ASTM INTERNATIONAL

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Standard Practice for
Specifying Color by Using the Optical Society of America Uniform Color Scales System[1]

This standard is issued under the fixed designation E1360; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

The Optical Society of America Uniform Color Scales (OSA-UCS) were developed by a committee of the Optical Society of America in the years between 1947 and 1974 in an effort to provide a system and a set of samples that represent the closest possible approximation to equal visual spacing (**1**).[2] The system is defined by a set of equations derived from the results of visual scaling experiments and related to the 1964 CIE system. The OSA sample set consisted of 558 atlas samples that fell at the lattice points of a rhombohedral close-packed arrangement within the color space defined by the equations. The unit in this spacing is a cuboctahedron, each color being surrounded by twelve equidistant nearest neighbors. See Fig. 1 and Fig. 2. Fig. 3 shows a OSA-UCS lightness plane plotted on the CIE 1964 chromaticity diagram. The OSA-UCS system is described in Appendix X1.

The system is independent of the OSA-UCS atlas samples, and other groups of samples could be chosen within the defined color space; however, for the visual determination of colors described in this standard, the OSA set of samples is used.

1. Scope

1.1 This practice provides a means for specifying the colors of objects in terms of the Optical Society of America Uniform Color Scales. Both computational and visual methods are included. The practice is limited to opaque objects, such as painted surfaces, viewed in daylight by an observer having normal color vision.

1.2 This practice does not cover the preparation of specimens. If the preparation of specimens is required in conjunction with this practice, a mutually agreed upon procedure shall be established.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]
D1535 Practice for Specifying Color by the Munsell System
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
E284 Terminology of Appearance
E308 Practice for Computing the Colors of Objects by Using the CIE System
E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *chromaticness, n*—an attribute of a visual sensation combining hue and chroma; the visual correlate of the colorimetric quantity chomaticity.

3.1.2 *hue, n*—the attribute of color perception by means of which an object is judged to be red, yellow, green, blue, or intermediate between some adjacent pair of these. In the OSA-UCS system each hue is denoted by its angle within a 360° circle beginning in the yellow direction on the right hand

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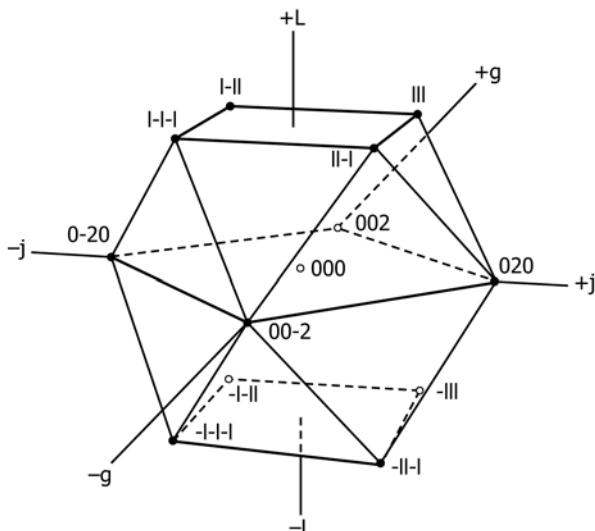
NOTE 1—Cuboctahedron showing location of *L, j,* and *g* axes through its center and the locations and *L, j, g* coordinates of the center point and its 12 nearest neighbors. The lattice of the OSA-UCS system is derived by extending this unit in all directions to the extremes of color space. In this drawing horizontal nearest-neighbor planes are emphasized with heavy lines. From Billmeyer, F. W., Jr., "Survey of Color Order Systems," *Color Research and Application*, Vol 12, (**2**). Copyright 1987, John Wiley & Sons.

FIG. 1 Cuboctahedron Showing Axes and Horizontal Planes
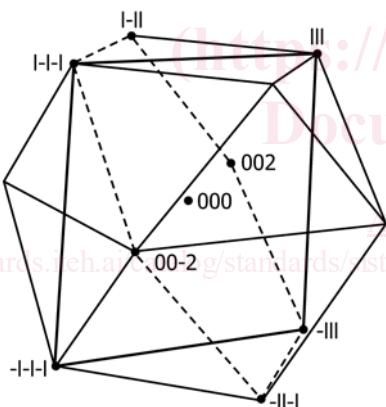
NOTE 1—Cuboctahedron of Fig. 1 showing a typical vertical plane () and a typical oblique plane (..........) containing nearest-neighbor colors. From Billmeyer, F. W., Jr., "Survey of Color Order Systems," *Color Research and Application*, Vol 12, (**2**). Copyright 1987, John Wiley & Sons.

