228	.3179	.0914	.0713	.0632	.4047	.3155	.0823	.0651	.1183	.3098	.2450	314
2	.1022	.0780	.0216	.5067	.3864	.0824	.0716	.0722	.3643	.3164	.0790	.0707	.0761	.3499	.3130	.0762	.0674	.1420	.2669	.2360	312
2/6	.0885	.0558	.0124	.5647	.3559	.0653	.0461	.0434	.4219	.2977	.0609	.0445	.0462	.4019	.2934	.0558	.0401	.0877	.3037	.2186	1124
4	.0687	.0453	.0105	.5522	.3639	.0516	.0384	.0359	.4094	.3053	.0484	.0373	.0381	.3907	.3015	.0447	.0342	.0720	.2960	.2268	860
2	.0598	.0442	.0123	.5143	.3803	.0479	.0400	.0420	.3686	.3083	.0457	.0394	.0445	.3529	.3041	.0444	.0373	.0839	.2679	.2253	322
10R 8/4	.7899	.6491	.1724	.4902	.4028	.6539	.6115	.5744	.3554	.3324	.6339	.6087	.6056	.3430	.3294	.6136	.5823	1.1293	.2639	.2504	722
7/8	.6797	.4921	.0333	.5416	.3921	.5161	.4290	.2776	.4221	.3509	.4914	.4228	.2934	.4069	.3501	.4366	.3842	0.5489	.3188	.2805	882
6	.6605	.5044	.1085	.5187	.3961	.5222	.4550	.3635	.3895	.3394	.5018	.4508	.3839	.3755	.3373	.4646	.4180	.7181	.2903	.2611	714
4	.6288	.4937	.1194	.5064	.3976	.5075	.4537	.3997	.3729	.3334	.4893	.4502	.4219	.3594	.3307	.4634	.4236	.7881	.2767	.2529	667
6/10	.5891	.3948	.0404	.5751	.3854	.4268	.3243	.1345	.4820	.3662	.4031	.3181	.1422	.4668	.3684	.3354	.2732	.2664	.3833	.3122	583
8	.5585	.3931	.0547	.5550	.3907	.4170	.3345	.1828	.4463	.3580	.3965	.3295	.1934	.4313	.3584	.3426	.2913	.3623	.3439	.2924	585
6	.5243	.3853	.0677	.5365	.3942	.4022	.3384	.2261	.4161	.3501	.3843	.3344	.2388	.4014	.3492	.3434	.3037	.4465	.3140	.2777	733
4	.4556	.3569	.0817	.5096	.3991	.3663	.3262	.2743	.3789	.3374	.3535	.3239	.2899	.3654	.3349	.3322	.3026	.5431	.2820	.2569	587

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*—Continued

Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
10R 6/4	.4710	.3673	.0802	.5128	.3999	.3755	.3347	.2667	.3844	.3426	.3621	.3326	.2814	.3710	.3407	.3360	.3095	.5254	.2870	.2643	1860
5/10	.3965	.2488	.0208	.5953	.3735	.2761	.1977	.0678	.5098	.3650	.2562	.1912	.0716	.4937	.3684	.2078	.1633	.1331	.4121	.3239	590
8	.3990	.2653	.0284	.5761	.3830	.2884	.2175	.0943	.4806	.3624	.2719	.2130	.0996	.4652	.3644	.2266	.1833	.1861	.3802	.3076	734
6	.3591	.2465	.0339	.5615	.3855	.2650	.2073	.1130	.4527	.3542	.2508	.2035	.1194	.4371	.3547	.2155	.1796	.2234	.3485	.2904	588
4	.3102	.2297	.0442	.5311	.3932	.2409	.2028	.1484	.4069	.3425	.2309	.2007	.1568	.3924	.3411	.2093	.1829	.2937	.3052	.2666	580
4/10	.3031	.1891	.0172	.5950	.3712	.2127	.1493	.0571	.5075	.3563	.1981	.1446	.0603	.4916	.3587	.1619	.1225	.1126	.4078	.3086	761
8	.2811	.1786	.0176	.5890	.3742	.1989	.1428	.0580	.4976	.3573	.1858	.1387	.0611	.4818	.3598	.1528	.1183	.1138	.3970	.3075	747
6	.2627	.1734	.0209	.5749	.3794	.1897	.1424	.0693	.4726	.3549	.1783	.1392	.0730	.4567	.3563	.1500	.1210	.1359	.3636	.2974	735
4	.2158	.1550	.0269	.5426	.3898	.1638	.1348	.0896	.4220	.3472	.1559	.1328	.0946	.4067	.3464	.1385	.1203	.1766	.3182	.2763	591
3/6	.1440	.0951	.0133	.5705	.3766	.1047	.0786	.0446	.4594	.3448	.0984	.0766	.0472	.4428	.3449	.0844	.0674	.0884	.3513	.2808	736
4	.1250	.0866	.0151	.5515	.3820	.0935	.0741	.0502	.4291	.3402	.0884	.0726	.0530	.4129	.3393	.0782	.0658	.0990	.3219	.2706	595
2/2	.0711	.0515	.0119	.5288	.3828	.0551	.0458	.0399	.3913	.3252	.0523	.0450	.0421	.3753	.3226	.0486	.0420	.0788	.2870	.2478	915
YR 8/4	.7567	.6314	.1590	.4891	.4081	.6255	.5970	.5271	.3575	.3412	.6068	.5950	.5557	.3453	.3386	.5829	.5690	1.0348	.2666	.2602	385
2	.7041	.6096	.1824	.4706	.4075	.6007	.5917	.6039	.3344	.3294	.5849	.5904	.6358	.3230	.3260	.5825	.5777	1.1813	.2488	.2467	384
7/10	.6736	.4888	.0415	.5595	.4060	.4941	.4178	.1309	.4738	.4007	.4696	.4129	.1378	.4603	.4047	.3870	.3629	0.2534	.3857	.3617	867
8	.6729	.4991	.0629	.5449	.4042	.5054	.4356	.2002	.4429	.3817	.4826	.4314	.2097	.4295	.3839	.4108	.3860	.3843	.3478	.3268	740
6	.6086	.4657	.0808	.5269	.4032	.4703	.4180	.2635	.4084	.3629	.4504	.4140	.2776	.3944	.3626	.4022	.3816	.5151	.3097	.2938	739
6	.6194	.4746	.0822	.5266	.4035	.4787	.4262	.2676	.4083	.3635	.4584	.4223	.2817	.3944	.3633	.4090	.3894	.5219	.3098	.2949	739
4	.5867	.4724	.1052	.5039	.4057	.4723	.4376	.3484	.3753	.3478	.4556	.4349	.3674	.3622	.3457	.4268	.4110	.6840	.2805	.2701	154
2	.5362	.4561	.1287	.4783	.4069	.4521	.4375	.4275	.3433	.3322	.4396	.4362	.4505	.3315	.3289	.4325	.4229	.8385	.2553	.2497	152
6/12	.5511	.3886	.0203	.5740	.4048	.3962	.3241	.0617	.5067	.4145	.3757	.3199	.0647	.4941	.4208	.2994	.2742	.1175	.4333	.3967	383
10	.5465	.3945	.0290	.5634	.4067	.3989	.3350	.0915	.4833	.4059	.3787	.3307	.0963	.4700	.4105	.3095	.2886	.1771	.3992	.3723	745
8	.5163	.3798	.0394	.5519	.4060	.3849	.3274	.1278	.4582	.3897	.3677	.3243	.1348	.4448	.3922	.3092	.2862	.2500	.3657	.3385	896
6	.4721	.3620	.0549	.5477	.4072	.3640	.3221	.1804	.4201	.3717	.3496	.3199	.1904	.4066	.3720	.3077	.2902	.3543	.3232	.3048	379
4	.4231	.3390	.0693	.5089	.4077	.3389	.3113	.2300	.3850	.3537	.3275	.3099	.2428	.3721	.3521	.3024	.2886	.4528	.2897	.2765	377
2	.3834	.3266	.0883	.4803	.4091	.3225	.3124	.2936	.3473	.3364	.3139	.3117	.3097	.3356	.3333	.3066	.3003	.5772	.2590	.2536	375
5/10	.3490	.2462	.0155	.5715	.4032	.2528	.2056	.0482	.4990	.4058	.2402	.2032	.0506	.4862	.4113	.1933	.1740	.0924	.4205	.3785	868
8	.3392	.2450	.0215	.5601	.4044	.2503	.2081	.0680	.4755	.3953	.2393	.2063	.0714	.4628	.3991	.1969	.1790	.1311	.3883	.3531	748
6	.3095	.2282	.0275	.5477	.4037	.2320	.1981	.0892	.4468	.3815	.2212	.1960	.0939	.4328	.3834	.1887	.1750	.1741	.3509	.3254	741
4	.2787	.2131	.0359	.5282	.4039	.2156	.1905	.1181	.4113	.3633	.2067	.1888	.1246	.3975	.3630	.1844	.1730	.2318	.3129	.2937	144
2	.2443	.2037	.0527	.4880	.4069	.2029	.1927	.1755	.3553	.3374	.1969	.1920	.1852	.3430	.3344	.1905	.1839	.3457	.2646	.2554	142
4/8	.2159	.1585	.0147	.5549	.4074	.1614	.1354	.0474	.4689	.3935	.1551	.1348	.0498	.4566	.3968	.1286	.1166	.0919	.3816	.3458	902
6	.2320	.1678	.0191	.5539	.4006	.1717	.1445	.0610	.4552	.3830	.1630	.1425	.0642	.4409	.3855	.1376	.1271	.1183	.3592	.3319	875
4	.2167	.1610	.0229	.5410	.4018	.1632	.1416	.0744	.4303	.3735	.1551	.1397	.0784	.4157	.3743	.1350	.1276	.1452	.3310	.3129	987
2	.1685	.1366	.0314	.5008	.4059	.1370	.1268	.1044	.3720	.3444	.1326	.1262	.1100	.3594	.3423	.1248	.1189	.2049	.2783	.2650	584
3/4	.1212	.0897	.0127	.5422	.4012	.0918	.0783	.0412	.4344	.3705	.0878	.0775	.0434	.4206	.3714	.0761	.0697	.0805	.3362	.3079	988
2	.0955	.0759	.0165	.5084	.4038	.0764	.0698	.0548	.3803	.3473	.0737	.0693	.0578	.3669	.3453	.0687	.0653	.1078	.2841	.2700	989
2	.0949	.0759	.0168	.5058	.4045	.0761	.0701	.0556	.3774	.3473	.0734	.0696	.0585	.3643	.3454	.0685	.0657	.1088	.2820	.2702	1201
2/2	.0592	.0473	.0113	.5026	.4017	.0477	.0439	.0371	.3707	.3411	.0461	.0436	.0391	.3576	.3387	.0434	.0415	.0726	.2757	.2634	857