FIG. 2 Cuboctahedron Showing Vertical and Oblique Planes

side of the hue circle and proceeding counterclockwise through the greens, blues, and reds to return to the yellow hue, 360, on the +*j* axis.

3.1.3 *OSA-UCS color system, n*—Optical Society of America Uniform Color Scales color order system based on equality of visual spacing, which uses the lightness scale ±*L* and the opponent-color scales ±*j*(yellowness-blueness) and ± *g*(greenness-redness). A color in the OSA-UCS system may be described by its *L, j, g* notation or by its lightness, *L*; hue angle, h_{OSA}, and chroma, c_{OSA}, designation.

NOTE 1—The conventional terms yellowness, greenness, blueness, and
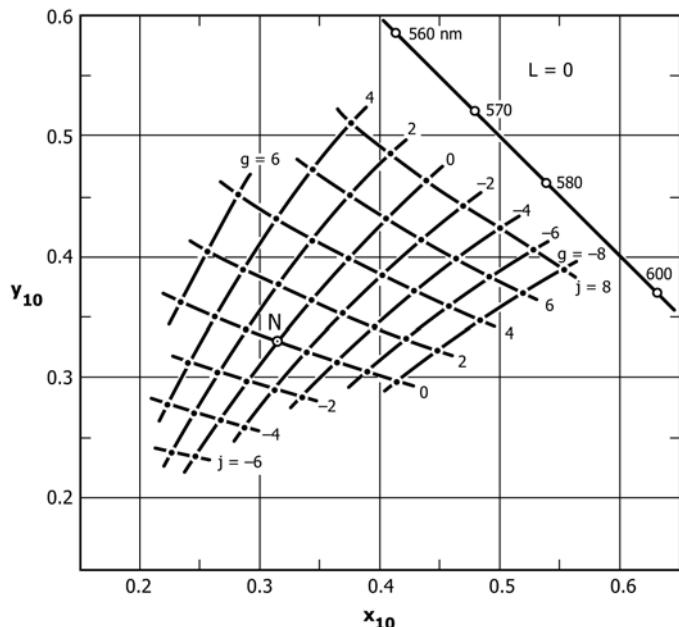
NOTE 1—CIE 1964 (x_{10}, y_{10})-chromaticity diagram showing chromaticity points (*j, g*) of colors of OSA Color System for lightness level *L* = 0. The chromaticity point *N* is that of the nominal gray (D_{65}) in the system. From Wyszecki, G., and Stiles, W. S., *Color Science*, 2nd ed., (**3**). Copyright 1982, John Wiley & Sons.

FIG. 3 OSA L = O Plane on the CIE 1964 Chromaticity Diagram

redness are used throughout this practice for convenience. However, this does not imply that the *j* and *g* axes indicate the locations of the corresponding unitary hues: The +*j* axis closely approximates the direction toward unitary yellow; but the +*g* axis divides the green and blue regions, the −*j* axis divides the blue and purple regions, and the −*g* axis locates pinks and magentas. It is probably best to think of *j* and *g* as abstract symbols unassociated with color names (**4**).

3.1.4 *OSA-UCS samples, n*—the Optical Society of America's physical exemplification of the OSA-UCS color system, which consisted of 558 samples displayed in a face-centered lattice in three-dimensional space such that each interior sample has 12 nearest neighbors at equal intervals from it. This configuration is sometimes referred to as a cuboctahedral or rhombohedral lattice.

3.2 *Definitions:*

3.2.1 The definitions in Practice D1535 and Terminology E284 are applicable to this practice.

4. Summary of Practice

4.1 *Computation Method*—CIE 1964 tristimulus values for standard illuminant D_{65} and the 1964 supplementary (10°) standard observer are obtained from spectrophotometric or colorimetric measurements. See Practice E308 and Practice E1164. Transformation equations (**5**) from CIE 1964 tristimulus values to OSA-UCS notations are given in Section 7, and the OSA-UCS notations and CIE specifications of the OSA atlas samples are given in Table 1.

4.2 *Visual Method*—Observers must have normal color vision. Specimens should be viewed on an essentially nonselective gray background of 30 % luminous reflectance, equivalent to the OSA-UCS notation *L = 0, j = 0, g = 0,* abbreviated

TABLE 1 CIE Specification for OSA-UCS Notations

OSA Lattice Coordinates			CIE Specifications			OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}	L	j	g	Y_{10}	x_{10}	y_{10}
A: Full-Step Colors						A: Full-Step Colors					
−7	−3	−1	3.22	0.2588	0.2169	0	−6		10.29	0.4236	0.2940
	−3	1	3.24	0.2152	0.2251	0	−4		10.83	0.3875	0.3053
						0	−2		11.25	0.3511	0.3176
	−1	−1	3.54	0.3113	0.2841	0	0		11.53	0.3139	0.3309
	−1	1	3.59	0.2569	0.3002	0	2		11.61	0.2756	0.3455
						0	4		11.45	0.2357	0.3617
	1	−1	3.79	0.3783	0.3571						
	1	1	3.92	0.3147	0.3858	2	−8		9.49	0.5132	0.3159
						2	−6		10.27	0.4751	0.3304
−6	−4	−2	4.85	0.2656	0.2044	2	−4		11.00	0.4363	0.3461
	−4	0	4.89	0.2304	0.2101	2	−2		11.62	0.3968	0.3631
	−4	2	4.88	0.1960	0.2164	2	0		12.04	0.3564	0.3816
						2	2		12.18	0.3145	0.4023
	−2	−4	5.05	0.3508	0.2471	2	4		11.97	0.2699	0.4262
	−2	−2	5.22	0.3090	0.2565						
	−2	0	5.32	0.2665	0.2670	4	−8		9.06	0.5677	0.3432
	−2	2	5.32	0.2239	0.2783	4	−6		9.97	0.5289	0.3627
						4	−4		10.89	0.4883	0.3837
	0	−6	4.85	0.4574	0.2841	4	−2		11.70	0.4466	0.4063
	0	−4	5.24	0.4103	0.2981	4	0		12.29	0.4038	0.4310
	0	−2	5.56	0.3626	0.3136	4	2		12.52	0.3592	0.4590
	0	0	5.75	0.3139	0.3309	4	4		12.29	0.3110	0.4927
	0	2	5.78	0.2632	0.3505						
						−3	−5	−1	13.44	0.2529	0.2238
	2	−6	5.00	0.5240	0.3260		−5	1	13.48	0.2276	0.2287
	2	−4	5.24	0.4774	0.3475		−5	3	13.45	0.2025	0.2339
	2	−2	5.73	0.4249	0.3710						
	2	0	6.06	0.3709	0.3974		−3	−5	13.71	0.3372	0.2488
	2	2	6.13	0.3139	0.4283		−3	−3	14.01	0.3088	0.2552
							−3	−1	14.21	0.2802	0.2621
−5	−5	−1	6.97	0.2402	0.1997		−3	1	14.30	0.2515	0.2694
	−5	1	6.99	0.2114	0.2044		−3	3	14.27	0.2224	0.2772
	−5	3	6.96	0.1829	0.2095		−3	5	14.11	0.1930	0.2855
	−3	−3	7.35	0.3069	0.2380		−1	−7	13.63	0.4063	0.2760
	−3	−1	7.48	0.2723	0.2454		−1	−5	14.18	0.3754	0.2845
	−3	1	7.52	0.2375	0.2533		−1	−3	14.64	0.3442	0.2937
	−3	3	7.48	0.2027	0.2619		−1	−1	14.97	0.3126	0.3035
							−1	1	15.14	0.2805	0.3140
	−1	−5	7.42	0.3907	0.2740		−1	3	15.12	0.2476	0.3254
	−1	−3	7.76	0.3516	0.2848		−1	5	14.89	0.2136	0.3377
	−1	−1	8.00	0.3122	0.2965						
	−1	1	8.10	0.2720	0.3093	1	−9		12.89	0.4840	0.2981
	−1	3	8.05	0.2305	0.3233	1	−7		13.71	0.4510	0.3089
						1	−5		14.47	0.4176	0.3206
	1	−7	6.95	0.4886	0.3026	1	−3		15.13	0.3839	0.3329
	1	−5	7.53	0.4463	0.3171	1	−1		15.62	0.3496	0.3465
	1	−3	8.04	0.4034	0.3329	1	1		15.90	0.3146	0.3609
	1	−1	8.43	0.3596	0.3503	1	3		15.90	0.2782	0.3771
	1	1	8.62	0.3147	0.3695	1	5		15.57	0.2397	0.3950
	1	3	8.56	0.2670	0.3916						
						3	−9		12.53	0.5328	0.3256
	3	−7	6.67	0.5505	0.3363	3	−7		13.53	0.4984	0.3399
	3	−5	7.39	0.5063	0.3568	3	−5		14.50	0.4631	0.3553
	3	−3	8.08	0.4604	0.3791	3	−3		15.37	0.4272	0.3717
	3	−1	8.65	0.4132	0.4035	3	−1		16.05	0.3906	0.3893
	3	1	8.96	0.3646	0.4307	3	1		16.46	0.3581	0.4087
	3	3	8.89	0.3127	0.4631	3	3		16.49	0.3139	0.4305
						3	5		16.03	0.2716	0.4561
−4	−4	−2	10.12	0.2758	0.2303						
	−4	0	10.20	0.2465	0.2362	5	−7		13.07	0.5465	0.3666
	−4	2	10.21	0.2172	0.2425	5	−5		14.21	0.5104	0.3863
	−4	4	10.13	0.1881	0.2492	5	−3		15.28	0.4732	0.4073
						5	−1		16.17	0.4349	0.4299
	−2	−4	10.45	0.3435	0.2642	5	1		16.72	0.3956	0.4548
	−2	−2	10.72	0.3104	0.2726	5	3		16.78	0.3543	0.4837
	−2	0	10.88	0.2770	0.2818	5	5		16.20	0.3092	0.5189
	−2	2	10.91	0.2430	0.2914						
	−2	4	10.80	0.2084	0.3022						
A: Full-Step Colors						A: Full-Step Colors					
−2	−6	0	17.31	0.2354	0.2183	1	−9		22.22	0.4541	0.3038
	−6	2	17.31	0.2133	0.2225	1	−7		23.26	0.4268	0.3129
						1	−5		24.20	0.3993	0.3226