10YR 8/8	.8119	.6627	.0804	.5221	.4262	.6249	.6049	.2514	.4219	.4084	.6004	.6019	.2644	.4094	.4104	.5177	.5546	.4849	.3325	.3562	1595
6	.7891	.6583	.1118	.5061	.4222	.6282	.6114	.3648	.3916	.3811	.6067	.6090	.3846	.3791	.3806	.5494	.5700	.7139	.2997	.3109	593
4	.7339	.6279	.1436	.4875	.4171	.6048	.5972	.4732	.3610	.3565	.5868	.5955	.4989	.3490	.3542	.5575	.5706	.9277	.2712	.2775	589
7/10	.5991	.4740	.0264	.5449	.4311	.4470	.4179	.0793	.4734	.4426	.4288	.4157	.0834	.4621	.4480	.3487	.3676	.1515	.4018	.4237	603
8	.6084	.4895	.0450	.5323	.4283	.4621	.4397	.1411	.4431	.4216	.4434	.4371	.1487	.4308	.4247	.3738	.3958	.2733	.3584	.3795	744
6	.5817	.4763	.0628	.5190	.4250	.4533	.4347	.2029	.4155	.3985	.4371	.4330	.2141	.4031	.3994	.3827	.3979	.3971	.3250	.3378	601
4	.5815	.4899	.0994	.4967	.4184	.4716	.4602	.3268	.3747	.3656	.4567	.4588	.3448	.3624	.3640	.4251	.4346	.6417	.2831	.2895	600
6/10	.5214	.4084	.0245	.5464	.4280	.3873	.3595	.0711	.4735	.4396	.3713	.3579	.0742	.4621	.4455	.3006	.3172	.1322	.4008	.4230	1422
8	.4912	.3887	.0342	.5374	.4252	.3713	.3457	.1080	.4512	.4201	.3569	.3443	.1114	.4393	.4237	.2978	.3084	.2037	.3677	.3808	749
6	.4721	.3770	.0425	.5295	.4229	.3611	.3392	.1352	.4322	.4059	.3468	.3373	.1425	.4196	.4081	.2971	.3068	.2629	.3428	.3540	750
4	.4011	.3376	.0596	.5024	.4229	.3218	.3149	.1952	.3869	.3786	.3116	.3141	.2060	.3747	.3777	.2843	.2946	.3833	.2955	.3062	605
5/8	.2999	.2379	.0166	.5409	.4292	.2266	.2099	.0507	.4651	.4308	.2191	.2099	.0532	.4544	.4353	.1795	.1844	.0966	.3898	.4005	612
6	.2966	.2360	.0269	.5301	.4218	.2267	.2121	.0853	.4325	.4047	.2177	.2109	.0898	.4199	.4069	.1864	.1918	.1654	.3428	.3529	743
4	.2719	.2236	.0331	.5143	.4230	.2145	.2048	.1077	.4070	.3885	.2078	.2045	.1137	.3951	.3888	.1841	.1878	.2111	.3159	.3221	610
4/4	.1819	.1467	.0171	.5262	.4243	.1413	.1318	.0548	.4309	.4019	.1372	.1320	.0577	.4198	.4037	.1174	.1181	.1063	.3435	.3455	613
3/2	.0915	.0755	.0130	.5084	.4195	.0730	.0696	.0421	.3953	.3768	.0709	.0696	.0443	.3836	.3765	.0638	.0644	.0820	.3035	.3064	933
2/2	.0650	.0537	.0124	.4954	.4098	.0529	.0505	.0410	.3664	.3496	.0511	.0502	.0432	.3538	.3474	.0483	.0479	.0803	.2739	.2711	934
Y 8/12	.7051	.6199	.0257	.5220	.4589	.5374	.5706	.0697	.4563	.4845	.5178	.5685	.0731	.4466	.4903	.4218	.5167	.1288	.3952	.4841	62
12	.6855	.5924	.0285	.5247	.4535	.5178	.5443	.0744	.4556	.4789	.4978	.5427	.0774	.4453	.4855	.4038	.4958	.1333	.3909	.4800	2054
10	.7190	.6269	.0343	.5209	.4542	.5474	.5784	.0959	.4481	.4734	.5265	.5760	.1004	.4377	.4789	.4328	.5281	.1780	.3800	.4638	857a
8	.7015	.6109	.0625	.5102	.4443	.5406	.5732	.1804	.4177	.4429	.5205	.5722	.1883	.4063	.4467	.4409	.5373	.3358	.3355	.4089	852
8	.7093	.6177	.0617	.5108	.4448	.5457	.5794	.1770	.4191	.4450	.5253	.5783	.1847	.4078	.4489	.4438	.5429	.3284	.3375	.4128	852
6	.6938	.6110	.0904	.4973	.4379	.5539	.5784	.2874	.3902	.4074	.5357	.5769	.3025	.3785	.4077	.4798	.5459	.5572	.3031	.3449	58
6	.6633	.5858	.0901	.4953	.4374	.5305	.5566	.2834	.3871	.4061	.5136	.5558	.2978	.3757	.4065	.4602	.5273	.5459	.3001	.3439	1221
4	.6626	.5871	.1239	.824	.4274	.5455	.5651	.4007	.3609	.3739	.5293	.5640	.4214	.3494	.3724	.4974	.5440	.7781	.2734	.2990	56
2	.6357	.5680	.1610	.4558	.4162	.5427	.5570	.5265	.3337	.3425	.5287	.5563	.5533	.3227	.3395	.5224	.5469	1.0233	.2496	.2614	54
7/10	.5248	.4558	.0258	.5215	.4530	.4018	.4189	.0738	.4492	.4683	.3881	.4183	.0775	.4391	.4733	.3192	.3802	0.1387	.3809	.4536	904
8	.5161	.4557	.0272	.5166	.4562	.3975	.4220	.0786	.4426	.4698	.3842	.4211	.0825	.4327	.4743	.3180	.3848	.1482	.3737	.4522	70
6	.5124	.4455	.0500	.5084	.4420	.4014	.4158	.1549	.4129	.4278	.3882	.4153	.1628	.4018	.4298	.3354	.3861	.2974	.3292	.3789	390
4	.5079	.4479	.0856	.4877	.4301	.4143	.4282	.2756	.3706	.3830	.4022	.4278	.2901	.3591	.3820	.3720	.4091	.5357	.2825	.3107	388
2	.5054	.4546	.1250	.4658	.4190	.4326	.4454	.4113	.3356	.3454	.4225	.4453	.4334	.3247	.3422	.4172	.4361	.8053	.2515	.2630	387
6/8	.3880	.3410	.0220	.5167	.4540	.3009	.3145	.0649	.4423	.4623	.2922	.3151	.0681	.4327	.4665	.2424	.2858	.1228	.3723	.4390	903
8	.3994	.3513	.0224	.5166	.4544	.3095	.3242	.0658	.4425	.4635	.3006	.3247	.0690	.4329	.4578	.2490	.2948	.1240	.3729	.4414	903
6	.3954	.3429	.0298	.5148	.4465	.3055	.3179	.0888	.4289	.4464	.2951	.3177	.0933	.4180	.4499	.2487	.2932	.1686	.3501	.4126	1212
4	.3715	.3266	.0548	.4934	.4338	.3000	.3100	.1755	.3819	.3946	.2913	.3099	.1848	.3706	.3943	.2643	.2935	.3410	.2941	.3265	392
2	.3675	.3292	.0862	.4694	.4205	.3121	.3211	.2828	.3407	.3505	.3045	.3210	.2980	.3297	.3476	.2977	.3131	.5534	.2557	.2690	391
5/6	.2406	.2136	.0180	.5095	.4523	.1893	.1984	.0554	.4271	.4479	.1846	.1993	.0583	.4175	.4506	.1561	.1815	.1066	.3514	.4086	947
4	.2372	.2101	.0314	.4956	.4389	.1910	.1987	.0998	.3902	.4059	.1860	.1991	.1051	.3794	.4061	.1662	.1867	.1936	.3041	.3417	394
2	.2436	.2177	.0549	.4720	.4217	.2057	.2117	.1795	.3446	.3548	.2005	.2116	.1889	.3336	.3522	.1943	.2059	.3501	.2590	.2744	395
4/4	.1495	.1322	.0180	.4989	.4411	.1200	.1243	.0566	.3988	.4131	.1172	.1247	.0594	.3888	.4140	.1031	.1156	.1089	.3146	.3529	412
2	.1628	.1461	.0351	.4733	.4247	.1369	.1419	.1145	.3481	.3609	.1335	.1419	.1205	.3371	.3584	.1284	.1377	.2233	.2624	.2813	397
3/2	.0788	.0707	.0183	.4698	.4213	.0668	.0689	.0596	.3419	.3529	.0652	.0689	.0627	.3312	.3502	.0634	.0871	.1161	.2570	.2723	398
2/2	.0557	.0489	.0117	.4793	.4204	.0461	.0472	.0374	.3528	.3610	.0449	.0472	.0392	.3420	.3593	.0425	.0456	.0721	.2653	.2849	858
10Y 8/8	.6737	.6292	.0563	.4956	.4629	.5283	.6035	.1587	.4094	.4676	.5113	.6037	.1656	.3993	.4714	.4340	.5727	.2932	.3339	.4406	599
6	.6619	.6171	.0971	.4810	.4485	.5380	.5996	.3002	.3742	.4170	.5230	.6001	.3150	.3637	.4173	.4725	.5781	.5747	.2907	.3557	581
4	.6590	.6119	.1333	.4693	.4358	.5541	.5997	.4294	.3500	.3788	.5410	.6004	.4515	.3396	.3769	.5143	.5839	.8330	.2663	.3023	578
7/8	.4940	.4662	.0316	.4980	.4701	.3894	.4440	.0872	.4230	.4823	.3792	.4454	.0910	.4141	.4864	.3169	.4149	.1600	.3553	.4653	862
6	.4723	.4497	.0493	.4863	.4629	.3809	.4334	.1518	.3943	.4486	.3712	.4341	.1598	.3846	.4498	.3255	.4109	.2920	.3165	.3995	604
4	.4832	.4541	.0895	.4706	.4422	.4055	.4439	.2894	.3531	.3898	.3966	.4449	.3050	.3733	.3880	.3733	.4296	.5648	.2729	.3141	608
6/6	.3665	.3437	.0291	.4957	.4649	.2909	.3278	.0830	.4145	.4671	.2838	.3292	.0866	.4056	.4706	.2398	.3072	.1536	.3423	.4385	617
4	.3671	.3393	.0583	.4800	.4437	.3007	.3291	.1842	.3694	.4043	.2926	.3294	.1937	.3587	.4038	.2681	.3170	.3559	.2849	.3369	615

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*—Continued

Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
10Y 5/6	.2480	.2345	.0245	.4892	.4626	.1996	.2250	.0736	.4006	.4517	.1952	.2262	.0772	.3916	.4536	.1687	.2119	.1395	.3243	.4074	921
4	.2431	.2292	.0342	.4800	.4525	.1989	.2224	.1059	.3773	.4219	.1943	.2232	.1111	.3676	.4223	.1745	.2131	.2028	.2956	.3610	619
4/4	.1510	.1430	.0212	.4791	.4537	.1245	.1385	.0672	.3771	.4194	.1221	.1392	.0707	.3677	.4192	.1102	.1320	.1302	.2959	.3544	622
3/2	.0863	.0801	.0186	.4665	.4330	.0730	.0788	.0598	.3449	.3726	.0713	.0789	.0627	.3348	.3706	.0683	.0772	.1154	.2617	.2959	935
2/2	.0535	.0493	.0119	.4666	.4299	.0453	.0484	.0382	.3431	.3672	.0443	.0485	.0401	.3331	.3653	.0424	.0473	.0737	.2597	.2897	939
GY 8/8	.5994	.6050	.0728	.4693	.4737	.4857	.6022	.2046	.3758	.4659	.4731	.6045	.2130	.3666	.4684	.4139	.5903	.3753	.3000	.4279	432
6	.6046	.5941	.1017	.4650	.4568	.4977	.5929	.3048	.3567	.4249	.4847	.5944	.3186	.3468	.4253	.4422	.5858	.5741	.2760	.3657	433
4	.6293	.6035	.1436	.4572	.4384	.5341	.6041	.4522	.3358	.3799	.5215	.6052	.4740	.3258	.3781	.5015	.6008	.8675	.2546	.3050	434
2	.6266	.5850	.1727	.4527	.4226	.5451	.5851	.5606	.3224	.3461	.5333	.5856	.5891	.3123	.3429	.5341	.5833	1.0881	.2422	.2645	435
7/10	.4121	.4295	.0355	.4699	.4897	.3344	.4263	.0961	.3903	.4975	.3270	.4282	.1002	.3822	.5006	.2800	.4128	0.1749	.3227	.4757	908
8	.4413	.4524	.0540	.4657	.4774	.3606	.4512	.1555	.3728	.4665	.3519	.4529	.1624	.3639	.4683	.3104	.4419	.2892	.2981	.4243	442
6	.4507	.4518	.0689	.4640	.4651	.3716	.4509	.2057	.3614	.4386	.3625	.4524	.2151	.3519	.4393	.3279	.4439	.3874	.2829	.3829	441
4	.4523	.4372	.0964	.4588	.4434	.3822	.4369	.3023	.3408	.3896	.3733	.4379	.3170	.3309	.3882	.3552	.4330	.5796	.2597	.3166	439
2	.4539	.4260	.1224	.4528	.4250	.3944	.4261	.3970	.3239	.3500	.3860	.4266	.4173	.3138	.3469	.3851	.4244	.7711	.2436	.2685	437
6/8	.3183	.3257	.0380	.4667	.4776	.2612	.3238	.1104	.3756	.4657	.2554	.3253	.1153	.3669	.4674	.2251	.3154	.2059	.3016	.4226	715
6	.3113	.3210	.0403	.4629	.4772	.2576	.3200	.1216	.3685	.4577	.2519	.3211	.1277	.3596	.4582	.2261	.3126	.2317	.2935	.4058	446
4	.3296	.3223	.0644	.4601	.4500	.2772	.3217	.2013	.3464	.4020	.2708	.3225	.2113	.3366	.4009	.2549	.3178	.3865	.2657	.3313	445
2	.3443	.3247	.0906	.4533	.4274	.2991	.3245	.2949	.3257	.3533	.2928	.3249	.3104	.3155	.3501	.2917	.3226	.5747	.2453	.2714	444
5/8	.1948	.2096	.0208	.4582	.4929	.1621	.2100	.0612	.3742	.4846	.1593	.2110	.0643	.3666	.4856	.1405	.2041	.1158	.3053	.4432	450
6	.1990	.2062	.0298	.4575	.4741	.1669	.2066	.0915	.3589	.4443	.1636	.2075	.0962	.3501	.4440	.1495	.2028	.1757	.2832	.3842	720
4	.2078	.2074	.0379	.4587	.4576	.1756	.2070	.1196	.3497	.4121	.1720	.2077	.1259	.3403	.4108	.1613	.2035	.2314	.2705	.3414	449
2	.2201	.2098	.0555	.4535	.4323	.1908	.2097	.1804	.3284	.3611	.1868	.2101	.1900	.3184	.3580	.1849	.2083	.3520	.2481	.2795	448
4/6	.1219	.1248	.0202	.4568	.4677	.1031	.1249	.0626	.3547	.4298	.1013	.1256	.0658	.3462	.4292	.0934	.1224	.1202	.2780	.3642	907
4	.1307	.1311	.0257	.4546	.4560	.1117	.1313	.0814	.3442	.4048	.1098	.1320	.0856	.3353	.4031	.1038	.1293	.1575	.2658	.3311	460
2	.1413	.1354	.0362	.4515	.4327	.1229	.1357	.1176	.3266	.3607	.1204	.1360	.1238	.3168	.3577	.1193	.1349	.2289	.2470	.2792	459
3/4	.0742	.0737	.0158	.4531	.4505	.0638	.0739	.0501	.3399	.3935	.0628	.0743	.0525	.3312	.3918	.0598	.0727	.0962	.2614	.3178	766
2	.0780	.0749	.0187	.4543	.4367	.0673	.0748	.0604	.3323	.3694	.0660	.0750	.0636	.3224	.3668	.0646	.0741	.1175	.2520	.2892	462
2/2	.0466	.0457	.0115	.4489	.4399	.0402	.0461	.0363	.3278	.3762	.0394	.0463	.0379	.3188	.3746	.0382	.0460	.0690	.2491	.3004	859
10GY 8/8	.5302	.5600	.1396	.4312	.4554	.4695	.5793	.4334	.3165	.3908	.4629	.5828	.4526	.3089	.3890	.4531	.5876	.8207	.2434	.3157	863
4	.5840	.6002	.1659	.4326	.4446	.5203	.6181	.5252	.3128	.3715	.5126	.6211	.5498	.3045	.3689	.5115	.6262	1.0049	.2387	.2923	611
7/8	.3503	.4147	.0810	.4141	.4902	.3115	.4399	.2359	.3155	.4455	.3085	.4439	.2447	.3094	.4452	.2922	.4520	0.4332	.2482	.3839	635
6	.3861	.4298	.0963	.4233	.4712	.3409	.4507	.2948	.3138	.4149	.3360	.4536	.3090	.3059	.4129	.3275	.4623	.5618	.2423	.3420	616
4	.4241	.4433	.1173	.4307	.4502	.3793	.4571	.3761	.3128	.3770	.3741	.4594	.3956	.3044	.3738	.3752	.4628	.7297	.2393	.2952	614
6/10	.2321	.2845	.0459	.4125	.5058	.2037	.3032	.1284	.3207	.4772	.2015	.3060	.1331	.3145	.4777	.1866	.3125	.2327	.2550	.4271	634
8	.2597	.3049	.0558	.4186	.4914	.2273	.3224	.1594	.3206	.4548	.2243	.3250	.1649	.3141	.4550	.2095	.3309	.2898	.2524	.3986	751
6	.2604	.3000	.0618	.4185	.4822	.2301	.3168	.1861	.3139	.4322	.2270	.3190	.1948	.3064	.4306	.2191	.3260	.3522	.2442	.3633	624
4	.2738	.2969	.0773	.4225	.4582	.2461	.3101	.2438	.3076	.3876	.2431	.3120	.2561	.2997	.3846	.2436	.3172	.4704	.2362	.3076	621
5/8	.1421	.1785	.0288	.4068	.5107	.1260	.1910	.0833	.3147	.4772	.1244	.1925	.0369	.3081	.4768	.1175	.1978	.1544	.2501	.4211	881
6	.1699	.2016	.0371	.4158	.4935	.1490	.2141	.1081	.3161	.4544	.1469	.2158	.1129	.3089	.4538	.1392	.2212	.2017	.2476	.3935	628

4	.1796	.1943	.0476	.4260	.4610	.1595	.2025	.1487	.3123	.3966	.1573	.2037	.1560	.3042	.3941	.1554	.2069	.2853	.2400	.3195	626
4/6	.1074	.1238	.0271	.4109	.4852	.0954	.1355	.0803	.3066	.4354	.0941	.1365	.0837	.2994	.4343	.0911	.1408	.1500	.2385	.3688	727
4	.1128	.1264	.0323	.4154	.4656	.1016	.1337	.1002	.3028	.3985	.1003	.1345	.1050	.2951	.3959	.1003	.1382	.1917	.2331	.3213	630
3/4	.0612	.0709	.0161	.4127	.4786	.0544	.0756	.0483	.3050	.4240	.0536	.0761	.0504	.2975	.4227	.0523	.0785	.0905	.2362	.3546	633
2/2	.0411	.0425	.0119	.4307	.4447	.0364	.0440	.0375	.3087	.3731	.0357	.0442	.0393	.2998	.3707	.0358	.0450	.0717	.2347	.2949	937
G 8/6	.4751	.5243	.1810	.4025	.4442	.4479	.5595	.5677	.2844	.3552	.4443	.5635	.5906	.2780	.3526	.4632	.5826	1.0682	.2191	.2756	214
4	.5440	.5626	.1912	.4192	.4335	.5003	.5881	.6123	.2942	.3458	.4939	.5909	.6409	.2862	.3424	.5139	.6052	1.1743	.2241	.2639	753
2	.5584	.5537	.1868	.4299	.4263	.5075	.5694	.6053	.3017	.3385	.5001	.5714	.6345	.2931	.3349	.5177	.5789	1.1675	.2287	.2557	212
7/6	.3433	.4019	.1402	.3878	.4539	.3286	.4381	.4328	.2739	.3652	.3264	.4418	.4496	.2681	.3628	.3431	.4639	0.8087	.2124	.2871	755
4	.3703	.4072	.1403	.4035	.4436	.3491	.4340	.4431	.2847	.3540	.3462	.4370	.4621	.2780	.3509	.3624	.4518	0.8400	.2191	.2731	184
2	.4095	.4095	.1424	.4260	.4259	.3755	.4231	.4626	.2977	.3355	.3705	.4248	.4853	.2894	.3317	.3870	.4317	.8945	.2259	.2520	182
6/6	.2084	.2707	.0925	.3645	.4736	.2043	.3040	.2765	.2604	.3873	.2037	.3070	.2858	.2557	.3855	.2146	.3283	.5070	.2044	.3127	206
4	.2587	.2929	.0997	.3972	.4497	.2453	.3151	.3128	.2809	.3609	.2436	.3175	.3262	.2745	.3578	.2554	.3301	.5917	.2169	.2804	204
2	.2834	.2909	.1001	.4203	.4314	.2614	.3032	.3237	.2943	.3413	.2584	.3046	.3398	.2862	.3374	.2707	.3112	.6267	.2240	.2575	202
5/8	.1158	.1631	.0528	.3492	.4916	.1134	.1875	.1521	.2503	.4139	.1128	.1896	.1568	.2457	.4128	.1182	.2067	.2747	.1972	.3447	1260
6	.1298	.1666	.0541	.3703	.4755	.1244	.1869	.1626	.2626	.3943	.1235	.1886	.1694	.2565	.3917	.1304	.2029	.3044	.2045	.3182	756
4	.1450	.1708	.0551	.3910	.4605	.1376	.1856	.1717	.2781	.3749	.1367	.1871	.1796	.2715	.3717	.1435	.1960	.3267	.2153	.2942	174
2	.1749	.1807	.0623	.4184	.4324	.1618	.1888	.2017	.2929	.3419	.1600	.1898	.2119	.2849	.3378	.1681	.1942	.3913	.2230	.2577	172
4/4	.0958	.1170	.0383	.3816	.4660	.0914	.1291	.1183	.2698	.3810	.0908	.1302	.1240	.2633	.3774	.0964	.1383	.2261	.2092	.3002	194
4	.1154	.1218	.0417	.4138	.4368	.1073	.1282	.1343	.2902	.3467	.1062	.1289	.1411	.2823	.3426	.1118	.1325	.2604	.2215	.2625	192
3/4	.0581	.0722	.0226	.3799	.4723	.0545	.0803	.0682	.2685	.3956	.0539	.0810	.0712	.2615	.3931	.0563	.0869	.1281	.2077	.3202	1264
2	.0608	.0661	.0222	.4080	.4432	.0564	.0703	.0706	.2859	.3565	.0557	.0707	.0741	.2779	.3527	.0586	.0735	.1361	.2184	.2741	188
2/2	.0329	.0348	.0126	.4097	.4332	.0300	.0373	.0396	.2805	.3487	.0293	.0374	.0414	.2714	.3457	.0310	.0395	.0753	.2123	.2711	752
10G 8/2	.5883	.5799	.1993	.4302	.4241	.5340	.5965	.6447	.3008	.3360	.5257	.5984	.6754	.2921	.3326	.5448	.6075	1.2407	.2277	.2539	938
7/4	.4088	.4389	.1629	.4045	.4344	.3864	.4672	.5197	.2813	.3402	.3825	.4699	.5429	.2741	.3368	.4067	.4879	0.9906	.2157	.2588	627
6/6	.2669	.3193	.1259	.3748	.4483	.2623	.3538	.3901	.2607	.3517	.2608	.3568	.4051	.2551	.3488	.2825	.3805	.7290	.2029	.2733	757
4	.2810	.3179	.1237	.3889	.4400	.2720	.3458	.3935	.2690	.3420	.2700	.3480	.4118	.2622	.3379	.2938	.3674	.7534	.2077	.2597	625
5/6	.1285	.1738	.0743	.3413	.4615	.1315	.2013	.2210	.2375	.3635	.1311	.2034	.2277	.2331	.3619	.1446	.2239	.4017	.1878	.2907	644
4	.1597	.1864	.0727	.3814	.4450	.1563	.2047	.2302	.2644	.3463	.1555	.2063	.2409	.2580	.3423	.1701	.2191	.4405	.2050	.2641	643
4/4	.0941	.1149	.0457	.3696	.4510	.0933	.1283	.1429	.2560	.3520	.0929	.1294	.1493	.2500	.3483	.1025	.1392	.2715	.1997	.2713	646
3/4	.0521	.0660	.0275	.3577	.4533	.0516	.0754	.0838	.2447	.3577	.0512	.0761	.0873	.2386	.3547	.0569	.0837	.1572	.1909	.2811	649
2/2	.0326	.0369	.0148	.3864	.4378	.0311	.0407	.0463	.2632	.3445	.0307	.0409	.0483	.2557	.3411	.0334	.0439	.0879	.2021	.2659	939
BG 8/2	.5955	.5887	.2146	.4257	.4208	.5473	.6082	.6981	.2953	.3281	.5394	.6101	.7318	.2867	.3243	.5673	.6219	1.3470	.2237	.2452	1107
7/4	.4169	.4367	.1736	.4058	.4251	.3963	.4634	.5613	.2789	.3261	.3924	.4657	.5880	.2713	.3221	.4240	.4839	1.0803	.2133	.2434	454
2	.4559	.4549	.1716	.4212	.4203	.4224	.4729	.5575	.2908	.3255	.4167	.4746	.5841	.2824	.3217	.4416	.4863	1.0742	.2206	.2429	768
6/6	.2738	.3143	.1406	.3757	.4313	.2731	.3473	.4458	.2561	.3257	.2716	.3498	.4650	.2500	.3220	.3034	.3743	0.8460	.1991	.2456	910
4	.2868	.3156	.1344	.3893	.4284	.2801	.3425	.4304	.2660	.3253	.2781	.3447	.4501	.2592	.3213	.3066	.3640	.8238	.2052	.2436	457
2	.3223	.3267	.1280	.4148	.4205	.3015	.3429	.4150	.2846	.3237	.2976	.3443	.4350	.2764	.3197	.3190	.3558	.8004	.2163	.2412	769
5/6	.1397	.1803	.0915	.3396	.4382	.1472	.2097	.2837	.2298	.3273	.1471	.2117	.2955	.2248	.3236	.1719	.2354	.5351	.1824	.2498	1115
4	.1667	.1908	.0874	.3747	.4289	.1667	.2112	.2773	.2545	.3224	.1659	.2128	.2893	.2483	.3185	.1862	.2281	.5270	.1978	.2423	476
2	.1875	.1958	.0781	.4064	.4243	.1782	.2077	.2538	.2785	.3247	.1764	.2087	.2664	.2707	.3204	.1915	.2171	.4918	.2127	.2411	767
4/6	.0868	.1147	.0634	.3278	.4328	.0934	.1354	.1937	.2211	.3205	.0933	.1368	.2003	.2168	.3179	.1098	.1538	.3574	.1769	.2476	478
4	.1087	.1267	.0591	.3690	.4303	.1100	.1413	.1876	.2506	.3218	.1096	.1423	.1958	.2447	.3179	.1240	.1533	.3566	.1957	.2418	480
2	.1221	.1291	.0539	.4002	.4230	.1171	.1382	.1742	.2727	.3217	.1160	.1389	.1826	.2652	.3175	.1270	.1456	.3358	.2088	.2393	770
3/6	.0482	.0640	.0380	.3209	.4262	.0525	.0767	.1165	.2135	.3123	.0524	.0775	.1210	.2088	.3090	.0635	.0886	.2179	.1716	.2394	773
4	.0515	.0624	.0321	.3528	.4273	.0528	.0716	.0997	.2357	.3196	.0525	.0722	.1037	.2299	.3161	.0607	.0800	.1876	.1850	.2437	486
2	.0602	.0665	.0298	.3848	.4249	.0591	.0727	.0953	.2602	.3202	.0586	.0731	.0998	.2532	.3158	.0656	.0780	.1831	.2008	.2388	771
2/4	.0296	.0344	.0180	.3610	.4198	.0293	.0395	.0550	.2367	.3190	.0289	.0398	.0572	.2299	.3159	.0331	.0444	.1030	.1834	.2462	488
2	.0323	.0347	.0155	.3912	.4204	.0308	.0379	.0492	.2613	.3216	.0304	.0381	.0514	.2533	.3178	.0336	.0410	.0939	.1996	.2432	772