3

TABLE 1 *Continued*

Left half:

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	−4	−2	18.10	0.2824	0.2474
	−4	0	18.23	0.2574	0.2531
	−4	2	18.26	0.2323	0.2591
	−4	4	18.18	0.2071	0.2655
	−2	−6	18.09	0.3658	0.2683
	−2	−4	18.58	0.3386	0.2754
	−2	−2	18.96	0.3112	0.2829
	−2	0	19.19	0.2836	0.2910
	−2	2	19.27	0.2555	0.2995
	−2	4	19.16	0.2268	0.3086
	−2	6	18.87	0.1977	0.3182
	0	−10	16.86	0.4609	0.2831
	0	−8	17.71	0.4320	0.2914
	0	−6	18.50	0.4029	0.3004
	0	−4	19.19	0.3736	0.3099
	0	−2	19.73	0.3440	0.3200
	0	0	20.10	0.3139	0.3309
	0	2	20.24	0.2831	0.3426
	0	4	20.12	0.2512	0.3553
	0	6	19.71	0.2180	0.3692
	2	−10	16.59	0.5043	0.3094
	2	−8	17.65	0.4739	0.3203
	2	−6	18.66	0.4430	0.3320
	2	−4	19.57	0.4118	0.3443
	2	−2	20.32	0.3801	0.3577
	2	0	20.84	0.3479	0.3719
	2	2	21.07	0.3147	0.3874
	2	4	20.93	0.2800	0.4046
	2	6	20.35	0.2430	0.4243
	4	−10	16.06	0.5486	0.3328
	4	−8	17.28	0.5175	0.3468
	4	−6	18.50	0.4853	0.3618
	4	−4	19.64	0.4525	0.3775
	4	−2	20.61	0.4192	0.3942
	4	0	21.32	0.3851	0.4124
	4	2	22.65	0.3500	0.4324
	4	4	21.49	0.3130	0.4551
	6	−10	15.33	0.5915	0.3515
	6	−8	18.65	0.5608	0.3691
	6	−6	18.02	0.5283	0.3877
	6	−4	19.36	0.4948	0.4072
	6	−2	20.55	0.4603	0.4282
	6	0	21.45	0.4250	0.4508
	6	2	21.89	0.3885	0.4758
	6	4	21.91	0.3498	0.5046
−1	−5	−1	22.61	0.2618	0.2405
	−5	1	22.69	0.2397	0.2454
	−5	3	22.66	0.2176	0.2504
	−3	−3	23.36	0.3099	0.2670
	−3	−1	23.67	0.2856	0.2734
	−3	1	23.81	0.2612	0.2801
	−3	3	23.81	0.2364	0.2871
	−3	5	23.64	0.2113	0.2945
	−1	−7	22.97	0.3911	0.2841
	−1	−5	23.68	0.3652	0.2917
	−1	−3	24.27	0.3392	0.2996
	−1	−1	24.70	0.3129	0.3081
	−1	1	24.94	0.2861	0.3171
	−1	3	24.96	0.2588	0.3266
	−1	5	24.74	0.2308	0.3369
A: Full-Step Colors					
	4	−6	28.55	0.4555	0.3594
	4	−4	29.81	0.4283	0.3719
	4	−2	30.87	0.4007	0.3852
	4	0	31.64	0.3726	0.3993
	4	2	32.05	0.3438	0.4146