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*—Continued

Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
10BG 8/2	.6173	.6057	.2293	.4251	.4171	.5695	.6258	.7475	.2931	.3221	.5614	.6277	.7834	.2846	.3182	.5940	.6406	1.4423	.2219	.2393	940
7/4	.4052	.4256	.1892	.3972	.4173	.3953	.4555	.6179	.2692	.3102	.3924	.4579	.6481	.2619	.3056	.4366	.4795	1.1954	.2068	.2271	645
6/6	.2518	.2983	.1589	.3552	.4208	.2653	.3375	.5073	.2390	.3041	.2651	.3402	.5289	.2337	.3000	.3102	.3706	0.9631	.1887	.2254	648
4	.2795	.3045	.1431	.3844	.4188	.2792	.3316	.4650	.2595	.3083	.2778	.3337	.4873	.2528	.3037	.3145	.3538	.8973	.2009	.2260	631
5/6	.1453	.1832	.1174	.3260	.4108	.1627	.2160	.3699	.2173	.2886	.1631	.2180	.3846	.2130	.2847	.2004	.2454	.6967	.1754	.2148	658
4	.1644	.1853	.0957	.3692	.4160	.1691	.2062	.3096	.2469	.3010	.1688	.2076	.3246	.2407	.2962	.1965	.2241	.5977	.1930	.2201	651
4/6	.0891	.1135	.0730	.3233	.4118	.0992	.1349	.2276	.2149	.2922	.0993	.1361	.2361	.2105	.2887	.1216	.1543	.4256	.1733	.2199	662
4	.0991	.1146	.0603	.3617	.4183	.1027	.1290	.1933	.2416	.3036	.1025	.1300	.2023	.2357	.2991	.1200	.1417	.3715	.1895	.2238	660
3/6	.0427	.0584	.0446	.2930	.4006	.0503	.0727	.1365	.1940	.2801	.0505	.0735	.1412	.1903	.2773	.0648	.0864	.2527	.1604	.2139	668
4	.0553	.0669	.0405	.3399	.4111	.0595	.0778	.1276	.2246	.2937	.0594	.0784	.1329	.2195	.2897	.0717	.0878	.2414	.1788	.2190	665
2/2	.0355	.0403	.0211	.3667	.4159	.0357	.0455	.0663	.2421	.3086	.0354	.0459	.0692	.2353	.3047	.0409	.0505	.1261	.1880	.2321	941
B 8/4	.5768	.5749	.2457	.4128	.4114	.5481	.6025	.8080	.2798	.3076	.5419	.6046	.8484	.2716	.3031	.5934	.6252	1.5691	.2129	.2243	464
2	.6151	.5973	.2424	.4228	.4106	.5735	.6179	.7989	.2882	.3105	.5657	.6195	.8393	.2794	.3060	.6100	.6346	1.5540	.2180	.2268	797
7/6	.3851	.4085	.2067	.3850	.4084	.3877	.4436	.6773	.2570	.2941	.3857	.4460	.7103	.2502	.2892	.4433	.4737	1.3110	.1990	.2126	911
4	.4159	.4283	.2011	.3979	.4097	.4077	.4575	.6605	.2672	.2998	.4045	.4595	.6932	.2598	.2951	.4548	.4819	1.2809	.2051	.2173	467
2	.4654	.4546	.1863	.4207	.4109	.4354	.4718	.6134	.2864	.3103	.4297	.4731	.6444	.2777	.3058	.4647	.4858	1.1930	.2168	.2266	775
6/6	.2370	.2739	.1726	.3467	.4008	.2595	.3128	.5595	.2293	.2764	.2600	.3152	.5849	.2241	.2717	.3177	.3473	1.0730	.1828	.1998	469
4	.2811	.2981	.1575	.3816	.4046	.2861	.3250	.5174	.2535	.2880	.2849	.3268	.5428	.2468	.2831	.3310	.3483	1.0028	.1968	.2071	470
2	.3096	.3074	.1401	.4089	.4060	.2980	.3234	.4637	.2747	.2981	.2951	.3245	.4876	.2665	.2931	.3287	.3371	0.9048	.2093	.2147	798
5/6	.1331	.1632	.1212	.3187	.3910	.1553	.1940	.3881	.2106	.2631	.1562	.1957	.4046	.2065	.2587	.1996	.2222	.7385	.1720	.1915	1276
4	.1539	.1737	.1057	.3552	.4008	.1662	.1959	.3455	.2349	.2768	.1664	.1972	.3617	.2294	.2719	.2015	.2153	.6658	.1862	.1989	114
2	.1793	.1807	.0858	.4023	.4053	.1749	.1917	.2831	.2692	.2951	.1733	.1925	.2971	.2615	.2904	.1947	.2012	.5493	.2060	.2129	112
4/8	.0760	.0949	.0865	.2953	.3688	.0946	.1172	.2747	.1945	.2409	.0954	.1183	.2855	.1911	.2370	.1276	.1383	.5183	.1627	.1764	1273
8	.0735	.0906	.0823	.2983	.3677	.0900	.1119	.2610	.1945	.2418	.0907	.1131	.2710	.1910	.2382	.1206	.1328	.4908	.1620	.1785	2052
6	.0868	.1067	.0877	.3087	.3795	.1045	.1287	.2806	.2033	.2506	.1052	.1299	.2921	.1995	.2464	.1375	.1493	.5322	.1679	.1823	776
4	.1163	.1278	.0805	.3583	.3937	.1237	.1447	.2621	.2331	.2728	.1236	.1457	.2749	.2271	.2677	.1505	.1606	.5076	.1838	.1962	914
2	.1250	.1282	.0624	.3961	.4061	.1231	.1374	.2057	.2640	.2947	.1221	.1380	.2162	.2564	.2897	.1388	.1455	.4007	.2026	.2124	777
3/6	.0509	.0644	.0586	.2927	.3704	.0626	.0802	.1830	.1920	.2463	.0628	.0809	.1894	.1886	.2430	.0833	.0954	.3411	.1603	.1835	494
4	.0510	.0599	.0425	.3326	.3904	.0574	.0700	.1363	.2177	.2656	.0576	.0706	.1422	.2129	.2612	.0722	.0795	.2600	.1755	.1931	495
2	.0627	.0658	.0346	.3844	.4036	.0635	.0715	.1140	.2551	.2872	.0633	.0719	.1199	.2481	.2819	.0736	.0765	.2227	.1975	.2053	496
2/2	.0335	.0349	.0180	.3877	.4038	.0330	.0381	.0583	.2552	.2946	.0326	.0383	.0611	.2474	.2900	.0374	.0412	.1124	.1960	.2157	779
10B 8/2	.6610	.6302	.2745	.4222	.4025	.6208	.6514	.9106	.2844	.2984	.6122	.6526	.9575	.2755	.2937	.6699	.6706	1.7770	.2149	.2151	942
7/6	.4053	.4205	.2348	.3821	.3965	.4150	.4576	.7761	.2517	.2776	.4133	.4599	.8145	.2449	.2725	.4851	.4906	1.5072	.1954	.1976	673
4	.4285	.4267	.2092	.4026	.4009	.4186	.4526	.6921	.2678	.2895	.4148	.4542	.7271	.2599	.2846	.4693	.4757	1.3474	.2047	.2075	780
6/6	.2806	.2995	.1824	.3680	.3928	.2969	.3320	.6015	.2413	.2699	.2965	.3339	.6310	.2351	.2647	.3571	.3612	1.1668	.1894	.1916	675
4	.3127	.3173	.1699	.3909	.3967	.3140	.3415	.5626	.2578	.2804	.3120	.3430	.5910	.2504	.2753	.3618	.3635	1.0954	.1987	.1996	781
5/6	.1714	.1877	.1316	.3493	.3825	.1907	.2132	.4344	.2275	.2543	.1913	.2146	.4555	.2221	.2491	.2397	.2366	0.8423	.1818	.1794	670
4	.1894	.1959	.1131	.3800	.3930	.1963	.2134	.3768	.2495	.2714	.1957	.2145	.3964	.2427	.2659	.2329	.2292	.7371	.1942	.1911	640
4/8	.0903	.1064	.1009	.3035	.3575	.1131	.1292	.3271	.1986	.2270	.1141	.1303	.3410	.1949	.2226	.1539	.1510	.6239	.1658	.1626	669
6	.1022	.1132	.0924	.3321	.3677	.1196	.1316	.3051	.2150	.2366	.1204	.1326	.3196	.2103	.2315	.1567	.1491	.5901	.1749	.1664	782

4	.1142	.1185	.0715	.3753	.3895	.1198	.1299	.2384	.2454	.2661	.1196	.1305	.2509	.2387	.2605	.1440	.1402	.4668	.1918	.1867	652
3/8	.0506	.0630	.0750	.2684	.3340	.0697	.0812	.2382	.1790	.2088	.0704	.0820	.2467	.1765	.2054	.0997	.0990	.4454	.1547	.1537	661
6	.0547	.0632	.0598	.3081	.3555	.0673	.0765	.1929	.1998	.2273	.0677	.0771	.2009	.1959	.2230	.0907	.0894	.3669	.1659	.1635	659
4	.0581	.0623	.0450	.3511	.3768	.0642	.0708	.1480	.2268	.2502	.0642	.0712	.1551	.2209	.2451	.0805	.0789	.2863	.1807	.1770	657
2/2	.0326	.0345	.0237	.3594	.3797	.0349	.0390	.0773	.2311	.2577	.0348	.0392	.0810	.2248	.2528	.0429	.0434	.1493	.1822	.1841	943a
PB 8/2	.6675	.6223	.2709	.4277	.3987	.6218	.6380	.9034	.2875	.2949	.6122	.6386	.9509	.2781	.2900	.6686	.6535	1.7686	.2163	.2114	808
7/6	.4482	.4311	.2329	.4030	.3876	.4430	.4556	.7802	.2639	.2714	.4390	.4567	.8211	.2557	.2660	.5074	.4794	1.5282	.2017	.1906	506
4	.4800	.4551	.2232	.4144	.3929	.4614	.4743	.7466	.2743	.2819	.4559	.4751	.7860	.2655	.2767	.5138	.4930	1.4635	.2080	.1996	786
2	.5079	.4771	.2097	.4251	.3994	.4757	.4907	.6988	.2857	.2947	.4688	.4914	.7354	.2765	.2898	.5137	.5037	1.3678	.2154	.2112	807
6/8	.3097	.3055	.1926	.3834	.3782	.3214	.3310	.6461	.2475	.2549	.3200	.3322	.6798	.2403	.2494	.3860	.3558	1.2655	.1923	.1773	1307
8	.3114	.3059	.2037	.3793	.3726	.3283	.3329	.6864	.2436	.2470	.3274	.3341	.7227	.2365	.2414	.4007	.3595	1.3476	.1901	.1706	513
6	.3297	.3184	.1918	.3926	.3791	.3364	.3404	.6472	.2541	.2571	.3345	.3413	.6818	.2464	.2514	.3986	.3621	1.2727	.1960	.1781	512
4	.3608	.3426	.1779	.4094	.3888	.3520	.3589	.5973	.2691	.2744	.3483	.3596	.6293	.2605	.2689	.3987	.3751	1.1736	.2048	.1926	787
2	.3587	.3338	.1532	.4241	.3947	.3383	.3432	.5132	.2831	.2873	.3336	.3436	.5407	.2739	.2821	.3694	.3528	1.0078	.2135	.2039	784
5/10	.1867	.1969	.1681	.3384	.3569	.2188	.2263	.5620	.2173	.2247	.2202	.2277	.5899	.2122	.2194	.2887	.2546	1.0945	.1763	.1554	1303
8	.2056	.2094	.1598	.3577	.3643	.2293	.2345	.5378	.2289	.2341	.2299	.2356	.5659	.2229	.2284	.2929	.2587	1.0544	.1824	.1611	517
6	.2090	.2063	.1347	.3800	.3751	.2202	.2241	.4551	.2448	.2492	.2198	.2250	.4797	.2377	.2434	.2687	.2414	0.8965	.1910	.1717	516
4	.2133	.2051	.1143	.4005	.3851	.2135	.2170	.3859	.2615	.2658	.2121	.2176	.4071	.2534	.2600	.2484	.2286	.7617	.2005	.1845	515
2	.2137	.2013	.0973	.4171	.3929	.2052	.2087	.3277	.2767	.2814	.2029	.2090	.3457	.2678	.2759	.2287	.2159	.6464	.2096	.1979	785
4/10	.1142	.1219	.1253	.3160	.3373	.1443	.1446	.4202	.2035	.2039	.1460	.1456	.4409	.1993	.1987	.2009	.1668	.8182	.1694	.1406	532
8	.1173	.1211	.1065	.3401	.3511	.1384	.1387	.3597	.2174	.2178	.1395	.1395	.3784	.2122	.2122	.1846	.1558	.7053	.1766	.1490	522
6	.1227	.1232	.0908	.3645	.3658	.1353	.1364	.3078	.2334	.2354	.1356	.1370	.3245	.2271	.2295	.1716	.1493	.6070	.1850	.1609	521
4	.1313	.1268	.0762	.3927	.3794	.1344	.1355	.2583	.2544	.2565	.1338	.1358	.2727	.2467	.2505	.1600	.1439	.5109	.1964	.1766	520
2	.1350	.1268	.0612	.4179	.3927	.1296	.1313	.2064	.2774	.2809	.1282	.1315	.2179	.2684	.2753	.1446	.1356	.4080	.2101	.1970	519
3/12	.0574	.0627	.0907	.2725	.2974	.0832	.0802	.2983	.1803	.1737	.0847	.0808	.3109	.1778	.1697	.1246	.0977	.5700	.1573	.1233	537
12	.0563	.0608	.0872	.2756	.2975	.0814	.0775	.2909	.1810	.1723	.0830	.0781	.3043	.1783	.1679	.1233	.0946	.5622	.1580	.1213	2053
10	.0651	.0692	.0836	.2987	.3175	.0871	.0844	.2790	.1934	.1873	.0884	.0850	.2921	.1899	.1825	.1257	.0995	.5400	.1643	.1300	534
8	.0621	.0649	.0686	.3175	.3319	.0786	.0768	.2306	.2036	.1990	.0796	.0773	.2421	.1994	.1938	.1099	.0886	.4500	.1695	.1366	532
6	.0661	.0663	.0568	.3493	.3506	.0763	.0749	.1923	.2222	.2180	.0768	.0753	.2025	.2166	.2123	.1007	.0834	.3784	.1790	.1483	530
4	.0659	.0643	.0441	.3779	.3689	.0703	.0699	.1500	.2422	.2409	.0702	.0701	.1583	.2352	.2348	.0871	.0755	.2968	.1896	.1643	528
2	.0698	.0660	.0345	.4100	.3876	.0685	.0689	.1168	.2695	.2711	.0679	.0690	.1234	.2608	.2652	.0783	.0718	.2315	.2052	.1882	526
2/6	.0326	.0337	.0377	.3138	.3238	.0412	.0405	.1251	.1993	.1959	.0416	.0407	.1310	.1950	.1910	.0577	.0475	.2421	.1662	.1367	804
4	.0330	.0334	.0309	.3395	.3432	.0388	.0385	.1033	.2150	.2129	.0390	.0386	.1085	.2096	.2076	.0518	.0436	.2015	.1745	.1469	805
2	.0342	.0329	.0204	.3906	.3759	.0352	.0353	.0689	.2523	.2530	.0350	.0353	.0726	.2447	.2473	.0419	.0376	.1356	.1950	.1747	806
2	.0363	.0353	.0231	.3834	.3725	.0378	.0383	.0776	.2459	.2490	.0376	.0384	.0817	.2384	.2433	.0457	.0413	.1524	.1910	.1724	--------
10PB 8/2	.7035	.6393	.2801	.4335	.3940	.6498	.6499	.9357	.2907	.2907	.6384	.6496	.9846	.2809	.2858	.6949	.6625	1.8314	.2179	.2078	945
7/6	.4889	.4300	.2155	.4309	.3791	.4598	.4365	.7316	.2825	.2681	.4519	.4357	.7717	.2723	.2626	.5077	.4463	1.4440	.2117	.1861	796
4	.5023	.4454	.2019	.4369	.3875	.4634	.4498	.6798	.2909	.2824	.4547	.4491	.7163	.2807	.2772	.4982	.4571	1.3366	.2174	.1994	790
6/8	.3680	.3132	.1952	.4199	.3574	.3623	.3200	.6768	.2666	.2534	.3577	.3190	.7165	.2567	.2290	.4253	.3310	1.3520	.2017	.1570	800
6	.3587	.3100	.1751	.4251	.3673	.3447	.3161	.5988	.2737	.2509	.3392	.3152	.6322	.2637	.2450	.3920	.3258	1.1860	.2059	.1712	797a
4	.3849	.3354	.1681	.4332	.3776	.3606	.3394	.5708	.2838	.2671	.3541	.3385	.6023	.2735	.2614	.3974	.3467	1.1278	.2123	.1852	791
5/10	.2291	.1933	.1503	.4001	.3375	.2413	.2014	.5291	.2483	.2072	.2401	.2009	.5616	.2395	.2004	.3038	.2126	1.0662	.1920	.1344	803
8	.2419	.2054	.1464	.4075	.3460	.2476	.2126	.5110	.2550	.2189	.2455	.2121	.5415	.2457	.2123	.3029	.2230	1.0244	.1954	.1439	801
6	.2423	.2090	.1309	.4162	.3589	.2399	.2149	.4519	.2645	.2371	.2369	.2144	.4780	.2549	.2307	.2822	.2235	0.9006	.2007	.1589	798a
4	.2467	.2144	.1167	.4270	.3711	.2363	.2180	.3999	.2766	.2553	.2327	.2175	.4227	.2666	.2492	.2675	.2238	.7948	.2080	.1740	792
4/10	.1439	.1174	.1035	.3944	.3217	.1563	.1224	.3688	.2414	.1890	.1560	.1220	.3923	.2327	.1820	.2038	.1300	.7483	.1884	.1201	696
8	.1490	.1241	.0996	.3998	.3329	.1578	.1291	.3517	.2470	.2021	.1570	.1287	.3736	.2381	.1952	.2001	.1364	.7103	.1912	.1303	802
6	.1512	.1281	.0890	.4106	.3479	.1535	.1321	.3104	.2576	.2217	.1520	.1317	.3290	.2481	.2150	.1863	.1381	.6227	.1967	.1458	799
4	.1468	.1264	.0732	.4239	.3649	.1426	.1288	.2526	.2721	.2458	.1406	.1285	.2674	.2620	.2395	.1644	.1326	.5046	.2051	.1655	793
3/10	.0868	.0659	.0777	.3769	.2859	.1031	.0693	.2843	.2258	.1517	.1039	.0690	.3041	.2179	.1446	.1465	.0750	.5864	.1813	.0929	864
8	.0874	.0703	.0599	.4019	.3230	.0936	.0724	.2143	.2461	.1903	.0933	.0720	.2283	.2370	.1830	.1208	.0760	.4365	.1908	.1201	701