Right half:

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	1	−3	25.00	0.3714	0.3330
	1	−1	25.60	0.3432	0.3439
	1	1	25.96	0.3145	0.3555
	1	3	26.02	0.2849	0.3682
	1	5	25.75	0.2541	0.3820
	3	−9	21.97	0.4933	0.3291
	3	−7	23.24	0.4646	0.3408
	3	−5	24.42	0.4357	0.3529
	3	−3	25.46	0.4063	0.3659
	3	−1	26.26	0.3764	0.3797
	3	1	26.77	0.3459	0.3946
	3	3	26.89	0.3144	0.4109
	3	5	26.54	0.2812	0.4292
	5	−9	21.43	0.5332	0.3520
	5	−7	22.89	0.5039	0.3664
	5	−5	24.31	0.4738	0.3815
	5	−3	25.58	0.4432	0.3975
	5	−1	26.60	0.4119	0.4146
	5	1	27.26	0.3801	0.4330
	5	3	27.45	0.3470	0.4535
	5	5	27.01	0.3119	0.4773
	7	−9	20.62	0.5724	0.3707
	7	−7	22.22	0.5431	0.3883
	7	−5	23.82	0.5127	0.4067
	7	−3	25.31	0.4814	0.4261
	7	−1	26.55	0.4493	0.4468
	7	1	27.38	0.4165	0.4694
	7	3	27.63	0.3823	0.4948
	7	5	27.09	0.3460	0.5249
0	−6	0	26.50	0.2457	0.2349
	−6	2	26.52	0.2260	0.2391
	−4	−2	27.49	0.2872	0.2598
	−4	0	27.68	0.2655	0.2652
	−4	2	27.75	0.2437	0.2708
	−4	4	27.68	0.2217	0.2767
	−2	−4	28.12	0.3350	0.2835
	−2	−2	28.58	0.3118	0.2903
	−2	0	28.88	0.2883	0.2974
	−2	2	29.00	0.2644	0.3049
	−2	4	28.93	0.2401	0.3128
	0	−8	27.22	0.4130	0.2972
	0	−6	28.14	0.3886	0.3050
	0	−4	28.93	0.3640	0.3131
	0	−2	29.57	0.3391	0.3218
	0	0	30.00	0.3138	0.3310
	0	2	30.20	0.2882	0.3406
	0	4	30.13	0.2617	0.3511
	0	6	29.77	0.2345	0.3622
	2	−8	27.35	0.4469	0.3230
	2	−6	28.50	0.4212	0.3327
	2	−4	29.52	0.3951	0.3429
	2	−2	30.36	0.3688	0.3537
	2	0	30.95	0.3421	0.3652
	2	2	31.25	0.3147	0.3775
	2	4	31.19	0.2863	0.3909
	2	6	30.73	0.2567	0.4056
	4	−8	27.16	0.4824	0.3475
A: Full-Step Colors					
	9	−7	31.66	0.5387	0.4045
	9	−5	33.55	0.5126	0.4214
	9	−3	35.29	0.4858	0.4389
	9	−1	36.76	0.4585	0.4578
	9	1	37.79	0.4305	0.4780