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*—Continued

Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
10PB 6	.0855	.0696	.0528	.4114	.3348	.0883	.0711	.1874	.2546	.2050	.0876	.0708	.1993	.2449	.1979	.1100	.0741	.3801	.1950	.1313	700
4	.0841	.0700	.0469	.418₂	.3483	.0841	.0713	.1643	.2630	.2232	.0831	.0711	.1743	.2530	.2163	.1009	.0739	.3308	.1996	.1461	794
2/6	.0433	.0351	.0277	.4081	.3306	.0455	.0358	.0988	.2529	.1985	.0454	.0356	.1051	.2437	.1916	.0574	.0372	.2002	.1947	.1261	707
4	.0447	.0370	.0281	.4074	.3369	.0466	.0380	.0992	.2535	.2067	.0463	.0378	.1054	.2444	.1997	.0581	.0397	.2005	.1949	.1331	878
P 8/4	.7006	.5974	.2643	.4484	.3824	.6318	.5940	.8897	.2986	.2808	.6167	.5913	.9372	.2875	.2756	.6671	.5984	1.7480	.2214	.1986	284
2	.6706	.5915	.2313	.4490	.3961	.5992	.5897	.7723	.3055	.3007	.5858	.5884	.8133	.2947	.2960	.6193	.5918	1.5143	.2272	.2171	282
7/6	.5577	.4476	.2133	.4577	.3673	.4972	.4381	.7256	.2994	.2638	.4824	.4341	.7654	.2868	.2581	.5274	.4391	1.4333	.2198	.1830	1337
4	.5314	.4492	.2013	.4496	.3801	.4790	.4457	.6795	.2986	.2778	.4674	.4434	.7162	.2873	.2725	.5072	.4487	1.3380	.2211	.1956	274
2	.4740	.4129	.1685	.4491	.3912	.4256	.4108	.5658	.3035	.2930	.4161	.4096	.5964	.2926	.2880	.4441	.4123	1.1132	.2255	.2093	272
6/8	.4211	.3232	.1848	.4533	.3479	.3846	.3157	.6363	.2877	.2362	.3735	.3118	.6721	.2751	.2297	.4246	.3187	1.2633	.2116	.1588	268
8	.4344	.3328	.1800	.4587	.3513	.3921	.3227	.6218	.2934	.2414	.3802	.3187	.6575	.2903	.2350	.4276	.3233	1.2384	.2149	.1625	2057
6	.4044	.3230	.1693	.4510	.3602	.3²81	.3179	.5788	.2910	.2514	.3582	.3150	.6111	.2789	.2453	.4009	.3211	1.1465	.2146	.1718	266
4	.3984	.3330	.1562	.4489	.3751	.3610	.3301	.5296	.2958	.2704	.3522	.32²2	.5588	.2843	.2648	.3863	.3329	1.0460	.2183	.1886	264
2	.3764	.3257	.1368	.4487	.3882	.3391	.3238	.4610	.3017	.2881	.3315	.3227	.4863	.2907	.2830	.3563	.3253	0.9092	.2240	.2045	262
5/10	.3004	.2129	.1422	.4583	.3248	.2768	.2039	.5008	.2820	.2078	.2680	.2002	.5310	.2883	.2003	.3156	.2049	1.0065	.2067	.1342	228
8	.2930	.2177	.1313	.4564	.3391	.2682	.2107	.4574	.2864	.2250	.2601	.2076	.4843	.2732	.2181	.2998	.2120	0.9150	.2102	.1486	226
6	.2612	.2018	.1094	.4563	.3526	.2368	.1965	.3774	.2921	.2424	.2299	.1942	.3992	.2793	.2359	.2591	.1974	.7520	.2144	.1633	224
4	.2413	.1964	.0964	.4518	.3677	.2188	.1934	.3297	.2950	.2606	.2133	.1919	.3484	.2830	.2546	.2362	.1945	.6545	.2176	.1792	222
2	.2299	.1976	.0833	.4500	.3868	.2070	.1959	.2818	.3023	.2861	.2024	.1952	.2975	.2912	.2808	.2179	.1964	.5574	.2243	.2021	220
4/12	.2177	.1362	.1054	.4740	.29⁶6	.1966	.1252	.3748	.2823	.1797	.1885	.1213	.3976	.2665	.1715	.2256	.1243	.7550	.2042	.1125	693
12	.23⁸1	.1474	.1060	.4844	.2999	.2101	.1336	.3802	.2902	.1845	.2007	.1292	.4041	.2733	.1759	.2372	.1307	.7721	.2081	.1146	2058
10	.2027	.1373	.0930	.4681	.3171	.1832	.1292	.3276	.2863	.2019	.1763	.1261	.3471	.2714	.1942	.2065	.1289	.6577	.2079	.1298	250
8	.1851	.1339	.0829	.4605	.3332	.1704	.1278	.2954	.2871	.2153	.1655	.1258	.3146	.2732	.2076	.1938	.1270	.6011	.2102	.1377	816
6	.1700	.1282	.0721	.4590	.3463	.1539	.1240	.2503	.2914	.2348	.1492	.1223	.2649	.2781	.2281	.1694	.1243	.5001	.2134	.1566	246
4	.1668	.1322	.0654	.4578	.3628	.1496	.1289	.2240	.2977	.2566	.1453	.1277	.2367	.2851	.2505	.1605	.1291	.4449	.2186	.1758	244
2	.1481	.1262	.0545	.4506	.3837	.1337	.1248	.1850	.3015	.2814	.1308	.1243	.1955	.2903	.2759	.1416	.1250	.3670	.2235	.1973	242
3/10	.1360	.0843	.0687	.4706	.2918	.1263	.0769	.2514	.2779	.1692	.1221	.0746	.2686	.2624	.1603	.1506	.0756	.5174	.2025	.1017	1319
8	.1189	.0806	.0579	.4620	.3133	.1105	.0759	.2072	.2807	.1929	.1070	.0743	.2204	.2664	.1850	.1284	.0756	.4207	.2055	.1210	298
6	.1079	.0777	.0502	.4576	.3295	.0999	.0744	.1778	.2837	.2113	.0970	.0732	.1889	.2701	.2039	.1141	.0744	.3593	.2083	.1358	296
4	.0966	.0730	.0414	.4579	.3460	.0881	.0705	.1446	.2906	.2325	.0856	.0696	.1533	.2774	.2257	.0977	.0704	.2900	.2132	.1538	294
2	.0909	.0749	.0341	.4546	.3746	.0817	.0736	.1166	.3006	.2706	.0797	.0731	.1232	.2887	.2650	.0869	.0735	.2313	.2218	.1877	292
2/6	.0544	.0371	.0259	.4631	.3160	.0511	.0346	.0955	.2820	.1911	.0498	.0340	.1024	.2676	.1824	.0606	.0340	.1985	.2068	.1160	306
4	.0503	.0373	.0223	.4577	.3398	.0467	.0358	.0796	.2879	.2208	.0455	.0353	.0849	.2746	.2132	.0532	.0355	.1627	.2116	.1412	1313
4	.0551	.0410	.0248	.4558	.3393	.0515	.0394	.0885	.2869	.2196	.0502	.0389	.0944	.2738	.2119	.0590	.0392	.1808	.2113	.1405	2059
2	.0460	.0363	.0184	.4569	.3599	.0422	.0351	.0650	.2966	.2466	.0412	.0348	.0691	.2843	.2397	.0465	.0347	.1316	.2186	.1632	877
2	.0503	.0390	.0208	.4564	.3544	.0460	.0378	.0733	.2930	.2406	.0450	.0374	.0779	.2804	.2335	.0511	.0376	.1483	.2157	.1587	2060
10P 8/4	.7343	.6280	.2446	.4570	.3908	.6490	.6182	.8230	.3105	.2958	.6327	.6158	.8677	.2990	.2910	.6667	.6146	1.6201	.2298	.2118	810
7/8	.6373	.4972	.1983	.4782	.3731	.5445	.4735	.6745	.3217	.2798	.5251	.4679	.7121	.3079	.2744	.5498	.4635	1.3347	.2342	.1974	1541
6	.5944	.4839	.1886	.4692	.3820	.5152	.4675	.6383	.3178	.2884	.4995	.4640	.6736	.3051	.2834	.5233	.4606	1.2607	.2331	.2052	1540
4	.5797	.4799	.1837	.4662	.3860	.5048	.4657	.6210	.3172	.2926	.4907	.4628	.6554	.3050	.2877	.5134	.4593	1.2268	.2334	.2088	1539

6/8	.4729	.3471	.1520	.4866	.3571	.4011	.3245	.5250	.3207	.2595	.3847	.3191	.5558	.3054	.2533	.4093	.3152	1.0485	.2309	.1778	1538
6	.4544	.3487	.1447	.4795	.3679	.3887	.3307	.4951	.3200	.2723	.3745	.3265	.5233	.3059	.2667	.3952	.3230	.9833	.2323	.1898	1537
4	.4220	.3372	.1332	.4729	.3779	.3637	.3238	.4515	.3193	.2843	.3518	.3209	.4764	.3062	.2792	.3683	.3179	.8916	.2334	.2015	1536
5/10	.3908	.2520	.1140	.5164	.3330	.3161	.2226	.3999	.3368	.2371	.2979	.2154	.4244	.3178	.2297	.3141	.2097	.8051	.2364	.1578	1535
8	.3559	.2406	.1052	.5072	.3429	.2905	.2174	.3644	.3331	.2492	.2751	.2116	.3858	.3153	.2425	.2886	.2075	.7286	.2356	.1694	1534
6	.3236	.2315	.0955	.4974	.3558	.2688	.2129	.3299	.3312	.2623	.2568	.2088	.3494	.3151	.2562	.2684	.2044	.6592	.2371	.1806	1533
4	.2985	.2277	.0904	.4841	.3693	.2534	.2143	.3098	.3259	.2757	.2441	.2116	.3274	.3117	.2702	.2549	.2079	.6154	.2364	.1928	1532
4/10	.2542	.1546	.0759	.5244	.3190	.2045	.1331	.2713	.3359	.2186	.1920	.1278	.2890	.3154	.2100	.2060	.1236	.5528	.2334	.1401	1531
8	.2419	.1581	.0734	.5110	.3340	.1983	.1406	.2589	.3317	.2352	.1878	.1364	.2752	.3133	.2276	.2003	.1330	.5238	.2337	.1551	1530
6	.2232	.1548	.0678	.5006	.3472	.1860	.1407	.2377	.3295	.2493	.1775	.1375	.2525	.3128	.2424	.1885	.1343	.4796	.2349	.1674	1529
4	.2031	.1525	.0627	.4855	.3646	.1730	.1428	.2170	.3247	.2680	.1668	.1408	.2299	.3102	.2620	.1759	.1381	.4342	.2350	.1846	1528
3/10	.1328	.0765	.0461	.5199	.2996	.1101	.0648	.1694	.3198	.1883	.1038	.0619	.1814	.2990	.1784	.1175	.0599	.3508	.2224	.1135	1527
8	.1331	.0810	.0431	.5175	.3149	.1095	.0700	.1560	.3265	.2087	.1034	.0674	.1666	.3065	.1996	.1139	.0652	.3205	.2279	.1306	1526
6	.1191	.0798	.0406	.4972	.3332	.1011	.0722	.1448	.3179	.2270	.0966	.0704	.1543	.3007	.2191	.1064	.0691	.2952	.2261	.1469	1525
4	.1117	.0795	.0354	.4927	.3510	.0948	.0731	.1245	.3242	.2500	.0910	.0718	.1324	.3084	.2430	.0977	.0702	.2524	.2325	.1670	1524
2/6	.0670	.0426	.0244	.4999	.3178	.0579	.0377	.0898	.3123	.2032	.0555	.0366	.0964	.2945	.1941	.0634	.0355	.1869	.2217	.1243	1523
2	.0601	.0407	.0216	.4910	.3327	.0521	.0370	.0779	.3119	.2215	.0501	.0362	.0834	.2954	.2133	.0563	.0354	.1606	.2230	.1404	723
RP 8/6	.7512	.6268	.2126	.4723	.3941	.6411	.6058	.7081	.3279	.3099	.6215	.6019	.7454	.3157	.3057	.6316	.5947	1.3862	.2418	.2276	1369
4	.7344	.6219	.2144	.4676	.3959	.6321	.6050	.7136	.3240	.3101	.6140	.6019	.7511	.3122	.3060	.6272	.5961	1.3963	.2394	.2276	1368
2	.7511	.6548	.2244	.4607	.4017	.6540	.6435	.7454	.3201	.3150	.6375	.6417	.7844	.3089	.3110	.6531	.6368	1.4572	.2377	.2318	1367
7/8	.6536	.5137	.1760	.4866	.3824	.5474	.4845	.5937	.3367	.2980	.5277	.4792	.6264	.3231	.2934	.5346	.4690	1.1712	.2458	.2157	1366
6	.6500	.5213	.1776	.4819	.3864	.5482	.4955	.5975	.3340	.3019	.5297	.4910	.6301	.3209	.2974	.5373	.4814	1.1771	.2447	.2192	1365
4	.6096	.5070	.1719	.4731	.3935	.5214	.4885	.5757	.3288	.3081	.5061	.4857	.6068	.3166	.3038	.5151	.4777	1.1319	.2424	.2248	1364
2	.5671	.4851	.1660	.4655	.3982	.4913	.4727	.5547	.3235	.3113	.4786	.4710	.5845	.3119	.3070	.4898	.4651	1.0893	.2396	.2275	1363
6/10	.5504	.3810	.1278	.5197	.3597	.4384	.3389	.4388	.3605	.2787	.4160	.3307	.4644	.3435	.2731	.4139	.3173	0.8747	.2577	.1976	1362
8	.5213	.3715	.1229	.5132	.3658	.4186	.3349	.4197	.3568	.2855	.3987	.3282	.4438	.3406	.2804	.3963	.3152	.8344	.2563	.2039	575
6	.4803	.3622	.1202	.4989	.3762	.3951	.3345	.4084	.3472	.2939	.3794	.3298	.4316	.3326	.2891	.3805	.3192	.8102	.2520	.2114	1360
4	.4552	.3641	.1247	.4822	.3857	.3850	.3454	.4214	.3343	.2998	.3726	.3424	.4450	.3212	.2952	.3789	.3347	.8333	.2449	.2164	1359
2	.3851	.3263	.1133	.4670	.3957	.3337	.3169	.3799	.3238	.3075	.3250	.3156	.4006	.3121	.3031	.3335	.3112	.7476	.2395	.2235	1358
5/10	.4308	.2724	.0840	.5472	.3460	.3283	.2301	.2934	.3854	.2702	.3073	.2219	.3116	.3655	.2639	.2980	.2074	.5915	.2717	.1890	1357
8	.3813	.2537	.0824	.5316	.3536	.2984	.2206	.2858	.3708	.2741	.2818	.2143	.3031	.3525	.2682	.2778	.2029	.5739	.2634	.1924	1356
6	.3330	.2346	.0772	.5164	.3620	.2670	.2099	.2661	.3593	.2826	.2542	.2055	.2820	.3428	.2771	.2531	.1964	.5327	.2577	.1999	1355
4	.2968	.2271	.0768	.4941	.3780	.2470	.2110	.2623	.3429	.2929	.2379	.2084	.2776	.3287	.2879	.2406	.2017	.5222	.2494	.2091	1354
2	.2692	.2225	.0762	.4740	.3918	.2304	.2138	.2559	.3291	.3054	.2237	.2125	.2698	.3169	.3010	.2280	.2089	.5035	.2425	.2221	1353
4/12	.3037	.1734	.0573	.5683	.3245	.2231	.1396	.2029	.3945	.2467	.2050	.1322	.2158	.3707	.2390	.1985	.1220	.4114	.2712	.1667	1352
10	.2776	.1650	.0547	.5582	.3318	.2072	.1359	.1934	.3862	.2534	.1916	.1297	.2059	.3634	.2461	.1871	.1206	.3932	.2670	.1721	1351
8	.2503	.1577	.0530	.5429	.3421	.1921	.1341	.1873	.3742	.2612	.1796	.1294	.1995	.3532	.2544	.1778	.1212	.3812	.2612	.1782	1350
6	.2365	.1598	.0553	.5236	.3539	.1881	.1406	.1918	.3614	.2701	.1784	.1371	.2033	.3439	.2642	.1783	.1304	.3846	.2572	.1881	554
4	.2104	.1550	.0538	.5019	.3698	.1734	.1418	.1855	.3464	.2833	.1665	.1397	.1966	.3311	.2778	.1688	.1344	.3717	.2501	.1991	1348
2	.1847	.1509	.0528	.4755	.3886	.1582	.1445	.1785	.3288	.3002	.1536	.1435	.1885	.3163	.2955	.1575	.1408	.3531	.2418	.2161	1347
3/10	.1654	.0932	.0311	.5710	.3217	.1209	.0743	.1126	.3928	.2413	.1110	.0703	.1206	.3677	.2329	.1084	.0642	.2327	.2674	.1583	1346
8	.1445	.0858	.0288	.5576	.3312	.1082	.0706	.1033	.3836	.2502	.1003	.0674	.1103	.3607	.2425	.0987	.0623	.2120	.2646	.1671	1345
6	.1210	.0776	.0257	.5396	.3460	.0935	.0664	.0906	.3732	.2652	.0877	.0643	.0965	.3529	.2586	.0868	.0603	.1845	.2619	.1818	1344
4	.1087	.0757	.0257	.5174	.3602	.0873	.0675	.0895	.3573	.2762	.0831	.0660	.0952	.3401	.2702	.0835	.0629	.1809	.2552	.1923	1370
2	.0884	.0695	.0243	.4851	.3816	.0749	.0654	.0831	.3351	.2930	.0725	.0648	.0880	.3217	.2879	.0742	.0631	.1657	.2448	.2081	1343
2/6	.0843	.0520	.0199	.5397	.3328	.0656	.0440	.0721	.3609	.2421	.0615	.0424	.0773	.3395	.2339	.0630	.0397	.1493	.2500	.1576	1342
4	.0736	.0476	.0170	.5327	.3445	.0577	.0411	.0605	.3621	.2582	.0543	.0399	.0646	.3421	.2511	.0549	.0376	.1239	.2537	.1736	1341
2	.0565	.0420	.0145	.5002	.3715	.0465	.0386	.0499	.3442	.2859	.0445	.0380	.0529	.3287	.2806	.0452	.0367	.0999	.2484	.2018	1340
10RP 8/6	.7907	.6533	.2106	.4779	.3949	.6712	.6251	.7068	.3351	.3121	.6513	.6215	.7456	.3227	.3079	.6562	.6066	1.3929	.2471	.2284	853
4	.7438	.6301	.2084	.4701	.3982	.6378	.6107	.6948	.3282	.3143	.6198	.6079	.7320	.3163	.3102	.6287	.5987	1.3630	.2427	.2311	1392
7/8	.6363	.4810	.1415	.5055	.3821	.5152	.4412	.4777	.3593	.3077	.4941	.4354	.5045	.3445	.3036	.4830	.4169	0.9452	.2618	.2259	1391

TABLE 2.—*Tristimulus specifications and trilinear coordinates of the Munsell standards for the four illuminants, A, C, "D," and "S," based on spectrophotometric data obtained at the National Bureau of Standards*—Continued

Munsell notation	For ICI illuminant A					For ICI illuminant C					For illuminant "D"					For illuminant "S"					Munsell painting number
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y	
10RP 6	.6237	.4877	.1483	.4951	.3871	.5129	.4551	.4983	.3498	.3104	.4935	.4502	.5257	.3359	.3064	.4873	.4350	.9820	.2559	.2284	1390
4	.5697	.4632	.1458	.4833	.3930	.4789	.4397	.4896	.3401	.3122	.4639	.4368	.5166	.3273	.3082	.4639	.4244	.9653	.2503	.2290	1389
6/10	.5586	.3737	.0953	.5435	.3637	.4255	.3210	.3256	.3969	.2994	.4009	.3123	.3447	.3790	.2952	.3764	.2902	.6492	.2861	.2205	1388
8	.5182	.3668	.1004	.5259	.3722	.4066	.3248	.3414	.3790	.3027	.3867	.3183	.3612	.3627	.2986	.3703	.2998	.6792	.2745	.2222	1387
6	.4751	.3553	.1039	.5085	.3803	.3835	.3240	.3521	.3620	.3057	.3676	.3195	.3721	.3471	.3016	.3589	.3049	.6983	.2635	.2238	1386
4	.4356	.3451	.1083	.4900	.3882	.3627	.3239	.3652	.3448	.3080	.3504	.3212	.3855	.3315	.3039	.3491	.3107	.7215	.2527	.2249	1385
5/10	.4431	.2690	.0594	.5743	.3486	.3208	.2180	.2048	.4315	.2931	.2971	.2088	.2173	.4108	.2887	.2691	.1888	.4111	.3097	.2173	1384
8	.4005	.2540	.0591	.5612	.3560	.2966	.2111	.2040	.4168	.2966	.2771	.2039	.2165	.3973	.2923	.2549	.1856	.4103	.2996	.2182	1383
6	.3638	.2512	.0657	.5344	.3691	.2819	.2191	.2251	.3882	.3018	.2673	.2143	.2386	.3712	.2976	.2536	.1996	.4504	.2806	.2210	1382
4	.3229	.2463	.0717	.5038	.3843	.2634	.2260	.2435	.3594	.3083	.2537	.2235	.2576	.3452	.3042	.2484	.2130	.4843	.2627	.2252	1381
4/10	.2988	.1724	.0384	.5864	.3383	.2119	.1358	.1345	.4395	.2817	.1943	.1289	.1431	.4167	.2764	.1754	.1151	.2728	.3114	.2044	1380
8	.2649	.1625	.0402	.5665	.3475	.1948	.1332	.1400	.4163	.2846	.1810	.1278	.1488	.3955	.2793	.1678	.1164	.2829	.2959	.2053	1379
6	.2310	.1495	.0379	.5521	.3574	.1740	.1262	.1312	.4035	.2924	.1633	.1222	.1393	.3844	.2876	.1532	.1125	.2643	.2890	.2123	1378
4	.1947	.1420	.0412	.5153	.3758	.1561	.1277	.1409	.3676	.3006	.1495	.1257	.1493	.3521	.2962	.1457	.1189	.2814	.2668	.2178	1377
3/10	.1756	.0958	.0237	.5952	.3246	.1223	.0735	.0849	.4356	.2621	.1107	.0690	.0907	.4094	.2552	.1010	.0612	.1744	.3002	.1818	1376
8	.1502	.0875	.0210	.5805	.3383	.1074	.0698	.0742	.4273	.2776	.0986	.0664	.0791	.4039	.2719	.0904	.0597	.1513	.3000	.1979	1375
6	.1371	.0856	.0219	.5603	.3500	.1016	.0712	.0765	.4075	.2855	.0945	.0685	.0814	.3867	.2803	.0885	.0628	.1550	.2889	.2051	1374
4	.1057	.0743	.0215	.5247	.3686	.0834	.0658	.0741	.3735	.2945	.0793	.0644	.0787	.3566	.2896	.0771	.0607	.1489	.2689	.2118	1373
2/6	.0844	.0506	.0152	.5620	.3367	.0626	.0416	.0544	.3949	.2621	.0579	.0397	.0581	.3718	.2551	.0558	.0364	.1115	.2740	.1788	1372
4	.0676	.0453	.0140	.5326	.3571	.0526	.0395	.0491	.3726	.2799	.0496	.0385	.0522	.3536	.2744	.0486	.0361	.0991	.2643	.1966	1371
N 9.6/	.9974	.9085	.3158	.4489	4089	8863	.9076	1.0461	.3121	.3196	.8684	.9075	1.1006	.3019	.3155	8983	.9066	2.0429	.2335	.2356	60
No. 57	.9166	.8344	.2867	.4498	.4095	.8123	.8329	0.9476	.3133	.3212	.7955	.8328	0.9966	.3031	.3173	.8201	.8313	1.8482	.2343	.2376	1486
N 9.4/	.9171	.8333	.2859	.4504	.4092	.8119	.8311	.9455	.3137	.3211	.7950	.8310	9944	.3034	.3171	.8193	.8292	1.8445	.2346	.2374	1486
N 9/	.7994	.7266	.2529	.4494	.4085	.7095	.7256	.8367	.3123	.3194	.6948	.7254	.8801	.3021	.3153	.7183	.7247	1.6330	.2335	.2356	1177
N 8/	.6315	.5759	.1966	.4498	.4102	.5591	.5751	.6484	.3136	.3226	.5474	.5750	.6815	.3035	.3188	.5632	.5741	1.2625	.2347	.2392	1176
N 7/	.4839	.4424	.1590	.4459	.4077	.4337	.4433	.5285	.3086	.3154	.4257	.4434	.5565	.2986	.3111	.4444	.4438	1.0349	.2311	.2308	1175
N 6/	.3324	.3032	.1076	.4473	.4079	.2972	.3032	.3579	.3102	.3164	.2916	.3033	.3768	.3001	.3121	.3036	.3030	0.7010	.2322	.2317	1071
N 5/	.2085	.1904	.0687	.4459	.4072	.1872	.1906	.2292	.3084	.3140	.1838	.1907	.2415	.2984	.3095	.1924	.1907	.4501	.2309	.2289	997
N 4/	.1323	.1207	.0438	.4457	.4068	.1189	.1209	.1462	.3080	.3131	.1167	.1209	.1542	.2979	.3086	.1224	.1209	.2875	.2306	.2278	1070
N 3/	.0717	.0651	.0237	.4469	.4054	.0643	.0651	.0792	.3084	.3119	.0631	.0651	.0835	.2981	.3073	.0662	.0651	.1558	.2306	.2267	1171
N 2/	.0333	.0301	.0109	.4479	.4051	.0298	.0300	.0366	.3091	.3114	.0292	.0300	.0386	.2987	.3069	.0306	.0300	.0720	.2310	.2262	1068
N 1/	.0168	.0153	.0056	.4461	.4066	.0151	.0154	.0185	.3075	.3137	.0147	.0153	.0195	.2970	.3093	.0155	.0154	.0364	.2298	.2291	1169