TABLE 1 *Continued*

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	4	4	32.01	0.3139	0.4315
	4	6	31.42	0.2822	0.4506
	6	−8	26.63	0.5186	0.3697
	6	−6	28.24	0.4910	0.3841
	6	−4	29.74		0.3992
	6	−2	31.02	0.4343	0.4152
	6	0	31.99	0.4052	0.4323
	6	2	32.52	0.3753	0.4510
	6	4	32.49	0.3440	0.4720
	8	−8	25.82	0.5544	0.3884
	8	−6	27.59	0.5267	0.4057
	8	−4	29.29	0.4982	0.4237
	8	−2	30.78	0.4691	0.4427
	8	0	31.95	0.4392	0.4632
	8	2	32.61	0.4086	0.4855
	8	4	32.59	0.3765	0.5111
1	−5	1	32.01	0.2493	0.2580
	−5	3	32.01	0.2298	0.2628
	−3	−3	32.80	0.3107	0.2760
	−3	−1	33.14	0.2897	0.2818
	−3	1	33.34	0.2686	0.2879
	−3	3	33.36	0.2471	0.2041
	−3	5	33.22	0.2254	0.3009
	−1	−5	33.21	0.3577	0.2971
	−1	−3	33.86	0.3355	0.3041
	−1	−1	34.34	0.3131	0.3114
	−1	1	34.64	0.2903	0.3193
	−1	3	34.71	0.2671	0.3274
	−1	5	34.54	0.2434	0.3361
	1	−7	32.90	0.4092	0.3158
	1	−5	33.91	0.3859	0.3240
	1	−3	34.77	0.3624	0.3328
	1	−1	35.42	0.3386	0.3420
	1	1	35.83	0.3144	0.3517
	1	3	35.96	0.2896	0.3620
	1	5	35.76	0.2641	0.3731
	3	−9	31.73	0.4645	0.3310
	3	−7	33.10	0.4403	0.3406
	3	−5	34.35	0.4159	0.3507
	3	−3	35.42	0.3912	0.3613
	3	−1	36.26	0.3662	0.3726
	3	1	36.81	0.3408	0.3845
	3	3	37.01	0.3146	0.3973
	3	5	36.79	0.2873	0.4113
	5	−7	32.96	0.4727	0.3643
	5	−5	34.45	0.4474	0.3764
	5	−3	35.76	0.4217	0.3891
	5	−1	36.80	0.3957	0.4026
	5	1	37.51	0.3691	0.4170
	5	3	37.78	0.3417	0.4327
	5	5	37.53	0.3132	0.4500
	7	−7	32.47	0.5058	0.3858
	7	−5	34.18	0.4798	0.4002
	7	−3	35.72	0.4535	0.4153
	7	−1	36.98	0.4266	0.4313
	7	1	37.85	0.3992	0.4485
	7	3	38.20	0.3709	0.4672
	7	5	37.92	0.3413	0.4887
A: Full-Step Colors					
	1	1	52.04	0.3143	0.3490
	1	3	52.24	0.2929	0.3578
	1	5	52.11	0.2709	0.3672
	3	−5	50.43	0.4024	0.3489

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	9	3	38.24	0.4017	0.5003
2	−4	0	39.65	0.2716	0.2739
	−4	2	39.76	0.2523	0.2792
	−4	4	39.71	0.2329	0.2847
	−2	−4	40.18	0.3324	0.2895
	−2	−2	40.73	0.3121	0.2956
	−2	0	41.10	0.2917	0.3020
	−2	2	41.28	0.2709	0.3087
	−2	4	41.24	0.2498	0.3156
	0	−6	40.32	0.3783	0.3083
	0	−4	41.22	0.3571	0.3155
	0	−2	41.95	0.3396	0.3231
	0	0	42.46	0.3138	0.3310
	0	2	42.72	0.2918	0.3392
	0	4	42.71	0.2692	0.3481
	0	6	42.40	0.2460	0.3575
	2	−6	40.90	0.4058	0.3329
	2	−4	42.04	0.3834	0.3417
	2	−2	42.97	0.3609	0.3508
	2	0	43.64	0.3380	0.3604
	2	2	44.01	0.3147	0.3706
	2	4	44.03	0.2907	0.3816
	2	6	43.66	0.2658	0.3934
	4	−6	41.17	0.4346	0.3570
	4	−4	42.55	0.4114	0.3674
	4	−2	43.70	0.3878	0.3783
	4	0	44.56	0.3639	0.3899
	4	2	45.05	0.3395	0.4023
	4	4	45.11	0.3143	0.4156
	6	−6	41.07	0.4646	0.3799
	6	−4	42.70	0.4406	0.3921
	6	−2	44.09	0.4162	0.4051
	6	0	45.14	0.3914	0.4188
	6	2	45.76	0.3660	0.4335
	6	4	45.86	0.3399	0.4496
	8	−6	40.58	0.4952	0.4008
	8	−4	42.45	0.4706	0.4152
	8	−2	44.07	0.4456	0.4303
	8	0	45.32	0.4202	0.4464
	8	2	46.08	0.3941	0.4637
	8	4	46.23	0.3672	0.4829
	10	−6	39.74	0.5257	0.4192
	10	−4	41.81	0.5009	0.4359
	10	−2	43.63	0.4756	0.4532
	10	0	45.09	0.4498	0.4719
	10	2	45.99	0.4233	0.4920
3	−3	−1	48.63	0.2926	0.2878
	−3	1	48.89	0.2738	0.2933
	−3	3	48.97	0.2549	0.2991
	−1	−5	48.76	0.3524	0.3010
	−1	−3	49.55	0.3329	0.3073
	−1	−1	50.15	0.3131	0.3139
	−1	1	50.53	0.2932	0.3208
	−1	3	50.66	0.2729	0.3279
	1	−5	49.74	0.3767	0.3251
	1	−3	50.75	0.3562	0.3327
	1	−1	51.52	0.3354	0.3406
A: Full-Step Colors					
	1	1	73.12	0.3143	0.3470
	3	−1	73.96	0.3540	0.3635
	3	1	74.76	0.3345	0.3722

TABLE 1 *Continued*

Left half:

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	3	−3	51.68	0.3810	0.3580
	3	−1	52.66	0.3593	0.3675
	3	1	53.32	0.3372	0.3776
	3	3	53.61	0.3147	0.3881
	5	−5	50.77	0.4293	0.3722
	5	−3	52.27	0.4071	0.3828
	5	−1	53.47	0.3846	0.3940
	5	1	54.30	0.3616	0.4059
	5	3	54.69	0.3381	0.4187
	7	−5	50.71	0.4568	0.3945
	7	−3	52.46	0.4343	0.4067
	7	−1	53.89	0.4110	0.4197
	7	1	54.90	0.3874	0.4337
	7	3	55.39	0.3632	0.4487
	9	−5	50.24	0.4851	0.4150
	9	−3	52.21	0.4623	0.4290
	9	−1	53.88	0.4385	0.4442
	9	1	55.08	0.4143	0.4603
	9	3	55.68	0.3895	0.4777
	11	−3	51.56	0.4905	0.4492
	11	−1	53.43	0.4665	0.4665
	11	1	54.81	0.4420	0.4850
4	−2	−2	58.70	0.3124	0.2996
	−2	0	59.18	0.2942	0.3054
	−2	2	59.43	0.2758	0.3114
	0	−4	59.39	0.3520	0.3173
	0	−2	60.26	0.3330	0.3240
	0	0	60.89	0.3138	0.3310
	0	2	61.24	0.2944	0.3383
	0	4	61.29	0.2746	0.3460
	2	−4	60.51	0.3750	0.3407
	2	−2	61.60	0.3551	0.3486
	2	0	62.40	0.3350	0.3569
	2	2	62.88	0.3146	0.3657
	2	4	62.98	0.2937	0.3750
	4	−4	61.30	0.3992	0.3638
	4	−2	62.63	0.3785	0.3732
	4	0	63.63	0.3576	0.3830
	4	2	64.24	0.3363	0.3934
	4	4	64.41	0.3145	0.4044
	6	−4	61.70	0.4244	0.3863
	6	−2	63.28	0.4031	0.3972
	6	0	64.50	0.3815	0.4086
	6	2	65.26	0.3594	0.4208
	8	−2	63.51	0.4286	0.4203
	8	0	64.94	0.4084	0.4335
	8	2	65.86	0.3838	0.4476
	10	−2	63.27	0.4548	0.4420
	10	0	64.92	0.4322	0.4571
	12	0	64.45	0.4584	0.4788
5	−1	−1	70.76	0.3132	0.3158
	−1	1	71.24	0.2954	0.3220
	1	−1	72.49	0.3330	0.3396
B: Half Step Colors					
	1.5	−1.5	28.40	0.3565	0.3492
	1.5	−0.5	28.68	0.3427	0.3549
	1.5	0.5	28.88	0.3288	0.3608
	1.5	1.5	29.01	0.3147	0.3668