Graphs similar to figures 2 to 8 could of course be plotted for the other illuminants, using the data given in table 2. While this has not been done for the present paper, it has seemed of interest to show the effect of the illuminant on the location and shape of the network. This is done in figure 9, where the values of x and y for Munsell value 5/ are plotted to the same scale for the four illuminants.
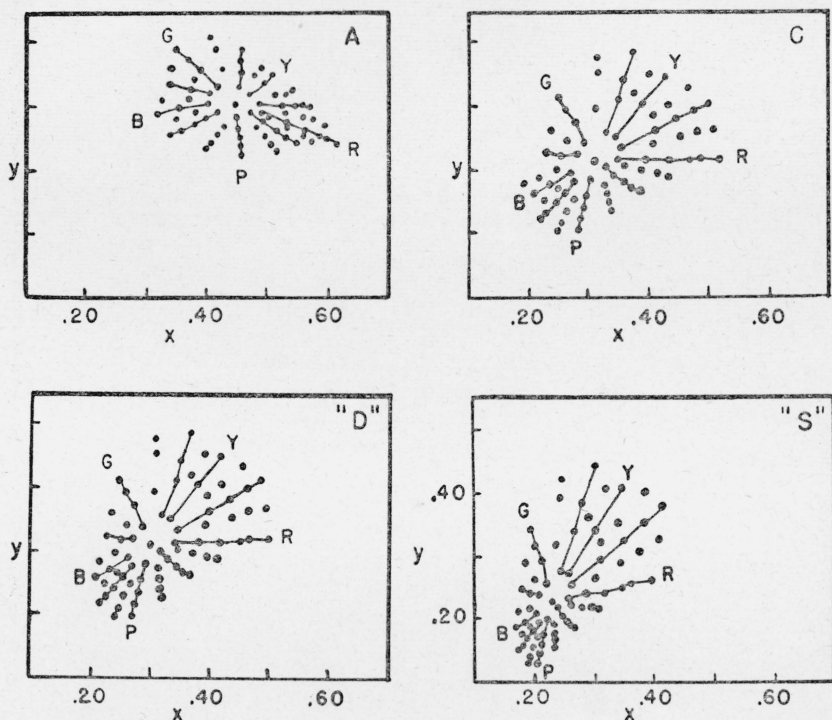

FIGURE 9.—*Values of x and y for samples of Munsell value 5/ for illuminants A, C, "D", and "S."*

This graph shows the effect of illuminant on the location and shape of the Munsell network.

V. COMPARISON WITH GLENN-KILLIAN DATA

Differences between the methods used by Glenn and Killian and those used at the National Bureau of Standards are understood to be as follows: (1) The Glenn-Killian spectrophotometric data were obtained with samples backed by "a standard white substance," the National Bureau of Standards data with samples backed with black paper, (2) the calibration curves (see above) run on each sheet at the National Bureau of Standards were not used by Glenn and Killian, and (3) the Glenn-Killian colorimetric computations were made by the selected-ordinate method, the NBS data by the weighted-ordinate method.

Spectrophotometric differences caused by the backing are illustrated in figure 10, in which are shown the curves obtained on four Munsell samples, each sample being run first with white backing and

then with black backing. The spectral reflections of the backings used for figure 10 are shown in the figure. It will be noted that the effect of backing becomes appreciable at wavelengths greater than 550 mμ approximately, if the values of apparent reflectance are greater than 0.60 or 0.65. (The slight separation of the curves for *PBP* 8/2
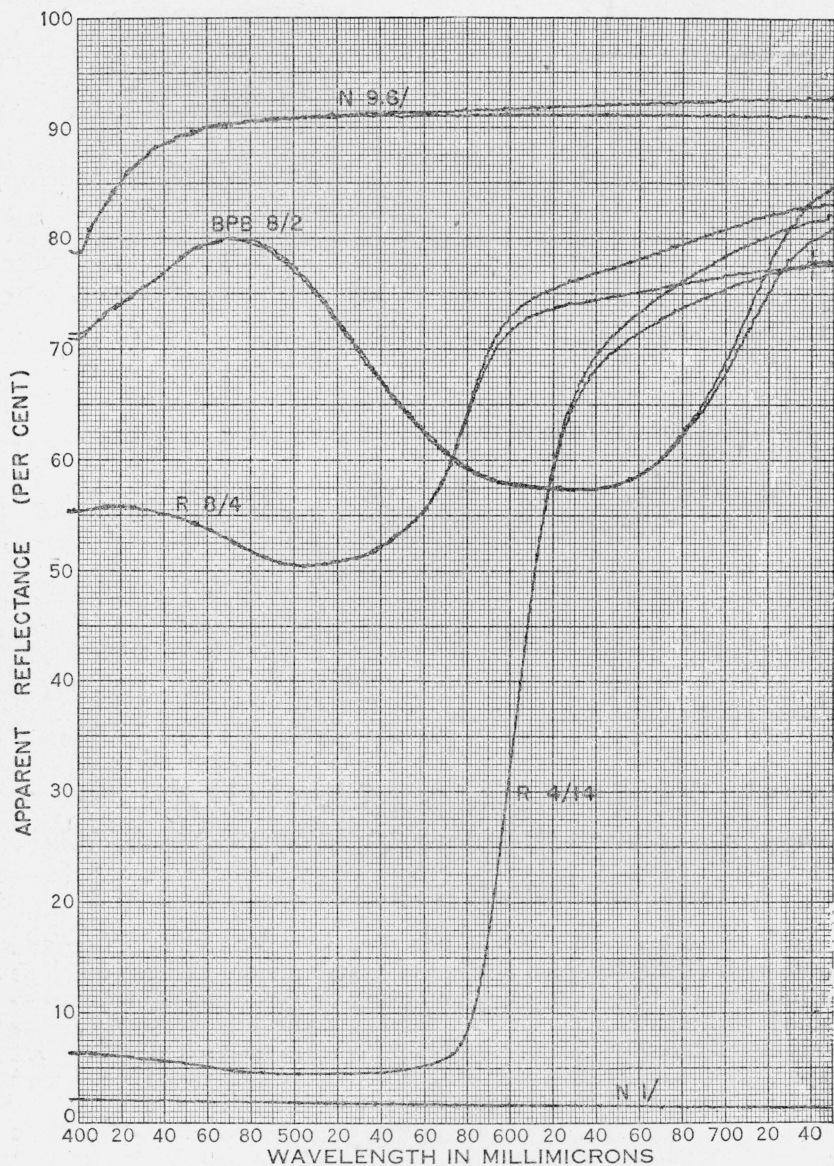
FIGURE 10.—*Effect of backing on the spectral apparent reflectance of Munsell samples.*

The upper curve of each pair was obtained with the sample backed with a white paper (*N* 9.6/), the lower curve with the sample backed with a black paper (*N*1/). Note that no difference in curves caused by difference in backing is apparent for values of reflectance less than 0.6 or at the shorter wavelengths.

between 480 and 600 mμ is not considered significant. It is probably caused by nonuniformity of the sample. Differences of this magnitude can be obtained when a sample is rerun with the same backing if the sample and backing have been removed and reinserted between runs.)

The effects of such spectrophotometric differences on the computed values of Y, x, and y are shown in table 3. Since these samples probably illustrate the maximum effects to be expected from the two backings, it is apparent that the differences in color caused by measurement with white or with black backing are mostly unimportant.

The use of calibration curves on each record sheet—those enabling corrections of wavelength errors, 100-percent and zero curve deviations, and aging of the MgO comparison surface, as used at the National Bureau of Standards—enables spectrophotometric data to be obtained with much less care and worry regarding certain details of operation than if these calibration curves were omitted. Omission of the curves makes it necessary for the operator to take great care, for example, in the insertion of the graph sheet in the instrument, in continually checking the wavelength calibration of the instrument, and in controlling or watching the graph paper for expansion or shrinkage with change of humidity. A new MgO comparison surface must be prepared each day, and the question of reproducibility of such surfaces thus enters. The possibility of erratic differences in results between the two investigations is thus present, but since different actual samples were measured, no further conclusions can be reached regarding the erratic differences between the Glenn-Killian and the National Bureau of Standards data.

TABLE 3.—*Effect of backing on colors of Munsell samples*

[Values are computed from the spectrophotometric curves shown in figure 10.]

Munsell sample	Values obtained with white backing minus values obtained with black backing		
	ΔY	Δx	Δy
R 4/14	+0.0007	+0.0010	−0.0002
R 8/4	+.0043	+.0023	+.0001
BPB 8/2	+.0000₁	+.0000₁	.0000₀
N 9.6/	+.0034	+.0007	+.0003

With respect to the differences between values of X, Y, Z, x, y, and z resulting from differences in computational procedure—30 selected ordinates, as against weighted ordinates at every $10m\mu$—it has been shown [21] that such differences are small for samples such as those considered here, much less than some of the differences shown. Only small and unimportant errors are therefore to be expected from this difference in computational procedure.

Detailed comparison of the values of x and y obtained by Glenn and Killian with those obtained at the National Bureau of Standards may be made by the inspection of figures 2 to 8 or by study of the published data. Only two additional points will be noted here.

1. Certain consistent differences in the respective chromaticities are apparent when the (x, y)-data for certain groups of samples having the

same hue designations (figs. 2 to 8) are replotted in a single graph, regardless of value level. This is particularly noticeable for the *10 GY, GY, P, 10 RP*, and *R* samples. However, although the maximum (x, y)-difference[4] between the Glenn-Killian and the National Bureau of Standards data is $\Delta x = 0.0143$ and $\Delta y = 0.0156$, inspection of figures 2 to 8 shows that in the great majority of cases there is good agreement between the two sets of data. Further effort to resolve the differences would seem unwarranted.

2. Differences in the average values of Y obtained in the two investigations are shown in table 4. The greatest ·differences are at the extremes. That for Munsell value 8/ may be caused partially by the differences in backing. That for Munsell value 2/ may indicate a real instrumental difference relating to the zero readings of the respective instruments; none of the 33 individual differences going into this average is negative. While the individual differences on which the values of table 4 are based reached a maximum of 0.036 (sample *P 7/2*), the final average value of $+0.002$ for all of the data is very small.[5]

TABLE 4.

Munsell value	Average differences in Y, Glenn-Killian values minus National Bureau of Standards values
8	+0.0031
7	+.0019
6	−.0006
5	+.0018
4	+.0020
3	+.0029
2	+.0039
Average	+0.002

VI. DERIVATION OF ISCC-NBS COLOR NAMES FROM ICI TRISTIMULUS DATA

The Munsell notations for chroma and hue may be determined from figures 2 to 8 for any color whose chromaticity falls within these diagrams by plotting its trilinear coordinates on the appropriate value-level diagrams and estimating the relative position of this point with respect to the points representing the nearest samples of constant hue and the nearest lines of constant chroma. The Munsell value of the color is found by interpolation or extrapolation between the values of apparent reflectance (Y) of the Munsell standards for illuminant *C* in table 2. By referring to the color-name charts in RP1239, the ISCC–NBS color name descriptive of that color will be found. Likewise, in disk colorimetry [21], given percentages of a certain set of disks may be transformed into trilinear coordinates, plotted in a similar manner, and the corresponding color name found. Thus the ISCC–

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[4] For *YR 2/2*. As is to be expected, the discrepancies in chromaticity are greatest at the lowest value level.
[5] Differences in Munsell value corresponding to the average differences in Y shown in table 4 are significant only at the lowest values. The difference, $\Delta Y = 0.0039$, corresponds to $\Delta V = 0.15$ at value level 2. It is believed that the NBS data are more reliable than the Glenn-Killian data at these low-value levels. For the neutral samples *N 1/, N 2/*, and *N 3/*, the Glenn-Killian values of Y are from 0.005 to 0.006 higher than the NBS values given in table 2. Independent check of these samples visually on the Priest-Lange reflectometer gave values lower than the Glenn-Killian values by 0.004, and closely agreeing with the NBS data of table 2.

NBS color name for a color may be found by the use of any spectrophotometer or colorimeter [22, 23] whose resultant values may be transformed into data based on the ICI standard observer and coordinate system. Likewise, any color system may be used as a comparison standard if the trilinear coordinates of each sample in that system are plotted on the (x, y)-diagrams and the ISCC–NBS color name determined through conversion to the Munsell notation.

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