OSA Lattice Coordinates			CIE Specifications		
L	j	g	Y_{10}	x_{10}	y_{10}
	5	−1	75.09	0.3762	0.3873
	5	1	76.07	0.3560	0.3974
B: Half-Step Colors					
−1.5	−1.5	−1.5	21.72	0.3121	0.2958
	−1.5	−0.5	21.86	0.2986	0.3000
	−1.5	0.5	21.96	0.2849	0.3043
	−1.5	1.5	22.01	0.2712	0.3088
	−0.5	−1.5	22.16	0.3275	0.3139
	−0.5	−0.5	22.34	0.3134	0.3188
	−0.5	0.5	22.46	0.2991	0.3238
	−0.5	1.5	22.53	0.2847	0.3290
	0.5	−1.5	22.56	0.3436	0.3323
	0.5	−0.5	22.77	0.3290	0.3378
	0.5	0.5	22.93	0.3143	0.3435
	0.5	1.5	23.02	0.2993	0.3495
	1.5	−1.5	22.91	0.3606	0.3507
	1.5	−0.5	23.16	0.3455	0.3570
	1.5	0.5	23.35	0.3302	0.3636
	1.5	1.5	23.46	0.3147	0.3704
−1	−2	−1	24.19	0.2988	0.2908
	−2	0	24.31	0.2861	0.2944
	−2	1	24.38	0.2732	0.2983
	−1	−2	24.51	0.3261	0.3038
	−1	0	24.84	0.2995	0.3125
	−1	2	24.97	0.2726	0.3216
	0	−2	24.94	0.3414	0.3210
	0	−1	25.17	0.3277	0.3259
	0	0	25.35	0.3139	0.3309
	0	1	25.47	0.2999	0.3362
	0	2	25.52	0.2858	0.3416
	1	−2	25.32	0.3574	0.3383
	1	0	25.81	0.3290	0.3496
	1	2	26.03	0.2998	0.3618
	2	−1	25.97	0.3595	0.3619
	2	0	26.22	0.3448	0.3683
	2	1	26.39	0.3298	0.3751
−0.5	−2.5	−0.5	26.63	0.2870	0.2856
	−2.5	0.5	26.72	0.2749	0.2891
	−1.5	−1.5	27.03	0.3123	0.2986
	−1.5	−0.5	27.19	0.2998	0.3026
	−1.5	0.5	27.31	0.2873	0.3066
	−1.5	1.5	27.37	0.2746	0.3107
	−0.5	−2.5	27.28	0.3393	0.3109
	−0.5	−1.5	27.53	0.3264	0.3152
	−0.5	−0.5	27.73	0.3134	0.3198
	−0.5	0.5	27.87	0.3003	0.3244
	−0.5	1.5	27.96	0.2871	0.3292
	−0.5	2.5	27.98	0.2738	0.3341
	0.5	−2.5	27.70	0.3544	0.3273
	0.5	−1.5	27.99	0.3411	0.3322
	0.5	−0.5	28.23	0.3277	0.3373
	0.5	0.5	28.40	0.3143	0.3424
	0.5	1.5	28.51	0.3005	0.3479
	0.5	2.5	28.54	0.2866	0.3536
B: Half Step Colors					
	0.5	1.5	32.44	0.3017	0.3464
	0.5	2.5	32.49	0.2890	0.3516
	1.5	−1.5	32.34	0.3529	0.3478
	1.5	−0.5	32.62	0.3403	0.3529